



Faculty of Engineering

**LONG TERM DEFLECTION AND CRACKING PERFORMANCE OF  
PALM SHELL AGGREGATE CONCRETE BEAM SUBJECTED TO  
TRANSVERSE LOADING**

**LIEW YU VOON**

**Bachelor of Engineering with Honours  
(Civil Engineering)  
2010**

# UNIVERSITI MALAYSIA SARAWAK

R13a

## BORANG PENGESAHAN STATUS TESIS

Judul: LONG TERM DEFLECTION AND CRACKING PERFORMANCE OF PALM SHELL  
AGGREGATE CONCRETE BEAM SUBJECTED TO TRANSVERSE LOADING

SESI PENGAJIAN: 2009/2010

Saya LIEW YU VOON  
(HURUF BESAR)

mengaku membenarkan tesis \* ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak.
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan.
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
5. \*\* Sila tandakan ( ✓ ) di kotak yang berkenaan

SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).

TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).

TIDAK TERHAD

Disahkan oleh

\_\_\_\_\_  
(TANDATANGAN PENULIS)

\_\_\_\_\_  
(TANDATANGAN PENYELIA)

Alamat tetap: LOT 307 R.P.R BATU 12 ,

JALAN KUCHING/SERIAN,

93250 KUCHING, SARAWAK

Prof Madya Dr.Ehsan Ahmed

Nama Penyelia

Tarikh: \_\_\_\_\_

Tarikh: \_\_\_\_\_

### CATATAN

- \* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda.
- \*\* Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

The following Final Year Project:

Title: Long Term Deflection And Cracking Performance of Palm  
Shell Aggregate Concrete Beam Subjected To Transverse  
Loading

Author: Liew Yu Voon

Metric: 16539

has been read and certified by

---

Prof Madya Dr.Ehsan Ahmed  
(Supervisor)

---

Date

**LONG TERM DEFLECTION AND CRACKING PERFORMANCE OF  
PALM SHELL AGGREGATE CONCRETE BEAM SUBJECTED TO  
TRANSVERSE LOADING**

**LEIW YU VOON**

This project is submitted to Faculty of Engineering,  
University Malaysia Sarawak in partial fulfillment of the requirements for the  
Degree of Bachelor of Engineering with Honours.  
(Civil Engineering) 2010

# ACKNOWLEDGEMENT

I am heartily thankful to my supervisor, Prof Madya Dr.Ehsan Ahmed, whose encouragement, guidance and support from the initial to the final level of the research. I also would like to thank him for showing me some information that related to the research.

Besides that, I would like to thank the Heavy Structures Laboratory, Department of Civil Engineering, Universiti Malaysia Sarawak, Malaysia for providing the material to me. Also, I would like to thank the technicians in the laboratory for providing good assistances to complete this research.

I also gratefully acknowledge to my friends and families for their understanding and support to finish this research. Without helps of them, I would face many difficulties while doing this research.

# ABSTRAK

Kajian ini adalah bertujuan untuk mengkaji kegunaan kulit kelapa sawit sebagai pengantian batu-bata untuk menghasilkan konkrit struktur. Satu eksperimen telah dijalankan untuk mengkaji perilaku defleksi dan belahan bagi kulit kelapa sawit konkrit balok dan konkrit biasa balok dengan 1500mm panjang apabila menahan beban dalam jangka masa panjang. (120 hari) Tambahan pula, Kajian leturan juga dijalankan dalam laporan tersebut. Sembilan batang konkrit balok telah disediakan di makmal. Empat batang kulit kelapa sawit konkrit balok dan dua konkrit biasa balok dibawah oleh beban yang berbeza dalam masa empat bulan. (120 days) Manakala, dua konkrit biasa balok dan satu kulit kelapa sawit konkrit digunakan untuk mengkaji kelenturan. Menurut eksperimen penilikan dan teoritis analisis, keputusan tersebut menunjukkan bahawa bahagian belahan balok dibawah bebanan mempunyai defleksi yang tinggi jika berbanding dengan bahagian yang tiada belahan. Hal ini menunjukkan bahawa teoritis hampiran berupaya memberi perkiraan yang dekat dalam defleksi bagi fungsi merangkap yang tinggi. Kulit kelapa sawit konkrit balok mempunyai defleksi yang tinggi berbanding dengan konkrit biasa. Bagi kajian leturan, beban yang digunakan untuk menahan kulit kelapa sawit konkrit balok lebih kecil daripada beban yang digunakan untuk menahan konkrit biasa balok.

# ABSTRACT

The research is about the use of oil palm shell (OPS) as coarse aggregate to produce structural concrete. An experimental investigation was designed to study the deflection and cracking behavior of Oil Palm Shell (OPS) beams and normal weight concrete beams under long-term sustained loading. Flexural test also involved in this study. Nine concrete beams were prepared at laboratory. Four OPS concrete beams and two normal weight concrete beams were subjected to different loading in four months. (120 days) The other two OPS concrete beams and one normal weight concrete beam were used to carry out the flexural test. From the experimental observation and theoretical analysis, the result shows that cracked section beams under sustained loading had produced larger deflection comparing to the uncracked section beams. This incident was concluded that theoretical approaches are able to give closer estimate of deflection for the larger values of creep function. In addition, OPS concrete beams showed larger deflection comparing to the normal weight concrete beam. The results from flexural test showed the loading that had applied to OPS concrete beam less than the loading that applied to the normal Weight concrete beams. Besides, the experimental results obtained were less than the theoretical result.

# TABLE OF CONTENTS

<b>CONTENT</b>	<b>PAGES</b>
ACKNOWLEDGEMENT	III
ABSTRAK	IV
ABSTRACT	V
TABLE OF CONTENT	VI
LIST OF TABLES	XII
LIST OF FIGURES	XIV
LIST OF ABBREVIATIONS	XVII
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Objective	4
1.3 Research program	4
1.4 Scope of the thesis	6
CHAPTER 2 LITERATURE REVIEW	7
2.1 Introduction	7
2.2 Deflection of concrete	7
2.2.1 Shrinkage	8

2.2.2	Creep	9
2.2.2.1	Factors of creep	10
2.3	Research review	11
2.3.1	Arockiasamy M., Chidambaram S., Amer A. and Shahawy M, 2000	12
2.3.2	Basri,H.B, Mannan M.A, Zain M.F.Zain, 1998	12
2.3.3	D.C.L.TEO, M.A.Mannan, V.J.Kurian, 2006	14
2.3.4	Gilbert R.I, 2001	15
2.3.5	Johnson Alengaram.U, Zamin Jumaat.Mohd, Hilmi Mahmud, 2008	17
2.3.6	Lim H.S, Kong K.H, and Mansur M.A, 2006	20
2.3.7	Mannan M.A, Ganepathy C, 2001	21
2.3.8	Maruyama I., Sato R., Sogabe T. and Sogo M, 2007	24
2.3.9	Tan K.H and Saha M.K, 2005	25
2.4	Conclusion	26
CHAPTER 3 METHODOLOGY		27
3.1	Introduction	27
3.2	Literature review	28
3.3	Theoretical analysis	28
3.4	Materials used	28
3.4.1	Oil palm shell (OPS)	29
3.4.2	Cement	30

3.4.3	Aggregates	31
3.4.4	Water	31
3.5	Material properties test	32
3.5.1	Aggregates	32
3.5.1.1	Test of specific gravity and absorption of coarse aggregate	32
3.5.1.2	Test of specific gravity and absorption of fine aggregate	33
3.5.1.3	Test of unit weight and void aggregate	33
3.5.1.4	Test of total moisture content and surface moisture content of aggregate	34
3.5.1.5	Sieve analysis of fine aggregates	34
3.5.1.5	Sieve analysis of coarse aggregates	34
3.5.2	Oil palm shell (OPS)	35
3.5.2.1	Test of specific gravity and absorption of oil palm shell (OPS)	35
3.5.2.2	Sieve analysis of oil palm shell (OPS)	35
3.5	Mix design	36
3.6	Preparation of beams	36
3.7	Preparation of concrete cubes	37
3.8	Testing the cubes and beams	38

3.8.1	Compressive test	38
3.8.2	Slump test	39
3.8.3	Flexural test	40
3.8.4	Long term deflection test	41
CHAPTER 4 THEORETICAL STUDY		45
4.1	Introduction	45
4.2	Modulus of rupture of concrete	46
4.3	Modulus of elasticity of concrete	47
4.4	Modulus of elasticity of steel	48
4.5	Instantaneous or short term deflection	49
4.5.1	Uncracked section	49
4.5.2	Cracked section	52
4.5.3	Effective moment of inertia	54
4.6	Long term analysis	56
4.6.1	Creep effect on the deflection under sustained load	56
4.6.2	Shrinkage	58
4.7	Flexural test	60
4.7.1	Ultimate load of palm shell concrete beams	60
4.7.1.1	To determine the moment	62
4.7.1.2	Determine the ultimate load of palm shell concrete beam	63

4.7.2	Determine the cracking load of palm shell concrete	65
4.7.2.1	Determine the cracking moment of palm shell concrete	67
4.7.2.2	Determine the cracking load moment of palm shell concrete	67
CHAPTER 5 EXPERIMENTAL STUDY, RESULTS AND DISCUSSION		68
5.1	Introduction	68
5.2	Materials properties test	68
5.2.1	Sieve analysis	71
5.2.1.1	Graph of sieve analysis for oil palm shell	72
5.2.1.2	Graph of sieve analysis for coarse aggregates	73
5.3	Mix proportional	73
5.4	Test on OPS concrete beams	76
5.4.1	Properties concrete test	77
5.4.2	Flexural test	78
5.4.3	Time dependent behavior test	85
5.4.3.1	For the 10% Oil Palm Shell Replacement in Concrete Beam	89
5.4.3.2	For the 15% Oil Palm Shell Replacement in Concrete Beam	90

5.4.3.3 For the Normal Weight Concrete Beam	91
CHAPTER 6 CONCLUSION AND RECOMMENDATION	95
6.1 Introduction	95
6.2 Conclusion	95
6.3 Recommendation	97
REFERENCES	99
APPENDIX A	104
APPENDIX B	110

# LIST OF ABBREVIATIONS

NWC	-Normal weight concrete
OPS	-Oil palm shell
PKSC	-Palm kernel shell concrete
CMS	-Cahaya Matahari Sarawak
CaO	- Lime
SiO <sub>2</sub>	- Silica
Al <sub>2</sub> O <sub>3</sub>	- Alumina
BS	-British standard
PSB	-Palm shell beam
PSBU	-Palm shell beam uncracked
PSBC	-Palm shell cracked

# LIST OF FIGURES

<b>FIGURE</b>	<b>PAGES</b>
1.0 Creep of concrete loaded and stored at different relative humidity	10
2.0 Crack width variation of PKSC and NWC beams	20
3.0 Deflection curve of normal concrete under different load applied	21
4.0 The allowable mix proportional of OPS	22
5.0 Deflection of the palm shell concrete slab	23
6.0 Moment versus deflection graph	24
7.0 Oil palm shell from mills	29
8.0 Setup of the flexural test	41
9.0 Setup of long-term deflection test	42
10.0 Flow chart of the research	43
10.1 Flow chart of the materials properties test	44

11.0	Uncracked transformed section	51
12.0	Cracked transform section	53
13.0	Section, strain and stress block	61
14.0	Loading distribution of flexural test	63
14.1	Free body diagrams	64
14.2	Shear force diagrams	64
14.3	Bending moment diagrams	64
15.0	Transformed section of uncracked section for flexural test	65
16.0	Graph of sieve analysis for oil palm shell	72
17.0	Graph of sieve analysis for coarse aggregates	73
18.0	Arrangement of apparatus of flexural test	79
19.0	Graph of load versus deflection for PSB-10%, PSB-15% and NWC	83
20.0	Time dependent test	85

21.0	Graph of deflection of 10% OPS concrete beam versus days for uncracked section (3.80kN/m)	89
22.0	Graph of deflection of 10% OPS concrete beam versus days for cracked section (6.81kN/m)	89
23.0	Graph of deflection of 15% OPS concrete beam versus days for uncracked section (3.80kN/m)	90
24.0	Graph of deflection of 15% OPS concrete beam versus days for cracked section (6.96kN/m)	90
25.0	Graph of deflection of normal weight concrete beam versus days for uncracked section (3.80kN/m)	91
26.0	Graph of deflection of normal weight concrete beam versus days for cracked section (9.43kN/m)	91

# LIST OF TABLE

<b>TABLE</b>		<b>PAGES</b>
1.0	Physical properties of oil palm shell and crushed stone	13
2.0	Properties of oil palm shell	14
3.0	Concrete strength, steel and size of beams	17
4.0	Ultimate load and deflection characteristics of PKSC and NWC beam	18
5.0	Moment capacity of PKSC and NWC	19
6.0	Properties of steel reinforcement	49
7.0	Properties of oil palm shell and coarse aggregate	69
8.0	Sieve analysis of oil palm shell	71
9.0	Sieve analysis of coarse aggregates	72
10.0	Compressive strength of palm shell concrete	74
11.0	Density of concrete with different quantity of OPS	75

12.0	Test program	76
13.0	Properties of concretes	78
14.0	Flexural test results for PSB-10%	80
15.0	Flexural test results for PSB-15%	81
16.0	Flexural test results for NWC	82
17.0	Ultimate load and cracking load	83
18.0	Long term deflection for 10% OPS beams	86
19.0	Long term deflection for 15% OPS beams	87
20.0	Long term deflection for normal weight concrete beams	88

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Malaysia is a country that produces oil palm. Since oil palm industry developed in Malaysia has grown a largest producer and exporter of oil palm in world. Oil palm industry in Malaysia has produce 17.60 million tonnes of palm oil in 2009 comparing to the production in 2008 is 17.56 million tones. (PALM OIL HQ 2009) This meaning that the production of palm oil is increasing in Malaysia.

From the mills, roughly over 4 millions tones of oil palm shell (OPS) solid waste is produced annually. Thus the large amount of waste produced has caused the nation's pollution problem occurs (Teo et al, 2006) One of the ways to prevent the pollution, these wastes would be utilization of some of these into constructive building materials. Besides that, OPS are light weight and having a naturally sized, thus it is suitable to be a replacement of aggregates in lightweight concrete in construction. It is also waste materials that do not produce toxic when they are mixed with concrete. This has indicated that OPS able to prevent the damage of natural resources and also able to control or maintain the ecological balance.

Recently, replacement aggregates with OPS can produce lightweight concrete with a moderate strength and it is able to be applied in flooring and walls. (Basri.H.B, Mannan.M.A. & Zain .M.F.M, 1998). There are some products of OPS concrete that have been done, for instance University Malaysia Sabah (UMS) has constructed a 2 meter span footbridge in the years of 2001 and an effective cost house with the area of about 59m<sup>2</sup> in the years 2003 (Teo et al, 2006 ). Therefore, the demand of the OPS concrete in construction development will be increasing and able to become an alternative approach in construction.

Moreover, OPS can save the expenses of construction. This is because OPS are waste material and easily to obtain. Thus, the cost of construction can be minimized by using replacing aggregate as OPS in concrete matrix.

Thus, the studies of performances have been carried out to show that oil palm shell aggregate concrete is applicable and able to have the same properties with normal concrete nowadays. Since the oil palm shell is considered lightweight, cost-effective and environmental friendly, it can be the alternative way to produce a lightweight concrete.

This report is about the investigation of long term deflection of beam with oil Palm Shell (OPS) as coarse aggregate. Before investigating the result, the some properties test on OPS had to be done. The purpose is to understand the properties

of the OPS. The design of mix proportion will be decided to produce a maximum compressive strength. The mix proportion of OPS with high compressive strength will be chosen to construct beam. There are some test will be taken on the beam. The tests are long term deflection test and flexural test. Besides that, the test also will be tested on Normal weight concrete. The reason is to do the comparison between OPS concrete and Normal weight concrete.

Oil palm shell is an ideal replacement material for coarse aggregate. However, oil palms shells still considering a new raising material. Most of the researches had done on the compressive strength and workability of the oil palm shell concrete. (Basri et al, 1998) Besides that, the properties of palm shell concrete also had been modified to increase their compression strength. (Mannan M.A, Ganepathy C, 2001) However, time dependent performance such as long term deflection, flexural performance of oil palm shell concrete have not observed.

Therefore, this research work is focusing on the OPS as an aggregate to produce maximum compressive strength of OPS concrete and study the time dependent behavior of the OPS concrete. The Coarse aggregate replaces by oil palm shell and added partially to obtain the maximum compressive strength of concrete mix proportional. The beam of oil palm shell concrete is designed based on the desirable strength and the tested is carried out in the laboratory to observe the effect of sustained load and time dependent behavior of the beam.

## **1.2 Objectives**

The objectives of the study are stated below:

- a) To design a suitable mix proportion for oil palm shell concrete with a maximum compressive strength.
- b) To study the flexural behavior of OPS concrete beams
- c) To investigate the long term deflection of OPS concrete beams
- d) To Compare the experimental result of OPS concrete beams with the corresponding result of normal weight concrete beams

## **1.3 Research program**

This section is written about the tasks that need to carry out in this research. There are two tasks that have to consider. The first task is theoretical study of the research. In the theoretical study, some literature review and analysis work are carried out.

The second task is the experimental work. Material properties test on the materials used in the research have to be taken. The reason is to obtain the specific gravity, bulk density, moisture content and water absorption of the materials.

Besides that, the main material used which is oil palm shell (OPS) also needs to investigate.

After the properties are done, the several samples are prepared which is oil palm shell concrete. The quantity of oil palm shell is added partially by reducing the quantity of the coarse aggregate in concrete. Then, the compressive strength test is tested on oil palm shell (OPS) concrete. The objective of this test is to obtain the maximum compressive strength of OPS concrete.

An oil palm shell (OPS) concrete beam is prepared after the maximum strength of OPS concrete is obtained. The different quantities of OPS concrete beams are casted. The flexural test and long term deflection test are carried out. The results from different quantity of OPS concrete beams are obtained. The results are compared and analyzed. The purpose is to study the behavior of the concrete under a sustain load in long term period.