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Foamed Aggregate Pervious Concrete – An Option for Road on Peat

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*Abstract***—** Foamed aggregate is a novel controlled density material developed for road construction on peat. This paper reports recent findings of the mix design and test method of pervious concrete. The high porosity allows water to pass through it, thereby allowing the recharging of water into designated retention ponds. Road on peat are designed to be above the most frequent flood levels. The water permeability of the concrete was determined with constant head water permeability test. The study is to establish an economical method for construction on problematic soils. The proprietary foamed aggregate of density between 900kg/m^3-1200 kg/m^3 was experimented. Since controlled density foamed aggregate is designed to co-exist with peat, a more durable road with less maintenance is expected. The self leveling foamed concrete of density about 1200 kg/m^3 is to be placed on the foamed aggregate with tyres and geosynthetics as a special provision for lateral restraint. It is hoped that more intensified research into the exploitation of used tyres for sustainable construction on problematic soil will lead to improved quality of life and conservation of the environment.

Keywords**:** foamed aggregates, pervious concrete, problematic soil, scrap tyres

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I. INTRODUCTION

Pervious concrete is a composite material consisting of coarse aggregate, Portland cement and water. It is different from normal concrete as the mixture contains no fines in it. The aggregate is usually of a single size and is bonded together by a cement paste. The result is a concrete with a high percentage of interconnected voids that allow the penetration of water through the material matrix. Normal concrete has a void ratio around 3-5% and pervious concrete has higher void ratios from 18-40% depending on its application. Pervious concrete differs from normal concrete in several other ways. Pervious concrete has lower compressive strength, higher permeability and a lower density. Its compressive strength could be 65% lower than the normal concrete.

Soft soil has high compressibility and low shear strength. General construction problems in soft soil are its low bearing capacity, excessive post construction settlement and instability on excavation and embankment. Kubota et.al [1] proposed measures to prevent heaving during the excavation of soft ground. Hanrahan E. T. et al [2] reported on the observations and design of road on peat. The experience gained from his work which started in 1953 highlighted on a lightweight substitute. Observation of road level and settlement for over 26 years led to the conclusion that settlement can be separately estimated under three headings, namely elastic settlement, consolidation and creep. A constitutive model has been developed for predicting settlement of road on peat. Lee, et.al [3] reported findings of the flexural strength of lightweight concrete containing palm oil clinker. Experience gained form the use of foamed concrete in civil engineering projects such as the SMART tunnel junction box [4, 5] has led to the development of foamed aggregate for use on the construction of road on peat. Ahmad Zaidi et.al [6] reported on the penetration resistance of foamed concrete. A simulation model based on rigid body dynamics and a shock resistance function was proposed to predict the penetration depth. Reasonable agreement was achieved between the experimental and simulation results. Chan, C.M. et al [7] conducted physical simulation of road embankment failures which provided a better understanding of the failure mechanism on site. Bujang, B.K. Huat [8] reported the utilization of scrap tyres as earth retaining wall. The cost of scrap tyre wall lowest compared with several other systems. Goh, K.S et al [9] reported the design and evaluation of permeable concrete road drain with recycled materials. A novel combination of foamed concrete and scrap tyre and geosynthetics could lead to a unique cost effective, environmental friendly and practical solution to the problems of road on peat.

II. Foamed Aggregate

Foamed aggregate is derived from foamed concrete produced in specified sizes ranging from 40 mm to100 mm. The compressive strength of foamed concrete depends on the density, water/cement ratio and cement content. The density of the foam can have an influence on the ultimate strength, particularly for the lower density foamed concretes. Uniformly sized small bubbles tends to produce higher ultimate strength at all densities. Studies on the effect of void size on the compressive strength indicated that the total volume of void of around 40% with void size about 0.1 mm tends to achieve the optimum performance in terms of consistency and strength. Foamed aggregate made of biomass silica of density around 1200 kg/m^3 achieved compressive strength of around 10 MPa.

III. Physical Model

In order to establish an economical method for the construction on problematic soils, an experimental construction of an access road of around 40 m long was planned. The typical cross section is shown in Figure 1.

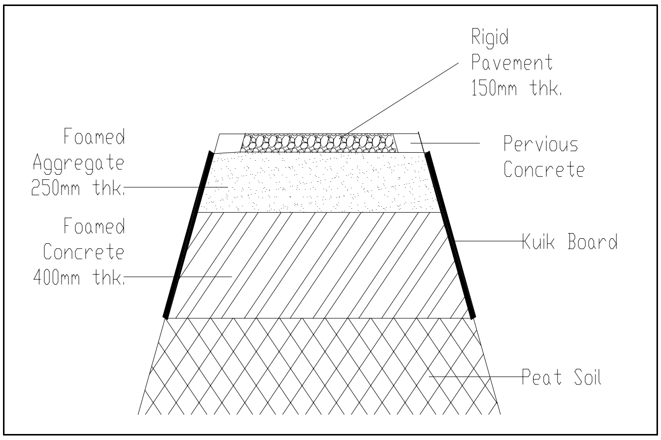

Figure 1: Typical cross section of road on peat

The use of foamed aggregate of sizes between 40 mm and 100 mm as the road base could reduce 30% of its total weight. A lightweight pervious concrete rigid pavement will be constructed as the finishing layer. A patent-pending precast composite wall system (to be known as KUIK Board) tied together with geogrid of tensile strength of around 1000 kN/m is specified for lateral restraint. The system is to be installed to reinforce the subbase and subgrade. Such novel geotechnical structure is to be known as reinforced peat (REPEAT). Mechanisms of failure have been identified at the Research Centre for Soft Soil (RECESS), UTHM. Factors affecting failure such as density, lateral restraint, moisture content of subgrade, thickness and strength of subbase and pavement were investigated.

To provide an economical working platform, biomass silica ash is used on the peat to absorb moisture and to a certain extend modify the properties of peat. The scrap tyres provides lateral support of the materials such as biomass silica and foamed aggregate. The self leveling foamed concrete of density about 1200 kg/m^3 is to be placed on the foamed aggregate with tyres as a special provision for lateral restraint. Two layers of tyres with a layer of geogrid sandwiched within it forms part of the system. The proprietary foamed aggregate of density 900 kg/m^3 was experimented in the first physical model. Cast-in-situ biomass silica foamed concrete of density 1200 kg/m^3 forms part of the substructure.

Settlement markers are to be installed at the ends and mid-span to monitor settlement. The data obtained will be used in numerical modeling at the subsequent phases of the project. This preliminary study is to pave way for the experimental construction of a stretch of road on peat in Sibu, Sarawak.

IV. Results

Biomass silica foamed aggregate of density around 900 kg/m3 and compressive strength 3 MPa was successfully produced and delivered to site. The pervious concrete of density around 1200 kg/m^3 achieved compressive strength of around 10 MPa and permeability performance of around 0.2 m^3/minute per m^2. Test results on density, strength and permeability are shown in Figures 2 to 5 below.

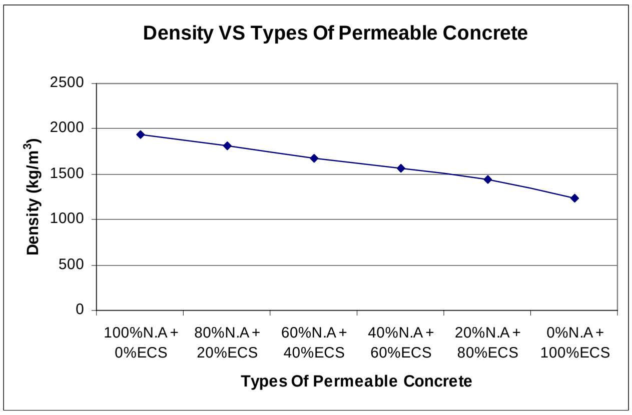

Figure 2: Density of pervious concrete

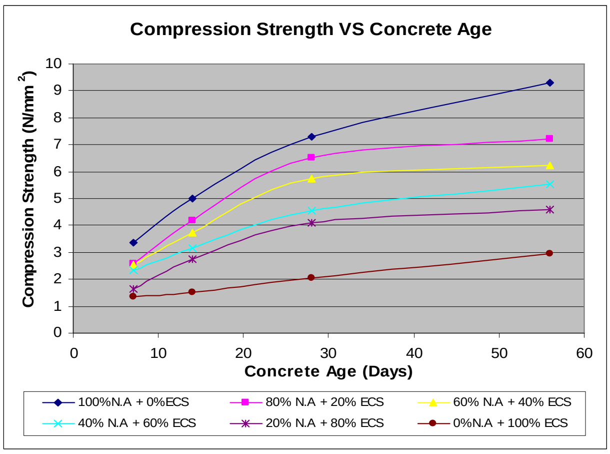

Figure 3: Compressive strength of pervious concrete

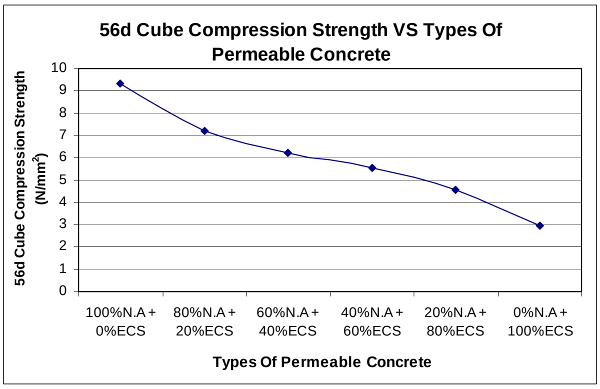

Figure 4: Compressive strength of pervious concrete at 56 days

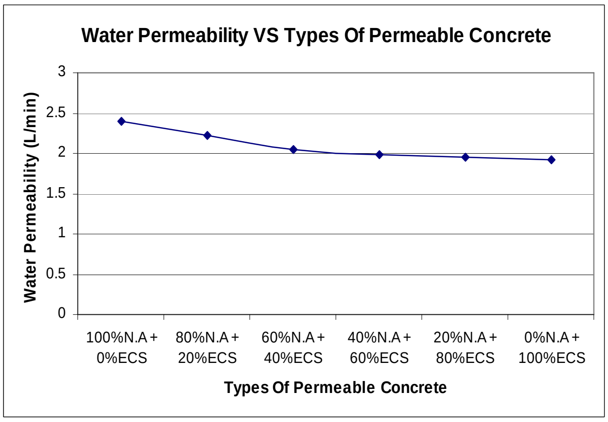

Figure 5: Water permeability of pervious concrete

V. CONCLUSION

1. Biomass silica foamed aggregate of density 900 kg/m3 and compressive strength around 3 MPa can be produced in a casting yard or on site up to 25 m^3/hour. The productivity can be enhanced with batching plant and mixer truck.

2. Controlled density and strength self-levelling foamed concrete can be produced and placed with the use of mixer truck and concrete pump to achieve 600 m^3/day round the clock.

3. Pervious concrete of density around 1200 kg/m^3 achieved compressive strength of around 10 MPa and permeability performance of around 0.2 m^3/minute per m^2.

4. A novel combination of the foamed aggregate and foamed concrete together with a precast composite wall system, tied up with geosynthetics and scrap tyres is in its preliminary stage. However, its structural, geotechnical and durability performance require further experimental data to justify its practical application for road on peat.

5. Optimum utilization of biomass silica foamed concrete require concerted collaborative effort from researchers and the construction industry to provide maximum benefit to turn the proposed method as a viable option for road on peat.

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APPENDIX

Photo 1: Location of project – RECESS, UTHM


Photo 2: Biomass silica foamed concrete block for use as foamed aggregate