

**FIBER REINFORCED CONCRETE USING
EMPTY FRUIT BUNCH (EFB) WASTE**

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**B. ENG (HONS) CIVIL ENGINEERING
UNIVERSITY MALAYSIA PAHANG**

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NURNADIANABILA BINTI ABD. HALIM

Thesis submitted in fulfillment of the requirements
for the award of the degree
of Bachelor in Civil Engineering (Hons)

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in term of scope and quality for the award of the degree of B.Eng.(Hons.) Civil Engineering.

Signature :
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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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TABLE OF CONTENT

	Page	
SUPERVISOR'S DECLARATION	ii	
STUDENT'S DECLARATION	iii	
ACKNOWLEDGEMENT	iv	
ABSTRACT	v	
ABSTRAK	vi	
TABLE OF CONTENT	vii	
LIST OF TABLES	x	
LIST OF FIGURES	xi	
LIST OF SYMBOLS	xiv	
LIST OF ABBREVIATIONS	xv	
CHAPTER 1 INTRODUCTION		
1.1	Background of Study	1
1.2	Problem Statement	3
1.3	Research Objectives	5
1.4	Scope of Study	5
1.5	Research Significance	6
CHAPTER 2 LITERATURE REVIEW		
2.1	Background of the Waste	8
2.2	Type of Waste in Malaysia	8
	2.2.1 Municipal Solid Waste	8
	2.2.2 Industrial Waste	9
	2.2.3 Hazardous Waste	10
	2.2.4 Residue	12
	2.2.5 Agricultural Waste	12
2.3	Empty fruit bunch waste (EFB)	13
	2.3.1 Empty fruit bunches (EFB) in a Concrete Mixture	14
	2.3.2 Empty fruit bunches (EFB) in Bricks Applications	15
2.4	Wastes in Reinforced Concrete	15

2.4.1	Mix Proportion of Empty Fruit Bunch (EFB) Fiber in RC	15
2.4.2	Advantages and Disadvantages of Empty Fruit Bunch (EFB) Fiber	16
2.5	Empty Fruit Bunch (EFB) Fiber Reinforced Concrete	17
2.5.1	Mechanical Properties	17
2.6	Reinforced Concrete (RC)	17
2.6.1	Fiber Reinforced Concrete (FRC)	18
2.6.2	Behavior of Fiber Reinforced Concrete (FRC)	19
2.6.2.1	Behavior of Steel Fiber Reinforced Concrete (SFRC)	19
2.6.2.2	Behavior of Glass Fiber Reinforced Concrete (GFRC)	20
2.6.2.3	Behavior of Synthetic Fiber Reinforced Concrete (SFRC)	21
2.6.2.4	Behavior of Natural Fiber Reinforced Concrete	21
2.7	Summary of Finding	22

CHAPTER 3 METHODOLOGY

3.1	Introduction	24
3.2	Preparation of Reinforced Concrete Using Empty Fruit Bunch (EFB) Fiber	24
3.2.1	Empty Fruit Bunch (EFB) Preparation	24
3.3	Material Characteristic	25
3.3.1	Concrete	25
3.3.2	Empty Fruit Bunch (EFB) fiber	26
3.4	Preparation of Concrete Mould	26
3.4.1	Concrete Cube	26
3.4.2	Cylindrical Specimen	27
3.4.3	Rectangular Beam	28
3.5	Specimen Details	29
3.5.1	Mix Design Reinforced Concrete with a Empty Fruit Bunch (EFB) Fibers	29
3.6	Laboratory Testing	31
3.6.1	Slump Test	32
3.6.2	Compressive Strength Test	33
3.6.3	Splitting Tensile Test	35
3.6.4	Flexural Strength Test	36
3.7	Research Flow Chart	38

CHAPTER 4 RESULT AND DISCUSSION

4.1	Overview	39
4.2	Slump Test	39
4.3	Compression Test	44
4.4	Splitting Tensile Test	59
4.5	Flexural Test	63

CHAPTER 5 CONCLUSION AND RECOMMEDATIONS

5.1	Overview	69
5.2	Conclusion	69
5.3	Recommendation	71

REFERENCES	72
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APPENDICES	72
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A	Design Mix Calculation	76
B	Compression Strength Test Results	79
C	Flexural Strength Test Results	89
D	Splitting Tensile Strength Test Results	91

LIST OF TABLES

Table No.	Title	Page
3.1	0.25% of empty fruit bunch (EFB) fiber	30
3.2	0.50% of empty fruit bunch (EFB) fiber	30
3.3	0.75% of empty fruit bunch (EFB) fiber.	30
3.4	1.00 % of empty fruit bunch (EFB) fiber	30
3.5	List of test that were conducted	31
3.6	Test matrix	32
4.1	Workability, Slump and Compacting Factor of concrete with 19 or 38 mm (3/4 or 1 ¹ / ₂ in) maximum size of aggregate.	41
4.2	The slump tests result in different percentages of EFB fiber in concrete mixtures.	43
4.3	The Summary of Compressive Strength Results	51
4.4	0 % of empty fruit bunch (EFB) fiber	59
4.5	The optimum percentages of EFB fiber is 0.25%	59
4.6	0 % of empty fruit bunch (EFB) fiber	64
4.7	The optimum percentages of EFB fiber is 0.25%	64
4.8	Amount of fiber used by weight of cement	77
4.9	Quantity of material for 1 mixture of 15 cubes (100 x 100 x 500mm x 15 cubes) = 0.015 m ³	77
4.10	Quantity of material for 1 mixture of 6 rectangular beams (100 x 150 x 500mm x 6 pcs beam) = 0.03 m ³	78
4.11	Quantity of material for 1 mixture of 6 cylinders (π x 150 x 500mm x 6pcs cylinder) = 0.03 m ³	78

LIST OF FIGURES

Figure No.	Title	Page
1.1	The statistical of oil and fats export (1990-2015F)	2
1.2	Empty fruit bunch (EFB)	3
1.3	Annual growth palm oil versus area	4
1.4	The empty fruit bunch (EFB) that have been sent back to the field for disposing or used for mulching	5
1.5	Empty fruit bunch (EFB) fiber	6
2.1	Disposal items classified under municipal waste.	9
2.2	Example of waste generated by varies industry.	10
2.3	Symbols of hazardous wastes	11
2.4	Type of hazardous waste that has a varying characteristic such as toxicity, corrosivity, and flammable	11
2.5	Proportionate annual production of agricultural waste in Malaysia	12
2.6	Unprocessed empty fruit bunches (EFB)	14
2.7	Processed empty fruit bunches (EFB) to produced fiber	14
2.8	Type of fiber used in concrete mixture influence the cracking and tensile strength.	20
2.9	Natural fibers	22
3.1	Empty fruit bunch (EFB) fiber	25
3.2	Empty fruit bunch (EFB) fiber with 5 cm length.	26
3.3	Concrete cube before and after concreting work	27
3.4	Cylinder mould before and after concreting work	28
3.5	Rectangular beam before and after concreting work	29
3.6	Apparatus of slump test	33

3.7	Cubes 100 mm x 100 mm x 100 mm (width x height x length)	34
3.8	Concrete cube tested by using the compression machine	34
3.9	Splitting tensile strength test machine)	35
3.10	Cylinder concrete tested by using the splitting tensile strength machine	36
3.11	Rectangular beam 100 mm x 100 mm x 500 mm (width x height x length	36
3.12	Flexural strength test machine	37
3.13	Rectangular beam tested by using flexural strength test machine	37
3.14	Research flow chart	38
4.1	Types of a slump	40
4.2	Slump test for 5 mixtures of fresh concrete	40
4.3	Type of failure of mode concrete compression test	45
4.4	Graph of 0% EFB Fiber content in the concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	46
4.5	Graph of 0.25 % EFB Fiber content in the concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	47
4.6	Graph of 0.50 % EFB Fiber content in the concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	48
4.7	Graph of 0.75% EFB Fiber content in the concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	49
4.8	Graph of 1.00% EFB Fiber content in the concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	50
4.9	Graph of 0%, 0.25%, 0.50%, 0.75% and 1.00% EFB fiber content in concrete mixture, Compressive strength (N/mm ²) versus Concrete Age, Days.	53
4.10	0% EFB fiber concrete cubes	54
4.11	0.25% EFB fiber concrete cubes	55

4.12	0.50% EFB fiber concrete cubes	56
4.13	0.75% EFB fiber concrete cubes	57
4.14	1.00 % EFB fiber concrete cubes	58
4.15	Graph of the Splitting Strength, N/mm^2 versus Concrete Age, Day	60
4.16	0% of the EFB fiber cylinder concrete	61
4.17	0.25% of the EFB fiber cylinder concrete	62
4.18	Graph of the flexural strength, N/mm^2 versus Concrete Age, Days.	65
4.19	0 % of the EFB fiber rectangular beam	66
4.20	0.25% of the EFB fiber rectangular beam	67

LIST OF SYMBOLS

f'_c Specified strength

LIST OF ABBREVIATION

EFB	Empty fruit bunch waste
FRC	Fiber reinforced concrete
MSW	Municipal solid waste
OPEFB	Oil palm empty fruit bunch
PKC	Palm kernel cake
SFRC	Steel fiber reinforced concrete
UMP	Universiti Malaysia Pahang
GFRC	Glass fiber reinforced concrete
SFRC	Synthetic fiber reinforced concrete

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ABSTRACT

Malaysia produced about half of the world palm oil production (10.8 million tonnes), thus making Malaysia as the world's largest producer and exporter of palm oil during this period (Abdullah & Sulaiman, 2013). The empty fruit bunch (EFB) is produced after the fresh fruit bunch is processed to produce oil palm mill. Due to the abundance of empty fruit bunch waste that was produced, it also generates waste management problem. EFB waste can be processed into fiber and can be used for other purposes. In this study, the EFB fibers are used as an additive in the concrete to control cracking due to plastic and drying shrinkage (Vajje & Krishna, 2013). Other than that, the usage of natural fibers are able to increase the concrete strength and reduce the plastic and drying shrinkage that can induce structural cracks. The main objectives of this study are to identify the optimum percentage of empty fruit bunch (EFB) fiber and to study the mechanical properties of empty fruit bunch (EFB) fiber in the reinforced concrete. This paper presents the compressive strength test, flexural strength test and splitting tensile strength test to study the mechanical properties of the concrete. In this experimental study, grade 25 MPa of concrete is used with a mix proportion of 1:1.5:3. The EFB fiber with percentages 0.25%, 0.50%, 0.75% and 1.00% was added into the concrete mixtures. The result shows that, the optimum percentage of EFB fiber 0.25% was identified as the most suitable percentage to be added into the concrete mixture. The findings from this experimental study shows that the optimum percentage of EFB fiber able to increase the early strength up to 10% of the concrete compared to the normal concrete. On the other hand, the strength increased for the flexural strength result of EFB fiber concrete up to 10% compared to the control mix. However, the splitting tensile strength for the EFB fiber lower 6% compared to the control mix. But with the addition of 0.25% EFB fiber able to resist the crack compared to the control mix.

ABSTRAK

Malaysia menghasilkan kira-kira separuh daripada pengeluaran minyak sawit dunia (10.8 juta tan metrik), sekali gus menjadikan Malaysia sebagai pengeluar dan pengeksport minyak sawit terbesar di dunia dalam tempoh ini (Abdullah & Sulaiman, 2013). Tandan kosong (EFB) dihasilkan selepas tandan buah segar diproses untuk menghasilkan minyak kelapa sawit. Oleh kerana sisa tandan buah kosong yang dihasilkan terlalu banyak, ia juga menyebabkan masalah pengurusan sisa buangan. Sisa EFB boleh diproses menjadi serat dan boleh digunakan untuk tujuan lain. Dalam kajian ini, gentian EFB digunakan sebagai bahan tambahan dalam konkrit untuk mengawal keretakan disebabkan oleh plastik dan pengecutan kering (Vajje & Krishna, 2013). Selain daripada itu, penggunaan gentian asli dapat meningkatkan kekuatan konkrit dan mengurangkan pengecutan plastik dan pengeringan yang boleh menyebabkan keretakan struktur. Objektif utama kajian ini adalah untuk mengenalpasti peratusan optimum buah kosong sekumpulan (EFB) serat dan untuk mengkaji sifat-sifat mekanikal kosong serat tandan buah (EFB) dalam konkrit bertetulang. Kertas kerja ini membentangkan ujian kekuatan mampatan, lenturan ujian kekuatan tegangan dan membelah tegangan ujian kekuatan untuk mengkaji sifat mekanikal konkrit. Dalam kajian eksperimen ini, gred 25 MPa konkrit digunakan dengan sebahagian campuran 1: 1.5: 3. Serat EFB dengan peratusan 0.25%, 0.50%, 0.75% dan 1.00% telah ditambah ke dalam campuran konkrit. Hasilnya menunjukkan bahawa, peratusan optimum gentian EFB 0.25% telah dikenal pasti sebagai peratusan yang paling sesuai untuk ditambah ke dalam campuran konkrit. Penemuan daripada kajian eksperimen ini menunjukkan bahawa peratusan optimum gentian EFB mampu meningkatkan kekuatan awal sehingga 10% daripada konkrit berbanding konkrit biasa. Sebaliknya, kekuatan meningkat untuk keputusan kekuatan lenturan konkrit EFB serat sehingga 10% berbanding konkrit biasa. Walau bagaimanapun, kekuatan tegangan membelah untuk serat EFB yang lebih rendah 6% berbanding konkrit biasa. Tetapi dengan tambahan 0.25% gentian EFB dapat menahan retak berbanding konkrit biasa.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Malaysia is one of the world's largest palm oil exporter and palm oil production by 44% and 39% respectively. Malaysia produced about half of the world palm oil production (10.8 million tons), thus making Malaysia as the world's largest producer and exporter of palm oil during this period (Abdullah & Sulaiman, 2013). In Malaysia, palm industry has grown rapidly. Many areas were opened up for oil palm plantation since 1920, during that time 400 hectares were planted and it expands up to 54000 hectares in 1960, the statistic is increased up to 5 million hectares in 2011. The oil palm growth is related to the world's demand for oils and fats and directly make palm oil become the largest production and the first player in the oils and fats trade. This makes palm oil plantation need to be harvested more and more to ensure fulfill the world demand. Oil palm is the most important product from Malaysia that has helped to change the scenario of its agriculture and economy (Abdullah & Sulaiman, 2013). Malaysia produced 17.9 million tons of palm oil as well as 2.1 million tons of palm kernel in 2009, at the same time, quite a lot of waste biomass was generated, including 2.3 million tons of PKC (palm kernel cake), 30 million tons of EFB (empty fruit bunch) and waste fruit fiber and etc.

Due to increases of palm oil cultivation, there is an abundance of raw materials available on the palm consisting of around 90% of biomass wastes and only around 10% of the oil.

About 90 million tons of oil palm fruit production were recorded in 1998; however, 43-45% of this was mill residues in the form of EFB, shell, and fiber (Abdullah & Sulaiman,2013).

According to the Waste Management World (2012), waste, including POME, from the region's 1000 plus Palm Oil plantations is a significant issue for plantation owners, local communities and the region in general and contributes significantly to total emissions. This statement also is supported by Zafar (2015), from the palm oil waste, almost 70% of the volume from the processing of fresh fruit bunch is removed as waste as empty fruit bunch (EFB), fibers and shells.

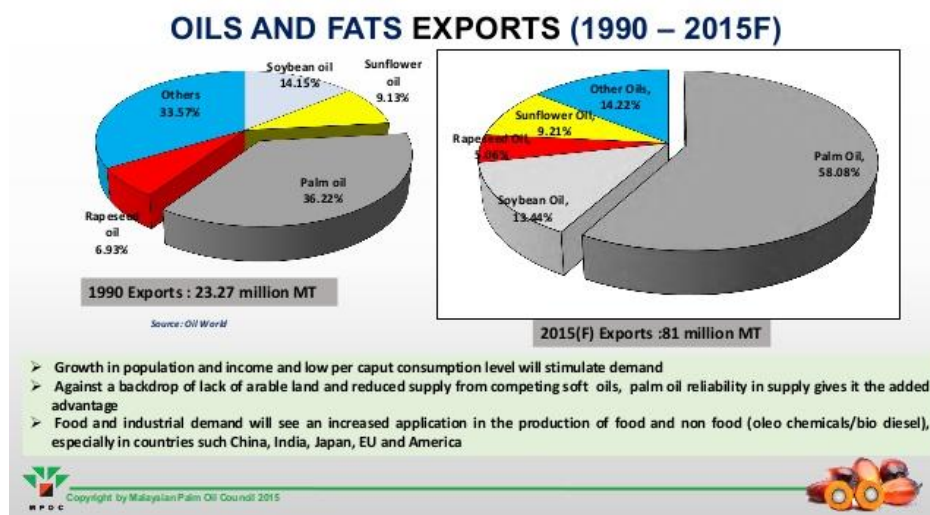


Figure 1.1: The statistical of oil and fats export (1990-2015F)

Source: MPOC

Figure 1.1 shows the palm oil is the highest exporter with 36.22% and 58.08% since 1990 and 2015.

Concrete is known as a composite material of sand, aggregates, cement and with the perfect amount of water. Concrete has its own characteristic that makes it is becoming popular in the construction industry in the world beside the steel and timber, concrete has high compressive strength, but lower in tensile strength. For conventional concrete also has its own specialty like good in thermal conductivity and sound insulation properties, good fire rating, non – combustible and ease of handling. Besides

that, concrete also has been invented by several researchers to produce concrete by using the waste material. Likes empty fruit bunch (EFB) fiber have been used in previous researchers into the concrete mixture to produce the concrete to improve certain aspects of concrete.

In this research, the empty fruit bunch (EFB) fiber used in concrete mixed as an additive. By using this empty fruit bunch (EFB) fiber into the concrete mixture will become a renewable of empty fruit bunch (EFB) fiber usage into the valuable and useful product where it can help to control the pollution and environmental sustainability.



Figure 1.2: Empty fruit bunch (EFB)

1.2 PROBLEM STATEMENT

In Malaysia, with an annual growth of 5.9%, areas under oil palm increased from 641,791 hectares in 1975 to 5.0 million hectares in 2011. By 2012, oil palm plantations occupied 15.4% Or 5.08 million of Malaysia's land mass (Adnan & Kum,2015). Empty fruit bunch (EFB) is produced after the fresh fruit bunch is a process to produced oil mill, the EFB will be sent back to the field for disposal and may be to be used for mulching. Due to the abundance of empty fruit bunch waste that was produced by the palm oil cultivation, it also generates to the other problem that related to waste management. According to Lim, (2010), replacement of fossil fuel for industrial use and consequently address the issue of waste management since the density of EFB

REFERENCE

- Abdullah, N., & Sulaiman, F. (2013). The Oil Palm Waste in Malaysia. *Biomass Now Sustainable Growth and Use*, 75 – 100.
https://www.researchgate.net/publication/259440691_The_Oil_Palm_Wastes_in_Malaysia
- Adnan A . Hezri & Kum, Y.D., (2015). Redefining Sustainable Agricultural For The Developing World. *Journal of Oil Palm, Environment & Health*, 42 - 55. <http://www.jopeh.com.my/index.php/jopecommon/article/view/96>
- Anonymous. (2008). Hazardous Waste Definitions. 1-7.
<http://www.deq.state.or.us/lq/pubs/docs/hw/Reporting/HWDefinitions.pdf>.
- Amit Rai & Y.P. Joshi. (2014). Applications and Properties of Fibre Reinforced Concrete. *International Journal of Engineering Research and Application*. 4(5), 123 - 131. Retrieved from <https://www.researchgate.net/file.PostFileLoader.html?id=57b079c8ed99e15b781760c1&assetKey=AS%3A394986303574020%401471183481550>.
- C. Selin Ravikumar, V.Ramasamy, T.S. Thandavamoorthy.,(2016). Effect of Fibers In Concrete Composites. *International Journal of Applied Engineering Research*. 10(1), Retrieved from http://www.academia.edu/11718923/Effect_of_Fibers_In_Concrete_Composites
- BS EN 2390 - 2: 2009, Testing Hardened Concrete, Part 2: Slump Test.
- BS EN 12390 - 3: 2009, Testing Hardened Concrete, Part 3: Compressive Strength Of Test Specimens
- BBS EN12390 - 5: 2009, Testing Hardened Concrete, Part 5: Flexural Strength Of Test Specimens.

Diaz,L.F., Savage G.M. & Eggerth L.L., (2005). Solid Waste Management. United NationsEnvironment Programme (UNEP) Publishers

John Elson., Aiswarya Sukumar (2014). Fiber Addition and Its Effect on Concrete, *International Journal of Innovative Research in Advanced Engineering*. 1(8),144–149. Retrieved from [http://www.ijirae.com/volumes/vol1/issue8/SPCE10083\(21\).pdf](http://www.ijirae.com/volumes/vol1/issue8/SPCE10083(21).pdf)

G. Plizzari, L. Vandewalle., (2010). Fiber Reinforced Concrete. Concrete: Microstructure, Properties, and Materials.

Jeffery R. Roesler, Salah A. Altoubat, David A.Lange,Klaus - Alexander Ried & Gregory R. Ulrich.,(2006). *Effect Of Synthetic Fibers On Structural Behavior Concrete Slabs - On - Ground*. Aci Materials Journal. 1(3). Retrieved from http://www.ripublication.com/ijcer_spl/ijcerv5n3spl_12.pdf.

Koehler, E. P., & Fowler, D. W. (2003). *Summary of Concrete Workability Test Methods*, International Center Aggregates Research (ICAR). 92. Retrieved from <https://www.researchgate.net/file.PostFileLoader.html?id=53f5b373cf57d762408b45fa&assetKey=AS%3A272119177383936%401441889676639>.

Lim Meng Hon, J., 2010. A case study on palm empty fruit bunch as energy feedstock. *SEGi Review*, 3(2), pp.3–15. Retrieved from: <http://www.onlinereview.segi.edu.my/flipbook/vol3-no2-art1/preview.html>.

Sharikant M.Harle. (2014). Review on the Performance of Glass Fiber Reinforced Concrete. *International Journal of Civil Engineering Research*. 5(3), 281 - 284. Retrieved from http://www.ripublication.com/ijcer_spl/ijcerv5n3spl_12.pdf.

Shama Parveen, Sohel Rana & Raul Fanguerio. (2012). *Natural Fiber Composites for Structural*. Retrieved from <http://paginas.fe.up.pt/~icnmmcs/abstracts/465.pdf>.

- M. Suhaimi & Ong.H.K., (2010). Composting empty fruit bunches of oil palm. *Journal Of Oil Palm Research*, 22(2), 1 - 4. Retrieved from http://www.agnet.org/htmlarea_file/library/20110804151206/eb505a.pdf
- Malárics, V., & Müller, H. S. (2010). Evaluation of the splitting tension test for concrete from a fracture mechanical point of view the. *Proceedings of the Fracture Mechanics of Concrete and Concrete Structures - Assessment, Durability, Monitoring and Retrofitting of Concrete Structures*, 709–716.
- Nrmca. (2013). *CIP 35 - Testing Compressive Strength of concrete*. Concrete In Practice - What, Why & How.
- Olaoye, R.A., Oluremi,J.R., & Ajamu, S.O., (2013). *The Use of Fibre Waste as Complement in Concrete for a Sustainable Environment*. 4(9), 91 - 98.Retrieved from <http://www.iiste.org/Journals/index.php/ISDE/article/viewFile/6258/6388>.
- Roslan Kolop, Haziman W.I.M, & J.W. Eng., (2010). *Properties Of Cement Blocks Containing High Content Of Oil Palm Empty Fruit Bunches (Efb) Fibres*. Retrieved from <http://eprints.uthm.edu.my/270/>
- Sallehan Ismail & Zaiton Yaacob., (2011). *Properties Of Laterite Brick Reinforced With Oil Palm Empty Fruit Bunch Fibres*. *Pertanika Journal of Science and Technology*. 19(1), 33 - 43. Retrieved from [http://pertanika.upm.edu.my/Pertanika%20PAPERS/JST%20Vol.%2019%20\(1\)%20Jan.%202011/%239%20Pg%2033-43.pdf](http://pertanika.upm.edu.my/Pertanika%20PAPERS/JST%20Vol.%2019%20(1)%20Jan.%202011/%239%20Pg%2033-43.pdf).
- Pshtiwan N.S.& S.S. Pimplikar.,(2011). *Glass Fiber Reinforced Concrete Use In Construction*. *International Journal of Technology And Engineering System (IJTES)*. 2(2). Retrieved from <http://www.ijcns.com/pdf/328.pdf>.
- United Nations. (2000). *Waste. State of the Environment in Asia and the Pacific*, 170–194. Retrieved from <http://www.unescap.org/esd/environment/soe/2000/download.asp>

- Vajje, S. & Krishna.N., (2013). Study On Addition Of The Natural Fibers Into Concrete. *International Journal Of Science & Technology Research*, 2 (11), 213 - 218.
- Wan Asma I,Mahanim S.,Zulkafli H., Osman S & Y.Mori. (2010). *Malaysia Oil Palm Biomass*. Retrieved from www2.gec.jp/gec/en/Activities/FY2009/ietc/wab/wab_day2-3.pdf
- Waste Management World. (2012). 2MW Biogas From Palm Oil Waste Project In Malaysia. Vienna: Industriemagazin Verlag. Portal Waste Management World. Retrieved On 24/12/2016. Retrieved From <https://waste-management-world.com/a/2mw-biogas-from-palm-oil-waste-projectin-malaysia>
- Zafar, S. (2015) *Agricultural Biomass in Malaysia*. Retrieved from BioEnergy Consult: <http://www.bioenergyconsult.com/agricultural-biomass-in-malaysia/>