PERFORMANCE OF CEMENT MORTAR CONTAINING CELLULOSIC NANOCRYSTALS FROM PALM OIL WASTE

DIANAH BINTI MAZLAN

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Civil Engineering)

School of Civil Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

MAY 2020

DEDICATION

Dedicated to the memory of my father, Mazlan Abu Mansor and my mother, Siti Aisah Abdul Wahid who always believed in my ability to be successful in the academic arena.

You are gone but your belief in me has made this journey possible.

ACKNOWLEDGEMENT

Firstly, I would like to express my sincere gratitude to my advisor Prof. Ir. Dr. Mohd Fadhil Md Din for the continuous support of my Ph.D. study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Ph.D. study.

Besides my advisor, I would like to thank the rest of my research co-advisors: Prof. Dr. Chiharu Tokoro, Assoc. Prof. Dr. Izni Syahrizal Ibrahim and Dr. Nur Hafizah Abd Khalid for their insightful comments and encouragement, but also for the hard question which incented me to widen my research from various perspectives.

I thank my fellow lab mates for the stimulating discussions, for the sleepless nights we were working together before deadlines, and for all the fun we have had in the last four years. Especially to my beloved friends, Khairun Nissa Mat Said and Zanariah Jahya for all the wise advice and support throughout my studies.

Last but not the least, I would like to thank my family: my late father Mazlan bin Abu Mansor, my late mother Siti Aisah Abdul Wahid, my brothers and sisters for supporting me spiritually throughout writing this thesis and my life in general.

ABSTRACT

A study on the utilization of cellulose nanocrystals (CNCs) as a natural-base additive in cement mortar as a strengthening agent had been conducted. Since cement-based materials such as concrete and mortar are known as the most utilized materials on earth after water, various studies on the cement mortar have been done to improve its properties to make more compatible with the current demand. Nowadays, the development of construction industries is going towards producing cement mortar that high in strength and environmentally friendly. However, to develop a cement mortar that as strong as concrete is challenging due to no coarse aggregate is used in the mortar mix. Thus, the development of new technologies and materials that can improve the strength of mortar without the usage of coarse aggregates was studied. These days, additive to strengthen the cement mortar by using natural resources had gained interest among researchers. Still, limited study had been conducted to study the outcome of natural-based additive in cement mortar as a strengthening agent. Thus, this research aims to investigate the changes in cement mortar properties and behavior after it is affected by a natural-based additive known as cellulose nanocrystals (CNCs). CNCs, known as advanced materials produced by using current advanced nanotechnologies and bring out the strongest part of the cellulose which is stronger than a strength of steel in tensile. The CNCs was used in cement mortar to study deeply on its characteristic and improvement contributed by CNCs. In this study, the mortar specimens were prepared with a mass ratio of 1: 2.75 (cement: fine aggregates), the water-cement ratio of 0.47 and 0.2 to 0.8% of CNCs addition by weight of cement content. Three types of curing regimes were executed known as a wrap, lime and water curing in order to find the most compatible curing method with CNCs mortar. The wrap curing method was found to produce better strength performance with the addition of CNCs compared to lime and water curing during the pilot study. Therefore, wrap curing was used throughout the study. The normal mortar was prepared as a control sample. Three important phases of tests were carried out in this study starting from chemical and physical tests characterization of the CNCs. This was followed by the performance of fresh and hardened properties of cement composites after incorporating the CNCs and ended with thermal performance tests of the CNCs mortar. The experimental results showed that the optimum percentage of CNCs used in the mix was 0.4% as it resulted in higher compressive, flexural and tensile strength. The cement mortar containing CNCs was found to perform effectively in improving the strength properties up to 43.6 %, 20 % and 147 % for compressive, flexural and tensile strength, respectively, as well as alter the thermal conductivity for 0.1% and 0.2% for the thermal resistance of cement mortar. All tests were carried out by following the American Standard Testing Method (ASTM), British Standards (BS) and Japanese International Standards (JIS) standards. Overall, test results including microstructure studies showed that CNCs can be used as an additive in cement mortar to strengthen the cement properties.

ABSTRAK

Kajian penggunaan nanokristal selulosa (CNCs) sebagai bahan tambahan semulajadi dalam mortar simen sebagai agen penguat telah dijalankan. Memandangkan bahan berasaskan simen seperti konkrit dan mortar dikenal pasti sebagai bahan yang kerap digunakan di bumi selepas air, pelbagai kajian terhadap mortar simen telah dijalankan bagi meningkatkan sifatnya untuk menjadikannya lebih sesuai dengan permintaan semasa. Pada masa kini, perkembangan industri pembinaan sedang menuju kearah penghasilan simen mortar berkekuatan tinggi dan mesra alam. Walau bagaimanapun, penghasilan mortar simen berkekuatan tinggi seperti konkrit adalah mencabar memandangkan agregat kasar tidak digunakan dalam campuran mortar. Sehubungan itu, pembangunan teknologi baru dan bahan bagi menambah baik kekuatan mortar tanpa penggunaan agregat kasar telah dikaji. Kebelakangan ini, pengunaan bahan tambah bagi meningkatkan kekuatan mortar simen dengan menggunakan bahan semulajadi telah menarik perhatian para penyelidik. Namun, kajian yang telah dijalankan bagi mengkaji kesan bahan tambahan semulajadi sebagai agen penguat dalam mortar simen adalah terhad. Oleh itu, tujuan kajian ini dijalankan adalah untuk mengkaji perubahan kepada sifat mortar simen dan kelakuannya selepas didedahkan kepada bahan tambah semulajadi yang dikenali sebagai nanokristal selulosa (CNCs). CNCs yang juga dikenali sebagai bahan terkini yang dihasilkan menggunakan teknologi nano terkini, mengeluarkan bahagian terkuat selulosa yang mana ianya lebih kuat berbanding kekuatan keluli dalam tegangan. CNCs digunakan dalam campuran mortar bagi mengkaji dengan lebih mendalam sifat dan penambah baikan yang disumbangkan oleh CNCs. Dalam kajian ini, spesimen mortar disediakan dengan nisbah berat 1: 2.75 (simen : agregat halus), nisbah air-simen 0.47 dan tambahan CNCs sebanyak 0.2 hingga 0.8% berdasarkan berat simen. Tiga kaedah pengawetan telah dijalankan iaitu pembungkusan, kapur dan pengawetan air bagi mengenalpasti kaedah yang paling sesuai bagi mortar CNCs. Kajian mendapati kaedah pengawetan secara pembungkusan menghasilkan prestasi kekuatan yang lebih baik bagi tambahan CNCs berbanding pengawetan kapur dan air semasa kajian perintis dilaksanakan. Oleh itu, kaedah pengawetan secara pembungkusan digunakan sepanjang kajian dijalankan. Mortar biasa disediakan sebagai sampel kawalan. Tiga fasa penting ujikaji telah dijalankan bermula dengan ujian kimia dan ujian fizikal CNCs. Ujikaji diteruskan dengan ujian prestasi konkrit basah dan konkrit keras komposit simen selepas menggabungkan CNCs dan berakhir dengan ujian prestasi termal mortar CNCs. Hasil kajian mendapati CNCs berkesan secara efektif dalam meningkatkan sifat kekuatan sehingga 43.6%, 20% dan 147% bagi kekuatan mampatan, lenturan dan tegangan disamping mengubah kekonduksian terma untuk 0.1% dan 0.2% bagi rintangan terma simen mortar. Ujian-ujian yang telah dijalankan adalah berdasarkan kepada American Standard Testing Method (ASTM), British Standard (BS) dan Japanese International Standards (JIS). Hasil kajian secara menyeluruh termasuk kajian terhadap mikrostruktur mendapati CNCs boleh digunakan sebagai bahan tambah dalam mortar simen untuk meningkatkan sifat simen.

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LIST OF ABBREVIATIONS

CNCs	-	Cellulose nanocrystals
MCCs	-	Microcrystalline cellulose
OPC	-	Ordinary Portland Cement
XRF	-	X-ray Fluorescence
TEM	-	Transmission Electron Microscopy
ASAP	-	Surface Area and Porosity Analyser
XRD	-	X-ray Diffraction
NDT	-	Non Destructive Test
FESEM	-	Field Emission Scanning Electron Microscopy
SEM/EDX	-	Scanning Electron Microscopy /Energy Dispersive X-ray
MLA	-	Mineral Liberation Analysis
FTIR	-	Fourier Transform Infrared Spectroscopy
TG/DTA	-	Thermo-gravimetric and Differential Temperature Analysis
ASTM	-	American Standard and Testing Manual
UPV	-	Ultrasonic Pulse Velocity
BS	-	British standard
HFM	-	Heat Flow Meter
LSP	-	Lignosulfonate plastisizer
NFS	-	Formaldehyde superplastisizer
ASTM	-	American Standard Testing Method
BS	-	British Standard
JIS	-	Japanese International Standard
TEMPO	-	Tetramethylpiperidine-1-oxyl
NDF	-	Neutral Detergent Fibre
ADL	-	Acid Detergent Fibre
ADF	-	Acid Detergent Lignin
MPOB	-	Malaysia Palm Oil Board
BET	-	Brunauer-Emmet-Teller
HFM	-	Heat Flow Meter
FLIR	-	Forward Looking Infrared Camera

ISO	-	International Organization for Standardization
RH	-	Relative humidity
UHI	-	Urban Heat Island

LIST OF SYMBOLS

°C	-	Celsius
w/w	-	Mass fraction
v/v	-	Volume concentration
m/v	-	Mass concentration
w/c	-	Water/cement ratio
L/D	-	Aspect ratio
kV	-	Kilo volt
%	-	Percent
L	-	Length
b	-	width
d	-	Thickness
P	-	Load
A	-	Area
σc	-	Compressive strength
GPa	-	Giga Pascal
cp	-	Centipoise
π	-	Pie
H	-	Height
Cu K-α	-	Copper K alpha
α	-	Alpha
°	-	Degree
P/P_o	-	Relative Pressure
RH	-	Relative Humidity
O_3	-	Silica
Al_2O_3	-	Alumina,
Fe_2O_3	-	Iron oxide
CaO	-	Calcium Oxide
MgO	-	Magnesia
N_2O	-	Sodium

P_2O_5	-	Phosphorus
$CaCO_3$	-	Carbonate
$Ca(OH)_2$	-	Calcium hydroxide
T_a	-	Ambient temperature
$CaSiO_5$	-	Alite
Ca_2SiO_4	-	Belite
CO_2	-	Carbon dioxide
mm	-	Millimetre
µm	-	Micrometer
ϕ	-	Diameter
β	-	Beta
nm	-	Nanometer
N	-	Normality
g	-	Gram
mV	-	Millivolt
Hg	-	Mercury
kN	-	Kilonewton
CSH	-	Calcium Silicate Hydrate
$Ca(SO)_4$	-	Calcium Sulphate
SiO_2	-	Silicon Oxide
$CaSiO_3$	-	Calcium Silicon Oxide
MPa	-	Mega Pascal
θ	-	theta
kBr	-	Potassium Bromide
psi	-	Pound per square inch
$WK^{-1}m^{-1}$	-	Watt per kelvin-meter
W/m^2	-	Watt per meter square

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The utilization of wastes products in construction materials has been widely investigated and studied by numerous researchers across the world (Johari et al., 2014). Malaysia is known as a country that produces high biomass production annually. Being a major agricultural commodity producer in the region, Malaysia produces at least 168 million tonnes of biomass in 2018, including timber and oil palm waste, rice husks, coconut trunk fibres, municipal waste and sugarcane waste annually (Hamzah et al., 2019). Most of these wastes were left rot at the field without commercial return (Abdullah and Sulaiman, 2013). This resulting in increasing the cause of air pollution due to open burning.

Agricultural waste knows with its higher lignocellulose content which is known as the most abundant and renewable natural biopolymer on earth. Cellulose can be found in plants such as flowers, trees, weeds, grasses, vines, and bushes. Other living things such as animals (mammals, herbivore, carnivore and omnivore) and bacteria like Acetobacter xylinum, Acetobacter, Azotobacter, Rhizobium, Pseudomonas, Salmonella, Alcaligenes etc. also contain a significant amount of cellulose (Abdul Khalil *et al.*, 2012, 2014; Abdullah and Sulaiman, 2013). Cellulose fibres or used as reinforcing materials in cement mortar materials help to improve the performance of mortar by increasing the resistance towards tensile stress, shrinkage, and modulus (Mohammed *et al.*, 2015). For that reason, the studied on the cellulose fibres in cement composites materials have been studied comprehensively in many ways by using various types of cellulose fibres (Sajjala, 2018a). However, drawbacks from the direct usage of cellulose in cement materials such as workability and degradation of strength after a certain period cause a new study on surface modification on cellulose (Mohammed *et al.*, 2015). Therefore, with the advanced technology, the surface-modified cellulose knows as cellulose nanocrystals (CNCs) was introduced and widely used in many industries such as automotive, aerospace, electronics, pharmaceutical and food industries (Barra *et al.*, 2015; Soltan *et al.*, 2017).

CNCs was discovered as early as 1949, however, CNCs did not receive much attention because of their nano sizes that cannot be imaged under present optical and microscopy equipment during that era (Eyley and Thielemans, 2014). Then, in 1992, the interest in CNCs was revealed when their colloidal suspensions unexpectedly showed liquid crystalline properties which been found when the advent of higher resolution imaging techniques such as atomic force microscopy (AFM) and transmission electron microscopy (TEM) (George and Sabapathi, 2015). The immense strength and stiffness of cellulose crystallites soon spurred interest in their potential to reinforce polymers.

These good properties of CNCs can be achieved by appropriate modification of CNCs in terms of physical, chemical or rheological properties based on desired improvements. The nanoparticles of CNCs are stabilized in aqueous suspension during the hydrolysis process with the form of negative charges on the surface of the nanoparticles (Pelissari *et al.*, 2014; Tian *et al.*, 2016). Furthermore, CNCs nanoscale particles are promising can be used as reinforcing agents in composites to produce high-performance nanocomposites. This phenomenon is due to the CNCs' basic physicochemical properties which content an anisotropic chiral nematic liquid crystalline phase (Eyley and Thielemans, 2014).

Cement mortar is a strong and relatively cheap construction material and is, therefore, present the most widely used material in the construction industry. The main constituent that contributes to mortar strength is Portland cement. It is estimated that cement (Portland clinker) production alone contributes about 7% of the global carbon dioxide emissions due to the burning of limestone and clay at a temperature of 1500 °C. During this process, calcium carbonate ($CaCO_3$) is converted to calcium oxide (CaO) and carbon dioxide is released (McDonald *et al.*, 2019). From an environmental standpoint, cement does not appear to be a sustainable material (Bediako *et al.*, 2016).

Therefore, the usage of a non-sustainable additive such as superplasticizer to improve the workability should be reduced.

Nowadays, the production of cement mortar that satisfied the application of lightweight industries such as in high rise buildings and floating structures is very hard to achieve (Takumi *et al.*, 2009). In lightweight industries, the strength and density of the composites were the major criteria that been observed. However, it very hard to achieve both high strength and low density at the same time by using the conventional method. This due to the basic theory of the cement composites strength is proportional to the density (Neville, 2006). Therefore, various options were introduced in the previous studies by using chemical or natural-based additive or cement-based replacement such as resin, fly ash, bottom ash, steel fibre and many more (Mohammed *et al.*, 2015; Khalid *et al.*, 2016; Zhang *et al.*, 2019)

In construction industries nowadays, various studies on developing better construction materials such as high strength cement composites or environmental friendly composites, which can be used in skyscrapers, bridges, sidewalks, highways, houses, and dams (Martínez-Barrera *et al.*, 2014). Besides that, in the production of cement mortar, the existing conventional mortar is known as a non-load bearing structure. This is due to the cement mortar matrix that does not contain coarse aggregates like a concrete matrix. Therefore, the addition of additive or reinforcing materials were needed to improve the performance of the mortar. Hence, causing difficulties in workability, dispersion of fibre, and reinforcing costs.

Based on the achievement of previous studies in discovered the unique properties of CNCs in improving various composites materials in diverges industries. Hence, this study discussed the effect of CNCs extracted from palm oil waste incorporated in cement mortar in enhancing its performance in terms of strength, microstructural and thermal performance.

1.2 Problem statement

Nowadays, the production of waste from palm oil industry has been increased from 13.9 million tonnes in September 2018 to 15.9 million tonnes in September 2019 (Malaysian Palm Oil Board, 2019). Demand in new construction building materials, such as strong, lightweight, thermally efficient, environmentally friendly and low-cost materials have been extremely high. However, to produce this type of material need advanced technology. These advanced technologies will cost a high amount of money.

Nowadays production of high strength cement mortar needs various addition of costly admixture to improve the quality of the physical performance of the cement composites (Mehra *et al.*, 2016; Zhang *et al.*, 2019). Example of mineral admixture and chemical admixture that been used in the cement composites industries to produce the high strength concrete or mortar such as fly ash or silica fume and naphthalene formaldehyde superplasticizers (NFS) or lignosulfonate plasticizers (LSP), respectively. Therefore, eco-friendly and low-cost admixture should be introduced and studied, to reduce the usage of mineral and chemical admixture in the later future.

Moreover, there are so many research has been done by the addition of natural or synthetic fibres in cement mortar or concrete to strengthen the composites. In Malaysia, the most common natural fibres that been used in the cement mortar as fibre reinforced material mix, were pineapple fibre, palm oil fibre, kenaf fibre, paddy straw fibre, sugarcane fibre, and banana fibre (Mohammed *et al.*, 2015; Sajjala, 2018a). However, this effort by using the micro sizes of fibres in the cement mortar mix cause difficulty and limitation in the workability stage. The higher the addition of micro sizes fibre will reduce the workability of the cement mortar as balling effect occurred during mixing. Hence, reduce the strength of the cement mortar as the aftermath.

On top of that, the addition of admixture or natural fibres in cement mortar provides any guarantee for long-lasting strength of the structure. This due to the natural behaviour of the micro sizes fibre, which exposed to decay after a long haul (Ahmad *et al.*, 2019). This decay effect will speed up if the cement mortar is not dense enough which provide more void or passage for air or water to penetrate inside the structure.

Therefore, an early precaution of the well-protected structure of cement mortar to prevent chemical attack and decay agents such as air or water to penetrate.

Thermal performance of cement mortar is important properties that need to be studies nowadays (Shahedan *et al.*, 2017). The extreme changed in the climate across the globe causing the importance of producing the construction material that has good thermal insulation rather than just toughness. The utilization thermal insulation of building becomes a great potential to reduce the building thermal load and consequently its energy consumption especially in harsh weather and lead to improvement of economical aspects of buildings. Therefore, more comfort in living and significant energy saving can be realized by buildings with proper materials, design and operation.

1.3 Aims of the study

Many studies in construction have expanding and focusing their studies on producing green and sustainable construction materials. Despite this strategic direction, the literature reveals that relatively little is known about the performance cement mortar incorporating with cellulose-based materials. Consequently, this research aims to narrow this research gap and conduct the research on the performance of CNCs incorporated in cement mortar, focusing on its physical and thermal performance. The results will be used to provide recommendations to the construction industries on the potential usage of CNCs mortar as a green and sustainable construction material.

1.4 Objectives of the study

Several objectives can be drawn according to the problem statement. The objectives are as follow:

1. To characterize the physical and chemical properties of cellulose nanocrystals (CNCs) extracted from palm oil fruit bunches wastes.

2. To determine the engineering properties of CNCs mortar by using the optimum amount of CNCs content.

3. To identify the contribution of CNCs in improving the mortar performance through microstructure study.

4. To investigate the performance of CNCs addition in cement mortar in terms of its impact towards heat

1.5 Research question

Four major questions need to be answered from this research:

1. What are the crucial components of CNCs that make it suitable to improve mortar physical and thermal performance?

2. How the addition of cellulose nanocrystals can contribute to the strength of the mortar?

3. What are the changes in microstructure study of mortar before and after incorporating CNCs?

4. How does the CNCs affect the mortar properties in improving the thermal performance?

1.6 Scope and limitation of the study

The versatility in the formulation of cellulose mortar led to wide acceptance in the construction industry. CNCs is potential to be used as alternative materials other than know cementitious materials such as palm oil fuel ash, slag or rice husk. This research focused on assessing the effect of CNCs addition in mortar matrix based on strength development, microstructures study and thermal performance. To achieve the expectation of the research, a limitation has been set up for this project by following the standard specification:

(a) Percentages of CNC as an additive are tested with 0.2 to 0.8% with 0.2% increment by volume of cement.

(b) The sizes of sand passing sieve between 850 µm to 600 µm and 600µm to 150µm.

(c) Test samples are including 50mm cubes for compressive strength, 40×40×160 mm prism for flexural strength test, Φ70×150 mm cylinders for splitting tensile test and 300x300x100mm bricks for thermal behaviour tests.

(d) Three types of curing regimes namely wrap, water, lime was used.

The tests were conducted based on the American Standard Testing Method (ASTM) standard and British Standard (BS). Some testing methods were adopted from previous researchers since it was not stated in any other established standard.

1.7 Significance of the study

Various application of CNCs reported by in previous studies by using traditional and advanced technology have unveiled many potentials of CNCs. Several studies found that, different sources of cellulose resulting in different properties of CNCs. In this study, the sources of cellulose which came from the abundant local agricultural waste which is palm oil fruit bunch waste have been chosen as the source of cellulose. With the usage of palm oil fruit bunch waste, the carbon emission from the palm oil industries can be reduced to a certain level. This due to less open burning activities will occur in order to dispose the waste.

The overall study can be summarised that the properties of cement mortar can be enhanced by using natural based additives. The natural additives such as CNCs can be a great opportunity to improve the physical properties, inner structure, mechanical properties and thermal performance in a sustainable and green way. Thus, with the improvement in the properties of cement mortar, the mortar can be applied in varies application such as good insulator for building, high rise building and bridge construction material.

With the positive effect of CNCs addition in cement mortar, this can be used to improve the conventional cement mortar used in the construction industries. With a little addition of CNCs can improve the properties of cement mortar. Since the CNCs is a nanomaterial, the little addition of the CNCs would not change the appearance of the common mortar. It only improves the inner structure of the cement mortar.

1.8 Thesis outline

Chapter 1 (Introduction): Chapter 1 discusses the background of the research comprising the statement of the problem, research objectives, research scope, the significance of the research, and limitations of the study.

Chapter 2 (Literature Review): Chapter 2 initially discusses the past research from various researchers all around the world. The main focus is to identify important performance criteria and parameters research that had been done and compared with current research. This chapter then discusses the history, studies, science and different approaches to the utilization of CNCs and its ability to enhance the properties of materials. The differing performance of CNCs as admixture evaluation methods are discussed by looking at the different admixture that each researcher had reported.

Chapter 3 (Research Methodology): Chapter 3 focuses on a testing method that had been conducted to evaluate the performance of CNCs-mortar. The methodology is separated into three parts: a) the characterization of CNCs as potential additive of cement composites, b) hardened properties of mortar incorporating CNCs, and c) microstructure observation of the CNCs-mortar. All the testing methods and parameters are discussed in this chapter.

Chapter 4 (Characterizations of Raw Materials of Cellulose Nanocrystals): Chapter 4 reports and explains the analyses undertaken for achieving the first objectives of this research. The results are discussed in this chapter. Some sections from objective 4 based on microstructure morphology are also included.

Chapter 5 (Properties of Mortar Contain CNCs as Potential Admixture): Chapter 5 discusses the performance of CNCs-mortar as to achieve the Objectives 2, 3 and 4. The correlation analysis was carried out to evaluate CNCs as the potential cement composites admixture.

Chapter 6 (Thermal Behaviour of CNCs-mortar): Chapter 6 converse about the potential of CNCs in improving the thermal behaviour of the cement composites materials by incorporating it. This chapter explains the results and analysis made to satisfied Objectives 5.

Chapter 7 (Conclusions and Recommendations): Chapter 7 concludes the findings of the overall research work that was undertaken. The contribution and implications of the findings toward the construction industry in general and performance evaluation, in particular, are explained. The limitations and possible improvements for future undertakings are also discussed. Suggestions for future research are conveyed in the final part of this chapter.

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LIST OF PUBLICATION

JOURNAL PUBLICATION

1. **Mazlan, D**., Krishnan, S., Din, M.F.M. et al. Effect of Cellulose Nanocrystals Extracted from Oil Palm Empty Fruit Bunch as Green Admixture for Mortar. Sci Rep 10, 6412, 2020 (Q1 Journal, Impact Factor 5.0)

2. **D. Mazlan**, M. F. Md Din, C. Tokoro, and I. S. Ibrahim, "Cellulose Nanocrystals Addition Effects on Cement Mortar Matrix Properties," Int. J. Adv. Mech. Civ. Eng., vol. 3, no. 1, pp. 44–48, 2016 (Scopus Indexed)

CONFERENCE/ PROCEEDING PUBLICATION

1. Zanariah Jahya, Zaiton Haron, Musli Nizam Yahya, **Dianah Mazlan** and Nadirah Darus. "Preliminary investigation of acoustical proeperties of concrete containing oil palm shellas an aggregate replacement,"*International conference on Civil & EnvironmentalEngineering 2017 (CENVIRON 2017),* Penang, Malaysia, 28-29 November 2017.

2. **D. Mazlan**, M.F. Md Din, C. Tokoro, I.S. Ibrahim. "Cellulose Nanocrystals Addition Effects On Cement Mortar Matrix Properties" *International Conference on Civil and Environmental Engineering (I2C2E),* pp. 1-5. Osaka, Japan, December 9th, 2015.

3. Ooi Theam Yiew, **Dianah Mazlan**, Mohd Fadhil Md Din, Azlan Abdul Rahman,Nur Suraya Kamsano., "Review On Urban Heat Island Mitigation Techniques And Impacts", International Conference on Sustainability Initiatives (ICSI) 2015 in conjunction with 8th ASEAN Environmental Engineering Conference (AEEC), Kuala Lumpur, Malaysia, 24- 25 August 2015