



Faculty of Engineering

**The Use of Lightweight Foamed Concrete as Fill Material for
Road Embankment on Soft Ground in Sarawak**

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The Use of Lightweight Foamed Concrete as Fill Material for Road
Embankment on Soft Ground in Sarawak

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Settlements are the main problem on soft ground construction in Sarawak. The research is to study the feasibility of using foamed concrete (FC) as fill material for road embankment on soft soil and peat soil (soft ground) by replacement method. This study focuses mainly on the idea of innovative “floating road embankment” on soft ground by density and bearing capacity comparisons. There are three (3) main approaches to be solved before applying on construction field, which is FC mixing techniques, appropriate properties of FC and FC road embankment design procedure. A new innovative mixing technique that could produce big volume mixing is developed. The technique is focused on the sequence of mixing, whereby adding water will be the last part of the mixing to avoid segregation. This technique also found that horizontal shaft mixer could produce the FC with no segregation. To perform the replacement, the research focuses on density at between 700-1300 kg/m³, where it is almost similar to the density of the soft soil and peat soil. It is found that workability is “just right” when the FC can perform self-compacting. The range of workability for small scale (less than 100 litres) and big scale production (more than 100 litres) are respectively at 13-16 cm and 16-19 cm. FC compressive strength shall not be less than 1 kN/m², which is better strength than normal soil and enough for supporting the load and resist the vehicles vibrations. The study also found that water-cement ratio at 0.2-0.3 could produce strength at the range of 1-3 kN/m². The additional admixture like Polyvinyl alcohol (PVA) and quarry dust could increase the strength highly at 300% and 60% respectively, but PVA is difficult to produce and is costly. The result of FC shrinkages is only 0.156%, which could be neglected in the production of FC. At the final stages of the research, the design procedure is developed and the lightweight embankment is applied on field at allowed settlement range. Finally the “lightweight FC road embankment” is successfully produced with saving time and cost.

Keywords: Foam concrete, density, workability, strength, settlement

Cadangan Kajian Kepada Kegunaan Konkrit Berbuih Ringan Sebagai Bahan Penambakan Kepada Tambakan Jalan Di Atas Tanah Lembut Di Sarawak

ABSTRAK

Pemendapan adalah masalah utama dalam pembinaan di atas kawasan tanah lembut di Sarawak. Kajian ini adalah untuk mengkaji kemungkinan menggunakan konkrit berbuih (FC) sebagai bahan pengisi untuk tambakan jalan di atas tanah lembut dan tanah gambut (soft ground) dengan kaedah penggantian. Kajian ini memfokuskan pada idea inovatif "tambak jalan terapung" berdasarkan perbandingan kepadatan dan daya galas. Terdapat tiga (3) pendekatan utama untuk diselesaikan sebelum pengaplikasian di tapak pembinaan, iaitu teknik pencampuran FC, sifat-sifat FC yang sesuai dan FC prosedur rekabentuk tambakan jalan. Teknik pencampuran inovatif baru yang dapat menghasilkan FC dalam isipadu yang besar. Teknik ini tertumpu pada urutan pencampuran, penambahkan air merupakan bahagian terakhir pencampuran untuk mengelakkan pemisahan. Teknik ini juga mendapati bahawa pengaduan aci mendatar dapat menghasilkan FC tanpa pemisahan. Untuk melakukan penggantian, penelitian ini memfokuskan pada ketumpatan di antara 700-1300 kg/m³, di mana ini merupakan ketumpatan yang paling dekat dengan tanah lembut dan tanah gambut. Didapati bahawa keboleherjaan "tepat" berlaku apabila FC dapat melakukan pemadatan diri. Julat keboleherjaan untuk skala kecil (kurang dari 100 liter) dan skala besar (lebih dari 100 liter) masing-masing adalah pada 12-16 cm dan 16-19 cm. Kekuatan mampatan FC tidak boleh kurang dari 1 kN/m², kerana kekuatan ini adalah lebih baik daripada kekuatan tanah biasa dan mencukupi untuk menyokong beban dan menahan getaran kenderaan. Kajian ini juga mendapati bahawa nisbah air-simen pada 0.2-0.3 dapat menghasilkan kekuatan pada 1-3 kN/m². Campuran tambahan seperti alkohol polivinil (PVA) dan debu kuari boleh meningkatkan kekuatan dalam 300% dan 60% masing-masing,

tetapi PVA sukar dihasilkan dan mahal. Pengecutan FC menunjukkan hanya 0.156% dan ini dapat diabaikan semasa penghasilan FC. Pada tahap akhir kajian ini, prosedur reka bentuk dihasilkan dan tambakan jalan ringan yang dibina di tapak pada julat pemendapan yang dibenarkan. Akhirnya "jalan raya FC ringan" berjaya dihasilkan dengan menjimatkan masa dan kos.

Kata kunci: *Konkrit berbuih, ketumpatan, kebolehkerjaan, kekuatan, mendapan*

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LIST OF ABBREVIATIONS

A	Area
ACC	Autoclaved Aerated Concrete
BS	British Standards
g	Gram
GTL	Paraffin Oil
kg	Kilogram
L, H, W	Length, Height, Width
M	Mass
m	Meter
m ²	Meter square
m ³	Cubic meter
mm	Millimeters
N	Newton
PFA	Pulverized Fly Ash
PVA	Polyvinyl Alcohol
SP	Super Plasticiser
UNIMAS	Universiti Malaysia Sarawak
%	Percent (or percentage)
θ	Degree of Rotation

CHAPTER 1

INTRODUCTION

1.1 General

Construction on soft ground area is a major problem in Sarawak, with problems like excessive settlement that could occur either during or after the construction phase due to its low bearing capacity. Road designers have also avoided constructing road and realigning the road alignment on these difficult areas. However, with rapid development and high demand, it is no longer possible to avoid road construction altogether in these areas. For example the coastal road requires alignment to pass through vast areas of soft ground zone in Samarahan, Sarikei, Sibul, Mukah and many other divisions in Sarawak.

It is high time that researchers work on new innovation in designing road on soft ground. The existing conventional design (refer Table 1.5) is well accepted by the industries but lacks quality and standard. Often, the construction cost becomes overly high and maintenance cost would also be an annual burden (refer Section 1.3.2).