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INNOVATION OF LIGHTWEIGHT CONCRETE SLAB

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ABSTRACT

A traditional slab has several negative effects on the economy, environment, and worker productivity. Therefore, it is intended for the lightweight concrete slab to replace the conventional one in the construction industry. According to previous studies, the removal of non-structural concrete from the center of the slab allows for the creation of a lightweight concrete slab using coconut shells. In order to assess the usability of the lightweight concrete slab, tests for flexural strength and compressive strength were conducted. It turned out that after 17.6 % concrete reduction, the results of the testing showed that the lightweight specimen had superior readings to the standard specimen. Since the demand for lightweight concrete components is expected to increase and reach its peak in 2028, this lightweight concrete innovation also aims to replace the conventional concrete slabs. It can also do this by cutting manufacturing costs because, while raw material costs are rising, the lightweight slab uses less concrete compared to normal concrete.

Keywords: Lightweight concrete slab, Concrete reduction, Removal non-structural concrete

1. INTRODUCTION

Sustainable building is described as the creation and responsible upkeep of a healthier physical environment related to resource sustainability and green principles. These concepts include resource reuse, reduction, and recycling, environmental conservation, life cycle economies, and the creation of a high-quality built environment (Bari, 2012). Significant amounts of domestic, industrial, and biomass waste are recycled to replace or supplement natural materials in the manufacturing of concrete. One strategy is to use alternative resources, such solid waste and by products, as building materials in the construction industry. One of the most common agricultural solid wastes in many tropical countries is coconut shell (Kumar, et.al., 2005). Despite a decline in production between 2014 and 2016, the Malaysian Agricultural Research and Development Institute (MARDI) report states that Malaysia is still among the top ten producers of coconuts worldwide (Tan, 2019). Therefore, to conserve a healthy built environment or sustainable construction, the Industrialised Building System (IBS) has to be widely implemented as a way to avoid environmental problems. Precast is a product made in a controlled environment (in a plant), before it is delivered to site and the installation (Jaillon et al., 2014). Several types of working slabs, like hollow-core blocks and double tee blocks, are discussed in the frames. The states adaptability enables them to be incorporated into foundations and structures in a variety of ways. Precast concrete has a benefit over regular slabs since it is produced in a controlled environment (Ahmed et al., 2019).

The purpose of this study is to investigate a lightweight concrete slab. Therefore, the objectives of this study are to investigate the most common issues relating to the precast concrete slab, to propose a lightweight concrete slab by using coconut shells in UiTM Perak and to determine the marketability potential of lightweight concrete slab in the construction market.

2. METHODOLOGY

2.1 Phase 1: Secondary Research

Phase 1 is secondary research where there was an approach to gathering, analysing, and evaluating non-numerical data which is known as qualitative research. During the early phases of this research; the secondary research, such as a review of existing research was conducted to acquire a deeper understanding of the innovation that fits the theme. During this phase, numerous types of lightweight slabs and past case studies relating to the slab were reviewed. The concerns and problems associated with the conventional slab were observed in UiTM Perak using this technique in order to achieve a better solution in this innovation. In order to determine whether coconut shells are a suitable natural substance for this innovative project, research of their qualities was also done.

2.2 Phase 2: Experimental Research

Phase 2 is the procedure of gathering and interpreting numerical data in order to come out with the concept which is known as quantitative research. In this method, an experimental method was used to test the tensile strength of this lightweight concrete slab since this innovation slab will involve the reduction of concrete.

2.2.1 Concrete Mix Design

The volume of concrete used was calculated for 6 cubes mould with 150mm x 150mm x 150mm dimensions. Table 1 shows the calculation of the G30 concrete volume for both moulds. To calculate 6 number of cubes 150mm x 150mm x 150mm = 20250000 mm^3 @ 0.020 m^3

Quantities	**Cement (Kg)**	**Water (Kg)**	**Fine Aggregate (Kg)**	**Coarse Aggregate (Kg) 20 Mm**
Per m^3 (To nearest 5kg)	352	190	680	1208
Per trial mix of 0.020 m^3	7.0	3.8	13.6	24.2

Table 1 G30 Design Mix

2.2.1 The Procedure of Lightweight Concrete Slab

The procedure of producing a lightweight concrete slab began by cleaning the coconut shells before being inserted into the moulds. Then, the moulds with 150mm x 150mm x 150mm dimension were coated with grease before the concreting work starts. The cleaned coconut shells with the average diameter were placed inside the moulds. Grade 30 concrete was produced, then poured into the moulds and vibrated. After 24 hours, the specimen was then removed from the moulds and the specimen was inserted to the curing tank for 7, 14 and 28 days.

2.3 Phase 3: Flexural Strength Test

One way to gauge the tensile strength of concrete was through its flexural strength. It evaluates a slab resistance to bending failure. The data was collected in Phase 3 to produce the discussion of the results and the conclusion. The procedure of flexural strength test began when the lightweight concrete specimen and normal concrete specimen was prepared. Then, the specimen was placed on the loading points and in proportion to the applied force, and the loading system need to be centred. The force-applying block was brought into contact with the specimen surface at the loading sites and the load on the specimen was applied until structure deformation. Lastly, the data of flexural strength was observed and recorded.

2.4 Phase 4: Compressive Strength Test

Compression testing determines the solidified concrete's compressive strength. This test may readily assess the psi of the concrete as well as the quality of the concrete being made (Haseb, 2017). The procedure of compressive strength test began when the lightweight concrete specimen and normal concrete specimen was prepared. The testing machine's bearing surface then needed to be cleaned. Then, the specimen was inserted into the machine so that the load was given to both sides of the specimen. The specimen’s centre was later aligned with the machine's base plate. The force was gradually applied to the specimen until it failed, as shown in Figure 1. The maximum load and the compressive strength displayed at the monitor was recorded.

Figure 1 Specimen Deformation

3. FINDINGS

This innovation is not only about the weight of the slab, but also about the additional qualities of the slab once non-structural concrete has been removed. The flexural strength test was carried out to find out the concrete's tensile strength and the slab's ability to withstand bending failure. Even though this innovative slab would remove some concrete by substituting coconut shells, compressive strength testing was also necessary to evaluate the concrete's strength.

3.1 Weight Comparisons

Figure 2 shows the comparisons of the weight between 150mm³ specimen cube of normal concrete and the lightweight concrete.

Normal Concrete
7.73kg

Lightweight Concrete
6.37kg

Figure 2 Weight Comparisons

3.2 Concrete Reductions

The weight difference between standard and lightweight concrete was 1.36kg. As a result, the percentage of concrete decrease was calculated as follows:

$$\frac{(\text{Wnc} - \text{Wlc})}{\text{Wnc}} \times 100\% \qquad \text{(Equation 1)}$$

Where,
Wnc = Weight of normal concrete
Wlc = Weight of lightweight concrete

$$\frac{(7.73\ \text{kg} - 6.37\ \text{kg})}{7.73\ \text{kg}} \times 100\% = 17.6\%$$

3.3 Flexural Strength

Specimen	Elastic Modulus (MPa)	Maximum Load (kN)	Flexural Strength (MPa)	Deformation / Crack (mm)
Normal	157.9	6.38	0.01055	3.25
Lightweight	694.5	11.81	0.01950	8.96

Table 2 Flexural Strength

3.4 Compressive Strength

Specimen	Day	Elastic Modulus (MPa)	Maximum Load (kN)	Compressive Strength (MPa)	Deformation/ Crack (mm)
Normal	**7**	2128.00	370.67	16.50	6.54
Lightweight		2354.20	447.04	19.90	6.11
Normal	**14**	1615.00	337.06	15.00	3.71
Lightweight		903.10	449.31	20.00	5.34
Normal	**28**	1460.50	370.75	16.50	5.55
Lightweight		2634.20	466.14	20.70	5.68

Table 3 Compressive Strength

3.5 Marketability Potential of Lightweight Concrete Slab

Lightweight concretes are produced from both natural resources and by-products of the Integrated Gasification Combined Cycle (IGCC). When designing precast or prestressed concrete, the construction industry specifies a compressive strength threshold of 3000-5000 psi. The demand for lightweight concrete has been continuously rising as a result of its many benefits and beneficial characteristics. However, the general public knows very little about these items. It is preferred by construction organisations because it offers a higher level of job quality, safety, and environmental friendliness. As a result, the market for lightweight concrete is estimated to grow at a Compound Annual Growth Rate (CAGR) of 7.9% from 2021 to 2028, reaching USD 61.63 billion. Due to the increased development of both commercial and residential structures worldwide, the market for lightweight concrete is expanding significantly (The Brainy Insights, 2022).

3.6 Reduction Construction Cost

As lightweight concrete involves the reduction of concrete, it will reduce the construction cost as the raw material of concrete increases. Sharuddin (2022) as Managing Director of Cement Industries of Malaysia Berhad (CIMA) mentioned that due to the extremely high market price of coal, cement-producing industries have had no alternative but to increase their costs since

2016 until the present. CIMA and other cement-producing industries in the nation were forced to boost cement prices in order to stay in business due to the rise in the cost of raw materials. Subsequently, the previous coal price was in the range of US $60 to US $70 per tonne but has since jumped to US $ 200 per tonne and may reach as high as US $400. This increase in the price of raw materials covers 30% to 40% of overall production costs.

4. CONCLUSION

The lightweight concrete slab will be used in this innovation as a way to minimise the weight of the structure of the precast slab components and to lower the material cost. This innovation will also be able to sustain the environment through the use of natural resources or recycled materials such as coconut shells and determine the marketability potential of this slab in the construction market. By incorporating the coconut shells and eliminating all non-structural concrete from the middle of the specimen, this lightweight concrete innovation is able to lower the amount of concrete by 17.6%. After the specimen was created, the compressive strength of this innovation was evaluated in a laboratory. Since this innovation would require reducing non-structural concrete in the middle of slabs, this testing would determine whether this lightweight slab can bear the stress. Hence, according to the testing, the results of the lightweight concrete in terms of compressive strength and flexural strength were high compared to the normal concrete because even though this slab involves the reduction of concrete, coconut shells have excellent physical strength and tensile strength and can withstand the stress. As the marketability of this innovation is anticipated to be significant, it can be used in other sectors of the building industry. This is because it is anticipated that the CAGR for lightweight concrete components will rise between 2021 and 2028 (The Brainy Insights, 2022).

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

nar

Setuju.

27.1.2023

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