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The British University in Dubai

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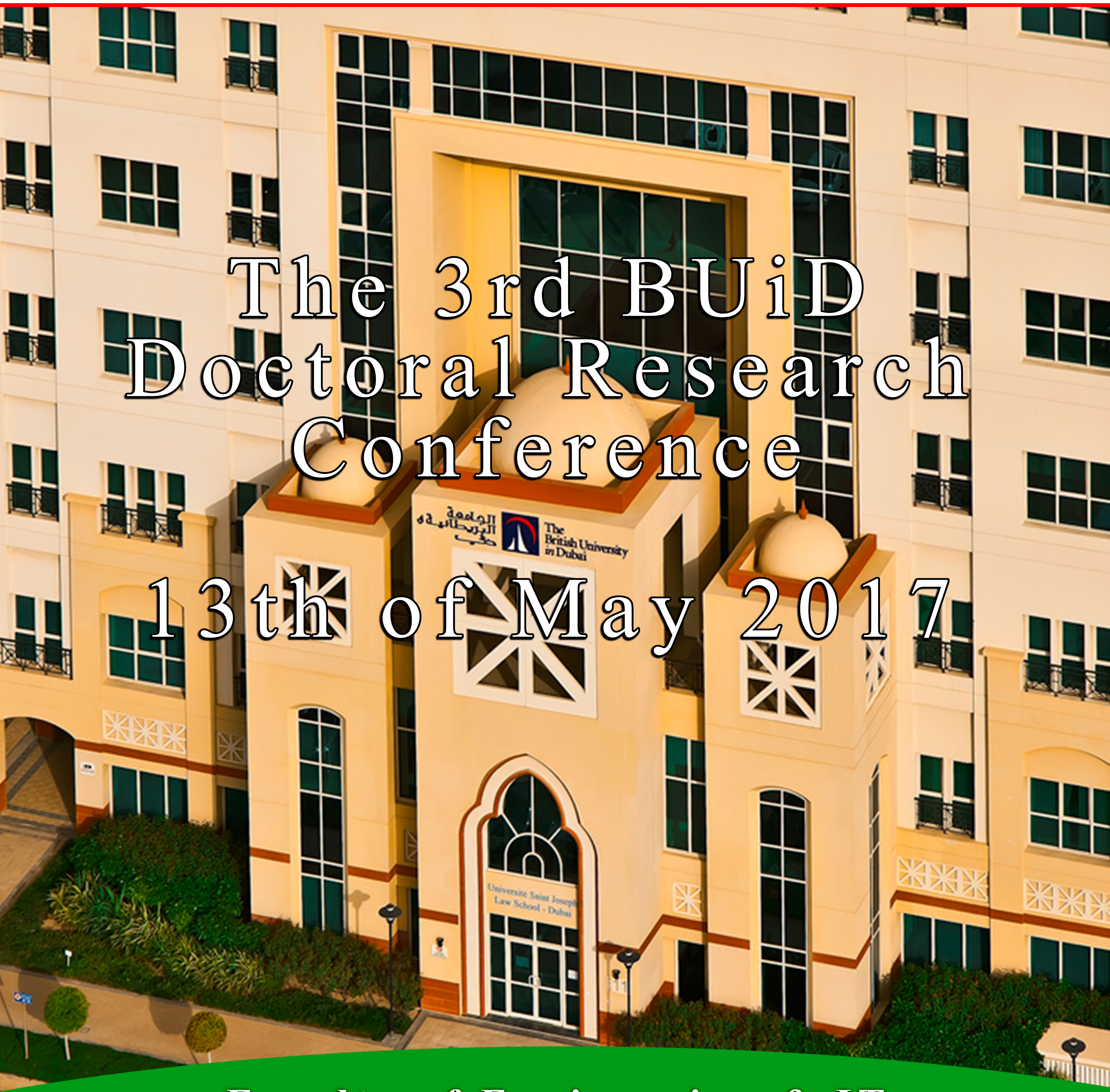
The 3rd BUiD Doctoral Research Conference

13th of May 2017



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The British University in Dubai
Doctoral Students Research Conference
BDRC2017
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We would like to take this opportunity to thank BUiD's Chancellor His Highness Sheikh Ahmed Bin Saeed Al Maktoum for his patronage and support of this event. We would also like to thank BUiD's Vice Chancellor Prof. Abdullah Alshamsi who supported the idea of establishing a national conference that offers a forum for regional & international PhD candidates to present their work to their peers.

The British University in Dubai, has been hosting Doctoral Conferences for three consecutive years (2015-2017), under the patronage of H.H. Sheikh Ahmed Bin Saeed Al Maktoum. The first conference that was held in May 2015 included 40 doctoral students presenting papers on their scientific research in such diverse areas as Sustainability, Innovation, Knowledge Management, Construction, Health Care, IT Security, Big Data, Complex Projects, Education, and Business Management. Many of the students are in full-time employment and have chosen thesis topics that address R&D challenges experienced in the workplace.

Sponsors of BUiD Doctoral Research Conferences have included Dubai International Academic City, Dubai Duty Free, Atkins, United Arab Emirates Khaleeji Chapter, and Al Sahel Contracting Company. Keynote presentations are given every year by academics from a range of GCC and UK universities such as the keynote presented in 2016 on "The Art and Science of doing a PhD" delivered by Professor Ghassan Aouad, President of the Applied Sciences University, Bahrain. Other keynotes have been presented by academics from the Universities of Glasgow and Loughborough.

Students from both BUiD and UK associate universities reviewed papers to gain experience and practice for their future academic activities. Academics from the University of Manchester, University of Glasgow and the University of Edinburgh have attended to support the conference, including reviewing and assessing nominations for the best paper awards. Awards have been presented for a wide range of full conference papers in Education, Project Management, Engineering & IT, Architecture, Sustainability and the Built Environment, and Business Management.

The past best paper awards address a wide range of PhD topics. In 2015: **Jacqueline Lottin** A Case Study Investigation of Special Needs Inclusion Policy Implementation in three Abu Dhabi Public Schools; **Mohammed Assaf** Examining the Perspectives of Public Schools' Grade 12 Emirati Students on Writing Challenges in English Language; **Vandana Gandhi** Parents Contribution to Preschool Children's Learning; **Yacoub Petro** Project Management Office Typology in UAE and its integration; **Shaima Al-Harmoudi** Stakeholder integration in open innovation construction Projects; **Shireen Chaya** Diversity Leveraging & Diversity-Competent Leadership: The Case of Leadership in UAE Organizations.

In 2016: **Lara Abdallah** A Study on the Perceptions of UAE private Secondary School Mathematics Teachers on the Impact of CPD Program Improvement*;* **Yan Zheng** (University of Glasgow) The Story, the Child, and the Touchscreen: How Story Apps Tell Stories; **Christine Unterhitzenberger** (Liverpool John Moores University) Organizational Justice and Construction Project Performance; **Shaikha Abdool** Electronic National Unified Medical Records and Application of Telemedicine; **Bertug Ozarisoy** (Cardiff University) Adaptation of Retrofit Strategies for Mass Housing Renewal and Urban Development order to meet the Demands of Energy Consumption, Occupants' Behaviour and their Cross-Cultural Influences in Northern Cyprus; **Eyad Megdadi** Multivariable Regulation of Gas Turbines for Automotive Applications.

In 2017: **Sandra Baroudi** An examination of factors that make international large-scale assessments effective: a case study of Lebanon; **Heba Daragmeh** Gifted and Talented Education Policy Analysis: A comparative study of the gifted and talented policies in the UAE, UK, USA, and Australia; **Selina Neri** From Quality to CSR; **Anmar Dulaimi** (Liverpool John Moores University) A Novel Cold Bituminous Emulsion Mixture for Road Pavement using A New Cementitious Filler; **Ala'a Abu Hijleh** Introducing System Dynamics Modeling to UAE Health Care Projects: Reducing patient waiting times; **Firoz Khan** The Future of Software Engineering: Visions of 2025 and Beyond; **Zahra Jwaida** (Liverpool John Moores University) Soft Subgrade Stabilisation Using Cement Kiln Dust and Ground Granulated Blast Slag.

Since 2016, conference attendance has grown to nearly 100 doctoral and masters students from the British University in Dubai and UAE based universities, including UAEU, Zayed University, Manipal University and Heriot-Watt University. As well as submissions from a number of UK based universities including universities from the UK alliance. Students from Cardiff University, University of Edinburgh, University of Glasgow, and Liverpool John Moores University have participated and presented at the conferences, in addition to students from elsewhere such as Skolkovo (Moscow School of Management) and the University of Rome.

Professor Ashly Pinnington
(Dean of Research)

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3rd BUiD Annual Doctoral Research Conference 2017	
Saturday 13th May 2017	
9:00 – 9:30	Registration
9:30-9:50	Welcome and Acknowledgements
9:50 - 10:20	**Keynote Presentation: Responsible Research** Prof Stephen McKinney, The University of Glasgow
10:20 – 10:55	**Keynote Presentation - Project Management Stream:** **Working with Industry – University & Companies** Prof. Ronald McCaffer, Loughborough University
10:55	Break
11:00 - 12:30	2 hours Concurrent Sessions
12:30 – 13:45	Lunch and Prayers
13:45 – 15:45	**Presentation Education Stream:** **Supporting Research, Developing Minds** Brian Chung - Al Qasimi Foundation's Overview of Current Studies at the Sheikh Saud bin Saqr Al Qasimi Foundation. followed by 1 hour 20 minutes Concurrent Session **Business Management Stream:** 2 hours Concurrent Session **Engineering & IT Stream:** 2 hours Concurrent Session
15:45 – 16:00	Break
16:00 – 18:00	Concurrent Sessions Paper Presentations Education, Engineering & IT, Business Management 2 hours RM3 Concurrent Sessions
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BDRC2017 CONFERENCE PROCEEDINGS

The British University in Dubai

Annual Doctoral Research Conference, 13th May 2017

Faculty of Engineering & IT

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Abstracts Only

The Future of Software Engineering After 50 Years

Abeer AlSereidi

The British University in Dubai

Abstract

Software engineering (SE) has come a long way, continuously shaping the path mankind has taken. It first extended its help to mankind by offloading computation problems from humans to computers. Slowly by slowly, it has grown to power up some of the most sophisticated things that could have been thought impossible 20 years ago. This paper goes through a number of state of the art technologies that are almost certainly going to make it to 50 years in the future. It takes a look at IoT, what is expected in its future and some of its challenges and solutions. The paper also discusses the future capabilities of Artificial Intelligence and evaluates whether it could one day take over the roles of man or go rogue. Drones are also keenly looked at in the paper and special attention is paid on the inevitable challenges that their widespread use will have. Another technology that is highlighted in the paper is that of wearables. Their anticipated future challenges are explored and solutions are given to each of these. The cloud is also discussed and its current and future problems are brought up. The paper tries to give viable solutions that will be applicable to solve those challenges. Lastly, the paper looks at the general security risks and issues that software engineering will inevitably have to face in 50 years.

Keywords: Artificial Intelligence; Internet of Things; Software Engineering; Cloud; Drones; Wearables

I. Introduction

Programming came to be first recognized in the 1960s as an activity that involved coding a computer. The term software engineering was coined in 1968 in a conference that was to discuss programming difficulties. Software engineering was used to refer to the disciplined, systematic approach to making software and maintaining them. The successful methodologies and tools that came later on to be commonly used for programming were languages that had modular, procedural or object -oriented approaches. Back in the 1960s, there were very few computers and programming started off essentially as a hard task. Programmers would write their programs outside the computers and then bring them to be queued for processing. At the time, computers were used solely for computation rather than to store data or for communication.

With time, the demands for programs grew and there were more complex problems to be solved. This led to the development of simpler and more robust programming languages. There began an advent for structured programming and this led to the development of structured programming languages such as Unix and C. However, C was seen as a poor implementation of structured programming although it was favored by learning institutions to teach programming because it had well-defined syntaxes. After structured programming came to the need for abstraction. The idea was to move coding as far away from machine language as possible. After a few years, people acquired personal computers and the demand for new and more complex software grew. There were many failed attempts to come up with a language that could make the demanded software. However, one distinct programming approach rose and came to be popular; it was called object-oriented programming. It made use of classes and objects. C++, Java, C-sharp and Object-Pascal came up at this time. However, after this, there was no major progress on software engineering. Computer hardware actually became faster than software did. Modern programming languages such as Java might be more advanced from the likes of C but they are still not perfect. Their manuals which span over hundreds of pages are still inadequate. Programmers are still facing constraints in software engineering.

The future of programming can, however, be said to be bright nevertheless. There are new challenges that have developed and software engineering is being used to address them. Today, there are so many inventions and innovations that could have been thought impossible 20 years ago. One of the most exciting directions that software engineering is taking is towards artificial intelligence. Software are being developed capable of self-learning. Recently, there has been the introduction of Internet of Things. Simple devices are connected on the same network enabling them to work together to achieve certain goals without human input. Another exciting development has been the automation of cars and planes to making them self-driving or unmanned respectfully. Several automobile companies such as Tesla have made cars capable of driving themselves to certain destinations. They can also accurately predict and avoid accidents. There has also been growth in making unmanned aircraft. Companies such as Boeing have shown their prowess in making these unmanned aircraft. They are still developing for some military organizations jet fighters and drones that can fly longer without any human present in the cockpit.

I. ARTIFICIAL INTELLIGENCE

Artificial Intelligence for long has been more of a theory than a practicality. It refers to the development of computers to be able to carry out tasks that require human intelligence such as decision making and visual perception [1]. Today, artificial intelligence has been successfully applied across many areas making robots more useful and at times even better at doing some tasks than humans. Artificial intelligence has been mainly supported by two things in software engineering; machine learning and advanced logic. Machine learning refers to making computers learn new things without having to be explicitly programmed [2]. In programming, there has been the development of new logic systems such as fuzzy logic that can take into account more logic states than simply true or false. Artificial intelligence is increasingly being used to make robots more independent of human inputs in a way such that they have their own ‘brains.’ These robots are learning on their own by being exposed to certain challenging environments to operate in. Software engineering has been leaning a lot towards AI of late.

There are certain areas that have been filled with hurdles that AI is removing. AI has been applied in SE to come up with a practice now referred to as Probabilistic Software Engineering. AI is being applied to handle problems in the real world that are very probabilistic. Fuzzy neural networks have been used to handle the probabilities. A good example of the application of AI in SE can be seen in the Bayesian probabilistic reasoning being used mostly to model how reliable a software can be [3]. There is a huge demand for AI in SE especially when it comes to making software systems that have to be personalized to the users. User behaviors are probabilistic and a lot of learning and prediction is needed to optimize it for them. In 50 years AI could take over SE from human beings but not completely. Humans will do part of the coding of a system while AI will be used to optimize the system to the relevant users, operating systems, and the IT resources available. AI will also be used to enable two different systems to better understand each other and even share information. Currently, there are some self-learning antivirus programs that automatically update each other when they detect new and previously unknown threats.

II. INTERNET OF THINGS

One of the current technological trends that are hitting the market is Internet of Things. ‘Things’ in this sense are machines that have sensors to capture, store, analyze and/or transmit data [4]. All the ‘things’ are connected to the internet which they use to upload the data for processing, to be used by other ‘things’ or to allow remote monitoring and control. IoT has been implemented in smart homes to control lights, doors, AC, entertainment systems and even to water plants. IoT has also been implemented in the health sector to make heart rate, blood sugar level and blood pressure monitors for patients. It is estimated that in 2020, there will be twenty-five billion IoT devices constantly transmitting data to each other or to humans. Software engineering is bending with the world towards making IoT systems. In 50 years, it is expected that IoT will be used to make possible smart cities that have ‘things' being used to offer public services such as security. This vision, however, has brought quite a number of challenges to software engineering. These IoT devices continually send out and receive data. Therefore, software engineers working on these devices need to make sure that their bandwidth requirements are low. They also run continuously so they need to be made in such a way that their energy and processing requirements are low and if possible much of the processing to be done outside of the device [5]. Software engineering also needs to innovate and come up with a design-driven development tool helping developers throughout the development life cycle of the ‘things.’

Another challenge that will be faced in the future by IoT is data management. With the number of IoT devices on the increase and with these devices in continuous communication, there will be lots of data doing rounds all over the internet. This is data that can be stolen by malicious persons if they get the chance. A feasible solution for this in SE would be to have data centers to store this data. The cloud will come as a solution to this requirement of a large enough, available, reliable and secure data storage point for the data generated by the IoT devices. There will also be an issue of third parties trying to get hold of the data generated by the IoT devices. Data from one’s home could be mined by these third parties in order to send adverts to the home owner. This will however be too intrusive and it will boil again towards privacy of the user. If a refrigerator is say out of fruits and it sends continuous adverts to the user of the stores one can get fruits, this could be perceived either way. On one hand it would be useful for the owner to know that he/she needs to buy fruits. However, it will be too intrusive to have third parties take control of this data and use it to advertise their items. A solution that SE might give to this problem would be giving exclusive ownership rights of the data generated by IoT devices to the owner. These devices would have to be built with an open setting that the user can use to control the availability of this information to third parties. If the ownership of this information is left to the manufacturers, there will be chaos with the amount of ad notifications that a user will be getting from third parties.

III. DRONES

A promising emerging technology that will most likely make it to the projected future of 50 years is that of drones. There are some key pointers that indeed drones will be a norm of the future. The largest e-commerce website, Amazon, has continued to test its Prime Air service. It is a service that will use drones to make purchase deliveries in 30 minutes. There has also been a major development in civilian drones making them more affordable and early adopters have been buying them in numbers. It is expected that in the future, humans will have to get used to bumping into drones almost everywhere. Civilians will most likely use them for aerial photography and businesses such as Amazon and Domino’s for door-step deliveries [6].

One key area that continues to shape the path of drones and push their applicability is in the military. The use of drones, just like the internet, was started in the military with the main aim being surveillance [7]. Over time, military drones have been made to fly for longer, to further places and carry more lethal payloads. There have been multiple reports of drone strikes being used to take out targets in places such as Syria and Afghanistan. They have successfully done that without exposing soldiers to direct harm from enemies. Some strikes have been done behind enemy lines, catching the targets by surprise. Achieving the same using soldiers would significantly be harder and often give the targets heads up to start fleeing before they are caught up with. Drones have been used to eliminate key terrorist group leaders causing destabilization of groups and confusion of the group members. Accuracy, stealth, and more firepower are now the key focus of military drones. Most countries are adding drones to their militaries and it is almost certain that in 50 years, almost all countries shall use drones in combat.

There are several significant challenges facing drones that need to be looked at. First of all, civilian drones will most likely lead to cluttered airspaces on top of the existing cluttered airspace. Assuming that most people will buy drones for their personal reasons, they will be too many such that navigation and finding a free enough airspace to comfortably fly will be hard. Not all that will be flying drones are going to be experts and this will see lots of midair collisions and damaged drones. An even greater threat is that of drones coming into collision with commercial airplanes. Some drones can fly as high as over one and a half miles in the sky. These could be sucked into engines of planes flying low, possibly during landings and takeoffs and possibly lead to aircraft crashes [8]. Besides the airspace being cluttered with drones, there is also a challenge of the currently existing clutter. Civilian drones will have to avoid a maze of billboards and electric wires in their flight paths. Dangerously placed, billboards will potentially blind these drones and wires being hard to spot from afar threaten to fry a number of the drones.

The use of closed platforms in the manufacture of drones is a challenge that will plague the communication and operation of drones. Today, several manufacturers are using their own unique ways in making drones. Drones have been built only to recognize signals coming from their manufacturers' controllers. There has not been any set ways to enable cross-platform communication of drones. This means that the air space will be full of small devices that will not be able to recognize and communicate with each other. The conventional airspace that has been used by planes, jets, and helicopters is very organized and there are sound ways that have been put up to allow communication between aircraft. Civilian drones have not kept to these expectations and this will be a big challenge in the future when there will be more drone manufacturers.

Another challenge that is more serious and cross-cutting to both civilian and military drones is the threat to privacy that the two will have. Civilian drones, being cheap and equipped with good cameras might be used by nosy people to spy on their neighbors. On the military side, however, there is a fear that military drones will be used for espionage purposes on enemies and at the same time civilians. Governments have already been found guilty of going through personal emails, phone calls and messages of their citizens. Drones will be a great addition to their spying initiatives as it will enable them to observe people from high in the sky. The threat of the loss of privacy to civilians due to drones being used to spy on them from left, right and center by the government and other civilians is real. Therefore, measures will have to be taken to prevent this from happening.

Another challenge that has already been observed in the military with the use of drones is in their accuracy. Drones are still not yet pinpoint accurate, yet they are being deployed to bomb targets. There have been quite a number of reports of drone strikes that have killed innocent people [9]. The reason behind this has either been operating on wrong intelligence and therefore hitting the wrong targets or inaccuracies within the drones themselves. The kill radius of a drone strike might still considerably be high in the future such that it could harm innocent people standing next to a target. Also concerning the killing of innocents, military drones could be misused by governments for extra-judicial killings within a certain country. A government could use them against political rivals or to suppress opposition leaders.

Software engineering has a few solutions that could be used to respond to the stated challenges. Concerning cluttering of airspaces that will lead to so many mid-air collisions, one recommendation could be used to solve this. Drone manufacturers should move away from their different ways of making the systems that fly drones and designate a given platform as the only one to be used. This will have also removed the bottleneck of lack of communication between drones. Drone manufacturers are also to come up with designated systems just like in aircraft to prevent collisions between drones or with aircraft. Software engineering has already solved a similar problem in commercial aviation using a system called TCAS that has prevented catastrophic midair collisions. All that is needed is a similar system to be developed just for drones.

As for privacy, there is little that software engineering can do to prevent someone from flying up a drone just to spy on neighbors or a government on its citizens. The most recommendable action here for the good of the future is to have several legislations governing the use of drones. This will prevent misuse of drones by both the government and civilians from intruding the privacy of people. The accuracy of military drones is an issue that might plague the military in the future. However, software engineering could be used to make pin-point accurate targeting and payload guiding systems. These will make sure that a target can be single-picked and taken down solely without risking the lives of innocent people. Today, the kill radius of a drone strike is still high and the said systems could reduce it to a few inches from a given target.

IV. WEARABLES

Probably the technology that can be predicted to bring an end to the era of smartphones in the coming future is that of wearables. They have now been developed to do more than smartphones are capable of. They have gotten advanced with time. Today, not only can they make calls, send messages, set reminders, show notifications and take pictures, they are also capable of being used for health monitoring. In 50 years, it is unimaginable just what the wearable technology will offer. One of the most awing capabilities of wearable technology has been shown in Microsoft HoloLens. They are glasses through which one can make and interact with holographs through augmented reality [10]. There are some predictions of the future wearables, most of which seem achievable. One prediction is that there will be special contact lenses that will come embedded with a personal assistant. A personal assistant in the eyes will help keep one’s life organized, provide contextual information, analyze environments and predict the most suitable reaction. Another prediction is a health monitoring watch that will keep track of one’s heart rate, blood pressure levels, temperature, oxygen levels and other health statistics. It will do all these outside the body on the wrist and will be in constant communication with doctors. It will also be responsible for calling for assistance when the wearer is involved in an accident or has a health emergency. There are many other predictions, some of which might sound far-fetched but if anything is to go buy from the last 50 years, all these predictions are achievable.

There are some foreseeable challenges in the wearable technology in the future as well. The greatest challenge will be making them on one open platform such that they can share data with each other. Today, the many companies that make wearables, just like drone manufacturers, use closed platforms. This means that, unless one buys wearables from the same company, they will act independently. Therefore, neither will take advantage of the data that another one collects. This is a big limitation. Another challenge will be environmental pollution. Obsolete computers and phones have shown just how much electronic waste could be a nuisance. It is predicted that there will be about 24 billion wearable devices in 2020, in 50 years, the number is unimaginably big. Once they go obsolete, their disposal will create an environmental nightmare if not done in the proper way.

Software engineering has some feasible solutions for the above-mentioned problems that will almost certainly be part of the future. As was said in drones, the best way forward with wearables is if there is one common platform used by all manufacturers when making the devices. With this common platform, each manufacturer will know the proper procedure calls to make when requesting information from another device.

V. CLOUD COMPUTING

One of the most successful and maturing technologies that is an absolute must for the future is cloud computing. Cloud computing has been adopted by many organizations and it will be an absolute requirement for all future organizations due to the amount of data that will be handled. Instead of investing in physical servers that can either lie idle and underutilized or at times be inefficient to handle voluminous data processing, organizations will all move to the more economical cloud [11]. With growth in the cloud infrastructures themselves, it is expected that cloud computing will be cheaper and more reliable. It will definitely shape the future because internet users are increasingly generating a lot more data. There is also a growing need for real-time processing systems capable of handling complex and unstructured data. Most of these new processing requirements are difficult to achieve using the conventional physical servers. In the future, the cloud will dominate data processing and organizations will have more reliable, stable, functional, available and secure processing environments.

Today, there are various vendors of cloud computing services and they are all using different platforms to support their cloud infrastructures. That means today’s cloud is heterogeneous and therefore, just like the above-discussed technologies, it is a major future challenge. Another challenge is that today's cloud services are implemented in open environments. This means that users are never aware of where exactly their applications are deployed. Therefore, when establishing a link between the cloud, and say a web interface that is not running on the cloud becomes quite difficult. It is, therefore, hard to give a cloud back-end a non-cloud front-end. Another challenge that will probably persist into the future is the issue of privacy and security. Within a cloud platform, the privacy of the data stored is not guaranteed as it would be if an organization was using a physical server which it had total control over [12]. In the cloud, data is scattered everywhere due to mirroring to ensure resilience. This also means that it is more exposed to hackers at the different physical locations it is stored in.

Freedom of use is yet another challenge that will come into the usability of the cloud in the future. Users are not allowed to have direct access to the systems that store their data. Data handling, data backup, and security of the cloud systems are exclusively done by the cloud vendor. Future users might want a little bit more access. As computing power increases, hackers become more powerful and capable of taking down bigger targets. In 50 years, no doubt that hackers will have immense hacking abilities and this will be a big challenge to cloud-based systems. Since the cloud will be holding most of the data and hosting many of the systems of the time, it will be a prime target. Security will be a great challenge to cloud vendors. Attacks might even span from within the cloud, in an environment where resources are shared between good clients and malicious clients.

SE may offer a few solutions to these anticipate future problems. As concerns the heterogeneity of the cloud, SE should develop platform-independent cloud models. These will be able to run across any platforms and will make the cloud more elastic. As is, it is very difficult to link cloud-based systems running on different vendors due to the platform restrictions. Once the cloud is made to be platform-independent, there will be just one cloud spanning across the whole world. All the restrictions between different vendors will be gone and there will be better collaboration between the systems supported by different vendors. As concerns privacy and security, there is only one sure way to assure users that their data is not accessible even by the vendors. The best solution that software engineering can give is total encryption of the segments of a cloud that a user has rented. Only the user shall have the key to access the encrypted data and/or systems deployed on the cloud. This will go a long way towards protecting the sensitive data that clients store even if hackers successfully breach into a vendor’s cloud infrastructure.

About the challenge of security, it is only feasible that cloud infrastructure is secured with intelligent security software. These intelligent and self-learning software will be able to detect threats from both within and outside the cloud. With the extensive resources available in a cloud set up, these intelligent solutions will be able to run without any resource constraints. Finally, concerning the transparency of the cloud and freedom of users to directly access the physical infrastructure running the cloud, SE has no solution for this. Such kind of freedom and transparency could jeopardize the security of the whole cloud infrastructure. It is best if clients are kept uninformed about it for the sake of security. Again, not all the cloud clients are saints, some could even be malicious groups continually examining cloud services for exploitable vulnerabilities.

VI. FUTURE CHALLENGES IN SOFTWARE ENGINEERING

Previously, software engineering was mostly focused on functionality and reliability of a software. However, the world today is insecure, dynamically changing and constantly coming up with more complex needs that software engineers need to address. There are currently very many challenges and new ones are expected to come up in the future. One of the most anticipated future challenges is in the processes, methodologies, and productivity of software engineering [13]. It is expected that the new advancements in technology will introduce changes to these three aspects of SE. It is expected that software quality shall no longer be judged on the lines of code but rather on usability, reliability, and scalability. Shorter development life cycles are also expected to triumph over the conventional long software development methodologies. Another challenge that is there currently and will definitely become more serious in the future is about privacy and security by design. Security is a serious challenge in developing software because of the existing malicious software and actors out to sabotage any software. It is expected that this will still be a challenge in the future as the strength, complexity, and damage that can be done by these software will be more. Privacy will also be a future challenge due to the amount of data sharing that new inventions are doing. Smart cars, smart homes, wearables and software with AI capabilities could be as harmful as they are going to be beneficial. The data that they collect if accessed by malicious people could be used to commit grievous crimes. Therefore, the intelligent devices will have to be built in a way such that they cannot leak their data to unauthorized people. This is a challenge considering that there will be about 25 billion of these devices in 3 years.

VII. SECURITY ISSUES AND RISKS

There are a number of risks and security issues foreseeable in software engineering in the next 50 years. The problems can even be identified today with the current inventions and innovations. One of these risks comes from AI whereby it could be a potential danger to the whole of humankind [14]. AI is going to get better to a point such that computers will out-compete humans in terms of skills and knowledge. A malicious person could make autonomous weapons designed to kill. A worldwide AI arms race could also be an inevitability and could spark an AI war leading to massive casualties and irreparable damage [15]. From another perspective, since the current move is to make AI machines more independent and self-learning, they could learn how to use rather destructive methods to achieve their goals. They could also deviate from doing what they were created to do and go rogue [16]. Another security issue that can be predicted to manifest in the future is IoT ransomware. This will be a malware designed to lock down and hold hostage homes, cars, industries even whole cities provided that they are running on IoT devices. Lastly, there will be a security risk of having too much personal information collected for big data, IoT and AI devices. The rate at which information is being collected by these three is surprisingly high. It can thus be said that there will almost be no privacy.

CONCLUSION

In conclusion, as the paper has highlighted several things that will be in the future of software engineering. From a humble beginning of making basic computation programs on cards using binary code, software engineering is today delivering the future. It has come up with several mind-boggling and complex inventions that have reshaped how humans have thought about the future. Things like autonomous driving cars, IoT being used to make smart cities and advancing robotics using AI are expected to be part of the future. There is also a great probability that the use if drones is going to extend into the future for both commercial and military purposes. Emerging technologies such as wearables are strongly kicking into the market and they even threaten to overtake smartphones. The cloud is maturing and with its offerings, there is very little possibility that it will not be part of the future.

However, with their many benefits comes huge risks and security issues. The paper has gone through several challenges expected to arise in the future of the said soon to be state of the art technologies. They might be actual challenges that are being experienced today even in the infancy of the technologies or mere predictions of what might be in their future paths. The paper has discussed the most viable solutions to counter each of the challenges. The paper has also keenly looked at the general challenges that will face software engineering too. It is however expected that the discipline will continually come up with solutions to combat the risks and address the discussed challenges and even more.

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Ammonia Removal using Sequencing Batch Reactor: The Effects of Organic Loading Rate

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Abstract

This study examines the impact of organic loading rate (OLR) on the effluent quality and sludge settling performance in a sequencing batch reactor. Four SBR reactors were used in this study; the working volume of each one is 5l. The reactors were operated under different potassium nitrate concentrations (50, 100, 150 and 200 mg/l), constant aeration, 1.0 l/min, ±20 C° temperature and 6 h cycle time. Each cycle of the SBR operation included Fill (30 minutes), React (240 minutes), Settle (30 minutes), Draw (30 minutes) and Idle (30 minutes). Influent and effluent samples were analysed for NH3-N to determine the removal efficiency. In addition, the sludge volume index (SVI) was used to study the sludge characteristics. The results obtained from this study, which operated for 60 days, showed that the sequencing batch reactor could biodegrade up to 91.5% for NH3-N with potassium nitrate concentration between 50 and 150 mg/l, and a steady sludge settling performance occurred during that range.

Keywords:

Ammonia; organic loading rate; sequencing batch reactor; sludge settling performance; sludge volume index.

Introduction

Every year, large concentrations of industrial wastewater contain organic matter, nitrogen, phosphorus and other trace elements such as carbon, calcium, potassium and iron are dumped into the rivers. This type of wastewater must be treated before it is discharged into rivers and other waterbodies; otherwise, the wastewater will damage the ecosystem, kill fishes and microorganisms in the waterbodies, and negatively affecting other animals that use these waterbodies, and having a detrimental effect on human health if people use the water. There are several types of treatment technologies that deal with this type of wastewater, such as physical treatment, chemical treatment and biological treatment. The latter is considered to be one of the most convenient technologies to treat industrial wastewater due to its economic advantages regarding operation costs. However, conventional biological treatment takes up a large amount of land and utilises several tanks in its operation; therefore, alternatives such as the sequencing batch reactor are being investigated and used [1, 2].

The SBR is a wastewater treatment system that works on the same mechanism as the activated sludge process (ASP). It has been applied successfully for treating domestic, industrial and other kinds of wastewater [3]. Additionally, the SBR is a fill and draw system which works in a cyclical time sequence, which means that it can operate in a lesser area than the conventional wastewater treatment methods. The SBR works as an equalisation, neutralisation and biological treatment and secondary clarifier in a single tank through a timed control sequence, which makes it attractive technology. Throughout one cycle, SBR technology has five operating steps – Fill, React, Settle, Draw and Idle. Due to its distinct one tank design and setup easiness, SBR has recently turn out to be an attractive technology. The SBR system outdoes the conventional activated sludge system by containing all treatment stages in a single tank, while in the conventional activated sludge system, the treatment units are in separate basins [4]. A substantial number of researchers have been optimising the SBR operating conditions to gain a better removal efficiency for undesired wastewater contaminants [5, 6]. One of the SBR's operating conditions is organic loading rate (OLR), which is considered to be a significant operating parameter in the SBR's design and operation. The growth rate of microorganisms in biological systems is dependent on the OLR. At a high OLR, microbial growth might increase intensely, while at a low OLR, microorganism food shortage takes place [7].

Due to the inadequate knowledge on the influence of the organic loading rate on the SBR performance, this study was implemented to find the impact of OLR on the effluent quality and sludge settling performance in a sequencing batch reactor.

1. Materials and methods

1.1 Experimental set-up of the SBR

Fig. 1 shows one of the four reactors used in this research. The capacity of each is 6.5L and the occupied volume is 5L; 1.5L of bacteria (biomass) plus 3.5L of synthetic wastewater were added to each reactor. The parameters of pH, DO, temperature and ORP were observed through sensors fitted in each reactor. The four SBR reactors were operated with different potassium nitrate concentrations: 50 mg/l, 100 mg/l, 150 mg/l and 200 mg/l respectively. Influent and effluent samples were taken from each reactor to determine the removal efficiency and settling performance and relate it to the OLR.

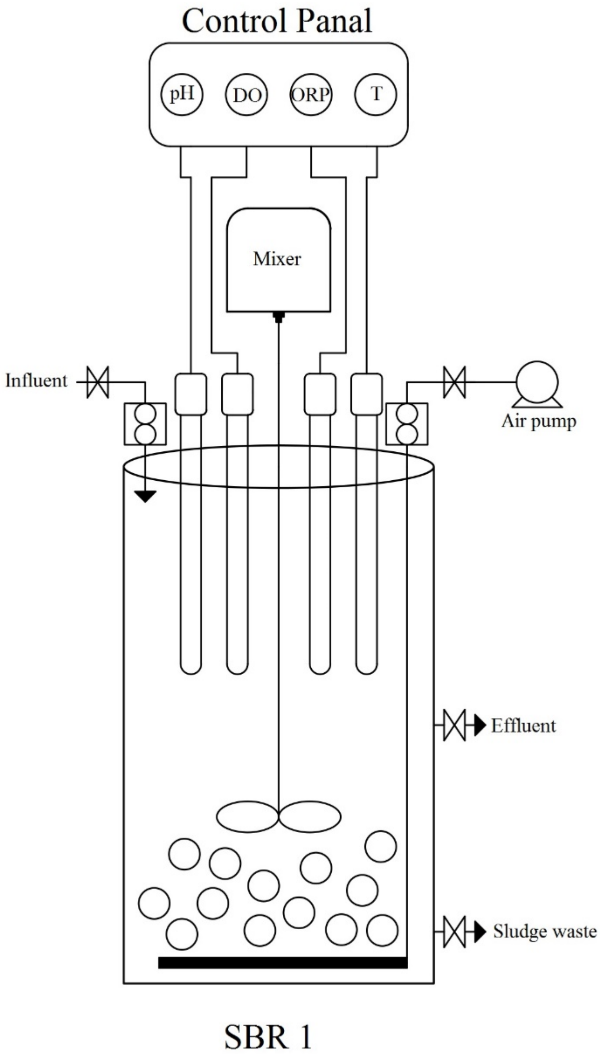

Fig. 1 Schematic diagram of one SBR

1.2 Synthetic wastewater

The activated sludge (bacteria) used to biodegrade the organic matter was taken from United Utilities, Sandon Docks, Liverpool, UK. The industrial wastewater was prepared by mixing the following chemicals with deionised water [8]: 500 mg glucose/L; 200 mg $NaHCO_3$/L; 25 mg NH_4Cl/L; 25 mg KNO_3/L; 5 mg KH_2PO_4/L; 5 mg $MgSO_4.7H_2O$/L; 1.5 mg $FeCl_3.6H_2O$/L; 0.15 mg $CaCl_2.2H_2O$/L.

1.3 Nutrient analysis

In this study, the influent and effluent samples were taken from the SBRs before and after the treatment cycle using a peristatic pump, and at that moment, the samples were filtered via a vacuum pump having filter paper (0.45 μm). The parameters of NH3-N and SVI were analysed according to the standard methods [9].

2 Results and Discussion

2.1 The impact of OLR on NH3-N removal

The concentrations and removal efficiency for NH3-N under different OLRs are shown in Fig. 2. There was no big change in the removal efficiency for NH3-N after increasing the potassium nitrate concentration from 50 mg/l to 100 mg/l and 150 mg/l; the average removal efficiency for NH3-N under 50 mg/l was 91.3%, and, after raising the potassium nitrate concentration to 100 mg/l, the average removal efficiency for NH3-N became 91.5%. Finally, when the potassium nitrate concentration was raised to 150 mg/l, the average removal efficiency for NH3-N became 91.1%. However, when increasing the potassium nitrate concentration to 200 mg/l, the removal efficiency dropped dramatically; the average removal efficiency for NH3-N during the 200 mg/l OLR was 86.5%. This result agreed with [10], who stated that at high ORL the removal of COD and nitrogen would be decreased. However, [11] reached high COD and nitrogen removal rates even under high ORL.

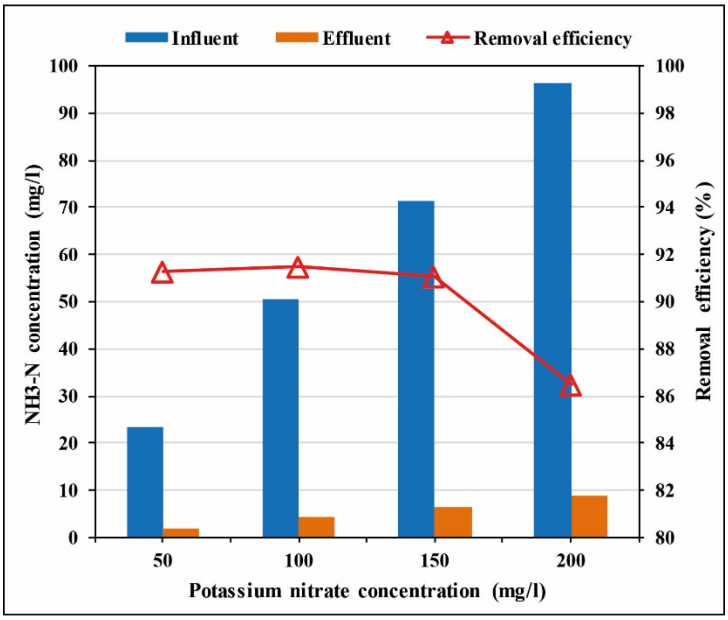

Fig. 2 The effects of OLR on the removal efficiency of ammonia

2.2 The impact of OLR on sludge settling performance

The impact of OLR on solids settling performance is shown in Fig. 3. The average SVI concentration for the 50 mg/l OLR was 32 ml/g, and it can be obviously seen that increasing the OLR to 100 mg/l did not affect the solid settling performance and the SVI was 33 ml/g. However, raising the OLR to 150 mg/l negatively affected the sludge settling performance and the SVI was raised to 37 ml/g. Further increasing the OLR to 200 mg/l made the settling even slower and the SVI was increased to 40 ml/g. In the same vein, [12] stated that increasing the OLR will lead to a relative increase in biomass concentration, which will result in high SVI and the settleability of the solids will decline. This agreed with [13], who reported an increase in the concentration of suspended solids when the initial concentration of COD was increased, which would also lead to an increase in the SVI and a subsequent drop in the solids' settleability.

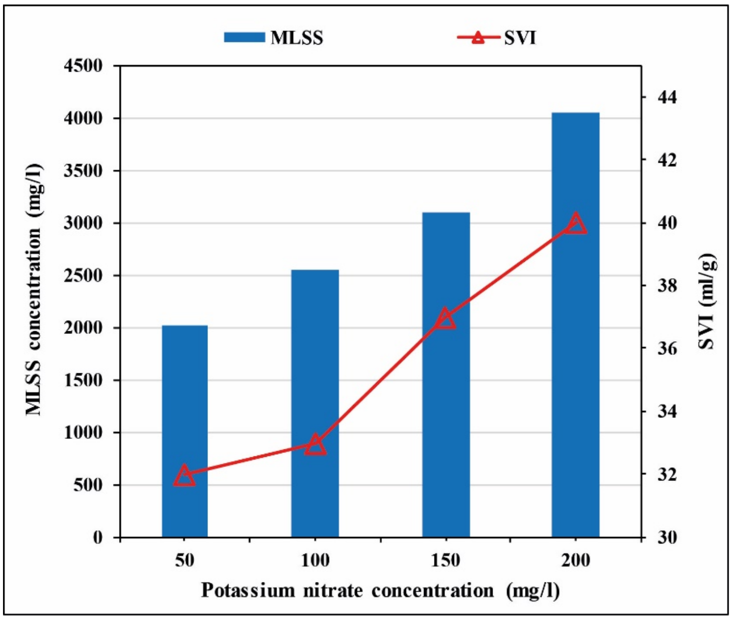

Fig. 3 The effects of OLR on the sludge settleability

Conclusion

SBR was investigated to treat synthetic industrial wastewater. The effects of four different organic loading rates on the performance SBR were examined. NH3-N was tested to determine the SBR treatment efficiency, and the SVI was used to determine the sludge settling performance. The results showed that SBR technology could work efficiently with potassium nitrate concentrations between 50 mg/l and 150 mg/l and could biodegrade up to 91.5% for NH3-N, and a steady sludge settling performance occurred during that range. However, increasing the potassium nitrate concentration to 200 mg/l decreased the removal efficiency and increased the settling time. Hence, the OLR was found to be a significant parameter that influences the operation of an SBR.

Acknowledgement

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Phosphate removal by utilizing different sorption materials as filter media: A comparative study

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Abstract. Many techniques have proposed for phosphate removal, but most of them did not provide a sustainable solution. The utilization of the phosphate sorption materials PSMs is one of the treatment methods that in line with the sustainability approach.

This paper focuses on the phosphorus sorption by using biomass bottom ash BBA, limestone and sand. This study has performed in laboratory columns (height 0.25, diameter 0.1 m and upflow configuration). The materials, which contain metals such as Fe/Al hydroxide or contain soluble (Ca and Mg), exhibited a significant tendency for phosphate sorption. X-ray fluorescence analyzer XRF has applied to analyses the chemical composition of the materials. The influence of particle size of the materials has taken into the consideration. The BBA, dolomite and sand have packed in the columns as filter media, and then a synthetic phosphate solution was pumped as influent. The BBA showed high phosphate sorption with short time in comparison with limestone and sand. On the other hand, the limestone showed a good phosphate sorption but the process required longer time than the other two materials. The sand reduced the phosphate drastically at the beginning of the process but its removal capability decreased faster than BBA and limestone.

As a conclusion, the results showed that the chemical composition for the materials plays the crucial role in the sorption process. Because BBA contained Fe/Al metals, it achieved the highest phosphate sorption.

Keywords: Eutrophication, filter media, phosphate, upflow filter, wastewater treatment

1. Introduction

The protection of water bodies from eutrophication became an essential requirement. Phosphorus is one of the elements, which contributes in the eutrophication of the aquatic environment. Most authors agreed that orthophosphate is dominating on other phosphorus compounds in municipal wastewater (Valsami-Jones, 2004, Farmer, 2001).

Currently, searching for materials with a significant affinity for P is required to achieve the necessary water quality as declared in the EU Water Framework Directive WFD (Kaasik et al., 2008). Based on this ground, many researchers considered the investigation on alternative materials has become essential as one of the sustainable technologies for P removal. According to Johansson Westholm (2006) these materials can be classified into three groups: natural materials, industrial by-products, and manufactured products. Recently, large number of Phosphorus sorbing materials PSMs have examined to determine their capability to remove P from wastewater. Many authors' states that the efficiency of the material that act as P filter is depend on the chemical composition of these materials. Especially, if they contain hydroxides and oxides such as Al, Fe, Ca and Mg (Vohla et al., 2011). In addition, the physical properties that characterize the material play a vital role in mechanism of P removal (Mann, 1996). The main target of this work is to investigate proper materials to act as P-filter media.

2. Materials and method

2.1 Filter material

Depending on their chemical composition and availability, the biomass bottom ash BBA and dolomite have been selected to assess their suitability as a phosphate filter materials. The chemical composition is responsible on the interaction between the materials and phosphate ions. Based on this fundamental, the materials were selected according to their chemical content from hydroxides and oxides. X-ray fluorescence analyser XRF was performed to show that BBA content 2.168 Aluminium oxide, 1.397 Iron oxide, 7.615 calcium oxide and the rest are silica and fines. While the dolomite contain 48.807 calcium oxide. In addition, the sand capability for phosphate removal has been inspected as standard filter material.

2.2 The synthetic influent

The predominant form of phosphorus in wastewater is the inorganic Phosphorus; especially, in form of orthophosphate. Therefore, monopotassium phosphate KH_2PO_4 is used as influent solution that pumped to the filtration system that set up in this work. The salt was dissolved in deionized water to prepare the phosphate solution. Commonly, the P concentrations in wastewater range from 5 to 10 mg P/l. therefore, the initial phosphate concentration in this work was 10 mg P/l as to simulate the maximum P concentration in wastewater that is most expectable.

2.3 Method

Three acrylic cylinders were used as filter columns in this experiment. The dimensions of each filter were 10 cm diameter and 30 cm depth. The depth of the packed media is 13 cm placed over 10 cm gravel layer lies at the bottom to maintain the influent transfer through the filter. The synthetic influent has pumped via submersible pumps at flow rate 1 l/min. The material also fractionated to 1 and 2 mm particle size groups to obtain better investigation in determining the influence of physical and chemical characteristics on phosphate sorping by PSMs.

3. Results and Discussion

The packet filter materials contain three types of minerals Al, Fe and Ca. According to XRF analysis, the BBA consists of Al, Fe and Ca in different percentages, while the dolomite contain calcium oxide. On the other hand, sand poorly consists of Al, Fe and Ca; the silica is the main constituent in sand.
The first run for each media has performed where the media packed without classify them according to their particle size. Figure 1 shows that phosphate removal of dolomite and sand were less efficient than BBA. The BBA was removed 72.17% from the phosphate at the end of the experiment duration, while the phosphate removal by dolomite and sand were 60% and 56% respectively.
The sand showed a faster phosphate removal for first 6 hr in comparison with dolomite. Afterward the dolomite starts to be efficient than sand. This indicates that the removal over the dolomite is slow and need for long contact time with the influent to retain the phosphate. At the start of the experiment for less than 30 minutes, the phosphate retention efficiency was almost convergent for all materials (roughly 20% P removal). Afterward the phosphate retention efficiency for BBA increased dramatically in comparison with other two materials. Therefore, the strongly phosphate-retaining material is BBA. Dolomite is slightly more efficient than sand.

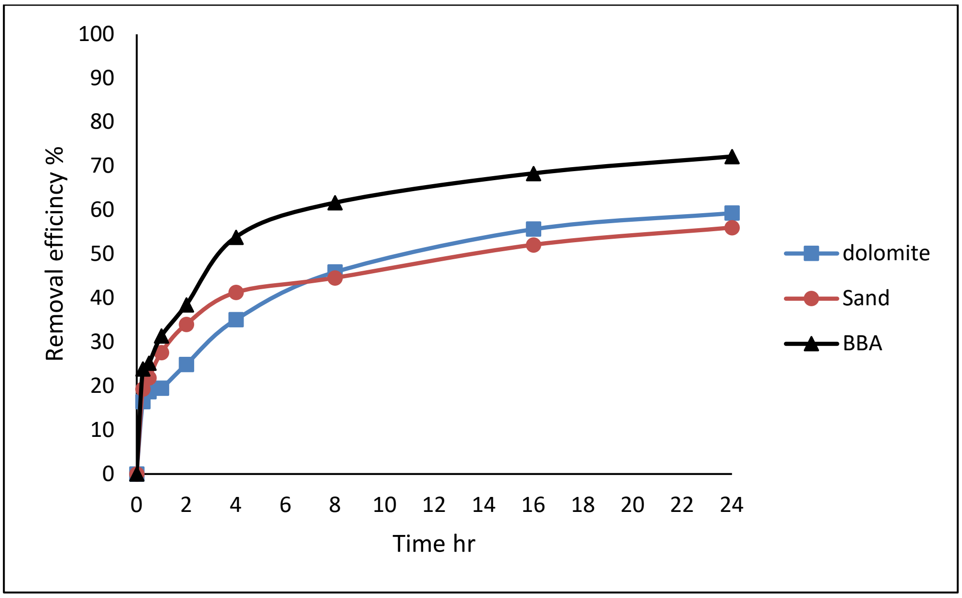

Figure 1: phosphate removal efficiency for the selected materials

Particle size is one of the main factors, which maintain the treatment efficiency. Furthermore, the durability and reliability of the filtration system. Each filter material was fractionated into two groups of particle size 1 and 2 mm by sieving. The outcomes of phosphate binding per unit mass of media for both particle size were compared with the materials at the total particle size as shown in figure 2. Obviously, at all particle sizes the phosphate uptake by BBA is better than dolomite and sand. Likewise, the materials at particle size 1 mm offers better sorption than other particle sizes because the small particle size correlates to the surface area positively.

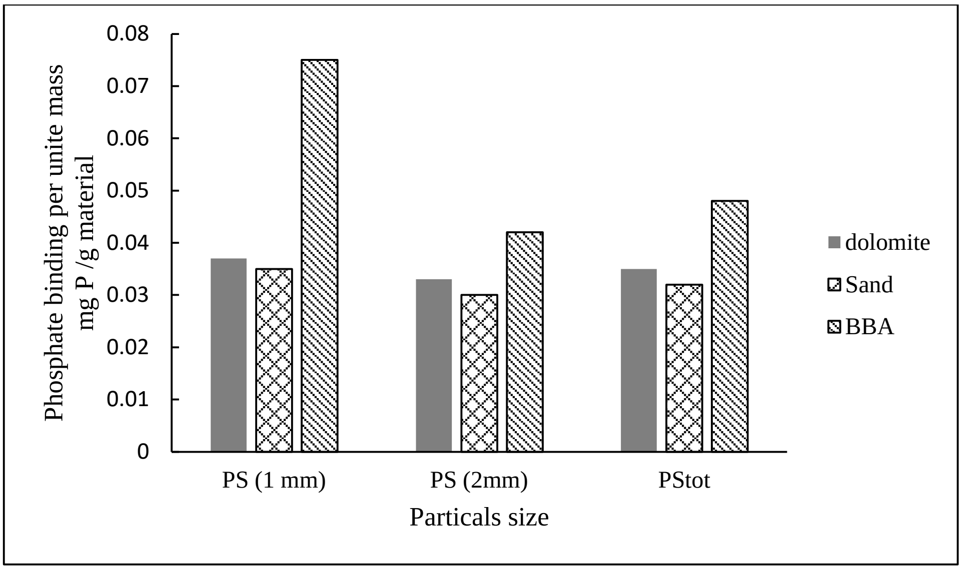

Figure 2: Influence of particle size on the phosphate sorption

The acceptable phosphate concentration, which discharged from wastewater into the water bodies, is 0.1 mg/l. This standard value is obtained when the phosphate retention rate reach 0.05 mg P/l. BBA showed an outstanding phosphate removal efficiency in comparison with dolomite and sand. The results suggested that the chemical composition for materials is the essential factor in retain the phosphate from the effluent. Especially, the material that contain the metals such as Fe/Al.

Conclusion

Sorption studies have carried out to define the phosphorus uptake by several materials were selected according to their chemical composition. Their chemical composition investigated by X-ray fluorescence analyser and the finding revealed that the BBA contain a Fe/Al and dolomite contain high percentage of Ca metal. BBA in comparison with dolomite and sand achieved better phosphate removal. The calcium ions need a plenty of time to absorb the phosphate ions. While, the Fe/Al hydroxides are adsorbing them rapidly. According to the results, the particle size is one of the key factors in phosphate removal process but its influence will not be valuable for phosphate removal without present the Fe/Al hydroxides and soluble Ca oxides in the material composition.

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A Novel Cold Bituminous Emulsion Mixture for Road Pavement using A New Cementitious Filler

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Abstract

Cold bituminous emulsion mixtures (CBEMs) are environmentally friendly with ecological and economic advantages in their production and laying. These mixtures are bituminous materials commonly made by mixing aggregates with an asphalt emulsion and water. However, weak early strength and the long curing time of these mixtures is considered unacceptable by road engineers to apply in pavement layers. A new binary blended cementitious filler (NBCF) has been developed to generate a new fast-curing CBEM. This NBCF was used as a replacement for the limestone filler; this contains a high calcium fly ash (HCFA) and metakaolin (MK). The Marshall Method for Emulsified Asphalt Aggregate Cold Mixture Design (MS-14) has been used to design the developed CBEM. The results have confirmed an improvement in performance of the CBEM compared to the conventional hot mix asphalt (HMA) regarding stiffness modulus. The new NBCF mixture offers stiffness modulus equivalent to the traditional HMA after 3 days. Furthermore, use of scanning electron microscopy (SEM) proved the generation of hydrate products at early and later ages that are responsible for the early and ultimate strength gain.

Keywords

High calcium fly ash, indirect stiffness modulus, metakaolin and scanning electron macroscopy.

Introduction

Hot mix asphalt (HMA) is a principle material in road pavement construction where such mixtures getting its full desired properties in a short time after application. Such mixtures used widely for base, binder course and surface layers. However, there are some restrictions associated with the production of such mixtures such as the greenhouse gas emission that contributes to global warming; the huge amount of energy needs to produce these mixtures and the safety of the humans when laid these mixtures in no open-air places such as tunnels. Accordingly, there is an increasing interest in growing sustainability in the construction of road pavement. One approach is to using cold bituminous emulsion mixtures (CBEMs) and substitute the conventional mineral filler with waste materials and by-products (Dulaimi et al., 2017). CBEMs have environmental advantages over HMA by being a cold product, and it is safe to use whilst also reducing energy. However, the long time necessary to achieve full strength and a slow rate of curing has led CBEMs to be considered inferior compared to HMA over the last decades.

Normally researchers use Ordinary Portland cement (OPC) to enhance the performance of CBEMs by reducing the curing time and improve the early strength (Al Nageim et al., 2012; Fang et al., 2016a; Fang et al., 2016b). Nevertheless, there is a heavy pressure to decrease cement consumption due to damage of environment caused by the extraction of raw material for the production of cement and global warming problem due to the CO_2 emission during its manufacture (Ouyang et al., 2011). The manufacture of 1 tonne of OPC assumes the consumption of 1.5 tonnes of quarry material, energy consumption of 5.6 Gj/tonne and an emission of approximately 0.9 tonne of CO_2 (O'Rourke et al., 2009).

Recently, several studies have been performed into the apply of waste materials and by-products in CBEMs in road pavement layers, including the use of fly ash as a replacement for the limestone filler (Al-Busaltan et al., 2012), Ground Granulated Blastfurnace Slag (GGBS) (Ellis et al., 2004), recycled aggregates from construction and demolition (C&D) (Gómez-Meijide and Pérez, 2015). Moreover, fluid catalytic cracking catalyst residue (FC3R) has been used by Dulaimi et al. (2016) as an activator to produce a new cementitious material for waste and by-products as a replacement for OPC in CBEMs. Using waste materials and by-products in CBEMs lead to decrease waste disposal and saving raw materials will contribute to sustainable development.

Sadique et al. (2013) combined fly ash rich in calcium and other one rich in alkali sulfates, with silica fume to develop a binder with 30 MPa strength. Another study implemented by Şahin et al. (2016) examined the use of a ground slag and a high-lime fly ash, rich in free lime and sulfates, to activate each other and generate mortars with useful strengths.

Metakaolin (MK) is a natural pozzolanic material derived from calcinated clay would have a higher potential for improving engineering properties in concrete (Ramli and Alonge, 2016). MK can be used as a partial replacement for cement which can contribute to economic, environmental, and technical benefits by provides a new usage for such by product materials leading to low cost construction materials as well as decreases carbon emissions (Mohseni et al., 2017). It was stated that the partial substitution of cement with MK considerably affects early strength.

There is no research on the use of high calcium fly ash (HCFA) with metakaolin (MT) to produce a new binary blended cementitious filler (NBCF) to use as an alternative material to OPC in the manufacture of CBEMs for road pavement construction. The new CBCM mixture was compared with the same mix proportions containing conventional limestone filler along with two control hot mix asphalts. As a result, the application of the new cementing material will reduce OPC use in CBEMs as well as decrease the volume of the waste disposal and a better environment will be guarantee. Furthermore, this research will make the application of the new cold asphalt concrete binder course mixtures in pavement construction become practical by eliminating the long-time curing range from (2-24) months.

Materials and Methods

2.1 Aggregates

Crushed granite aggregate was used in this investigation to produce the CBEM. The properties of aggregate were evaluated according to the EN 13108-1 (European Committee for Standardization, 2006). Aggregate complied with AC 20mm binder course materials in roads pavement construction. The physical properties of the coarse aggregate were: apparent density 2.67 Mg/m^3 and water absorption 0.8% while for the fine aggregate: apparent density 2.65 Mg/m^3 and water absorption 1.7%. Aggregate gradation is given in Table 1.

Table 1. Graduation of the aggregates

Test sieve aperture size, (mm)	Mass passing specification range (%)	Mass passing mid (%)
20	99-100	100
10	61-63	62
6.3	47	47
2	27-33	30
0.250	11-15	13
0.063	6.0	6.0

2.2 Fillers

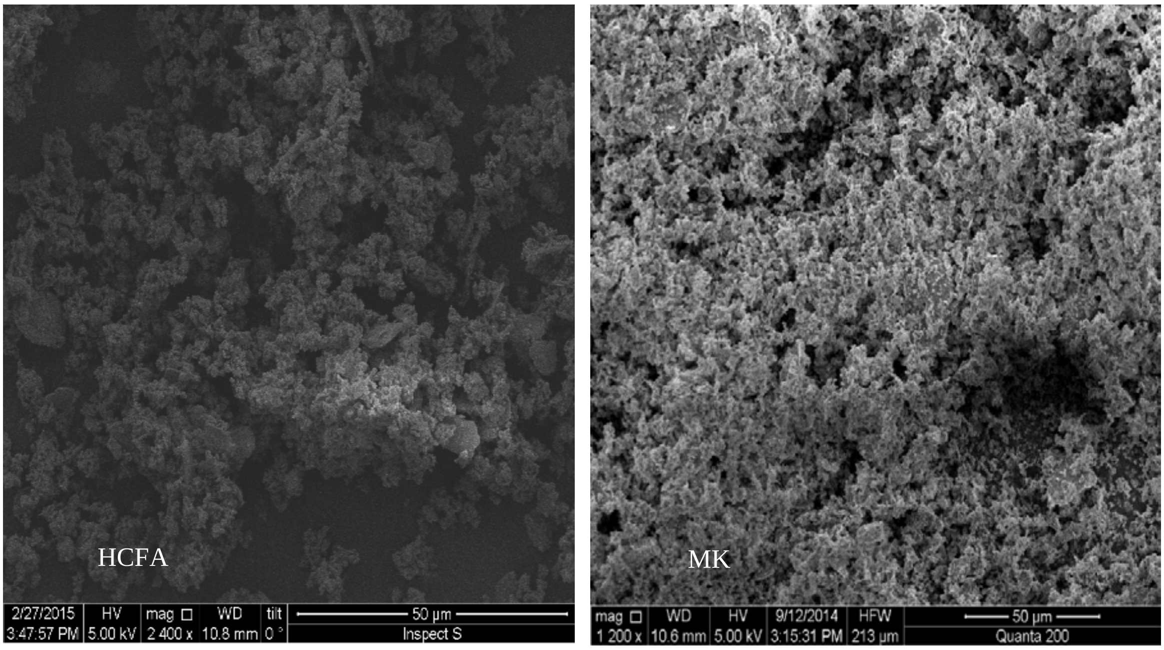
High calcium fly ash (HCFA) from power generation plant was analysed as filler in this study. In addition, Metakaolin type MetaMax supplied by BASF which produced by controlled calcination showing a high level of pozzolanic reactivity. It can react with the free lime by-product of Portland cement hydration to generate cementitious calcium silicate and calcium aluminate products. Limestone filler (LF) and Ordinary Portland cement (OPC) were utilized for preparing the control cold mixtures. Figure 1 shows the morphology of the fillers used in this research. Chosen SEM photos of the four fillers show that the LF and OPC formed in cube shaped crystals. While, it can be seen that HCFA and MK are agglomerated. Table 2 shows the chemical compositions by energy dispersive X-ray fluorescence (EDXRF) spectrometer of all fillers used in this research. HCFA is rich with calcium, while the main oxides in MK are Al_2O_3 and SiO_2. It was stated by Acharya and Patro (2015) that calcium hydroxide reacts with pozzolanic materials in the moisture present at normal temperatures to form calcium silicate hydrate C-S-H gel.

Table 2. EDXRF of the selected fillers, %

Chemical composition	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	SO_3	K_2O	TiO_2	Na_2O
HCFA	67.057	24.762	2.430	2.845	0.000	0.340	0.266	0.473	1.826
MK	0.023	45.252	44.627	0.407	0.348	0.078	0.125	1.64	0.901
OPC	62.379	26.639	2.435	1.572	1.745	2.588	0.724	0.385	1.533
LF	76.36	16.703	0	0.981	0	0.096	0.348	0.185	2.258

2.3 Bitumen and emulsion

Cationic slow setting bitumen emulsion (C60B5) supplied by Jobling Purser, Newcastle, UK was used in this research. The bitumen base is 100/150 pen with bitumen residual content is 60%. This type of bitumen emulsion is preferred because of its capability to coat the aggregate and to guarantee high adhesion between aggregate particles. Two penetration-grade bitumen 100/150 and 40/60 produced by Nynas, UK were selected for hot asphalt mixtures.



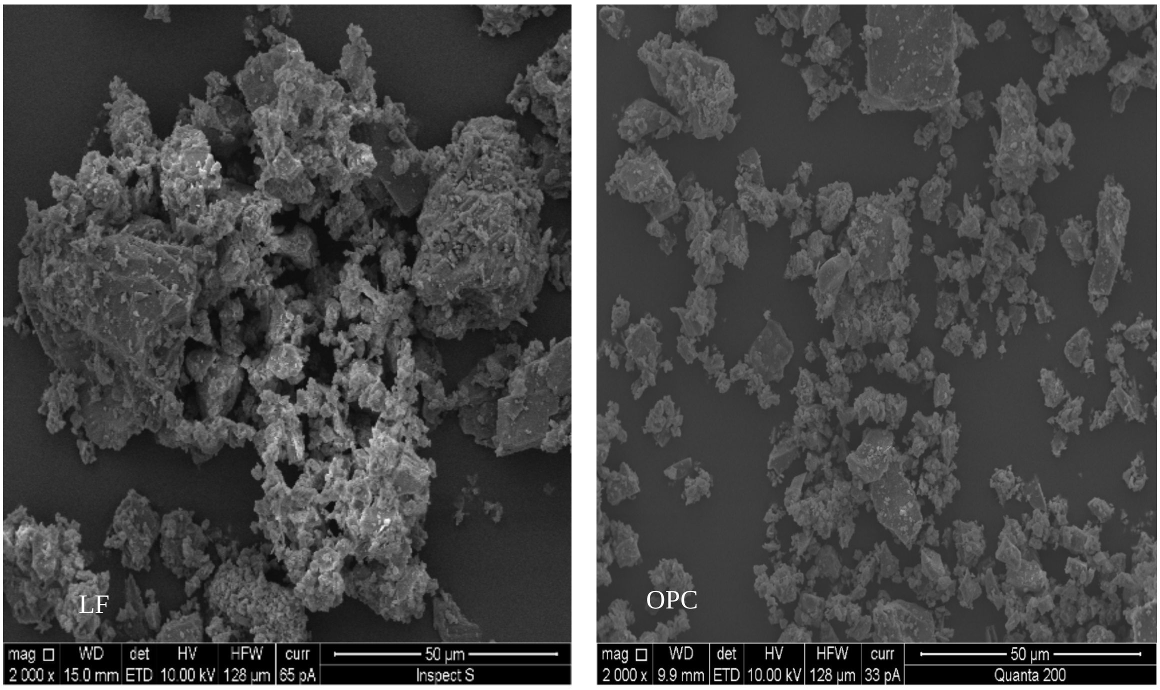


Figure 1. SEM view of fillers

2.4 Mix design, testing method and samples preparation

There is no universally accepted mix design procedure for CBEM at present. Some procedures are available to select the optimum emulsion and water content for CBEM mixtures (Jenkins, 2000; Thanaya, 2003; Asphalt Institute, 1989). The Marshall mix design procedure, as specified by the Asphalt Institute, (Marshall Method for Emulsified Asphalt Aggregate Cold Mixture Design), (Asphalt Institute, 1989) was used in this investigation. To manufacture the CBEM, the aggregate gradation, which was an AC 20mm was selected in accordance with the limits given by the EN 13108-1 (European Committee for Standardization, 2006).

The behaviour of the samples manufactured with HCFA which was substituted for traditional limestone filler while MT was used as supplementary cementitious material to generate the NBCF. The samples were removed from moulds after 24 hours and after that, all the samples were left in the lab at 20 ^{o}C and tested at various ages, i.e. 3 and 28 days. In addition, both grades of AC 20mm hot mix were stored at 20 ^{o}C and tested in similar ages. A cold asphalt concrete binder course containing limestone was also used for comparison. All indirect stiffness modulus test values are the average of three specimens to ensure the reliability of the results. The indirect tensile stiffness modulus (ITSM) test has been conducted to examine the effect of replacing the LF with HCFA and the effect of the addition of MK. The test was performed according to BS EN 12697-26 (European Committee for Standardization, 2012). This test is a non-destructive generally used for the evaluation of the stiffness modulus of bituminous mixes (Figure 2). Stiffness modulus is necessary in road pavement for adequate structural design. It can be considered as an indicator of the structural behaviour of such mixtures as it is connected to the capability to distribute traffic loads. The results have been compared with a standard hot AC 20mm dense mixture. Two types of hot mixtures (AC 20mm dense binder course

100/150 and AC 20mm dense binder course 40/60) have been used throughout with the same gradation and type of aggregate. Following the requirements of the PD 6691:2010 (European Committee for Standardization, 2015) 4.6% optimum binder content by weight of aggregate was used for the AC 20mm dense mixtures. Specimens were fabricated and compacted at room temperature (20 ^{o}C), whereas 100/150 and 40/60 mixtures were mixed at (155^{o}C) and (165^{o}C), respectively.

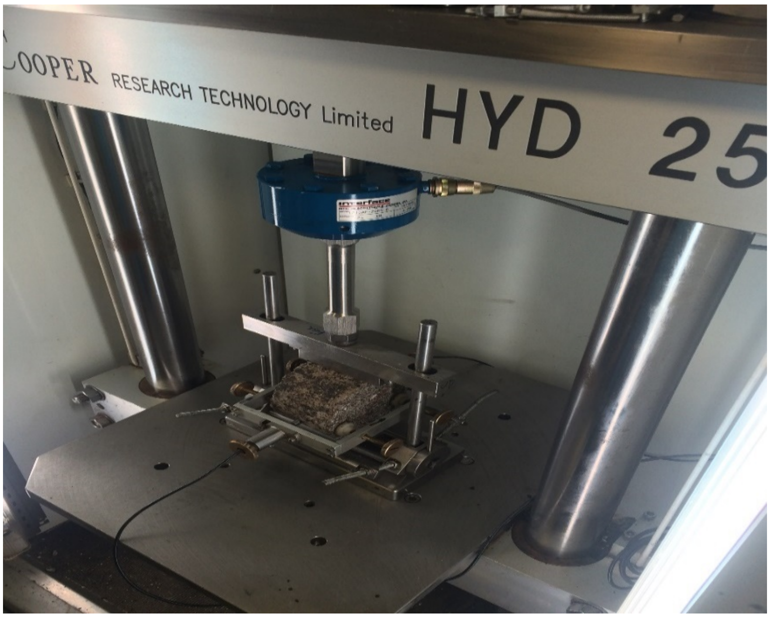


Figure 2. ITSM apparatus used in this research

The microstructure was studied on fracture surfaces by the scanning electron microscope. Pastes samples were prepared to obtain specimens for examination by scanning electron microscopy (SEM). These samples were used to recognize the changes in the materials at different ages of curing. The pastes were moulded into a cylinder specimens, which were kept for 24 hours in room temperature and then demoulded. After that, the samples were removed and allowed to dry, after which testing was achieved. Proper fragments were taken off from the core of the paste at 3 and 28 days for SEM observation. Figure 3 shows the samples for SEM observation from the pastes samples. These specimens were mounted into aluminium stubs and the fracture surface of the hydrated paste specimens was coated with palladium by an auto fine sputter coater.

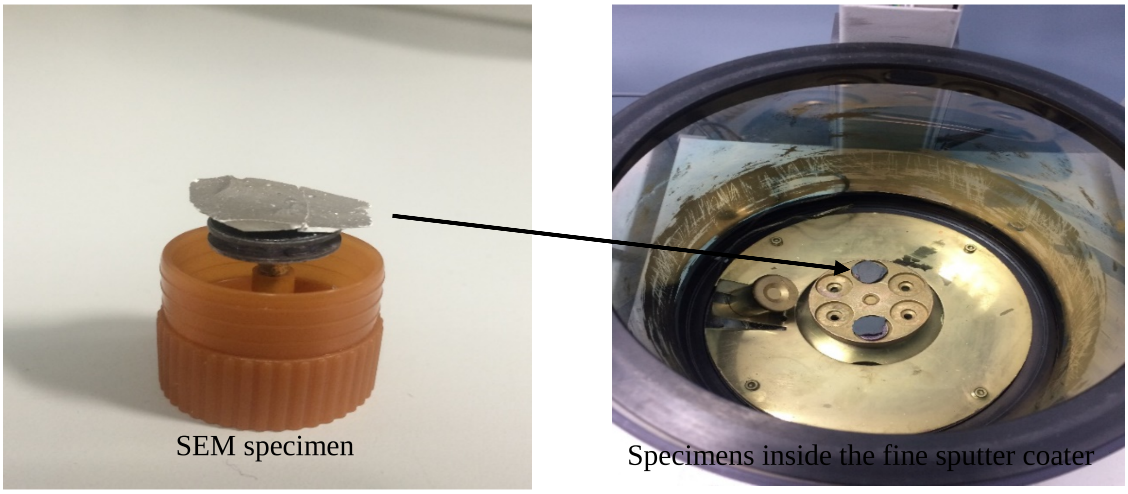


Figure 3. Samples for SEM observation

Results and Discussion

3.1 ITSM improvement

In this research, HCFA treatments were achieved through a substitution for the traditional LF in the CBEMs. Accordingly, HCFA treatment was achieved by replacing LF with 3% and 6%. In HCFA mixture, as seen in Figure 4, a substantial increase was observed when HCFA completely substituted the traditional LF. HCFA treated mixture shows higher stiffness modulus than LF and this indicating a positive effect by adding this waste filler. The generation of another cementitious binder inside the CBEM mixture and the consumption of trapped water in this mixture are the main two reasons for this improvement in ITSM. However, the ITSM of the HCFA is still less than the OPC mixture after three days. It can be seen that LF shows lower ITSM in comparison to other mixture making this mixture unsuitable for pavement application due to the long curing time needed to achieve an acceptable ITSM.

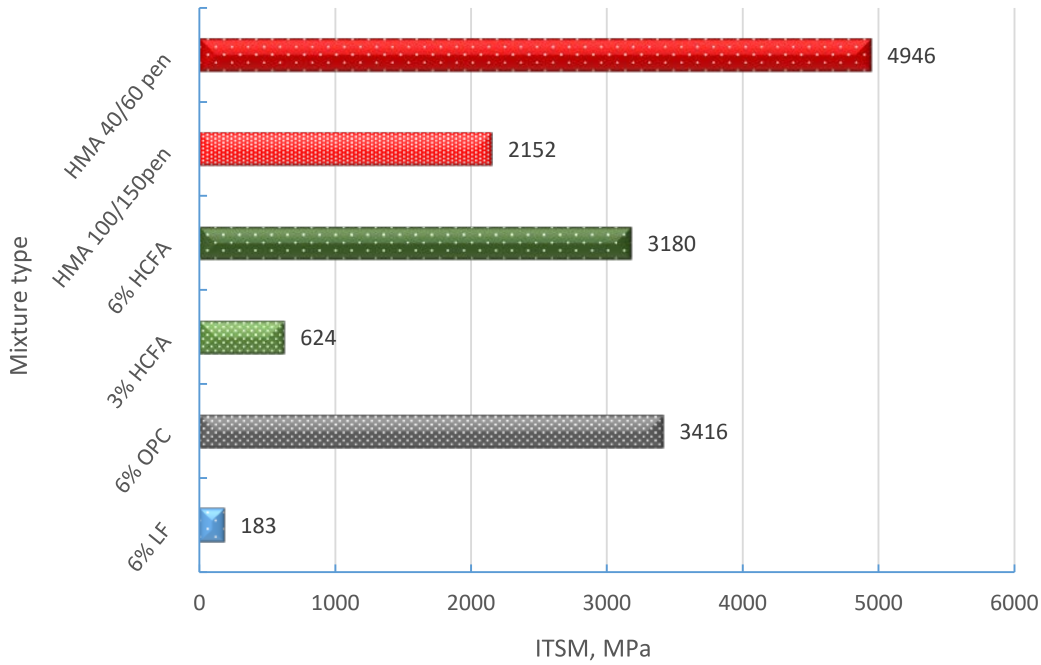


Figure 4. ITSM after 3 days

The next step in this research is to activate the HCFA by using MK through partial replacement of the HCFA and when a balanced oxides compositions were achieved, a new binary blended cementitious filler (NBCF) was produced, Figure 5. This NBCF composed of 4% HCFA and 2% MK that produce higher ITSM after 3 days. The pozzolanic particles of the MK activate the hydration process of the HCFA leading to the generation of more calcium silicate hydrate gel and calcium aluminum silicate hydrate. These results have been confirmed by SEM observation in the next section.

It was reported by Ismail and Jaeel (2014) that silica and alumina content may form additional calcium silicate hydrate (C-S-H) gel through reacting with calcium hydroxide generating during the cement hydration, leading to increase the strength.

It can be seen from the literature that the low early stiffness of CBEM is one of the major shortcomings of such mixtures when using traditional LF. However, an outstanding stiffness increase was obtained after three days of normal curing by using the HCFA and the NBCF. The achieved stiffness contributes successfully to decreasing the curing time in the field. The early ITSM of HCFA and NBCF are approximately 17 and 24 times higher than those of the control LF mixture. In comparison, the stiffness modulus of HMA 100/150 and HMA 40/60 were 2152 and 4946 MPa and was achieved by the NBCF within the first three days whereas the LF never reached this ITSM value even after 28 days curing, Figure 6.

In relative terms, these outcomes are consistent with those achieved by Al-Busaltan (2012) and Al Nageim et al. (2012). Nevertheless, the values of ITSM were higher than the previous studies and this might be related to the materials characterization and the activation method adopted in this research.

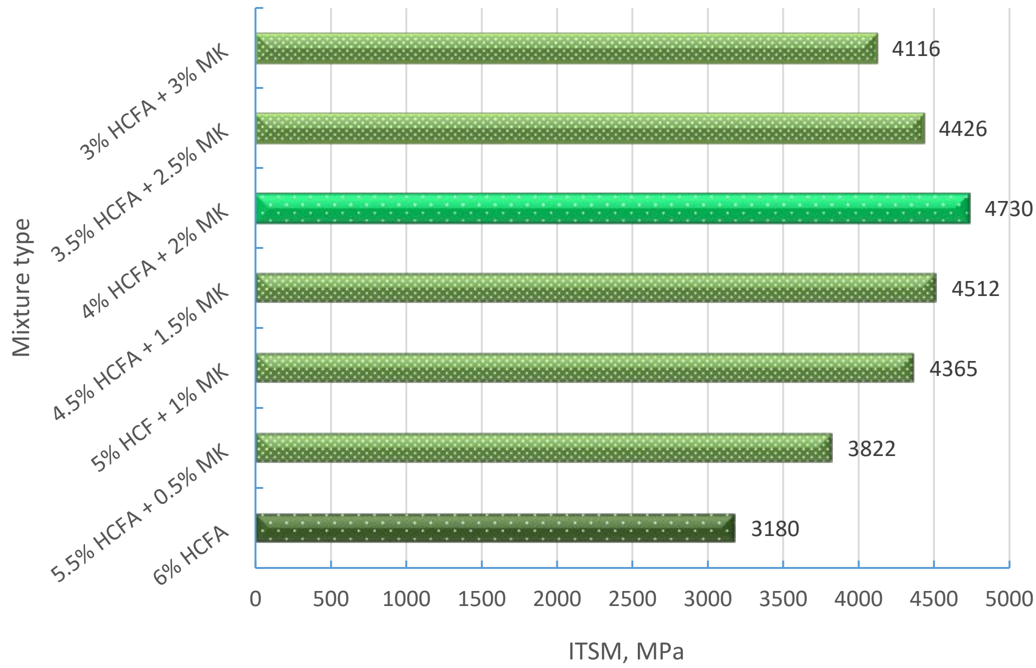


Figure 5. Optimization to achieve the NBCF after 3 days

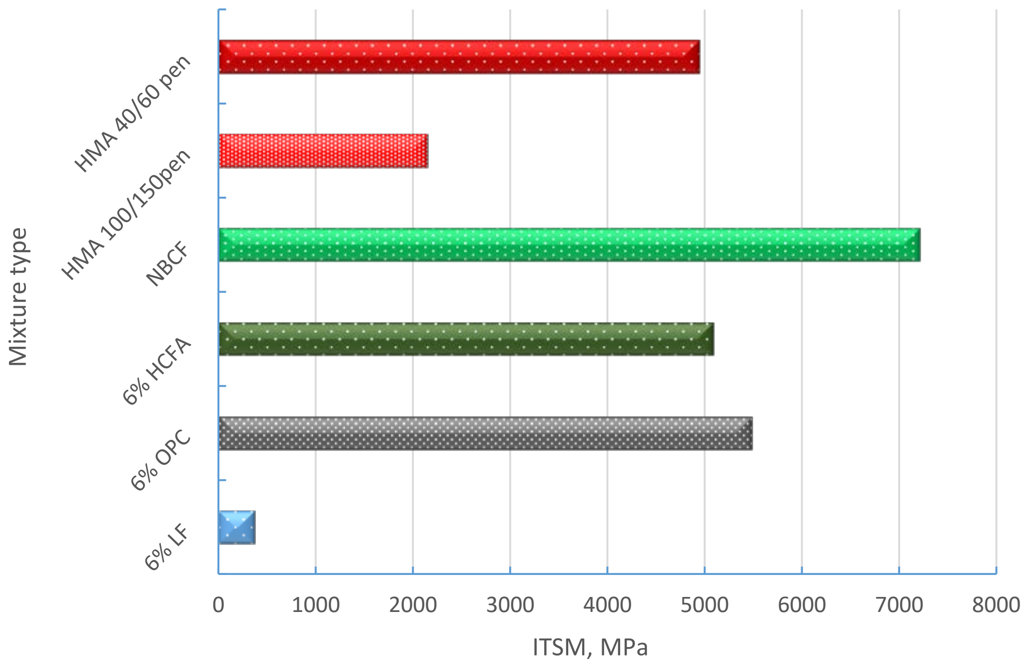


Figure 6. ITSM after 28 days

3.2 Scanning electron microscopy (SEM) assessment

SEM is a technique can reveal the details of very fine objects. Many researchers have used it for assessing the microstructure of cementitious materials. A calcium silicate hydrate (C-S-H) gel was observed in the NBCF paste which is considered as one of the major hydration products able to change the microstructure of NBCF, Figure 7. This gel has a shape of flaky aspect-like, rounded and compact globule-like (Nassar, 2016). In addition, Portlandite with tiny hexagonal plate-like shape is also observed in Figure 7. Based on the SEM observation for NBCF, there is an indication that a change in the morphology occurred after mixing with water which shows the reactivity of this filler and its ability to improve the internal microstructure, as revealed by the microstructural observation. The SEM observation after 28 days, Figure 8 reveals the generation of a C-S-H gel that creates dense microstructures leading to more strength development. Figure 8 shows the growth and development of the hydration products in NBCF. There is a formation of additional C-S-H gel which was observed after 28 days. It was revealed that after 28 curing days, the existence of C-S-H gel and Portlandite was evidently detected in many places in the NBCF sample.

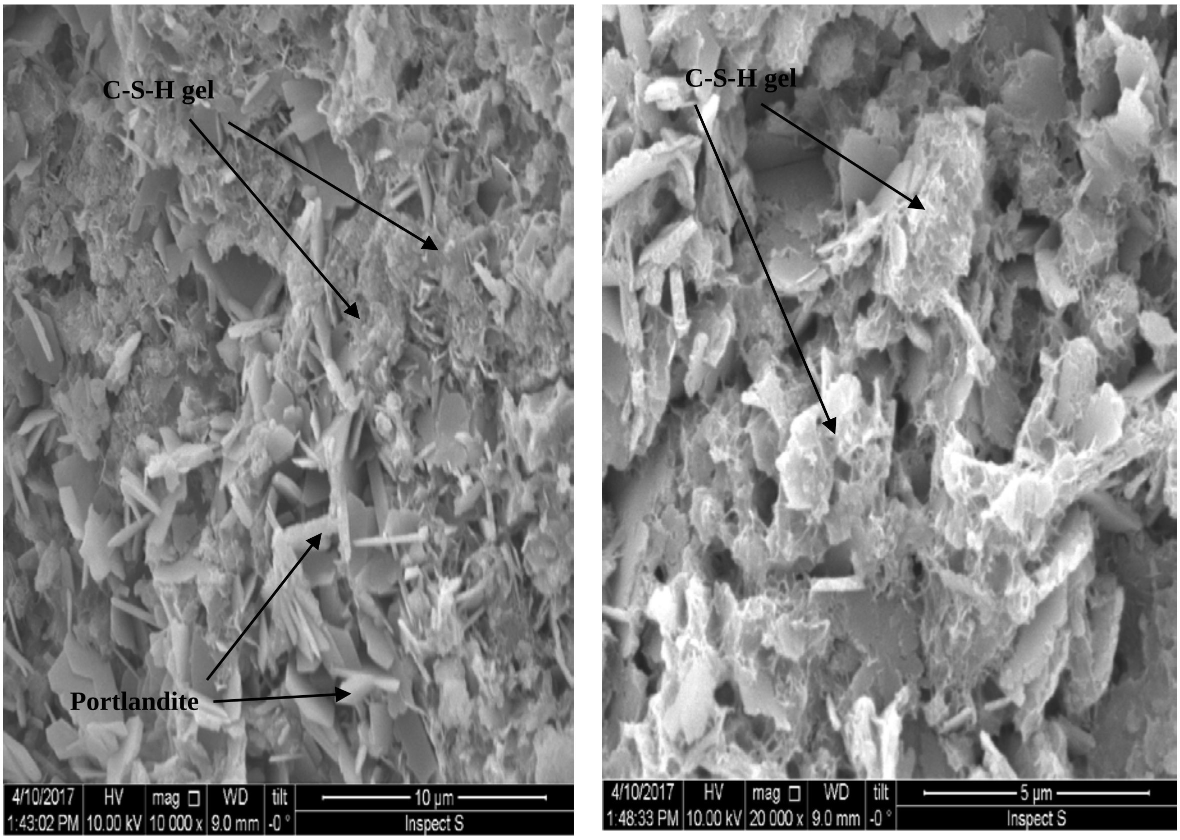


Figure 7. Morphology details of the microstructure of NBCF after 3 days

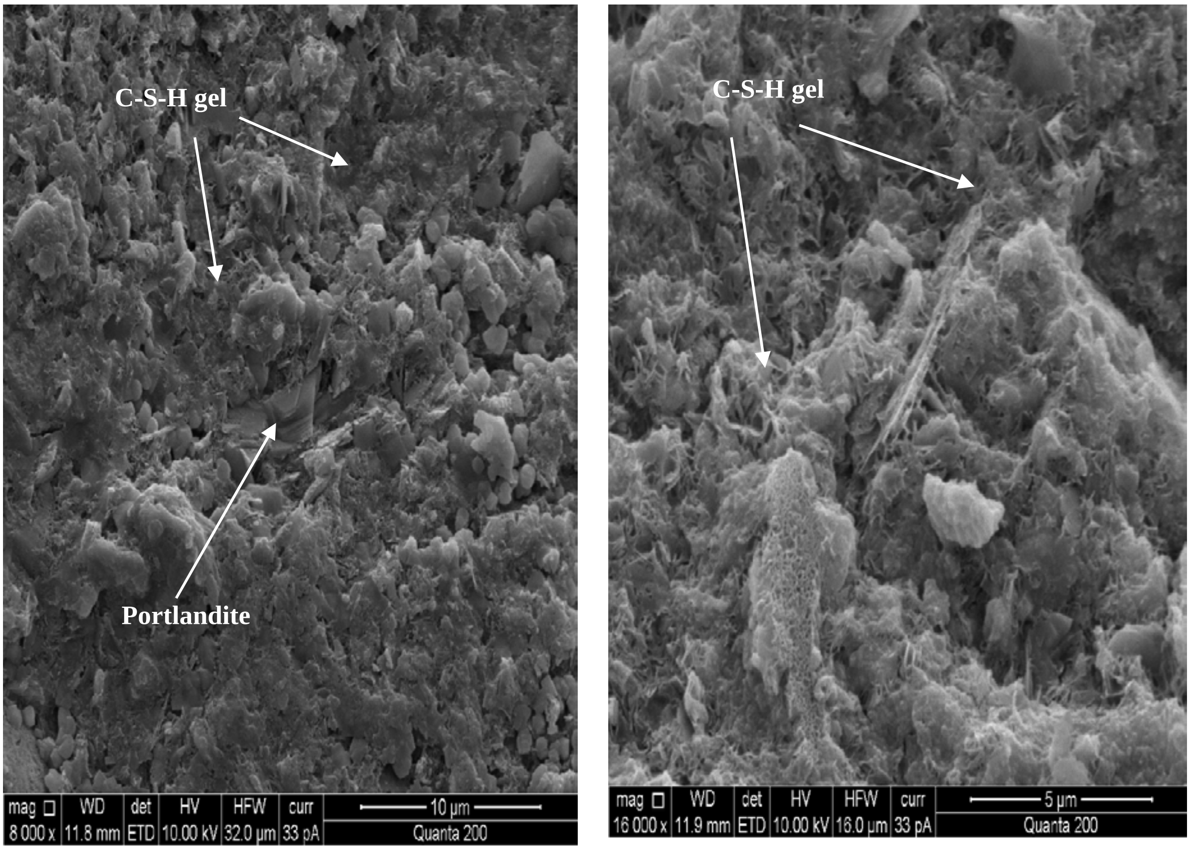


Figure 8. Morphology details of the microstructure of NBCF after 28 days

Conclusions

The effect of blending high calcium fly ash and high silica-alumina material, MK were found to be effective for filler substitution which resulted in improvements the mechanical properties in terms of ITSM. Stiffness development of the NBCF was very high at early and later ages in comparison to the control LF mixture and the two reference HMA.

MK has been used for the first time to activate the HCFA in CBEMs, which revealed outstanding enhancement. After 3 days, the replacing of 2% of the HCFA by MK increased the ITSM by around 50% in comparison to the HCFA mixture. This new mixture is appropriate for heavily trafficked roads and has a positive impact by minimizing the curing time.

Microstructural investigations revealed that this was due to the pozzolanic reaction provided by the MK. Using SEM, mixture treated with NBCF was observed to develop significantly larger amounts of hydrated products at both early and later ages.

Finally, while this paper has studied ITSM and the microstructure, other mechanical and durability properties also need to be considered in future work.

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Modelling of Pile-Soil Interaction of Concrete Model Piles Penetrated in Sand Soil

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ABSTRACT

Unreliable assessment of soil-pile interaction for concrete piles subjected to lateral loads has been cited as a barrier to the wider utilization of piles to support structures under the action of lateral loads. In this paper, the details of Winkler theory for beam on elastic foundation (BoEF) has been emphasised. A series of experimental tests has been conducted for the evaluation of model input parameters. Moreover, 40mm concrete model piles were penetrated in dense sand soil. Three types of model piles have been utilized by varying the aspect ratios from 12, 17 and 25 to examine the behaviour of both rigid and flexible piles. The results reveal that, lateral applied load, piles slenderness ratio, and sand morphology, as confirmed by scanning electronic microscopy (SEM) play significant role in the factors effecting the pile capacity and its lateral response.

KEYWORDS: soil-pile interaction, Winkler theory, beam on elastic foundation, pile foundation.

1. INTRODUCTION

Understanding the behaviour of the piles in the soil effective zone and the precise simulation of the sand-pile interface together with the capacity of piles subjected to combined vertical and lateral loads are vital topics and are core to research in the field of geotechnical engineering [1-4]. However, an advanced constitutive model that has the ability to handle these complexities is required. An efficient and economic tool to precisely model the soil-pile interaction is finite element analysis (FEA), which is a versatile analysis technique which has ability to model linear and nonlinear material properties, elastic and plastic behaviours, and other complex features. In FEA simulation, the application of a large number of loads is required along with significant computational effort. Nevertheless, FEA along with Winkler theory can extend the understanding of the response and performance of pile foundations and gives a better insight into model pile stiffness and the non-linearity at different stages under the applied loads.

2. THE NUMERICAL MODEL

Finite element modelling (FEM) is a tool that provides numerical solutions to problems that are difficult to solve analytically. In FEM, the structural element body is divided into small discrete elements, which can be solved simultaneously. These elements are joined to each other by nodes. Moreover, the main advantage of this approach is that few input parameters (parametric study) are required and these can be found by conducting simple experimental tests. For modelling the high non-linearity induced from the soil-pile interaction, this can be achieved by adopting a reasonable level of repeatability and using parameter sensitivity testing. An elasto-perfectly plastic approach is developed along with the application of Mohr-Coulomb failure criterion and is adopted in the application of the elastic solutions in an iterative procedure to simulate the behaviour of the soil-pile interaction. The most common application to precisely examine of the combined soil-structure interaction is referred to as the "*p-y*" method [4-9]. The *p-y* curves application along with the theory of Winkler Beam on Elastic model (WBEM) (Figure 1) have been utilized for analysis. According to Winkler theory, the elasto-plastic sand domain was defined as a series of narrowly spaced independent springs (Figure 2). Furthermore, the spring modulus stiffness is equal to horizontal modulus of subgrade reaction (K_h) as shown in Equation 1.

$$k_h = \frac{p}{y} \qquad \ldots\ldots\ldots\ldots \qquad 1$$

Where y the lateral is pile displacement and p is the lateral soil stiffness.

$$EI\frac{d^4y}{dz^4} + p = 0 \qquad \ldots\ldots\ldots\ldots \qquad 2$$

EI is the model pile stiffness, and $k_h \text{ x } y = p$. Thus, equation 2 can be revised as follows:

$$\frac{d^4y}{dz^4} + \frac{k_h(z) \text{ x } y}{EI} = 0 \qquad \ldots\ldots\ldots\ldots \qquad 3$$

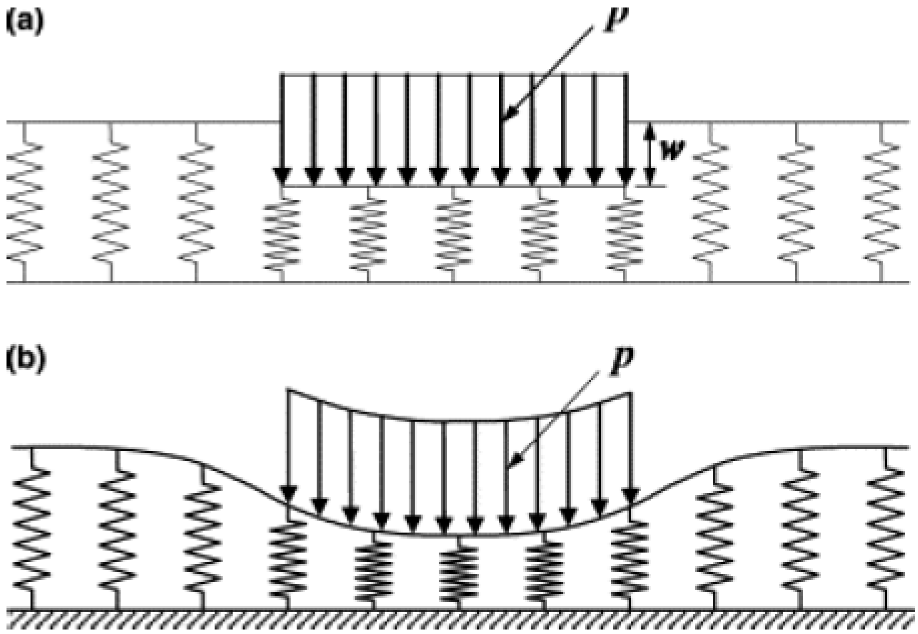

Figure 1. Winkler theory, beam on elastic foundation, modified after (Winkler, 1867)

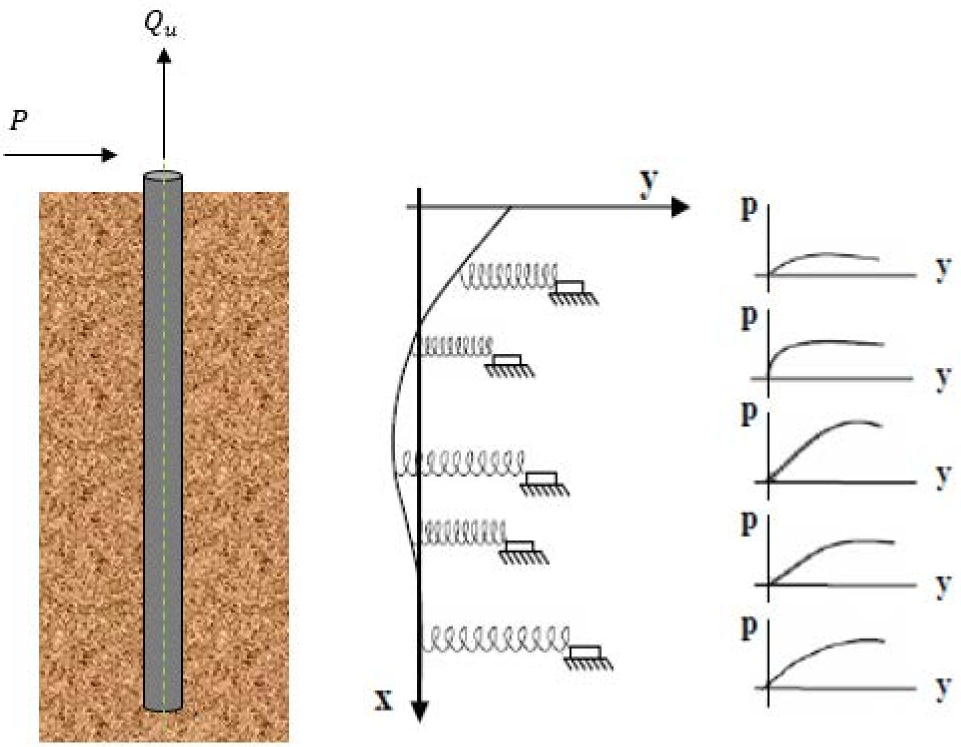

Figure 2: Soil- pile interaction of a model pile based on the *p*-*y* curves method, modified after [10].

3. LOADING SYSTEM AND PROPOSED PILE FOUNDATION

Square reinforced concrete model piles are adopted in this simulation, taking into account three different aspect ratios to simulate the response of both long piles and short piles. In addition, the loads were applied at the tip of the model piles and at an extra length of about 30mm to minimize the contact load with the soil surface with the model pile heads allowed to rotate freely. To overcome the issues of the effective stress and to minimize the failure wedge from extending up to the wall of the sand domain, Robinsky and Morrison [11] recommended that the distance between the sand and the pile varies from (3-5) times the pile diameter. However, the pile diameter utilized in this study is (40) mm and the sand domain size is (1000 x 1000 x 1500) mm, (Figure 3). The material properties of the concrete pile and the test (ID) are taken from Gere and Timoshenko [12] as presented in Table, 1.

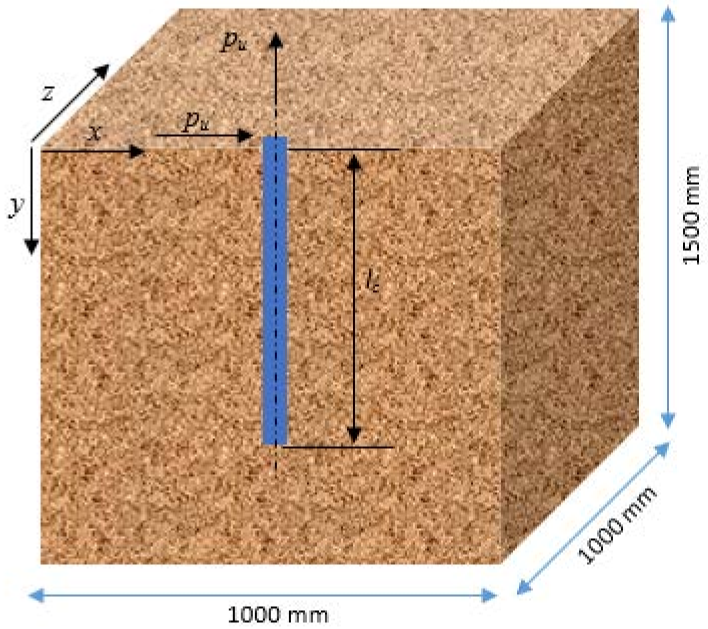

Figure 3: Pile model subjected to combined loads adopted in the FE numerical modelling

Table 1: Properties of the model pile input parameters and testing ID.

Test ID	Poisson's ratio, υ	Aspect ratio, l/d	Sand mass relative density, Dr %	Initial modulus of Elasticity, E, GPa	Thermal coefficient	Test depth (mm)
T SC1-1	0.2	12	75 %	25.12	0.9 *10-5	510
T SC1-2	0.2	17	75 %	25.12	0.9 *10-5	710
T SC1-3	0.2	25	75 %	25.12	0.9 *10-5	1030

4. MODEL PILES SCALING FACTOR

According to the geotechnical scaling law [13], and with consideration of the boundary influence, Equation 4 can be used when the soil stiffness modulus in the radial effective zone of the sand container and in the site (full scale) are identical.

$$E_m I_m = \frac{1}{n^4} E_p I_p \qquad \text{……………………………………………………} \qquad 4$$

Where

$E_m I_m$ is the model pile modules of elasticity and moment of inertia respectively,

$E_p I_p$ is the modules of elasticity and moment of inertia for the prototype pile respectively,

n^4 is the scaling factor.

This section presents the finite element analysis and results for the response of the concrete model piles having different embedment depths. The concrete model piles embedded in a chamber with dimensions (1000 x 1000 x 1500) mm^3 in a dry cohesionless soil layer throughout all the simulations.

5. RESULTS AND DISCUSSION

Figure 4 depicts the profile of the pile head displacement versus pile depth. It can be realised that the behavior of the flexible pile to the applied loads is non-linear. It can also be noticed that the pile head displacement markedly decreases with increasing penetrated depth [2, 14, 15]. The end bearing pile capacity and the unit skin friction increases with increasing the pile depth in the effective stress-strain zone. It is important to note that the rigid pile with a maximum head displacement around 17.3mm essentially rotates with a depth at approximately 2mm from the point of the applied load. Whereas, the upper portion of the pile with penetrated depth at 1000mm tends to bend at depth of around 200mm reaching zero displacement at 500mm from the point load. These results are due to reduction in the flexural rigidity (EI) for the long pile.

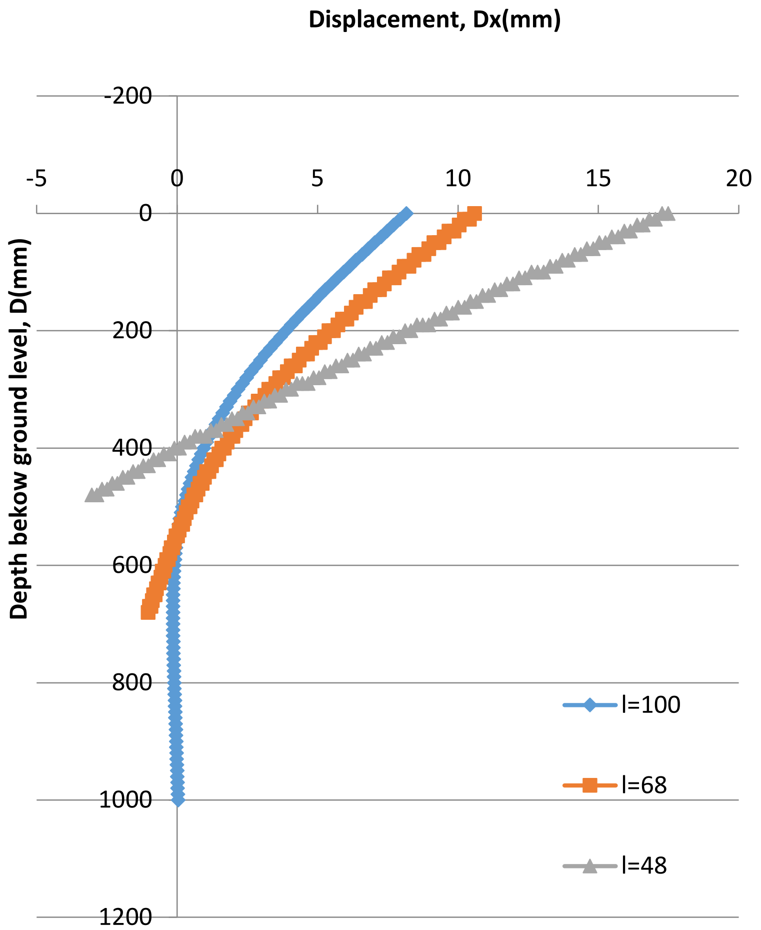

Figure 4: Pile distancement profile versus depth.

Figure 5 documents the moment distribution versus ground depth. One of the major advantages of using the finite element method - Winkler theory (Beam on Elastic Foundation) is that it has the ability to accommodate the non-linearity of the elastic-plastic constitutive model. It can be depicted that for all model piles the moment profiles are markedly non-linear, with maximum and minimum values of about 160Nm and 285Nm for rigid and flexible piles respectively. Furthermore, for pile aspect ratios 12 and 17, moment profiles exhibit a rigid behavior with a max moment occurring at nearly the midpoint of the pile length. Whereas, for (l_c/d) the max value occurred at approximately 390mm below the sand depth.

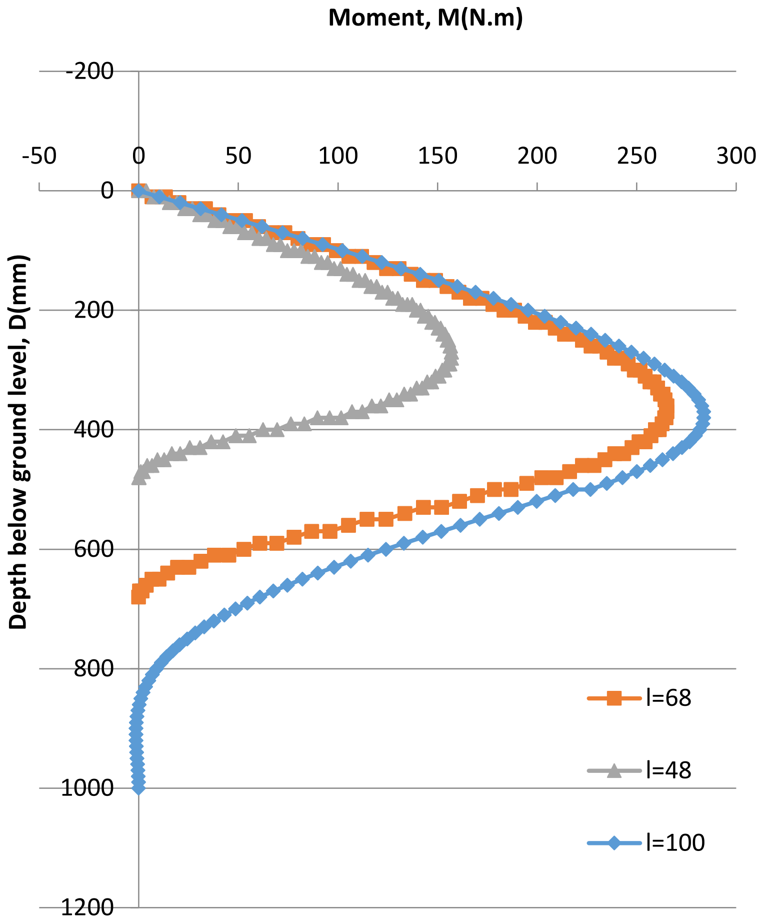

Figure 5: The profile of the moment versus soil depth.

The profiles of the shear force are revealed in Figure 6. It can be shown that at early stages from the applied load, the shear profiles for the model piles are close to each other. This verifies the repeatability and stability of the test and applied methodology. Moreover, it can be clearly realised that for a pile with l_c/d = 12 the maximum shear force of approximately 1450N is developed at depth of 400mm. Whereas, for a long pile with penetration depth of 1000mm, the max shear is around 950N at 550mm from the point of the applied load. This is due to the fact that the flexural rigidity (EI) of the short pile is higher than the long pile.

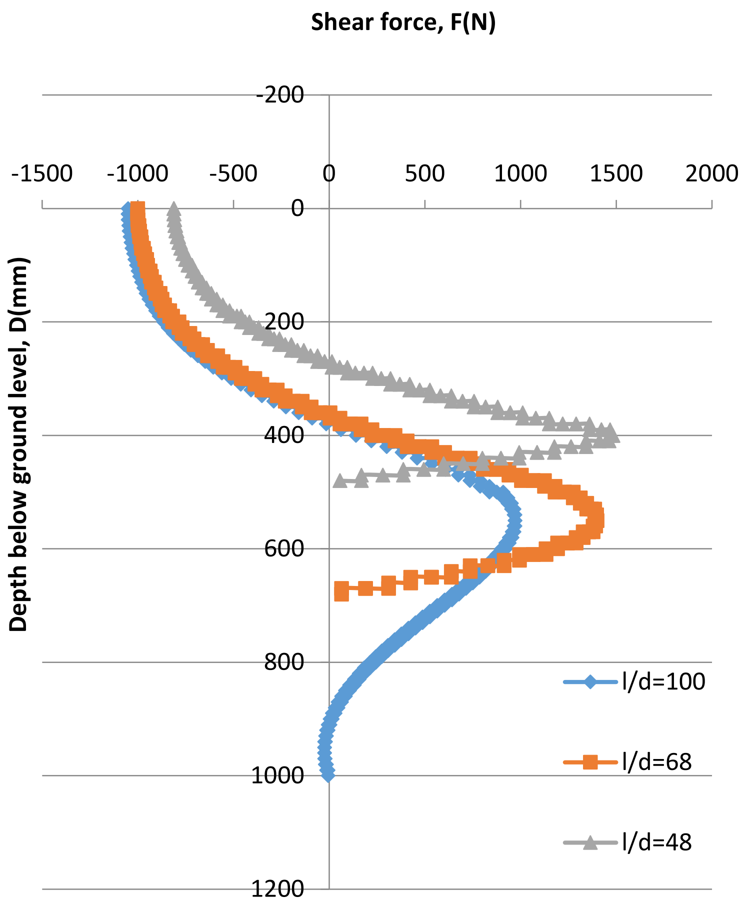

Figure 6: Shear force distribution versus ground depth

The soil resistance profile versus ground depth is illustrated in Figure 7. Comparison of the ground reaction for combined soil-pile interface, the maximum soil resistance of 1500N/m^2 occurred for a short pile with (l_c/d = 12). While, for a model pile with (l_c/d = 17) the ground reaction is slightly less by about 50N/m^2. It can also be observed that for a short pile, the positive ground reaction changed to negative at a depth of 400mm. Whereas, for model piles with aspect ratios l/d = 17 and 25, the position for zero ground resistance shifted down slightly to a depth of 550mm from the point of the applied load. Therefore, the net soil resistance decreases with increase of (l_c/d) ratios.

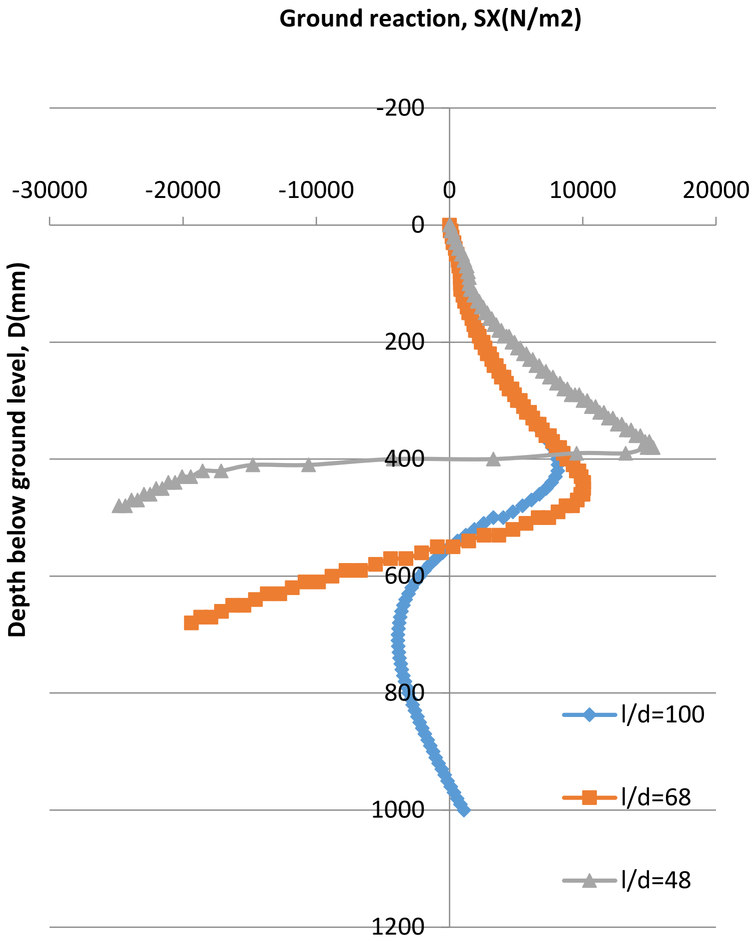

Figure 7: Shear force distribution versus ground depth.

CONCLUSION

The following conclusion can be drawn:

A developed finite element code (FEC) has been adopted to explore the elasto-plastic soil-pile interaction. The results obtained have been found by conducting numerous experimental tests and have been utilised as exact input parameters to develop the numerical simulation. The results revealed that the most effective parameters that play key roles in controlling the pile bearing capacity and the combined interface between soil-pile in the effective zone are, method of pile installation, pile flexural rigidity, soil shear strength parameters, pile materials, pile geometry, pile penetrated depth, lateral earth pressure coefficient and modulus of subgrade interaction K_h.

Moreover, the pile head displacement profiles, ground reaction, flexural rigidity, moment and shear decrease with increasing model pile slenderness ratio (l_c/d). The pile bearing capacity increases with increasing pile depth in the effective soil domain. This is due to the frictional resistance improvement between the pile-sand interactions.

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The Development of a New Cementitious Material Produced From Cement and GGBS

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Abstract

The aim of this research is to study the effect of using Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement to Ordinary Portland Cement (OPC) and produce a more environmentally friendly cementitious material with comparable compressive strength to OPC. Six mixes were prepared with different percentages of GGBS replacement 0%, 10%, 20%, 30%, 40% and 50% of the weight of OPC. The compressive strength with ages of 7 and 28 days was used for evaluating the performance of the tested specimens in comparison to the control mix with (0% GGBS). The results demonstrated that the compressive strength at the age of 7 days for the mixes with 10% and 20% GGBS were higher than the control mix by 2% and 4%, respectively. However, the addition of 30%, 40% and 50% caused a reduction in the compressive strength relative to control mix by 3.6%, 12.7% and 15.6%, respectively. Interestingly, all the mixes containing GGBS provided higher compressive strength in comparison to the control mix at the age of 28 days. This means that increasing the period of curing for mixes containing GGBS can improve the compressive strength. At 50%, GGBS substitution the strength of mortar was better than the strength of control mix at 28 days. In this study, the optimum replacement of OPC by GGBS was considered to be 50%. Such replacement will contribute to reduce the CO_2 emissions (carbon footprint) and at the same time provide better compressive strength at suitable curing times.

Keywords: Cementitious material, compressive strength, GGBS and OPC.

Introduction

Cement based concrete is the most used construction material worldwide with production of about 10 billion tonnes per year in modern industrial society (Aprianti, 2017). It is estimated that the use of concrete as a construction material is about double the total of all other construction materials such as steel, wood, etc. (Mcleod, 2005). This is because concrete is versatile and has many desirable characteristics such as strength, high fire resistance, affordability and it can be moulded in to any shape (Aprianti, et al., 2015). The annual consumption of cement worldwide is about 2.9 billion tonnes and due to the rapid development in the construction industry worldwide, therefore inevitably there will be an increase in the production of cement that is expected to be about 5% annually (Karim, et al., 2013) and (Jafer, et al., 2015).

The production of cement is responsible for almost 6-8% of all the CO_2 emissions worldwide (Hawileh, et al., 2017). This is because the production of one tonne of cement is associated with nearly one-tonne CO_2 emissions into the atmosphere (Aprianti, 2017). This fact put the cement industry as the third largest producer of Greenhouse gases after the sectors of transportation and energy generation (Mcleod, 2005). Therefore, in order to comply with the Kyoto Protocol to reduce the CO_2 emissions, many studies have been carried out for investigating the effectiveness of other viable alternative cementitious materials such as by-products or waste materials from different resources to be used as cement replacement and produce new environmentally friendly cementitious materials (Aprianti, et al., 2015).

One of the known viable alternative materials to OPC in different applications, such as concrete production and soil stabilization is Ground Granulated Blast Furnace Slag (GGBS). GGBS is a by-product material of iron or steel that is extracted from blast furnaces in water or steam, in order to produce granular particles that are then dried and ground in a rotating ball-mill into a very fine powder of GGBS (Grist, et al., 2015).

An investigation has been carried out by Hawileh, et al., (2017) to evaluate the effect of using GGBS as a partial replacement to OPC in reinforced concrete (RC) beams. The results indicated that the RC beams with up to 70% GGBS replacement to OPC have similar performance in comparison to the control beam with (0% GGBS) in terms of both compressive and tensile strengths. In addition, an experimental study on the replacement of OPC with GGBS in concrete has been conducted by Mangamma, et al., (2016) by using two types of concrete (M20 and M30). The results demonstrated that the replacement of OPC by up to 50% GGBS were generally close to the results of the normal mix and the maximum compressive strength was achieved by the 30% replacement. Furthermore, Oner & Akyuz (2007) have carried out an experimental study to determine the optimum dosage of GGBS as partial replacement to OPC in concrete production that provided the best compressive strength when comparing to the control mix. The results showed that the concretes with different percentages of replacement to OPC have lower early strength relative to the control concretes having the same binder content. However, with increasing curing period, the compressive strength for the GGBS concretes were improved with increasing the GGBS content up 59%. Furthermore, the optimum level of GGBS concrete that provided the highest compressive strength in comparison to the control concrete was 55%.

This paper presents the results of experimental work to investigate the utilization of GGBS as partial replacement to OPC on compressive strength. The replacements of GGBS were (0%, 10%, 20%, 30%, 40%

and 50%) by the weight of OPC, and the compressive strength for ages of 7 and 28 days were used for assessing the performance of the Binary Blended Cementitious Material (BBCM) mortar cubes in comparison to the control mix (0% GGBS).

Materials

Sand

The sand used is this experimental study was building sand passing through 3.35 mm IS sieve. Table 1 below shows the physical properties of the sand.

Table 1. The physical properties of the sand

Property	Value
Maximum size of the smallest 10% of the	0.12 mm
Maximum size of the smallest 10% of the	0.19 mm
Maximum size of the smallest 10% of the	0.28 mm
Uniformly coefficient (C_u)	2.33
Coefficient of curvature (C_c)	1.07
Saturated Surface Dry	2.62 kg/m3
Classification of sand	Uniformly graded sand
Max Water Absorption	2.8% WA

From the coefficient of uniformity (Cu), coefficient of curvature (Cc) and the particle size distribution chart showing in Figure 1, the sand that has been used in the mix of the mortars can be classified as uniformly graded sand. Uniformly graded sand means that it consists of particles that are all about the same size and it has more void spaces between the particles (Ahmed, 2014).

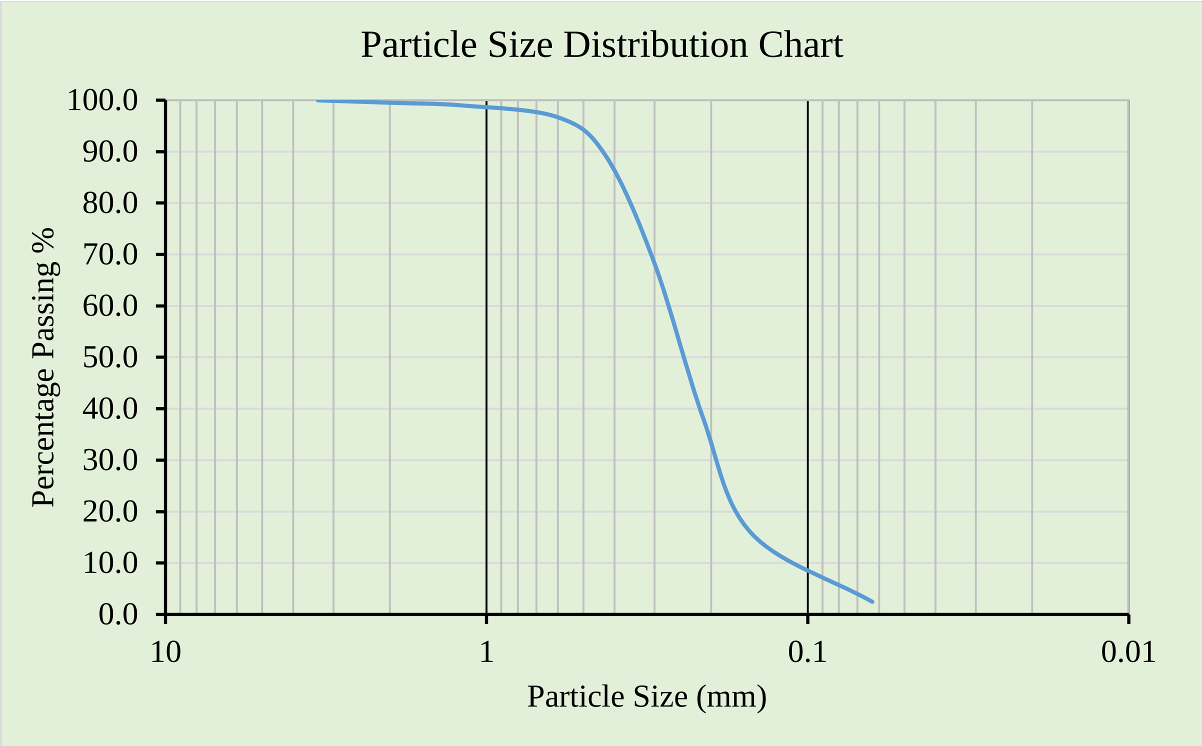


Figure 1. Particle size distribution chart of sand

Cement

The cement used in this study was Ordinary Portland Cement type CEM-II/A/LL 32.5-N. This cement was supplied by CEMEX, Warwichshire, UK. The specific gravity of OPC is 2.936 kg/m^3.

Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast Furnace Slag (GGBS) is a by-product material of iron or steel that extracted from blast furnaces. Hanson Heidelberg Cement Group supplied the GGBS for this research. The specific gravity of GGBS is 2.9 kg/m^3, and it complies with BS EN 15167-1 standards as provided by the supplier.

Mixing, casting and curing of specimens

1. Prepare all the material needed for the mortar mix, this starts with weighing the sand, the cement, the GGBS and the water.
2. Initially, all the materials of the mortar except the water were mixed together for about 2 minutes, and then the water was added to the mix and the paste mixed until uniform prior to placing in the mould.
3. Then the mortars were cast inside the steel prism moulds with dimensions of (160mm x 40mm x 40mm) and compacted by tamping rod according to (BS EN 1015-11: 2007), which requires the casting to be in two layers with compaction of 25 tamps for each layer.
4. The mortar prisms were demoulded after 24 hours from the start of the casting process and the samples were placed in small containers for curing until the time of testing.

Method of testing

At the time of testing, the mortars with dimensions of (160mm x 40mm x 40mm) were cut into three equal smaller prisms. Two steel plates with dimensions of (40mm x 40mm) were placed on the top and bottom of the mortar cubes, in order to make the surface exposed to load with the dimensions of (40mm x 40mm) to correspond the dimensions of mortar cubes and the testing machine set according to BS EN 1015-11: 2007. The rate of loading for the compressive testing machine was (0.4 MPa/s). Three mortar cubes for each percentage of replacement (0%, 10%, 20%, 30%, 40% and 50%) were tested on each day of curing and an average obtained giving an idea of the potential quality of the new cementitious material to be used instead of cement.

Mix proportions

Ten mixtures were prepared that contained GGBS as a replacement to cement. The replacement of GGBS were (0%, 10%, 20%, 30%, 40% and 50%) of the weight of OPC. The compressive strength at ages of 7 and 28 days have been used for evaluating the performance of the BBCM mortar cubs in comparison to the control mix with (0% GGBS). The water to binder ratio (W/B) and the binder to sand ratio (B/S) that have been used for this study were (0.4) and (1:2.5) respectively. Table 2 shows the mix proportions for all the specimens.

Table 2. Mix proportions

MIX	OPC	GGBS
G0	100%	0%
G10	90%	10%
G20	80%	20%
G30	70%	30%
G40	60%	40%
G50	50%	50%

Results and Discussion

Physical Properties

Two tests were carried out to investigate the physical properties of the OPC and GGBS, which they are:

1) **Particle Size Distribution (PSD)**

PSD test is an important physical test that provided information about the fineness of the materials. Figure 2 shows the PSD of the OPC and GGBS as obtained from the laser particle size analyser.

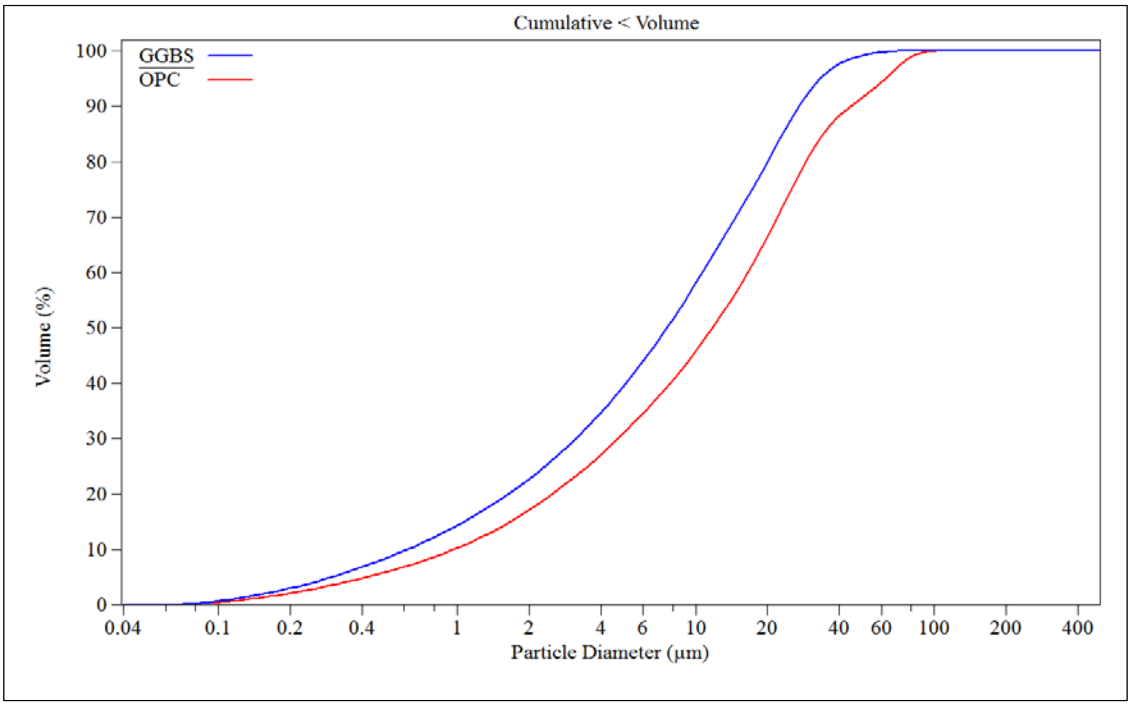


Figure 2. Cumulative particle size distribution of OPC and GGBS

In addition, Table 3 shows the differences in d_{10}, d_{50}, and d_{90} for the GGBS in comparison to OPC.

Table 3. Volume statistics for OPC and GGBS

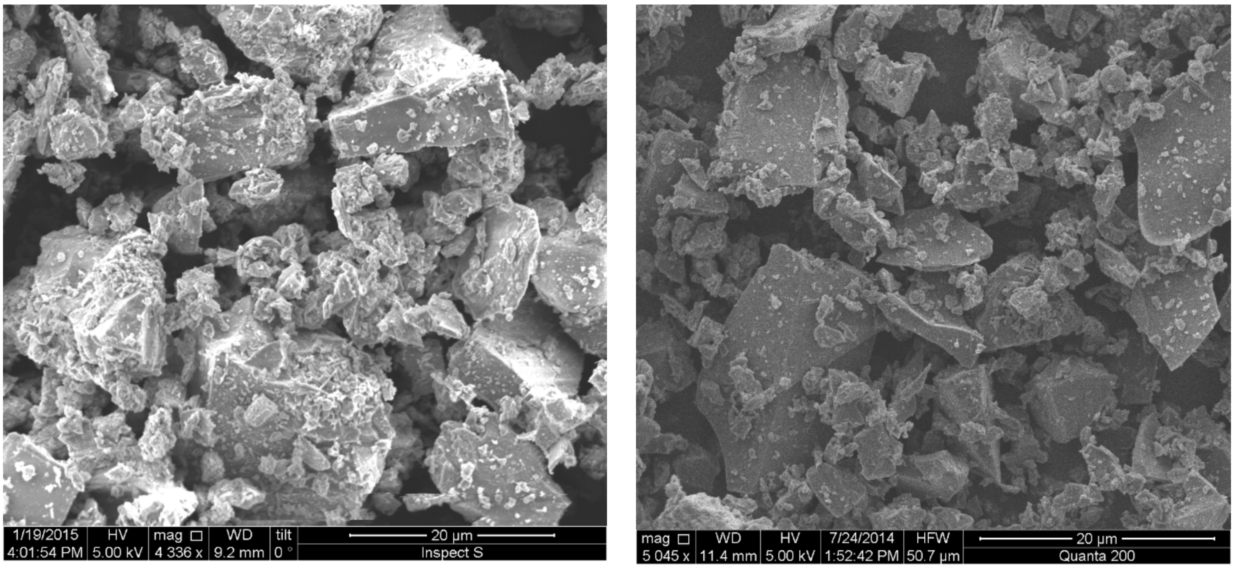
Item	OPC	GGBS
d_{10} (µm)	0.936	0.62
D_{50} (µm)	13.08	7.542
D_{90} (µm)	54.29	27.96
Mean (µm)	21.10	11.55
Median (µm)	13.08	7.542

The particle size distribution and the specific surface area (SSA) of OPC and GGBS have a significant effect on the compressive strength of the mortars. Celik, et al., (2008) found that the finer the particles of waste materials used as partial replacement to cement in concrete production, the higher compressive strength obtained. It can be seen from the particle size distribution chart in Figure 2 that GGBS has finer particle size relative to OPC. This means that the GGBS has a higher pozzolanic reactivity than the OPC as it has a higher SSA (ZHAO, et al., 2016).

2) Scanning electronic microscopy test (SEM)

The SEM test was carried out on the GGBS and OPC to realise the general shape of material particles that would help in anticipating the behaviour of these two materials when they were mixed to produce a binary blended cementitious material. Figures 3 a and b illustrate SEM testing images of the binder materials.

From the SEM test results, it can be seen that both the OPC and GGBS have angular and flaky shape and the GGBS material particles are finer than the OPC, which agreed with the PSD tests.



(a) OPC (b) GGBS

Figure 3. SEM test images of the binder materials

Chemical Properties

Three tests were conducted to indicate the chemical properties of the OPC and GGBS, which they are:

1) pH value

Solutions of dried and pulverised OPC with water and GGBS with water were made to find the pH value of both OPC and GGBS. This method of measuring the pH is according to BS ISO 10390:2005. The results of the pH value for OPC and GGBS were 13.04 and 11.65 respectively.

2) Loss of Ignition (LOI)

The loss of ignition is a method to find the content of the organic matter in materials; the adopted procedure is described in BS 7755-3.8:1995. The obtained values for the LOI were 0.28 % for OPC and 0.373 for GGBS.

3) X-Ray Florescence Spectrometry (XRF)

The elemental composition of OPC and GGBS were analysed by the energy dispersive X-ray florescence spectrometer apparatus (EDXRF). This test evaluates the major oxide and trace elements for both OPC and GGBS by providing the chemical composition, which is considered as the most important indicator for material quality in different applications. Table 4 below shows the chemical properties for OPC and GGBS.

Table 4. Chemical properties for OPC and GGBS

Item	OPC	GGBS
CaO %	65.108	42.506
SiO_2 %	24.783	41.060
Al_2O_3 %	1.716	5.105
Fe_2O_3 %	1.628	…….
MgO %	1.322	4.248
Na_2O %	1.337	3.093
K_2O %	0.811	0.685
SO_3 %	2.542	1.271
TiO_2 %	0.342	0.976
SrO %	0.116	0.086
CuO %	0.014	……
MnO %	0.039	0.655
P_2O_5 %	0.242	0.270
Cl^-	0.040	0.044

Compressive Strength

The compressive strengths of the mortars for different percentage combinations of OPC and GGBS with different curing ages are shown in Table 5.

Table 5. Compressive strength for 7 and 28 days

MIX	OPC	GGBS	7 days (MPa)	28 days (MPa)
G0	100%	0%	27.5	29.1
G10	90%	10%	28.0	29.3
G20	80%	20%	28.6	31.6
G30	70%	30%	26.5	32.1
G40	60%	40%	24.0	31.0
G50	50%	50%	23.2	30.0

The compressive strength at 7 days for different percentages of the combination of GGBS and OPC is also expressed graphically in Figure 4.

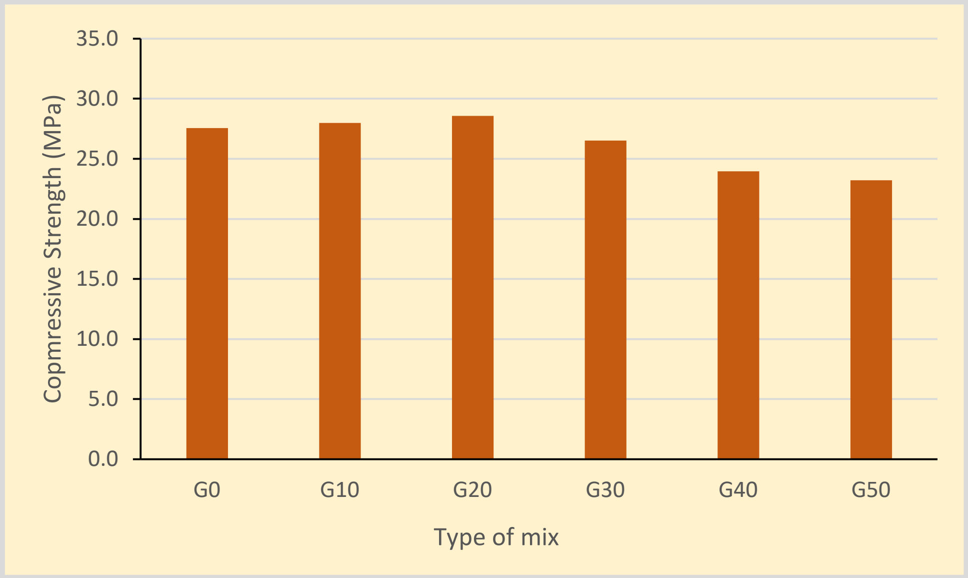


Figure 4. The effect of GGBS on compressive strength at 7 days

It can be seen from the bar chart above (Fig, 4) that at the age of 7 days, only G10 and G20 showed an increment in the compressive strength by about 2% for G10 and 4% for G20 in comparison with the control mortar with 0% GGBS. However, the addition of 30% GGBS cused a reduction in the compressive strength by about 3.6%. Furthermore, the replacement of OPC by 40% and 50% GGBS, resulted in a significant decrease in compressive strength, with reduction of between 12.7% and 15.6% for G40 and G50, respectively. This is not in agreement with what has been obtained by (Kumar, 2013), which found that at the age of 7 days increasing the amount of GGBS as replacement to OPC can enhance the compressive strength. This however may be caused due to the slow acquisition of strength at initial curing ages for the mixes contain more than 30% GGBS.

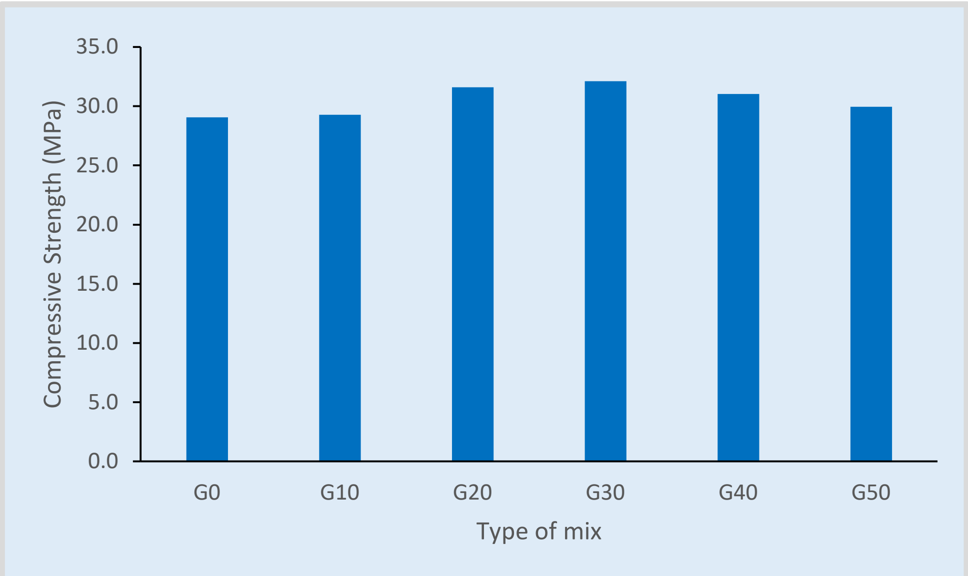


Figure 5. Effect of GGBS on compressive strength at 28 days

A glance at the bar chart above (Fig. 5) reveals that at the age of 28 days, the compressive strength increased 0.7, 8.6, 10.3, 6.5 and 3.1% for mixes G10, G20, G30, G40 and G50, respectively when compared to the control mix. This means that at the age of 28 days, the presence of GGBS in the mixes have improved the compressive strength for all the mixes in comparison to the control mix. This agreed with the findings concluded by (Mangamma, et al., 2016) and (Cheng, et al., 2005).

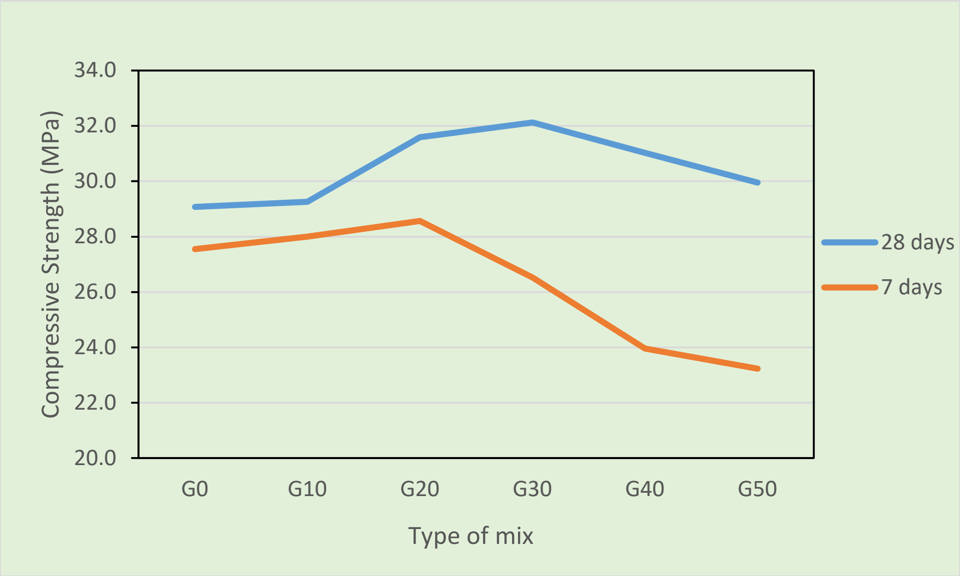


Figure 6. Compressive Strength Development Curves

From the results shown in Figure 6, it can be seen that the compressive strength of all the mixes increased with age. With increase in age from 7 to 28 days, increase in compressive strength of mixes G10, G20, G30, G40 and G50 was observed to be 4.6, 10.5, 21.1, 29.2 and 29.3% respectively. A comparative study of compressive strength between 7 and 28 days indicated that percentage of increase is less in control mix in comparison to all other mixes containing GGBS except G10. In addition, test results indicated that the inclusion of GGBS enhanced the compressive strength with increasing the age of curing. This performance can be attributed to the glassy phase of GGBS that reacts slowly with water and takes time to gain the hydroxyl ions from the hydration product of OPC to breakdown the glassy phase at early age. At 50%, GGBS substitution, the strength of mortar was superior to the strength of control mix at 28 days. So the maximum replacement of OPC by GGBS was considered to be 50% in this study.

Conclusion

The aim of this study was to investigate the effect of using GGBS as a partial replacement to OPC and to produce a more environmentally friendly cementitious material with comparable compressive strength to OPC. According to the results of the experimental investigations, it can conclude that:

- Mortar containing GGBS is significantly affected by the age of curing. Curing for more than 7 days is crucial for the strength development of the mortars containing GGBS.
- At the age of 7 days, only the mortars with 10% and 20% GGBS have shown improvement in the compressive strength relative to the control mix. However, the mortars with 30%, 40% and 50% GGBS have caused a reduction in the compressive strength in comparison to the control mix. This can be due to the slow pozzolonic reaction for mortars with high percentage of GGBS and largely dependent on the formation of calcium hydroxide that requires time.
- At the age of 28 days, all the mixes that containing GGBS showed higher compressive strength in comparison to the control mix.
- At 50%, GGBS substitution, the strength of mortar was higher than the strength of control mix at 28 days. So the maximum replacement of OPC by GGBS was considered to be 50% in this study.

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Social cohesiveness and planned neighbourhoods in Dubai;
The process of making urban living intimate, sincere and enduring

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ABSTRACT

Contemporary cities are major drivers of socio-cultural and economic change. In an era of transnational migration, cities are witnessing pressures of the influx of migrant population. The ongoing urban transformation is reshaping urban social fabric. There is, therefore, demand for a new approach to urban planning and design that addresses issues such as social inclusion, social interactions and social cohesiveness. As against Louis Wirth's notion of 'urbanism' which foresees emerging urban centres as anonymous, superficial and transitory in nature, urban planners and designers should enhance urban living to be intimate, sincere and enduring.

PURPOSE

This study falls under the purview of urban social sustainability which signifies the sustenance of social relations within the built environment creating physical, cultural and social spaces that encourage social cohesiveness and well-being. Neighbourhoods are places for social encounters and interactions that play a vital role in creating vibrant spaces for residents. Social cohesion, in turn, can strengthen social ties and a sense of community and belonging. A community that lacks social cohesiveness can create division and diversified groups which can deteriorate urban living.

Dubai, an emerging global city, is a home to more than a million expatriate population from diverse social and cultural backgrounds. The city accommodates more than 80% working and living expatriate population. The study focuses on how thoughtful urban planning and designing of cohesive community neighbourhoods contribute to intimate, sincere and enduring urban living. The study aims to analyse, compare and reflect on the relationship between urban planning, design and social cohesiveness in the two selected planned neighbourhoods, International City and The Greens in Dubai.

DESIGN/ METHODOLOGY/ APPROACH

The study follows convergent parallel mixed research methods with quantitative and qualitative analysis to understand the resident's experience in the neighbourhoods based on attributes of social cohesiveness that include social interactions, social ties, and sense of community belonging. The observation analyses look at the behaviours of the residents within the common spaces created through built forms in the community. A qualitative study seeks to assess the role of different stakeholders such as architects, urban designers, developers and real estate agents, property developers in planning a socially cohesive neighbourhood.

FINDINGS

The application of multivariate analysis to assess enduring social relations shared interests and shared values, and social ties within the community indicate negative autocorrelation for the International City while non-auto-correlation for The Greens based on Durbin-Watson statistics.

Type	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
						R Square Change	F Change	df1	df2	Sig. F Change	
International city	1	.539[d]	.290	.210	.652	.290	3.598	5	44	.008	1.311
The Greens	1	.458[e]	.210	.120	.778	.210	2.338	5	44	.050	2.020

a. Predictors: (Constant), Informal Face to Face, Enduring Social Relation, Shared Values, Strong Social Ties, Shared Interests
b. Dependent Variable: Common Space Outdoor
c. Predictors: (Constant), Informal Face to Face, Enduring Social Relation, Shared Interests, Strong Social Ties, Shared Values
d. Predictors: (Constant), Informal Face to Face, Strong Social Ties, Shared Interests, Enduring Social Relation, Shared Values
e. Predictors: (Constant), Informal Face to Face, Shared Interests, Strong Social Ties, Enduring Social Relation, Shared Values

Table 1: Model Summary, multivariate analysis

The findings of the study indicate that the extent of social interactions in the Greens is greater than the International City. The sense of community and belonging and social ties within the community are stronger in the Greens than in the International city.

The qualitative analysis was carried out in four phases, Phase-I as Reading and initial coding, Phase-II as Developing subordinate themes, Phase-III as Developing superordinate themes and Phase-IV as in within case and cross-case analysis. An Interpretative phenomenological analysis was applied to understand the user experience.

Social Interactions	International City	Greens
Average level of interaction	6	0
No social interaction	3	0
No social interaction due to cultural differences	3	0
No opportunities to interact	25	0
No time to interact	5	1
There is no need to interact	1	0
High level of social interaction	0	27
Minimum social interaction	21	3

Table 2: Qualitative analysis for social interaction in selected neighbourhoods

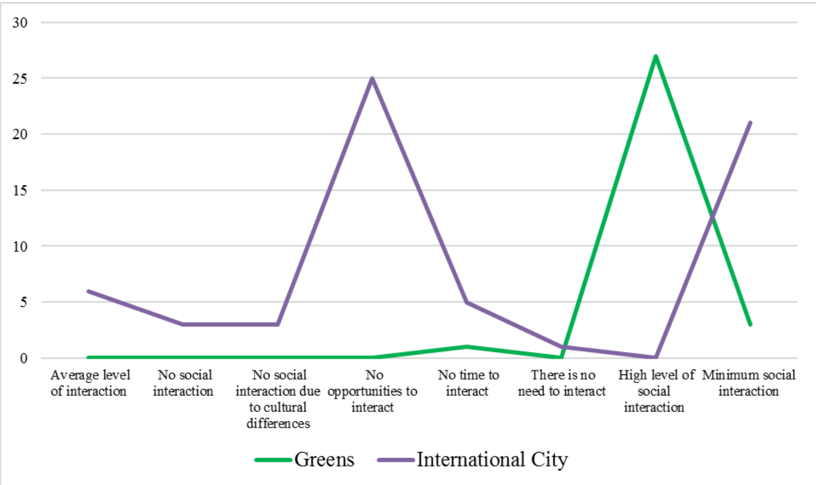

Figure 1: Qualitative analysis to assess social interaction in the selected neighbourhoods

The findings of the qualitative analysis indicate that the residents in the Greens experience high level of social interaction than the residents of the International City. The International City residents cite lack of opportunities as the major reason for the low level of social interactions.

The spatial analysis to understand further behavioural study of residents in the communities indicate that the inward looking built form of the layout of the Greens are more conducive to social interactions and vibrant activity for the residents than the built form of the International City.

RESEARCH LIMITATIONS/IMPLICATIONS

The study does not distinguish residents based on nationality due to non-availability of data of nationality of residents in the neighbourhood. The study can be implied further in the next phase with data based on nationalities to understand the socio-cultural background of the migrant population, their choice of neighbourhood in the context of urban living.

PRACTICAL IMPLICATIONS

The vision of the city of Dubai as outlined in the Dubai 2021 plan by the Government of Dubai has one of the key themes of inclusive and cohesive society. The study contributes knowledge in building inclusive and cohesive multicultural society.

SOCIAL IMPLICATIONS

As the concept of 'smart city' is gaining momentum, the design of urban spaces has to be smarter in planning and designing to enhance sociability. Social cohesion should, therefore, be demonstrated in planning and design approaches for residential community design. Vibrant and friendly communities are the key to a socially cohesive society and urban living. As the concept of community living is disappearing, building sustainable communities should be on the urban planning agenda.

ORIGINALITY/VALUE

Dubai is a unique model of a city that has a multicultural expatriate and transient population, promoting social cohesiveness as an ethos and in practice is the need of the hour. The outcomes of the study apply to cities in the Gulf to build socially cohesive neighbourhoods and sustainable communities.

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THE EFFECT OF CKD CONTENT ON THE GEOTECHNICAL PROPERTIES OF GGBS-STABILISED KAOLIN CLAYS

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ABSTRACT

The Soft soils are considered one of the biggest concerns for civil engineering projects in many parts of the world. Usually, soft soils are replaced with stronger materials to mitigate their problems, but because of the high cost of this method, alternative methods have been tried by different researches and the most common method is soil stabilisation. Traditionally, lime and cement are used in soil stabilisation. However, production of lime and cement has negative environmental and economic impacts, so several studies have carried out to find alternative sustainable waste material that could be incorporated in soil stabilisation as a replacement to the traditional stabilizers. This paper represents the results of a laboratory work utilizing Cement Kiln Dust (CKD) as an activator to Ground Granulated Blast Furnace Slag (GGBS) in stabilisation of a Kaolin soil. The Kaolin soil was treated with three percentages of the total binder (GGBS+CKD) which are (2.5, 5, and 7.5%) of dry soil weight, and the proportions of GGBS to CKD were (50% GGBS: 50% CKD) and (70% GGBS: 30% CKD). Improvement levels were assessed based on the results of the consistency limits, compaction parameters, and Unconfined Compressive Strength (UCS) tests. UCS test was conducted on specimens at 7 days of curing. Results showed that GGBS activated by CKD improved the physical properties of kaolin soil effectively, where the plasticity index (PI) decreased from 20 for the untreated kaolin soil to 19.2 for mixture with (50% GGBS: 50% CKD) for 7.5% binder percentage. The results of the unconfined compressive strength test (UCS) revealed that (50% GGBS: 50% CKD) with 7.5% binder developed the UCS significantly from 262.26kPa for the untreated soil samples up to 1295.57kPa at 7 days of curing.

KEYWORDS: *Cement kiln dust (CKD), Ground Granulated Blast Furnace Slag (GGBS), kaolin soil stabilisation and unconfined compressive strength (UCS).*

1- INTRODUCTION

Generally, soil can be defined as "any loose surface material overlying solid rocks". Roads decomposition and the subsequent removal, transportation and weathering of decomposition products lead to forming of soils (Chmeisse, 1992).

Soil is still widely used construction material, due to its low cost, availability and workability. However, many soils; especially soft soils (silty, clayey, peat or organic soils) are with reduced shear strength, capable of large deformations under relatively small loads, and are therefore considered one of the biggest concerns in geotechnical engineering (Cristelo et. al. 2013).

Kaolinite is classified as a clay mineral, and its chemical composition is $Al_2Si_2O_5(OH)_4$ (George et. al. 2013). China clay or kaolin is the main types of Kaolinite rocks. Low shrink-swell capacity and cation capacity are the main properties of these rocks. The chemical weathering of aluminium silicate minerals, such as feldspar leads to forming a white mineral, which is Kaolinite (Budhu, 2008).

Soil stabilisation is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties (Sen, 2012).

Chemical stabilisation is the most effective technique in the case of clay soils because it can be used to change the material's nature (Alrubaye et. al. 2016). In chemical soil stabilisation, the desired soil property is achieved depending on chemical reactions between stabilizers (cementitious materials) and soil minerals with presence of water (Makusa, 2012).

The oldest stabiliser used in the soil stabilisation was lime. In 1924, lime was firstly utilised as a soil stabilising agent in modern engineering practice in USA (Tyrer, 1987).

Cement, mostly ordinary Portland cement (OPC), is considered second most traditional used stabiliser agent, which has been utilised from 1960's (EuroSoilStab, 2002). However, production of OPC and lime has negative environmental impacts, such as manufacturing 1 ton of OPC leads to 0.95 tonne of carbon dioxide (CO_2) emission and 5000MJ energy consumption (Yaolin et. al. 2015), and these values are 0.79 tonne and 3200MJ for CaO (Shand, 2006). Therefore, several studies have conducted to find alternative sustainable industrial and/or agricultural waste materials that could be incorporated in soil stabilisation; as a replacement to the conventional stabilisers. For example: Fly ash (Jafer et. al. 2016), rice hust ash (RHA) (Bagheri et. al. 2014), cement kiln dust (CKD) (Okafora and Egbeb, 2013).

Ground Granulated Blast Furnace Slag (GGBS), which is a by-product of the industry of iron, is one of these materials. GGBS is widely available in UK (Higgins, 2005). Generation of 1 tonne of GGBS consumes 1300MJ of energy and emits 0.07 tonne of CO_2 (Yaolin et. al. 2015).

GGBS has been used widely in soil stabilisation. Yado and Tripathi (2013) used GGBS as a stabiliser for a soft soil. It was concluded that inclusion of GGBS improves the strength performance of soft soils, for example, UCS of 9% GGBS modified soil was approximately 28% higher than UCS of raw soil. However, GGBS is considered a slow cementitious material on its own, so OPC and lime are normally used to activate and accelerate GGBS hydration by providing sufficient alkalinity (Higgins, 2005).

Gupta and Seehra (1989) studied the strength performance of improved lime-GGBS soil. The UCS and CBR of lime-GGBS stabilised soil with and without gypsum addition, or with partial replacement of GGBS by fly ash were higher than UCS of raw soil.

Shekhar et. al. (2012) investigated the effect of GGBS on strength of black cotton soil (BCS) with addition of small percentage of lime. It was found that the strength of (BCS + 30% GGBS + 4% lime) was approximately up to 18 times higher than the untreated BCS.

CKD is a by-product generated throughout cement production. Although the quantities of CKD generated per tonne of cement have been reduced substantially in the recent advanced technologies in the cement production process, disposal of CKD is a significant economic and environmental problem in most plants of cement (Wild et. al. 1996).

Baghdadi (1990) studied the effect of CKD on strength properties of Kaolinite soil. It was found that addition of 16% CKD by dry weight led to increase the UCS of CKD treated Kaolinite soil from 210 to 1115kPa at 28 days curing.

Another study (Miller and Azadb, 2000) showed that the compressive strength of unsoaked CKD treated Namontmorillonite clay increased by 150% at 28 days of curing.

The most common used soil stabiliser is ($Ca(OH)_2$), which increases soils' stability by reacting with clay (pozzolanic reaction) (Diamond and Kinter, 1965). As there are a considerable amounts of free-lime in some CKDs, stabilisation mechanism of the CKD-treated soils is expected to be similar.

In addition, the high alkalinity of CKD makes it an appropriate material for GGBS activation by enhancing reactivity of early age (Sadique and Coakley, 2016). Therefore, latent hydraulic materials, such as GGBS, could be activated by using CKDs (Dulaimi et. al. 2017).

Dulaimi et. al. (2017) developed a new cold bituminous emulsion mixture by using a new Binary Blended Cementitious Filler comprising of GGBS and CKD. GGBS was used as a replacement to the conventional limestone filler, and CKD was used as an activator. They showed that indirect stiffness modulus and rutting resistance were improved significantly by adding CKD to the GGBS.

This paper reports on the experimental work carried out to investigate the potential of using CKDs-activated GGBS as a stabiliser to kaolin soil. (2.5%, 5%, and 7.5%) of the dry soil weight were the percentages of the binder with two ratios of (CKDs: GGBS) which were (50:50 and 30:70).

2- MATERIALS

2.1 soil

The soil used in this study was Kaolin soil. The physical properties of the tested soil are presented in Table 1.

Table 1. Physical properties of Kaolin clay soil

Property	LL (%)	PL (%)	PI (%)	MDD (g/cm^3)	OMC (%)	UCC (kPa)	Clay (%)	Silt (%)
Value	41.4	20.0	21.4	1.61	21.5	262.261	24.04	75.96

2.2 Ground Granulated Blast Furnace Slag (GGBS)

GGBS; a by-product material resulting from manufacturing iron was supplied by Hanson Cement Group. Chemical properties of the GGBS were investigated by measuring the PH level and X-ray fluorescence analysis. Table 2 shows the results of these tests.

Table 2. Chemical composition of the GGBS

element	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	SO_3	K_2O	TiO_2	pH
Content %	40.13	37.73	5.75	4.26	0.01	0.00	0.61	0.65	10

2.3 Cement Kiln Dusts (CKD)

CKD is a fine powdery, particulate material readily entrained in the combustion gases moving through the cement kiln. CKD used in this study was supplied by CEMEX. Chemical properties of CKD were investigated by measuring the PH level and and X-ray fluorescence analysis. Table 3 shows the results of these tests.

Table 3. Chemical composition of the CKD

element	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	SO_3	K_2O	TiO_2	pH
Content %	51.0	12.5	3.5	0.5	2.5	4.0	5.5	0.0	12.75

3- EXPERIMENTAL WORKS

3.1 METHODOLOGY

Kaolin soil was treated with three percentages of the total binder (GGBS+CKD) (2.5, 5, and 7.5% of the dry weight of treated soil, and the proportion of GGBS to CKD were 50:50 and 70:30.

The percentages of replacement GGBS by CKD were selected depending on previous researches that used CKDs as an activator to GGBS. One study, Gdoutos and Shah (2003) studied the characterisation of binary blends containing 50% GGBS and 50% CKD in terms of the rates of heat evolution, strength development, hydration products, and time of initial setting. Other study: Dulaimi et. al. (2017) investigated improvement in the performance of CBEMs comprising GGBS and CKD as a replacement to the conventional limestone filler by activating materials to form cementitious hydrated products. The results revealed that the optimum ITSM was achieved by 4% GGBS and 2% CKD. The ITSM after 2 days curing of new binary blended cementitious filler was approximately 12 times higher than conventional limestone filler mixture.

Consistency limits (LL, PL, and PI) and compaction parameters (MDD, and OMC) tests were conducted for samples of untreated and treated soil by dry manual mixing for about 5 minutes. Then the required pastes for conducting the tests were produced by adding tap water straight away.

In terms of UCS tests, specimens were prepared by using a constant volume mould with specific dimensions of 38mm in diameter and 76mm in height. A hydraulic jack to press the soil-binder paste inside the mould was used. All tread soil specimens were cured for 7 and 28 days prior to being subjected to UCS testing.

3.2 Laboratory Test

In this study, three main experiments were carried out to investigate the effects of CKDs-activated GGBS binder on the physical and geotechnical properties of the kaolin soil, and these tests are:

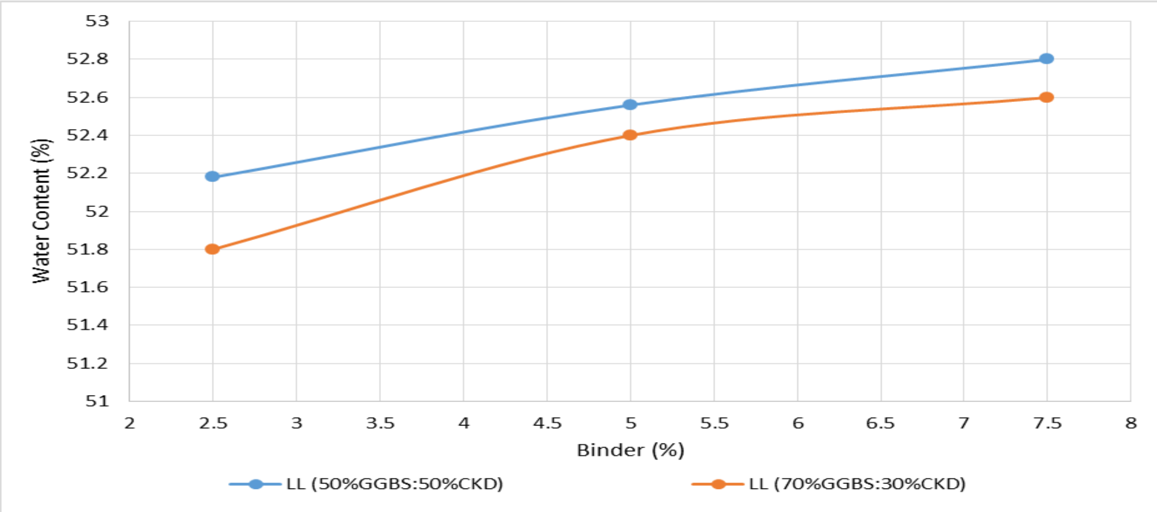
- Consistency limits test (LL, PL, and PI): BS 1377-2:1990 (British Standard) were followed to conduct this test. However, LLs were determined by using the Cone Penetrometer device.
- Compaction Parameter test: the standard proctor compaction method was adopted in this test according to BS 1377-4:1990 (British Standard) to determine the MDD and OMC for treated and untreated kaolin soil.
- Unconfined Compressive Strength (UCS) test: was conducted according to BS 1377-7:1990 (British Standard) on specimens of untreated and treated kaolin soil.

4- RESULTS AND DISCUSSION

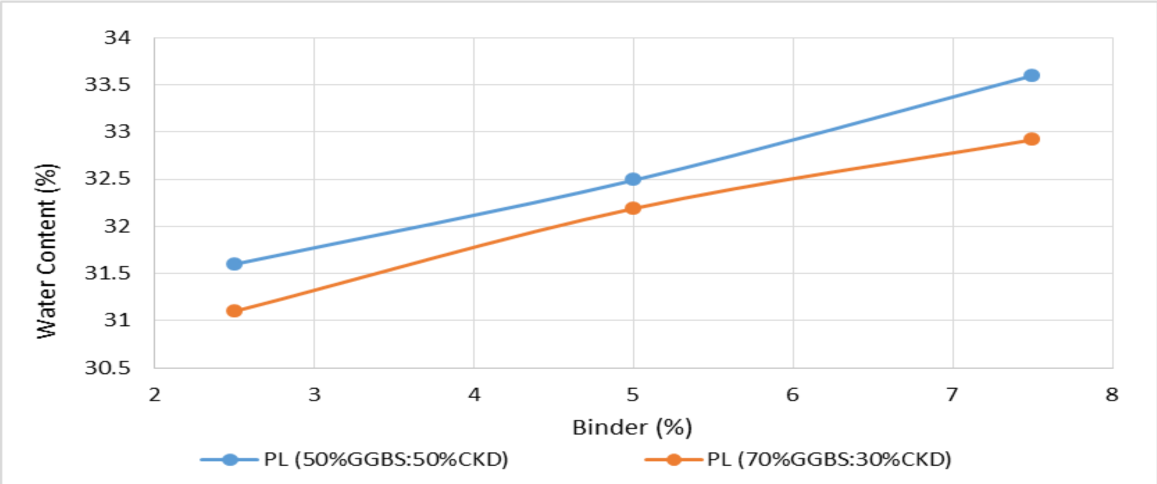
4.1 Consistency limits

Figures 1a, b and c show the LL, PL, and PI for the Kaolin soil treated with (50% GGBS: 50% CKD) and (70% GGBS: 30% CKD) at different binder percentages (2.5%, 5% and 7.5%) of the dry soil weight. It can be seen that the LL and PL increased with increasing the binder percentages and the increase in mixture of

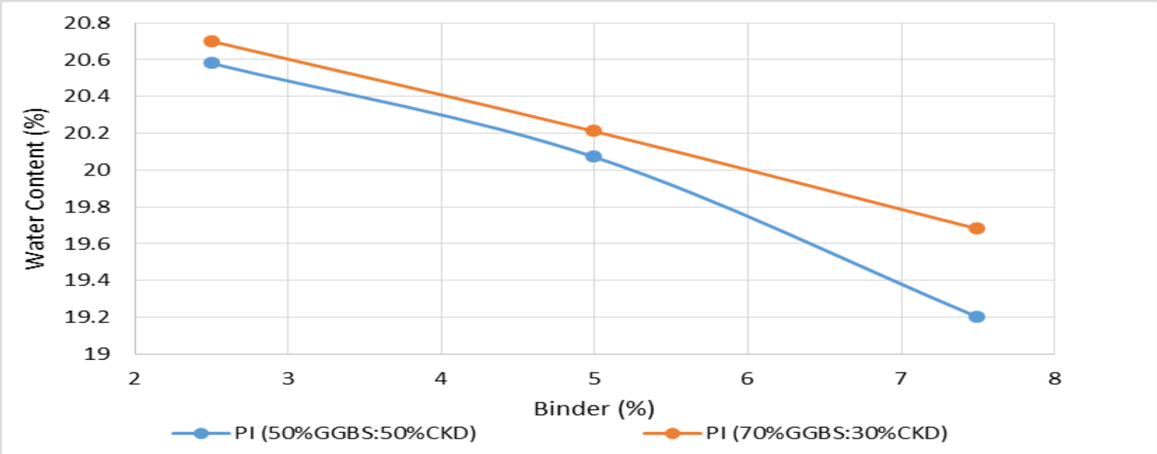
50% GGBS: 50% CKD is higher than that for mixture of 70% GGBS: 30% CKD. Also the increase in PL is more than that for LL thus, the PI value decreased (as PI = LL-PL). In addition, the PI decreased from 20.0 for the untreated kaolin soil to 19.2 for mixture with 50% GGBS: 50% CKD at 7.5 binder dosage. These changes in the consistency limits of the soft Kaolin soil are attributed to the cations ions exchange that occur between the minerals of the clay in the kaolin soil and the binder materials (Ouf, 2001).



(a) Liquid Limits



(b) Plastic Limits



(c) Plasticity Index

Figure 1. The Consistency Limits of the treated Kaolin soil with CKD-activated GGBS (a) Liquid Limits (b) Plastic Limits (c) Plasticity Index

4.2 Compaction Parameters

This test was carried out for kaolin soil mixed with 50% GGBS: 50% CKD and 70% GGBS: 30% CKD for three different percentages of binder 2.5%, 5% and 7.5% of the dry soil weight in order to determine MDD and OMC for both corresponding (GGBS:CKD) ratios and for each binder percentage; as shown in Figures 2 and 3. The obtained values were used to prepare the specimens of UCS test.

From Figures 2, 3, it is observed that a decrease in the MDD and an increase in OMC for mixture comprising kaolin soil + 50% GGBS: 50% CKD is more than that in mixture of kaolin soil + 70% GGBS: 30% CKD for the total binder content. Also, for the same GGBS:CKD ratio, the MDD decreased and the OMC increased with an increase in the total binder content.

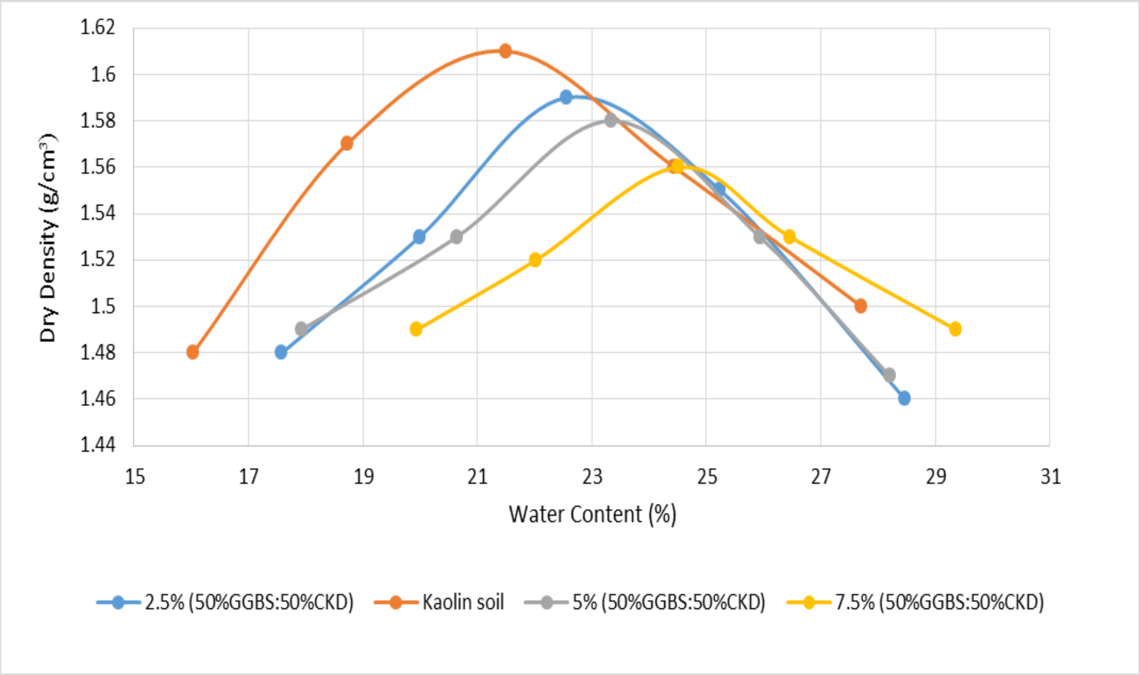


Figure 2. Compaction parameters for Kaolin soil only, kaolin soil + (50%GGBS: 50%CKD) for (2.5%, 5%, 7.5%) binder

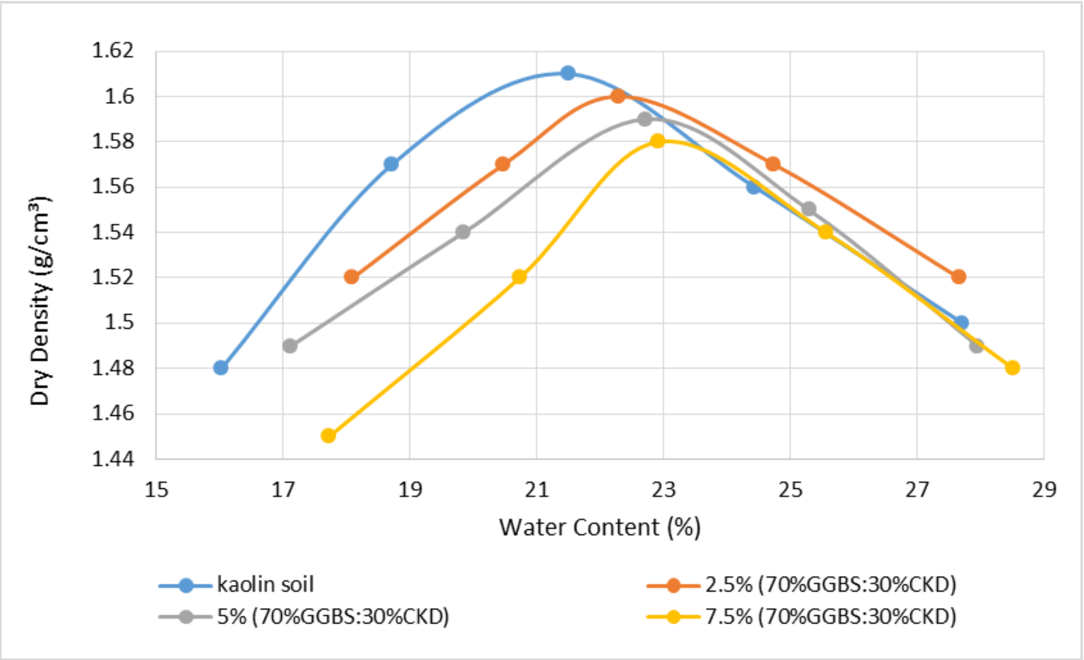


Figure 3. Compaction parameters for Kaolin soil only, kaolin soil + (70%GGBS: 30%CKD) for (2.5%, 5%, 7.5%) binder

4.3 Unconfined Compressive Strength (UCS)

The results of UCS tests are shown in Figures 4, 5 and 6 which represent the improvement of UCS values with binder percentages at 7 days curing time for kaolin soil treated with CKD-activated GGBS with 50% GGBS : 50% CKD and 70% GGBS : 30% CKD. From these figures, it can be seen that the UCS of the kaolin soil increased with an increase in the total binder content, and the increase of UCS of 50% GGBS: 50% CKD was higher than that of 70% GGBS: 30% CKD. In addition, it can be noticed from Figures 5 and 6 that soil treated with 50% GGBS: 50% CKD with 7.5% binder achieved the maximum UCS (1295.57kPa at 7 days of curing, in comparison to the UCS of the untreated kaolin soil (262.26kPa). The increase in the UCS with an increase in the total binder content could be contributed to the formation of new cementitious materials due to the reaction of the GGBS activated by CKD with the clay portion of the kaolin soil. While the increase in the UCS for 50% GGBS: 50% CKD comparing to 70% GGBS: 30% CKD is because of that GGBS is required a sufficient amount of the activator (CKD) to be activated (Ouf, 2001).

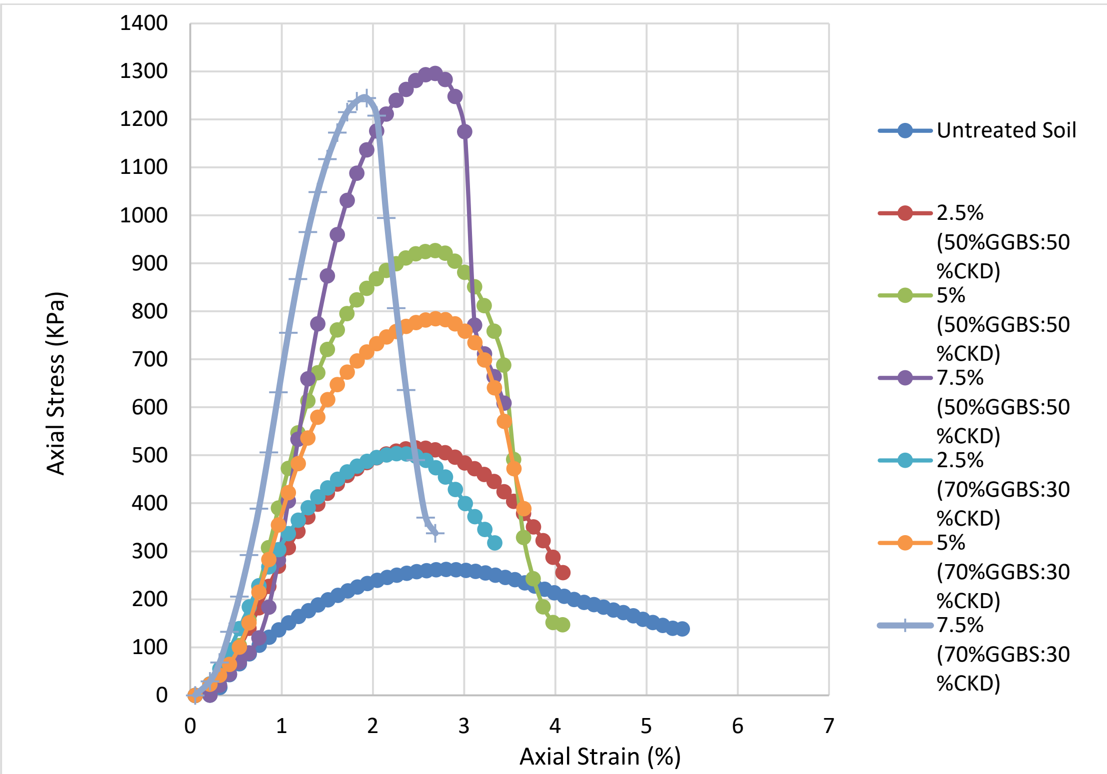


Figure 4. Typical stress-strain data from unconfined compressive strength test on Kaolin soil treated with CKD-activated GGBS after 7 days of curing.

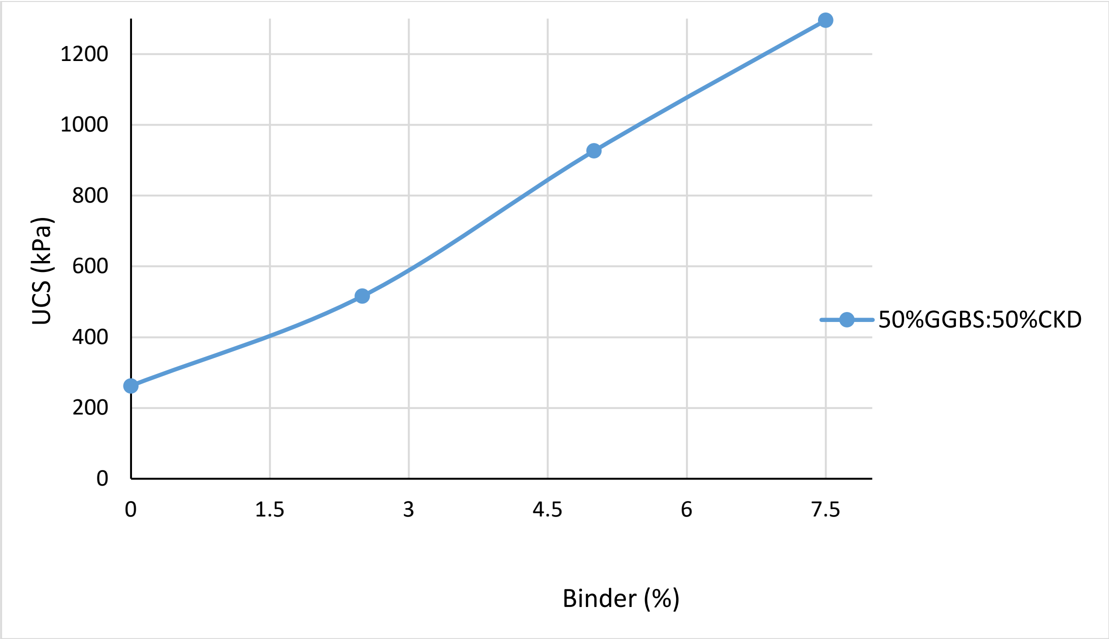


Figure 5. Effect of binder percentages on UCS of Kaolin soil treated with CKD-activated GGBS with 50% GGBS: 50% CKD after 7 days of curing.

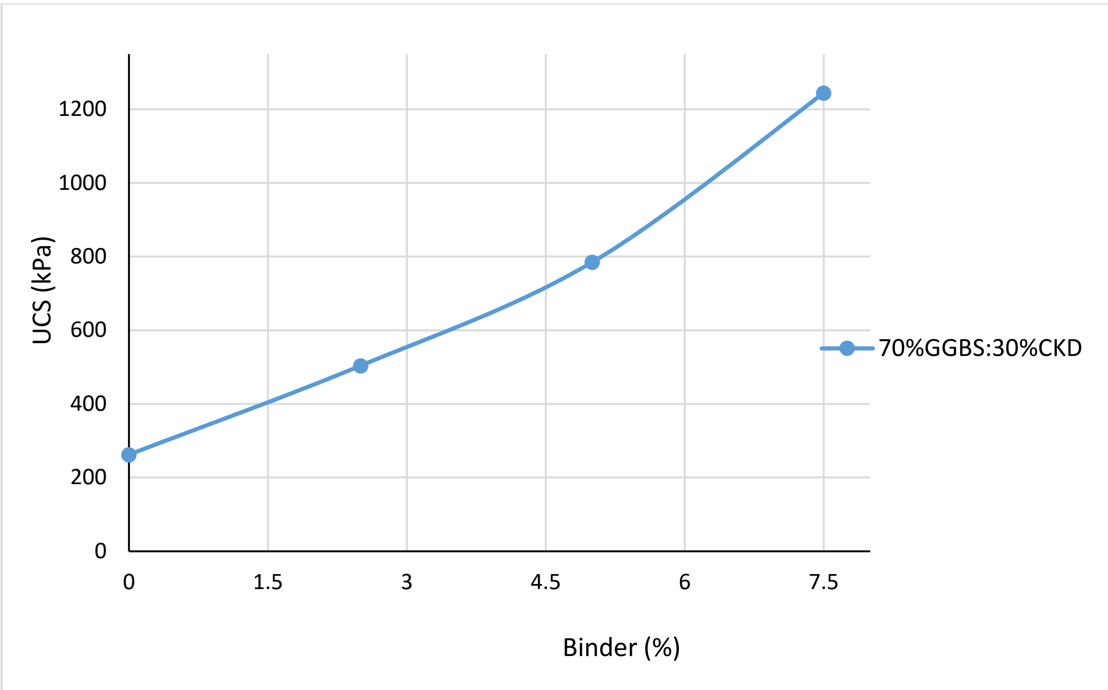


Figure 6. Effect of binder percentages on UCS of Kaolin soil treated with CKD-activated GGBS with 70% GGBS: 30% CKD after 7 days of curing.

CONCLUSION

Stabilisation of kaolin soil utilising GGBS and CKD is found to be an effective means for enhancement the engineering performance of kaolin soil. According to the results obtained from the experimental investigation, the following conclusion can be drawn:

- The LL and PL increased with increasing the binder percentages, and the increase in mixture of kaolin soil + 50% GGBS: 50% CKD was higher than that for mixture of kaolin soil + 70% GGBS: 30% CKD.
- The decrease in MDD and the increase in OMC for mixture comprising kaolin soil + 50% GGBS: 50% CKD was more than that in mixture of kaolin soil + 70% GGBS: 30% CKD for the total binder content.
- Soil treated with 50% GGBS: 50% CKD with 7.5% binder achieved the maximum UCS 1295.57kPa at 7 days curing compared to the UCS of the untreated kaolin soil (262.26kPa).

FUTURE WORK

In this paper, the UCS results were for 7 days cured specimens, so the compressive strength of the stabilised soil at 28 days will be carried out in the future. In addition, the compressibility of the CKD-activated kaolin soil will be investigated along with studying the microstructural utilizing the scanning electronic microscopy (SEM) technique as future works.

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The Soft Soil Stabilisation Using Binary Blending of Ordinary Portland Cement And High Alumina Silica Waste Material

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Abstract

The field of geotechnical engineering faces many problems related to construction on soft soil. These problems are often presented as settlement issues. Ordinary Portland cement (OPC) is one of the most preferable binders used in soil stabilisation. However, Waste materials can be used as replacement materials to reduce the usage of cement and achieve approximately the same results for soil stabilisation. The purpose of this research is to evaluate the engineering properties of a soft soil treated with 9% of binders of different binary blended mixtures produced from OPC and a particular high alumina-silica waste material (HASW). The experimental investigations were conducted to find the optimum binary mixture by determining the soil compacting, Atterberg limits and the unconfined compressive strength (UCS). Soil samples in each test contain 9% binder of different ratios of OPC and HASW by the dry weight of soil. The ratios of OPC:HASW in the samples were 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The UCS tests were carried out on the specimens under different curing periods (7 and 28 days) to evaluate the effect of curing time on the performance of the binary mixtures. The experimental results show that, the use of HASW improved the physical soil properties by reducing the Plasticity Index (PI) from 18.35 to 13.02 by replacing 50% OPC in the binder. Moreover, the UCS test results show that the ratio of OPC to HASW 70:30 was the optimum and this ratio increased the UCS value from 134.2kPa to 1107.445kPa for 28 days curing which was over the UCS achieved from the soil samples treated with the reference binder (OPC) 1100kPa.

Keywords: HASW, physical properties, soil stabilisation, unconfined compressive strength.

Introduction

Soft soils are defined as soils that consist of large quantities of fine particles like silty and clayey soils (Kamon and Bergado, 1991). The typical characterizing of soft soils are: low shear strength, highly compressible and low permeability. The value of shear strength is low for soft soil and reported as typically less than 40kPa, physically can be deformed by light finger pressure (Mohamad, et al, 2016). Therefore, the problems associated with soft soils could be summarised as: being susceptible to liquefaction defined as the loss of strength in saturated conditions, and being cohesion-less due to the build-up of pore water pressures during dynamic loading (Assimak, 2010). Expansive issues in soft soil, also called shrink-swell, is a very common soft soil problem. Depending upon the supply of moisture in the ground, shrink-swell soils will experience changes in volume of up to thirty per-cent or more (Verma and Maru, 2013).

Soft soils are found in many places in the world and especially in coastal cities like Shanghai, Tianjin and Vancouver and there is a large expanse of them existing in the South West of England and South Wales. This soft land has been used for agricultural, industrial, commercial and residential developments for many centuries (O'Neill, 2017). Overall, the problems of construction on soft soil consists of insufficient bearing capacity, excessive post construction settlement and instability on excavation and embankment forming. Experimentally, the problems of settlement can be defined as a deformation of the soil because of applying stresses. Moreover, settlement will cause changes to the load carrying system geometry (Mohamad, et al, 2016). Therefore, in many cases the soft soil should be treated to improve its compressive strength, the resistance to deformation and to improve the hydraulic properties which can be achieved by various soil improvement techniques (Cristelo et al, 2013).

Soil stabilisation is considered one of the processes for improving the of the soil properties, especially the engineering ones for making soil more stable. As a result of increasing the intensity of construction in the urban areas (densely populated), this created al need to construct on soft soil, which is considered unsuitable for construction. Therefore, one of the most important needs in this decade is research about the best soil stabilisers and to improve soil stabilisation techniques for the replacement of poor soil in such sites (Kumari et al, 2016).

There are many soil stabilisation methods which include mechanical and chemical methods. Mechanical stabilisation includes the processes of removal and pre-compression for soft soil. The first process is characterised by excavating the loose and organic soil and replacing it by a stronger more suitable soil. While the second process is characterised by using the soft soil itself with the application of static load to reduce the air voids and increase the bearing capacity of soil. These two methods are expensive because they need special equipment to and technologies which need time and money. Chemical stabilisation is achieved by mixing chemical materials to soil. This process include adding cement, lime and other chemical materials. This method is considered more economic (Das, 2003).

Ordinary Portland cement is used as additive for soil stabilisation. The purpose of the addition is to modify and improve the soil properties by increasing compressive strength and durability (resistance against the effect of moisture, freeze and thaw) together with the reduction in shrinkage and swelling potential; and to control the erosion of inorganic soils (Oswell and Joshi, 1986). The treatment of soft soil by cement increases the plastic limit and the maximum dry density of sand and highly plastic clays while it decreases the maximum dry density of silt and liquid limit, which mainly reduces Plasticity Index. That means the optimum water content will increase or decrease depending on soil type (Kezdi, 1979).

In addition to cement, the lime used to stabilise soft soil effectively could be used alone or mixed with either cement, bitumen or fly ash. The main use lime is to stabilize the base and the subgrade of roads by adding enough quantities of lime and water to produce a suitable result. The mixture of lime and water will increase the soil pH above 10.5, which helps the soil particles to break down. The use of lime will change the nature of the soil by changing the adsorbed layer, increasing the optimum water content, thus increasing the strength and durability of soil. Additionally, the use of lime will decrease the high Plasticity Index and the maximum compacted density due to pozzolanic action (Negi and et al, 2013).

The chemical reaction depends on silica and alumina which react with calcium from the cement and lime to create calcium-silicate-hydrates (CSH) and calcium-aluminate-hydrates (CAH) which are considered the main components in cementations materials. The availability of these two products will increase the strength of lime-stabilised soil layers by forming a matrix. The advantages of this matrix is that the soil is transformed from a sandy, granular material to a hard, relatively impermeable layer with significant load bearing capacity. The process begins within hours and can continue for years in a properly designed system. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible (Negi et. al, 2013).

Many problems related to soil stabilisation via the use of cement have been identified. The cement manufacturing process is considered the biggest consumer of energy and one of the main reasons for climate change. The cement industry needs enormous amounts of resources such as fossil fuels and raw materials which considered non-renewable materials (Potgieter, 2012). The consumption of energy and raw materials will send dust and gases to atmosphere which are also considered harmful. Cement manufacturing sends nitrogen oxides (NOx), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulphur dioxide, carbon monoxide, and still smaller quantities of organic compounds and heavy metals (Hurford et al, 2002). In addition to that, the toxic metal and organic compounds are spread to the air from the cement kiln and the processes of cooling clinker, operating crushers, grinders, and materials-handling equipment causes further harmful emissions.

Scientists have found that each tonne of Portland cement clinker produce almost one tonne of CO_2 and other greenhouse gases (GHGs) to atmosphere. These amounts of emissions do not just affect the air quality, but impacts badly on human health. The cement manufacturing has local and global impacts on the environment like global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity etc. (Kumar et al, 2013). In addition to environmental impact, scientists found a relationship between the emissions of cement manufacturing and the human health. They found that these emissions cause allergy, itchy eyes, respiratory diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, cardio-vascular diseases and even premature death (Mehraj et al, 2013).

At present, the Industrial wastes, which are produced from many different Industries, are considered a significant problem and the ways of disposal an even bigger problem. The non-biodegradable waste causes environmental pollution for the neighbouring areas not just in the location of production. Also, the disposal of industrial waste are considered very dangerous because most of industrial waste has chemical components that affect human health and bio-diversity. Therefore, the landfill of the industrial waste should be minimised to lower the amount and reduce the landfill tax levied on the producer. The reduction in landfill amount could be achieved by using these wastes in many fields such as in soil stabilisation. The use of industrial waste for soil stabilisation is considered economical and an eco-friendly resource which reduces the pollution and disposal problems (Sen and Mishra, 2010).

There are many studies in soil stability by using different additive materials. Generally, the materials for soil stabilisation are divided into two kinds: traditional materials like (Portland cement, cement-fly ash, lime, fly ash with lime, etc.), and non-traditional materials (Jeb et. al., 2007), (Makusa, 2012) and (Dhanoa, 2013). Recently, researchers have tried to develop new cementitious materials for soil stabilisation purposes. These supplementary cementitious materials could be used alone or mixed with small amounts of cement and lime. The non-traditional materials could be pozzolanic materials or waste materials like silica fume (SF), ground granulated blast furnace slag (GGBS), pulverised fuel ash (PFA) and cement kiln dust (CKD). These materials characterised by their eco-friendly credentials, reduction of industrial waste, reduction of landfill, low cost, ease of application, short curing time etc. Such materials could be used with cement to improve the properties of cement-based stabilisers such as workability, durability, and strength (Sadique et al, 2013).

Jafer et al, (2015) presents evidence about the suitability of a waste material (WM) for soft soil stabilisation. The results showed that the WM used in the study improved the physical properties of the soft soil, for example: the Plasticity Index (PI), which had been decreased significantly. After mixing the soil with 12% of WM and 15% WM the PI values were decreased from 21 to 13.64 and 13.10 respectively. Moreover, the unconfined compressive strength results indicated that 12% of WM was the optimum and this percentage developed the UCS value from 202kPa to 500kPa for 28 day cured samples, which is equal to approximately 2.5 times the UCS value for untreated soil.

MATERIALS AND METHODOLOGY

Soil sample

The source of the soil which was used in this research is the banks of the River Alt in Hightown to the north of Liverpool. The soil was collected at depth about (0.3 - 0.5m) below the ground level. After collecting the soil samples, they were stored in plastic bags the capacity of each bag was about (20 - 25kg), these bags were sealed with all soil information before transport soil to the laboratory. The specimens were processed immediately after soil arriving to the laboratory to find (NMC) the natural moisture content. The remaining soil was dried in the oven at 110^{o}C for use it in the other experiments. In the first instance, the soil classification was determined along with the consistency limits test and particle size distribution test. Moreover, the compressive strength for the virgin soil (untreated soil sample) was evaluated via the unconfined compressive strength test (UCS). Table 1 shows the main properties of soft soil which identify by physical and chemical analysis of the soil. Table 2 indicates the chemical analysis of the cement and waste material with Figure 1 illustrating the X-ray powder diffraction (XRD) results for the HASW.

Table 1. The engineering properties of the virgin soil used in the study

Property	**Value**
Natural moisture content, NMC %	37.5
Liquid Limit, LL %	39.2
Plasticity Index, PI	18.35
Sand %	12.07
Silt %	75.03
Clay %	12.9
Specific Gravity (Gs)	2.61
γ_{dmax} g/cm^3	1.63
Optimum moisture content, OMC %	20
PH	7.78
Organic matter content %	7.95
Unconfined Compressive Strength, q_u kPa	134.2

Ordinary Portland cement (OPC)

In this study the commercial OPC was supplied by CEMEX Company in Warwickshire, UK, which is OPC type CEM-II/A/LL 32.5-N.

Waste Material (WM)

The waste material (HASW) used in this study is composed of agglomerated particles. It has a sufficient content of Alumina-silicate, which makes it eligible to be used as a blending material.

Table 2. Chemical analysis of the cement and waste material

Material	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	SO_3	K_2O	TiO_2	Na_2o
HASW	0.05	35.45	44.17	0.69	0.37	0	0.05	0	0
OPC	62.34	26.64	2.44	1.57	1.75	2.59	0.72	0.39	1.53

EXPERIMENTAL WORK

Mixing proportions

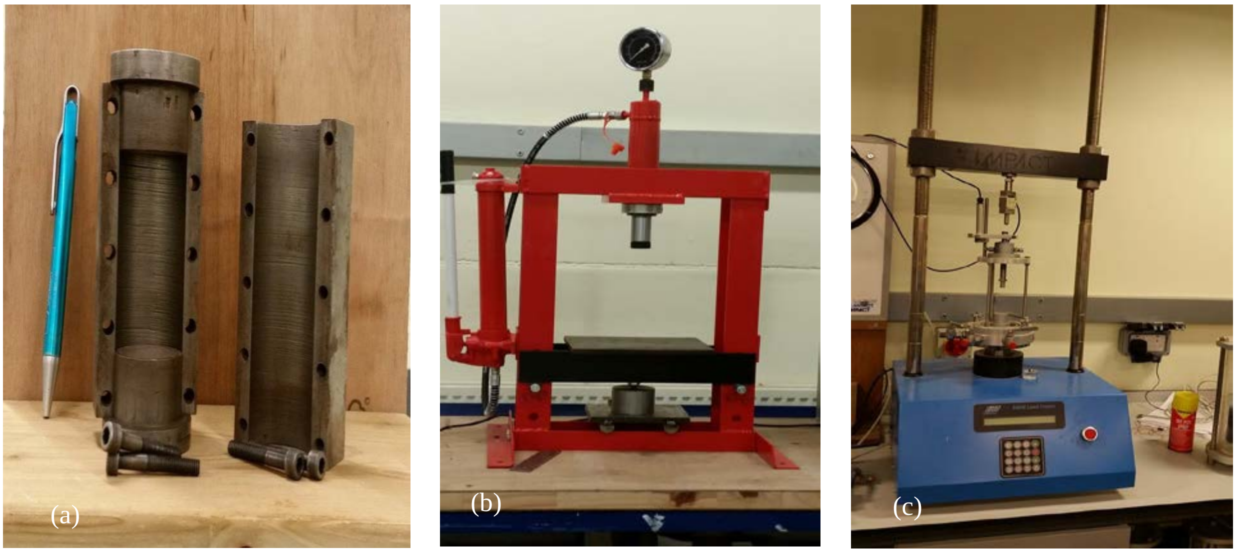
Testing was carried out using five binary mixtures with different proportions of OPC and HASW along with virgin soil and soil treated with 9% OPC as reference mixture (100% of the binder used) as illustrated in Table 3.

Table 3. Binder mixing proportions used in this study

Mix ID	OPC %	HASW %
VS	0	0
Ref.	100	0
B1	90	10
B2	80	20
B3	70	30
B4	60	40
B5	50	50

Sample Preparation

After preparing the soil, the soil sample was ground to break any chunks and sieved in preparation for testing. Testing was carried out immediately after mixing the soil with binder and water depending on the standard procedure for each test. Soil samples in each test contain 9% binder of different ratios of OPC and HASW by the dry weight of soil. The HASW percentage ranged from 10% to 50% by the dry weight of the binder ratio. While preparing the UCS test specimens a special mould according to the standard requirements (D = 38mm and H = 76mm) as shown in Figure 1-A was used. The samples consisted of soil, binder and water; with the amount of soil and water depending on the maximum dry density (MDD) and optimum moisture content (OMC) for each binder ratio. The mixture of soil, binder and water should be prepared and then formed under pressure in the mould to create the UCS test specimens (Figure 1-B. The specimens for treated soil were cured between 7 - 28 days. The UCS tests were performed on a computerised tri-axial machine by applying vertical load only with horizontal stress in the tri-axial cell, $\sigma 3 = 0$. as shown in Figure 1-C.



Figures 1. Fixed volume mould, Compression rig and tri-axial machine

Laboratory Tests

The experiments as following

Atterberg limits test: this test was performed by using the fall-cone penetration and the soil crumble methods, to find the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI). The tests were carried out according to the British Standard BS 1377-2:1990 (British Standard, 1990a).

The Standard Proctor compaction: the compaction parameters test was used to determine the maximum dry density (MDD) and optimum moisture content (OMC) for each binder ratio. The experimental method was undertaken as per the British Standard BS 1377-4:1990 (British Standard, 1990b) using an electrical compaction machine. The soil was dried and passed through sieve No. 3.35mm to provide a sample of around 2000g of soil. The soil was mixed with water and different binder ratios, then compacted in the mould in three layers. Each layer was compacted with 25 blows by using a 2.5kg hammer.

Unconfined Compressive Strength test: was carried out according to British Standard BS 13777:1990 (British Standard, 1990c), by producing four samples for each binder ratio, the samples were tested during different curing periods (7 and 28 days). The samples contained soil, binder and water mixed together and compacted in the mould by using hydraulic load. The curing was carried out by covering in cling film and storied at 20 ± 2°C.

RESULTS AND DISCUSSION

Atterberg limits

The Figure 2 shows the changing in the LL, PL and PI for the untreated soil (VS sample) and the soil after mixing (Ref., B1, B2, B3, B4 and B5). The figure indicates that the LL was increased when cement was added to soil which continued to be the case after HASW was added in different ratios. Moreover, the PI was reduced when the soil was mixed with cement. The decrease in the cement content and the increasing HASW ratios mixed with soil reduced the PI value. Table 4 demonstrates the LL, PL and PI values from the Atterberg limits tests, it shows a PI value decrease from 18.35 for the VS sample to 12.48 for sample B2. The treatment of soil with (OPC + HASW) leads to a reduction in PI in spite of increasing both LL and PL.

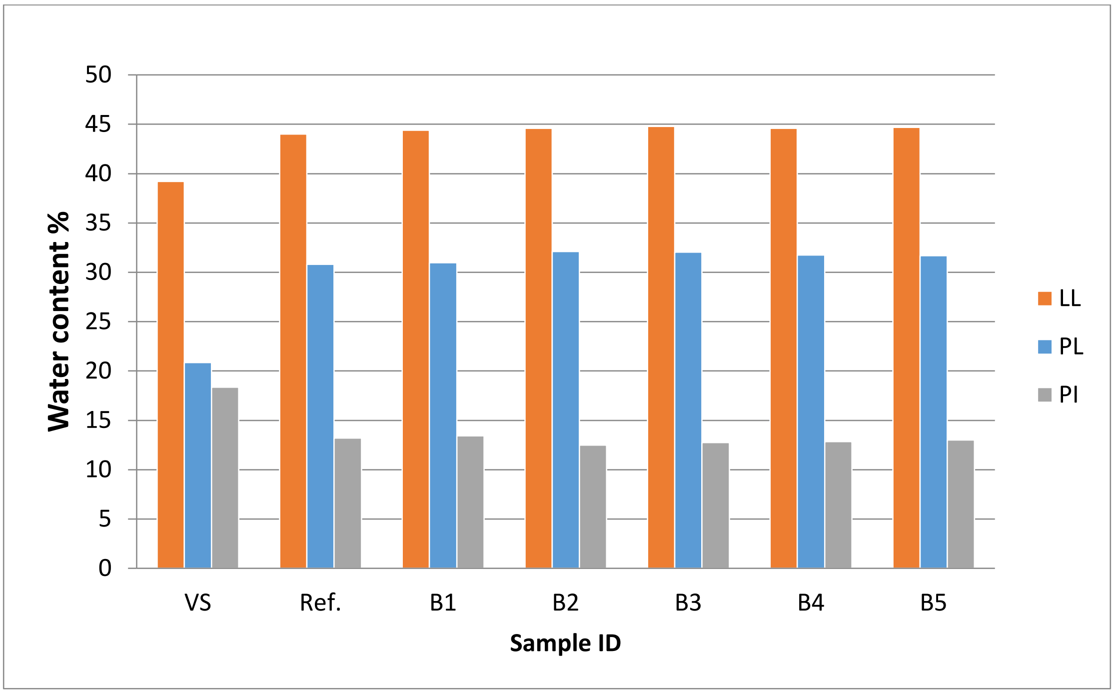


Figure 2. Atterberg limits after cement and HASW treatment

Table 4. The results of the Atterberg limits tests

Ratio	LL	PL	PI
VS	39.20	20.85	18.35
Ref.	44.00	30.80	13.20
B1	44.40	30.96	13.44
B2	44.60	32.12	12.48
B3	44.80	32.05	12.75
B4	44.60	31.74	12.86
B5	44.70	31.68	13.02

Compaction Parameters Tests

The results of the compaction tests in Figure 3 show that, the treatment of soil by HASW decreased MDD and increased the OMC with continuous increase in HASW content. The results indicated that the MDD decreased noticeably from 1.58 Mg/cm3 to 1.534Mg/cm3 for HASW proportion 0% to 50% respectively by the binder weight. After that, the decrement in the dry density became stable. Meanwhile, the OMC increased from approximately 20% to less than 23%. The decrease in MDD may contribute to decrease in the compressive strength of the sample. With respect to the OMC, the increments occurring gives an indication of the decrease of the workability of the cement-soil mixture treated with HASW. This behaviour of the compaction parameters of the soil sample after HASW treatment could be attributed to the increase in the water demand of the soil-binder mixtures, which replaced a part of the soil that is associated with lower water demand due to the clay minerals in the treated soil. Moreover, the decrease occurring in the dry density may be attributable to the fineness of HASW particles which Increase the surface area of the molecules, increasing the area of interaction.

Unconfined Compressive Strength Tests (UCS)

The graph of stress-strain for samples without binder and with binder in different ratios for both ages of curing 7 and 28 days are illustrated in Figure 4. It show that after 7 days of curing some samples (B1, B2, B3) refer to slight increments in the compressive strength of sample and the best sample is B3 with (70% OPC + 30% HASW). However; the samples were tested after 28 days that there was a significant increment in the soil compressive strength values comparison to VS sample. As shown in Figure 5 – 28 days curing results, the samples that treated with 20% and 30% HASW exhibited similar stress-strain diagrams as well as indicating the higher compressive strength among the other samples.

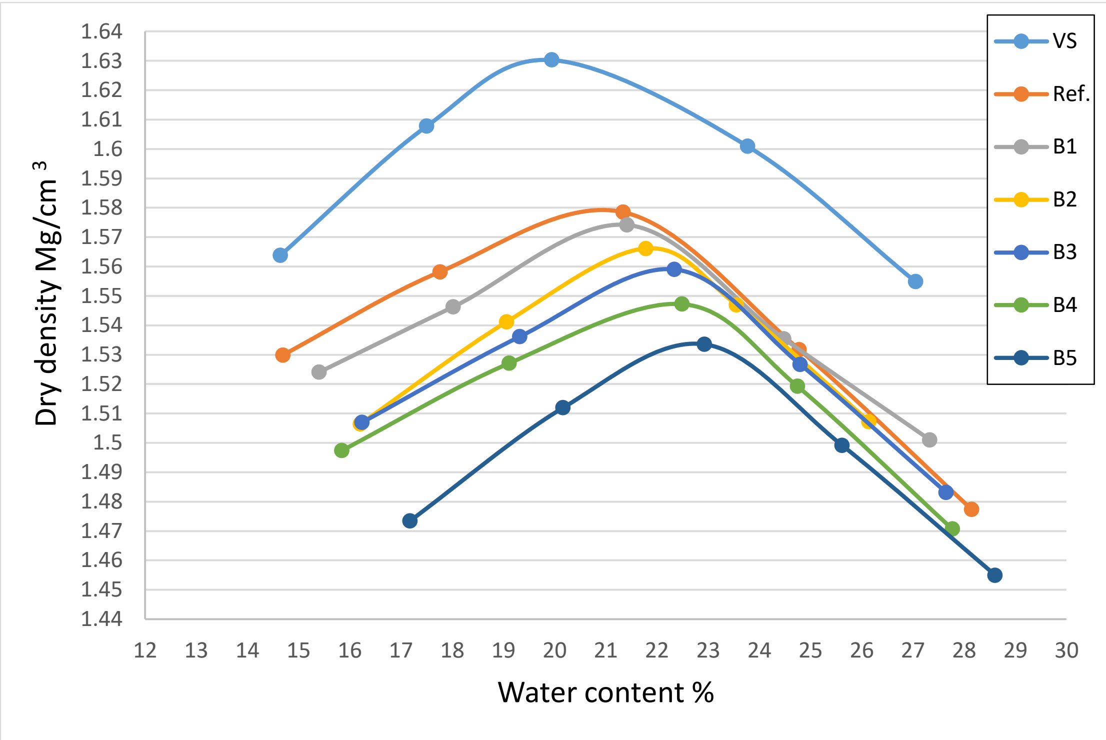


Figure 3. Dry density Vs - moisture content for the soil samples

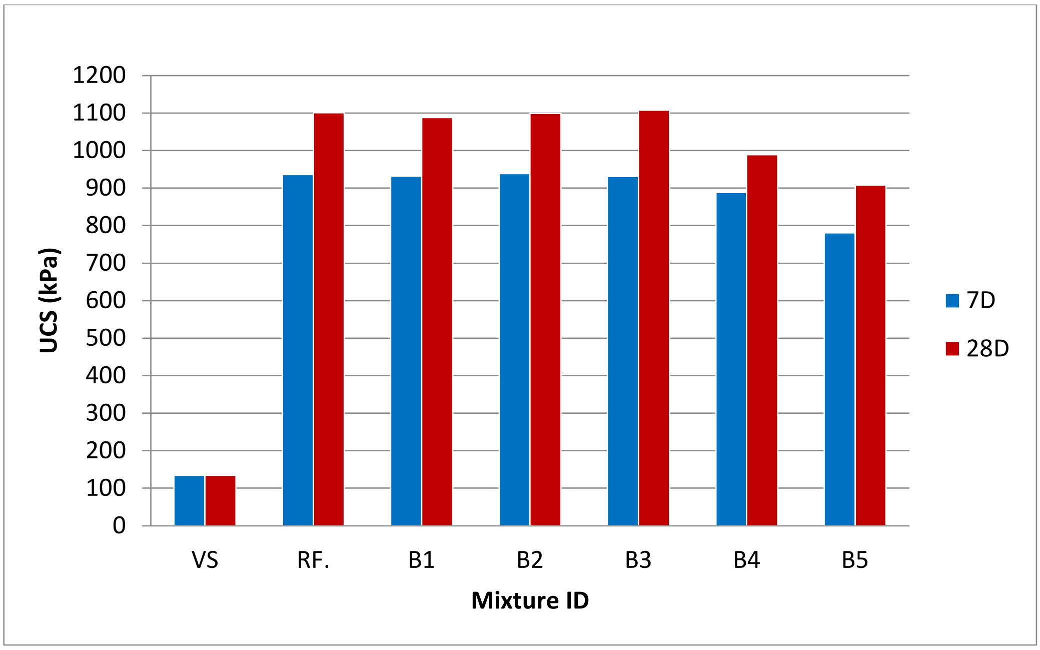


Figure 4. UCS results of the soil samples after before and after treatment

Figure 5 shows development in UCS with the curing time for untreated and treated soil with the binder mixture of OPC+HASW. The results shows that UCS of soil samples significantly increased from 930kPa at 7 days curing time up to 1107kPa at 28 curing days. The UCS development rate increases during 7 to 28 days. However; the UCS gained at 28 curing days of sample B3 gave higher results than RF sample. The figure 5 illustrates that the UCS of the samples increases with addition of the waste material at 28 curing days.

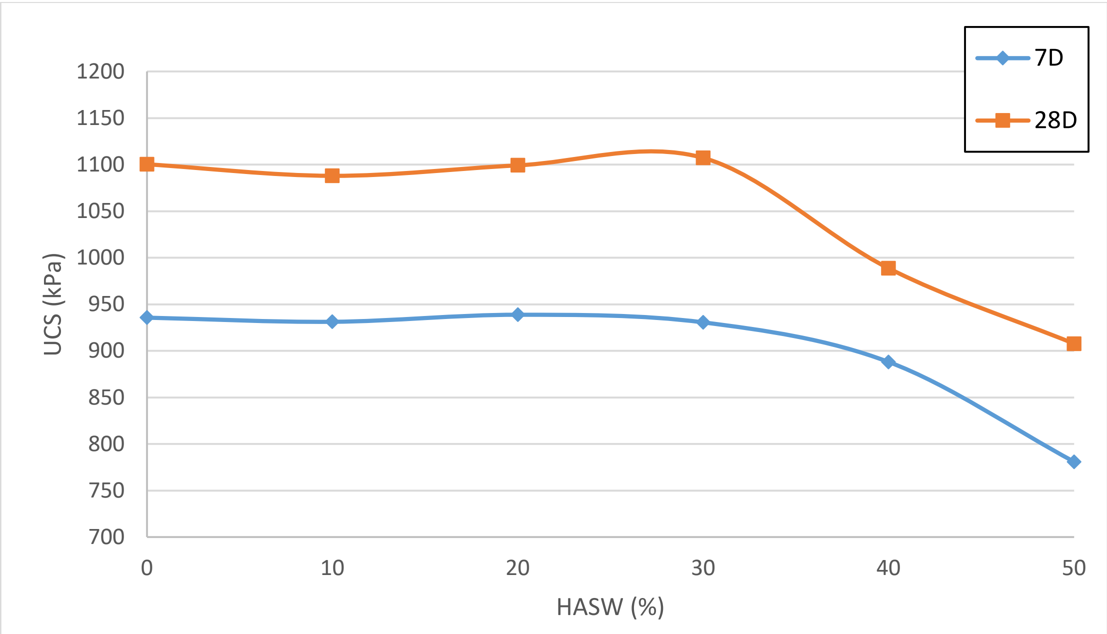


Figure 5. Effect of HASW treatment on UCS development of cement stabilised soil

CONCLUSION

The effect of pozzolanic reaction of HASW in the binary blending system with OPC on the geotechnical properties of soft soil was investigated in this research. This provides a novel approach for the use of a waste material that has not been previously implemented to reduce the use of OPC and develop a new binder material for the use in soft soil stabilisation. The following conclusion can be stated based on the results obtained in this study:

- The HASW used in the experiments show that the physical soil properties were improved such as reducing the plasticity index (PI) from 18.35 to 13.02 for 50% HASW by the dry soil weight.
- The use of HASW in the compaction test led to a significant decrease in the maximum dry density and an increase the water content.
- The use of HASW has significantly improved the unconfined compressive strength of the soft soil. The results showed that UCS was increased from 134.2kPa for untreated sample to 1107kPa for sample B3 after 28 days curing, which is higher than the UCS for RF sample (with 100% OPC by binder weight).
- According to the results obtained from this study, a new binary blended cementitious binder wad developed.

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The Future of Software Engineering: Visions of 2025 and Beyond

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Abstract – In the current technological scenario of the industry and businesses, there has been increasing need of software within systems and also an increasing demand being put onto software-intensive systems. This in effect will lead to a significant evolution of software engineering processes over the next twenty years. This is due to the fact of emerging technological advancements like Industry 4.0 and Internet of Things in the IT field, among other new developments. This paper identifies some key research challenges which will be faced by the software engineering field and articulates information that is derived from the key research specializations within software engineering. The paper analyses the current state of art trends in software engineering. The future of software engineering in the context of Industry 4.0 which includes emerging technological platforms like Internet of Things. The societal impact aspect of future trends in software engineering is also addressed in this paper.

Keywords—*Software Engineering; Internet of Things; Future trends; Industry 4.0; Interaction-Oriented Software Engineering*

INTRODUCTION

The future of software engineering is only possible by understanding the past and the present status of software engineering. With the advent of many new technological advancements like Internet of Things (IoT) and Industry 4.0, the importance of a refined software engineering process in the future is much more paramount. Moreover, also observed is the fact that software engineering is an established process which has its own process, technologies and discipline of the application. Software Engineering in the current world uses the established methods and tools across multiple domains including proprietary real-time industry for the control of energy, transportation systems, manufacturing automation in factories and general end-user applications.

With more and more industries embracing Internet connected infrastructures, the software engineering domain is no longer the primary de-facto standards for just professional software developers. The focus is shifting in these emerging fields from coding to make the machines work, to ensure that the software developed is of extremely high quality for the purpose for which the software was created.

In this paper, we identify some key some key software engineering challenges. The paper is structured as follows. Section II provides general background information about software engineering. Section III identifies and discusses the relationship between IoT and importance of implementing a successful procedure for software engineering. Section IV further highlights the concept of Industry 4.0 and the integration of software engineering for successful projects. The next section illustrates the societal aspects and impacts in relation to software engineering in the future. In the final section of the paper, the future trends related to software engineering is predicted and speculated upon.

BACKGROUND INFORMATION

Society is increasingly relying on software in many areas including entertainment, education, politics, industrial and civil infrastructures, economic and business initiatives, as well as work and personal activities, among many others [1]. All these areas have become inextricably linked with software systems and applications. As such, software development is a field that requires support, improvement, and research. In the software engineering domain, the focus has been to tackle problems and issues. However, there are challenges that still remain to be overcome.

Challenges in Software Engineering

Firstly, Fuggetta and Di Nitto have pointed out that the internet has become an environment for development through which cooperation among developers occurs [1]. As such, there are many changes in which software evolves from conception to deployment. One example of such change is crowd-sourcing; an area the researchers observe needs to be better evaluated and understood.

Another challenge is that software continuously evolves as a result of new requirements. The requirement not only creates a challenge with software deployment, but also the required technologies that should operate reliably over the Internet and the support needed in such an environment. Most importantly, the different types of applications that are deployed in the short term and then replaced with others, coupled with those which are deployed for the long term means that current models and standards should adapt to the various emerging contexts [1].

Current Research in Software Engineering

The field of software engineering has over time shown that developers and engineers are critical to the success and outcomes of projects [2]. Nevertheless, research on the human aspect has been scarce in comparison with a focus on process or technology. Increasing dissatisfaction with poor quality of software as well as growing interest in agile methods has begun to place more emphasis on the human aspect of research in software engineering.

Empirical research studies in software engineering illustrate the types of factors which have an impact on crucial outcomes such as quality and cost, but it has also been ascertained that programmers often hold prior opinion on some of these issues [3]. In a study of IBM developers, for example, it was found that they held prior beliefs on certain issues and their opinions were based on experience instead of findings from prior empirical research. While such prior opinions are important, especially because developers are professionals who are highly trained with beliefs that are critical to their work, dissemination of empirical evidence to the profession is nevertheless important.

Interestingly, it has been previously proposed that evidence-based software engineering should be adopted, and that systematic review of software engineering literature should be used to support evidence-based software engineering [4]. Since these proposals were made in 2004 and 2005, systematic reviews have gained relevance in empirical software engineering. As they became more popular among software engineers, the systematic review process also started receiving attention. Against this background, therefore, the researcher's systematic review concerned with either technique to improve the process or experiences with the process found that systematic reviews face criticism because there are no appropriate digital libraries for software engineering and that the systematic review process itself is time consuming.

IoT and Software Engineering

Wireless sensor network technologies have become a part of everyday life, allowing for the measurement and understanding of indicators in the environment that range from natural resources and delicate ecologies, to environments in the urban areas [5]. These devices have proliferated to form the Internet of Things (IoT) through which sensors and actuators blend into the environment and provide information across platforms that result in a common operating picture (COP).

The IoT has grown out of its early stages with the introduction of enabling device technologies such as embedded actuator and sensor nodes, near field communication devices, and RFID tags and readers [5]. This evolution from the www, to web2, web3, and now IoT means that sophisticated, intuitive queries must continue to be developed to meet data-on-demand. Most significantly is the fact that the IoT devices creates huge amounts of data, an observation which means that sophisticated artificial intelligence algorithms should be developed so that the data can be understood and used intelligently.

A. Software Defined Systems (SDSys)

Jararweh et al made an observation that there are huge amounts of data generated through the IoT. This data requires innovative ideas in the management and design of the IoT network so that its performance can be enhanced and accelerated. To meet this challenge is the Software Defined Systems (SDSys), a new model that simplifies underlying system architecture by removing management operations and controls from the devices in the IoT, and channeling such operations into a software layer and middleware layer [6].

Significantly, Jaraweh et al argue that several SDSys can be used to describe a Software Defined Internet of Things (SDIoT). This comprises a Software Defined Network (SDN) that separates operations conducted at the data plane from those at the control plane, the Software Defined Storage (STStore) which separates the data storage layer and data control layer operations, and the Software Defined Security (SDSec) which separates the processing and forwarding plane from the security control plane. In this way, the IoT management operations are made simpler [6].

Developing applications for the IoT is difficult because there are many related issues that need to be overcome. The issue includes the fact that there is an absence of high level abstractions and no separation of concerns which makes it challenging to address heterogeneity and the large scale. In addition, applications have to be developed in a manner which addresses various life-cycle phases. The development requires an analysis of application logic so that tasks can be distributed over an underlying network, followed by implementation of tasks for distinct hardware [7]. Fig. 1 below illustrates the abstractions in an IoT.

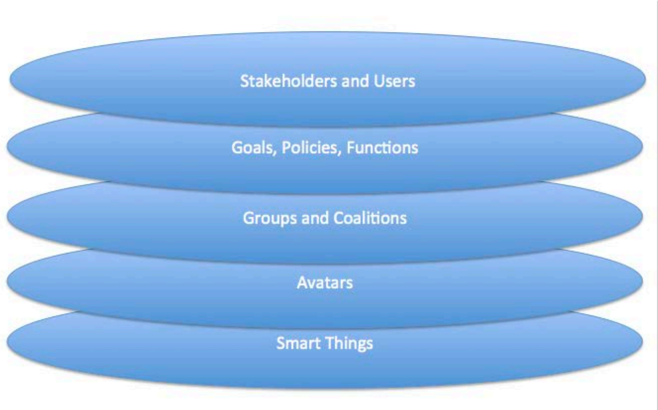

Fig. 1: The Abstractions for IoT System, adapted from [8]

IoT Requirements

Despite the fact that IoT can enhance quality, efficiency, and innovation, and connect transportation systems, automotive, medical, and production with Information Technology (IT) systems in a manner that can provide vital information for businesses, many companies do not appreciate the combined IT, software needs, and required architectures that are needed to take advantage of IoT [9]. Corporate executives, for examples, understand the value chain but are least concerned with technology; IT departments seem removed from real products and people; while engineering departments view IT with suspicion, preferring to concentrate on embedded electronics and system development.

Fig. 2 below illustrates the complexity of the IoT for modern manufacturing [10]. For IoT to provide useful information to an enterprise, appreciation should be made of the various levels; that is, the machines and devices at the lowest level, a business application, and the ease with which all the information is transacted through cloud computing.

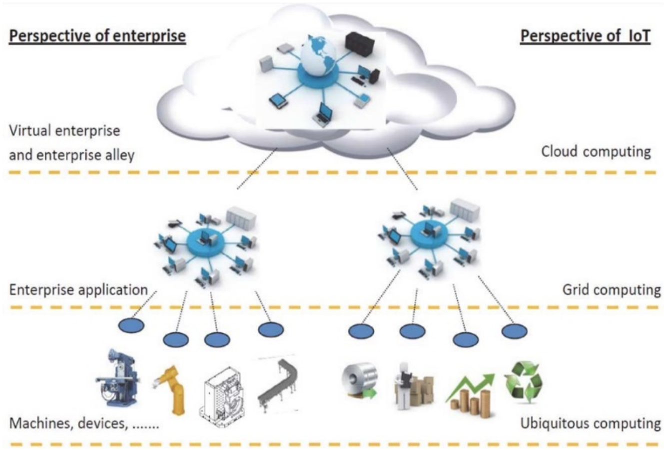

Fig. 2: Internet of Things (IoT) for Modern Manufacturing adapted from [10]

An interesting perspective on the use of IoT is observed [8]. The functionalities of IoT services and applications should not be merely related to the fundamental principle that data is generated from sensing and actuating, but smarter devices can be deployed to conduct some long term functions in autonomy and in the socio-physical space they reside. These services can range from autonomous personal assistants or even just basic cleaning robots [8].

INDUSTRY 4.0 AND SOFTWARE ENGINEERING

Industry 4.0 is a term that has its origin from Germany as “Industrie 4.0” [11]. From a global perspective, comparable ideas are General Electric’s

Industrial Internet. Such an industrial internet, similar in description to Industry 4.0, is supported with a budget of 2 billion dollars by the U.S. government for purposes of researching and developing *Advanced Manufacturing*. Other terms that are used to describe Industry 4.0 include *Integrated Industry*, *Smart Manufacturing*, and *Smart Industry*.

Leveraging with Industry 4.0

Industry 4.0 can be described as networking within an Internet of Things (IoT), people, data, and services. Significantly, it is characterized by a number of features. The technology enables vertical networking of smart products and smart factories, horizontal integration of customers and business partners, through-engineering that includes the production process and end product, and exponential technologies which allow for mass market application since their computing power has risen while their size and costs have gone down [12].

Integrating Networks

The manufacturing industry in Germany, for example, is facing stiff global competition with regard to costs of production as well as quality. Since the cost of labor is high, competing countries have been able to gain an advantage in quality and productivity. As such, many companies in Germany are leveraging the ideas of Industry 4.0 through which companies participate in integrated networks, so that core competencies are shared.

In Industry 4.0, all businesses in the network are able to access real time product information in a virtualized space which obliterates boundaries and allows for mass customization and agile manufacturing. The presence of cyber-physical systems ensures that machines are able to communicate, and rapid product innovation becomes possible since modeling techniques and modular simulation is shared across the network. In essence, Industry 4.0 enables collaborative networks through its intelligent automation [13].

Most importantly, industrial automation is increasingly relying on software. The German Engineering Federation, for example, points out that the ratio of software development to cost of machinery has doubled from 20 to 40 percent within one decade [14]. In essence, this continuing trend will mean that automation systems developers and suppliers will in future be mainly concerned with software engineering. This is not curious since software engineering is applicable in many domains including applications related to information processing, web-commerce, trade, databases, manufacturing automation, and even real-time control of transportation and energy systems.

Quality Management

Today's business climate is characterized by intense competition in which the quality of products, services, and processes determines if they will be successful. As such, quality management continues to be indispensable and integral in corporate management of every organization [15]. Since Industry 4.0 provides enormous social, ecological, and economic potential, it also stands to play a critical role in quality management. Against this background is the fact that ERP systems are software applications which track and control huge volumes of data that is essential for quality management. As such, they can leverage the advantages provided by Industry 4.0 and will in future be of value in quality management to address Industry 4.0 research challenges.

Self Awareness

A prediction is that Industry 4.0 will in future create a fleet-wide information system that will enable machines to be self-aware, the ability to self-assess own degradation and health and also utilize smart decision making to keep problems at bay. This will only be achieved through smart analytics. However, one reason why self-awareness in machines has not been fully achieved is because Prognosis and Health Management systems (PHM) have a low level of adaptability [16]. At issue is the fact that the PHM algorithm is developed from experimental data in the lab and cannot change after implementation unless it is re-trained. This is a challenge for developers because in practice real-time data is from numerous machines which generate much more data than that which is generated from the lab. As such, algorithms that are capable of learning from real-time data will in future have to be developed.

The Future of Industry 4.0

In their analysis of German manufacturing in relation to the impact of Industry 4.0, it was found that the next ten years will experience a 6 percent growth in employment [17]. During the short term, repetitive tasks will be replaced with more automation. However, the increased use of software, analytics, and connectivity will create more demand for people with skills in IT technologies and software development, including mechatronics professionals having expertise in software. In addition, suppliers will increasingly need to offer services driven by analytics [17].

There are many complex challenges that will confront Industry 4.0 practitioners in the future [18]. For example, there is system complexity in Industrial IoT devices because such devices may also have within them other IoT systems. Another challenge is management complexity related to software, networked systems, security, configuration, and compliance. Thames and Schaefer argue that software defined systems (SDNs) are best placed to overcome such challenges.

SOFTWARE ENGINEERING IN THE EVOLVING SOCIETY

Interaction-Oriented Software Engineering (IOSE)

The aim of social machines is to enable social processes through the administrative support provided by computers. However, a social-technical machine as conceived by Chopra and Singh would be a Social Technical System (STS), going beyond the current emphasis of the technical parameters in social machines to give meaning to social processes [19]. Interaction-Oriented Software Engineering (IOSE) is able to connect with STS's social fundamentals.

The main objective of IOSE would be social protocols. In the IOSE, social expectations are given computational status and the progress of the interactions tracked by concerned principals. For example, a business contract can represent a social protocol that would then be given computational status. IOSE challenges the current principles of software engineering, and leads to new areas of research in information processing.

Big Data

Big data, along with many disruptive technologies such as the Internet of Things (IoT), cloud computing, mobile computing, and social networking has created many opportunities for business through innovation, made project life cycles shorter, and made business transactions faster [20]. However, big data systems face the challenge of responding to mixed requests requiring either quick response or others requiring complex analytics before reply. Meeting these computational needs in a cost effective manner is a big challenge in software engineering. In addition, the high availability in an eco-system with thousands of nodes forming an application means that network and hardware failures will occur. As such, the data architectures and distributed software should be resilient.

Computational modeling

Computational modeling is increasingly important for scientists and engineers because events can be addressed in real-time. Meteorologists are able to make forecasts using current conditions, and also determine how changing conditions will have any impact. Using computational models thus hastens the process of forecasting instead of the time consuming work of extrapolating historical data. Computational modeling also makes it possible for natural phenomena that occur at a slow pace to be analyzed by scientists such as climatologists or geologists [21].

Additionally, computational modeling allows phenomena that are experimentally dangerous, such as nuclear reactions, to be studied safely [21]. However, in their study among software engineers and developers, Heaton and Carver found that software engineers need to contribute more to scientific software development so that it can become more accurate. In their view, scientific software developers are only now starting to accept the practices of software engineering to make their software more reliable.

Ethical Concerns and Sustainability

Current software systems are in an eco-system that is complex and hyper-connected [22]. As such, software engineers are designing systems which are more open, and can absorb huge amounts of intricately linked data affecting people. Such software systems also contribute to fighting crime, energy demand, sustainable living, and also empowering groups in society who have been marginalized. This, therefore, means that software engineers must address ethical issues which are inevitable in software which has become so socially embedded. These ethical issues have usually been treated as requirements which are non-functional and also as issues to be considered against the better good [22].

In fact, another study on sustainable software engineering among academics found that there is very little in the software engineering curriculum about sustainability, the main focus being energy efficiency that is taught in a fact-based manner [23]. A researcher, however, argues that these approaches are insufficient since software changes constantly and as such ethics in software engineering must be relational and contextual [22].

There is another speculation which views that little research has been conducted on the place of software systems in the sustainability of society. According to the authors, this concern has only received attention in the early processes of the design of user interfaces during processes of software design [24]. The National Research Council of USA holds the view that information systems have a critical role to play in society, and "apps" deployed via smartphones is especially relevant in this debate because they have an impact on the welfare of society. Most importantly, research and analysis about socio-technical systems and their role in values, like privacy, while they are at the design stage, should be conducted.

FUTURE OF SOFTWARE ENGINEERING

In an article written in 2001 for the American Society for Quality by John Cusick, a software expert, a prediction has been made that software engineering would remain useful in the future if those in the field were able to engage with the design of large-scale systems, were able to tackle complexity, enable communication and organization, and manage software evolution. In addition, software engineering was to be able to assist engineers and teams obtain objectives efficiently, and also arrive at solutions which were effective [25].

Scaling Out

According to Poppendieck, software engineering in the next decade will continue to experience scaling out, a phenomenon where scaling up is no longer possible [26]. Google's sheer growth in the 2000's meant that it could not continue scaling up, but resorted to multiple servers to meet increased traffic. In layman's terms, it is more practical to get two people to lift a heavier load than trying to get a large person to lift the same load. In addition, the researcher noted that platforms would continue to be a disruptive power. Companies such as YouTube, AirBnB, and Spotify, create an environment in which people are able to connect together and have transactions [26].

Engaging with Critical Issues

Alan Perlis, the first recipient of the Turin Award, described the relationship between computers and humans as one of a youth in endless puberty but constantly growing out of his clothes [27]. Our lives are heavily influenced and interfered by software, and though the discipline of software engineering is quite new, society has been seen to be maturing. In one sense, the time has come to engage in a discussion about critical issues like security, privacy, dependability, and affordability.

All these are crucial subjects because they are with society every day. For example, software flaws are wasting taxpayer money, emergency call centers to be unreachable, malfunctions in planes and cars, theft of credit card data, and the closure of airspaces. In addition, smart objects can be used for nefarious purposes to disrupt normal day to day activity of people [27]. However, as the researcher argue, there is a lot of reason to be optimistic about the future of software engineering.

In relation to software analytics, it is speculated that the past focused on reporting and modeling, the present focuses on alerting and recommending, while the future will extrapolate and predict [28]. In essence, the future of software engineering will allow decision making which is data driven, better software artifacts will be developed using logic based tools, and the future will witness challenges posed by new platforms.

CONCLUSION

The future of computing and industries that use computing-based equipment, in general, is largely based on software written to make them work. The software-intensive systems, in general, are an integral part of human civilization and will continue to do so in the future. Computing products are an essential part of human lives, and humans are more and more interacting and using these devices in their daily routine. The success of these devices is based on the software on which the devices operates and in effect contribute to the general acceptability and success of these devices. There have been several major and distinctive methodologies used in the past and also currently to build such software systems.

The future with technologies like Industry 4.0 and IoT still needs software for its successful operation. With newer technologies that may come up in the future and the nature of such systems that is being built continues to change, it is important to attend to the not just the technical elements of software development, but also the general effect of such technologies on society as a whole.

The future of software engineering is to be controlled and manipulated by upcoming generations, and some certain pro-action and determination are needed to adapt towards the successful implementation.

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The effect of a high alumina silica waste material on the engineering properties of a cement-stabilised soft soil

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Abstract

In many parts of the world, soft soils are unsuitable for civil engineering projects because they lose dimensional stability and strength. Thus, such soils will be either replaced by another material, which complies with the specified requirements, or improved by stabilisation, which is a common practice nowadays .Soil stabilisation can be achieved either mechanically or chemically. It has traditionally relied on treatment with lime, cement, and special additives such as pozzolanic materials. For the purpose of reducing the cost, cutting CO_2 emissions and minimizing the pressure on landfill, several studies have focused on finding alternatives that can be used as a replacement to cement such as sustainable waste materials. This paper represents an experimental investigation of the stabilisation of a silty clayey soil using new alumina-silica waste material (HASW), which has excellent pozzolanic properties and is produced as a waste from oil industries and refineries. The influence of HASW on the physical and engineering properties of the selected soil has been studied by conducting Atterberg limits, compaction parameters and unconfined compressive strength testing after 7 days curing. Different percentages of HASW were added (1.5, 3, 4.5 and 6 %), by the dry weight of the soft soil, combined with only 3% of ordinary Portland cement (OPC) to produce various admixtures. The results indicated the HASW has a positive impact on the engineering and physical properties of soft soil. Additionally, it can be recommended that addition 3% OPC and 6% HASW is the optimum amount since it reduced the plasticity index (PI), reduced the maximum dry density (MDD) and increased the optimum moisture content (OMC), thus improving the compressive strength within 7 days curing.

Keywords: HASW, physical properties and soft soil stabilisation.

Introduction

Soil is the oldest material used in the construction due to its wide spread availability, low cost and easy workability. However, many soils, particularly soft clayey soils, are unsuitable for the construction requirements because they loss dimensional stability and strength. Thus, such soils will be either replaced by another material which complies with the specified requirements, or the properties of the existing soil improved by stabilisation, which is a common practice nowadays, so as to fulfil the design criteria (Cristelo et al., 2013). Therefore, soil stabilisation is the process of changing some properties of soil either chemically or mechanically so as the improved soil could be produced with all the desired engineering properties. The main aim of soil stabilisation is to increase the durability, the strength, and to prevent the formation of dust and erosion in soils (Sen and Kashyap, 2012). Additionally, soil stabilisation has a history which reaches 5000 years into the past, in the area of building practice (Ingles, 1978). It has often been used even in ages, places where engineering skill has been minimal such as in lime-stabilised floors of Saxon England, or the straw, and blood stabilised mud houses of West Africa (Chmeisse, 1992). Traditionally, lime and Ordinary Portland cement (OPC) were the oldest materials used in the stabilisation of soft soils as primary binders. The ability of lime and OPC to hold the soil particles together forming a strong structure is what makes them the preferred option in soil stabilisation as corroborated by many research projects and publications (Farouk and Shahien, 2013; Modarres and Nosoudy, 2015 ; Jafer et al., 2016b). However, these materials are occasionally mixed with pozzolanic materials which are rich in silica (SiO_2).

For many years, the ground stabilisation using Ordinary Portland cement is the worldwide method for earth structural works. This is because it can modify the physical properties of treated soils such as the Atterberg limits and particle size distribution. Moreover, it can improve the geotechnical properties of soil such as the swell-shrink stress resistance and strength (Jauberthie et al., 2010; Yi et al., 2015; Vakili et al., 2016; Horpibulsuk, 2017). However, there are many issues related to the utilisation of cement, for example the environmental and economic drawbacks. The cost of OPC has rapidly increased due to the rise in the energy costs. Additionally, it has been found that every ton of OPC manufactured emits about one ton of CO2 in to the atmosphere (Aprianti et al., 2015). Moreover, the dust and Sulphur dioxide (SO_2) aerosol emissions released from the manufacturing plants can pose severe health problems such as long-term respiratory diseases. Moreover, SO2 contributes primarily in the transboundary contamination via acid rain. Furthermore, heavy metals including lead, that present within the raw materials and fuels of cement manufacturing, can be toxic at high concentrations (Bye, 2011). Hence, all of these issues could make it non-friendly and inappropriate for sustainable development. Therefore, several studies have focused on finding alternative materials to reduce the use of OPC. These materials are often called supplementary cementitious materials (SCMs) which have pozzolanic properties. Although, these materials do not have any cementitious properties, they could form cementitious compounds when mixed with cement (National Ready Mix Concrete Association, 2000).

Supplementary cementitious materials (SCMs), such as silica fume (SF), rice husk ash (RHA), palm oil fly ash (POFA), pulverized fuel ash (PFA), ground granulated blast furnace slag (GGBS) ,etc. , have been used by many researchers (Brooks, 2010; Ahmed et al.,2011; Manso et al., 2013; Fattah et al., 2014; Modarres and Nosoudy, 2015; Jafar et al., 2015; Ozdemir, 2016; Hossain and Mol,2014; Roy,2014) . These materials have been used to raise the formation of calcium aluminate hydrated (C-A-H) or calcium silicate hydrated (C-S-H) which are called the cementitious gel, and which are responsible for improving the strength of stabilised soil (Modarres and Nosoudy, 2015). Lin et al. (2007) indicated that the fineness and the specific surface area of these materials are dominant in developing the engineering and physical properties of soft soils since they are the reason behind increasing the density and decreasing the cohesion of soft soils.

One of the SCMs that have been used in recent years is HASW which is an inorganic material produced as a waste from the oil industries and refineries. This waste material is rich in alumina and silica so it has excellent pozzolanic properties. It has been used in the production of alkali-activated binders (Tashima et al., 2014), the preparation of geo polymers (Mas et al., 2016), and have been combined to develop a new cold asphalt binder course bituminous emulsion mixture (Dulaimi et al., 2017). Additionally, many studies indicated that using this material in the concrete and Portland cement mortar helped in improving the mechanical properties and durability of these materials (Chen et al., 2004; Soriano et al., 2013).

In this study, HASW was used for the first time in the stabilisation of a soft silty-clayey soil .The improvement in the physical and geotechnical properties of the soft soil were assessed according to Atterberg limits, compaction parameters and unconfined compressive strength test results. A fixed and small amount of OPC was used (3 % by the dry weight of the soil), and then varying percentages of HASW were added (1.5%, 3%, 4.5% and 6%) combined with the 3% cement to produce various admixtures. The effect of this waste material on the soft clayey soil was largely evaluated dependant on the results of UCS testing, which were obtained from samples subjected to 0 and 7 days of curing at ambient temperature. The use of this material in soil stabilisation will benefit the environment, as it will reduce the amount of cement utilised along with the disposal of waste.

Materials and methodology

1.1 Soil sample

In this study, the soft soil was collected from the riverbank of the River Alt estuary, which is located in Hightown to the north of Liverpool. The soil samples were taken from a depth approximately (0.3 -0.5 m) below the ground level and placed in plastic bags each about 20 -25 kg, then sealed and sent to the laboratory. As soon as the samples arrived to the laboratory, the natural moisture content was calculated according to BS EN ISO 17892-1:2014 (European Committee for Standardization, 2014) by taking a suitable specimen from the soil. Further samples of soil were dried in an oven at 110˚C to be used in the remaining experiments. In addition, the soil was classified using particle size distribution and the consistency limits tests. The particle size distribution testing was conducted in accordance to BS EN ISO 17892-4:2014, and the Atterberg limits testing in accordance to BS 1377-2:1990 (British Standard, 1996). Other physical and geotechnical properties of the virgin soft soil such as compaction parameters and unconfined compressive strength tests were then carried out. Additionally, some of the chemical properties of the soft soil such as pH were specified by conducting a chemical analysis. Table (1) below illustrates the main engineering properties of the virgin soil that was used in this research. It was found from the classification of soil that it contained 12.9% clay 12.07 % sand and 75.03% silt. While the result of consistency limits were 39 % Liquid Limit, 20.51 % Plastic Limit and 18.49 % Plasticity Index. Hence, according to the results of particle size distribution, Atterberg limits, and the Unified Soil Classification System (USCS), the soil used in this study was classified as an intermediate plasticity silty clay with sand (CI).

Table 1. Main physical and engineering properties of the soft soil

Properties	**Value**
Natural Moisture Content NMC %	37.5
Liquid Limit LL %	39
Plasticity Index PI %	18.49
Sand %	12.07
Silt %	75.03
Clay %	12.9
Specific Gravity (Gs)	2.67
γ d max Mg/cm³	1.63
Optimum moisture content OMC %	20.50
pH	7.78
Organic Matter Content %	7.95
Unconfined Compressive Strength qu (kPa)	249.842

1.2 Binder materials

Two types of binders were utilised in this research which are traditional stabiliser represented by the Ordinary Portland Cement (OPC), and HASW. In terms of OPC, a commercial cement type CEM-II/A/LL 32.5-N was used, and was supplied by Cemex quality department, Warwickshire, UK. While HASW was for the first time used in soil stabilisation and was utilised with different percentages ranging from (1.5 – 6 %) by the dry weight of the soft soil. Table (2) illustrates the chemical analysis, which was conducted by energy dispersive X-ray fluorescence (EDXRF) for both OPC and HASW. It can observed from Table (2) that OPC contains 65.21 % CaO and 24.56% SiO_2, while HASW contains 44.167 % and 35.455% of aluminium and silicon oxides, respectively.

Table 2. Main chemical properties of the binder materials used in this study

Material	CaO%	SiO_2%	Al_2O_3%	Fe_2O_3%	MgO%	K_2O %	SO_3 %	Na_2O %
OPC	65.21	24.56	1.7	1.64	1.3	0.82	2.62	1.34
HASW	0.047	35.452	44.167	0.368	0.684	0.049	0	0

2. Laboratory Work and Experiments

2.1 Sample preparation and conditioning

Once the soft soil is dried, it is crushed to break down any large pieces agglomerated and then prepared for the Atterberg limits and compaction parameters tests. Different percentages of binder were used which ranging from 3% OPC only to 3% OPC combined with (1.5, 3, 4.5 and 6 %) HASW by the dry weight of the treated soil. The UCS testing was then conducted. A constant volume mould was used for preparing UCS specimens which was subjected to a static load provided by a manual hydraulic jack as depicted in Figure 1 below. Following this, the specimens were forced out the mould, weighted, then covered in cling film, sealed in well-sealed plastic bags, and stored in the room at temperature of 20 ± 2˚ C for curing. According to the standard requirements, the specimens were pressed in the mould which was 38 mm in diameter and 76 mm in height. Additionally, these specimens were produced with specific densities according to the corresponding maximum dry density (MDD) and the optimum moisture content (OMC) which were obtained from compaction testing for each type of binder utilised. The treated soil specimens were cured for 7 days before they were subjected to UCS test. UCS testing was carried out by using a computerised triaxial machine and the results of UCS were obtained by applying only vertical load and removing any horizontal stress in the triaxial cell (i.e. $\sigma 3 = 0$).

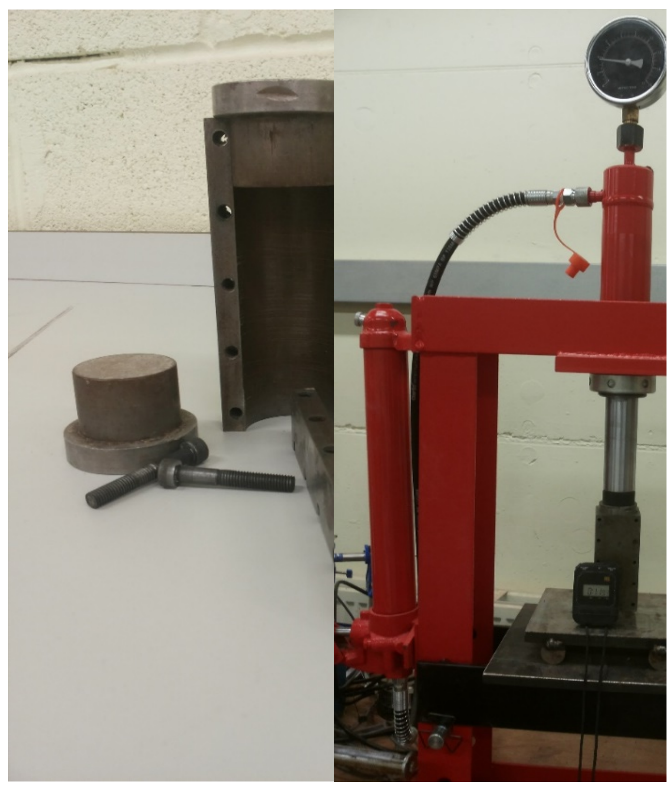

Figure 1. Fixed volume mould and the hydraulic jack used in this study

2.2 Laboratory Experiments

The influence of binder materials on the physical and engineering properties of the soft soil was determined by conducting three principle tests which were:

- Atterberg limits tests including Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI).These limits were carried out according to BS 1377-2:1990 (British Standard, 1996). A cone penetrometer device was used for calculating the LL as it is the preferred method in the British standard. It relies on the penetration measurements, which were taken by penetrating a standardized cone into the specified mass of soft soil. For Plastic Limits testing, the soft soil is rolled out until its diameter becomes about 3mm in which case the soil crumbles, and at this stage, a sample is taken for measuring the moisture content. This test is usually conducted along with the Liquid Limit test.
- Standard Proctor compaction test: this test was conducted in accordance to BS 1377-4:1990 (British Standard, 2002) to find the maximum dry density and the corresponding optimum moisture content. A suitable amount of water, which is suggested by the BS based on soil type, was added to 2000 g of dry powdered soil. The soil then was mixed properly and compacted in a standard mould using a 2.5 kg hammer with three layers; each layer was subjected to 25 blows. A sample for moisture content measurements was taken. After that, the soil was crumbled and remixed with a 3% increment of water, and the same tests repeated, thus at least five compactions were made.
- Unconfined compressive strength test: this test was conducted according to BS 1377-7:1990 (British Standard, 1994). Two groups of specimens were prepared for two different curing periods (0 and 7 days), and for more reliable results, for each corresponding period of curing, two specimens were prepared for each percentage of HASW.

Results and Discussion

2.3 Atterberg Limits

The influence of adding 3% OPC and then 3% OPC combined with various percentages of HASW (1.5 ,3,4.5 and 6%) by the dry weight of the treated soil , on the consistency limits is shown in Figure 2. It can be noticed that both the LL and PL increased with 3% OPC treatment and then continued to increase with adding different percentages of HASW. However, the increase in PL is more than that for LL, and this resulted in decreasing the value of PI (since PI = LL - PL). Moreover, it can be observed that there is a significant decrease in PI for soil treated with 3% OPC and the decrease was highly noticeable for soil treated with 3% OPC combined with 1.5 % HASW. The value of PI continued to decline gradually for the soil treated with 3%, 4.5 % and 6% HASW. It can be seen from Table 3 that the PI reduced sharply from 18.49 for the virgin soil (VS) to 15.25 for the soil treated with 3% OPC. Also, it can be noticed that PI was significantly reduced to 8.53 for the soil treated with 3% OPC combined with 6% HASW. This reduction in PI value denotes the improvement in soil properties. In addition, a similar behaviour was noticed in previous research studies on soft clayey soils stabilised with rice husk ash, lime, fly ash, and cement (Bash, 2005; CHOOBBASTI et al., 2010; Jafer et al., 2015; Jafer et al., 2016). The process of cations exchange between HASW, OPC, and the clay minerals in the soft soil could be the reason behind the changes in the consistency limits.

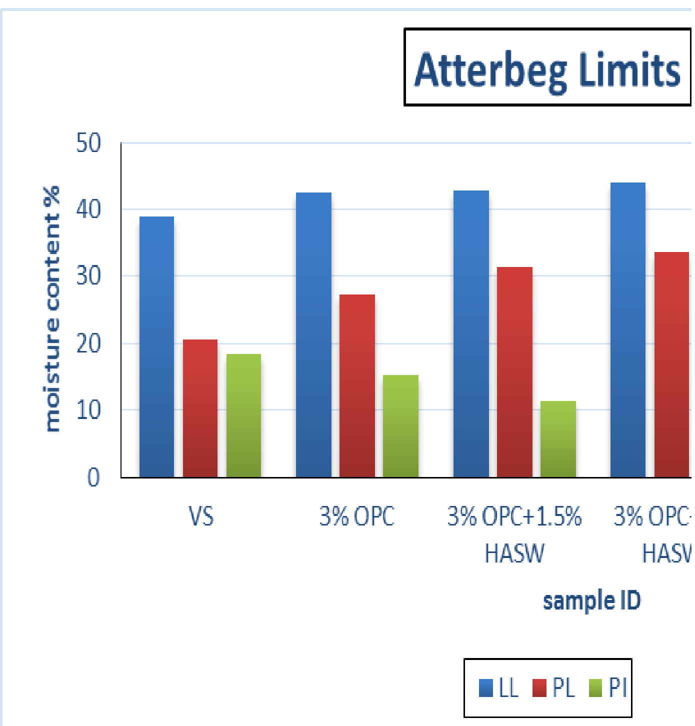

Figure 2. Atterberg limits after OPC and HASW treatment

Table 3. Atterberg Limits results for virgin soil and after the treatment with cement and HASW

Item	LL	PL	PI
VS	39		
3% OPC	42.64		
3% OPC+1.5% HASW	42.8		
3% OPC+3% HASW	44		
3% OPC+4.5% HASW	44.3		
3% OPC+6% HASW	43.9		

4.2 Compaction Parameters Test

This test was carried out to determine the OMC and MDD for untreated soil and for the soil treated with various percentages of HASW material. The importance of finding the MDD and OMC comes from their contribution in preparing the specimens required for other geotechnical experiments such as UCS, swelling potential, California Bearing Ratio, compressibility, and triaxial tests. The effect of adding 3% OPC and 3% OPC combined with various percentages of HASW on the compaction characteristics of the tested soft soil has been presented in Figure 3 below. The Figure shows that the addition of OPC and HASW decreased the amount of MDD and increased the OMC with increasing percentages of HASW. Hence, the results demonstrated that the MDD decreased slightly from 1.61 Mg/cm^3 to 1.59 Mg/cm^3 for the cement - stabilised soil after adding 1.5% and 6% HASW, respectively. However, the OMC increased from 22.50% for 3% OPC and 1.5 % HASW stabilised soil to 23.00% for the soil treated with 3% OPC combined with 3% and 4.5% HASW, respectively. The OMC then increased to 23.50% for the cement - stabilised soil after adding 6% HASW. Similar behaviour was also observed for soft clayey soil stabilised with lime, fly ash, rice husk ash, and volcanic ash by previous researchers (Rahman, 1986; Senol et al., 2006; Hossain, 2011). The increase in OMC could probably be attributed firstly to cement interaction which could increase the amount of water held by the flocculent of soil structure. Secondly, it could be attributed to the elevated water absorption by HASW material as a result of its porous properties. Principally, the characteristics of proctor test are based on specific gravities and grain size distribution of both the stabiliser and soil (Hossain and Mol, 2011). Despite the fact that the increase in the dry density reflects the improvement in soil properties, both cement and HASW material decrease the dry density. Reducing the dry density decreases the cost of compaction and make it economical because it reduces the compactive energy that is required to obtain its MDD (Basha, 2005).

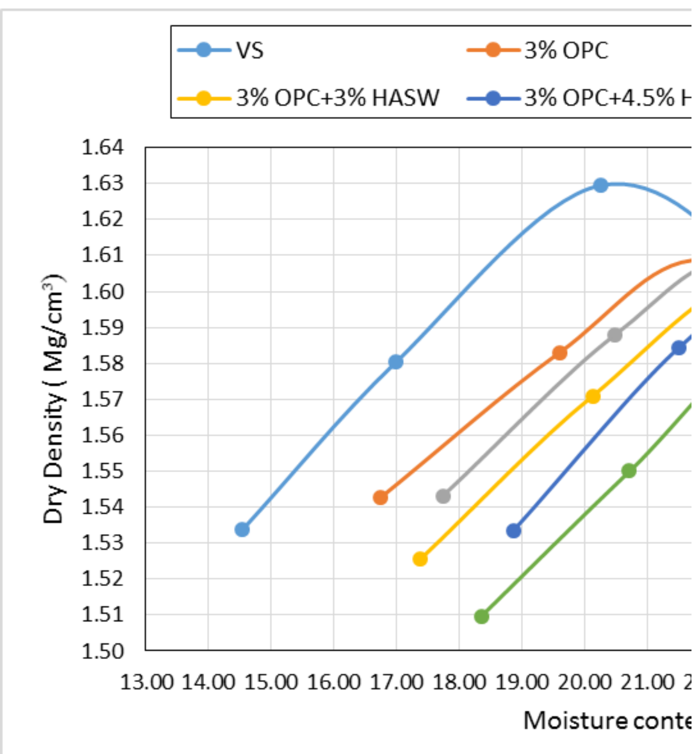

Figure 3. Compaction parameters of the cement-stabilised soil after HASW treatment

4.3 Unconfined compressive strength test (UCS)

The stress-strain relationship for the cement-stabilised soil with and without HASW for 7 days curing is illustrated in Figure (4). It can be clearly noticed that after 7 days curing, the compressive strength of the stabilised silty clayey soft soil has significantly developed. It was noticed that the cement is obviously an active stabiliser as only 3% OPC gives UCS of approximately 543.546 kPa compared to about 250 kPa for the virgin soil. Figure (4) also depicts that HASW percentages combined with 3% OPC significantly developed the strength of the tested soil; however, it gives a slight increment in the UCS compared to 3% OPC –stabilised soil. Hence, with raising the percentages of HASW material, the compressive strength of the stabilised soil increased slightly from 565.711 kPa to 645.775 kPa for the cement - stabilised soil after adding 1.5 % and 6% HASW by the dry weight of soft soil, respectively.

From Figure (5), it can be recognised that the cement- stabilised soil treated with 4.5% HASW shows a noticeable increase in the compressive strength at seven days curing where the UCS elevated from 250 kPa for untreated soil to 642.174 kPa. The compressive strength developed further with 6% HASW treatment as it raised to 645.775 kPa. Meanwhile, the tested soil stabilised with other percentages of HASW gave compressive strengths close to each other ranging from 543.546 kPa to 609.100 kPa. Therefore, it can be identified from

Figure (5) that the optimum combination is 3% OPC mixed with 6% HASW which also satisfied the consistency limits. This behaviour can be attributed to the pozzolanic reaction of HASW with the cement .Since HASW contains high content of alumina and silica, which reacted with cement and resulted in increasing the configuration of cementitious products, the compressive strength of the tested soil increased. In this way, the cement - stabilised soil can be produced by using only a small amount of cement and this would result in reducing the construction costs since cement is more expensive compared with HASW, as well as reducing the environmental issues.

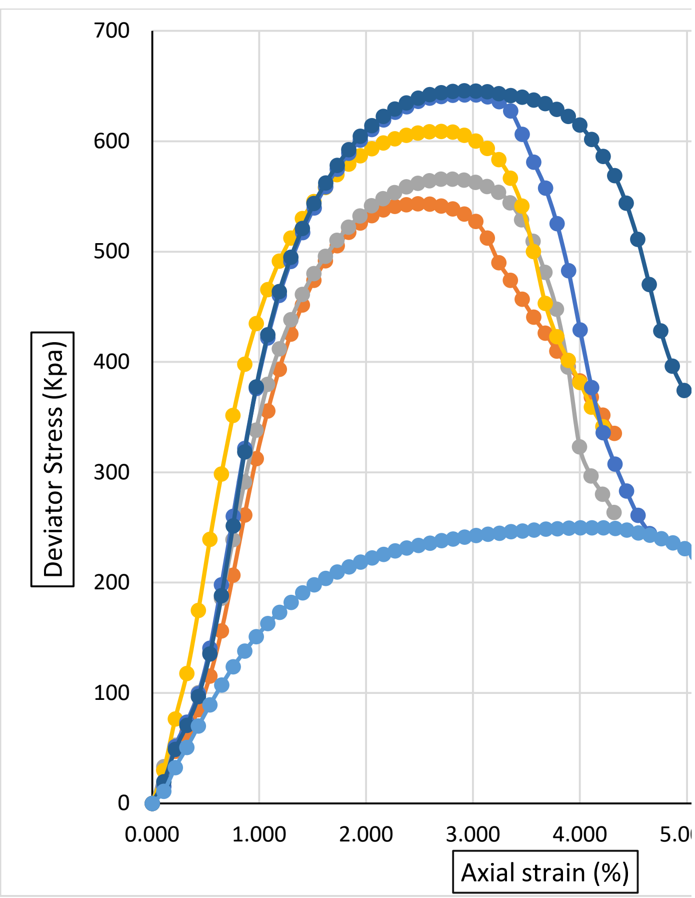

Figure 4. Stress-strain diagrams of the UCS test for the cement-stabilised soil after HASW treatment.

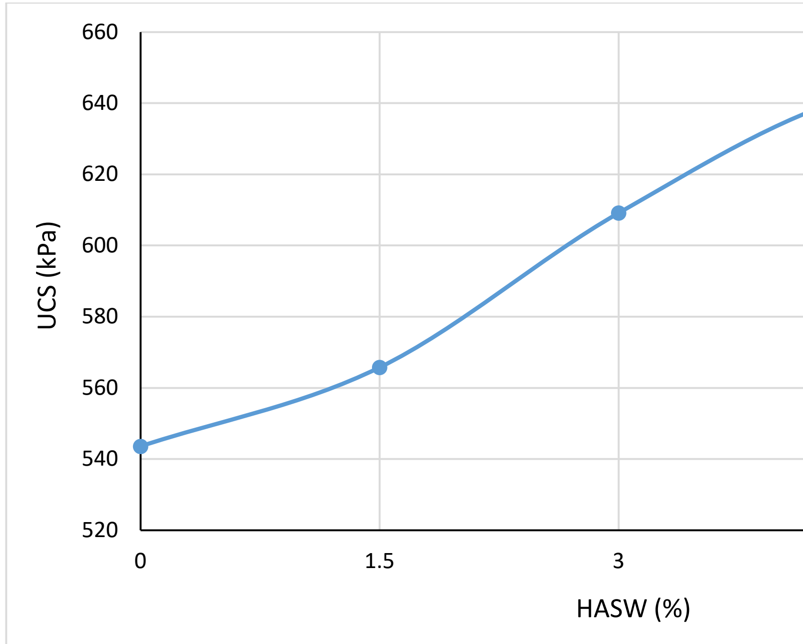

Figure 5. Effect of HASW on strength development of soil treated with 3% OPC at 7 days of curing

5. Conclusion

In this study, various percentages of HASW have been mixed with only 3% OPC to study their effect on different characteristics of the silty clayey soil such as Atterberg limits, compaction parameters and unconfined compressive strength. The results of this investigation are:

- The use of HASW have a positive effect on the results of the Atterberg limits as it reduces the plasticity index (PI) .The results showed that with the use of 3% OPC combined 6% HASW , the PI reduced from 18.49% for virgin soil to 8.53% .

- Additionally, MDD decreased and OMC increased with the increase of HASW, which would reduce the cost of compaction and make it economical because it reduces the required compactive energy to obtain its MDD.
- The HASW developed the unconfined compressive strength of the silty clayey soft soil as it increased from 250kPa for untreated soil to 645.775kPa with 6% HASW after 7 days curing. Thus, 3% OPC and 6% HASW is the best combination to achieve the required strength and it is expected that this strength would have developed further after 28 days curing. Therefore, it can be concluded that using HASW in soil stabilisation has the ability to develop its physical and engineering properties during short periods of curing. In addition, it would be less expensive than cement and more environmentally friendly.

Future Work

As the results of UCS test presented in this paper were for 7 days curing, the compressive strength of stabilised soil at 28 days of curing will be covered in the future. Moreover, the effect of HASW on the compressibility of the cement-treated soil will be investigated along with the microstructural study using the scanning electronic microscopy (SEM) technique as future works.

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Influence of electrodes spacing on internal temperature of electrocoagulation (EC) cells during the removal (Fe II) from drinking water

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Abstract

The electrocoagulation (EC) method, which is in situ generation of coagulating ions by applying direct electrical current to metallic electrodes, has recently been applied to remove a wide spectrum of pollutants from waters and wastewaters. However, its efficiency is highly influenced by key operational parameters such as electrolysis time and current density. Therefore, the current investigation has been carried out to explore the influence of electrodes spacing on the performance of EC method in terms of internal temperature iron removal from drinking water.

To achieve the planned target, iron containing synthetic water samples were electrolysed, for 25 min, using a flow column electrocoagulation reactor (FCER), at three different distances between electrodes (5, 10, and 20 mm). The progression of temperature of water being treated was measured at 5 minutes intervals over a 25 minutes period. These batch experiments were commenced at a constant current density of 1.5 mA/cm^2 and initial pH of 6.

The results obtained showed that the amount of produced heat is directly proportional to the DBE, where it has been noticed that the water temperature increased by about 9% as the distance between electrodes increased from 5 to 20 mm, respectively.

Keywords — Iron removal, energy consumption, flow column, electrocoagulation.

Introduction

During the last few decades different methods have been practiced to treat drinking water, such as chemical precipitation (Toyoda and Taira, 2000), biological treatment (Alattabi *et al.*, 2016), membrane separation (Ndiaye *et al.*, 2005), and electrocoagulation (EC) (Tezcan Un *et al.*, 2013; Hashim *et al.*, 2017a). However, recent studies have demonstrated that the EC method is an attractive alternative for traditional treatment processes, as it does not require chemical handling, is easy to perform, produces fewer total dissolved solids, and remarkably reduces the sludge volume (Mollah *et al.*, 2001; Zhu *et al.*, 2007; Emamjomeh and Sivakumar, 2009; Hashim *et al.*, 2017c).

This method has been practiced during the last century to treat different pollutants such as iron (Amrose *et al.*, 2013; Hashim *et al.*, 2017c), fluoride (Zhu *et al.*, 2007; Hashim *et al.*, 2017a), organic matter (Vepsäläinen *et al.*, 2012), dye (Amani-Ghadim *et al.*, 2013), crystal violet (Durango-Usuga *et al.*, 2010), nitrate (Yehya *et al.*, 2014; Hashim *et al.*, 2017b), arsenic (Kobya *et al.*, 2011), and water hardness (Malakootian *et al.*, 2010). However, the efficiency of this method is very sensitive to several operating parameters such as the initial pH of solution, current density, solution chemistry, and solution conductivity (Mollah *et al.*, 2001; Zhao *et al.*, 2009; Hashim *et al.*, 2016b; Hashim *et al.*, 2016a).

Therefore, some researchers investigated the influence of some key parameters on the performance of the EC method. For instance, the effect of co-existing anions on fluoride removal in the EC method was investigated by Hu *et al.* (2003). Irdemez *et al.* (2006a) studied the influence of pH on both energy consumption and phosphate removal using iron electrodes. Similarly, the influence of current density on phosphate removal using either iron or aluminium electrodes was explored in another study by Irdemez *et al.* (2006b). Additionally, Wan *et al.* (2011) investigated the influence of water chemistry on the removal of arsenic from drinking water.

Thus, the present project has been devoted to investigate the effect of distance between electrodes (DBE) on the temperature of water being treated. The internal temperature of EC cells has been investigated as it plays an essential role in the electrocoagulation processes, where it not only significantly influences the solubility of the precipitates, but also influences the production rate of hydroxyl radicals, and dissolving of electrodes, and consequently the removal efficiency (Vepsäläinen *et al.*, 2009; Chou and Huang, 2009; Hashim *et al.*, 2015). A new electrocoagulation reactor (FCER), which reactor utilises the concept of flow columns to enhance the performance of EC reactors, has been used in current study to explore the influence of the DBE on water temperature in the EC method.

Materials and methods

The batch electrocoagulation experiments were commenced using a new bench-scale EC reactor (FCER) having a total volume of 2.16 L (Figure 1). FCER consists of a Perspex container with a radius of 5.25 cm that contains a flow column. The flow column consists of three PVC rods, spacers, and perforated discoid electrodes that made from aluminium. More details about the FCER are mentioned by Hashim *et al.* (2017b); Hashim *et al.* (2015). This reactor was supplied with a rectifier (HQ Power; Model: PS 3010, 0-10 A, 0–30 V) to generate the required electrical current.

The impact of DBE on the internal temperature of the EC unit was explored using 20 mg/L iron containing synthetic water samples. These samples were prepared by dissolving the required amount of $FeSO_4 \cdot 7H_2O$ in deionised water. The initial pH of these synthetic samples was adjusted at 6 using a proper amount of 1 M

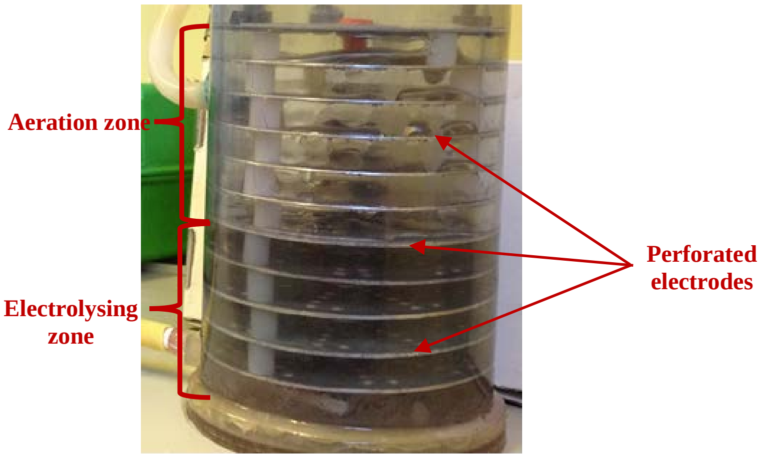

Figure 1: the new reactor FCER.

HCl or 1 M NaOH solutions, while the conductivity of these samples was adjusted to 320 µS/cm using the required amount of NaCl. All experiments were commenced at an initial temperature of 20 ^{0}C, which controlled using water bath (Nickel-Electro: Clifton).

It is noteworthy to highlight that all chemicals were supplied by Sigma Aldrich and used as supplied.

The prepared samples were electrolysed for 25 min at different DBEs (5, 10, and 20 mm) at a constant current density of 1.5 mA/cm^2, and initial pH of 6. The progress of water temperature removal was monitored by collecting 10 mL samples periodically from the reactor over the course of the treatment process. Then, the temperature of the collected samples was using a Hanna device (Model: HI 98130). After each run, the electrodes were washed with HCl and then rinsed with deionised water.

The percentage of the increase in water temperature (T %) was calculated as follows:

$$T\,\% = \frac{T_0 - T_t}{T_o} \times 100\% \qquad (1)$$

Where, T_0 is the initial water temperature, and T_t is temperature of water at any time during the course of the treatment process, in ^{0}C, respectively.

Results and Discussion

Ohmic heating, which is known as Joule heating, is the phenomenon of heat generation in a conductor due to the flow of current, and the amount of the produced heat is in proportion to the magnitude of both current and electrical resistance (Alwis and Fryer, 1990). The amount of generated heat can be determined according to the flowing equation (Castro, 2007):

$$Q = R \,.\, I^2 \qquad (2)$$

where Q is the generated heat (J/sec), R is the electrical resistance (ohm), and I is the applied current (Amber).

Therefore, the DBE plays a key role in temperature generation within solution being treated as it significantly influences the electrical resistance (Eq.3) (Ghosh *et al.*, 2008), and consequently the water temperature. Where, the relation between the ohmic potential drop and the DBE could be explained by the following equation (Ghosh *et al.*, 2008):

$$IR = I.\frac{d}{A.k} \qquad (3)$$

Where IR is the ohmic potential drop, I is the applied current (A), d is the DBE (m), A is the active surface area of the anode (m^2), and k is specific conductivity (μS/m).

In order to investigate the influence of DBE on heat generation inside FCER, water samples with an iron concentration of 20 mg/L were electrolysed for 25 min at different DBEs (5, 10, and 20 mm). The applied current density was kept constant at 1.5 mA/cm^2 during the course of experiments.

As seen in Figure 4, the amount of produced heat is directly proportional to the DBE. Where it has been noticed that the water temperature increased from 20.2 ^{0}C at DBE of 5mm to 22 ^{0}C at DBE of 20 mm after

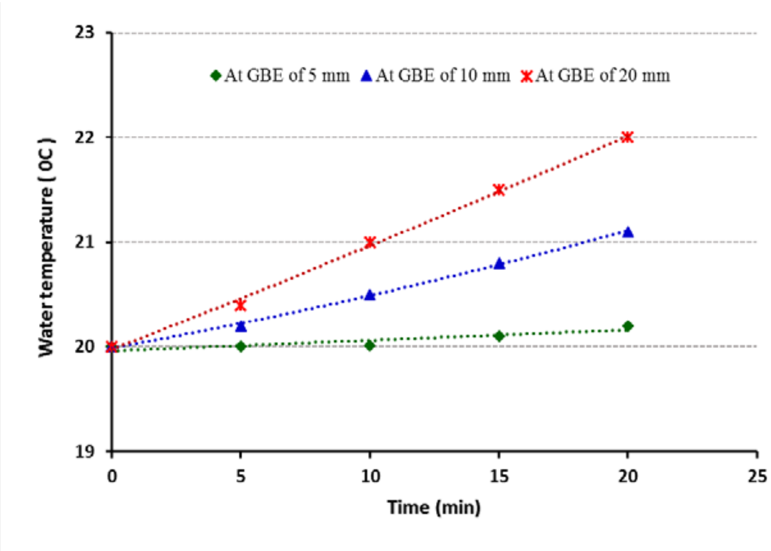

Figure 4: Influence of DBE on water temperature.

25 min of electrolysing. Hence, the lowest value of the studied DBEs can ensure a virtually stable temperature level during the course of the electrolysing process.

Conclusion

The results obtained from the current projects highlights that the performance of the EC method could be significantly enhanced by optimising the distance between electrodes, as the latter caverns both the electrodes dissolving rate and water temperature. Additionally, optimising the distance between electrodes can significantly minimising the energy consumption of the EC units, which in turn minimising the operating cost of this method.

Therefore, in the current investigation, DBE of 5 mm was found to be very effective for the removal of iron from water.

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Analysing the Critical Risk Factors of Oil and Gas Pipeline Projects in Iraq

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ABSTRACT

Purpose- Oil and Gas Pipelines (OGPs) are the safest mode of transportation for petroleum products. Yet, OGPs are facing a massive range of safety, design and operational risks such as sabotage, design defects, corrosion, material ageing, poor quality, misuse and geological disasters. These risks have resulted in OGP project management becoming more challenging and complex, particularly in developing countries with poor security systems. Additionally, there are two significant problems associated with OGP projects in these countries. The first is the different characteristics of risk factors, and the second is the real shortage of historical data required for any risk evaluation study. These problems mean that the currently accessible risk evolution methods cannot evaluate OGPs risk factors accurately. This paper aims to provide a proper understanding of the characteristics of OGPs risk factors in these countries. It also aims to identify the critical risk factors and their degree of probability and severity in pipeline projects, to avoid the loss of life and increased costs that result from risks to safety.

Methodology- A quantitative research approach is adopted in this paper. Additionally, an industry survey was conducted by using a semi-structured questionnaire. The questionnaire was distributed online amongst the people who are associated with OGP projects in Iraq. SPSS 23 was used to analyse a total of 180 successful questionnaire responses. The survey findings in terms of critical risk factors and their ranking in order of risk index of severity and probability are presented in tables and graphs.

Findings- A total of 30 risk factors associated with OGP projects have been identified as critical risk factors and ranked them into a scale of probability and severity index. Third-party disruption (such as terrorism, theft and sabotage) was found to be the most critical safety risk factor whereas the failure form pipe corrosion was ranked the top most operational risk.

Implications- The list of OPG critical safety and operational risk factors provides the first-stage findings. These findings will be implemented to develop a conceptual framework and a computer-based model for OGPs risk management system at the next stage of the research.

Keywords: *Oil and gas pipelines; risk factors; probability; severity; risk management; safety risk; operational risks and terrorism and sabotage.*

1. Introduction

Oil and gas pipelines (OGPs) are some of the most important and significant critical infrastructures for any country because they are the safest and most economical mode of transportation for petroleum products. However, the number of accidents and the vast range of problems associated with them have severe consequences for the pipelines (Cunha, 2016). Compared to safe countries, pipeline disruption is a cause for concern in developing countries with low levels of security because of internal wars and terrorist organisations. This hazardous environment often results in malicious terrorist attacks on OGPs and makes their risk management more challenging and complex. The main risk factors for a long-distance OGPs include the following four factors: third-party disruption (TPD), misuse, corrosion damage and design flaws (Guo *et al*., 2016). The term 'third-party role' refers to pipelines being accidentally damaged by employees, natural phenomena such as soil movement (landslides, mudslides, foundation collapse and floods), and surface load (caused by blasting construction, illegal buildings compressing pipelines and ground live loads) (Peng *et al*., 2016). Similarly, Muhlbauer (2004) has defined TPD as any direct or indirect action against the infrastructure that is taken individually or by a group in order to obstruct the functionality of the infrastructures system. In this study, TPD refers to all individuals, organisations and mechanical tools that cause expected and/or accidental damage to the pipelines during different project stages. Consequently, proper attention needs to be given to pipeline disruption problems, because neglecting this critical issue has resulted in the disruption of business activity, grave casualties, the expenditure of time and efforts, and economic losses in the oil and gas industry.

Preventing or preparing for something unexpected is almost impossible since nobody knows when or how a crisis will occur, or what will be affected by it (Labaka *et al.*, 2016). Pipeline failures cannot be entirely avoided. Nevertheless, an appropriate and accurate risk evaluation method can contribute in providing reasonable and effectual risk management measures to reduce the overall risk of failure (Guo *et al.*, 2016). For that reason, adequate facilities like 'risk registration' and 'risk assessment' are essential for the risk factor analysis procedure (Whipple and Pitblado, 2009). Evidently, historical records are a valuable information source for risk management studies (Ruijsscher, 2016). Unfortunately, the above-mentioned necessary facilities and databases are not available in developing countries, especially troubled ones, which is making it more challenging and demanding to obtain accurate risk evaluation methods for OGPs risk evaluation.

Rest of the paper is organised as follows. Problem statement, objective of the paper, literature review, methodology with questionnaire survey, results, discussion of survey results followed by conclusion and discussion.

2. PROBLEM STATEMENT

Dealing with OGPs risk factors as the most severe risks is resulting in a great deal of wasteful expenditure and effort (Srivastava and Gupta, 2010). In addition, risk analysis requires a proper knowledge-base and database (Prochazkova, 2010) and real-time data (Balfe *et al.*, 2014) which can provide a verified level of input in the successful development of a risk registry. Risk registers should contain all analysed risks in order to prioritise the areas that require managerial attention and present the risk management profile (Filippina and Dreherb, 2004; Whipple and Pitblado, 2009). Although accurate failure probability and severity values are required, these values are still imprecise, deficient and vague (Khakzad *et al.*, 2011). The probability of TPD risk factors and the similar failure model cannot be calculated by using currently available analytical methods because the historical failure data have not been established yet (Peng *et al*., 2016; Ge *et al*., 2015). Unfortunately, authentic OGPs risk evaluation studies are unachievable as long as the (1) knowledge, (2) essential data, (3) real-time inputs, (4) factor identification facilities and (5) factor probabilities evaluation are not at the required level. These five critical problems are associated with OGP projects in developing and troubled countries and are obstructing risk analysis efforts. Therefore, there is a vital and urgent need for beneficial OGPs risk analytical studies and risk management tools that can identify and rank the OGPs risk factors and contribute to solving these five diagnosed problems.

3. OBJECTIVE OF THE PAPER

This article aims to identify OGPs critical risk factors in countries where pipeline projects are suffering severe consequences from terrorism and sabotage attacks in addition to other risk factors. It also aims to provide a good understating about the characteristics of risk in these countries, and to rank the factors in order of their probability and the severity of their effect on the pipeline. Furthermore, the intention is to provide real input data and to overcome the problem of the shortage of available data. This paper will prepare a table that shows the risk factors and their probability, severity, index and ranking. A risk table that identifies the risk factors and deals with the individual impact of each risk is the first and most fundamental step for any risk evaluation and assessment procedure. This table could help decision-makers, policy-makers and researchers to understand the nature of OGPs risk management in hazardous environments and circumstances. A proper understanding of risk factors can contribute to the adoption of a sustainable risk management strategy during the different stages of OGP projects. Most importantly, accurate results of numerical risk analysis will provide a basis for designing a computer-based model that could be implemented to reduce OGPs risk management challenges and complexity. Iraq is one of a number of troubled, developing countries, and it is the case study in this paper. As this is the first study in the country, it will strongly contribute to the OGP project risk management field in Iraq and in other countries that are in a similar situation.

4. Literature Review

Data about pipeline failures during the project's planning, design, construction, operation and maintenance stages have been examined from different countries around the world in order to identify the critical risk factors associated with OGP projects. This comprehensive data review has been carried out to ensure that the risk factors involved in this research will provide valuable knowledge about OGPs risks in various environments and circumstances. It will also make the research's results suitable for and applicable to many countries and will overcome the crucial problem of the shortage of available data and historical records in developing countries like Iraq. As a summary, Table 1 addresses the most common OGPs risk factors worldwide. This table will be used later on in the research to analyse the risk factors' probability and severity through a quantitative research approach and a questionnaire.

Table 1: Critical risk factors from reviewed articles

Risk Factors	**Author**
Public's low legal and moral awareness	Li *et al.* (2016) and Peng *et al.* (2016).
Socio-political factors such as poverty and education level	Nnadi *et al.* (2014), Mubin and Mubin, (2008), Guo *et al.* (2016), Anifowose *et al.* (2012) and Onuoha, (2008).
Thieves	Nnadi *et al.* (2014) and Onuoha, (2008).
Terrorism and sabotage	Nnadi *et al.* (2014), Mubin and Mubin, (2008), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015), Anifowose *et al.* (2012) and Onuoha, (2008).
Threats to staff (kidnap and/or murder)	Rowland (2011).
Leakage of sensitive information	Srivastava and Gupta (2010) and Wu *et al.* (2015).
Geographical location like 'Hot-Zones'	Srivastava and Gupta (2010).
Conflicts over land ownership	Mather *et al.* (2001) and Macdonald and Cosham (2005).
Accessibility of pipelines	Srivastava and Gupta (2010).
Geological risks like erosion, soil movement and landslides	Mubin and Mubin (2008), Guo *et al.* (2016) and Riegert (2011).

Vehicle accidents	Peng et al. (2016)
Animal accidents	Rowland (2011) and Mubin and Mubin (2008).
Lack of compliance with the safety regulations	Nnadi *et al.* (2014) and Guo *et al.* (2016).
Non-availability of warning signs	Guo *et al.* (2016) and Kabir *et al.* (2015).
Sabotage opportunities arising due to the exposed pipeline, e.g. above-ground pipeline	Rowland (2011).
Lack of regular inspection and proper maintenance	Balfe *et al.* (2014), Nnadi *et al.* (2014), Guo *et al.* (2016), Lu *et al.* (2015), Wu *et al.* (2015) and Anifowose *et al.* (2012).
Inadequate risk management methods	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Natural disasters and weather conditions	Nnadi *et al.* (2014), Mubin and Mubin (2008), Anifowose *et al.* (2012) and Onuoha (2008).
Shortage of high-quality IT services and modern equipment	Nnadi *et al.* (2014) and Mubin and Mubin (2008).
Weak ability to identify and monitor the threats	Nnadi *et al.* (2014)
Corrosion: lack of cathodic protection and anticorrosive coating	Nnadi *et al.* (2014), Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.(* 2015), Wu *et al.* (2015), Riegert, (2011) and Sulaiman and Tan (2014).
Design, construction, material and manufacturing defects	Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015), Wu *et al.* (2015), Riegert (2011) and Sulaiman and Tan (2014).
Operational errors like human errors and equipment failure	Balfe *et al.* (2014), Nnadi *et al.* (2014), Mubin and Mubi, (2008), Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015) and Wu *et al.* (2015).
Hacker attacks on the operating or control system	Srivastava and Gupta (2010).
The law does not apply to saboteurs	Peng *et al.* (2016) and Mubin and Mubin (2008).

Stakeholders are not paying proper attention	Nnadi *et al.*, (2014).
Few researchers are dealing with this problem	Nnadi *et al.* (2014).
Lack of historical records about accidents and lack of risk registration	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Lack of proper training schemes	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Corruption	Nnadi *et al.* (2014).

5. METHODOLOGY

5.1. Questionnaire Survey Development

Because risk factors are characteristically uncertain, vague and random, risk models can accommodate a more personal style of thinking, cognition and processing capability (Guo *et al.*, 2016). This research is engaged with people who are in touch with the OGPs problem and, most importantly, it wants to obtain a consensus view and perception that reflects the reality of OGPs risk factors as far as possible (Sa'idi *et al.*, 2014). A questionnaire survey is utilised because it is one of the most widely used methods for additional data collecting. A semi-structured questionnaire survey was designed and distributed online to OGPs stakeholders in Iraq. The questionnaire has been designed based on the findings of the risk factors' data review (Table 1). The questionnaire's purpose is to evaluate the risk factors' probability and severity based on the real knowledge and expertise of the OGPs stakeholders.

The survey was conducted using the 'SoGoSurvey' website. A snowball sampling technique was used for recruiting respondents from government and private agencies who have relevant experience with OGP projects, for example, consultants, planners, designers, construction workers, operators, maintenance workers, administrators, owners, clients and researchers. An online or Internet questionnaire survey has been adopted in this research because it is easy to manage, inexpensive and a quick data collection method (Dolnicar *et al.*, 2009). However, online surveys have some limitations or disadvantages, such as Internet accessibility might not be available for the targeted sample, web security issues regarding anonymity and knowledge about the website, and computer literacy. These disadvantages could result in a low response rate (Czaja and Blair, 2005). On other side, researchers like Czaja and Blair (2005) and Bertot (2009) have concluded from different international samples that the online survey is the easiest form of data collection and real cooperation is provided via open-ended questions.

The final data collection instrument consisted of 12 questions divided into three sections with 95 items in total. Before carrying out the main survey, a pilot survey was conducted, and all ambiguous questions were revised or discarded to improve clarity. The study utilised different response formats, including drop-down, multiple-choice and open-ended questions. This article discusses question numbers 1, 2, 3, 4 and 5. Questions 1, 2 and 3 ask about each participant's occupation, experience and degree of education respectively. Six choices are listed in the first question for participants to select their occupation in relation to OGP projects. Likewise, four choices are listed in the second and third questions to describe the participants' experience and degree of education. Questions 4 and 5 were included to understand the stakeholders' perception about the risk factors' probability and severity. The 30 risk factors listed in these two questions have been identified previously in Table 1. These questions were designed as multi-choice questions by using a five-point Likert scale from 5 to 1. Question number 4 was about ranking the risk factors in order of probability of occurrence, where 5 means almost certain, 4 means likely, 3 means possible, 2 means unlikely, and finally 1 means rare; whereas question number 5 was about ranking the risk factors in order of severity on the OGPs, where 5 means catastrophic, 4 means major, 3 means moderate, 2 means minor and lastly 1 means negligible. Figure 1 and Table 3 represent the statistical analysis results for these questions.

5.2. Survey Sampling and Data Collection

There is a need in any survey to select the right sample from the targeted population. This is because, in general, questionnaire surveys create many non-respondents, therefore getting the right people to participate is extremely important. As mentioned previously, the snowball sampling technique is utilised in this research to ensure widespread distribution of the survey (Dragan and Maniu, 2013; Ameen and Mourshed, 2016) among OGPs Iraqi stockholders. This technique works as follows: the survey is initially distributed by the authors to a number of previously identified participants, who forward it to others, and so forth until the required number of responses is reached (Ameen and Mourshed, 2016). This technique can help to collect data from a large number of participants. The survey was started on 26th of February 2017 by sending the online link to potential participants via social networks. The survey closed on the 16th of March 2017 with a total of 180 responses.

5.3. Data Analysis

The Statistical Package for the Social Sciences 23 (SPSS 23) is used to calculate the Cronbach's alpha coefficient factor (α) to assess the questionnaire's reliability. The α measures the reliability and the internal consistency or average correlation of the survey items (Cronbach, 1951; Webb *et al.*, 2006; Ameen and Mourshed, 2016). Depending on the scale's nature and purpose, different levels of reliability are required; Pallant (2005) recommends 0.7 as a minimum reliability level. Table 2 shows the α of the questionnaire and the paper's related items.

SPSS 23 is used to analyse the questionnaire statistically. The statistical frequency analysis for each item in questions 1 to 3 has been performed as shown in Figure 1. As stated previously in this paper, a scale from 5 to 1 was assumed for questions 4 and 5 to score each risk factor's probability and degree of impact, where 5 means the most 'extreme' risk probability or severity and 1 the 'lowest'. In order to determine each factor's probability and severity, the chosen items are analysed by using the descriptive statistics analysis method to calculate the factors' frequencies summation and means. Then, the total score of RI for each factor is mathematically calculated by using equation 1 (Hill, 1993; Chamzini, 2014; Sa'idi *et al.*, 2014).

$$RI = (RP \times RS)/5 \quad \ldots (1)$$

Where: RI is risk index, RP is risk probability, and RS is risk severity. The risk factors' probability, severity and index have been ranked depending on their value. Table 3 presents the probability, severity, index and ranking for each risk factor.

6. RESULTS

6.1. Reliability and Validity

As mentioned earlier, SPSS 23 has been used to examine the questionnaire's reliability and calculate the Cronbach's alpha. The results are presented in Table 2.

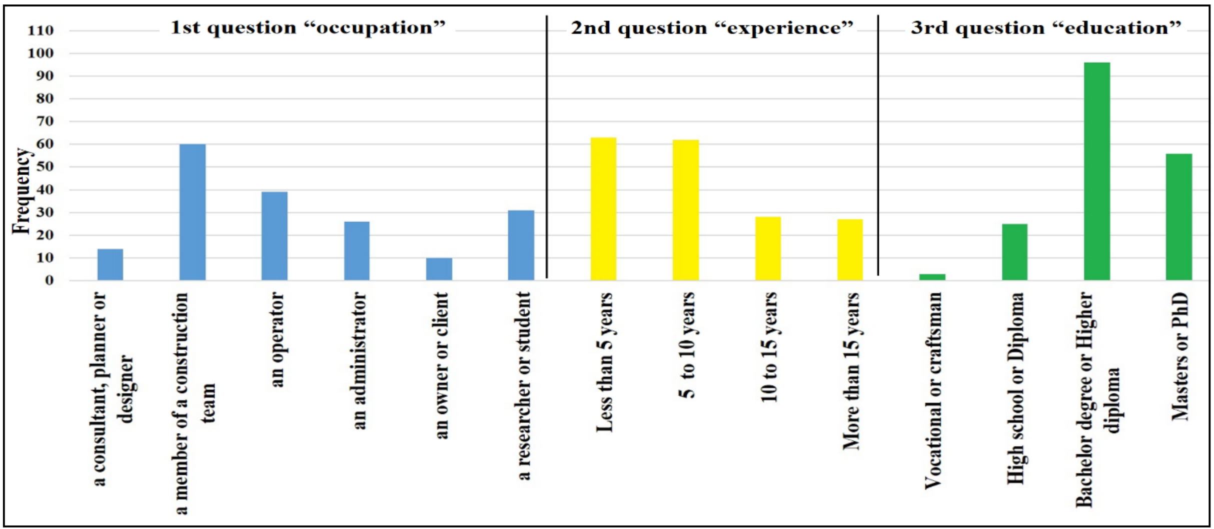
Table 2: Cronbach's alpha case processing summary (SPSS 23)

Case Processing Summary	Valid		Excluded a		Total		Number of items	Cronbach's alpha
	N	%	N	%	N	%		
All of the questionnaire items	180	100	0	0	100	0	95	0.909
Questions No. 4 and 5	180	100	0	0	100	0	60	0.926
Question No. 4	180	100	0	0	100	0	30	0.918
Question No. 5	180	100	0	0	100	0	30	0.863

a Listwise deletion based on all variables in the procedure (SPSS 23).

6.2. Participants' Demographic Data

One hundred and eighty responders successfully answered the questionnaire's questions. Figure 1 provides their demographic information such as occupation, experience and educational degree level.



The question 1 frequency analysis results indicate that the biggest group of participants is the construction workers group, with 60 responders and 33.3% of the total 180 responders. This is followed by the other groups, in this order: the operators group, with 39 responders and 21.7%; the researchers group, with 31 responders and 17.2%; the administrators group, with 26 responders and 14.4 %; the consultants, planners and designers group, with 14 responders and 7.8%; and, lastly, the owners and clients group, with 10 responders and 5.6%. Similarly, question 2 results indicate that most of the participants have less than five years of experience, with a total of 63 responders and 35% in this category. The participants with 5-10, 10-15, and more than 15 years of experience follow, with 62 responders and 34.4%; 28 responders and 15.6%; and 27 responders and 15% respectively. In question 3, the Bachelor's or Higher Diploma degree holders form the majority of the participants, with 96 responders and 53.3%. The Master's and PhD degree holders are next, with 56 responders and 31.1%, followed by the High School or Diploma degree holders, with 25 responders and 13.9%; and last is Vocational, with three responders and 1.7%.

6.3. Risk Probability, Severity, Index and Ranking

The values of RP, RS and RI and the risk ranking have been found using SPSS 23 statistical analysis facilities, as shown in Table 3.

Table 3 Risks' probability, severity, index and ranking

Risk Factors	RP			RS			RI	
	Sum [a]	Mean [b]	Ranking	Sum [a]	Mean [b]	Ranking	Index [c]	Ranking
Terrorism and sabotage	728	4.044	1	814	4.522	1	3.658	1
Corruption	720	4	2	778	4.322	2	3.458	2
Thieves	674	3.744	3	739	4.106	4	3.074	3
Geographical location like 'Hot-Zones'	673	3.739	4	739	4.106	5	3.070	4
The law does not apply to saboteurs	653	3.628	12	751	4.172	3	3.027	5

Corrosion and lack of protection against it	668	3.711	6	712	3.956	6	2.936	6
Improper safety regulations	666	3.7	7	707	3.928	8	2.907	7
Public's low legal and moral awareness	669	3.717	5	692	3.844	11	2.858	8
Improper inspection and maintenance	658	3.656	10	703	3.906	9	2.856	9
Weak ability to identify and monitor the threats	658	3.656	11	699	3.883	10	2.839	10
Stakeholders are not paying proper attention	642	3.567	18	712	3.956	7	2.822	11
Lack of proper training	650	3.611	16	675	3.750	13	2.708	12
Sabotage opportunities arising due to the exposed pipeline, e.g. above-ground pipeline	661	3.672	8	662	3.678	16	2.701	13
Limited warning signs	651	3.617	15	660	3.667	17	2.652	14
Shortage of IT services and modern equipment	661	3.672	9	650	3.611	19	2.652	15
Lack of historical records about accidents and lack of risk registration	644	3.578	17	667	3.706	15	2.652	16
The pipeline is easy to access	651	3.617	14	659	3.661	18	2.648	17

Few researchers are dealing with this problem	652	3.622	13	645	3.583	20	2.596	18
Design, construction and material defects	598	3.322	22	687	3.817	12	2.536	19
Conflicts over land ownership	627	3.483	19	644	3.578	21	2.492	20
Threats to staff	598	3.322	21	668	3.711	14	2.466	21
Socio-political factors such as poverty and education level	621	3.45	20	612	3.400	24	2.346	22
Operational errors	554	3.078	24	642	3.567	22	2.196	23
Inadequate risk management	579	3.217	23	604	3.356	25	2.159	24
Leakage of sensitive information	535	2.972	25	628	3.489	23	2.074	25
Geological risks such as groundwater and landslides	492	2.733	26	574	3.189	26	1.743	26
Natural disasters and weather conditions	473	2.628	27	546	3.033	27	1.594	27
Vehicle accidents	437	2.428	28	486	2.700	29	1.311	28
Hacker attacks on the operating or control system	401	2.228	29	524	2.911	28	1.297	29
Animal accidents	337	1.872	30	365	2.028	30	0.759	30

a $Sum = \sum(5 - Frequency \times 5 + 4 - Frequency \times 4 + 3 - Frequency \times 3 + 2 - Frequency \times 2 + 1 - Frequency \times 1)$

b $Mean = {Sum}/_{N} = {Sum}/_{N}$ Where N= number of participants = 180 and c Equation 1.

7. DISCUSSION AND CONCLUSION

7.1. Discussion

Along with a comprehensive and in-depth literature review, the stakeholders' perceptions are vital and valuable in identifying the OGPs problems. This is because stakeholders' perceptions are based on their real experience in the OGPs context, which makes them qualified to monitor the existing problems of TPD. For that reason, it is expected that the questionnaire survey results will provide a kind of database for OGPs risk factors in the country of study, Iraq.

The questionnaire data are reliable because all α values are above 0.7, as shown in Table 2. The demographic information about the 180 responders reflects the diversity of the successfully collected sample, as shown in Figure 1. This decent level of diversity means the questionnaire has definitely reached the targeted population because all the categories are represented in the survey. Proper sampling reflects the identification of more realistic risk factors, and enhances the final results. In other words, it provides the verified and valuable data required for the risk factor evaluation process.

In this paper, 30 risk factors have been investigated and ranked on a five-point Likert scale from 5-1. Overall, the probability analysis of these factors indicates that the most frequent factors were terrorism and sabotage (mean= 4.044), corruption (mean= 4.000), thieves (mean= 3.744), hot-zones (mean= 3.739) and the public's low awareness (mean= 3.717). Geological (mean= 2.733), natural disasters (mean= 2.628), vehicle accidents (mean= 2.428), hackers (mean= 2.228) and animal accidents (mean= 1.872) were the less frequent factors. In the same way, the risk factors were ranked regarding the severity degree. The factors' severity ranking shows that the most severe risks were terrorism and sabotage (mean= 4.522), corruption (mean= 4.322), the law does not apply to saboteurs (mean= 4.172), thieves (mean= 4.106) and hot-zones (mean= 4.106). On the other side, the geological risks (mean= 3.189), natural disasters (mean= 3.033), hackers (mean= 2.911), vehicle accidents (mean= 2.700) and animal accidents (mean= 2.028) were the less severe factors. The RI values highlight the hazardous risk factors. The factors with the highest impact on the pipeline projects were terrorism and sabotage (RI= 3.658), corruption (RI= 3.458), thieves (RI= 3.074), hot-zones (RI= 3.070) and the law does not apply to saboteurs (RI= 3.027). Geological risks (RI= 1.743), natural disasters and weather conditions (RI= 1.594), vehicle accidents (RI= 1.311), hacker attacks (RI= 1.297) and animal accidents (RI= 0.759) were the factors that had less impact. Table 3 has shown the risk factors' probability, severity, index and ranking.

In this paper, the 30 risk factors have been classified into five groups, namely: security and social factors; pipeline location factors; health, safety and environment (HSE) factors; operational factors; and rules and regulations factors. For the security and social factors, terrorism and sabotage factors are always at the top of the most influencing factors ranking list. They are followed by thefts; public's low legal and moral awareness; threats to staff; socio-political factors such as poverty and education level; and leakage of sensitive information. Amongst the risk factors related to the pipeline's location, it has been found that hot-zones are the most risky and accidents due to animal crossing are the least. Meanwhile, easy access to the pipeline; conflicts over land ownership; geological risk; and vehicle accidents are the 2nd, 3rd, 4th and 5th ranking factors respectively. HSE factors are ranked as follows: improper safety regulations; inadequate inspection and maintenance; the pipelines are exposed and above the ground; limited warning signs; risk management nature character; and, last of all, natural disaster and weather conditions. Corrosion and the lack of protection against it are the major operational issues facing the pipes. This is followed by weak ability to monitor the risk factors; limited availability of IT; design, construction and material defects; and operational error, which are the 2nd, 3rd, 4th and 5th issues respectively. Problems caused by hacker attacks on the operating or control system have the least impact on the pipeline system in Iraq. The group of risk factors related to the rules and regulations have been evaluated as follows: corruption and the law does not apply to saboteurs and thieves are the factors with the highest impact among this type of risk. The rest of the rules and regulations factors are ranked as follows: stakeholders are not paying proper attention; lack of proper training; lack of an accident database and historical records; and, lastly, few researchers looking into this subject.

The top five risk factors in Table 3 indicate that the Iraqi OGPs stakeholders are most increasingly concerned with security and social issues; rules and regulations; and the pipelines' geographical locations, because terrorist and theft acts have become respectively the first and third most pressing factors facing OGPs in Iraq. Additionally, corruption is the second top risk factor, and the law does not apply to saboteurs and thieves is the fourth, both of which are obstructing pipeline projects in Iraq. Hot-zones are fifth in this top five list, and so are also a cause for concern.

7.2. Conclusion

OGP projects are complex and risky; the risk management challenges are increasing day by day due to the vast range of problems facing pipeline projects and the insecure global environment. Balfe *et al.* (2014) stated that, in order to maintain safe and secure construction and operation circumstances, monitoring studies must be continuously conducted, and translated into formats that can be reviewed, understood and analysed. For that reason, this article has been written to represent the final outcomes of this research. Common OGPs risk factors have been identified based on an extensive review of the causes of pipeline failure around the word. A quantitative research approach has been adopted to evaluate the 30 identified factors. The probability and severity of risk factors have been determined based on the statistical analysis results of a questionnaire survey with a total of 180 respondents. The RI for each factor was mathematically calculated to rank the risk factors in relation to their degree of influence on OGPs. Their ranking indicates that terrorism and sabotage acts, corruption, hot-zones and the law is not applied to saboteurs are the risks that have the highest impact on OGPs. On the other side, geological hazards, natural disasters and weather conditions, vehicle accidents, hacker attacks and animal accidents are the factors with the least impact. TPD risks occupied the top positions in the ranked list of OGP risk factors. Furthermore, the prioritised risk factors showed an essential need to understand the profile of TPD in Iraqi OGP projects. TPD should be an important focus for management in order to mitigate and limit damage to pipelines.

The research's findings could support decision-makers, policy-makers and researchers to understand the nature of TPD to OGPs properly in troubled countries like Iraq. A ranked list of risk factors could help to provide more active and suitable risk management methods to avoid or minimise the adverse impact of risks in OGP projects. Precisely, OGPs stakeholders could use the outcomes (presented in tables 1 and 3) as a database and tools for risk evaluation at different stages of a pipeline project. T findings could also be used for monitoring and prioritising risks during design, re-design, construction, operation, inspection and maintenance activities. Respectively, these numerical results will be adopted to develop a new computer-based model for OGPs risk management at the next stage of the research.

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Engaged and transforming projects and programmes: CSR in organisations in the UAE

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Abstract

Corporate Social Responsibility (CSR) is an increasingly influential business concept throughout the world. It has evolved over the last two decades and is believed to be at a more developed stage in Western countries. In contrast, CSR in the GCC and MENA countries is generally thought to have not reached the same level of development. The literature implies that CSR is misunderstood in this region and is mainly philanthropic in nature.

This research study aims to investigate developments in CSR in the UAE, especially those that reveal different levels of awareness and implementation of CSR. The study consists of data analysed from 29 interviews conducted with CSR representatives of UAE based organisations over the period of 2011 to 2016.

The interviews were conducted with individuals with CSR roles and responsibilities as part of their job. Analysis of the data uncovered themes relating to CSR in the UAE, including, education, leadership, CSR strategy, and industry and compliance contexts. The findings and identified themes were then compared with the literature on CSR and project management, including theories by Matten and Moon (2008) and Porter and Kramer (2006). Specifically, they were assessed against the CSR stages model developed by Mirvis and Googins (2006) to give an indication of their degree of 'implicit' and 'explicit' development as well as project management theories such as the project delivery system (Too and Weaver, 2014) and the programmification theory by Maylor et al. (2004).

In contrast to popular belief, the comparison reveals that CSR activity in the UAE is more developed than has been implied in the literature on the MENA region. The data analysis has shown a more sophisticated level of project managed CSR activity, with the majority of organisations implementing CSR through projects and programmes.

Overall, it is argued that strategic and socio-economic levels of project managed CSR do exist in some organisations in the UAE. These organisations show that CSR related activity in the UAE is not just philanthropic and that CSR activities are strategically implemented in the UAE across a range of dimensions, from elementary to transforming stages of development. Particularly, in the form of projects and programmes.

Purpose

The purpose of this research is to develop our knowledge of CSR in the UAE through institutional, organisational and project management theories. CSR is a dynamic term, which seems to have different meanings dependent on the context. In the MENA region, previous studies have argued that CSR in the region is relatively undeveloped as well as misinterpreted (Katsioloudes and Brodtkorb, 2007; Jamali and Neville, 2011). CSR in MENA countries is portrayed as mainly philanthropic in practice, although many of the managers and other employees interviewed in research studies express an interest in engaging in a wider range of activities (Jamali, 2009; Jamali and Neville, 2011). Overall, there is not much information on the details of CSR activities in the UAE available in the current CSR literature and theoretical debates.

This study aims to contribute to fill the gap in the knowledge on CSR in the UAE and its potential implications for the MENA region. The significance of such research is that it will provide insight on CSR in a country in the MENA region considered to be a combination of under-developed and developing countries, some which have been rapidly developing such as the UAE. . It will also assist other research studies interested in progress in CSR in MENA countries.

The study will not only address a gap in literature but also contribute ideas for studying CSR in developing countries. Most literature shows that CSR is mainly philanthropic and at its early stages when it comes to developing countries, however, this research aims to investigate more how CSR is actually changing and growing in a developing country.

CSR theory and practice in Middle Eastern and North African (MENA) countries

Knowledge about CSR has spread worldwide and developed and developing countries are under increasing pressure to engage in CSR activities. Yet, despite globalisation and the growth in popularity of CSR, it seems that MENA countries have still not reached the same level of practice in CSR as western countries. Jamali and Neville (2011, p. 613) illustrate this point through their CSR-related research in Lebanon; noting that, “All interviewees generally agreed that CSR in Lebanon is still in its infancy and there are very few signs of the infiltration of a global CSR institutional infrastructure.”

Each culture regards CSR differently. Jamali and Neville (2011, p. 601) state that “CSR in developing economies has been recently characterized as more extensive than commonly believed, less embedded in corporate strategies, and less politically rooted than in most high income countries”. Likewise, Jamali et al. (2008, p. 173) conclude that, “Yet, in view of vastly differing national cultures and institutional realities, mixed orientations to CSR continue to be salient in different contexts, oscillating between the classical perspective which considers CSR as a burden on competitiveness and the modern perspective that views CSR as instrumental for business success.” It seems that the viewpoints on CSR are diverse and differ between organizations and across industries and economies. In contrast to western countries, it seems that CSR in Africa and the Middle-East is more philanthropic and “culturally-embedded” (Jamali et al., 2009). Furthermore, Jamali and Neville (2011, p. 601,) state that “CSR activity in developing countries is, therefore, portrayed in these writings as on-going and extensive, although it tends to be less formalized, more sunken, and more philanthropic in nature (Amaeshi et al., 2006; Visser, 2008). It also draws on deeply engrained cultural/religious values and is primarily oriented toward local communities (Jamali et al., 2009; Visser, 2008).”

Despite the lower practice level or “lower priority” of CSR in developing countries that the literature has implied (Retab et al., 2006), Jamali et al. (2008, p. 189) state that “Hence, while some managers in this part of the world still adhere to the perspective that ‘the business of business is business,’ there seems to be a larger proportion of managers in the Middle Eastern context that see an added value from CSR and in serving a wider array of stakeholders. This is reassuring indeed”. According to Retab et al. (2006), CSR in Dubai is positively related to financial performance, employee commitment, and corporate reputation. Compared to western or more developed countries, these are similar intended outcomes from CSR.

However, Retab et al. (2006) also consider the UAE as one of the “emerging economies” along with China and India, where despite their growth, CSR is still “a low priority”. This could be due to ineffective stakeholder management where companies fail to appreciate the significance of strategically managing their stakeholders in relation to CSR. Some firms in Dubai can do more to inform stakeholders of the CSR initiatives being implemented or else stakeholders may not acknowledge the advantages of CSR (Retab et al., 2006).

Retab et al., (2006) recognize ineffective means of communication, and the diversity of cultures and priorities in Dubai as drivers for ineffective stakeholder management and thus less engagement in CSR. Moreover, Retab et al. (2006, p. 375) explain this point in more detail by adding; "Further, because of the lack of communication platforms to disseminate information about CSR activities, CSR efforts often go unnoticed and are largely unknown to stakeholders and subsequently may not have an impact on performance." This reflects on their earlier point of CSR being a "low priority", which could be due to the fact that stakeholders are not even aware of the CSR initiatives being undertaken by firms and so do not know about the added value to organizational performance that CSR can provide. However, despite the ineffective stakeholder management found in the case of Dubai, Retab et al. (2006) conclude from their empirical research that, in contrast to their hypotheses and expectations, CSR turned out to be positively related to both financial performance and corporate reputation. Furthermore, the findings confirmed their other hypothesis of CSR being positively related to employee commitment in emerging economies.

Project Managing for the case of CSR

Pellegrinelli (2002, p. 229) study the use of project and programme management for organisational change. This is an aspect of project management that can prove to be of importance in the area of CSR and especially the implementation of strategic CSR activities; to elaborate on this the author states "Emergent thinking on programme management best practice has focused on the internal context, namely the marshalling of projects and resources to achieve the desired strategic and/or synergy benefits." The author speaks of utilizing project management for achieving strategic organisational goals. In the world of CSR, this one of the dilemmas organisations face when it comes to adopting CSR, philanthropic CSR is no longer sufficient and organizations are looking to strategic forms of CSR that will serve the community but also the organization. Moreover, the purpose of organizational change seems to be linked to both concepts of project management and CSR. Also, Too and Weaver (2014, p. 1384) claim "Project management techniques have frequently been applied to the tasks of planning and implementing necessary operational changes".

It can be argued that project managing CSR will help keep CSR aligned with organisational goals and strategies. The author adds, "Programmes are also well placed to establish a bridge between projects and the strategic goals of an organization… leaders have increasing used projects and programmes to implement or support the realisation of corporate strategy [6–9]." Similarly, Lycett et al. (2004) state that "There is an increasing recognition that programme management provides a means to bridge the gap between project delivery and organisational strategy." Too et al. (2004, p. 1390) also state that "Projects and programs are created to deliver the change needed to achieve the organization's strategic and tactical objectives. Management 'by project' is fundamental to support, sustain and grow the business."

Looking deeper into the idea of project management as a means of structure and successful implementation, we can look at the essential skills of project management. Pellegrini (2002) presents a number of areas where project management skills are needed, the areas listed that overlap with areas of strategic CSR implementation include approach and strategy for the project/programme, cultural Awareness, understanding client's objectives and commercial awareness. The project management of CSR could help with focusing on these areas and keeping CSR strategic. Without taking any of these areas into account in a structured way, the CSR activity could lead to high costs and lost opportunity.

Another dilemma related to the implementation of CSR is costs and financial risks. Carvalho et. al (2015, p. 1510) look at elements of project success in relation to project management. These include "financial criteria have been used to measure project performance,including economic return and cost/benefit analyses". These criteria are relevant and applicable to CSR projects and programmes where the costs associated with the project can usually have an impact on whether it is implemented or not. Project management goals are also relevant to the implementation of CSR. Lycett et al. (2004, p. 290) list some goals that should be taken into account when implementing CSR initiatives, one of which addresses the issue of aligning CSR activity to strategy; "Better alignment with business drivers, goals and strategy". The authors add "Improves the linkage between the strategic direction of organisations and the management activities required to achieve these strategic objectives" This brings to mind the idea of project managing CSR to make it more strategic and ensure that it is serving organizational goals as well as social goals.

Research methodology

To explore the condition of CSR in the UAE, there is a need to understand how it is perceived and managed by organizations and so the qualitative methodological approach was taken. As the research aims to explore CSR from different perspectives, qualitative methods allow close proximity to the subjects, which is important in this exploratory research context since it has the capacity to collect rich data (Kvale and Brinkmann, 2009).

To collect the data, 29 UAE based organisations involved in CSR were selected. These organisations operate in a range of industries including, retail, construction, technology and NGOs. They ranged from medium to large size, and were based in the semi-government and private sectors. The sample therefore includes different industries, sectors and size of organisation.

CSR is specific to each organisation's culture and strategy (Duarte, 2010).The qualitative data collection of this exploratory study consists of three sets of interviews with CSR-related managers of UAE based organisations, conducted over the years 2011-2016. The interviews involved questions on CSR, lasted for 40–60 minutes and data were collected on CSR definition, strategy, implementation, challenges and failures.

Data from the CSR interviews was analysed using the grounded theory and the aid of NVIVO software. Firstly, transcripts were thoroughly read and open coded, this consisted of creating as many relevant codes as possible for all of the transcribed data.

The second step undertaken in grounded theory analysis is selective coding based on categories selected after open coding. In this case the categories included CSR strategy, project management, leadership, global CSR, government, education, CSR issues and implementing CSR.

Theoretical coding was the final step and involves creating theoretical categories from the selected codes stemming from the data. These include CSR Nature, CSR in the MENA, Putting CSR into Practice and Project Managing CSR.

Main findings and contribution

The findings and their correlation with literature implications and theoretical categories are summarized in the table below:

Theoretical Category	Academic Literature Theory	Data findings
Putting CSR into Practice	"Companies being successful in managing CSR activities could have their CSR values embedded into their work philosophy and culture by the founder and since the beginning of the organisations." (Virakul et al., 2009, p. 1991),	"This is what our CEO believes, and then this is what the organisation believes", therefore it's more DNA like, business like."
CSR Nature	"In the wake of anti-globalisation movements…and at a time	"That's really the global trend is this, which is what we call it sustainability not really

	when the market strength of corporations is derived largely from brand image, there has been a need for companies to demonstrate an awareness of social, human and environmental issues." (Sahlin-Andersson, 2006, p. 596)	CSR now anymore. It's how to be sustainable in your business... But then we talk about CSR or CR, you're talking about how you conduct your own business"
CSR in the MENA	Political, financial, economical, educational and cultural systems shape CSR (Matten and Moon, 2008)	"Naturally, the UK, Europe, Australia and America and Canada, there is more regulation…so there is a certain piece where you do have to do as the regulation requires, however, we make sure we don't do it because we have to but because we want to, because we feel its an important part of our business."
Project Managing CSR	"There is a significant growth in the adoption of project management disciplines to accomplish work in different sectors and industries." (Too et al., 2014, p. 1382)	"Well, for the organization, obviously for us we have deliverables associated with those projects and programs."

As seen, it is clear that the association made between project management and CSR in theory is actually present in practice. 99% of the organisations examined run their CSR operations, regardless of the nature and sophistication, through projects and programmes.

However, it should be mentioned, that on the CSR nature and development, in contrast to what has been mentioned in the literature, these recent and relevant sets of data have shown that a high level of strategic and socio-economic CSR activity does indeed exist in the UAE and possibly the MENA.

Depending on the CSR nature in the organization, the CSR strategy is implemented and put into practice via CSR projects and programmes. This sheds light and addresses the gap in literature on the current and actually strategic nature of CSR practices in the UAE.

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Software Engineering Conception on 2025

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Abstract—The fast growth of technology over the past decade has changed software on different aspects, such as type of users, architecture, processing capabilities, and software engineering has been developed over the past years to reached a level of robustness from requirements engineering, to design and development to tools that are generating software code. However, software engineers yet facing some challenges in the current state of practice, the gap between theory and practice has been considered the main problem, complexity of software and higher level of integrity and systems of systems has put a challenge to software engineering that has to go over to make sure software being developed keeps the best quality and sustainability and bugs free. In the next 10 years, with the expected growth and development of software and hardware both, some new challenges will be facing software engineers on many aspects, we are highlighting some of it in this research and proposing some solution to those challenges showing how software engineering will look like on 2025.

Keywords: Software Engineering, Internet of Things, Big Data, Smart Cities, Industry 4.0.

1 Introduction

Software engineering in the past decades has played the main role responsible for the industry of software development or production, the discipline of software engineering is about managing and controlling all phases of the software production process from requirement to design, build, testing and verification, to produce a quality and bugs free software that is reliable and highly available. However, literature has always claims a gap between theory and practice, and for this challenge there was always recommendation to close this gap in many different ways, mainly more education and more elaboration of industry to the research and development. Many had investigated this fact trying to explain some weakness or customers dissatisfaction regarding software developed, or to measure software company's best practices that has been found somehow is not complying with software engineering state of practice.

In this research, we investigate the state of art and state of practice of software engineering throughout several research that has been done during the past decade. A deeper look to the software development life cycle (SDLC) methodologies that has been implemented in several software development companies, and compare it with software engineering best practice, while researchers claimed a gap between theory and practice, there is a tangible possibility to a level of certainty of potential low quality software that will not be able to be a part of the future growth and development of information technology in general. And some has a critical path that will no longer work with the next generation of software, and will not be exposed to the world in the next decades.

A future expectation of the software engineering paradigm has been highlighting some of points regarding how a software engineer has to think in the future, considering some of the research fields that scientists are working on, brain interfaces are what developers are expected to deal with in the coming 50 years as expected by Chris Parnin [1]. As many research in this field is giving some promising results at the time those results will be commercially in market, software industry will be in need to come up with a software engineering practices that comply with its requirements, regulations, policies and procedures to build software that is using brain neutral pulses to translate it to orders and remote devices interactions.

The fast growth of information technology is a result of many factors due to the increased competition of industry competitors, and the achievement of the research and development in the fields of hardware and software both the same, will increase software systems complexity, and more complexity of interfacing, integrating, and interoperability with other complex software systems. This growth shows the need to adoupt more roubust software engineering methodologies that will ease the software development process to faster producing a good quality software capable tp compete and enter the market very fast.

Software is almost will be in everything, IoT is a revolution of this era, smart devices, smart cards, almost everything is becoming smart, and it’s all about software and artificial intelligence that makes those machines easy to use and more comfortable, and on the other hand making the software industry more complex and needs more efforts or impossible to operate if same old Software Engineering methodologies still being doubted. Current state of Software Engineering practice and challenges will be discussed in section 2. Section 3 will discuss Software Engineering challenges over different aspects highlighting both challenges and suggesting future expectations. Section 4 discussing the new concept of Software Engineering of the entire ecosystem, and finally the conclusion section that will discuss the new conception of Software Engineering of the entire ecosystem, and finally the conclusion section that will discuss the new conception of Software Engineering on 2025.

2 SOFTWARE ENGINEERING STATE OF PRACTICE

A survey investigated the state of practice of Software Engineering in the Netherlands by Vonek et.al [2] has come up with interesting 22 findings among Dutch software companies, with servey questions they could have observed the methodologies of software development companies has been useing, requirements gathering methods, design and build methods, and testing and quality measurements. Their observations concluded by the fact that there is a gap between the state of art and state of practice in the field of Software Engineering. A set of recommendations that are feasible for Software Engineering should consider to come up with current challenges, from developing the tools for requirements engineering process, to requirements validation process and methods, to refactoring value, and finally test-driven development. However, we are not expecting those challenges in the future, because the time research and industry will be working to come over those challenges, and due to the fact of the rapid changing of life and involvement of smart devices and IoT's we are expecting different challenges even to appear, which we will discuss it further in the next sections.

Another study in Finland by Uolevi et.al [3] has been done through a survey investigating the software engineering practice over the stages of the software development process, their findings has highlighted more gaps of Requirements Engineering field more that other stages of the software development process, however at the end they resulted in the same gap of Vonken et.al [2], and hence this would support the fact that there is a need to close distance between the theory and practice in the field of Software Engineering, which we can consider it the first challenge of the current stage, and therefore it will be also one of the first challenges in the future.

Requirements obviously why we build software, and herein proper requirements engineering playing important role of Software Engineering. Requirements Engineering state of practice survey by Neill and Lplante [4] has come up with some observations of RE state of practice, lake of using formal methods in requirements engineering is being considered a challenge that may affect proper requirements engineering. Quality of products is not being affected by ad hoc development. Waterfall model is widely being used in Software Development industry, and short duration project is better succeed. However, they didn't consider big systems or system of systems in their surveys, which we expect to be major topic in the future as a result of the need of more integrity between systems and more interoperability.

Software development state of practice has been surveyed by Cusumano et.al [5], the survey was over world wide countries classified to: India, USA, Japan and Europe & Others. Practices were Architecture Specifications, Functional Specification, Detailed Design, Code Generation, Design Reviews, Code Reviews and Pair Programming. India showed the best practice that linked to performance and quality of products, and this shows the importance of state of practice of Software Engineering that contributing of software production industry. The challenge again has been connected to the gap between practice and theory, which support our assumption: Overcoming current Software Engineering challenges will make it easier in the future to focus on different challenges that will appear.

With the appearance of IoT devices and the potential growth of those devices the next 10 years, a new Software Engineering challenges [6] has to be addressed, specially for projects that need more collaboration between different industry domains. Engineering, Telecommunication and Computer Science are involved in designing IoT devices that responsible for transmitting signals to the cloud and being analysed to give a certain KPI's that will help decision makers to make better decisions. Such a challenge can be defined as Software Engineering should being extended beyond computer science in the future. Similar challenges of Software Engineering currently exist in Embeded Systems [7], were software engineers of such systems are not of the domain of Computer Science, they rather Electronic Engineers whom designing the hardware.

Best practices of Software Engineering of Embedded Systems have been designed in mathematical form by Darbari and Ahmed [8] as a contribution of recent Software Engineering effort, the functional requirements specifications used formal specifications yet will lead to better quality since such a systems criticality and privacy is being considered important.

3 SOFTWARE ENGINEERING CHALLENGES ON DIFFERENT ASPECTS

Software Engineering challenges varies over different aspects, each of them needs to be studied and tacled differently, because of the nature of the challenge, level of criticality and impact varies.

The type of software today has become different than 10 years back, IoT [9], Smart Cities [10], Big Data [11], and Industry 4.0 [12], all have had the need to change software from KBMS to real-time systems that have different requirements and architectures. That lead for new Software Engineering methodologies to be adopted on different scales, however, far from the technical side of software systems the SE discipline still the same but new challenges that we are going discuss on the next sections for this new changes.

3.1 The Quality Aspect

Producing good quality software is the main goal for Software Engineers. Quality measurements varies based on the type of software, meeting customer requirements, customer satisfaction, results accuracy, response speed, better predictions…etc are all a quality KPI's that can evaluate a software product. Quality challenge of Software Engineering currently is different than its definition in the future, because the type of needs will be more complicated and further dimensions need to be taken in considerations.

An extensive testing of the software during the development phase currently to make sure requirements matching can be a solution to Software Engineers, but with increasing complexity of future systems, Software Engineers need to come up with more robust techniques for testing and quality control methods that will cope with the high level of integrity and complexity. For real-time systems it's difficult to conduct testing specially when interoperability is being considered to real-time, which need special type of simulation tools to be involved and more cost to the software productions projects.

As a new technology evolves more in the future like virtual reality [13], it might be on of the solutions to Software Engineers to develop a new testing techniques that will cost less than real-time scenarios.

3.2 Security and Privacy

More challenges on the level of security and privacy has appeared, the Cloud computing, Social Network on the web, smart phones, smart devices all are vulnerable systems for hacking, this put more responsibility on the shoulders of Software Engineers, more investment on Cyber Security and new methods of testing and searching to close back doors of the software production phases.

The Future is will extend this challenge to privacy also, there should be a global agreement on privacy legalities formation; However, the diversity of societies from culture, demography, ideology have to be considered. Although we are expecting this to be more easy in the coming years, because of technology contributing of closing the gap and differences between civilizations through media, social networking, and ease of transportation. Societies will be more similar, and better accepting their differences and adopting common formation of privacy concept.

Data Security and Data Engineering need to be more involved in developing security and privacy standards towards global societies. Despite the fact that governments and politicians will be in need to make sure that security is the main aspect of any software system that they will be using or developing, and therefore, segregation of software architecture might be a need for Software Engineers to think about and to find a set of standards towards security best practices.

3.3 Social Impact of Software Systems

Technology has a huge impact on most of societies, while some has been considered positive, there are many concerns or expectations of a future impact may affect societies negatively. Social Media has witnessed both impacts on the past decade until today, however, people was responsible of all that in the first place, but lake of education and understanding of this new revolution might created many bad incidents or negatively affected societies on aspects like privacy, blackmail, frauding, misleading, and falsifying facts. The future will witness more evolving of technology and software in people lives, and the challenge that will face Software Engineers is to consider the social impact of any software to be developed, the natural resources consumption, the privacy of people using it, and the malicious attacks to peoples behaviours.

3.4 Governance and Legality

Enterprise software companies has been investing more into governance for the importance to have a robust processes and procedures that control the software development, production and operation. Enterprise Architecure and CMMI level has proven better quality and control over the industry. However, small to medium companies may not have the capabilities for such investment, though their produced software value is not less and have a good presence in the software market. The challenge for Software Engineers is to contribute in developing the governance mechanism of software production process, and to have to develop better tools that automating the quality control process to ensure quality of products.

Globalization and interoperating societies and economy will create a challenge on the world to develop the legalities towards different countries and societies, taking into their consideration the most important common ethics and social acceptance of ways that software will impact it. Hence Software Engineering will be in need to have extra efforts to consider those legalities when they designing their systems.

4 SOFTWARE EGINEERING NEW CONCEPT (THE ENTIRE ECOSYSTEM)

Different visions or expectations of the Software Engineering discipline in the next decades has been in literature. Some expected disappearing of Software Engineers or limiting their work to minimum level due to massive development of artificial intelligent systems that have the capabilities to engineer and generate totally software systems with full functional requirements by the year 2060 [14]. Though we think this hypothesis yet not much valid since such intelligent systems needs software engineers to make it, and might need re-engineering as far as technology will keep changing.

Software engineering tomorrow should be starting today, this was a conclusion for Parnin [1] with interesting feasible expectations for the future of Software Engineering considering two major factors: Software will be usable by almost everyone of the world population, the number of software usage varies from less than a day to many years, and the future paradigm will evolve more of different techniques such as Neural-embodied and augmented programming. We think the challenge then will be more on Software Engineers to consider more Data Engineering and social impact considerations when they design the software.

Artificial Intelligence, Smart Cities, Industry revolution, IoT, Autonomicity, Globalization, Smart Devices, and many other new technology will be factors to change the way of thinking and discipline of Software Engineering, more elaboration between those concepts will create the need to think in different manner, integrity of all the concepts and it's interoperability will produce a wide range of aspects that a Software Engineer has to keep in mind and develop a concrete methods to keep their software compliance to those aspects.

Conclusion

While this revolutionary growth of software of the current generation, there will be some potential aspirations for the software next era like Fifth Generation of communication, smart cities, IoT that will touch most of devices on this planet, from all this there are a need to change the Software Engineering methodologies to cope with this change, we believe that the current software engineering methods and models been used will not fit the next generation of software that because of several factors: increasing of cascade impact of failure, increasing dependability of devices, the intercommunication between devices and softwares, all this will generate the proper motivation for software engineers to change the way of thinking and to put a standard framework that will avoid or make the impact of failure less and producing more robust software systems.

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Future of Software Engineering: A Vision of 2040 and Beyond

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Abstract— Imagine it is the year 2025. The software industry has become the most capable and dependable medium to help organizations provide their products in a competitive manner. In 2025, software engineering supports differentiation and rapid adaptability in enterprise. Commercial sectors have increased their capacity to cater to increased software-intensive demands. Information has increased in complexity due to a need to be accessible across multinational and multicultural global enterprises. Steady progress in software engineering has led to visionary innovations and wonderful opportunities through newly driven technology. One of most important features of the landscape of technology in 2025 is the contribution of the Internet of Things (IoT), namely, the interconnectivity of physical items.

The past, present, and future of software engineering is a vital subject in today's world. The role that software engineering plays in contemporary society is influential in topical news coverage and general information dissemination. In particular, some key topics include the current state of the art and practice in software development, software of 2025, the development of software in 2040, and the possible problems and challenges of future work in the field. This paper describes and interrogates some of the visionary ideas applicable to tackling future engineering challenges with the examples of self-adaptive systems, power monitoring systems and the development of more advanced software languages.

Keywords—software engineering; Internet of Things; state of the art; state of practice; web-based programming; end-user; self-adaptive system

INTRODUCTION

The world of 2025 will involve the frequent use of the internet to find solutions to day-to-day problems, including the availability and accessibility of information, trade enhancement, and communication. Lowry [1] identifies a fundamental problem involving a changing environment that will require urgent solutions available through innovation in software. De Lemos et al. [2] believe the changes in the environment will contribute to the evolution of the software industry to become more flexible, resilient, robust, dependable, and energy- efficient. With a growing technological influence, the challenges to successful development will continue to persist, especially in developing active software management systems. In 2025, software engineering will be a central sector in competitive business. The sector and its proponents will be responsible for designing specific programs that manage to meet consumer and human needs. In 2025, it will become necessary to apply the discoveries of the discipline in the establishment, maintenance, and development of end- user satisfaction. The discipline of software engineering will continue to increase its relevance on a day to day level in 2025 with the ubiquity of mobile computers. The importance of software engineering as identified by KO, et al. [3] includes reducing the cost of developing software, improving time management through designing efficient programs, reducing complexity in understanding software models and increases in productivity. It is arguable that both present and future challenges affecting humans will require the application of software engineering on a much larger scale.

This paper is comprised of seven sections organized as follows: Section II describes the current state of the art and state of practice in software engineering, section III covers the software of 2025, while section IV discusses the software engineering of 2040. The information included in Sections V and VI involve the challenges and problems of software development in 2040 and the visionary ideas necessary to address the challenges respectively. This paper concludes with Section VII providing a summary of the discussions and a direction for the future of engineering in software.

CURRENT STATE OF THE ART AND STATE OF THE PRACTICE IN SOFTWARE ENGINEERING

In developing software products, it is essential to understand the state of practice in 2025. Through a research study by KO, et al. [3], most programming in 2025 will not be written by professional software developers, but rather by people who have a command of other domains and systems. Due to the need to incorporate less professional human resources, the state of practice in 2025 will create a complex situation. Vyatkin [4] explains fundamentals in designing software, including a balance between the process and product and function versus non-functionality. Moreover, it is important to consider any new characteristic of the program before its implementation. For the software user in 2025, a customized, customer goal-oriented experience will be important. The challenges that appear in software engineering will particularly focus on the efficiency and compatibility of the software over a long period. Different end-users drive different issues that will not be easy to manage. However, through complex but helpful measures, solutions will be possible.

In 2025, programming will utilize more models to allow its extensive scale, possibilities and adaptations. The ability to share codes will establish the application of an interactive web, especially in devices such as mobile phones and personal computers according to Ko et al. [3]. Vyatkin [4] further provides examples of the common domains characterizing state-of-the-art software engineering including web commerce, trade, information processing, database management, automation, and real-time control of activities. The attainability of efficient functioning of these domains will be an outcome of the development of programming languages specialized for particular fields.

As for software engineering in automation of the industrial sector, Vyatkin [4] identifies some of the most important operational standards, including IEC 61131-3 which will provide up to four different programming languages to facilitate the mobility of software in automation. Moreover, the standard can integrate software from one programmable logic controller (PLC) type into another, which will allow a plus in the number of vendors. ISA 88/95 are two relevant standards which will act as solutions to problems relating to system integration and application configuration [4]. Other examples include IEC 61499 which focuses on improved interoperation of automation software. IEC 61850 will address the need to work with regular communication as a means to prevent the use of individualistic protocols in the automation of power systems. It will also go further to disintegrate power subunits to generate a representation of an object-orientated system. The standard will manage to encapsulate data attributes, which can be used to allow the functioning of devices [4]. Apart from data encapsulation, the standard will wrap the data representing it in the form of logic nodes (LN).

According to Lethbridge et al. [5], software maintenance is an important practice in software engineering. The process includes the updating of software-supporting documentation as frequently as possible to manage information of the code efficiently. Lethbridge et al. [5] provide a survey on the frequency of documentation of changes in software information. The study concluded that some software engineers are failing to provide frequent updates to the evolution in coding. The study further highlights the fact that document updating contributes to factors such as the amount of changes in the code and the urgency of a change request. Concerning documentation, Lethbridge et al. [5] explain how different functions are performed, including assisting the user to learn about a program, testing a system, maintaining the software, answering questions concerning the system, and solving problems occurring in the software system.

Graaf et al. [6] address a rather complex common state of the practice in software engineering involving the development of embedded software. The software is complex, though its use is rapidly spreading throughout society. Embedded systems require specific technologies determined by factors such as cost, time, and reliability [6]. The imperative is the production and selling of hardware, a product of the software. Although the devices operate using the technology, the software itself is not for sale. Its function includes facilitating the operation of the gadgets. The advantages of the software include less power consumption, a rather minimal memory capacity to operate, and most importantly, few people are needed to run the equipment efficiently. Embedded software is a realization of the usefulness of automation. The internet of things (IoT) provides an interconnection of networks, extrapolated from Gubbi et al. [7]. In particular, the IoT applies the use of the embedded system. About the extensive use of the internet and software, Gubbi et al. [7] explain that high usage of the web and overreliance on software solutions will contribute to massive amounts of data. The availability of extensive data translates to the necessity of more storage, management, and modification of the data analysis systems. In 2025, there will be widespread use of the IoT with prominent applications becoming noticeable in the media, in the monitoring of environmental conditions, in the management of infrastructure, in design and manufacturing, in the management of energy, in healthcare provision including the provision of medications, in the automation of homes, in transportation and for consumer purposes [3].

Based on Lowry [1], knowledge-based software engineering (KBSE) will be another yet well-developed system of 2025. The success of the development will be an outcome of the rapid innovations in hardware, making it necessary to advance the software as well. In 2025, KBSE will rely heavily on computer- aided software, which enables the re-modification of the hardware. An interesting segment in 2025 will be the ability of KBSE to realize transformational programming [1]. In agreement with the knowledge from Vyatkin [4] on the spread of automation, Lowry [1] describes transformational programming as an automatic system effectively integrating both prototyping and coding activities. When discussing automation in coding, it is important to highlight that 2025 will mark a decrease in human guidance in the development of codes.

As provided by Boehm [8], there is no doubt that a characteristic of 2025 will be the extensive application of web-based programming. The creation of web-based systems provides for the numerous products in software that characterize the communication industry. Today, software developed programs allow mass communication through social websites incorporated into applications. Moreover, the use of the application becomes accessible through its presence in gadgets such as mobile phones, tablets, and personal computers. It is important to realize the development of Smartphones, iPhones, iPads, and tablets as providers of the ability to carry out greater functions than simple gadgets such as the phone. Consequently, the use of web-based programs transform into increased output in both software and hardware. Currently, there is an upsurge in online business markets using software-developed applications. The software is being integrated into all the key industries to provide information, educate the user as a market platform, and to obtain customer feedback.

THE SOFTWARE OF 2025

In 2025, current trends in programming will demonstrate an increase in the use of codes and coding language. Extrapolated from Boehm [8], coding will be relevant in 2025, but will be more developed. Ko et al. [3] further explain that JavaScript will be more of an internet protocol by 2025. The system's development and efficiency will help it to gain popularity in 2025. The software language provides numerous advantages, especially its compatibility with other systems. Nevertheless, Boehm [8] notes that to continue enjoying the benefits of the model, current software engineers must incorporate it into web browsers. Consequently, by gaining the support of the different browsers, its usefulness will maximize in the future. In 2025, new software languages, which were developed to meet the extensive technology inventions of the earlier 2020s, will be in use.

An imperative important in the changes that will occur in the world of software engineering in 2025 will be the development of artificial intelligence (AI). Lowry [1] explains the adoption of AI techniques as tools to enhance the efficiency of prototyping. Moreover, AI techniques are useful in the establishment of flexible and easy to modify systems, especially in innovative environments. It also creates a stable foundation in the evolution of user-friendly information systems [1]. The use of AI programming models in 2025 will provide easier modification and maintenance of software programs. Consequently, the advantages of AI models encourage their adoption in different conventional fields including graphic user interface, constraint-based and objected-orientated programming [1]. Automotive systems will be able to interpret different codes without needing a human presence. The use of AI will explain the increased challenges in the world of programmers. In 2025, there will be a need to develop more software models compatible with future technologies.

SOFTWARE ENGINEERING IN 2040

Progressing from 2025, one looks to 2040. The world will be in a constant state of development engineered by advances in the fields of technology, science, mathematics, and engineering. By the year 2040, as described by Boehm [8], most of the population will be knowledgeable about software engineering. The extensive use of software products and applications in society will steadily rise. In particular, the need to solve problems persistent in the community through the application of technology will be a leading contributor to the adaptability of software programs in everyday life. Software engineering [13] will point to a significantly advanced scale of software to manage the future challenges inherent in humanity. Industries and business firms are realizing the need to adapt automation as a strategy to increase output and compete for market leadership. An example of progress in the application of software includes the current 500-million codes that manage health care insurance. It is important to note that the use of code will continue in the decades to come. In particular, Software Engineering [13] indicates a change in government policies and services to incorporate the application of software technologies. According to Boehm [8], software provides a solution to competitive markets, particularly through the differentiation of products. The public will become more advanced in software programs like data management and is in fact already reaping its benefits. Nevertheless, with the growing population of software engineers, it is highly likely that more challenges will develop, especially in designing programs and integration of operations.

In regards to Boehm [8], the use of electronic equipment is growing rapidly, particularly in developing countries. Electronic equipment provides humans with e-tools to efficiently manage tasks and improve performance. It is in the author’s opinion that by the year 2040, the performance of activities will heavily rely on electronic machinery. The imperative is the ability of this equipment to handle tasks, which will be a result of carefully designed software programs. Already, challenges in the economic sector are forcing companies to decrease their employment rates. Moreover, firms are opting to invest in automation as an alternative to increasing output without incurring massive expenditure in wages and taxes.

Knowledge in software development is likely to integrate with other relevant disciplines. In particular, Boehm [8] notes the growing relationship between software engineering and other forms of engineering. As described in the article, the current trends point to interdependency in knowledge, especially in the scientific fields. Therefore, by 2040 experience in software development will be available in multiple areas both scientific and nonscientific. Its application in other vital areas will be of great benefit. Moreover, the population will need such skills to develop even more useful ideas to tackle the challenges of the time. As developments in different fields progress, so does the complexity of problems. Therefore, with an obsolete direction in software engineering, most of the world population will be in a position to utilize software or understand its operation.

A state-of-the-art implementation of software engineering in 2040 will include the use of network-centric systems of systems (NCSOS). This type of system will revolutionize software architecture to include a spiral process model. An advantage of the systems of systems network will be the production of more efficient means of addressing problems in the world of software. Nevertheless, there will be more user-based programming models. Much of these programs will be highly user-friendly, allowing an easier integration with other software packages. Boehm [8] explains the production of new products using exploratory development processes. The process will be more active in fields such as biology, biotechnology, and nanotechnology. The application of the process will be a factor in the need to provide the population with robust, reliable, dependable, and highly cost-effective programs to meet the increase in demand.

Software Engineering [13] explains neural-embodied and augmented programming. The realization of brain-interface will be a possible development of software engineering of the 2040 period. The development of the technology will involve creating accounts for mental capabilities in line with the stressors of the time. Moreover, other important factors that will need consideration in developing software in 2040 include the age of the population and human memory capacity. The creation of software will incorporate passive technologies by the application of both biological and neurological sensors to produce functional prototypes [13]. Sensors will collect signals whose uses include the provision of feedback. The availability of feedback places developers at a position of advantage in designing the models of the programs.

It is worthwhile to note the increasing shift of software towards cloud computing programs. The shift contributes to the benefits of internet-based computing that further achieves better and efficient data management. The system is highly versatile and cost profitable. By 2040, with an increase in the human population, a majority of software will operate under cloud computing systems. In regards to Jaworski et al. [9], the inevitable shift includes the application of cloud computing foci on the scalability of the scheme. Jaworski et al. [9] further provide an example of the future of managing heavy traffic in major cities [9]. The paper supports the application of cloud computing in the development of an intelligent transportation system, AI, the IoT, smart devices, automated data security, sensor technology and many other advanced interfaces for the general public. Automated and self-driven cars will be available in 2040.

MAJOR PROBLEMS AND CHALLENGES OF SOFTWARE ENGINEERING IN 2040

The major challenge of 2040 will be how to handle the bulk of data originating from different sources in an efficient manner. Moreover, based on Lethbridge et al. [5], the increased use of software will bring about the challenge of updating documentation. Much as it is a problem today, one can only imagine the magnitude of the problem in the decades to come. The adaptation of automation to solve problems in industrial production is not without challenges. Based on Vogel-Heuser et al. [10], a change in one sector of engineering affects other integrated areas. In particular, the development of new products to meet the need to automate requires a combination of technology and system engineering. The urgent challenge is how to integrate the different development phases of the various disciplines in creating the end-product. Moreover, Vogel-Heuser et al. [10] highlight the difficulties in managing automation during the engineering stage. Consequently, there will be a need to continually adjust the development of appropriate software to meet the engineering technology of inter-operate systems.

It is important to consider the end-user as a necessary power in challenging the software engineering of the future. Vogel-Heuser et al. [10] note that, in automation, software developers will face the problem of designing programs suitable for different customer needs. Nevertheless, there will be an issue with the development of an integrated system for managing the various end-user applications. As mentioned, the trends in software engineering point to the development of interconnected systems to handle the increasing demand of software solutions in everyday life. Furthermore, as noted by Vyatkin [4], the growing demand for dependability in automation will reciprocate in an increase for development of more formal models in the software. As a result, engineers in the field will need new tools to meet the demand. Regarding the challenge of managing ultra-large systems (ULS), Northrop, et al. [12] describes three critical challenges including monitoring and assessment, design and evolution, and orchestration and control. The three sets of problems in the ULS highlight some of the key characteristics that developers, lawmakers and society as a whole will be prone to experience in 2040. To a greater extent, it will be challenging to efficiently develop a quality system that manages to integrate different end-users while still remaining highly efficient.

One cannot ignore the importance of power in running software programs. Fuggetta and Di Nitto [11] highlight energy consumption, which creates a significant challenge at present and will continue to do so in the future. The advent of mobile smartphones, AI, tablets and other mobile devices influence the shift to portable devices. Moreover, with automation inevitable in the future, the population will turn to online sources of work, which indicates a high dependency on mobile equipment. Consequently, software developers will be forced to develop programs that are concerned with power. Additionally, it will mean a redesigning of hardware resources to meet energy consumption, security, quality, testing and various dependencies between these processes.

The relevance of software developers will continue to decrease with the development of AI [14]. A significant factor contributing to their decline in performance will be the availability of web-designing tools available to the public. A disadvantage of these tools is that they do not require software. Moreover, AI replaces human input in developing and managing software. Therefore, only a few developers will be needed to achieve the different automation necessary in various industries.

VISIONARY IDEAS TO OVERCOME PROBLEMS AND CHALLENGES

As discussed in this paper, software engineering faces multiple challenges. In particular, with the advancement of its use in solving current and future problems, it becomes necessary to identify probable ideas to tackle problems in order to continue enjoying the benefits of the software. Therefore, I believe the development of a self-adaptive system will provide an efficient means of integrating the needs of different users. According to De Lemos et al. [2], a self-adaptive system will manage to self-configure, allowing a smooth operation for the various requirements of the users. Moreover, a self-adaptive system comes with the advantage of being reliable, energy-efficient and dependable in an ever-changing environment.

The system should be able to incorporate different languages to manage uncertainty. The availability of multiple languages makes the system flexible and much easier to understand, especially for the user. In regards to the change in the run-time management of different systems, it is my opinion that a possible solution would be to develop a universal program in run-time management. The program should work with a command line language to allow different software to work simultaneously without error.

Power conservation is a field worth mentioning because it will require new ideas to meet the ever-increasing demand for power. The author believes designing an automatic power monitoring system will ensure that software and hardware conserve energy. Suggestions from Gubbi et al. [7] concur that the need to manage energy use in the future will surpass production. Home use regulation of energy allows people to be directly involved with the IoT. Similarly, the use of a power monitoring system will enable people to monitor their power consumption at any given place and time. I further hold the opinion that surveillance systems should incorporate time factors whereby the supply of power to run the system is under time regulation. An advantage of this model will be the active management of energy since it will only be available for software use at a designated time of the day.

Gubbi et al. [7] further explain that effective power consumption is attainable by the application of a continuous monitoring system. Information obtained will assist in designing energy-conserving hardware. Moreover, it will be quite relevant for future research on software engineering. Currently, power conservation measures address the regulation of its use in domestic appliances. Therefore, with the increased use of software and its applications, it is quite essential also to design methods of conserving energy.

CONCLUSION

It is evident that software engineering provides a solution to present and future social challenges in everyday life. Critical areas concerning the current state of the art and practice in software engineering include the ability of the software to meet the desired user goal. The imperative is the ability of the model to integrate different users and manage different levels of uncertainty. Having looked at the current issues in software development, I project by the year 2040 that some of the outstanding features of software engineering will be rapid automation, advances in cloud computing, software solutions in all aspects of life, and interdependency of software engineering to other fields. One of the key future challenges in software engineering will be data management. There will be extensive data originating from different programs, making its management difficult. In the future, there will be a need to develop creative ideas to manage challenges in the discipline. The author recommends the application of power conservation measures through a monitoring process to regulate the amount of energy consumption, the development of a self-adaptive system, and the creation of more software. For effective software engineering, the major contribution and effort required is high-quality learning and implementation. Through such experiences, a professional software engineer will deliver ideal innovations in future technological generations.

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Software Process

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Abstract

This paper describes the journey of the Software Process research. It provides a summary of the current research and practice, discover new challenges, and suggest an uncomprehensive list of Software Process issues that need to be investigated by future research.

Introduction

Software is becoming fundamental component of our daily activities. Software is impeded in almost every activity in our society from personal activities to business and work-related activities. To name a few of these daily activities that are governed by software: software has been an important constituent in social media, education, communication, economics and business, homes, civil and industrial infrastructures, and automation of our daily activities. Accordingly, software development and its process has to be studied and reviewed to be able to support the new trends and future social needs.

Software Engineers have been studying the previous problems and issues in the previous five or six decades. Software Engineering research focused on the software process by trying to understand, describe, evaluate, automate, and improve the techniques, policies, and procedures being used to control this type of process. Even though, many of these research initiatives in software engineering process have produced many remarkable results, many of those research initiatives and objectives have been poorly modeled or exaggerated, whereas others went unnoticed. However, there still many problems are awaiting to be addressed using authentic methodologies.

This research paper has the following structure:

- Section 2 reviews the history of software applications.
- Section 3 reviews the trends of the Software Process research during the 90’s
- Section 4 reviews the trends of the Software Process research during the 2000’s
- Section 5 Identify the emergent challenges and demands coming from the market.
- Section 6 Recommend some guidelines and propositions for future research.
- Section 7 Concluding remarks.

1. Overview of the Journey Software Applications

In the late 40's and early 50's the first computer programs used binary code (Machine Language) to tell the computer what to do, by entering long strings of binary code. They entered data into the computer by turning switches, or punch cards. From the late 50's to the late sixties software engineers developed specific languages to work on specific machines (Assembly languages).

By the early seventies high level languages, operating systems and computer networks started to emerge such as Prolog, basic SQL, DOS, SAS, Dbas, Unix, VMS, Ethernet, and telnet. During the 1980's new line of computers called personal or desk-top computers have seen the light by Apple computers and later by other computer manufacturers. More advanced high level programming languages were developed such as Pascal and C languages. More advanced operating systems and networks were developed such as OS2, Windows, and TCP/IP. During this decade new general-purpose software started to see the light such as Databases, word-processing, spreadsheet, and presentation software.

During the 90's new line of mobility computers have emerged which are called Laptops. High level languages started to take new approach by developing object oriented languages instead of procedural oriented languages such as Java and C++. Linux operating system was developed during this decade. The 90's have seen the rise of the internet and new software business model which is called browsers. During this decade new computer languages that are close to human languages have emerged. These languages are called script languages such as Java script and XML. Moreover, new web-based software business concepts have begun to see the light, such as search engines, and personal and institutional webpages. Examples of these are Yahoo, and hotpot. Microsoft has released many versions of windows and the most important one is Windows 95.

The first decade of the new century has seen many developments in terms of social business models. New ways of social interactions that are depicted by software applications have emerged. It became a reality where Friends, collages can communicate, chat, and exchange data and information instantly as if they are in a face to face situation. Some early examples of applications that provided such type of communication are Facebook. Voice calls and video called have become ubiquitous. The internet has become more interactive where users can modify data and information instead of just accessing them. This decade has seen the rise of more mobility type of smaller in size computer machines such as notebooks, tablets, and smart phones. Such machines required an updated version of the existing operating systems, and software applications. New operating systems have come into existence for such machines such as Androids. This decade has seen the rise of new concept of data storage and computing which is called cloud storage and cloud computing.

During the 2010's smart technologies and autonomous software systems, have started to see the light. Billions of sensors, cameras, impeded systems are scattered around the world in our infrastructures which opens the road for sensing the environment around us. Humans are becoming more connected than ever. Data and information is becoming pervasive. New concepts of application ownership and marketing (store for applications, App stores) such as App store from apple, Play store from google, and Galaxy Apps from Samsung. Cloud storages is becoming universal such as Dropbox, and google drive.

Even though many of the human tasks have been automated by software during the modest small period of a half a century of the age of software engineering, software engineers are looking ahead for autonomous software systems where decision making is handed over to machines. The semi-autonomous cars started to penetrate the market such as cars from Tesla and legacy automobile manufacturers. It is expected that in the next 5 years that fully autonomous cars will become available to consumers and business sectors.

2. Software Process from 1987 to 2000

At the turn of the century, it was evident that researchers and experts have started to question the value of the research results achieved in the 90's. In addition to that there was a strong feeling among researchers in software engineering that research in this area has reached a turning point and needs to be rethought. There were unanswered questions about the research in the last decade. Did the research address the problems faced by developers, or the research was just an intellectual exercise. Did the research affect the real-life scenarios of the way software is apprehended, developed, deployed, used, and managed? The researcher in [1] investigated four main Software Process research areas during the 1990's.

The first area of research was Process modeling and support. Since the software process involve many diverse entities such as professionals, organizations, policies, tools and different support environments, Models and languages for describing such processes is very essential. Many Process Modeling Language (PML) were created as a result of this research. These languages dealt with issues such as inconsistency management and integration of different developers.

The second research area which was investigated was Improvement of the software process. Since the activities of developing software are inherently dynamic evolving continuously over time, it is vital to identify research approaches to learn if such process has reached maturity and to improve it. The third area of research in research process that was investigated is metrics and empirical studies. It is the assessment of the behavior and performance of software process. Many researchers proposed and established techniques for empirical studies. Such metrics were able to evaluate the performance of the software processes. The last are of investigation were the real applied processes such as the Unified Process and the Personal Software Process. The research in [2, 3, 4] attempted to assess the significance, quality and areas of improvements for the identified four areas of research during the 1990's. These papers identified a number of criticisms.

The problem with previous research is that it did not recognize Software Processes as human-centered processes [5]. It is important to realize that software processes have common ingredients with real life processes [6], so it was not worthy to think of software processes as distinctive entities that needs an autonomous and separate research area. For example, it could have been very useful if researchers studied workflow management, as it could have given them a good insight about the software process.

The second problem is that researchers did not also realize that Software Process Improvement is also a real life process improvement. Therefore, they ignored other contributions from other disciplines. The third problem has to deal with the purpose of process languages. The purposes of these language must be redefined. It was found that most of the developed languages are complex, not dynamic, hard to apply in real situations, and hard to see their impact on software development practices and policies. The fourth problem is that empirical studies become a research exercise with no concrete relevance.

4 Software Process in the Past Decade

In the last decade, Software Process research have changed dramatically. Some of the previous research issues at the end of 90's were addressed, in particular the recognition that the Software process is multi-disciplinary. For example the Capability Maturity Model which was used during the 90's was replaced with a new one called Capability Maturity Model Integration. The new model CMMI adds the role of **the** organizational factors.

Currently the research direction does not pay much attention to modeling and processes execution, as they have realized that full automation of processes is limited to specific phases of the process such as code generation. Researchers have also reached a consensus that software process performance is framed by the conduct of organizations and individuals [7].The following subsections draw the big picture of the research trends that were characterized by this shift.

4.1 Social Aspects

Research during the past decade have been gradually realizing the effect of social features on software processes. The literature review of social organizational structures by [8] has identified certain social process that are appropriate in the software processes domain. The study by [9] concluded that the availability of technology does not always improve performance of individuals in an organization. However, improvement happens as a result of proper interaction between individual-centered social aspects and technology. Therefore, the two element can't be studied in isolation.

The researcher in [10] by interpreted the socio-technical systems in the software process environment by employing the socio-technical congruence to express the fit between product dependencies, the resulting task dependences, and the actual coordination activities occurring during the development process. The research in [11, 12], concluded that in order to improve the performance of the software process, it is very important to identify the coordination requirements represented as task dependencies in a timely manner.

4.2 Agile Software Development Approach

Due to the importance of the interaction between software development process and social aspects, and the realization that the process can't be a rigid process as represented by the water fall process, a group of software engineers created general principles for developing software and software process. Agile software development is a class of software development methods where the process is dynamic and involves self-organizing, cross-functional teams that respond quickly to changing in requirements at any phase of the development life cycle.

The Agile principles are:

- Deliver a valuable product in a timely manner.
- A customer can change the product requirements at any time in the development process.
- Incremental, and spiral approaches, frequent product deliveries are essential traits
- Close interactions and face to face communication between customers and developers are required.
- Projects implementation require motivated and trusted individuals.
- The metric measurement of project progress is a working software.
- Sustainable Software Process, able to maintain a constant pace.
- Always paying attention to excellence and excellent design.
- It is very important to use simple procedures and not complicated procedures.
- Working teams should be self-organized.
- Teams should always reflect on their effectiveness and adjust accordingly.

The Agile Software Development initiative has generated many methods. One the emerged methods which is very popular and successful is Scrum [13]. The Scum process is organized in gallops, i.e., development stages, a maximum of one month each. Every gallop is focusing in developing a specified features. The developing teams hold short daily meeting to discuss what they have been doing the day before, what they are going to do today, and if there are issues to discuss. User requirement changes are welcomed and implemented in future gallops rather than the current one. At the end of each gallop, the features of concern should fully implemented, verified, documented, and shipped to the customer.

Scrum has shown its applicability according to several studies and experiences. One of these experiences is application of Scrum at Google [14]. At the beginning stages of the development of any application neither the customer nor the developers have the full realization or requirements of the complete application. However, the big picture is realized. So Scrum allowed developing teams to have full control over the process by prioritizing features, frequent deliveries, realistic deadlines, and frequent customer feedback.

Another method that belong apply Agile principles is called the Lean method. The main principles of the Lean methodology is eliminating waste during the development process. This method considers any additional feature in the application or an additional activity in the process that does not add any value to customer as a waste [11]. These none value concepts include Partially done work, Extra processes, Extra features, Task switching, Waiting, Motion, Defects, Management activities.

4.3 Global Software Engineering (GSE)

Agility is more challenging when development teams are distributed across different countries [5]. In such situations, development teams may face a number of needs: One challenge is to establish continuous communication with customers and teams at different locations. Another consideration is deal with the availability of remote workers, and to lower costs by basing part of the process to a remote organization. To that end, researchers have realized the essentiality of developing GSE procedures.

Researchers have studied these emerging challenges, and have identified tools and approaches to tackle them. One stream of studies focuses on how applicable many of the agile methodologies and more specifically Scrum method to GSE [15]. Other study streams of studies talk about the effect of the development process architectural choices [16]. Yet others study the effectiveness of exploiting pioneering tools to sustain awareness. Other studies tell success stories of cooperation [17]. However, despite the big amount of research in this area, it is very difficult to induce general conclusions from the proposed solutions that have been suggested by the research community.

It is generally agreed that success is determined by the capability to create effective mutual relations and trust between software developers. However, research has not proven that we can use such methods in a GSE [5].

4.4 The Role of Empirical Software Engineering

Empirical studies in software process have seen considerable progress. The studies used methodologies of good quality, where their proposed results have good external validity. The paper in [18] focused the evaluation the methods used in empirical studies, investigating their advantages, disadvantages. Moreover, there are many ongoing research studies, such [19] focusing on conscientious empirical studies aiming investigating the advantages of some new human-centered approaches, practices, and methods. Yet other research directions are aiming at demonstrating the validity of a research hypothesis [20].

The incredible growth of open source projects, has opened new frontiers for empirical studies. Many of older imperial studies were hard to repeat by other researches, because of the scarcity of open projects that lead to the scarcity of data and observations available for the studies. Thus, the quality and finding of such studies were negatively affected. The growth of open source projects has enhanced the amount of data and observations used by researchers. As a result, large scale empirical analysis became possible, resulting in a substantial improvement of the quality and validity of the empirical studies and their findings.

4.5 Model-Driven Engineering

It is an approach to software process where each business sector is matched with an abstract shared requirements, so projects for any business with in this sector are similarly developed. Such driven models improves traceability, automatic code generation for targeted platforms.

Model-Driven Architecture (MDA) version1.0.1 is a main example of such models that was released in 2003 [23]. Even though it was planned to be replaced by a new one by 2005, the new version has not seen the light yet. However, research around MDA is still rolling, as seen from the many conferences and workshops such as MODELS-2013 are devoted to software engineering model-driven approaches.

The MDA approach describe the system to be consistent three different models. The first model is the Computation Independent Model (CIM) that describes requirements, enterprise architectures, and business models for specific business. In this model, the general business logic in the application is described and modeled. The second model is the Platform Independent Model (PIM) elements of the system that are specific the system platform are abstracted. The third model is the Platform Specific Model (PSM) where features that are specific platform (e.g., Java Platform Enterprise) are described. Once a given platform is defined, the given PIM model will be transfigured into PSM model, appropriate for automatic code generation.

Even though industry has not fully adopted Model-Driven, research has some worthwhile case studies. [21] Provided some suggestions on how to adopt model-driven approach in maritime and energy companies. One of these companies have used Model-Driven Engineering for a process of safety certification, thus guaranteeing safety requirement traceability.

4.6 Application Life Cycle Management

These are a group of software products that offer automation for some activities of the application life cycle such as generating ready code, testing, and for mapping managerial responsibilities with software development life cycle.

The ALM tools currently do not provide any integration with in the software processes. However, the integration of software development is the objective of the DevOps. DevOps creates a set of procedures and principals for collaboration between IT departments such QA, and operations. This involves cross-functional teams from deferent department responsible for the development of the application. Team performance is measured by the quality and stability of the final product, rather than traditionally measurement of productivity. The case study of [22] narrated that Amazon cross-functional teams are totally accountable for the operation and development of a class of services.

5. Major Challenges

The first class of challenges comes from the fact that the internet is becoming the development environment for most of the applications. Development and required collaboration over the internet is becoming very common across departments and teams with in a single organization, across different organizations, and across dispersed individuals. So, the concept of development environment, development-team have been fundamentally redefined. Current software development is no longer a rigid or isolated process, but it is the product of interaction, integration, and cooperation amongst developers and between developers and end-users working in a connected environment [23]. This requires great change in approaches governing the software development stages. One example of such changes is Crowdsourcing [24]. This require from us to develop profound methods of deployments and updates. Also, we have to develop methods to operate on internet wide scale.

Currently different applications are developed for different purposes. Some of these applications their life time does not exceed two weeks, others are real-time applications where security, privacy and safety are important. As a result of that a more dynamic software process that takes into consideration these different contexts must be realized.

The second group of challenges come from the fact that the Internet is becoming the execution environment. It has become the trend that real time and none real time applications are executed over the internet. In the past decade new trends have come into existence. These trends include Internet of things, Smart services, connected cars, disappearing computers, Cloud computing, IaaS), PaaS, and (SaaS). These trends create new challenges to the software process and to the development process. How developers will be supported to deal with these new trends? Does the increasing scale of the internet has an impact on the existing development process? How are the users involved?

The third class of challenges pertain to the fact that user are mobile fanatic. The change from traditional computing devices (e.g. laptops, desk tops) into mobile devices (mobiles and tablets) creates new challenges to software developers and to the software process. The new devices unveil new models of user interaction. Thus, new type of user interfaces must be defined in terms of increased user usability and new interaction contexts. We need to define new models that are able to make use of the underlying characteristics of these new devices. So, it is mandatory to integrate software process and methods with the industry design process techniques and methods. The software development process should take into consideration the final varying reliability of the internet connection. Software development process should take into consideration device power consumption.

The fourth class of challenges is related to the fact that the internet is the fundamental distribution environment. Once bugs and faults are discovered, developers need to rush updates more frequently through the internet. Since development is not any more confined by local markets, software demands should adhere to the specific requirements and restraints of such market.

The above trends created new distribution echo systems and business models such as the tens of app stores. Most of such apps are not developed by legacy development companies, but small developers and individuals who are scattered around the globe. On the other spectrum software, the role of the operating systems is becoming less and less important as applications are becoming more and more web-based. Applications are becoming independent of operating systems and dependent on browsers.

6. Research Issues and Directions

The trends in the previous section are extremely evolving and complex. Thus it is very important to continuously reassess the research directions mentioned in section three even though many of these research directions deal in one way or another with the current and future trends mentioned in section four. This reassessment of current research directions help researchers pinpoint overlooked topics, emphasize important ones, and find convincing answers to others

6.1 Convergence instead of strict compliance

Most of the development activities can't be strictly automated (section3), because development process is human-centered and has to be very dynamic. So, it is not beneficial to force developers to follow strict and rigid step-by-step procedures. That does not mean that there are few development activities that are inherently repetitive and can be automated such as configuration management and software deployment. In software development irregularity is a winner, where regularity is a loser.

Therefore, instead of emphasizing total adherence to a strict set of rules and procedures, we must make sure that the process is elastic and converges toward the desired outcome. So here the convergence is essential and strict compliance is not essential. Convergence means that irregularities are dealt with, managed and controlled by developers as they occur.

Even though many development companies claim that they follow a successful agile methods, most of the development activities are still implemented using the sequential water fall processes. So it is very important to find new approaches, methods, designs, and solutions that adhere to agility and convergence.

6.2 Software Process Visualization

To be able to understand a phenomenon, we must understand its behavior. In section 3 we have seen some existing tools that produce matrices as a result code analysis and testing. However, such matrices are not adequate enough to fully assess the evolving complex development process. So, it is essential to realize new assessment methods to represent development process. What we need is not just an improvement over the current tools and matrices, or more appealing interfaces, however what we need is new archetypes of enabling technologies that are able to spontaneously describe the state of a process.

6.3 Privacy, and Security

Software is becoming available anywhere, any time, and for every individual. Big systems are composed of distributed connected components such as legacy computers, mobiles, servers and millions of sensors. So such mobility and connectivity has consequences on security and privacy. Security threats can propagate from any component of the system.

Is the software process equipped with tools that can assess the level of privacy, and security of the developed systems? Do we have methods and tools that can prove to customers that the developed application has acceptable levels of privacy and security? Is the issue of privacy and security the responsibility of the customer, developing company or has a shared responsibility?

Research should detect and study these issues and threats, assess the impact that these issues can have on development process, and recommend threat management and control methods. We can't ignore these issues and pretend as they are of concern for every entity from individuals to organizations all over the world.

6.4 Business and Organizational Models

The large mesh of approaches used to visualize software, and the emergence of mobile service, stores, and open source software have fundamentally changed the structure of the software market. Software is becoming very complex product. First of all, software is considered a consumer product whose cost is determined by the characteristics of that market. Second of all, Software components are impeded in most real life complex products and services. For those two reasons, it is becoming harder to find business models that is characterized by customer satisfaction, investments return, and novelty assurance.

Many legacy software organizations are driven to change the models of their business, the position of their market, and the focus of their product. For example, Microsoft has transformed it product from client application and positioned itself as a cloud computing oriented (IaaS, SaaS, and PaaS). It is a necessity to analyze such change in position to avoid inappropriate commoditization of software, as software is not a commodity and not a free product.

Conclusion

The involvedness of software have been radically increasing over the past 3 decades. These days, software is impeded in aspect of human life e.g. Products, services, or process. These changes are imposing challenges on software development teams. Groundbreaking and new approaches are needed to overcome the involvement of software development activities. As a result of that, the Software Process research plays a fundamental role in all organized communities and organizations.

During the past decade, software process shifted from modeling, and automation of software, to attending to nonfunctional human-centered issues by investigating multidisciplinary approaches to human-centered models. This type of shift require from us continuous focus on investigating related research disciplines, benefit from experiences and knowledge of other industries, initiating experimental long-term activities using empirical and case studies. The Software engineering community need to be understanding of current trends in the market and the society, as there is no single unique approach to the challenges facing the software process research. Software Process research is exceedingly complex and multidimensional. We should make use of the know-how that is available in other discipline domains.

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Soft soil stabilisation using ground granulated blast furnace slag

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Abstract

A Soft soil has significant problems, most importantly poor shear strengths and high compressibility. Being present in engineering projects locations, remediation becomes essential to prevent excessive post- construction settlement and to avoid insufficient bearing capacity. Chemical soil stabilisation is the most popular technique for remediation of such poor ground conditions. Cement and lime are the common traditional stabilisers that have been incorporated for stabilising the soil. However, the high environmental and financial cost associated with cement and lime raise the need to identify new more sustainable alternatives. Thus, researchers have investigated the utilisation of waste and by-product materials that possessed pozzolanic or hydraulic characteristics as a replacement for cement and lime. This paper presents the results of a laboratory study on the stabilisation of silty clay soil collected from the shoulders of the River Alt situated in Hightown to the north of Liverpool using a ground granulated blast furnace slag (GGBS). The influence of GGBS on the physical and geotechnical characteristics of the soil such as Atterberg limits, compaction parameters (maximum dry density (MMD) and optimum moisture content (OMC)) and soil strength (unconfined compressive strength (UCS)) has been investigated. GGBS was added in various percentages (3, 6, 9 and 12%). Improvement levels were indicated by UCS testing carried out on specimens after 7 days of curing. Results indicated increase in the maximum dry density increased and decrease in the optimum moisture content with increase the GGBS content up to around 9% after that .i.e. at 12% the MDD and OMC gave reversed trend. In term of Atterberg limits, the liquid limit decreased, the plastic limit increased and plasticity index decreased with increase GGBS content. Based on the strength result obtained from UCS test, 6% of GGBS by the dry weight of the treated soil is the optimum binder to stabilise the soft soil.

Keywords: ground granulated blast slag, soft soil, soil stabilisation, unconfined compressive strength.

1. **Introduction**

Soft soil is considered as one of the most problematic soils in civil engineering because of the high degree of compressibility and instability, low permeability, low compressive strength (less than 40kpa) and potential to swell with high water content as it contains minerals such as montmorillonite that are able to absorb water (Bell, 1992; Rajasekaran, 2005; Nordin, 2010; Mohamad et al., 2015). Therefore, when soft soil is encountered in locations designated for civil engineering projects, the possible alternative solutions can be either abandon the site, or remove and replace the soil. However, these solutions are not always feasible and they can be expensive. Thus, researchers have investigated improving the engineering properties of the native problem soil by several methods, most importantly soil stabilisation (Makusa, 2012; Jafer et al., 2015; Kumar and Kazal, 2015). Soil stabilisation is the process of amending the physical and geotechnical characteristics of the soft soil such as strength, permeability, durability and compressibility either mechanically or by the addition of chemical stabilisers to be suitable for construction and meet engineering design standards including permanency (Makusa, 2012). Cement and lime are the most important traditional stabilisers and have been investigated by many researchers (Miura et al., 2002; Al-Tabbaa, 2003; Raoul, et al., 2010; Farouk and Shahien, 2013; Kitazume and Terashi 2013 and Önal, 2014).

However, cement production has many drawbacks such as carbon dioxide emission (CO_2), energy consumption and natural resources exhausting. The production of 1 tonne of cement leads to consume 1.5 tonnes of natural resources, consumes an energy of 5.6Gj/tonne and emits 0.9 tonne of CO_2. Thus, the manufacture of cement is responsible for the production of about 5% of total anthropogenic CO_2 emission (O'Rourke et al., 2009). The cement market is expected to grow at rate of 5% each year. The negative environmental impact of cement manufacture in addition to the high cost has encouraged researchers to find sustainable alternatives to replace cement partially or totally in soil stabilisation. These materials are called supplementary cementitious materials which are waste or by-products and possess hydraulic or pozzolanic characteristics such as fly ash (FA), rice husk ash (RHA) and GGBS (National Ready Mix Concrete Association, 2000). The use of the waste and by-product materials for soil stabilisation can help mitigate the issues of disposal and environmental pollution (Jafer et al., 2015).

The potential of using GGBS to stabilise the soils was investigated by various researchers. Sharma & Sivapullaiah, (2011) studied the use of fly ash and/ or GGBS with lime as a stabiliser added to a black cotton soil. Samples with various combinations were prepared and their characteristics were investigated through compaction tests and unconfined compressive strength. The results showed a decrease in the OMC and MDD with the addition of GGBS to the soil. The increase in the fly ash- GGBS content increase the UCS.

Manjunath.et al., (2012) carried out research on the influence of GGBS and lime on the unconfined compressive strength properties of black cotton soil. Lime and GGBS were added in various combination with curing of 0, 7 & 28 days. The results showed that soil stabilised with GGBS and lime gave strength higher than that with lime only. The optimum mixture identified that with 30% GGBS and 4% lime, the strength was 18 times more than the black cotton soil alone after 28 days curing.

Yadu & Tripathi, (2013) investigated the potential of using GGBS as a stabiliser for the soft soil. GGBS was incorporated at 3, 6, & 9%. The characteristics of the stabilised soil were indicated by compaction and unconfined compressive strength. The results revealed improvement in UCS with the addition of GGBS where 9% was the optimum percentage.

Ormila & Preethi, (2014) studied the effect of adding GGBS to expensive soil collected from Palur, Tamil Nadu at various percentages (15%, 20%, and 25%). They indicated that addition of GGBS can improve the unconfined compressive strength of the soil given that 20% GGBS is the optimum content with an increase in strength of 73.79% after curing of 21 days.

Goodarzi & Salimi, (2015) investigated the use of GGBS and basic oxygen furnace slag (BOFS) on the stabilisation of dispersive soil. The slags were separately incorporated from 2.5% to 30%. The properties of the stabilised soil were indicated by Atterberg limit, UCS, XRD and SEM micrographs. The results indicated that GGBS and BOFS enhanced the performance of the soil and that BOFS has higher activity when compared with GGBS.

The current study has investigated the utilisation of GGBS as a stabiliser for soft soil. The level of enhancement in the physical characteristics of the stabilised soil was obtained from consistency limits and compaction paramaters. The geotechnical properties were indicated using unconfined compressive strength at 7 days of curing. The soft soil was treated with GGBS at different percentages (0, 3, 6, 9 & 12%).

2. Experimental programme

2.1. Materials

a) Soft Soil

The soil was collected from the shoulders of the River Alt which is situated in Hightown to the north of Liverpool. The soil was taken from a depth of about 30cm and 50cm below the ground level. The extracted samples were placed in sealed plastic packs 20-25kg each before transporting to the research laboratory. The specimens were taken to measure the in-situ moisture content while, the other sub-samples of the soil were dried in the oven at 110C^{o}. The soil was then classified according to BS EN ISO 17892-4: 2014 and its consistency limits and compaction parameters measured in accordance to BS EN ISO 1377-2 and 4:1990 (British Standard, 1990) respectively. The chemical properties of the soil were indicated by conducting a chemical analysis. The characteristics of the soil utilised in this research are shown in Table 1. The classification of the soil indicated that it contains clay, silt and sand at 12.9%, 75.03% and 12.07% respectively. The characteristics of the soil presented in Table 1 along with the unified soil classification system (USCS) showed that the soil utilised in this study is a silty clay with sand (CI) and its plasticity is intermediate.

Table 1. The main engineering characteristics of the soil utilised in this research.

Characteristics	**Value**
In-situ Moisture Content %	37.5
Liquid Limit LL %	39.5
Plasticity Index PI	18.37
Sand %	12.07
Silt %	75.03
Clay %	12.9
Specific Gravity (SG)	2.67
γ d max Mg/m3	1.59
Optimum moisture content OMC %	22
pH	7.78
Organic Matter Content %	7.95
Unconfined Compressive Strength qu (kPa)	134

b) Ground granulated blast slag (GGBS)

GGBS is by-product materials produced from manufacture of iron. It mainly consists of lime, alumina, and silicate. There are similarity between GGBS and ordinary Portland cement in oxides types but not the percentage (Sha and Pereira, 2001; Oner and Akyuz, 2007). During the production of GGBS, its cementitious characteristics increases because molten slag chills rapidly after leaving the furnace. The rapid chilling leads to decrease in the crystallisation and transforms the molten slag into a glassy material (Thanaya, 2012). The chemical composition of GGBS utilised in this research is given in Table (2).

Table 2. The chemical characteristics of GGBS used in this study.

Items	**CaO**	**SiO**	**Al_2O_3**	**MgO**	**Fe_2O_3**	**SO_3**	**K_2O**	**TiO_2**	**pH**
GGBS	40.13	37.73	5.75	4.26	0.01	0.0	0.61	0.65	8.5

2.2. Mix proportion

GGBS used in this study was mixed with the soft soil in various proportions (0, 3, 6, 9 and 12%) by the dry weight of the soft soil to obtain the optimum amount for stabilisation.

2.3. Laboratory test

The physical and geotechnical characteristics of the soft soil stabilised with GGBS were investigated by the following tests:

- Atterberg limits tests- (liquid limit (LL), plastic limit (PL), and Plasticity index (IP)). These limits were investigated in accordance with BS 1377-2: 1990 (British Standard, 1990).
- Standard Proctor Compaction tests- were carried out to determine the maximum dry density and optimum moisture content. The standard compaction parameters tests in this study were conducted in accordance to the British Standard BS 1377-4:1990 (British Standard, 1990b). A sample for compaction testing was prepared by mixing 2000 g of dry soil with five contents of water. For each water content, the soil was placed in the mould and compacted in three layers, each with 25 blows using 2.5 kg hammer.
- Unconfined compressive strength test- was conducted in accordance to British Standard BS 1377-7:1990 (British Standard, 1990c). The samples for UCS were prepared by using the specific densities that were obtained from the compaction tests as the maximum dry density and water content that corresponding to the optimum moisture content for each binder type. Then, the samples were placed in the mould with 76 mm height and 38 mm diameter according to the standard requirements. The soil-binder mixtures in the mould were compacted for 5 minutes using hydraulic loading. This was following by extruding the specimens, weighing them, covering in cling film, enclosing in sealed plastic bags and storing for curing of 7 days at room temperature of 20+/- 2 ^{0}C. At least, two specimens were prepared for each binder percentage. After the curing, the UCS testing was carried out by utilising a computerised triaxial machine

and the value of the UCS was measured by subjecting the samples to vertical load only with no horizontal stress in the triaxial cell ($\sigma 3 = 0$).

4. Results and Discussion

4.1. Atterberg limits

The results of Atterberg limits of soil treated with 0, 3, 6, 9 & 12% by dry weight of the soft soil is shown in Figure 1. The figure shows that increasing the GGBS content resulted in decrease in the liquid limit and increase in the plastic limit. The Plasticity index decreased from 18 to below 15. These observations are in consistent with the results indicated by (Akinmusuru, J.O. 1990; Ouf , 2001; Yadu & Tripathi, 2013).

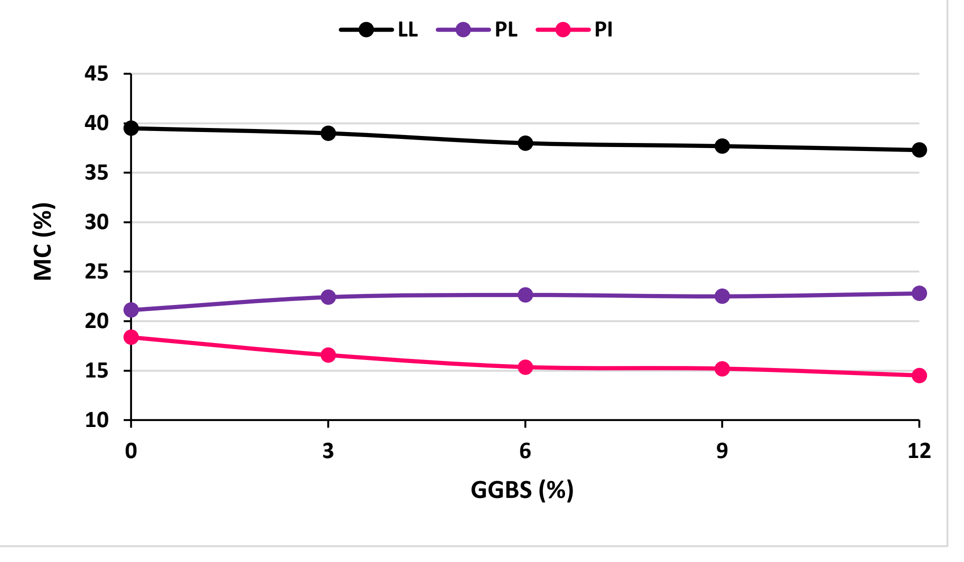


Figure 1. Atterberg limits after GGBS treatment

4.2. Compaction parameters test

This test aims to indicate the maximum dry density (MDD) and the optimum moisture content (OMC) for untreated soil and soil treated with various percentage of GGBS. The values of MDD and OMC are significantly important as they are used in the preparation of samples for other tests such as unconfined compressive strength, compressibility, and swelling potential. Standard proctor tests were conducted on the soft soil incorporating various percentages of GGBS (0, 3, 6, 9 & 12%). The results of the compaction tests which are shown in Figure 2 and 3 (a & b) indicate that increase GGBS content caused increase in the MDD and decrease in the OMC with increase the GGBS content up to 9%. By increase the GGBS content further to 12%, the OMC and the MDD increased and decreased respectively. This trend similar to that observed by (Akinmusuru, 1990; Yadu & Tripathi, 2013; Padmaraj & Chandrakaran, 2017). The increase in the MDD can be attributed to the specific gravity of GGBS (2.89) which is higher than that of the soil (2.67). While, the decrease in the OMC with increase GGBS content may be the result of decreasing the quantity of free silt and clay fraction with the addition of GGBS, thus the smaller surface area required less water (Yadu & Tripathi, 2013). However, the behaviour at 12% GGBS may be due to the higher amount of GGBS in the soft soil and decrease in the amount coarse materials so make it more difficult to attain good compaction (Akinmusuru, 1990).

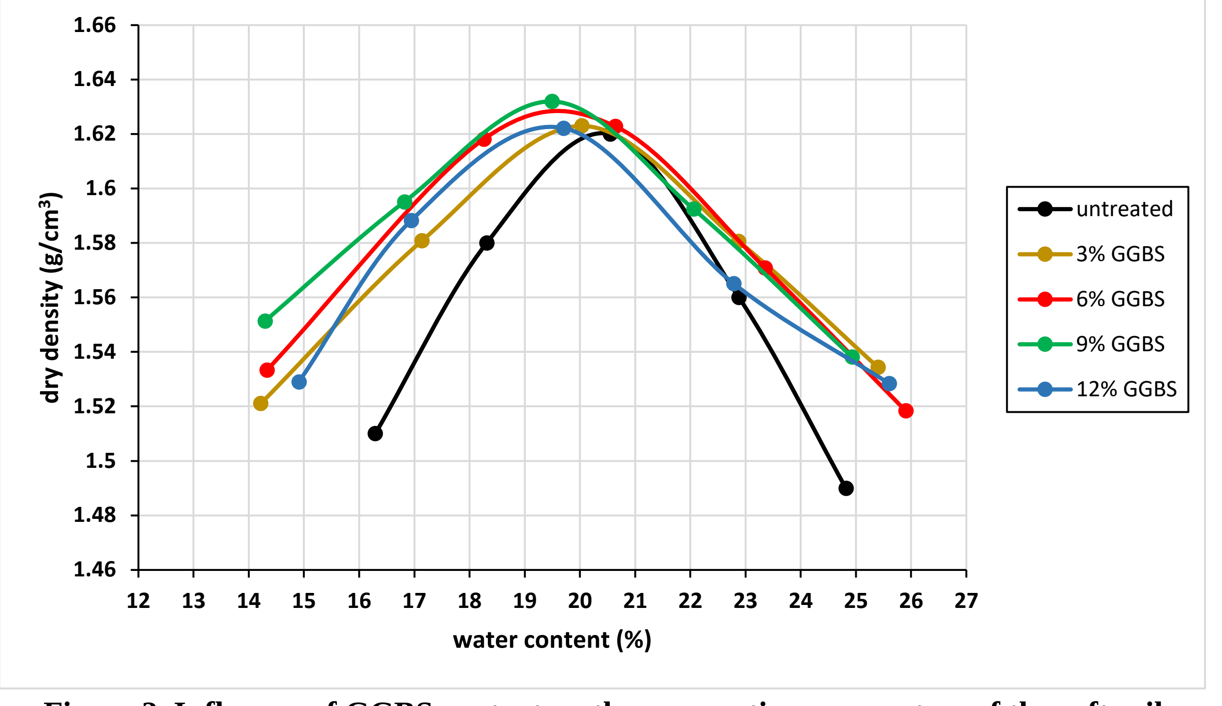


Figure 2. Influence of GGBS content on the compaction parameters of the soft soil

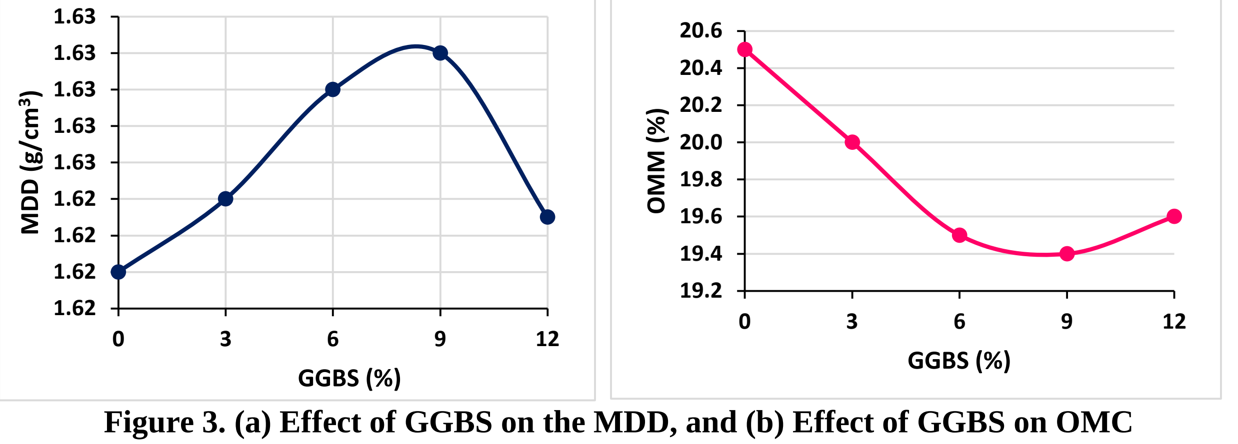


Figure 3. (a) Effect of GGBS on the MDD, and (b) Effect of GGBS on OMC

4.3. Unconfined compressive strength

This test represents a useful method to measure the shear strength of treated soil as it provides an indication of the effectiveness of the stabiliser agent used. The results obtained on soil stabilised with (0, 3, 6, 9 and 12% GGBS by the weight of the dry soil) after curing for 7 days are shown in Figures 4 & 5 below.

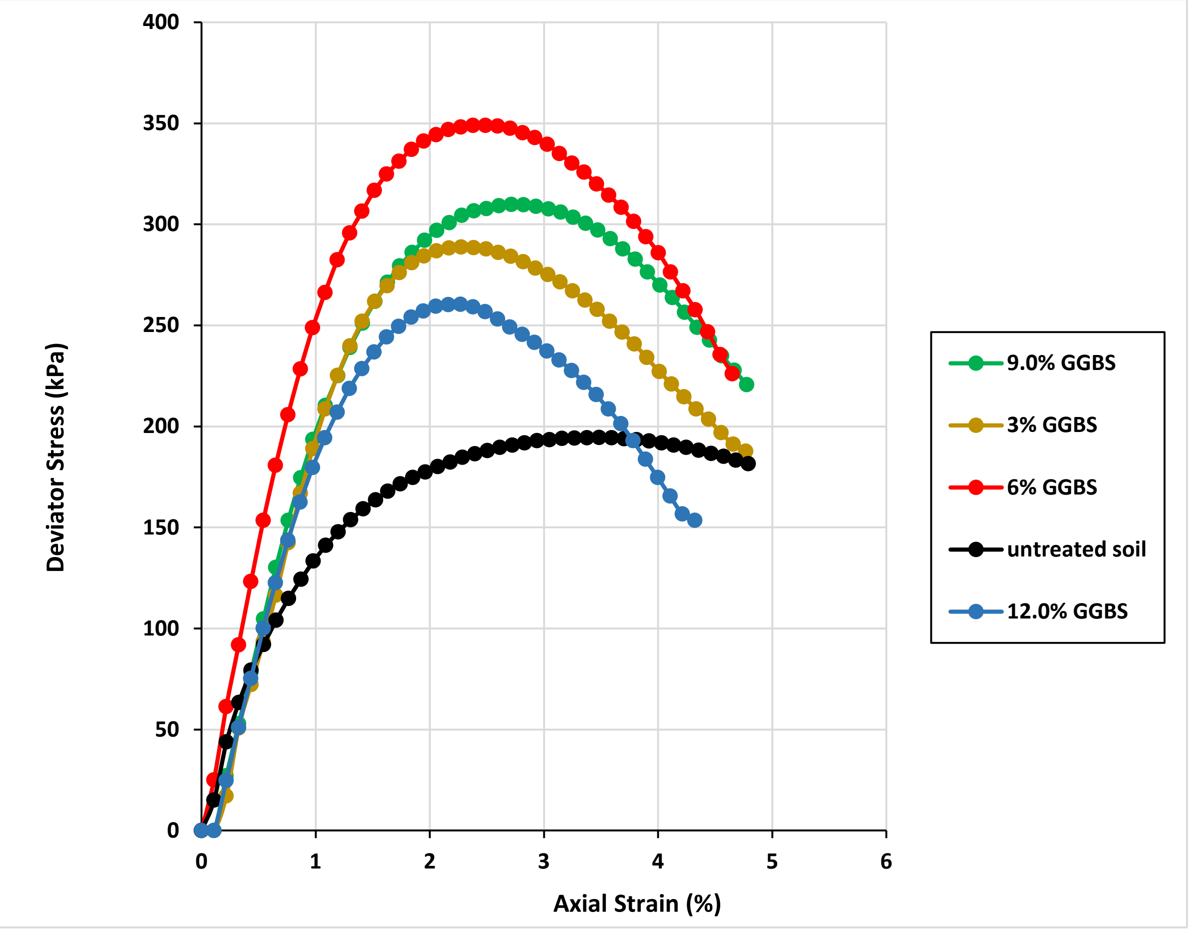
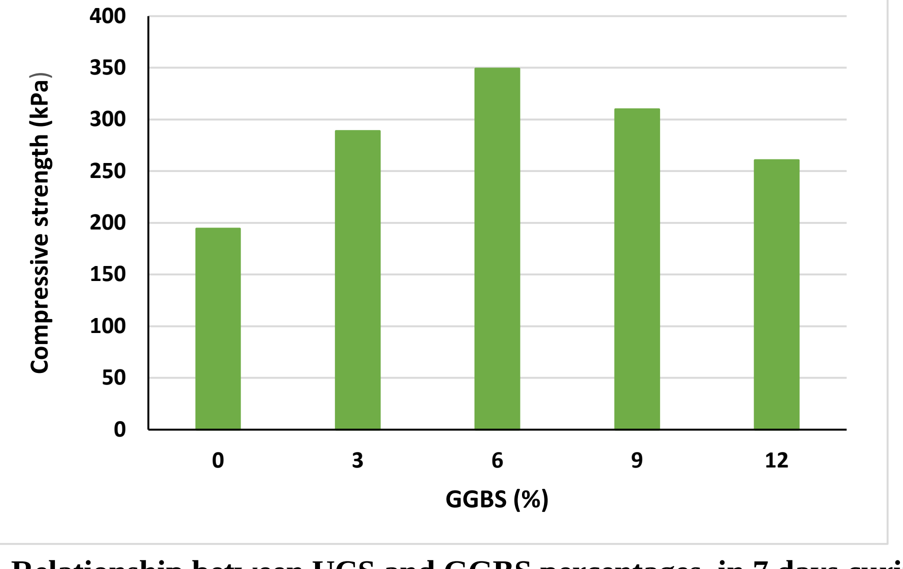


Figure 4. Stress-strain relationship for soil treated with different contents of GGBS at 7 days curing

Figure



5.

Relationship between UCS and GGBS percentages in 7 days curing

The figures show that GGBS can enhance the strength of the soil up to a content of 6%. At contents of 9% and 12%, the strength decreased. The improvement can be explained by the development of cementitious compound between the GGBS and the soil (Yadu & Tripathi, 2013). It has been reported by the previous researchers (Higgins, 2005; Nidzam and Kinuthia,

2010) that the GGBS has a minimal degree of hydration due to its low pH and for it to be effective in terms of soil stabilisation it should be activated with a suitable activator in order to break its glassy phase. Thus, in the future work, the second stage of optimisation process will be carried out involving the activation of GGBS with alkaline sulphate activator such as cement kiln dust (CKD).

The reduction in the strength with 9% and 12% GGBS may have resulted from the introduction of an excessive amount of GGBS to the soil that led to the formation of weak bonds between the soil and the cementitious compounds obtained (Yadu & Tripathi, 2013).

Conclusion

This study has been carried out to investigate the effect of GGBS on the physical and engineering properties of the soft soil. The soft soil selected for this study was classified according to the USCS as CI. The soft soil was mixed with GGBS at different percentages (0, 3, 6, 9 & 12%). The results indicate that the use of GGBS gave an improvement in the physical and strength characteristics of the soil. With the addition of GGBS to the soil, the Plasticity Index decreased while MDD and OMC increased and decreased respectively. Based on the UCS tests, the optimum amount of GGBS was 6% as it increased the strength by about 80% of that of soft soil. In spite of the improvement indicated in this research, it was not sufficiently high as GGBS is a latent hydraulic material and needs an activator to break its glassy phase.

Future work

The UCS of the soil treated with GGBS at 28 days of curing will be covered in the future works. Additionally, the effect of binary blending, of 6% binders produced from CKD and GGBS with different proportions, on the engineering and geotechnical properties of the soil used in this research project will be considered as the second stage of future works. Moreover, the most promising binder will be involved in the microstructural study using the scanning electronic microscopy (SEM) technique.

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Soft Subgrade Stabilisation Using Cement Kiln Dust and Ground Granulated Blast Slag

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Abstract

Soft soils are undesirable soils due to their low shear strength and high compressibility. Should such soils be used for pavement subgrade, remediation is essential to avoid potential pavement failure because strength and volume stability are important properties in subgrade construction. A most common approach for remediating such weak soils is the utilisation of chemical soil stabilisation. Since the development of soil stabilisation, binder materials including lime and ordinary Portland cement have traditionally been used for stabilising soils. However, there is currently a need to determine alternative sustainable materials that are capable of providing comparable or better performances than that of lime or cement, provided their significant financial and environmental costs. This research hence investigates the utilisation of waste materials in the stabilisation of intermediate plasticity clayey silt with sand (CI) collected from HighTown to the north of Liverpool, in the UK. Ground granulated blast slag (GGBS) activated by cement kiln dust (CKD) have been used as a stabilising agent and their effect on the physical and geotechnical properties of the soft soil have been measured using the consistency limits, compaction parameters (optimum moisture content (OMC) and maximum dry density (MDD)) and California Bearing Ratio (CBR) tests. A constant binder of 9% consisting of (100% GGBS; 100% CKD; 75% GGBS

+ 25% CKD; and 50% GGBS+ 50 % CKD; 25% GGBS: 75 CKD) was used to produce various mixtures. The CBR test was carried out on samples cured for 7 days. The results showed that the 9% GGBS increased the liquid limit, the plastic limit and MDD and reduced the Plasticity Index and the OMC while the 9% CKD provided opposite results. The combination of GGBS and CKD followed the same trend as that of CKD and was dependent on the content of the CKD, with the higher content the more extreme the result. The binder contained 100% of GGBS indicated a CBR value equal to 8.5%, double the value of the untreated soil while the binder of 100% CKD gave a substantially higher CBR value of 18.9%. However, the activation of 75% GGBS with 25% CKD significantly improved the CBR value by 78.8% of that obtained for the sole GGBS mixture indicating that the activation is very viable.

Keywords: California bearing ratio (CBR), GGBS, CKD and Soft subgrade stabilisation.

Introduction

In the pavement structure, the subgrade layer represents the lowest layer that is located underneath the base course or surface course, relying on the pavement type. This layer, generally, constructed from different soil materials that can be either soft or wet (Dhakal, 2012). The special features of these soils are the high degree of compressibility and low permeability compared to other soil types. However, firm subgrade is very important in road construction and properties such as volume stability and strength of the subgrade play a significant role in the overall pavement performance. While Soft subgrade is unable to support pavement loading and thus represent the primarily responsible factor for the failure of many road pavements (Behiry, 2014; Yadav et al., 2017).

A potential solution for such soil is the replacement with high-quality fill materials. However, the replacement of soft subgrade soil is not always the effective option because of the high cost of excavation and imported materials. Thus, researchers have been driven to look for alternative methods, which include the process of soil stabilisation (Jafer et al., 2015). According to Makusa (2012), soil stabilisation is the process of amending the physical and geotechnical characteristics (strength, permeability, compressibility and bearing capacity) of a soft soil either mechanically or by the addition of suitable chemical stabilisers such that it permanently becomes suitable for construction and meets the engineering design standards. Chemical soil stabilisation has traditionally been performed using cement and lime. Although soil stabilisation with either lime or cement binder is very effective (Miura et al., 2002; Raoul et al., 2010), it has many environmental problems, most importantly CO_2 emissions, cost, energy and consumption of natural materials (O'Rourke et al., 2009; Sargent, 2015). Accordingly, waste and by-product materials such as fly ash, rand ice husk ash have been utilised by many researchers as an alternative sustainable solution for subgrade stabilisation (Senol et al., 2006; Yadav et al, 2017).

The potential of using ground granulated blast slag (GGBS) or cement kiln dust (CKD) for the stabilisation of weak subgrade soils has been investigated by various researchers. Ismail and Belal (2014) studied the addition of various percentages of GGBS (5%, 10%, and 20%) to two types of soil. The results indicated that the GGBS reduced the Plasticity Index and maximum dry density and increased the optimum moisture content.

Pai and Patel (2016) investigated the effect of GGBS and GGBS-lime mixes on the strength improvement pf expansive soil. 3, 6, 9 and 12% of GGBS were used in GGBS-Soil mixes while 2 parts of GGBS and 1 part of lime were used for the percentages of 3, 6, 9, and 12% in GGBS-lime mixes. The results showed that the California bearing ratio (CBR) ranged from 6 %- 31% in GGBS-Soil mixes and 22%-48% in GGBS-lime mixes indicating that the addition of lime to the GGBS provided a superior binder.

Okafor and Egbe (2013) conducted laboratory tests for testing the compaction, consistency limits and strength of sandy soil stabilised with 2-24% CKD. The results indicated that increasing the CKD content resulted in an increment in the optimum moisture content, and a reduction in the maximum dry density and plasticity index. Also, upon increasing the CKD content from 0-24% by the dry weight of the soil, the CBR value increased from 22% to 80 %.

A non-traditional binder made from GGBS and CKD was investigated by Chaunsali and Peethamparan (2011) in concrete. Their combination provided a significant compressive strength after 2 days of curing. The use of GGBS as a sole binder in concrete required the addition of a suitable activator to provide a high alkaline environment for breaking the glassy structure of the GGBS and improving its rate of hydration. CKD has a similar composition to that of the cement with higher alkali percentages thus, it is appropriate for the activation of GGBS (Sadique and Coakley, 2016). In addition, the activation of GGBS with lime provided a superior result in terms of increasing the strength of the soil than using GGBS alone (OUF, 2001; Rabbani et al., 2016). Thus, the main aim of this study is to investigate the improvement in the strength of soft soil stabilised using GGBS activated by CKD. The strength was determined through California Bearing Ratio (CBR).

1. Materials

1.1 soft soil

The soil samples utilised in this research were collected from the River Alt, HighTown, North of Liverpool, UK at a depth ranging from 0.3m to 0.5m below the ground level. After extracting, the collected soil samples were placed in plastic bags of around 20-25 kg each, sealed and then transferred to the laboratory. Upon reaching the laboratory, soil specimens were taken for measuring the natural moisture content (NMC) of the collected soil. This was accomplished according to the BS EN ISO 17892-1:2014 (European Committee for Standardization, 2014). While the remaining soil was oven dried at 110^{o}C for 48 hrs prior to use for conducting the intended research experiments.

At the beginning, the properties of the natural soil were established by carrying out tests including the following: i) particle size distribution (according to the

BS EN ISO 17892-4:2014), ii) consistency limits (according to BS 1377-2 and 4:1990) and iii) compaction and CBR (according to the BS 1377-2 and 4:1990). The results are given in Table 1 below. The soft soil was found to consist of 12.07% sand, 75.03% silts and 12.9% clay. The Liquid Limit (LL) was found to be 39.5% while the Plastic Limit (PL) and the Plasticity Index (PI) were 19.56 and 19.94 respectively. Thus in accordance with the Unified Soil Classification System (USCS), the soil was classified as intermediate plasticity clayey silt with sand (CI).

Table 1. Physical and engineering properties of the soft soil

Property	Value
Natural water content %	37.5
LL%	39.5
PL%	19.56
PI	19.94
Sand %	12.07
Silt %	75.03
Clay %	12.9
Specific Gravity (SG)	2.67
Maximum Dry Density (MDD) Mg/m^3	1.62
Optimum Moisture Content (OMC) %	20.7
pH	7.78
Organic Matter Content %	7.95
CBR value	4.3

1.2 Ground Granulated Blast Slag (GGBS)

The GGBS is produced by chilling a molten iron slag, which is the by-product of steel and iron industry, to obtain a granular and glassy substance which then dried and ground to produce a fine product (Bandyopadhyay et al., 2016). GGBS has the ability to bind soil due to its cementitious properties. It comprises lime, silica, and alumina, which are the same components of cement however in various percentages (Oner and Akyuz, 2007). The chemical composition of the GGBS used in this research is shown in Table 2 below. GGBS is normally utilised in cement manufacturing giving a cost effective and environmentally friendly product with sufficient strength (Song and Sarawathy, 2006).

1.3 Cement Kiln Dust (CKD)

CKD is a by-product of cement manufacturing, classified upon the kiln process being either wet or dry (Bandyopadhyay et al., 2016). The main variance between the two main types of CKD is their calcium content, as CKD obtained from dry process has a higher amount of calcium than that from the wet process. CKD consists mainly of lime, silica, alumina and iron with high alkalinity making it an excellent activator (Siddique, 2006). The chemical composition of CKD used in this research is shown in Table 2 below. The CKD utilised in this study was produced by the dry process.

Table 2. Chemical composition of GGBS and CKD

Materia	CaO	SiO	Al_2O	Mg	Fe_2O_3	SO	K_2	TiO	pH
GGBS	40.1	37.7	5.75	4.26	0.01	0.0	0.61	0.65	8.5
CKD	51.0	12.5	3.5	0.5	2.5	4.0	5.5	0.0	12.7

2. Laboratory work

2.1 mix proportions

In this study, the soil was treated with 9% binder that consists of (100% GGBS; 100% CKD; 75% GGBS + 25% CKD; and 50% GGBS+ 50 % CKD; 25% GGBS; 75% CKD).

2.2 laboratory tests

The physical and bearing properties of the treated soil were investigated in the laboratory by carrying out the following tests:

- Consistency Limits tests: LL, PL and PI were established according to the BS 1377- 2:1990 (British Standard, 1990).

- Standard Proctor Compaction test: this test was carried out according to the BS 1377-4:1990 (British Standard, 2002). In this test, a weight of 2000 g from the dried powdered soil or a soil-binder mixture was used. This weight was then mixed with five various water content. For each water percentage, a 2.5 kg rammer was used to compact the soil paste in three layers within a standard mould, each layer was subjected to 25 blows.
- California Bearing Ratio (CBR): this test was carried out according to the BS 1377-4:1990 (British Standard, 2002). The test gives a measure of the relative strength between the compacted soil sample and that of the crushed rock. It is based on the measured relationship between the forces required to penetrate the plunger of an area of 19.35 cm^2 in a compacted soil at a specified rate of penetration. At the beginning of the test, 5000g of dried powdered soil was mixed with the optimum moisture content obtained from the standard Proctor compaction test. The soil paste was then compacted in a standard mould using 2.5 kg rammer; the soil was divided into three layers each compacted to 62 blows. Seven days of curing at room temperature of (20 ± 2^oC) was used for each proportion of the binder content and the samples were kept to cure within the mould after wrapping in cling film and sealing in well-sealed plastic bags. At the end of the curing period, the penetration test was conducted at a rate of 1.27mm/min after using a surcharge load of 4.52kg to represent the field pavement load. The force was read for each 0.25 mm penetration of the plunger including the one at 2.5 mm and 5.0 mm which were expressed as percentages of the standard forces at these values (i.e.13.2 kN and 20kN respectively) to give the CBR value.

4. Results and Discussion

4.1. Consistency Limit

The results of LL, PL, and PI for the treated soil with the various proportions of CKD and GGBS are shown in Figure 1. It can be seen that the 9% GGBS increased the LL and the PL and reduced the PI. The results are consistence with other researchers OUF (2001), and Yadu and Tripathi (2013). Whereas, 9% CKD significantly increased the LL, PL and reduced the PI. CKD was also observed to increase the LL and PL and reduces the PI in other research carried out by Zaman et al. (1992) and Sreekrishnavilasam et al. (2007). Activation of GGBS by CKD followed the same trend of the CKD for all CKD proportions and the increment in LL and PL reduced with decreasing the amount of CKD in the mixes while PI increased with the reduction in CKD content.

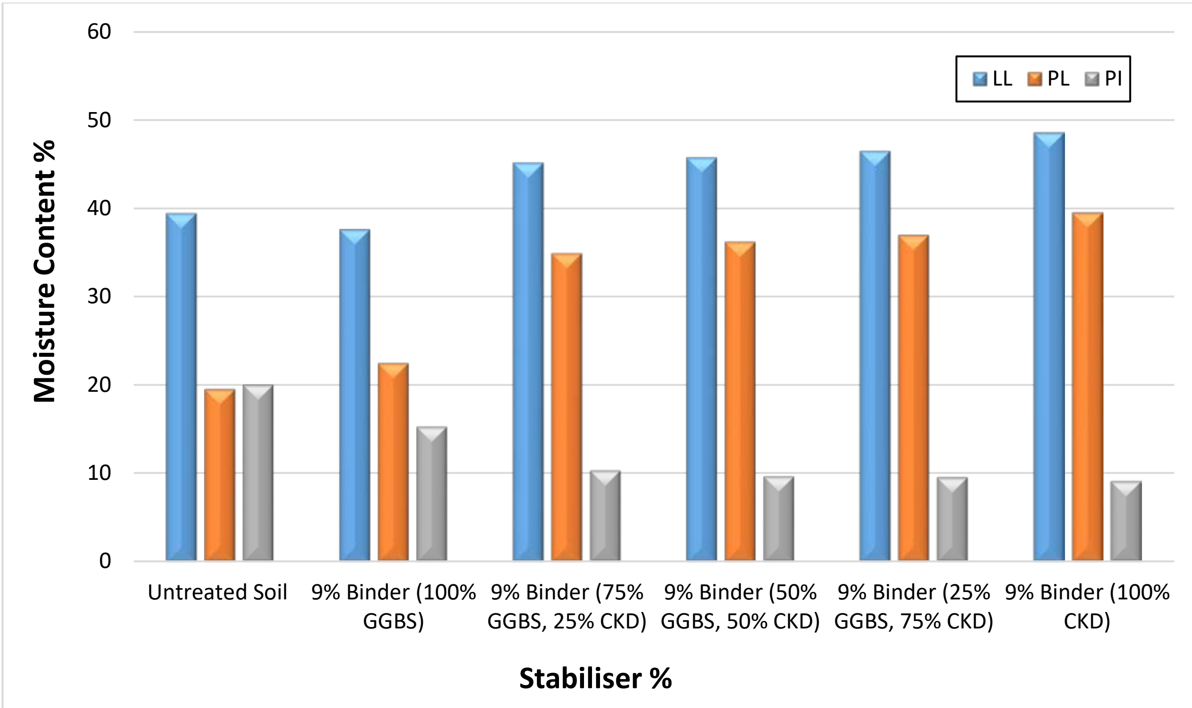

Figure 1. Influence of GGBS and CKD and their combination on the consistency limits of the soft soil

4.2 Compaction Parameters

Compaction is the process by which the soil particles are packed close to each other. The determination of the compaction parameters (i.e. the MDD and OMC of the soil plays an important role since their values are utilised in other experiments such as California Bearing ratio (CBR), Unconfined compressive strength (UCS) and swelling potential.

The results of the Proctor compaction tests performed on the treated soil with various percentages of GGBS and CKD are shown in the Figures 2, and 3. It can be seen that blending the soil with 9% of GGBS led to a slight reduction in the OMC and a noticeable increase in the MDD. Adding GGBS might decrease the amount of free silt and clay, reducing the surface area and hence the amount of water required (Yadu and Tripathi, 2013). Additionally, GGBS acts as a filler having higher specific gravity (2.89) in the voids of the soil and hence increased the MDD (Yadu and Tripathi, 2013).

On the other hand, the 9% binder of CKD significantly increased the OMC and reduced the MDD. This is because CKD is a very fine material demanding a high quantity of water and displace the soil particles making them float in the CKD and hence causing a reduction in the MDD (Abudllah, 2009; Al-Homidy, 2013).

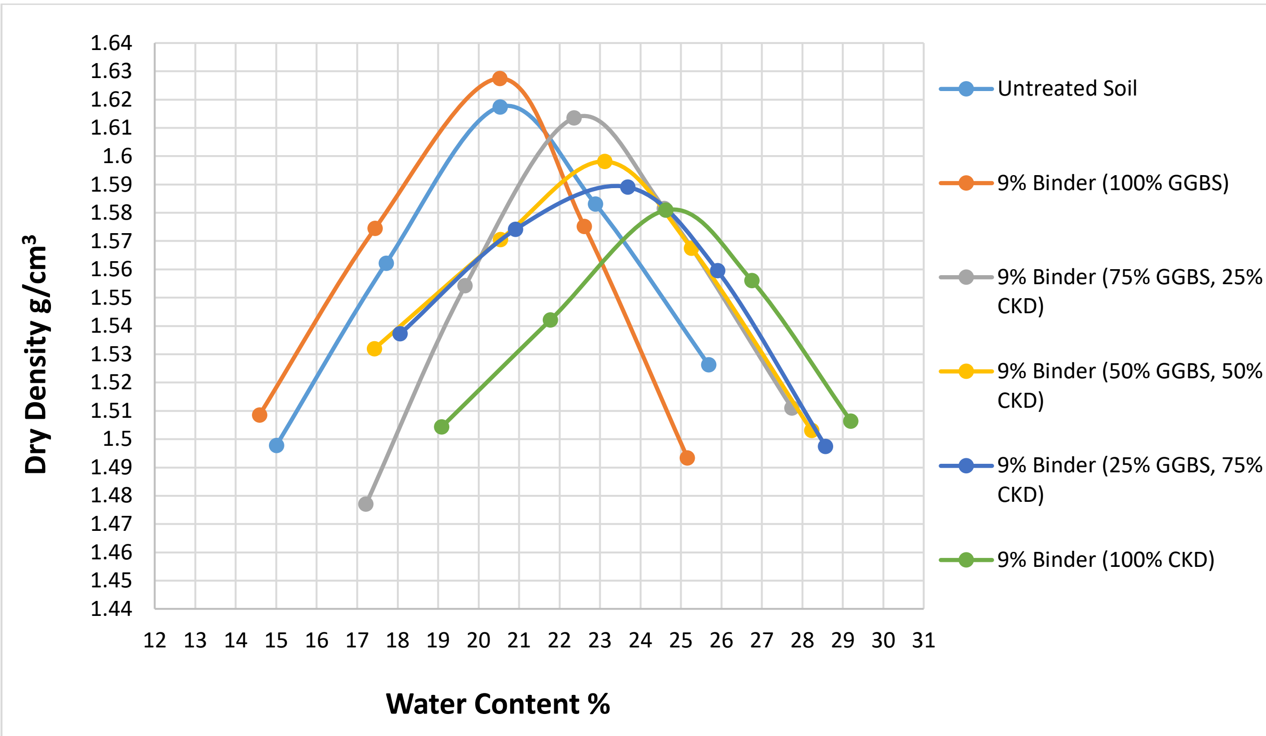

Figure 2. Influence of GGBS and CKD and their combination on the compaction parameters of the soft soil

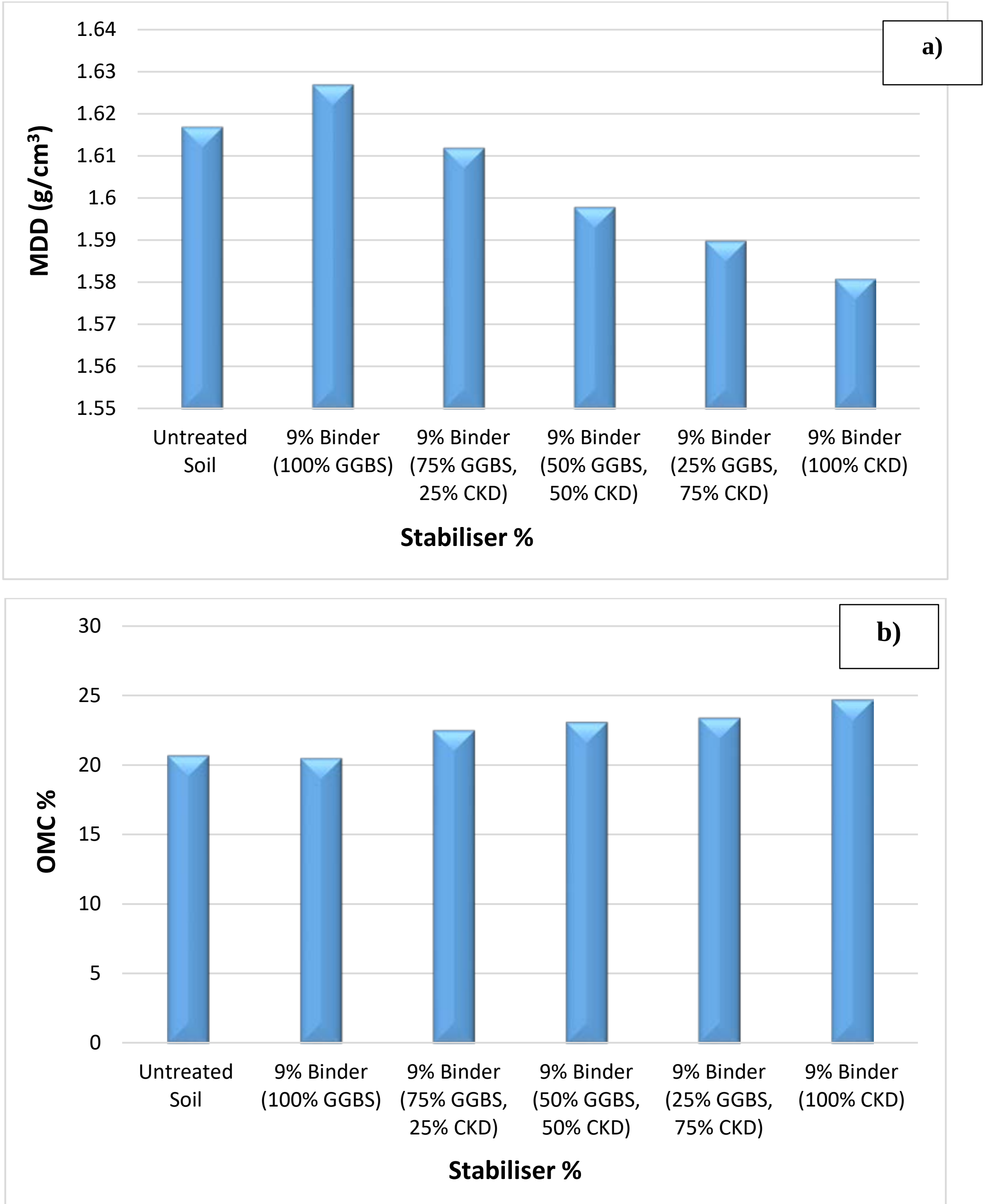

Figure 3. Influence of GGBS and CKD and their combination on a) the MDD and b) the OMC of the soft soil

It appears from the above that the CKD is by far more active than the GGBS in terms of the change in the MDD and OMC compared to untreated soil. This resulted in a trend similar to that of CKD when combining both GGBS and CKD. The OMC increased and the MDD decreased with the increase in the percentage of CKD to that of GGBS. The same trend was observed by many researchers who utilised alkaline activated GGBS (OUF, 2001; Rabbani et al., 2016).

4.3 California Bearing Ratio (CBR)

CBR represents the prime design input in pavement construction because it measures the shear strength of material utilised in the subgrade at a specified moisture content. A majority of the charts utilised in the design of pavement are dependent on the subgrade CBR value. CBR also provide an indication of the suitability of the soil materials for road subgrade construction (Dhakal, 2012; Leliso, 2013). Soils having CBR values ranging from 3-7% are classified as poor subgrade soils (Ismaiel, 2006), which is the case of the untreated soft soil used in this study (Table 3). It is also not practical to construct on a subgrade layer with CBR less than 15 without the provision of a capping layer or the increment in the sub-base thickness in order to distribute the loading on the weak subgrade. Having a high value of CBR indicate a strong and stable subgrade platform and thus may lead to the omission in of the capping layer and reduction of the sub-base thickness (Leliso, 2013).

The results of the CBR testing obtained after curing of 7 days are given in Table 3. The addition of 9% GGBS doubled the value of the CBR obtained for the untreated soil. This may be attributed to the cementations compounds that are formed between the GGBS and the soil (Yadu and Tripathi, 2013). However, a significantly higher improvement was obtained when 9% CKD was utilised as a stabilising agent. This can be attributed to the fact that the CKD contains significantly a higher active lime than the GGBS and thus results in more cementitious compounds formed between the CKD and the treated soil. GGBS was identified previously (Higgins, 2005; Nidzam and Kinuthia, 2010) to have a minimal degree of hydration. Using 25% of CKD to activate the GGBS and increase its rate of hydration gave a substantial increment in the CBR value than a sole GGBS mixture. The CBR value obtained by the activation increased to 15.2% compared to 8.5% of the GGBS mixture, giving a very viable improvement for the untreated soil.

Table 3. CBR results of the soft stabilised soil

Stabiliser type and content	CBR Value %

Untreated Soil (no stabiliser)	4.3
9% Binder (100% GGBS)	8.5
9% Binder (75% GGBS, 25% CKD)	15.2
9% Binder (100% CKD)	18.9

Conclusions

This research has been carried out for evaluating the potential of using ground granulated blast slag (GGBS) activated by cement kiln dust (CKD) as a chemical stabiliser for the stabilisation of soft subgrades. The soft soil used was classified as CI according to the Unified Soil Classification System (USCS). The soft soil was mixed with 9% binder that consist of (100% GGBS; 100% CKD; 75% GGBS + 25% CKD; and 50% GGBS+ 50 % CKD; 25% GGBS; 75% CKD). Experiments were carried out to evaluate the physical and strength properties of treated and untreated soil. The results indicated significantly higher improvements in the physical and associated strength properties when the GGBS was activated with CKD or when CKD was used alone rather than using a sole GGBS binder, indicating that the activation of GGBS is viable. The CBR value obtained with 9% binder of GGBS was twice of that obtained from the untreated soil which was 4.3%, whereas 9% CKD increased the CBR value of the soft soil by more than four times (from 4.3% to 18.9%). While the GGBS improved the CBR value of the subgrade, the provision of capping and the sub-base layer should still have adequate thickness to distribute the loading. However, the activation of the GGBS provided a CBR value with which both capping and sub-base layers can be omitted. The value of CBR obtained by mixing 25% of CKD with 75% of GGBS was 15.2 %, which is 78.8% higher than that of the sole GGBS mixture.

Future Work

Future work will complete the CBR tests on the remaining percentages in this study followed by carrying out the unconfined compressive strength and scanning electron microscopy (SEM). This will provide a more investigation and allow for the determination of the optimum mixture.

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Impact of new method for laying separate sewer system on pavement layers

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ABSTRACT

The method of installing underground infrastructure has a significant influence on road resistance and performance under live loads such as traffic. This research presents a new method for laying separate sewer systems by using one trench to sit both sanitary pipe and storm pipe and considers the effects of this approach on the pavement strength. Experimental tests have been conducted in the laboratory using a trench 2.5x0.45x1 metre to install two pipes one over the other (sanitary pipe in the bottom and storm pipe on top). Two cases have tested, the first case using 5 cm surface layer of cold mix asphalt while the second is using soil. A series of loads were applied to test the behaviour of this new system and its effects on the pavement surface layer and the buried pipe. The comparison between the rut print of the live load on the soil layer and the pavement layer was conducted. Results demonstrated that using the cold mix asphalt is still insufficient to provide enough safety to protect buried pipe as a reason of needing to relatively long time to acquire high stiffness. Therefore, minimum cover depth to protect pipelines still required.

Keywords: Cold mix asphalt, laying method, pipeline-soil interaction and separate sewer system.

INTRODUCTION

Traditionally drainage systems are two types, the old one is combined sewer system that carry both foul flow and storm water through a single pipe to wastewater treatment plant (WWTW). Since the middle of this century, separate sewer system was depended in many countries to cope with new environment regulation, this system using two sets of pipelines one to convey foul flow to (WWTW) and the other to convey the storm water to the nearest watercourse. Drainage system help to maintain appropriate interactions between the natural water cycle and human activities and save water resources and environment from the negative effects of pollutants. Choosing the type of drainage system is depended on many factors such as master plan of the city, topographic elevations of the area, economic stability and the regulations of region.

The conventional method for managing the urban storm water focuses on preserving public health and protecting urban areas from flooding. Standardised methods are used for rapid removal of storm-waters out of the urban areas with limited consideration of the downstream secondary effect (Chocat et al. 2001). About 70% of the sewer system in the UK and many EU countries such as Germany, France, and Belgium is combined sewer system (Read and Vickridge 1997). Combined sewage system is designed to release untreated overflows directly to watercourses by a Combined Sewer Overflow (CSO) structure, in order to keep the hydraulic load of the sewer system at a manageable level (Brombach 2005). (CSOs) are used for flood control (Passerat et al. 2011); this structure diverts exceeding flow which is mixing sewage and storm water, to the receiving watercourses, thus adding to the pollution load (Isel et al. 2014), In addition, they have a negative aesthetic impact. The Chartered Institution of Water and Environmental Management (CIWEM) deems CSOs as economically feasible safety valves for the sewer system even though it has some negative environmental impacts (BBC 2009). The number of CSOs in the UK is approximately 25,000, which about one-third were counted unsatisfactory performance (Thompson, 2012).

The separate sewer system is using today in the UK, EU and the USA in all new development areas have identified as one solution to avoid the negative impact of CSOs. The storm water is generally less polluted than the wastewater and mixing these flows causes difficulties at the management of the sewer networks and (WWTW) as well, especially during heavy rainfall events. Implementing the traditional separate sewer system in the UK or EU is challenging in some area as a reason of the narrow streets, which are more common in the UK residential areas figure 1 presents sample of the narrow street in terrace residential area.

Figure 1. Narrow street in terrace residential area in the UK

A high initial cost of the separate sewer system and large area required to incubate the two sets of pipes are considered the main disadvantages of the traditional separate sewer system. This research proposes a new method to setting the separate sewer system using one trench to set up the storm pipe and sanitary pipe, one over one, and study the effect of this new system on the surface pavement.

Influence of the infrastructure installation method on the pavement surface.

Soil-structure interaction influences pipe performance and is a function of both the pipe properties and embedment soil properties, and therefore impacts total system costs (Moser and Folkman 2008). Drainage systems and utilities installed below the road networks need to cope with design requirements to support the facilities such as traffic loads and ensure adequate performance of the roadway system surfaces. A properly designed pipe may fail due to poor installation techniques. Both functions of buried pipes; hydraulic and structural, need to test and provide adequate safety to carry the fluid flow and to support surrounding ground, supporting the weight of the ground and any external load such as traffic load. Inappropriate pipe installation can cause serious problems not only to the pipe itself but also to pavements and buildings or equipment. The reaction of the pipe-soil system against load depends on the pipes material types, for example, effecting of loads on the pipe-soil system is different between using the flexible pipe and the rigid, this is because the flexible pipe has less stiffness than surrounding soil while the rigid pipe has more stiffness. Figure 2 and 3 shows reactions of pipes in both cases (NYSDOT 2013).

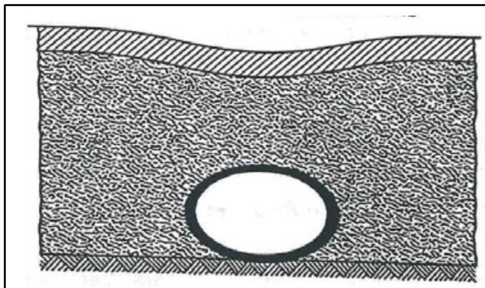

Figure 2. Deformation in road surface in the flexible pipe case

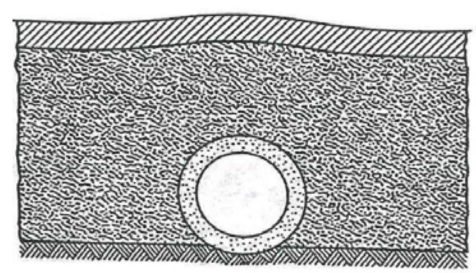

Figure 3. Deformation in road surface in the rigid pipe case

EXPERIMENTAL WORKS

The physical model with dimensions 2.5x1x.45 meter is used to setup the pipe-soil system under hydraulic loads to simulate the traffic loads Figure 4 shows the physical model set up in the rig. Two cases have been tested in this model; the first one when the surface layer is soil and the second one when cold mix asphalt is laid. Identifying the material properties to use it as input data for mathematical model is one of initial process in analyses behaviours of the buried pipe and road surface. Soil properties were identified through series of lab tests on the soil specimen; Table 1 shows the summary of soil properties. Cold mix asphalt properties presented in Table 2.

Table 1. Model parameters

Items	Parameters	Value
Soil	Density	1685 kg/m^3
	E	16.943 MPa
	υ	0.295
	Mohr–Coulomb	
	ϕ	31.7
	C	50 kpa
	φ	2

Table 2. Model parameters

Items	Parameters	Value
Cold Mixing Asphalt	Density	2200 kg/m^3
	E	1178 MPa
	υ	0.35
	Creep	
	A	0.000322892
	n	1.736588357
	m	-0.022368417
	Tem	20

A series of live loads is based on the AASHTO H-15, H-20 and H-25 represents a 15, 20 and 25 ton was applied on the system as a static load. The cover depth for the pipe is 40 cm and the PVC pipe diameter is 160 mm. Transducers and recorder were used to monitoring the displacement of the tire footprint plate against the loads and cross section deformation of the pipe. The final rut on both surfaces of the soil and the pavement are presented in Figure 5 a and b. Figure 6 shows the displacement against each load.

Figure 4. physical model set up in the rig

Figure 5-a. Rutting in Pavement surface **Figure 5-b.** Rutting in Soil surface

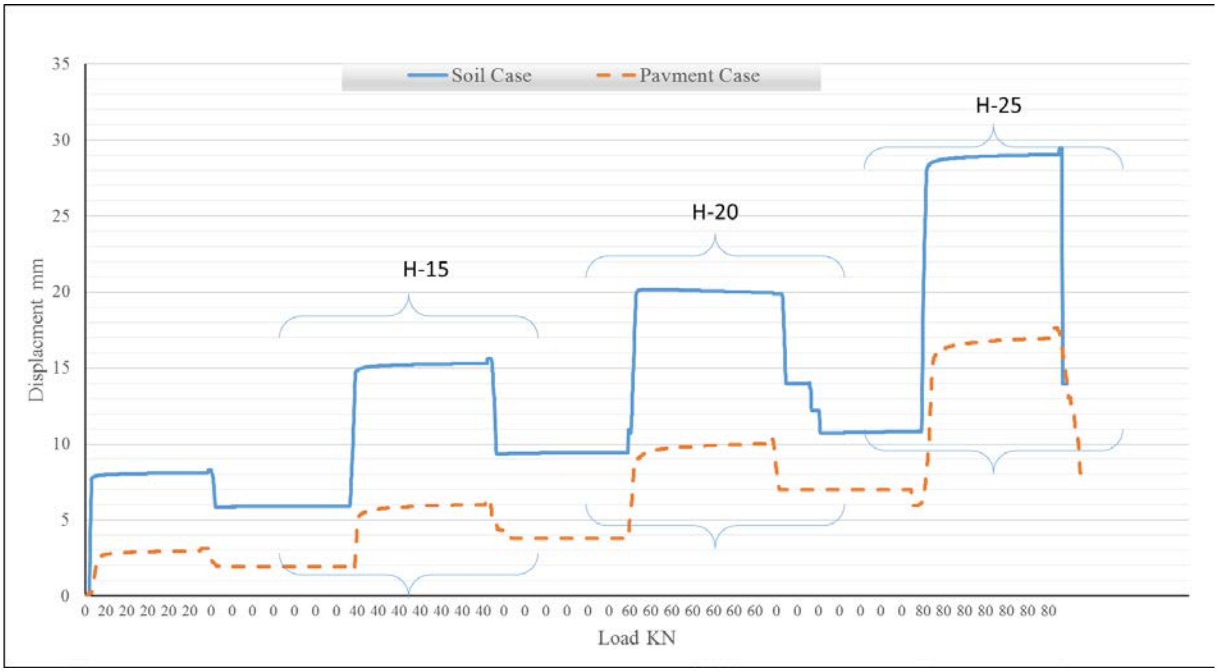

Figure 6. Displacement on the tire footprint plate load in two cases

DEFORMATION OF THE BURIED PIPE

A flexible pipe can flex by about 3% without structural distress. The pipe that does not meet this criterion is usually considered a rigid pipe. The UK Highways Agency specify 5% for flexible pipes, while the design criteria of the water industry specify allowable deformation of 6% as a maximum. In both cases, when using cold mixing asphalt as pavement for the surface layer or using soil instead, the deformation of the pipe is still within the design criteria of buried flexible pipe which is about 1%, Figure 7 shows the deformation of pipe in both cases.

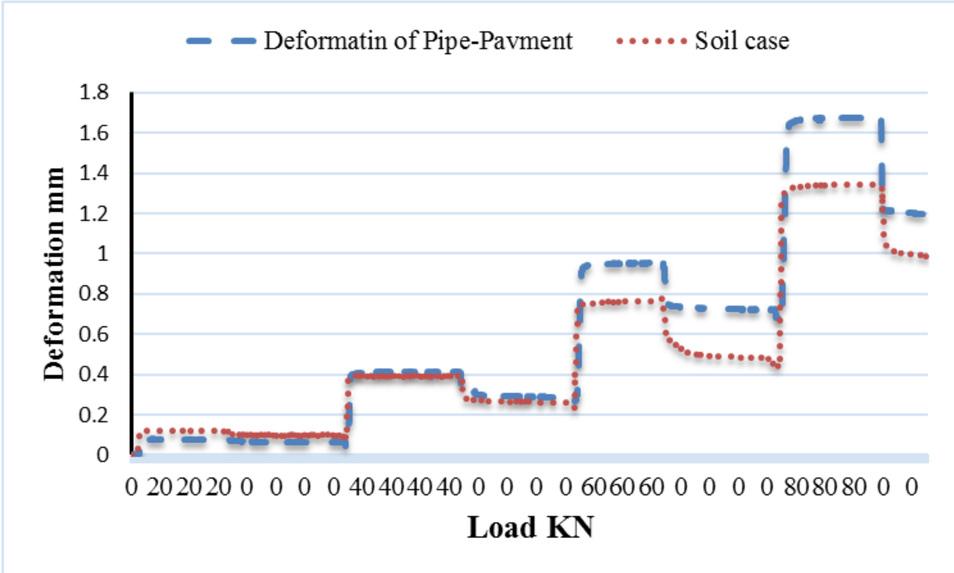

Figure 7. Deformation of the pipe

CONCLUSION

The comparison between rut in soil and pavement demonstrated that the reduction of the vertical displacement in cold mixing asphalt pavement is about 50% compared when using the soil. However, this displacement is still over the design criteria because the cold mixing asphalt needs a long time to reach the required stiffness. The pavement layer typically mitigates the load effects on the pipe; experimental results shows that using the cold mixing asphalt at seven days age, which has a low stiffness, doesn’t make a big difference from using soil and doesn’t decrease the stress on the pipe specifically under high live load. Therefor it is recommended not using the cold mixing asphalt in a surface layer only with minimum cover depth of soil over the pipe to provide enough protection for both pipe and pavement surface layer. The pipe deformation was within the design criteria of the buried flexible pipe.

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The Effect of the Built Environment on the Younger Generation

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EXTENDED ABSTRACT

This research examines the topic of the built environment and its effect on the younger generation, in the context of emigration from the countryside to the capital and abroad. The stages of the research are: exploring the reasons, handling options through similar foreign examples; after consultation with exerts all over the world, creating a complex urban development standard. By using this, the population and the living standard would increasing on the countryside and in the smaller towns, and the economy growing, to reach these goals we need eco-friendly solutions, and renewable energy consumption as much as possible.

This social phenomenon effect was studied from surveys among the younger generations, and it revealed that the most motivating factors for mobility was the qualitative higher education and proper working possibilities. Only after this comes the housing conditions. When these chances are missing in a town, it is impossible to keep the young generations there. Besides these aspects, the other main needs are the entertainment and relaxing, which need to be spent in a high-quality environment. 7.5% of the questioned wanted to study, especially in smaller towns, because of the above-mentioned reasons. I would like to give a solution to increase their number with my research.

I have found some contemporary solutions in European countries such as the Netherlands, Spain and Portugal. It seems to be a reasonable pathway to follow the recycling of the abandoned industrial buildings, restoration of the listed buildings, increasing the green areas and public spaces, highlight on the

tourist attractions, develop the recreational activities, and introduce new technologies. In this study, I would like to show a possible example for introducing a new technology and how to connect the positive aspects and raise the efficiency of it in a smaller city.

My research started off from a very pressing global issue, which is the solid waste pollution, and it is a huge problem on the mainland and in the oceans as well. The ocean pollution affects everybody, since the tiny plastic elements are consumed by the ocean beings, so it gets into the human body also. The waste risks many animals' lives and habitat. Yearly, 2.5 billion tons of solid waste enters to the oceans, almost half of that is plastic waste, which only decomposes after 450-500 years.

A possible solution could be for a factory, where the solid plastic waste could be recycled, and produces household objects, such as furniture, and building elements. The best way to create these objects is a burgeoning technology, the 3D printing, and thermoforming. This technology could appear on most coastal cities of the world, since the pollution is a worldwide problem.
In Europe, the waste recycling average is around 20-25%, so I wanted to find a country for a prototype building, where the recycling rate is quite low, so there is enough material to use, and the new technology could give more positive effects. Because of these, I chose Portugal, since they have 1800 km long ocean coastline, and the economy crises affects them on a high level.
In Portugal, the targeted city is Porto, the old capital of the country, where the Douro river meets the Atlantic Ocean. Inside the city, I found a place where it is possible to connect a ship directly to the buildings, because I wanted to separate the manufacturing process, which would have been done on a ship, and on land. The ship based functions are the direct waste collection from the water, cleaning, selection, grinding, and forming into plastic fibre, like this, the waste is not imported to the mainland. Besides these, the method is cost-efficient, since the transport, the collection and the processing happens at the same time.

The land-based phases are the design process, planning, forming, chemical and static researches, so it could give hundreds of new jobs to the young experts. Here, the locals and the tourists can find an informative function with lectures, gallery and a shop also, and this will take place in a striking building, which attracts the visitors.

At the household objects' design I chose two kinds of ways to create them: one with well-designed and unique objects, which could raise the income of the factory; the other is more like a charity system: when the locals bring the selected plastic waste, they can get mass-produced objects from cheaper technology, for free.

One of the most important issues in this project is to take advantage of the renewable energy sources. The place I choose for the prototype buildings is on a breakwater pier in the centre of Porto, in the outfall of the Douro river and the Atlantic Ocean. It gives unique situation to the building, where we can use solar energy, because there is no shading here; the wind energy from north-west; the constant flowing of the river; the huge waves of the ocean and the tide also. These factors could be used with facade elements on the designed buildings in an aesthetic way.

This pier was refurbished in 2005 by a local architect office called Carlos Prata Arquitecto, and their work gives unique appearance to the pier, which should be protected as much as possible. Here takes place a lighthouse and a tunel inside the concrete, furthermore a restaurant and a beach at the beginning of the breakwater pier.

The designed buildings should respect the previous work of the designers, and they also have to be very attractive to bring this function closer to the people. My conception is to create a building complex as a public, informative factory, a place where the people would love to spend their spare time.
The only limiting factor on the site is the extreme weather, so the building should conform to this situation. For example, from the breakwater side, the buildings have to be very narrow to resist the waves, but in the same time,

they have to be able to catch the wind and the sunlight on a big surface, and some of them need direct connection to the ship, so these will form the shape of the buildings. Besides these expectations, I want the buildings to look like they are ’floating’ above the pier, like this, the original shape of it would be visible and protects the panorama also.

The project currently in the conception phase, but the predicted structure for them will be an assembled steel structure, which could be removed from the pier, when the city will not need the buildings anymore on this site and they would be portable also.

Summarizing, this project is a self-supporting furniture and household object factory, which is a touristic attraction, brings attention to the waste recycling, and stimulate the locals to cooperate in the environmental protection. It creates hundreds of workplaces, increase the economy, affects all of the generations, and gives a proposed solution for a serious environmental issue.

Evaluating the Mechanical Strength of Bund Wall Using Smoothed Particle Hydrodynamics (SPH) in Abaqus

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ABSTRACT

Above Ground Storage Tanks (AGST) are large vessels that contain regulated substances. In the past, many countries have experienced collapses of their containment facilities, resulting in severe consequences for the economy, environment and the immediate community. To reduce the extent of tank failures, regulations require that these storage tanks have to be surrounded by secondary and tertiary containment systems. The secondary containment also called a bund is any catchment that aims at minimising the consequences of failure in the primary containment by containing any occurring spillage. Existing bund walls are designed to only withstand the 'hydrostatic' pressure, while previous catastrophic incidents demonstrated that the bund walls failed to keep their structural integrity and therefore triggered the total loss of the stored material. It is therefore crucial to determine the behaviour of the structure under the effect of dynamic pressure. This is achievable through various techniques mainly experimentally and numerically. Numerical simulation is always the preferred method due to the cost savings and risk reduction. The simulation of a structure that is subjected to fluid impact is possible in Abaqus through Smoothed Particle Hydrodynamic technique which is a meshless method to model complex fluid flows. The bund wall is modelled using the classic finite element method upon which Abaqus is built.

Keywords: Storage Tanks; Bunds; Catastrophic Failure; Finite Element Analysis; Smoothed Particle Hydrodynamics.

1. INTRODUCTION

The development of oil and gas industry requires the construction of structures that ensure the storage of the material complies with the safety regulations. In the UK, the regulations require that storage tanks; which are called also primary containments because they are in direct contact with the materials; have to be surrounded by secondary containment which are provided by the means of bund wall constructed from concrete or earth. The role of the secondary containment is to contain any spillage in case of partial or total failure of the primary containment. For a further mitigation in case of failure, tertiary containment might be provided by means of lagoons, sacrificial areas such as car parks, etc. (CIRIA, 2014) In this research, the focus is limited on the secondary containment. Currently, the existing bund facilities are designed to withstand the hydrostatic pressure only, in which case the bund wall collapses whenever a complete failure of the storage tank occurs. Such cases mean that the hydrodynamic pressure is dominant over the hydrostatic pressure. Previous researches suggest that the amount of hydrodynamic pressure can reach 16 times the hydrostatic pressure (Atherton, 2008). Moreover, in the event of failure of storage tank, the fluid hits the bund wall over a short period of time. The very fast transient rise of pressure can excite the modal vibration of the structure and most of such cases ended up with a complete failure of the tank accordingly to the documented accidents. Therefore, it is very important to investigate the behaviour of the bund wall under dynamic pressure. The present paper deals with analysing the structural integrity of a bund wall via the use of Finite Element Analysis technique. The analysis involves the modelling of the bulk of fluid using Smoothed Particle Hydrodynamics technique incorporated within Abaqus software.

2. SMOOTHED PARTICLE HYDRODYNAMICS

Smoothed Particle Hydrodynamics (SPH) is a computational method for approximating the numerical solution of the partial differential equations describing fluid dynamics (Monaghan, 1992). In contrast to the traditional numerical methods such as Finite Difference Method and Finite Volume Method in which the computational domain is divided into cells, SPH is a meshless technique (Sasson et al, 2016) where the fluid is replaced by a set of particles. The method dates back to 1977 and was initially applied to astrophysical and cosmological problems for gas dynamic problems (Randles and Libersky, 1996). The use of the method has then extended to accommodate incompressible flows by assuming that the flow is slightly compressible with an appropriate equation of state. The application of the method for this type of flow included the simulation of breaking on arbitrary structures, waves on beaches, sloshing tanks and bow waves produced by certain ship hulls and liquid metal moulding. Another class of problems that can be solved with SPH technique is the analysis of fracture of brittle solids where more accurate results can be obtained than from the finite element or the finite difference method. SPH is used as well for virtual reality surgery**.** Many commercial software packages are now incorporating the method such as Dyna3D, Autodyn and Abaqus.

The method has some attractive advantages. The first advantage in these is that the pure advection in the momentum equation is treated exactly. The second advantage is that with SPH it is easy to deal with interface problems where more than one material is simulated, whilst interface problems are difficult to deal with when using the traditional methods such as Finite Difference Method. The third advantage is that the resolution can be dependent on time and position making the method suitable for many geophysical and astrophysical problems. The fourth advantage is that the method offers a reduction in computation and storage by limiting the computation in only where the matter is particularly in problems involving fragments, drops or stars. Finally, SPH can deal easily with complex physics due to the similarity with molecular dynamics. The SPH technique is based on an interpolation method allowing any function to be expressed in terms of its values at a set of disordered points (Monaghan, 2005).

In the case of SPH, we want to express the fluid properties in any point in the simulation domain by using an interpolation function. The interpolation of a quantity A that is function of spatial coordinate is based on the integral interpolant as given in equation (1)

$$(r) = \int (r') \, w(r - r', h) dr' \,, \quad (1)$$

where $w(r - r', h)$ is the kernel and dr' is a differential volume element.

In practice, kernel function tends to the delta function when the smoothing length h tends to zero. If we take for example a unidimensional problem, Gingold and Monaghan (1977) used a Gaussian Kernel given by equation (2)

$$w(x, h) = \exp\left(-\frac{x^2}{h^2}\right) / (h\sqrt{\pi}) . \quad (2)$$

For three-dimensional problems, Lucy (1977) used the following kernel given by equation (3)

$$(r, h) = \left(\frac{105}{16\pi h^3}\right)\left(1 - \frac{r}{h}\right)^3\left(1 + \frac{3r}{h}\right) , \quad (3)$$

when $0 \leq r \leq h$ and zero otherwise. The most common type of kernels are based on Schoenberg M_n splines given by equation (4),

$$M_n(x, h) = \frac{1}{2\pi}\int_{-\infty}^{\infty}\left(\frac{\sin kh/2}{kh/2}\right)^n \cos(kx) \, dk . \quad (4)$$

After discretisation, equation (2) yields equation (5) that represents the interpolation of all points within the influence domain governed by the Kernel function around the point of interest.

$$(r) = \sum_b m_b \frac{A_b}{\rho_b} W_{ab},$$
(5)

where

a = interpolation point, A_b = desired characteristic, ρ_b = Density of neighbouring particle, m_b = mass of neighbouring particle and W_{ab} =Kernel function.

Fig.1. shows the influence domain centered around the particle a. The circle of radius h which is the smoothing length contains the neighbouring particles influencing the particle of interest a.

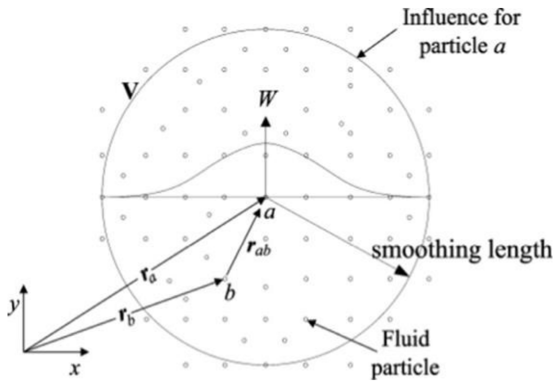


FIG.1. PARTICLE INTERACTIONS IN SPH WITHIN THE INFLUENCE DOMAIN GOVERNED BY THE KERNEL FUNCTION (TAK ET AL, 2013)

3. FINITE ELEMENT MODELLING

The structural integrity of the bund wall made of plain concrete was analysed using Abaqus software, which is a finite element program widely used within the academic, research and industrial community. It was released by Hibbitt, Karlsson & Sorensen Inc. of Rhode Island in 1978 (Hassan, 2013). Abaqus software was mainly written to solve solid and structural mechanics problems involving nonlinear response. It contains an extensive material library allowing to solve a variety of problems and it consists in three core products which are Abaqus /Standard, Abaqus/Explicit and Abaqus CAE. Recently, starting from Abaqus 6.10, Computational Fluid Dynamics module was incorporated as well.

3.1 Modelling Procedures

For solid and structure analysis, Abaqus offers many modelling procedures mainly static stress/displacement analysis and dynamics stress/displacement analysis. In the former, it is assumed that the effect of inertia is neglected while in the latter, both of the damping term and inertia term in the equation of motion are included. The more complex governing equation is given by equation (6)

$$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = \{F\}, \tag{6}$$

where $[M]$ is the mass matrix, $[C]$ is the damping matrix and $[K]$ is the stiffness matrix.

For Dynamic problems, Abaqus offers two-analysis procedures, which are implicit dynamic analysis and explicit dynamic analysis (Abaqus Analysis User's guide 2016).

4. IMPLICIT DYNAMIC ANALYSIS

Implicit dynamic analysis is used when nonlinear dynamic response is being studied and can be used for a wide range of applications. Those applications include the study of dynamic response that requires transient fidelity and involves minimal energy dissipation, dynamic response that involves nonlinearity, contact and moderate energy dissipation and quasi static response in which considerable energy dissipation provides stability and improved convergence behaviour for determining an essentially static solution. The approach is based on approximating the solution of one-step based on the solution of the previous time step. The process requires that the integration operator matrix is inverted and a set of nonlinear equilibrium equations must be solved at each time increment. The advantage with this approach is that large time steps could be taken without affecting the stability of the solution since the time integration scheme is unconditionally stable, but because the stiffness matrix has to be inverted in every time step, the computation becomes more expensive especially for large models (Abaqus Analysis User's Guide 2016).

5. EXPLICIT DYNAMIC ANALYSIS

Explicit dynamic analysis is used when the dynamic response of short time events are studied such as impact problems. It also allows to perform quasi-static analyses with complicated contact conditions. In contrast to implicit dynamic where nodal accelerations are solved iteratively, in explicit dynamic they are solved directly as the inverse of the diagonal mass matrix multiplied by the net nodal force vector, which includes contribution from exterior forces, element stress, damping, bulk viscosity and hour glass control. Once accelerations are known at time n, velocity and displacements are then calculated at time n+1/2 and time n respectively. An explicit central-difference time integration scheme is used which is a conditionally stable scheme requiring small time steps hence more increments, but the advantage is that each increment is cheaper than an increment in implicit dynamic procedure (Abaqus Analysis User's guide 2016).

B. 3.2 Material Modelling

Abaqus contains an extensive material library suitable to model a variety of problems in continuum mechanics. In particular, to model concrete structures there are three available materials models. A brief overview is given for the Concrete smeared cracking model (CSC) and brittle cracking model (BC) but a detailed description of the Concrete damage plasticity (CDP) model is presented.

VIII. CONCRETE SMEARED CRACKING MODEL (CSC)

This model is only available in Abaqus/Standard. It is designed for applications where the concrete is subjected to essentially monotonic straining at low confining pressures. It is intended to model all types of structures including beams, trusses, shells and solids. It is used with reinforced concrete structures but can be used to model concrete as well. It consists of an isotropically hardening yield surface that is active when the stress is dominantly compressive and an independent "crack detection surface" that determines if a point fails by cracking (Abaqus 6.12 Analysis User's manual 2012).

IX. BRITTLE CRACKING MODEL (BC)

This model is only available in Abaqus/Explicit. It is intended to model all types of structures including beams, trusses, shells and solids, and materials such as ceramics or brittle rocks. It can be used for plain concrete even though it is intended primarily for the analysis of reinforced concrete structures. It is appropriate for applications in which the behaviour is dominated by tensile cracking and assumes that the compressive behaviour is always linear elastic (Abaqus

6.12 Analysis User's manual 2012).

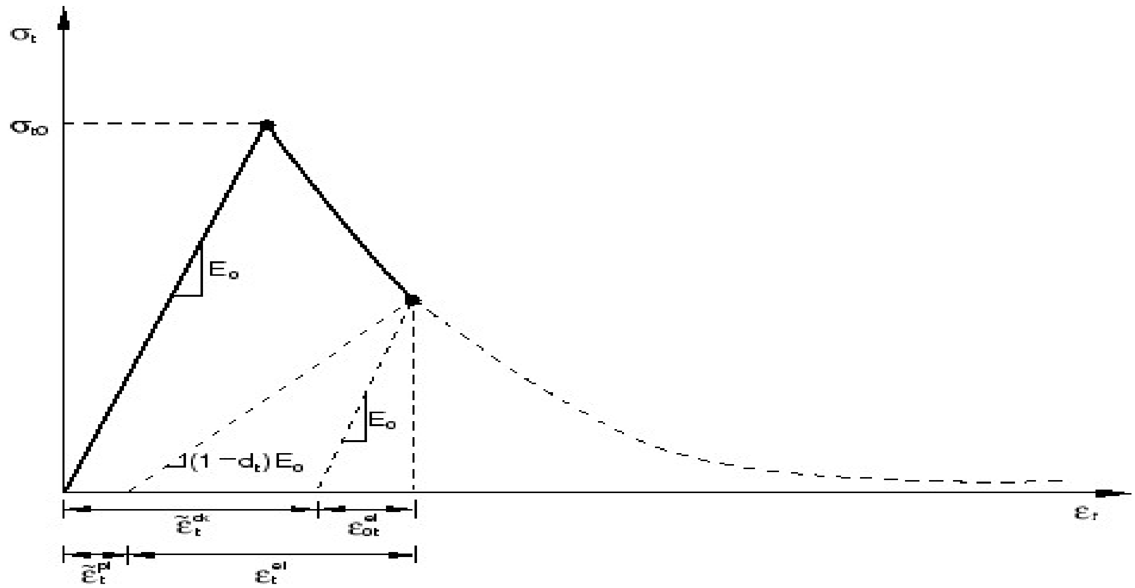
X. CONCRETE DAMAGED PLASTICITY MODEL (CDP)

This model is available in both of Abaqus/Standard and Abaqus/Explicit. It allows to model concrete and other quasi-brittle materials in all types of structures. It is intended to model primarily reinforced concrete structures but can be used for plain concrete. It is designed for applications in which concrete structure is subjected to monotonic, cyclic, and/or dynamic loading under low confining pressures. It is based on the concept of isotropic damaged elasticity in combination with isotropic tensile and compressive plasticity in order to represent the inelastic behaviour of concrete.

The linear elastic behaviour for the concrete is defined through the elastic module and Poisson's ratio. The main two failure mechanisms are tensile cracking and compressive crushing of the concrete material, which are controlled by two hardening variables: the tensile equivalent plastic strain $\tilde{\varepsilon}_t^{pl}$ and the compressive equivalent plastic strain $\tilde{\varepsilon}_c^{pl}$.

For the tensile behaviour, beyond failure stress, micro cracks are formed and this is represented macroscopically with a softening stress-strain response as shown in fig.2 (Abaqus 6.12

Analysis User’s manual 2012).



XI. FIG.2. TENSION STIFFENING MODEL, STRESS CRACKING STRAIN APPROACH (ABAQUS 6.12 ANALYSIS USER’S MANUAL 2012)

The linear branch represents the linear elastic response of the concrete. When the stress reaches σ_{t0}, the concrete fails which is characterised by cracks formation. This behaviour is represented by the descending part of the curve. If the concrete is unloaded from any point from the softening part, the model assumes that the elastic stiffness is either damaged or degraded. The damage is characterised by damage variable d_t that takes the values from zero to one and is defined from experimental uniaxial tensile test data using equation (7),

$$d_t = 1 - \frac{\sigma_t}{\bar{\sigma}},$$

(7)

where $\bar{\sigma_t}$ is the effective tensile stress.

The degraded elasticity stiffness is then calculated using equation (8)

$$E = (1 - d_t)_0,$$

(8)

where E_0 is the initial tensile stress (Hassan, 2013).

Under compression, the response of concrete exhibits a linear elastic behaviour followed by a plastic regime depicted by Fig.3.

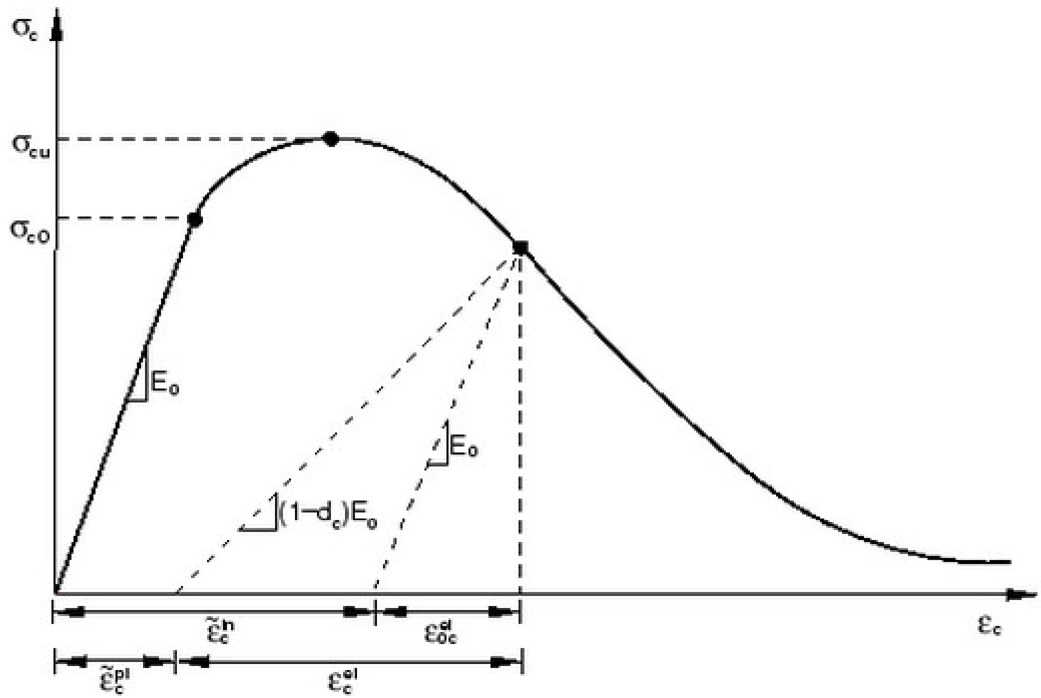


Fig.3. Compression hardening model (Abaqus 6.12 Analysis User's manual 2012) The plastic regime is characterised by stress hardening, which is the branch of the curve going from σ_{c0} to σ_{cu} followed by strain softening beyond the ultimate stress σ_{cu}. Similar to the tensile behaviour, if the concrete is unloaded on any point beyond the elastic stage, the elastic stiffness is damaged by a degradation factor d_c, which is obtained from experimental uniaxial compression data and using equation (9) (Hassan, 2013),

$$d_c = 1 - \frac{\sigma_c}{\bar{\sigma}_c}, \quad (9)$$

where $\bar{\sigma}_c$ is the effective compressive stress.

The degraded elasticity stiffness is then calculated using equation (10),

$E = (1 - d_c)_0.$

(10)

In addition to tensile and compressive characteristic curves, other parameters are required to calibrate the model, which are:

- The dilation angle in degree ψ which is usually between 20 and 40 degrees.
- Flow potential eccentricity $\mathcal{E}$, the default is 0.1.
- Ratio of initial equibiaxial compressive yield stress to initial uniaxial compressive yield stress (f_{b0} / f_{c0}), the default value is 1.16.
- The ratio of second stress invariant on second stress invariant on the compressive meridian K_c , the default is 0.6.
- A viscosity parameter (μ) that defines visco-plastic regularisation and the default value is set as 0 (Hassan, 2013).

6. Finite Element Procedure

Under catastrophic failure of the storage tank, the fluid escapes the tank rapidly and hits the bund wall. This type of behaviour falls within the impact type of problems, which excites the vibration modes of the structure. Therefore, the problem is solved using dynamic explicit approach that is suitable for impact problems. The material model chosen to model the concrete is CDP model which is appropriate for dynamic loading. All the steps taken to model this problem are detailed in below.

A. *6.1 Creating the model*

The model is composed of three parts, which are the fluid column modelled as a deformable part and then converted to SPH particles, the ground modelled as a rigid body since it is assumed that the ground does not undergo any deformations under the pressure applied by the fluid and a bund wall modelled as deformable body. All parts are modelled in 3D space.

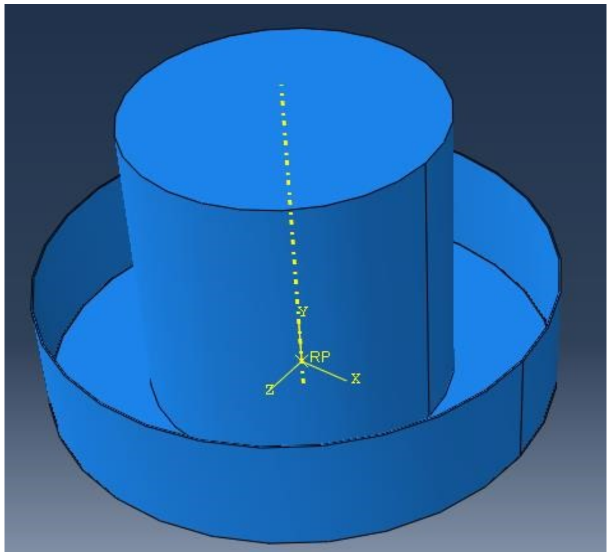


Fig.4. 3D model of the fluid, bund wall and ground

B. *6.2 Materials properties input*

The material input parameters of the concrete were obtained from Abaqus Example problem Guide that corresponds to a standard concrete. The concrete tension stiffening was defined using the stress displacement approach because it is the most suitable approach to model concrete without steel fibres and this is also recommended by Abaqus manual.

 CONCRETE

The concrete is modelled by giving its elastic parameters, the parameters for CDP model, its compressive behaviour and its tension stiffening given by Table 1, Table 2, Table 3 and Table 4 respectively.

XII. TABLE 1: ELASTIC PARAMETERS FOR CONCRETE

Density Kg/m^3	2643
Young's Modulus GPa	31
Poisson's ratio	0.15

XIII. TABLE 2: THE PARAMETERS FOR CDP MODEL

Dilation angle (degrees)	36.31
Eccentricity	0.1
fb0 / fc0	1.16
K_c	0.667

μ	0

XIV. TABLE 3: COMPRESSIVE BEHAVIOUR OF THE CONCRETE

Yield stress (MPa)	Inelastic strain
13	0
24	0.001

XV. TABLE 4: CONCRETE TENSION STIFFENING

Yield stress	Displacement	Damage variable	Displacement
2900000	0	0	0
1943930	6.6185E-005	0.381217	6.6185E-005
1303050	0.00012286	0.617107	0.00012286
873463	0.000173427	0.763072	0.000173427
585500	0.00022019	0.853393	0.00022019
392472	0.000264718	0.909282	0.000264718
263082	0.000308088	0.943865	0.000308088
176349	0.00035105	0.965265	0.00035105
118210	0.000394138	0.978506	0.000394138
79238.8	0.000437744	0.9867	0.000437744
53115.4	0.000482165	0.99177	0.000482165

 WATER

Water was modelled using the equation of state in the form of linear U_S-U_p Hugoniot. The parameters required to calibrate the mdoel were taken from Abaqus manual and are summarised in the table 5 and table 6.

XVI. TABLE 5: PHYSICAL PROPERTIES OF WATER

Mass density Kg/m^3	1000
Dynamic viscosity N s/m^2	0.001002

XVII. TABLE 6: PARAMETERS OF EQUATION OF STATE OF WATER

C0	1481
s	0
Gamma0	0

6.3 Boundary and loading configurations

To replicate the exact boundary and loading configuration of the storage tank and a bund wall during a catastrophic failure, the ground and the bottom area of the bund were fixed. A gravity load was applied for all parts in addition to an initial velocity for the water equal to 2.35 m/s.

Fig.5 depicts the load configuration and the boundary condition.

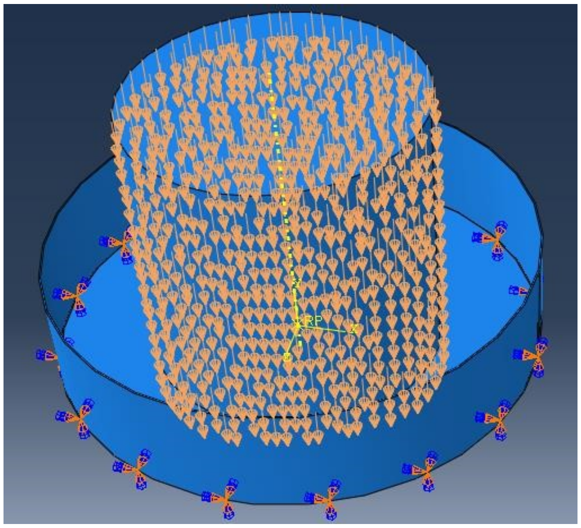


Fig.5. Boundary conditions and load configuration

6.4 Element

Abaqus element library offers a wide range of elements that are suitable for different analyses; they range from solid, shell to beam. In this case, the bund wall is modelled using solid element with an aspect ratio equal to 1 to reduce errors in numerical solution. The bottom is modelled as a rigid body which means the meshing size is not important. The column of water is modelled using hexagonal elements and then converted to PC3D during the analysis because the fluid is modelled with SPH method. Fig.6 shows the mesh of all parts.

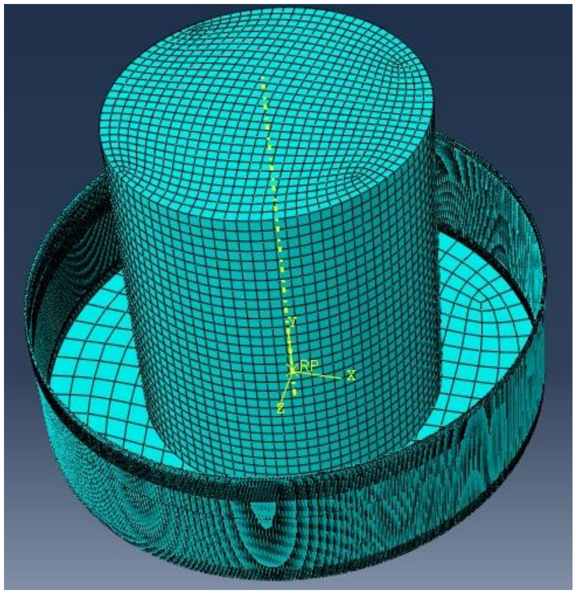


Fig. 6. Mesh of fluid, tank and ground

6.5 Output

The post processing in abaqus is read in visualization module that allows animations, plots, tabular output to be obtained. The usual output parameters such as stress, strain, displacement were requested in addition to DAMAGEC and DAMAGET, which are the two parameters that show whether the concrete has undergone damage under compressive and tensile loading respectively.

7. RESULTS AND DISCUSSION

Fig.7 and Fig.8 show DAMAGET parameter with which it is shown if the concrete has undergone damage under tensile loading. Fig.7 corresponds to the start of simulation where the fluid is at rest. DAMAGET is equal to zero everywhere in the bund. At t=0.15, the fluid hits the bund wall and causes the damage of the bund wall. A maximum value of the Damage due to the tensile load equal to 20% is reached which implies that the bund has failed meaning that the bund wall is not suitable to function anymore. It should be noted that the CDP model does not support the element deletion option that eliminates the element from the model once the damage criteria if fulfilled. Therefore, even a small percentage of DAMAGET means that the bund wall failed and a new design has to be suggested.

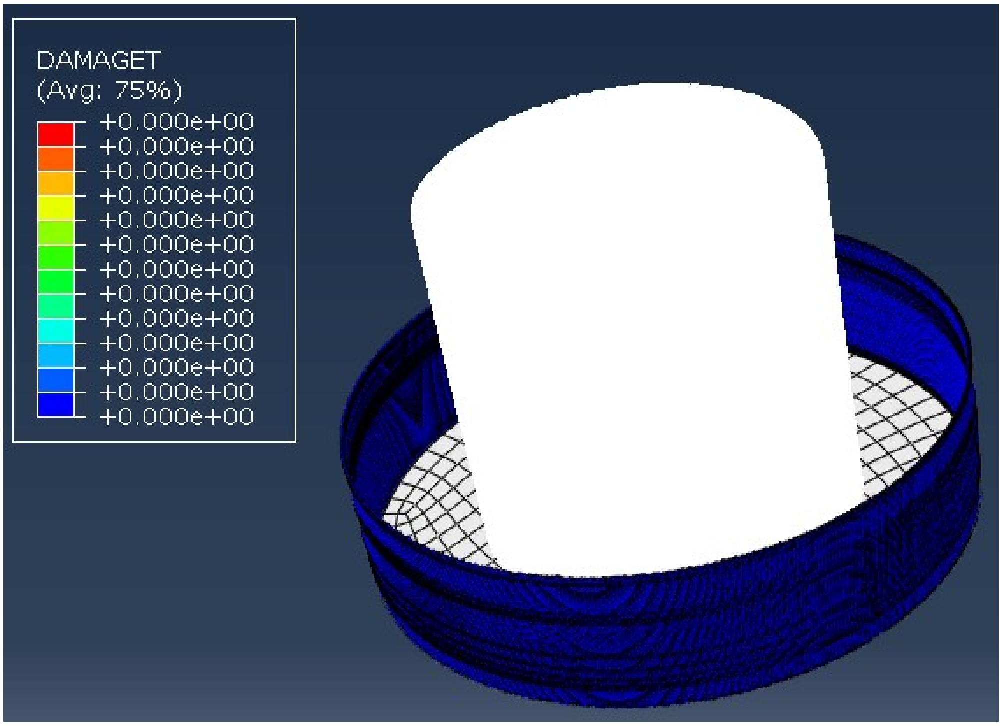


Fig.7. Fluid at rest at t=0s

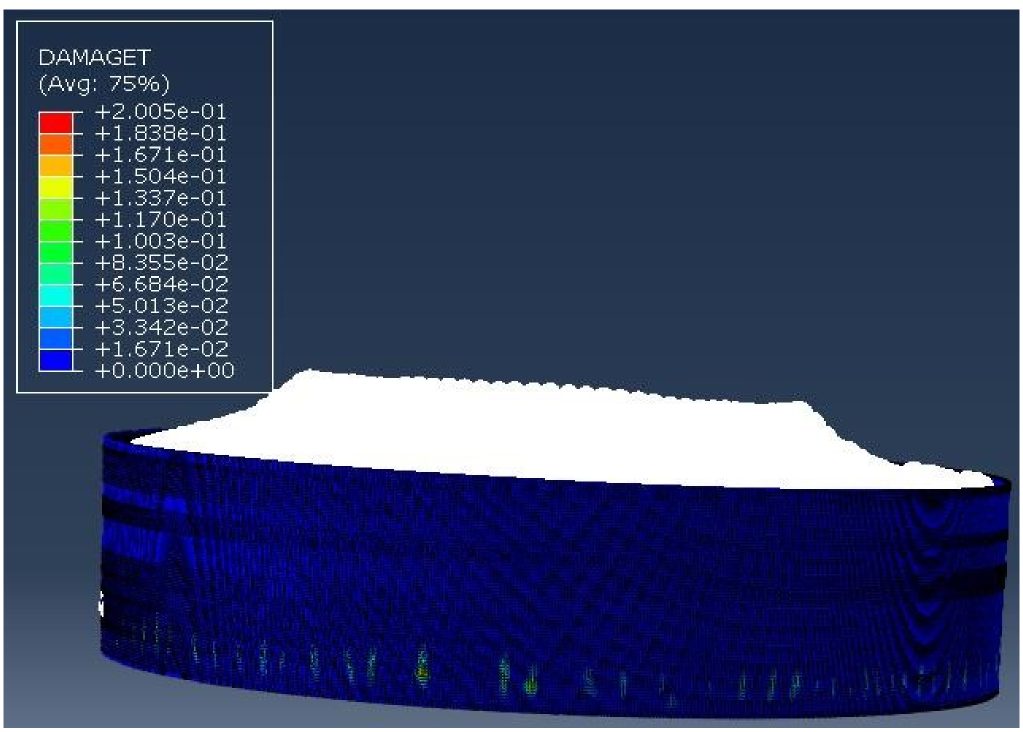


Fig.8. Damage of the bund due to fluid impact, t=0.15s

8. Conclusion

The catastrophic failure of storage tanks is a very serious problem that resulted in disastrous effects throughout the history. The occurrence of a complete failure of a storage tank is very rare and the partial failure is more likely to happen. However, it is crucial to provide a bund wall that is able to withstand the impact of the wave in case of catastrophic failure. Current bund wall have shown that their structural integrity is harmed against dynamic pressure, therefore it is important to redesign the bund wall to mitigate any aftereffects in case of total failure. In this paper, an investigation of the structural integrity of bund wall system has been presented. The tank made of concrete was analysed using Abaqus. The bulk of fluid was modelled through Spherical Particle Hydrodynamic technique and the bund wall was analysed using the dynamic explicit technique. It has been shown that a bund wall made of concrete is not able to resist the impact of a fluid therefore a new design has to be suggested.

Acknowledgments

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Software Engineering: Regulations and Standardizations Enforcement

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Abstract

This paper will go through the major challenges to the software engineering which are result from the emerging technologies like Service Oriented Architecture, Big Data, Internet of Things, and Cloud Computing, and we will introduce the need of a software regulator that will be responsible for creating rules and regulation that will be applied to software educational institutes and software development companies, and this regulator will be responsible for licensing software engineers to be sure that they have the required skills to continue in the market, and also will be responsible for inspecting software products to make sure that they are following the published quality measures. The main aim of the proposed organization is to help the community to have a good quality software products and monitor the market to avoid any crisis that could happen to the software industry.

Keywords: Big Data, Cloud computing, Internet of things, Service Oriented Architecture, Software Engineering

I. INTRODUCTION

SOFT WARE Engineering challenges are increased in the last 20 years due to the rapid progress that is happing to the technology, and we need to understand the root cause of these challenges by presenting the latest technologies and their effects on the software industry and try to introduce the preventive actions that could mitigate the risks results from adapting such technologies. We will start with a fast introduction about software engineering history and then we will discuss the current challenges results from the new technologies and at the end we will propose a solution that we think it could help in reducing the side effects of adapting such technologies.

II. COMPUTERS AND PROGRAMMING LANGUAGES HISTORY

Software engineering as a discipline was evolved as a result of advances that happened in computing power, and the new tools, techniques, and programming languages. In this section we will go through the history of computers and programming languages and its effects on the software engineering.

A. Computers

Analog computers were developed and used in the war weapons. ENIAC (Electronic Numerical Integrator and Computer) is considered the first digital computer and it was built in 1946 by Presper Eckert and John Mauchly. In 1974, MITS created the Atair 8800 which considered one of the first personal computers which led to the rise of personal and commercial software in the 1980s. After a lot of tries to create a mobile computer, IBM created KAYPRO 2000 which was considered the first commercial laptop in 1985. Smart Phones, Smart Devices started to evolve at the beginning of the 2000s, which created the need for having a specific software for these devices. [48]

B. Programming Languages

The first programming language, PLANKALKUL was developed between 1943 and 1945 by Konrad Zeus. In 1957, IBM created FORTRAN and it was widely used as a programming language and in 1962 the Department of Defense in the United States releases COBOL. In 1970, and after a lot of researches about the Structured Programing and Data Structure, Niklaus Wirth, and Kathleen Jensen created PASCAL. Under the pressure of creating the operating system UNIX, Dennis Richie created C language. Information Hiding concepts and Encapsulation led to the creation of the first Object Oriented Language SIMULA67, which was developed by O. J. Dahl and Kristen Niggard in 1967, followed by Ada in 1980 and C++ in 1983. The programming languages were created for a specific platform until 1995 when James Gosling created JAVA which can run on any platform that has JAVA Virtual Machine. After the rising of World Wide Web in 1989 which was invented by Tim Berners-Lee, HTML used to create web pages and a whole set of scripting languages were created to facilitate internet applications development. SWIFT was released by Apple in 2014 to create smart devices applications. JULIA 2012, SAS, PYTHON 1991, and R 1993 are used for
Analyzing Big Data. [49]

III. SOFTWARE ENGINEERING EVOLVEMENT

IEEE defines software engineering as "The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software, and the study of these approaches; that is, the application of engineering to software. "[16]

The aim of Software Engineering is to answer questions like how to create a software, how to measure its quality, how to measure the size of a software application, and how to create secure and error free software.

A. The Past

Although Software Engineering was considered as a discipline in 1968 at the "NATO Conference", researchers started developing software programs about twenty years earlier when Tom Kilburn developed the first simple stored program in 1948 at the University of Manchester. The software term was used for the first time by John W. Tukey at 1958. Software Crisis happened between 1965 and 1985 when a large software project failed ex. Operating system OS/360 project, and many weak applications were created with a lot of security issues and bugs that in some cases was lethal ex. Therac-25 case. During the late of 1980s public and private organizations were trying to solve these issues by introducing new tools like CASE tools to help in software creation, developing new methodologies like (SDLC) Software Development Life Cycle, emphasizing on documentation, improving the programmers' skills, and increasing the professionalism by creating the software engineering code of ethics, and licensing.[22]

In 1990s, and after the evolving of World Wide Web the distributed systems and data caused spreading of the software methodologies that are depending on rapid development and a new branch of software development was created, called Web Development. In 2000s and due to the rise of Management Information Systems that is designed for decision making and e-commerce, new Architects were created like Model Driven Architecture (MDA), and during this decade, agile concepts started to take the lead between software development methodologies. Open Source software took a lot of attention during this decade, and it was found that the old development model like the Waterfall model was not suitable, so they used different models for open source development like Rapid Application Development, Spiral Lifecycle, and Extreme Programming.

B. The Present

Health Information Systems, e-government, and large scale applications raised the need of Integration and Interoperability between software applications and because of this, new frameworks were

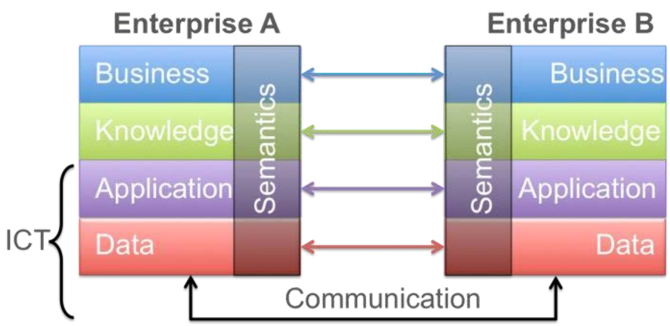

Fig. 1. “MDI and Interoperability levels.” [44]

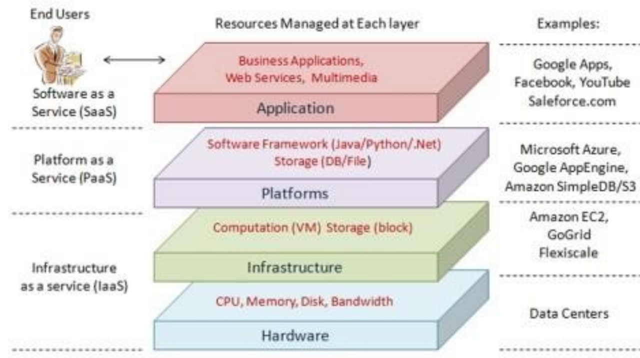

Fig. 3. «Cloud Computing Architecture» [45]

developed, for example, Model Driven Interoperability (MIDI). MDI was derived from MDA and it focuses about interoperable between applications at different levels, starting from data at the bottom of the model, going to interface and then business and knowledge on the top of the model. The Big Data term refers to the huge amount of data that can’t be handled using the old technique of storing, processing, or searching and also refers to using the descriptive and predictive techniques to get insights knowledge of the data and to discover hidden patterns. The availability of this data helped to improve disciplines like Business Intelligence, Data Mining, and Natural Language Processing, and besides using the analytic techniques on the structured data, it is being used for unstructured data like texts, audio, images, and video data. DevOps and Agile techniques are commonly used for creating big data software products. [1]

Service Oriented Architecture (SOA) evolved after the need to create rapid development applications and avoid the risk of crating huge applications at once. This architecture is dividing the software application into independent, and communicated processes and functions according to business needs.

With this architecture we can reduce application complexities and creating highly integrated applications. SOA Implementation Framework is used by software engineers to achieve SOA goals.

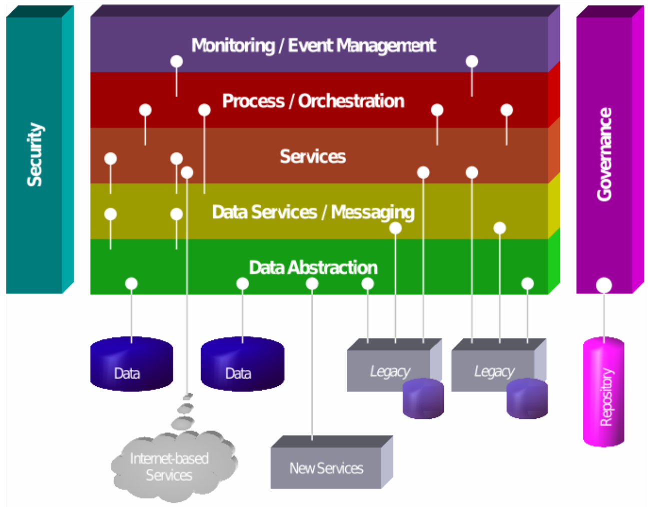

Fig. 2. "SOA meta-model, The Linthicum Group, 2007" [35]

Cloud Computing became the trend now, and it has been called the new normal. The architecture of the cloud enables software engineers to provide infrastructure, platforms, and software as a service, this architecture enables scalability, and elasticity, and at the same it is cost effective because of using the computing resources effectively. [4] Agile Development concepts are widely used for Cloud Computing Development through using methods like Scrum or Extreme Development because it enables the rapid development, incorporate customer feedback quickly, and it helps in utilizing the working forces efficiently. [13]

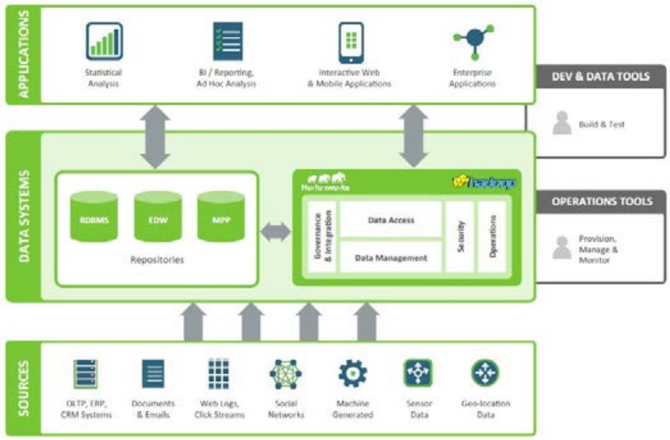

Fig. 4. “Big Data Architecture” [46]

Internet of Things (IoT) is connecting people, processes, and physical objects like mobile phones, computers, washing machines, air conditioners, medical products, or anything that has software and sensors and connected via the network. IoT has a lot of applications in health care by mentoring the patients through medical devices. IoT can be used in applications that can track the customers and provide them with personalized products. Integrating between devices can help in mentoring the environment, reducing energy consumption, and building intelligent houses. The IoT development framework includes device software, communication protocol, applications integration, data analytics, and the end user application.

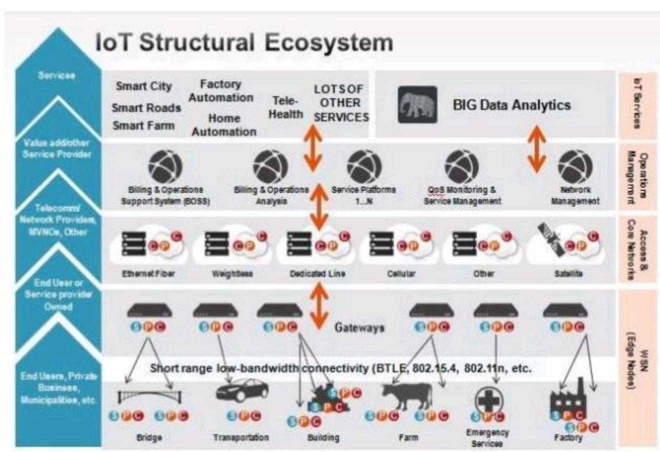

Fig. 5. “Internet of Things Architecture” [47]

IV. SOFTWARE ENGINEERING CHALLENGES

In this section we will discuss the current and the future software engineering challenges that result from the previously mentioned advances in technology.

A. Service Oriented Architecture Challenges

SOA applications are built using protocols and languages like SOAP, XML, and WSDL and those open standards does not have a predefined security architecture which makes the SOA application subject to security attacks or unauthorized logging.

Many SOA applications are failed due to lack of documentation, standardizations, rules and policies which affects the reusability of the service and the undesired performance and also increase the dependency on the vendor.

Improper planning of the scalability could due to a serious performance issue, due to increase of service users with insufficient underlying computing resources.

Due to using services from multiple sources and platforms SOA application is complex and needs a lot integration and continuous testing because the service or its platform is subject to be changed or updated. [7]

B. Cloud Computing Challenges

Outsourcing infrastructure, platforms, and software to a third parity raised a lot of questions about how to insure privacy and security of our applications and the data, especially after several successful attacks to some well-known cloud servers. Internet and networks connectivity became the bottle nick of any cloud service and any local or global connectivity issue could affect availability or reliability of the service. [45]

Lack of applied standardization, policies and rules raise some questions about how to measure the quality of the cloud services and how to maintain the desirable performance.

Interoperability complexity increased because of the need to integrate between different cloud services and between on- premise applications and the cloud applications. [12]

Performance of the cloud services became a challenge, due integration complexity, bandwidth limitation, and the continuous increase of cloud services users.

C. Big Data Challenges

Increase data volume creates challenges in data storing, distributing, processing, visualizing, searching, and transferring, and how to accomplish all of this in a competitive speed.

The increase in data growth that is coming from different resources result in trying to find new techniques to efficiently extract, transform, and load data and at the same time maintain its quality.

The large amount of data and its features increased the complexity of creating and storing metadata and how to visualize it to create a clear understanding of the undelaying data.

Big data that could be structured or unstructured, became an increasing challenge to programming languages, tools and techniques that are used for describing and analyzing data, those tools need continuous updates to get the most of this data treasures

Big Data raised many questions about how to secure data and maintain the privacy while distributing it several nodes and sites, how to monitor compliance and how to encrypt the data while transfer it.

D. IoT Challenges

Lack of solid standardization, protocols, policies, and rules that facilitate continues, reliable, and safe connectivity between smart objects.

How to store and analyze this large amount of data that is generated from those connected smart devices and also how to visualize it and make it available to the end user.

IoT application is a complex application that is depending on the continuous connectivity between devices and also the integration between sensors and functionalities of interoperable devices. [19]

IoT application uses Big Data, SOA, and Cloud Computing concepts and it inherits their complexity and challenges. [10]

E. System of Systems Challenges

Now there many large independent systems that are created and integrated, this system that includes many integrated systems is called System of Systems, and to create and maintain this system we need a lot of changes in our traditional software engineering techniques.

There are many challenges of creating such systems, for example, how to integrate those independent systems, how to operate and monitor such system, how to create a model that could simulate the interaction between those systems, what is the standardizations, polices and rules that will guide us while developing this system, and how to secure the container system and its individual-linked components. [37]

F. General Challenges

Huge number of programmers and software engineers that are added to the market from different disciplines and with different understanding of software engineering standards could reduce the quality and security of the end product.

Migrating old legacy systems to the new frameworks needs a lot of reverse engineering to extract the undocumented knowledge from the old code and rewrite it using modern languages and tools.

Developing new software products using scattered locations and offshore programmers, implies updating our techniques in software development, and software project management.

Now we have a large software community that is sharing his experiences and codes through the internet which create a huge opportunity for the junior software engineer, but also has a threat of distributing non-authorized and non-secure codes which could create a software quality issue.

V. THE NEED FOR SOFTWARE REGULATOR

Between 1965 and 1985 when the software crisis happened, researchers found that among the reasons of this crisis are the incompetent software engineers and the lack of applying software development, quality and security standardizations. Now and after the fourth industrial revolution, and as a result of software applications divergence, complexity and its ultra-scale growth plus the total dependency on software applications, the question is, are we ready for any software crisis, what is the preventive actions to avoid global applications failure, and how to reduce the negative results if this happened.

In this section we will introduce the idea of having a software regulator that will have a mission of enforcing software standardizations and it will work closely with the internal business regulators, companies, and governmental entities to make sure that the developed software, and the software engineers are following policies and the rules which ensure the creation of secure and a good quality software. In the next section we will discuss the expected role of the regulator in enforcing software education standards, and license software engineers and software companies, and also monitor quality of the software itself to help in making it secure and Interoperable.

A. Software Education

Due to the continuous needs of software engineers, there are many public and private institutions that are providing the market with its needs, but the question is, are all of those institutions provide software engineers with the latest stabilized tools and techniques that will enable him to handle software development problems. So far though the increasing in software engineering complexity and disciplines, still the software education away from the advances that are happening and every year there are thousands of graduated software engineers without a specific domain knowledge and without the needed skills to join the market.[3]

There is a big gap between what the software engineering theoretical studies and the market practice and in many cases, there is no direct link between the educational institution and the software industry, also in many institutions there no evidence that they are teaching their students software quality, security, testing , or integration standards. The software engineering regulator will check the compliance of the educational institute with the latest industry practice, and will make sure that the graduated software engineer is equipped with the latest knowledge and standardization that will help him in creating a secure, and a good quality software, and in case if this institution failed to comply with the regulator education standards, it will not be allowed to give the software engineering degree.

B. Software engineers and companies licensing

In many situations you can find programmers, system administrators, system analysts, database administrators, and software project managers that aren't graduated from software engineering institutes and there is no evidence that they are applying software standardizations, and rules which creates vulnerable environments. There are many software companies in the market that aren't follow the standard way of creating secure, and a stable software product and also they are hiring a low cost resources without paying attention to the quality of their knowledge.

The software engineering regulator will make sure that no one will practice any discipline of software engineering unless he has the license to do so, and this license will be based on his education or his certifications that is comply with the published software engineering required skills, and also this license will not be permeant license, the software engineer has to prove that he is aware of the new technologies and standardization in his field by show the evidences of his continuous education and his continuous practice of software engineering. The software engineering regulator will not license any company until it follows the published standardization within software development, testing, and integration. The software company has to follow the regulations about the qualifications of the hired software engineers, and it has to show the evidence that it helps them to develop themselves.

For each software engineering discipline there many certifications, the regulator has to help the software engineering society be identifying those certifications that will help the software engineer to obtain and maintain his license, and also the regulator has to help the software companies to obtain the accepted certification that show their compliance with the regulations.

C. Software Licensing

Software companies, individuals, IT departments, public and private organizations are creating software but is the created software follows the standards that make it secure and integrable, and doesn’t harm the people or companies that are using it. Between 1985 and 1987, there is about six reported incidents about patients that were subjected to high dosage radiation, resulting death and injures because of a programing bug in the software that installed on the radiation machine (Therac-25 case). In 2012, Knight Capital released new trading software without proper testing which cost a loss with about 440 million dollar. In 2015, a bug in the software that is calculating the prisoner’s sentence period in the USA causes 3200 prisoners to be early released. In 2014 Apple iCloud servers had a security issue which enabled hackers to publish the hacked account personal data.

In every country, there are many organizations that are monitoring created products to make sure that it follows the published standardizations and we can’t find the same for the software product, despite its increasing effects on business and human life. Not only software companies, engineers, institutes have to be license, but also software application needs to be licensed to make sure that it follows the internal and external policies, and in case if it is integrated with global systems it will not cause any damages to whole system. Before releasing any software in the market software regulator has to check the new product to make sure that it is following all regulations related to software quality and security, and the same has to be repeated if there is a major update on the released application. Every licensed software has to have a license expiry date, and regulator has to decide to extend this expiry date or the tools and techniques used in this application became absolute and could cause serious problems.

In case of general software bug or issue, software regulator has to warn the anticipated affected organizations and individuals and it will make sure that all software applications that are affected because of this issue will be updated. Any software application that needs to be integrated with other systems inside the system of systems architecture has to be compliance with the integration requirements to make sure that it will not fail the overall system in case of any individual failure.

VI. CONCLUSION

Software engineering is being evolved since the beginning of the previous century and the advances that happened in computers, programming language and smart devices affected tools, techniques, and the methodologies that are used in software creation. The new emerging technologies like Big Data, IoT, and Cloud Computing increased the complexity of the software product and created many challenges that have to be addressed and studies to facilitate the progress in software engineering.

In this paper we are proposing the need of software community to have a regulator to make sure that the software engineering education is up to the required standards and it is linked with industry, and to be responsible software engineers competencies and skills and regulate any facility that is introducing software to the public, and also monitor the developed software to make sure that it is created with acceptable quality and security, aiming to avoid any damages that could happen to people and economy because vulnerable software. The main objective of the proposed regulator is to organize the software market and quickly responds to the new challenges and evolutions. In the next researches we will discuss the structure of the proposed regulator organization, how to finance this organization, how to create a link between it and current standardization organizations, and how to avoid disadvantages that results from the proposed rules and regulations.

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Hoteliers’ attitude towards solid waste source separation through mega festivals: A pilot study in Karbala

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ABSTRACT

Management of solid waste generated from religious gathering has been, until now, the topic of few studies. This is confusing as the religious festivals are significant Municipal Solid Waste (MSW) generators and, in the same time, mismanagement of the generated MSW can cause grave threats to the environment. Source separation is an effective method to minimize the amount of the generated waste where the community plays a vital part about its success. This paper aims to identify hotels managers’ attitude and readiness to be part in a proposed MSW source separation plan during mega events in the city of Kerbala, Iraq. This is done using a pilot survey conducted with 29 hotel managers’ during one religious festival. Mixed method approach with the assistance of questionnaire was employed for collecting data about hoteliers waste management awareness and willingness to practise source separation. The result indicates that, although the majority of the hoteliers have low awareness about MSW management subjects, (65.5 %) were willing to practice MSW source separation. In addition, the hoteliers suggest that developing waste storage system by providing recycling bins will encourage pilgrims to practice source separation. Thus, Kerbala MSW management authority can use the result of this study to implement MSW source separation program during religious events.

Keywords: Environmental awareness, Kerbala, major festivals, recycling and hoteliers.

1. Introduction

Tourism is a significant industry in the world that is represents 8% of the world's total job and 9% of the world's gross domestic product (El Hanandeh, 2013, MercoPress, 2010). This industry can sustain high level of employment and income in many countries. However, it is a source of negative impacts on environment and public health. One of the most significant impacts of tourism is the generation of solid waste (Mateu-Sbert et al., 2013). One form of tourism industry is the religious tourism where people travel to participate in particular festivals significance in their faith. According to The World Religious Tourism Association (World Religious Travel Association, 2011), every year, around 300 million people participates in religious festivals around the world.

Several religious festivals occur in the city of Kerbala, Iraq every year which are attended by millions of visitors (Obaid et al., 2014). The dramatic increase in the city population during these festivals causes a substantial increase in the quantity of the solid waste generated that tremendously affects its Waste Management System (WMS). Currently, the city is using basic WMS that leads to significant impacts on the local environment and public health. In addition, the growing costs of waste collection, treatment and disposal have escalated the problems of managing festivals wastes (Cierjacks et al., 2012).

Waste management is an important issue as improper waste management will affects other issues including operation costs, land scarcity, and negative impacts on environment and human health (Sheau-Ting et al., 2016). solid waste recycling is an effective method used to minimize the quantity of the generated waste where the community plays a vibrant part about its success (Fujii et al., 2014). However, funding deficiency and low public participation are problems facing the success of the municipal solid waste management plans particularly in developing countries such as Iraq (Keramitsoglou and Tsagarakis, 2013). Babaei et al. (Babaei et al., 2015) stated that about 60-80% of the European countries solid waste are recycled while an insignificant percentage of waste is treated similarly in developing countries. Therefore, large quantities of municipal solid waste are disposed of in the landfill without recovery. Proper infrastructures are necessary for a successful waste management system. However, understanding the system users' preference and knowledge greatly affects the success of waste management system (Babaei et al., 2015). Therefore, conducting a comprehensive survey to investigate affecting variables such as public preference, involvement willingness and knowledge is clearly essential. Many research reported in the literature have studied and assessed these variables (Purcell and Magette, 2010). Only a dearth of studies have investigated these variables during mega events (Alsebaei, 2014). To achieve a functional solid waste management plan during mega festivals, it is important to study and understand the variables that dramatically affects community involvement in the recycling scheme.

In order to develop the primitive system currently used in Kerbala, it is crucial to investigate public preference and willingness to participate in a recycling scheme during mega festivals. Therefore, this study has been devoted to understand public reaction towards introducing a recycling program during mega festivals. To achieve this goal, Ashura, a multi-million event take place in Kerbala attracting up to 5 million visitors, has been selected as a study event (AFP, 2016).

2. METHODOLOGY

2.1 Study area

Kerbala is one of the main tourism centres in Iraq since it is hosting several traditional festivals attended by millions of visitors. It is situated southwest of the Iraqi capital Fig (1), Baghdad, covering an area of 5023km2 (Abdulredha, 2012).The estimated population of the city is 1,003,516 residents (Republic of Iraq Ministry of Planning Central Statistical Organization, 2010). According to the city authority, the city compromises 848 hotels that are fully occupied during each festival.

Ashura, one of the main festival in Kerbala, is lasting up to 10 days and attracting more than 5 million tourist (AFP, 2016). In 2014, this festival produced around 12,000 tons of solid waste. It is worth noting here that exact numbers on waste amount do not exist and have had to be estimated by the collection authority. Primitive municipal waste management system is currently available in the city. Produced waste are collected and transported to final destination, landfill site, without treatment and recovery.

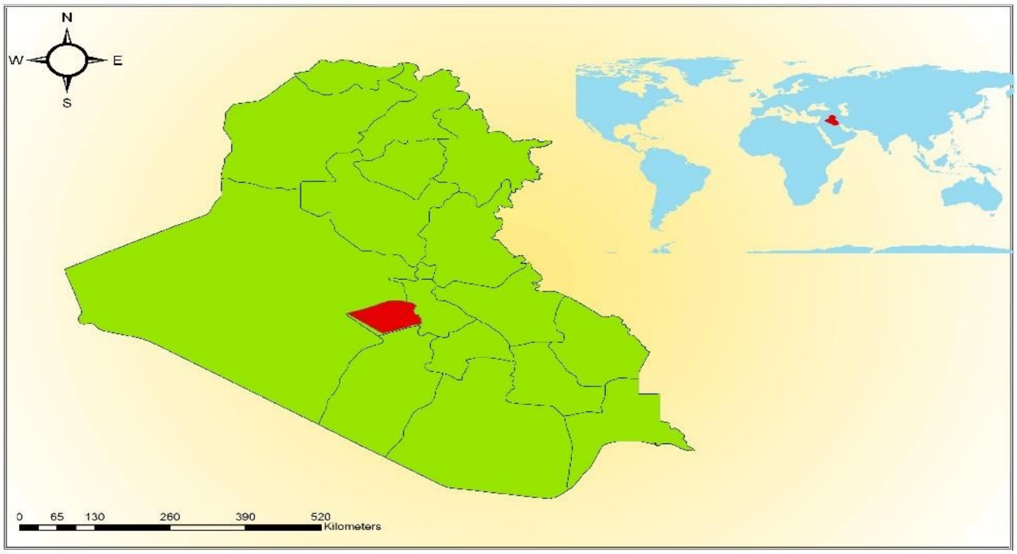

Figure 1. Kerbala City Location

2.2 Data collection and analysis

A pilot survey was carried out to study hoteliers' knowledge about solid waste recycling and their willingness to practice source separation. A total of 29 hotels managers' were randomly selected from the city centre to gather the required data. Research assistants personally contacted all of the 29 hotel managers and asked them to fill a structured questionnaire containing open-ended and close-ended questions. The questionnaire consist of two parts: the first part contains a group of questions exploring the hoteliers' knowledge level about environmental pollution, waste pollution, waste recycling, waste reduction, and waste composting. The other part included questions exploring hoteliers' intention to practice source separation, and the actions that can motivates them to practice source separation. Statistical Package for Social Science analysis was performed using SPSS software (version 23; SPSS Inc., Chicago, IL). The hoteliers' responses such as willing to practice solid waste source separation and awareness were examined using descriptive statistics.

3. Result and discussion

3.1 Demographic attributes

The demographics variables (gender, education level, and age group) of the participants are summarized in table 1. The majority of the hoteliers had received higher education degrees. All the respondents were males, which it is expected owing to the cultural norms of the city.

Most of the hotels managers' falls within the age 36 to 45 years.

A. *Table 2. Respondent Profile*

Groups	Groups	Observer's number	Observer's Percentage	Total
Education level	Completed higher education	19	65.5 %	29 (100%)
	Completed secondary education	7	24.1 %	
	Completed primary education	3	10.3 %	
Gender	Male	29	100 %	29 (100%)
	Female	0	0.0 %	
Age Group	18-25	2	6.9 %	29 (100%)
	26-35	12	41.4 %	
	36-45	14	48.3 %	
	>45	1	3.4 %	

3.2 Solid waste separation and recycling

Public support and participation plays an essential part in the success of any solid waste management system (Babaei et al., 2015). Therefore, this study attempts to measure hoteliers attitudes towards the application of source separation and recycling scheme during mage festivals. The results of this researches shows low knowledge level across the respondents about several subjects including environmental pollution, solid waste pollution, waste recycling, waste reductions, and backyards composition (27.5 %, 17.2 %, 3.4 %, 3.4 %, 3.4% respectively). About 65.5 % of the hoteliers were willing to practice recycling and source separation (Fig. 2) owing to their desire improve waste collection system (84.4 %), enhance the city economic (63.1%) and because it is their duty(26.3%).

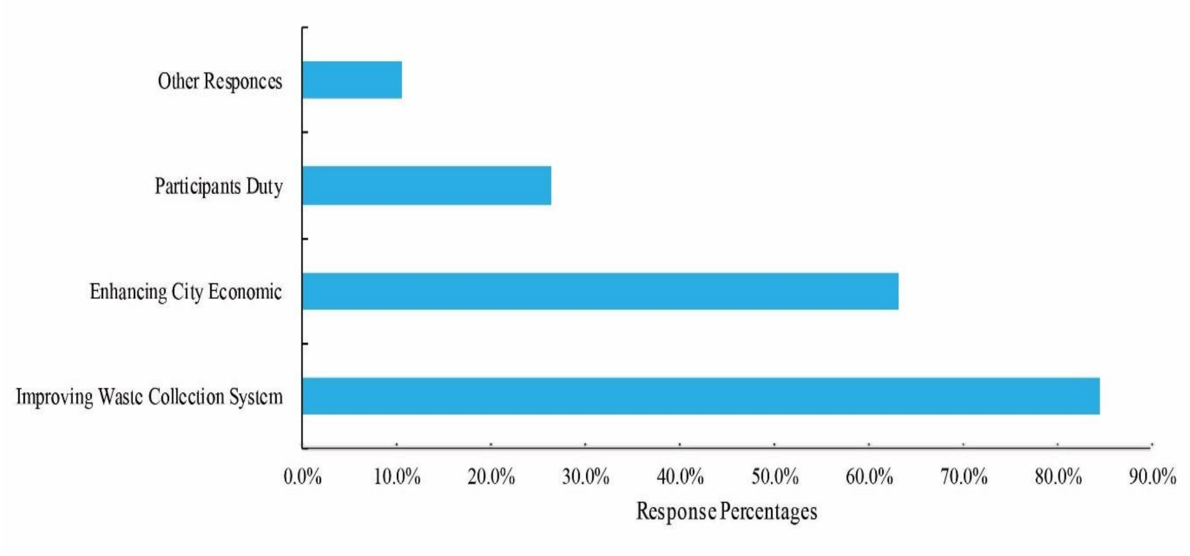

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Figure 2. Categorized answers to the question, “The goal of participating in WSS plan?”

Citizens’ participation in waste recycling and source separation schemes is changing according to public awareness and the availability of recycling opportunities (Keramitsoglou and Tsagarakis, 2013). Around 34.4 % of the hoteliers were not willing to practice waste source separation due to several reasons including low public awareness (90 %), unavailable recycling service (80%), and lack of financial rewards or penalties (10 %). Research shows that the public willingness to participate in recycling plan increases when the recycling bins were positioned near their houses (Gonzalez-Torre and Adenso-Diaz, 2005, Grodzi´nska-Jurczak, 2003). Likewise, low public awareness negatively affects (Babaei et al., 2015). For these reasons, introducing a recycling plan during mega festivals starts with providing recycling bins and rising the public awareness.

1) *3.3 Separated waste collection*

Currently, curbside waste collection system is applied in Kerbala during mega festivals. Waste generators collects the waste in plastic bags or small container and move it to the curb. Yearly, Kerbala municipality provide around 1000 plastic containers in the event area to increase waste collection efficiency. Majority of the hoteliers store their waste by using these containers.

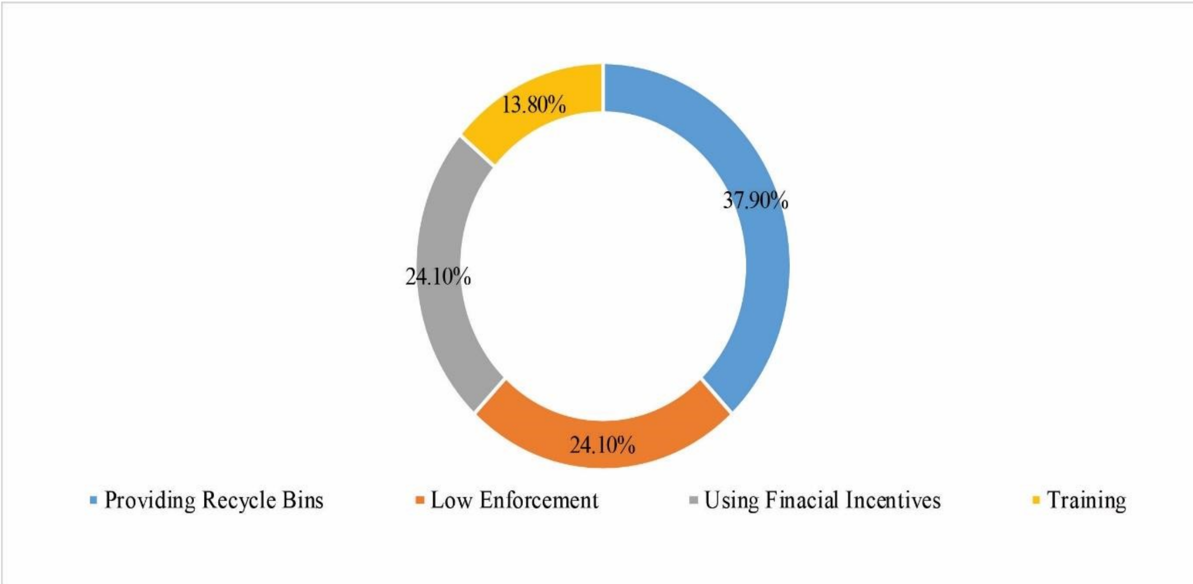

Figure 3. Responses to the question “what is prefer red sorting option for you?”

Introducing an effective solid waste-recycling program requires high participation rate by the hoteliers. Therefore, ascertaining hotel managers’ preferences for recycling is essential. Accordingly, hoteliers were requested to choose the best attributes that would promote their participation in solid waste recycling plan. The majority of the respondent (37.9 %) asked for recycling containers to be involved in the practice. Another 24.1% of the respondents proposed that rewards might increase

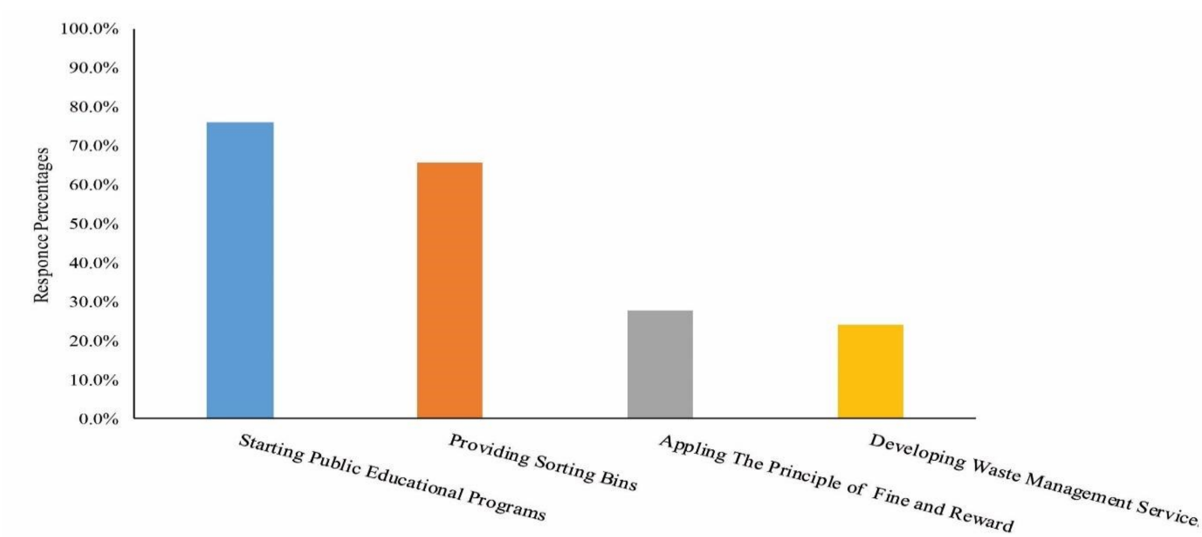

Figure 4. Classified responses to the open-ended question “the actions that would motivates visitors’ participation in the recycling program?”

hoteliers participation rate. Similarly, 24.1% suggest low enforcement might increase participation rate. While, around 13.8 % suggests that training programs would raise the rate of waste separation and recycling (Fig. 3). In addition, the hoteliers were asked to suggest actions that increase Kerbala visitors' engagements in such system. Actions such as providing recycling containers in the events area (65.5 %), imposing fines and rewards (27.6 %), and starting educational programs (75.9 %) (Fig. 4). Establishing a recyclable waste storage system and commencing educational plans during festivals are basically essential to introduce a recycling scheme since the majority of the hoteliers were willing to practice waste source separation (65.5 %).

4. CONCLUSION

A key player in the success of a waste management system is the public involvement. Thus, it is crucial to investigate public attitude towards the application of a new development such as the introduction of a recycling program. As the management system applied in Kerbala lacks the use of recycling scheme, it is complex to understand the public reaction towards a source separation and recycling program. Therefore, this pilot study was devoted estimates hoteliers participation rate in a recycling program during mega festivals.

The outcome indicates that despite the fact that the majority of the hotel managers have low knowledge about waste management subjects such as waste pollution, waste recycling, and waste reduction, a significant percentage of them (65.5 %) were positive towards the involvement in the recycling program during major festivals. In addition, providing proper solid waste management infrastructures and initiating educational programs to rise the public awareness and knowledge seems to be crucial to the success of the recycling program.

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Software Engineering Challenges and Roadmap Beyond 2030

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Abstract

In 2030, majority of the cities would convert into smart cities. Technology would become part of everyday life whether it's at workplace, home or public life. People, devices and city infrastructure would be connected. Disruptive technologies, which are at their exploratory stages, would become essential in 2030. These technologies include Internet of Things (IoT), Artificial Intelligence (AI), 3D printing, autonomous vehicle, robots, blockchain, systems of systems etc. Software engineering is at the core of these technologies. These technologies would create new opportunities and challenges. This paper will present the state of art and state of practice in software engineering in 2030, the major challenges in the software engineering discipline in 2030, and finally propose a roadmap to overcome these challenges.

Keywords—Software Engineering; Challenges; Security; Privacy; Roadmap.

I. INTRODUCTION

A. State of Art

Technologies such as 3D printing, autonomous transport systems, AI, digital money are disruptive technologies. They will be wide spread in 2030 [1]. They would change the life of individuals and business operation. The below section describes the state of art in 2030.

- Integrated Ecosystem

The ecosystem in the smart city is a representation of complex systems of systems, large-scale distributed systems. There are high interdependencies between domains, systems, enterprises and society [2]. The whole city is interconnected. People, devices and infrastructure are interconnected through IoT. Sensors are core component of every system. These sensors take instant decisions as a response to continuous changes in the environment. They also have AI based software, which enable them to self-learn, adapt to their environment and optimize the prediction continuously [1, 2]. They work autonomously.

An example of an integrated system is transportation. Autonomous public buses send continuous automated messages to bus stations to update the stations sign with their estimated arrival time based on the road traffic and their location. When the bus reaches a bus station, it senses if there are people at the bus stop and stops accordingly. Another example is the autonomous cars, which drop their passengers at the workplace. Then they search for the cheapest parking based on the parking information shared in near by areas. Once the owners finish their work, they request their autonomous cars to pick them up. The cars inform their owners about the parking fees to be paid [2].

There are many organizations working on an integrated mobility solutions which include vehicles, pedestrians and infrastructure. Example of such organizations is Ford which is collaborating with U.S. Department of Transportation and with a European consortium called Safe and Intelligent Mobility to create an integrated mobility solution [3].

Another example of integrated system is mining. Rio Tinto is using automated drilling equipments, and automated trucks and trains to extract minerals [3]. Moreover, wearable and telemedicine is widely used to monitor health in real-time [4].

- Smart Machines

AI in the physical form like robotics and software form i.e. algorithms and smart machines is extensively used to perform certain tasks such as responding to patient enquiries, providing a second opinion to a doctor, providing legal advices in a form of virtual lawyer in the cloud and creating an advertisement for a media company [5].

AI as intelligent system, which performs humans job, is known as virtual talent. Virtual talent became an industry, which is widely used. Virtual talent can be provided on the cloud, virtual talent as a service, or could be deployed within the orgnization. Virtual talent can perform an independent task without human involvement. Virtual talent is used in order to speed up the task completion, provide higher accuracy and quality results or overcome the shortage of specialized resources [6]. Moreover, it can perform the job 24/7 maintaining the same level of quality. Virtual talent is also used to assist employees and make them more effective [1]. It enables employees to make better decisions through its capability to analyze huge set of data, and its capability to learn from the environment over a period of time [2, 7]. Moreover, virtual talent is not biased to any culture or any other preference unless that was there in the resources used, thus they produce neutral results [7]. AI is also used to replace functions within the organization such as marketing, HR, legal and regulatory providers which was assumed that only humans could do [1, 2, 6, 7, 8]

- 3D Printing

3D printing is been used extensively in various domains such as healthcare and construction. It is been used to produce only what is needed, when it is needed and where it is needed [9].

In the medical sector, medical devices, implants and prostheses, are been created with the help of 3D printing. The 3D printing allows customers to have a very customized design of the prostheses. The 3D printing is of an interest to everyone and the society is becoming very knowledgeable of technology. A 17-year-old high school student made a prosthetic arm [9]. In construction, 3D printing is used to create the building materials, and furniture [9].

- Blockchain

Blockchain is a decentralized distributed network that stores transactions securely [10]. There are many applications, which are built using blockchain as its core architecture these includes health records, contracts, e-voting, identity and logistic [11].

B. B. State of Practice

The software engineering process within an organization would also evolve in 2030 to adapt to the state of art, the environment dynamic and customer needs as well as the current generation within the organization. The below section describes the state of practice in 2030.

- Software Development

Open Source:

The software development within an organization does not depend solely on in-house or third party development. It leverages the available open source frameworks and build software on top of it [2]. This is due to two main factors 1) the current generation, millennial, is keen on transparency and thus keen in having or contributing to open source [12], thus there is a high growth in the availability of open source frameworks, libraries and projects, 2) there is a continuous high demand from customers on frequent changes and new requirements, thus, time to market is a key factor for organization success and in-house development is a time consuming.

API:

There is a very high demand from customers to have an integrated ecosystem, and innovate solutions. Thus, organization is building on other organization functions or data through their exposed APIs. Organizations also publish their own APIs to allow the public to create innovative solutions. These APIs could be free of cost. An example of that is the AT&T M2X platform which is provided to developers with a free to use IoT API for a limited number of devices and data [13, 14]. Another example is Ford, which provides its vehicle APIs to developers to build applications [3].

- Resources

Software Engineers:

Organizations are not limited to in-house resources. They use a mix of in-house, contracted and outsource software engineers. Contracted and outsource engineers are required due to the need of having a very specific skill, which is required for a short period of time. Such resources are very expensive to hire [2]. Another mechanism for sourcing is crowdsourcing. It is used to expedite the completion of tasks such as fixing bugs in the software or building new independent component or library [15].

Virtual Talent as Organization Resource:

As per [7], 50% of high performing tasks will be distributed between human and virtual resources. These virtual talents are available as cloud-based service with different business models such as usage based or license based [7].

- Delivery Model

The delivery model is based on quick development and release to the market. Organizations are adopting fail-fast experimentation to validate customer demands [8].

- Agile as Development Methodology

Customer demands are frequently increasing. Moreover, technology is changing rapidly. Organizations are required to have a quick delivery and ability to scale with these frequent changes [16].

In order to adapt to the frequent changes, organizations are adopting agile as a development methodology. Solution teams are divided into smaller teams in order to focus on different deliverables, be able to produce quick deliverables, and have the flexibility to prioritize the requirements [16]. These teams do not only consist of software engineers but also span across the organization to include all the roles required to deliver a solution to the customer.

II. CHALLENGES

The state of art and state of practice in 2030 will introduce new set of challenges in IT organizations and software engineering principles. It will also make existing challenges more complicated. This section describes some of the main challenges in 2030:

A. Privacy

Data sharing through the integrated ecosystem is increasing exponentially. This has increased people concerns about their own privacy [6, 17]. System boundaries are hard to be defined in such an interconnected ecosystem [8]. Moreover, organizations are operating in new model of external and internal resources as well as the mix of human resources and smart machines. This has increased their challenge of ensuring data protection.

B. Secuirty

The amount of data that is been generated through IoT and other technologies is increasing very rapidly. Moreover, the volume and the value of digital content that is been created, is very high. Digital content includes 3D printer digital files, smart machine algorithms, digital media etc. Remote applications in IoT sensors need to be accessed and updated remotely. All these files are transmitted over the network. These files need to be stored securely and transmitted over a secure network. Any compromise to the digital content may lead to significant business loss and may risk organizations and individuals. Examples of cyber-attack impact are loss of revenue due to unlicensed copying of 3D printed design file, loss of intellectual property through illegal copies, ethical or health issues due to modification of pharmaceutical files, and safety issues due to corrupted files while updating IoT devices such as Tesla powertrain [3].

C. Eithic

The increased use of AI has replaced certain human jobs with machines [6, 7]. This has been looked at as reducing the employment opportunity especially for low profile jobs. Moreover, organization employees in certain functions such as HR are concerned that they will be not required with the rise of virtual talents [7].

D. Orgnization Readiness

Not all organizations will be capable to adapt and execute the new models rightly. Some of the challenges that will be faced on an organization level are:

- Virtual Resource

Hiring a virtual talent require tasks to be well defined. Deciding on when to use a virtual talent, a human talent or mix of both requires a deep understanding of the task, and the capabilities of each resource. In addition, it requires the integration of outcomes of tasks to deliver the complete solution. Organizations need to have an understanding on how to manage copyrights and regulations when using virtual talent [7].

- Resources Skillset

Technology is becoming a core of every business and organization process. Organizations, which have only specialist to perform the tasks, will not be able to cope up with the new business demands. Specialized resources will not be able to realize the impact of using technology on traditional operations such as the digital copyright issues. Moreover, traditional resources will not be able to manage digital business such as virtual talent.
Moreover, software engineers would need to have knowledge in different domains as technology is intersecting with various domains. For example, 3D printing in health sector requires knowledge in bioengineering, software engineering and art [9, 18]. Another example is in the media sector, which requires understanding of streaming, storage and security [3].

- Cross domains collaboration

Delivery of any innovative solutions required close collaboration between different professionals. For example, anthropologists are required to interpret customer behaviors and psychology, designers are required to create unique customer experiences, software engineers are required to develop the solution leveraging internal and external capabilities and API, and data scientists are required to analyze the huge volume of data and provide insight to improve the product [16].

- Agile

Organizations need to be capable to work in an agile structure. They should be able to delegate authority and yet ensure governance and delivery. Individuals from different departments need to work together. Silos between departments will fail and slow the delivery. Organizations should be able to balance between the team size, skills and synergy to decide on when to reform the teams [17]. However, not all leaders who are used to give commands be able to work with this new degree of freedom, volatility and uncertainties [16].

E. Quality and Liability

Due to the fact that organizations are building their software based on other organizations software, the quality of the product depends on the overall quality of all the software components that constitute the final product. Moreover, organizations are leveraging open source, third party components, virtual talent and different external resources to develop their solution. The quality of the delivery becomes extremely complex.

The fast delivery cycles increase the error rate. It also compromises the design and architecture of the software leading to technical debt. The design issues will be harder to fix as there are many components that have been built on that codebase [19].

Quality compromise might lead to very serious consequences. For example, failure in autonomous vehicles could lead to loss of human lives. A virtual talent might cause failure or unintended circumstances. Defining the liability and legal contract would be a challenge [7].

F. Data Managment

The volume and value of digital content is increasing. Organizations will not be able to build an infrastructure internally to manage different aspects of data management such as storage, security and access [3].

III. ROADMAP

In order for organizations to be ready for 2030, they need to refine their strategy and start implementing certain changes. Orgnizations should consider that they will no more be working in isolation. They need to consider the larger ecosystem that the organization will operate in to define its value [2]. Below are some of the aspects that organizations need to consider in their strategy and operating model in order to be ready for 2030.

A. Orgnization

In order to fasten the decision, increase the productivity and collaboration, organizations should empower individuals and operate in a more decentralized structure. Organizations need to adapt a mesh like structure internally and externally [5]. This allows peers in an organization to have more power to collaborate with each others without the need to move up the hierarchy. Similarly, they would need to connect to their peer externally.

B. CIO Role

Majority of the organization function and city will be technology driven. Due to the fact that technology will be the core of everyday life, there will be lots of data generated from customers, systems and environment. CIO will have more insight about customers, systems and environment, thus they would be able to drive the organization revenue. Organizations should consider empowering CIO to focus and be authorized not only on technology but also on revenue creation through new business initiatives and customer engagement [2, 8]. CIO will have greater perception for the organization, thus more capable to create business strategy and proactively create revenue-generating opportunity [8].

Organizations should encourage more collaboration between the CIO and other senior executives within the organization and exchange of ideas [8]. This is required due to the fact that CIO will need to support other functions in the future [5]. CIO will need to support HR when hiring virtual talent [5]. CIO will need to support the CFO in managing digital money and blockchain technologies used for ledgers. Moreover, they need to discuss opportunities and risks and decide on the right financial operating model [5]. CIO also will be helping the head of legal who should oversee the ethical issues of AI and other technologies.

CIO will be managing both human and virtual talents. The human resources will have to have skills beyond traditional IT skills, such as social science and design [5]. Thus, CIO would need to have the appropriate knowledge to be able to manage the diversity in the resources skills.

C. Agile

The CIO will have to operate in an agile structure. Small cross-functional teams will need to be created with sufficient authority to prioritize their delivery. The team will be experimenting with different ideas. The CIO will need to guide the team and monitor their progress. The team will be self-managed and autonomous. CIO will have to observe how the team is collaborating and adapting to the change. CIO should decide on when to form and reform the team based on their synergy and delivery. CIO should ensure that the team remains small to ensure that the team is focus and excited. The requirements and backlog will have to be revisited to ensure the customer priority is been met and the environment changes are considered [16].

D. Requirements

The requirements of solutions should not be limited to traditional ways of requirements gathering. It should consider available information such as customer social media activities [5]. Social analytics will be key to discover disruptive trends, innovative ideas and even potential customers.

E. Resources

Software engineers should be always up to date as technology is changing very frequently. Software development will not be only about developing code. Software engineers need to consider the fact that their code will be used in a larger ecosystem. Thus, software engineers need to consider not only the security of their code, but also the security of their artifacts, their storage and their transmission between systems. They should also consider the mechanism of updating their software in a distributed systems [20]. Moreover, they should consider the privacy of the user and the energy utilization.

The developed software would need to respond dynamically to the environment. It has to consider the continuous data flow from sensors. Software engineers need to have a good probability and statistics as the software developed need to adapt to the environment and learn from previous decisions. Data science would be core of software engineering. Moreover, in the future, few of the software engineers would have detailed knowledge about the frameworks and software they are building on. The key skill that would be required is the ability to understand, evaluate and use different existing frameworks [21]. They should be able to search for APIs that could improve their products, evaluate them, and select the appropriate API from both functionality and sustainability aspects [17].

In addition, software engineers need to consider the development of API which is secure, easy to discover, include community features such as tagging and recommendations, gather statistics such as customer activities and application performance [17]. Software engineers should be capable of analyzing the data collected from different resources and improve their applications according to that.

The software development team would need various skillsets apart from engineering such as art. These skillsets will help them to understand and collaborate with other team members within the organization [16]. Morever, software engineers will need to have the right skill to engage with customers and ensure the customer experience is taken into consideration. They need to consider the different channels the solution will be delivered through.

Millennials who are already leading the technology today, will comprise 75% of the global workforce by 2025 according to [20]. They have different requirements and expectations from organizations which are focused on innovation and society contribution. Organizations will need to consider that in their strategy in order to attract and maintain talent resources.

F. Research

The technology will keep evolving rapidly. Organizations will need to invest in research and development. They need to conduct different experiments and explore new ideas leveraging available algorithms.

Organizations need to look at different model to create innovation solutions and build innovative capabilities. The models could include partnership with universities, crowdsourcing, and hack-a-thons [8, 20, 22].

G. Education

Organizations will have to consider continuous learning and development of its existing resources across all departments. This will ensure that employees have all the required skills to succeed in the dynamic environment. AT&T is one of the organizations, which follows that. Organizations can leverage the wide spread available online courses [20].

Moreover, organizations would need to assets the skillset required and partner with universities to ensure that required talent for the future are been developed. Universities will have to consider mix of courses to provide students with required fundamentals. For example, courses related to math, science and design would be required for 3D printing engineer [9].

Universities will also need to provide software engineering students with the skills required to evaluate the quality of third party frameworks as well as their own code. The development cycle will be very quick thus they need to understand the trades off the design choices. They would need to be able to analyze the cost of the development vs. the value, in order to make a decision [19].

H. Software Quality

Maintaining a good quality of software engineering will be challenging due to the fast experimental deliveries and the increased use of open source and other third party syetems. CIO will need to use intelligent software assurance and monitoring (ISAM) provider [25]. ISAM will be recommending open source frameworks based on their qualities through advance code search capabilities. It uses analytics to identify quality code through user feedback and random test cases. It can also identify the frameworks that work well together to avoid any architectural mismatch. The tools will also be able to validate the architecture and design decision and suggest the required refactoring [19]. Moreover, it uses different sources of information such as number of developers, number of commits, number of reported bugs to provide end users with a recommendations about the quality and sustainability of the framework. CIO can use these tools to validate third party tools as well as the software developed in house.

Moreover, developers should consider the data generated from by user in various channels and software logs to enhance the quality of the applications.

I. Legal

Organizations should be up to date with local and international regulations [8]. The legal department within the organization should be aware of cybersecurity, data security, data privacy and legal compliance [5]. They should work closely with the CIO to ensure that the API used is safe legally. Moreover, they should be ensuring that the policies and regulations of organization shared API is secure for the organization. Laws and regulations would need to protect the business from any risk due to the illegal usage of its digital content. Moreover, organizations need to continuously ensure that it follows any regulations related to ethics when using virtual talents.

CONCLUSION

Technology will continue to advance to make people life easier and more efficient. It will be part of everyday life. Organizations will need to respond to the exponential development of technology. Technology is already been disruptive to organizations and traditional business. Technology is bringing more complex challenges in term of privacy, security, data management, and software quality. The skill sets required to develop software will differ. It will need to consider the dynamic changes within environments in term of sensors and data flow. It will need to monitor user behavior and feedback to enhance its features. It will also need to consider the security when storing or transmission files to update remote applications. Organizations will need to have a clear roadmap to sustain the rapid changes. The strategy needs to consider the software engineering skill sets, fast innovation, legal aspects among other aspects.

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The Future of Sustainable Software Engineering

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ABSTRACT

Our world in the 21st century is facing a lot of challenges that need to be addressed and solved. Some of the challenges are environmental ones like the global warming, climate change, sustainable development, etc. Our ICT world can play an important role in reducing the effects of such problems when we reach to the point of being able to reduce power and resources' consumptions in compared to power savings in ICT. The aim of this paper is to introduce the concept of sustainable software engineering and the contributions toward modifying the generic software development model to reflect sustainability. Also, the paper addresses some of the challenges that are facing the growth of sustainable software engineering field. Finally, the paper is concluded by having a discussion about the future of sustainable software engineering in the coming 30 years.

KEYWORDS ***SUSTAINABLE SOFTWARE ENGINEERING, GREEN IT, GREEN SOFTWARE.***

INTRODUCTION

It is clear that developing software products is not anymore oriented around the main factors of cost, time and quality. Instead, another important factor is incorporated in the software lifecycle development; which is sustainability. Generally, sustainability is defined as how we can utilize the current available resources to meet our needs as governments and societies without risking their existence for the future generations [1].

There have been many studies rely on software role to reduce power consumption resulted from Information and Communication Technology ICT as, for example, hardware is responsible for 2% of the world's CO_2 emissions [1]. Therefore, there are many trials to enhance software development life cycle to include sustainable processes in order to produce sustainable software or what is so called green software.

The report consists of seven sections. Section 2 introduces the concept of software engineering briefly. Then in section 3, sustainable software engineering and its importance are discussed. In addition, section 4 summarizes three proposed sustainable software engineering models. After that, the challenges facing the sustainable software engineering discipline are discussed in section 5 and a viewpoint about its future in the coming 30 years is presented in section 6. Finally, section 7 concludes the paper and draws the future work to be done.

1. Software Engineering

The objectives of Software Engineering (SE) discipline are to develop, and maintain reliable and efficient software systems that satisfy all the specifications and requirements defined by customers. Therefore, there are many software lifecycle models and methods in use, such as: waterfall model, V-Shaped model, Spiral method, Iterative and Incremental method, etc. [2].

Among all models and methodologies, the typical software engineering process phases are as follows [3]:

1. ***Requirements Analysis Phase***: the stage of collecting and understanding the services to be delivered by the system to the end users along with any anticipated limitations.
2. ***Design Phase***: based on the listed requirements and specifications of the software system, the architecture of the system is defined and the main abstractions and their relationships are set.

3. ***Implementation Phase***: in this stage, the system is implemented using a specific programming language(s) based on the predefined design of the system.

4. ***Testing Phase***: the stage of making sure that the implemented system meets the predefined requirements in addition to verifying that there are no defects or faults in the software system.

5. ***Usage Phase***: determines how the end users are going to use the software product based on its specifications.

6. ***Maintenance Phase***: when the system has to be changed due to applying enhancements and correcting errors or upgrading to a newer version. The cost of this stage is high when it is compared with the costs of other stages especially if the applied changes are due to changes in requirements or to the inclusion of new ones.

7. ***Disposal Phase***: when the software is no longer used or not up to date, it is replaced.

2. SUSTAINABLE SOFTWARE ENGINEERING

There are two important terms to be defined: sustainable software and sustainable software engineering [4]:

- ***Sustainable software*** is software that either has insignificant or no impacts on environment, economy, society, etc. as consequences of its development and usage processes. Also, sustainable software could have positive impact on sustainable development.
- ***Sustainable software engineering*** is the art of developing and producing sustainable software where all impacts (either positive or negative) on sustainability: economy, society and the environment during the entire life cycle of the software product are regularly tested, documented and enhanced. Indeed, the main goals of developing software: meet customers' needs, reliability and long lasting software are considered as the same level of sustainability consideration.

The field of sustainability in software engineering is expected to grow more and more in the future years motivated by the anticipated huge global power consumption of ICT. For example, according to [5] the consumed energy of world's data centers will be tripled in the next 10 years. Moreover, a study based in Japan states that if the data centers' growth maintain their increase at the same rate as today, it is expected that the dedicated electricity supply for the data centers will be entirely consumed by the year 2030 [5].

Another example which highlights the importance of finding sustainable solutions for the massive increase of IT devices and Internet usage is the anticipated increase of the consumed energy by servers and data centers in Germany as shown in figure1 [6]. It is clearly observed that the electricity consumption is increasing over years and this trend is expected to continue in the coming years as well.

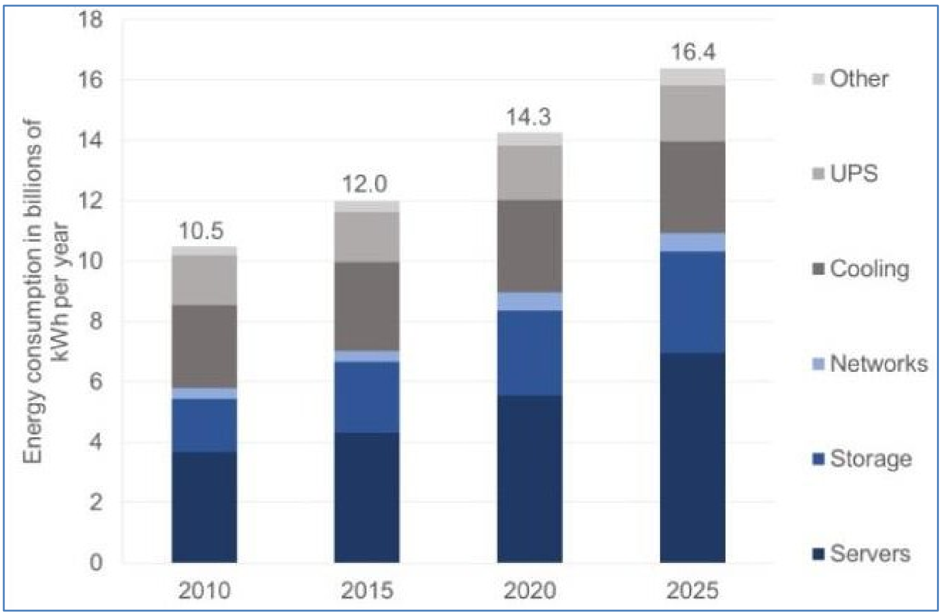

Figure 1. Energy Consumption of Servers and Data Centers in Germany Since 2010 and the Forecast Till 2025. [6]

C. Why to move forward toward sustainable software development?

Currently most of software development processes are not considering energy savings. Compared to the focus on hardware optimization to reduce energy consumption, the efforts are not in the same level with software development. For instance, operating systems are being developed over years to provide users with the same tasks in the expense of utilizing and using more and more IT resources [7].

Moreover, with the great needs of software applications and their developments, the more power and resources' consumptions are needed and consequently the negative impacts on the environment are increasing. As mentioned before, most of the researches in the green IT field focused on the hardware effects. Therefore, many initiatives have been proposed to reduce the effects of hardware use in our environment, such as: improving cooling methods of data centers, power management tools, and proper disposal and recycling of hardware parts, etc. [8].

Furthermore, the vendors of IT equipment can help in contributing to the efforts of reducing power consumption. For instance, IBM is supporting the sustainable IT by developing an affordable technology to use efficient solar chips in their products [9].

Nevertheless, the focus now is becoming more and more on the software development and production impacts on the environment [10]. In order to make notable sustainability advancements, there are three measures of sustainability to be considered and be taken care of: financial, environmental and social measures. For each sustainability measure, software engineering has to address relevant issues. For example, for social sustainability the question: “what are the effects of the software systems on society?” needs an answer. Similarly, for environmental sustainability, which is the main focus of this paper, sustainable software engineering must investigate, for example, how software can be designed and use in a way makes it adjustable for the future changes with less efforts and effects in our environment [1].

3. EXAMPLES OF PROPOSED SUSTAINABLE SOFTWARE MODELS

In general, sustainable development can be defined as the use of resources to accomplish and meet the requirements of human with the consideration of all possible impacts on society, economic, and environment [10].

There are some attempts to modify software development process to generate models for sustainable software engineering. Examples of such models are [10], [11] and [4].

XVIII. PROPOSED MODEL 1 [4]

According to [4], the proposed improvements were done on part of the software product lifecycle which is the development phase. The proposed enhancements introduce some activities that are suggested to achieve the target of applying sustainable software engineering. As depicted in Fig.2, the added elements to the development phase are:

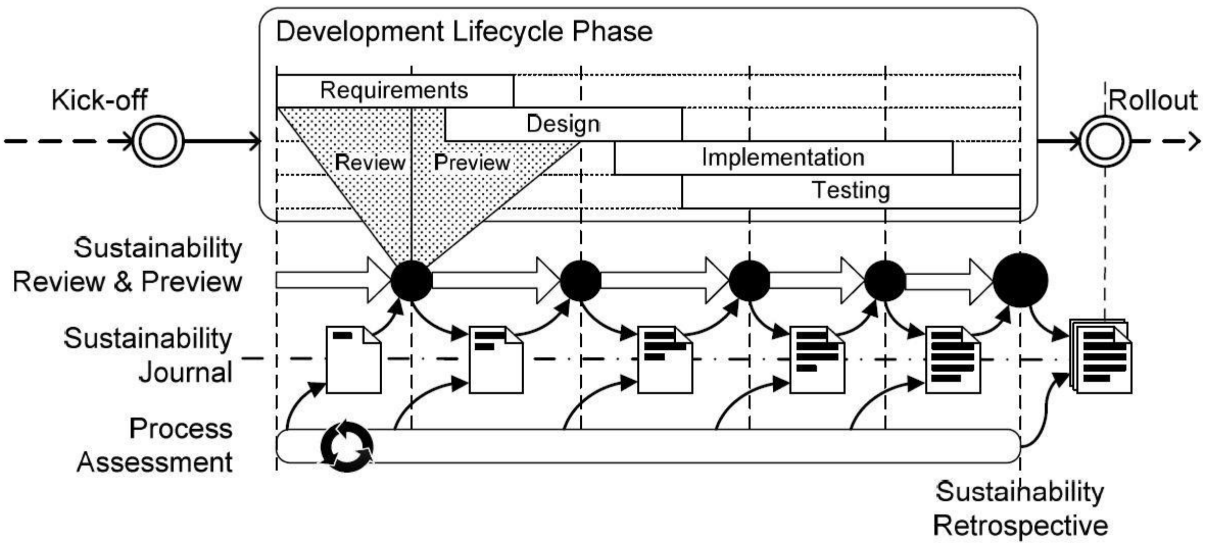

Figure 2. The Enhanced Model for Sustainable Software Engineering [4]

1. ***Sustainability reviews and previews element***: monitors the work done in each development stage and assesses the outcomes to see if they match the sustainability requirements. The output and the collected data of this element are fed and saved by the sustainability journal element. In another words, the sustainability reviews and previews element evaluates the effects of using the product.

2. ***Process assessment element:*** collects data that have effects on environmental sustainability such as: ventilation, energy consumption by lightings and workstations, energy for heating, etc. This element targets evaluating the impacts of the process.

3. ***Sustainability retrospective element***: reviews all the collected data and combines the results gained by the use of the product impacts assessed by sustainability reviews and previews and the results of process impacts assessed by the process assessment element. Also, sustainability retrospective is responsible for making a comprehensive assessment of the software development process and providing suggestions for future projects by highlighting best practices regarding sustainability issues.

4. ***Sustainability journal element:*** is the main structured element to document all the outcomes of other elements in order to provide a well comprehensive documentation for all aspects and issues related to sustainability throughout the software development process.

5. ***Other supporting elements:*** are used to support the process of collecting data and information about the impacts of sustainability in the software development process such as guidelines and educational materials. The target is to familiarize software developers with sustainability issues that they might not be aware about like first order, second order and third order effects.

According to [4], the proposed enhancements on the generic software development process are independent to the software development methodologies being used. For example, the proposed model is applied to *OpenUp* and *Surum* methodologies successfully.

XIX. PROPOSED MODEL 2 [11]

On the other hand and based on the research work of [11], a green conceptual software engineering process is proposed to support all software stakeholders in ensuring sustainable ways of developing, administrating and using the software product. The model consists of four main parts as show in Fig.3:

1. ***Life Cycle of Software Product***. Its main objective is to evaluate the effects of the software life cycle in sustainable development based on the three main measures of sustainability; environmental, economic and social measures. It is important to note that the first order effects are easy to identify and assess, while the second and third order impacts are difficult to deal with.
2. ***Sustainability Criteria and Metrics***. The proposed model is able to represent the different sustainability criteria and metrics and where do they fit in each life cycle phase. For example, for quality metrics related to reusability or modifiability of software, they are observed in the Development phase. Also, metrics like usability and accessibility are observed in the Usage phase.
3. ***Procedure Models***. This part includes the procedure models and the circumstances under which the software is produced under sustainable conditions. For example, the sub-procedure *Use* is used to check the sustainable measures such as energy consumption and energy efficiency in regular basis for the sake of improvement. Also, settings for the best software macro-configurations, at the organizational level, and the best software micro-configurations, at the users levels, are provided to assist the sustainable development in the proposed conceptual model.
4. ***Recommendations and Tools***. This part provides all software stakeholders with best sustainable practices, guidelines, reports, etc. to support in adapting green manners while developing and using the software. Also, it recommends tools, either software tools or paper based, for the same purpose. For example, administrators are provided with guidelines about the best practices to administer and run data centers in energy efficient manners.

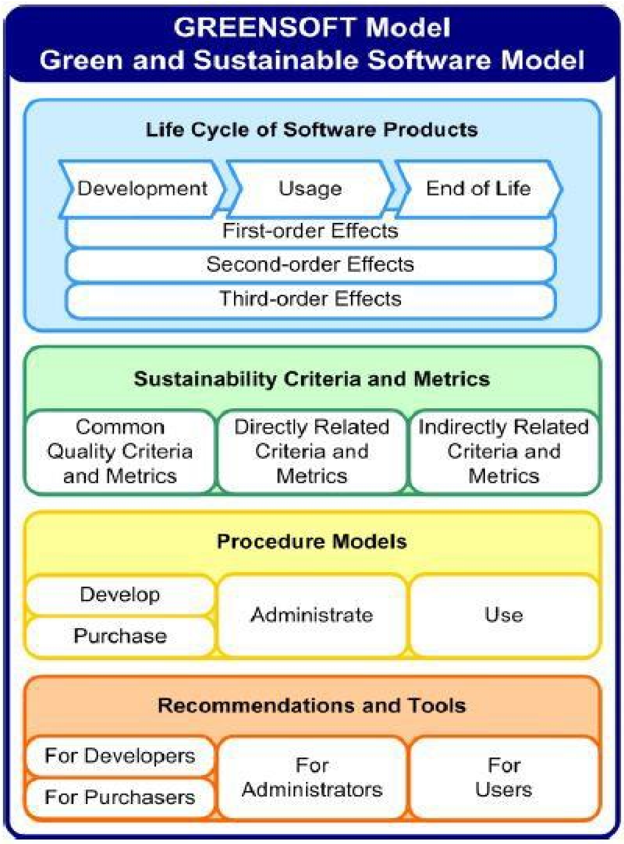

Figure 3. GREENSOFT Conceptual Reference Model [11]

XX. PROPOSED MODEL 3 [10]

Besides the efforts of [4] and [11], [10] has suggested green software engineering process that covers all the stages of software life cycle. The proposed process is said to be sustainable taking into account different software development methods such as the sequential, iterative and agile methods. According to [10], the suggested model doesn't concentrate only on how the life cycle of software can affect the environment, but also how the software itself can assist in maintaining the sustainability of the environment.

The developed proposed software model consists of two parts: Level One and Level Two.

- **Level One**. The model is adopting the iterative software development methodology for the sake of being able to make changes in the requirements whenever needed throughout the whole process. In addition, it engages some of agile principles such as allowing all stakeholders of the software development: software developers, end users and businessmen, to work together throughout the whole stages of the project as their continuous feedback contributes to producing sustainable software. Therefore, the proposed model includes measures and evaluation metrics that included in all life cycle stages of the software production as follows:

- ***Requirements Phase***: when it is decided not to continue developing a system due to the results of the feasibility study, then energy efficiency results are scored. Also, a set of practical goals that match the target of environmental sustainably can be implemented in this stage, such as: use internet for communication rather than other means of transportation, reduce unnecessary functions in the developed system, including and using reusable systems, etc.

- ***Design and Implementation***: some design strategies are suggested to encourage increasing the sustainability during this stage, such as: writing compact lines of code based on the programming language being used and the experience of the programmers. Also, sticking to the requirements when designing and implementing the subsystems produces efficient algorithms with lesser lines of codes.

- ***Testing***: in case the developed system failed to gain the customer's satisfaction, the requirements are revised and the engineers are going to spend more hours and consume more energy in order to rectify the faults in the system. Therefore, it is advisable to include a testing phase in the requirements stage to make sure that all requirements are valid and meets the customers' expectations so the developer and the tester are in the same page.

- ***Green Analysis***: this is a suggested phase by the model in order to increase the energy efficiency of the whole process. For instance, in this stage the carried out tests are for the sake of measuring energy efficiency and make sure that usage metrics are measured and studied such as CPU usage. Fig.4 shows the proposed process for this stage.

Figure 4. Green Analysis Stage [10]

- ***Usage***: it is believed that it is the responsibility of different stakeholders to handle the product in green sustainable manner. For example, software developers can engage power management features in the software and the users of the applications can follow environmentally sustainable manners of use such as close the software application or the monitor whenever they are not in use.

- ***Maintenance***: some advisable guidelines are to have well-written and structured lines of codes to make the process of changing the codes faster and as a result reducing energy consumption. Also, educating and familiarizing maintenance engineers about the software that they are going to modify are essential in order to promote energy efficiency.

- ***Disposal***: as the disposal of obsolete hardware causes a lot of energy and resource consumption, recycling or reusing them is advisable. Similarly, recycling software by multi using the software lines of codes for several projects can minimize the development software cost.

- **Level Two**: It consists of the taken measures by software to contribute to green computing. Five categories of software tactics are suggested in the second level of the proposed model and they are presented in Fig.5 as follows: 1) operating systems that create power profiles to reduce the energy consumption of hardware equipment, 2) virtualization as multiple of application are running in one computer system which lead to less power consumption by running less systems, 3) written codes to be used for energy allocation, for example codes used to direct the data flow toward servers that have less energy consumption, 4) the use of performance monitoring counters where the power consumptions of applications are calculated based on their CPU usage, and 5) fine grained green computing.

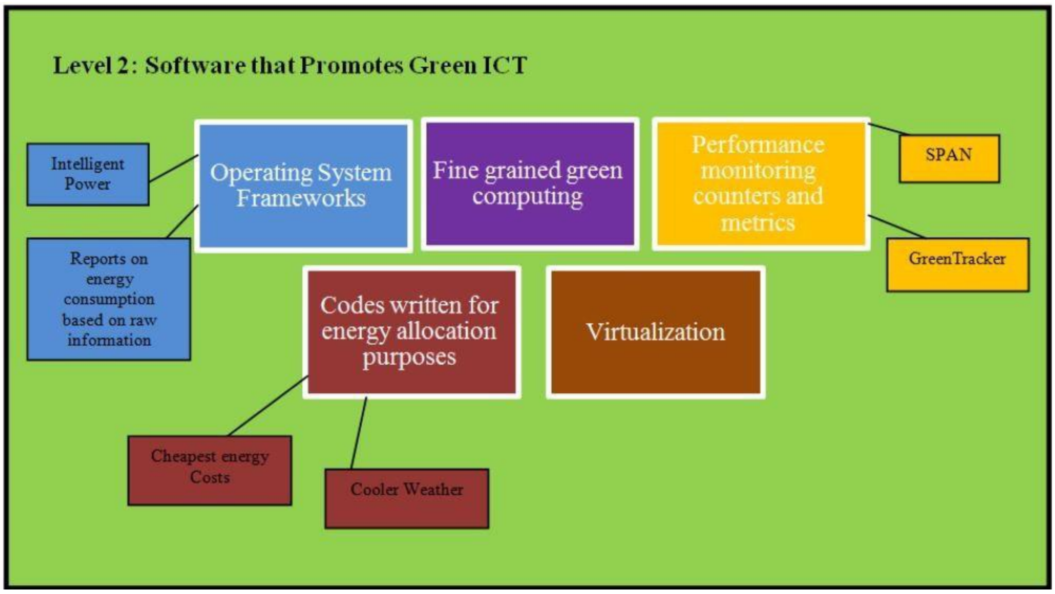

Figure 5. Second Level of the Proposed Green Model [10]

When the proposed model by [10] is compared to GREENSOFT model proposed by [11], it is found that the model focused on two important phases of software life cycle and their effects in our environment. According to [10], the model gives high attention to the requirements phase as it affects all next stages and any changes to be made on the requirements in later stages would be very costly. Also, [10] argues that the testing phase should be part of every stage of the software life cycle and not only after the implementation.

5. SUSTAINABLE SOFTWARE ENGINEERING CHALLENGES

There are many challenges and barriers that hinder the advancements of the sustainable software engineering domain. Some of the challenges are:

- Most of the carried researches focused on the effects and impacts of hardware usage on the environment without paying enough attention to how the development of software can either minimize the negative impacts of the ICT on the environment or affect it positively [1].
- The dimensions of sustainability in software engineering are not fully identified yet.

  More conceptual models to be created and verified in addition to exploring and inventing suitable sustainable techniques to be used all over the development and usage stages of a software .
- It is early to state that we've reached to a level of stability to confirm the best practices and practical frameworks that suggest the best methods of designing and coding software with minimal energy consumption. In another words, there is lack in defining standard metrics and tools that effectively measure energy consumption of software systems and applications in order to locate the exact impacts of developing software applications on energy efficiency [7].
- Green computing and sustainable software engineering are in their first steps of development and we need to conduct more efforts and build a strong knowledgebase to educate two key players: software engineers and end users. Software engineers need to be directed toward creating tools that support them to recognize and monitor energy consumption of software during its life cycle development and while it is in use. Unfortunately, the current available knowledge lacks providing such tools. Also, the awareness of software end users about the greenness of software applications and the best usage behavior they have to follow are important to be delivered to them [12].

- The pace of progressing in the green computing field should cope with the fast progress of energy needs of IT equipment, such as data centers, and the rise of energy cost, as well [9].
- The complexity of the architectural designs of some IT equipment leads to higher power consumption in addition to raising the complexity of system software designed for such equipment [8].

6. Sustainable Software Engineering in 30 Years Ahead

With the exponential growth of business and personal computing demands, the increase of energy cost in addition to all related environmental issues like global warming, the need for finding sustainable solutions will follow the same trend and it becomes an urgent need more than before.

Also, although sustainable software engineering is a pioneering field, it is still in its first steps of exploring how to achieve sustainability through software development and usage in the ICT world. In fact, there is much more work to be done in this discipline to overcome the current observed challenges and be ready for unexpected challenges in the future.

The following are suggestions for some research topics in sustainable software engineering in order to make notable advancements in this field:

- It is important to standardize the concepts and definitions related to sustainable software engineering in order to make it easier to compare different efforts achieved in the field.
- More conceptual software development models to be created and verified in addition to exploring and inventing suitable sustainable techniques to be used all over the development and usage stages of a software.
- The IT vendors can play more effective role in producing IT equipment that consider

  sustainable requirements as priority during manufacturing stage and consequently this would help the software engineers to work at the same level of interest with other parties to achieve the main goal of sustainable development.

- Addressing the complexity of the architectural designs of some IT equipment is demanded as this would help in designing and implementing less complicated system software via sustainable software engineering process.

7. Conclusion

It is evident that sustainable software engineering plays essential role in developing green software in addition to considering sustainable measures during the process of software development. Indeed this would contribute to the reduction of power consumption of IT devices in our environment.

On the other hand, green computing is gaining more and more attention by researchers in recent years. Several enhancements on the software lifecycle processes are proposed to incorporate sustainability measures. However, the efforts are still in their initial stages and they are encountering many challenges and barriers. These challenges are the foundation for the research area topics in sustainable software engineering field for the future coming years.

In conclusion, it is believed that the green computing and all sustainability considerations in ICT field are the major forces for the development of sustainable software engineering and other IT sectors.

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ABSTRACTS ONLY

Project Success and Failure Criteria

Mohamed Hassan Murad

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Abstract

It is obvious from the literature that most people have the wrong perceptions regarding the success or failure of a project. Therefore, this paper aims to identify the project and the ongoing debate regarding the notion of project success and failure. This paper shall contribute to understating the success of the project, in order to enhance delivering successful projects.

Systems Dynamics for Cost Modelling of Construction Projects in The United Arab Emirates

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Abstract

The project management field in the United Arab Emirates have experienced several challenges regarding its performance and delivery due to factors and elements which are affecting the time, cost, and quality; however, this can drive to a significant failure of the projects and loose too much money and time which are not affordable according the country's leadership statement. Also, the demand of having too many developments and improvements in a short period of time required to make more projects than before with less cost tolerances especially after the collapse of oil prices globally and the direction of changing the nature of the country's economics shape. Moreover, the mandatory sustainable developments from the environmental and business perspective made the budgets of projects more sensitive to the complexity and size of the construction project. This is a problem that needed to have a solution in related with the public projects and the motivation of developing the cost modelling and estimation in the United Arab Emirates is that it has significant gaps which required to be filled in order to contribute in the project management body of knowledge. The significance of this research study come from focusing on the optimization of costs and budgets while maximizing the profits, eliminating or minimizing the cost overrun of the construction projects, increase the accuracy of the project management decision making results, deliver successfully the important complicated construction projects without fail; moreover, the significant of this study is also coming from supporting the government's vision, plans, and leadership for reaching the level of being globally a leading sustainable country and economy. The end result of this study is a construction project cost model at the preconstruction stage from the perspective of clients and developers in the United Arab Emirates. So, by having a systems dynamics model for the construction cost using VINSEM software while utilizing the capabilities of the SPSS software and Monte Carlo modelling approaches, it will be easier to make a project management decision regarding the construction project from its beginning which is minimizing the costs and eliminating the cash overrun in the following stages due to the appropriate threats and opportunity management which starts at the pre-construction stage of the building projects. The following theses is going to give a detailed introduction about the research project in chapter 1; then, it will cover the research gap and scientific support in chapter 2; then, chapter 3 and 4 will discuss the variables of the model and build the required research model (SD); after that, the model will be tested an validated through the use of the real data of "PARK VIEW TOWER" building project in Al REEM Island; and finally, the discussion and conclusion chapters will be in chapters 6 and 7 which are analyzing the results and the knowledge contribution to the project management field.

Software Engineering for BIG Data: Future and Challenges

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Abstract

Software Engineering is a growing desperate need to combat the ongoing advancements on cloud. With the advancements where data accumulates every second on the cloud and ought to be either structured or unstructured thus joining the BIG data, brings in additional challenges. These challenges are outrageous in terms of data analytics for not just structured data but as well for the unstructured data. Hence, calling for a need to vision 2025 and provide illustrative judgements to the research community. This paper attempts to put forward the state-of-the-art and state-of-the-practice of software engineering be in 2025, highlighting the major problems and challenges then. Lastly the visionary ideas for overcoming the problems and challenges.

Improving the Lighting Performance of a Bus Depot Facility

Mohammed Mahboob

and

Dr. Riad Saraiji

The British University in Dubai

Abstract

This study aims at improving the current lighting condition in one of the busiest bus deports in Dubai and compares the effectiveness of the planned measures compared to current condition. The real illumination level in the depot was calculated using Lux meter to validate the model. The study concluded that 60.5 % of energy saving could be achieved while enhancing the overall illuminance condition with the planned strategies. The average LUX level was decreased by 33 % but the light uniformity was improved by 75% when compared maximum to average lux level therefore a better lighting distribution was achieved and the illumination of the critical areas in the depots was improved. A new metric was developed to find the effect of buses shading each other's. The metric is termed the shading factor. This factor was improved by 78% after installing the new lighting system.

Flow-Cytometry Best Match Data Retrieval System using EMD

Minat Allah E. Abdel Salam

The British University in Dubai

Abstract:

Is there a way to find the similarity between different FC datasets belonging to different people, aiming on linking datasets with common characteristics or features, with the highest similarity precision possible, and within the least time possible? – Using EMD!

Dynamic Cyber Resilience in Mesh Networks

Mazen Juma

The British University in Dubai

Abstract

The main goal of this research is to develop dynamic cyber resilience approach for mesh networks as a proposed solution for the problem statement. The minor goal of this research is to analyze the performance comparison of dynamic cyber resilience approach with the current well-established cyber security and resilience approaches based on considered evaluation metrics.

Technical and Economic Aspects of Implementing Solar PV and Wind Renewable Energy in Fujairah – UAE

Nawal Al Hanaee

The British University in Dubai

Abstract

In a strong and safe union, knowledgeable and innovative Emiratis will confidently build a competitive and resilient economy. They will thrive as a cohesive society bonded to its identity, and enjoy the highest standards of living within a nurturing and sustainable environment.

Applying Sustainable Strategies on Urban Community in the UAE

Tahani Yousuf

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Abstract:

Building Energy consumption has risen rapidly in recent years due to population growth, global climate change and the demand for comfort in indoor surroundings (Perez-Lombarda et al., 2008). Furthermore, as asserted by Perez-Lombarda et al.(2008), residential buildings contribution towards global energy consumption is about 40%.

This consumption emanates mostly from ventilation, heating and air conditioning systems. Despite fossil fuels being the principal electricity production source, its reserves are finite. Mitigating the dependency on fossil fuels in residential buildings is needed (Joelsson, 2008)

In fact, it has been discovered that the residential and commercial sectors are responsible for almost 40% of the consumption of energy in the UAE (Al-sallal, 2014).

Al Bastakiya: Passive Design Techniques in Traditional Architecture

Abu Zayed Isra

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Abstract

Dubai's image is one of a face-paced, modern metropolitan city reaching for the stars. A city whose buildings reach the highest peaks and construction phases change quarterly. But there is one part of Dubai which remains unchanged. It is Dubai's grasp of its heritage and cultural identity. It is from this origin which one must extract the true nature of sustainable living which the countries elders first introduced as simple fishermen on the coastlines of the Dubai creek. Although traditional architecture in Dubai has taken a back seat during Dubai's rise to fame, it is still one of pride and identity. Through its modest architecture it excels at incorporating sophisticated passive design techniques. Ones which have now been brought to the forefront of sustainable architecture. This paper looks at the passive design techniques incorporated in the Bastakiya Heritage community. Through studying the benefits of the area's urban design, wind towers, mashrabiya and etc. We can learn from the sustainable design processes of the past and how we can work towards incorporating them into Dubai's modern architecture to ensure a sustainable future.

Keywords: Sustainable Architecture, Sustainable Design, Dubai, Passive Design.

Introducing System Dynamics Modeling to UAE Health Care Projects: Reducing patient waiting times

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ABSTRACT

The usage of system dynamics (SD) modeling science in health care settings is not yet widespread, however, the applications and lessons learnt from some countries such as the UK, USA and Canada, that recognized and used SD methods for addressing complex health care problems and improving health care delivery efficiency motivated this study. The aim of this research is to explore the value and role of SD modeling in health care projects. The objectives for achieving the overall aim are two folds: (1) to review of the literature by selecting some academic studies investigating the effectiveness of SD modeling for health care development; and (2) to contribute to the literature, through a living case study, by assessing the usefulness of SD in health care delivery system in the United Arab Emirates (UAE). This research is not scoped around a particular question, but is meant to explore important factors and factors relationships related to patient waiting times at the emergency room (ER) of a public hospital at the city of Abu-Dhabi using a SD approach. It is mainly to describe in a systematic manner the adequate levels of hospital service efficiency and quality required to enhance the performance of the ER, aiming to reduce emergency patient waiting times. In addition, this study makes a substantial contribution to the health care study concerns in the U.A.E.; it aims to encourage policy makers and project managers to rethink the potential value and role of SD modeling methods and work on innovative approach to address projects related health care system challenges appropriately.

Key words: System dynamics; Health care projects; Hospital efficiency; Emergency room; Patient waiting times; UAE

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