PROPERTIES OF FOAM CONCRETE WITH FIXED PERCENTAGE OF EXPANDED POLYSTYRENE

NUH MUIZZUDDIN BIN AHMAD FAUZI

This project is submitted to

Faculty of Engineering,

University Malaysia Sarawak

To fulfill the requirement for the

Degree of Bachelor of Engineering with Honors

(Civil Engineering) 2009

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN

JUDUL: PROPERTIES OF FOAM CONCRETE WITH FIXED PERCENTAGE OF EXPANDED POLYSTYRENE

SESI PENGAJIAN: 2009-2010

Saya **NUH MUIZZUDDIN BIN AHMAD FAUZI**
(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: 16,Jalan Desa Sentosa 18,
Desa Sentosa,
Teras Jernang,
43650 Bandar Baru Bangi,
Selangor.

Madam Azida Binti Rashidi
(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 atau TERHAD.

The Following Final Year Project:

Title : Properties of Foam Concrete with Fixed Percentage of Expanded Polystyrene

Author : NUH MUIZZUDIIN BIN AHMAD FAUZI

Metric Number : 16966

Was read and certified by:

_____ Date: _____

(Madam Azida Binti Rashidi)
Project Supervisor
Faculty of Engineering
Universiti Malaysia Sarawak

For my beloved family and friends

Thanks for everything.

ACKNOWLEDGEMENT

Alhamdulillah, first of all, I would like to thank Allah SWT, the Al-Mighty, with His guidance and wishes that this final year project can be completed successfully. I would like to express my greatest appreciation to my supervisor, Mdm Azida Binti Rashidi, for her generous guidance, advice and motivation throughout this research.

My sincere appreciation also extends to all my friends, my special friend and the structural laboratory personnel, Mr Adha Abd Wahab, who was directly or indirectly involved in the process of producing this research report, for his generous assistance, useful views and tips. Without his support and contribution, this research project would not have been possible. My special appreciation also goes to Nor Hanisah Mad Halid, Mohd Khalique and Mohd Rizal Ghazali for contributing in my laboratory work and checking my report.

Finally, I would never finish this project without the encouragement and prayers from my parent and my beloved family members. Special thanks dedicated to my beloved parents and family, for their continuing financial and morale supports throughout my studies. All the hard works and perseverance that I put in this project is not easy without their motivations and endless supports.

ABSTRACT

Foam concrete can be classified as a lightweight concrete which consists of cement, sand, water and foam. The use of foam concrete has been used widely across countries such as USA, United Kingdom and Sweden. The main specialties of foam concrete are its low density, acceptable strength for structure use and high workability. These will result in reduction of dead load, faster building rates in construction and lower the handling costs. In order to improve the properties of foam concrete, many researches are done such as adding different material as fillers, superplasticizers and other admixtures.

In this project, the properties and behavior of foam concrete containing fixed percentage of expanded polystyrene was investigated. The properties studied were compressive strength, absorption capacity, density test and workability of foam concrete. With limitations of 20% and 30% of expanded polystyrene used, different results were obtained. The experimental results show that the foam concrete with higher percentage of expanded polystyrene gives lower strength and density. The results also show that increasing foam percentage provide higher workability and capacity of water absorption. Thus, percentages of foam and expanded polystyrene influence the properties of foam concrete.

ABSTRAK

Konkrit busa boleh dikategorikan sebagai konkrti ringan yang mengandungi simen, pasir, air dan busa. Konkrit busa telah digunakan dengan meluasnya hingga ke USA, United Kingdom dan Sweden. Keistimewaan utama konkrit busa adalah kerana sifatnya yang kurang tumpat, mempunyai kekuatan yang boleh digunakan dalam struktur dan kebolehkerjaan yang tinggi. Kelebihan konkrit busa adalah kerana ia dapat mengurangkan beban mati, kadar pembinaan yang cepat dan mengurangkan kos penyelenggaraan. Bagi menambahbaikkan lagi konkrit busa, banyak kajian telah dilakukan seperti dengan menambah bahan-bahan lain sebagai bahan ganti, superplasticizers dan lain-lain.

Dalam projek ini, sifat dan tindakbalas konkrit busa yang mengandungi biji-bijian polistirena padat telah disiasat. Sifat-sifat yang dikaji adalah kekuatan mampatan, penyerapan air, ketumpatan dan kebolehkerjaan oleh konkrit busa. Dengan hanya menggunakan 20% dan 30% biji-bijian polistirene padat, pelbagai keputusan telah dapat diperoleh. Hasil dari eksperimen mendapati konkrit busa yang mengandungi lebih banyk biji-bijian polistirene padat menghasilkan kekuatan dan ketumpatan yang rendah. Keputusan juga mendapati penambahan busa menghasilkan kebolehkerjaan yang tinggi dan penyerapan air yang lebih tinggi. Jadi, peratusan busa dan biji-bijian polistirena padat mempengaruhi sifat-sifat konkrit busa.

LIST OF TABLES

Table		Page No.
2.1	Typical properties of foamed concrete	16
2.2	Summary of the Properties of Foam Concrete	17
3.1	Grading limits for fine aggregate	30
3.2	Volume for each sample	35
3.3	Mix proportion with 20% of EPS	36
3.4	Mix proportion with 30% of EPS	36
4.1	Labeling for mixing	44
4.2	Data of average weight and density of Condition 1	50
4.3	Data of average weight and density of Condition 2	51
4.4	Data of average weight and density Control Mix	51
4.5	Strength test result for Condition 1(20% EPS)	55
4.6	Strength test result for Condition 2(30% EPS)	56
4.7	Strength test result for Control Mix	56
4.8	Water absorption result for Condition 1	65
4.9	Water absorption result for Condition 2	66
4.10	Water absorption result for Control Mix	66

LIST OF FIGURES

Figure		Page No.
2.1	Structure of Expanded Polystyrene	11
2.2	Relationship between compressive strength and fresh density	20
2.3	Comparison basic mix and foam concrete mix	22
3.1	Ordinary Portland Cement (OPC)	29
3.2	Expanded Polystyrene	31
3.3	Foam Generator	33
3.4	Air Compressor	34
3.5	150mm x 150mm x 150mm mould	35
3.6	Compressive Strength Machine	38
3.7	Curing Tank	39
3.8	Electronic Weighting Machine	40
3.9	Flow Table Test	41
4.1	Influence of density and percentage of foam on the flow for Condition 1	46
4.2	Influence of density and percentage of foam on the flow for Condition 2	47
4.3	Influence of density and percentage of EPS on the flow for Control Mix	48

4.4	Influence of percentage of EPS and foam on the flow for Control Mix	49
4.5	Comparison of different percentage of EPS and foam to density	52
4.6	Influence of density, percentage of foam and EPS on the compressive strength of foamed concrete	53
4.7	Comparison strength between 0%, 15%, 30% and 50% of foam in Condition 1 (20% EPS)	57
4.8	Comparison strength between 0%, 15%, 30% and 50% of foam in Condition 1 (20% EPS)	58
4.9	Comparison strength between 0%, 15%, 30% and 50% of foam in Condition 2 (30% EPS)	59
4.10	Comparison strength between 0%, 15%, 30% and 50% of foam in Condition 2 (30% EPS)	60
4.11	Comparison strength between CM, CM1 and CM2	61
4.12	Comparison strength between CM, CM1 and CM2	62
4.13	Comparison strength between 20% EPS, 30% EPS and Control Mix	63
4.14	Comparison water absorption for Condition 1 (20% EPS)	67
4.15	Comparison water absorption for Condition 2 (30% EPS)	69
4.16	Comparison water absorption for Control Mix	70

LIST OF SYMBOLS

ρ	-	density
%	-	percentage
kg	-	kilograms
m	-	meter
m^3	-	meter cubes
kg/m^3	-	density
mm	-	millimeter
g	-	gram

TABLE CONTENT

CONTENT	PAGE
Acknowledgement	i
Abstract	ii
Abstrak	iii
List of Tables	iv
List of Figures	v
List of Symbols	
CHAPTER 1 INTRODUCTION	1
1.1 Background of Study	1
1.2 Problem Statement	4
1.3 Research Objectives	5
1.4 Scope of Research	6
1.5 Brief Outline of the Project	7
1.6 Conclusion	8
CHAPTER 2 LITERATURE REVIEW	9
2.1 Introduction	9

2.2 Component of Foam Concrete 10
2.2.1 Cement 10
2.2.2 Sand 10
2.2.3 Water Cement Ratio 10
2.2.4 Expanded Polystyrene 11
2.2.4.1 EPS Properties 13
2.2.5 Foam 14
2.2.5.1 Foam Concrete Advantages 14
2.2.5.2 Properties of Foam Concrete 15
2.3 Previous Study 17
2.3.1 Settlement and Stability 17
2.3.2 Density and Compressive Strength 18
2.3.3 Workability 20
2.3.4 Absorption 21
2.3.4.1 Water Absorption Behavior 22
2.3.4.1.1 Effect of foam volume 22
2.3.4.1.2 Effect of EPS 23
2.4 Conclusion 24

CHAPTER 3 METHODOLOGY 25

3.1 Background 25

3.2 Introduction 25

3.2.1 Preparation Material 26

3.3 Preparation Material for Foam concrete 27

3.3.1 Mixing the Foam Concrete 27

3.3.2 Casting 27

3.3.3 Curing 28

3.4 Material Used in the Experiment 28

3.4.1 Cement 28

3.4.2 Water Cement : Ratio 29

3.4.3 Sand 29

3.4.4 Foaming Agent 31

3.4.5 Expanded Polystyrene (EPS) 31

3.5 The Machinery and Equipment 32

3.5.1 Concrete/Mortar Mixer 32

3.5.2 Foam Generator 32

3.5.3 Air Compressor 33

3.5.4 Steel Mould 34

3.6 Mix Proportion 35

3.7 Test Procedure 37

3.7.1 Compression Strength Test 37

3.7.2 Water Absorption Test 39

3.7.3 Weight Density Test 40

3.7.4 Flow Table Test 41

3.8 Conclusion 42

CHAPTER 4 RESULTS, ANALYSIS AND DISCUSSIONS 43

4.1 Introduction 43

4.2 Flow Table Test 45

4.2.1 Flow for Condition 1 45

4.2.2 Flow for Condition 2 47

4.2.3 Flow for Control Mix 48

4.2.4 Comparison of Flow and Foam Content 49

4.3 Weight Density Test 50

4.3.1 Foam Volume and Density Comparison 52

4.3.2 Strength and Density Comparison 53

4.4 Compressive Strength Test 54

4.4.1 Condition 1 57

4.4.2 Condition 2 58

4.4.3 Control Mix 61

4.4.4 Overall Strength 63

4.5 Water Absorption Test 65

4.5.1 Water Absorption for Condition 1 67

4.5.2 Water Absorption for Condition 2 68

4.5.3 Water Absorption for Control Mix 70

4.6 Conclusion 71

CHAPTER 5 CONCLUSION & RECOMMENDATION 72

5.1 Conclusion 72

5.2 Recommendation 74

REFERENCES 75

APPENDIX 77

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Foam concrete is made by mixing of foam, mortar and fine aggregates. Foam concrete can also be called foamed mortar (Aldridge, July 2005). The purpose of adding foam into the base mix is to lower the density of base materials and increase its yield.

The rule of forming foam concrete is by having cement-based mortar mixing with at least 20% by volume air (Jones and McCarthy, 2004). In basic proportion of the foam concrete is a mixing of sand, cement, and water and pre-foamed which in itself is a mixture of foaming agent (synthetic or protein based), water and air (Aldridge, 2005). The ratio of each material depends on the purpose of applications of foam concrete.(Ramamurthy et al., 2009)

Glocal ChemVentures Pvt. Ltd.(2005) defined that the foam concrete is a lightweight concrete and can be used for varieties of uses. Glocal ChemVentures Pvt. Ltd. (2005) invented a

range of dry density of foam concrete that can be from 400kg/m^3 to 1600kg/m^3 which can produce compressive strengths having a range of 1MPa to 15MPa.

Generally, there are two stages of preparing the foam concrete. The process starts with preparation of mortar which includes cement, sand and water. Second stage is mixing foam with the mortar using compressed air, through the nozzle of a generator.

Portland cement is the main cementitious component of foam concrete. Its contents usually between 300 and 500 kg/m^3. Rapid hardening Portland cement, high alumina and calcium sulfoaluminate cements that can be used in foam concrete having to reduce setting times and improve early strengths.

For water/cement ratio usually used ranges from 0.4 to 0.8. The ratio depends on the cement composition, consistence requirement, and uses of chemical admixtures, while ensuring foam stability.

The coarse aggregate is not allowed to be used in the foam concrete mixing because it would settle in the lightweight grout and cause collapse of the foam during mixing. If fine aggregate is used, then the fine sands with particle size up to 5.0mm distribution are recommended to use in foam concrete.

In producing the foam concrete, two types of pre-formed foam are available:

1) Wet Foam:
    - Wet foam is suitable for the production of high density of foamed materials
    - The producing is by spraying a solution of the foaming agent and water over a fine mesh.
2) Dry Foam:
    - Involved compression of air in the producing process. Dry foam is produced by solution of foaming agent and water through a series of high-density restriction and forcing compressed air into a mixing chamber. This compression process will pressurized air into the solution, expand the solution into a thick and tight foam. During the production of foam concrete, the dry foam are passed onto the foamed material when the foam is blended with the base materials (Aldridge, 2005)

Research and development on foam concrete started in Netherland on 1980s and 1990s. Various of findings about the advantages of the foam concrete was discovered and foam concrete started to be used in many construction applications including replacement of existing soil, lateral load reduction raft foundation, soil stabilization and blinding(Aldridge, 2005)

1.2 Problem Statement

Foam concrete has widely used by many engineers for the structure and construction because it has high strength for structural purpose and has lower density than normal concrete. Low material for construction helps in development housing and road on weak soil.

However in producing the foam concrete, fine sand is not allowed to use with densities greater than 1200 kg/m3. Solution for the problem and at the same time improve the properties of the material, filler can be used as replacement. Filler that available are coarse fly ash, lime, chalk, crushed stone (Aldridge, 2000), expanded polystyrene granules and etc.

Expanded Polystyrene (EPS) is not friendly material. EPS foam takes a very long time to decompose in the environment which caused pollution. Introducing EPS in cement and concrete field can help improving the environment and upgrade the construction field.

The properties of EPS which is light in weight and hydrophobic give effect on the characteristics of foam concrete. EPS foam concrete has different properties from normal concrete and foam concrete. In order to find the differences, several tests will be conducted.

1.3 Research Objectives

The objectives of the Final Year Project are:

1. To find flow ability of foam concrete for different percentage of EPS and foam.
2. To find compressive strength for foam concrete.
3. To investigate the properties of foam concrete for 20 percent and 30 percent of EPS content with different percentage of foam added.
4. To find the relationship of foam concrete for different percentage of EPS and foam with the absorption of water.
5. To study the relationship of density and compression of foam concrete.

1.4 Scope of Research

This study provides understanding of properties of the foam concrete and the strength of the sample when the EPS as filler is added. The comparison of the strength and the workability of the foam concrete with different percentages of foam are investigated also in this research.

These are the limitation in this project:

1. The size of samples was 150 x 150 x150mm.
2. Water-cement-ratio of 0.4 was used for all samples.
3. Cubes were tested at the age 1,7 and 21 days.
4. There are four tests involved which are compressive strength, water absorption test, density test and workability test.

1.5 Brief Outline of the Project

Chapter 1: brief introduction of foam concrete, material used and the problem related with EPS. The problem statement, objectives, and scope of study are stated in this chapter.

Chapter 2: discusses the previous studies regarding foam concrete with EPS as filler and its effect. The discussion mainly related with the tests related to the research.

Chapter 3: explains the material, equipment and the procedure of test which will be conducted.

Chapter 4: the laboratory test were discussed and analyzed in this chapter. The laboratory tests were based on compression test, absorption test, flow table test and density test.

Chapter 5: conclude the overall findings and summaries of the study. Recommendations were proposed in this chapter to improve the study in the future.

1.6 Conclusion

Chapter 1 above discussed about the production of the foam concrete and the pollution problem from the decompose of EPS material. Applications of EPS in foam concrete have been studied by many researchers. In this chapter, the objective and scope of work or research also been stated clearly to have better idea on the research is. The next chapter focused on literature review discussing about the previous research about the foam concrete and the properties of foam concrete with the filler to have better understanding about the research.