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A Comparison of Concrete Slump Test with Different Percentage of Polystyrene and Sawdust Replacement

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Abstract : The comparison of replacing natural coarse aggregate with polystyrene and fine aggregate with sawdust on the slump value of concrete is discussed in this study. Ordinary concrete was utilized as a control sample in this study to compare with different percentage replacement of aggregates. The objective of this study was to determine the slump value with different replacements of lightweight material. Furthermore, this study was carried out to obtain the density and mass of concrete with different material replacement rates. Sample preparation involved four types of concrete that were mixed: a control sample, a 5%, 10%, and 15% of polystyrene and sawdust replacement. The slump test, density, and mass measurement were determined to assess the efficacy of replacement material of coarse and fine aggregates in this study. Based on the findings, the slump value is higher for 15% replacement which is 145 mm while for 10% and 5% replacement, the slump value is 75 mm and 0 mm, respectively. This show that the workability of concrete increase with 15% of polystyrene and sawdust replacement.

Keywords: Concrete, Lightweight, Polystyrene, Sawdust, Slump Test

1. Introduction

Concrete is a combination of cement, sand, aggregate, and water. These are added according to a certain pre-determined rate. Concrete is used as a building material for walkways, constructing building structures such as columns and beams, roads, and building walls. Lightweight concrete is usually used as a partition wall or as a structure that does not hold loads. Lightweight concrete is an important discovery for solving common concrete problems. This concrete is made with a mixture of lightweight materials so that the result is lighter. Lightweight concrete has a lower density and heat conduction than

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ordinary concrete [1]. Since the strength of concrete is influenced by its mixed material, then studies on its mixed material are carried out. It is intended to obtain lighter concrete results. Substitute materials such as polystyrene and sawdust have been identified to produce lightweight concrete. This study will focus on the comparison of concrete slump tests for different mixes in the percentage of replacement.

Lightweight concrete becomes an alternative to replace the use of regular concrete to reduce costs and apply the 3Rs of Reduce, Reuse and Recycle. However, the use of lightweight concrete requires a more in-depth study in terms of workability, concrete slump, compressive strength, and water absorption. Therefore, this study was conducted to obtain the differences in terms of slump testing for lightweight concrete with different replacement percentages. With this study, the workability of concrete mixes will be known to determine the most optimal mixtures. This study aimed to examine the mixture of polystyrene and sawdust whether it fits the range of accepted slump values. The importance of this study is to compare the slump test when mixed with replacement materials

2. Materials and Methods

2.1 Materials

The materials used to produce lightweight concrete cubes are polystyrene and sawdust as substitutes. There are 4 concrete mixtures, namely ordinary concrete as a control sample and 3 concrete mixtures with different polystyrene and sawdust replacement which are 5%, 10%, and 15%. The size of the cube mold used in this study is 100 mm x 100 mm x 100 mm. **Table 1** shows the total mass of each material used. Each mixture needs to make six cubes and the total cubes used in this study are twenty-four.

Table 1: Mass of each ingredient used for each mixture

No.of Sample	Replacement Percentage (%)	Water (kg)	Cement (kg)	Fine Aggregate		Coarse Aggregate	
				Sand (kg)	Sawdust (kg)	Aggregate (kg)	Polystyrene (kg)
1	0	1.26	2.4	3.24 (100)	0 (0)	7.53 (100)	0 (0)
2	5	1.26	2.4	3.08 (95)	0.063 (5)	7.15 (95)	0.015 (5)
3	10	1.26	2.4	3.92 (90)	0.126 (10)	6.78 (90)	0.030 (10)
4	15	1.26	2.4	2.75 (85)	0.189 (15)	6.40 (85)	0.045 (15)
Total		5.04	9.6	11.99	0.378	27.86	0.09

Note: percent % (mass)

2.2 Methods

A concrete slump test was carried out to check the workability of freshly made concrete. This test is conducted to achieve the objective of this study. The slump test was conducted according to BS 1881: Part 102: 1983 [2]. **Figure 1** shows the workflow for the slump test procedures [3].

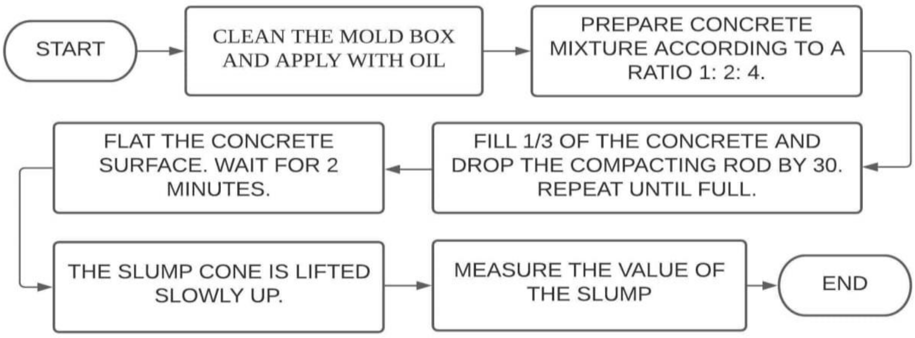

Figure 1: Work flow for the slump test procedures

2.3 Measurement of Density

Density is a measure of mass per unit volume. The percentage of concrete density is important to take into account for making concrete. Concrete mass was measured from immersion of concrete in water for 14 and 28 days. Concrete volume is 0.01m X 0.01m X 0.01m which is 0.001m^3. The percentage density of concrete can be determined based on **Equation 1**:

$$\text{Density} = \frac{\text{Concrete Mass (kg)}}{\text{Concrete Volume (m}^3)} \qquad \textbf{Eq. 1}$$

3. Results and Discussions

Once testing of concrete is completed, data are collected, recorded, evaluated, and discussed. To facilitate understanding, the data is interpreted in the form of tables, graphs and charts. All test findings were compared to study how differences in the percentage of replacement affected the findings. Concrete mixes with different percentages of replacement have also produced different concrete workability when slump test is performed.

3.1 Slump Test

The slump test is the main testing conducted in this study. This test was performed to study the effect of polystyrene and sawdust substitution on concrete workability [5]. There was no difference in a slump for the control mixture, 0% and 5% replacement as both produced zero slumps. Zero slump concrete is defined as concrete with a stiff or very dry consistency that does not show a measurable slump after the removal of the slump cone. The degree of workability for zero slumps is very low. While, for 10% and 15% replacement, the slump values recorded are 75 mm and 145 mm respectively. Shear slump is due to lack of cement and shows adhesion relationship in a concrete mixture. A collapse value of 75 mm indicates moderate workability. Moderate workability is suitably used in a variety of construction works. For concrete with 15% replacement, the slump value of 145 mm shows high workability. The high workability indicates that this concrete is highly functional and easily mixed, transported, placed, and compacted in structures. Concrete workability requirements vary with each type of construction and compaction method used. For example, the workability of concrete required for the construction of a concrete slab can be similar to the construction of a floor. From the slump tests that have been conducted, there are 2 types of slumps that have been recorded. The results for 0% and 5% replacement mixtures, both types are zero slumps while for 10% and 15% mixtures, the type of slump that has been recorded is shear slump with slump values of 75 mm and 145 mm respectively. **Table 2** and **Figure 2** show the type of slump for each percentage of replacement and slump value against percentage of substitute material.

Table 2: The type of slump for each percentage of replacement

Replacement Percentage (%)	Types of Slump	Slump Value (mm)
0	Zero Slump	0
5	Zero Slump	0
10	Shear Slump	75
15	Shear Slump	145

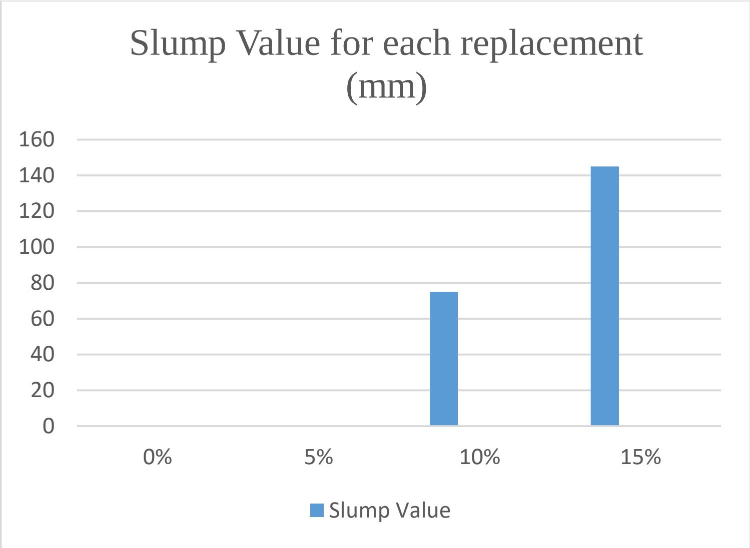

Figure 2: Slump value against percentage of substitute material

3.2 Mass

The mass of concrete is measured to identify its density. This is because each lightweight concrete has a difference in strength and density according to the material and the force applied during the compaction process. Measuring the mass of each concrete cube is very important because it can help users differentiate in terms of density and strength. A total of 6 cubes for each mixture were weighed and averaged. Each sample of mixtures records the different values of mass. **Table 3** shows the mass for each percentage of replacement for 14 and 28 curing days

Table 3: Mass for each replacement percentage for 14 and 28 days

No.of Sample	Replacement Percentage (%)	Mass for 14 days (kg)	Mass for 28 days (kg)
1	0	2.323	2.271
2	5	2.034	1.969
3	10	1.805	1.844
4	15	1.607	1.582

There is a difference in the mass of each lightweight concrete according to the percentage of substitute material used. For the control sample, 0% replacement, the mass is higher than other mixture samples. This is because for control concrete there are not mixed with substitute materials such as polystyrene and sawdust. Thus, the control sample is heavier than others because the use of fine and coarse aggregates is more. The mass value decreases as the percentage of substitute material increases. This is because when the percentage of substitute increases, the mass of the sand and 20 mm aggregate decreases as it is replaced with sawdust and polystyrene which have a lower density. **Figure 3 (a)** and **Figure 3 (b)** shows the sample cube of concrete for 10% and 15% replacement.

Figure 3 (a) 10% of Replacement Concrete

Figure 3 (b) 15% of Replacement Concrete

3.3 Density

Density is a scalar quantity that allows measuring the total mass of concrete to the volume of a cube. The smaller volume of the concrete cube, the greater its density [4]. Each mixture has a different density because the mass is also different. The density obtained from the mass measured after the cube concrete is immersed in water. There are 4 different densities according to the mass and percentage of replacement material used. **Table 4** shows the density for each percentage of replacement for 14 and 28 days.

Table 4: Density for each replacement percentage for 14 and 28 days

No.of Sample	Replacement Percentage (%)	Density for 14 days (kg/m^3)	Density for 28 days (kg/m^3)
1	0	2323.44	2270.72
2	5	2033.80	1969.25
3	10	1805.09	1844.26
4	15	1607.26	1581.92

3.4 Results

Data obtained from the results of concrete tests were recorded, analyzed, and discussed. The results were presented in the form of tables and figures for easy understanding. All experimental results were analyzed to see the comparison of results between tests on the concrete of different densities. Several factors influence the slump test data. For example, the properties of the material such as chemistry, fineness, particle size distribution, moisture content, and temperature of the cement material. Dry lightweight concrete will be removed and weighed to determine the mass value of each sample of concrete cubes. Mass data were recorded and compared with each other. Once the mass value is known, the density value for each sample also can be identified. Based on **Figure 4** and **Figure 5**, it can be observed that the mass of lightweight concrete decreases as the percentage of substitute material increases. In addition, the lower the mass concrete will lower the density too.

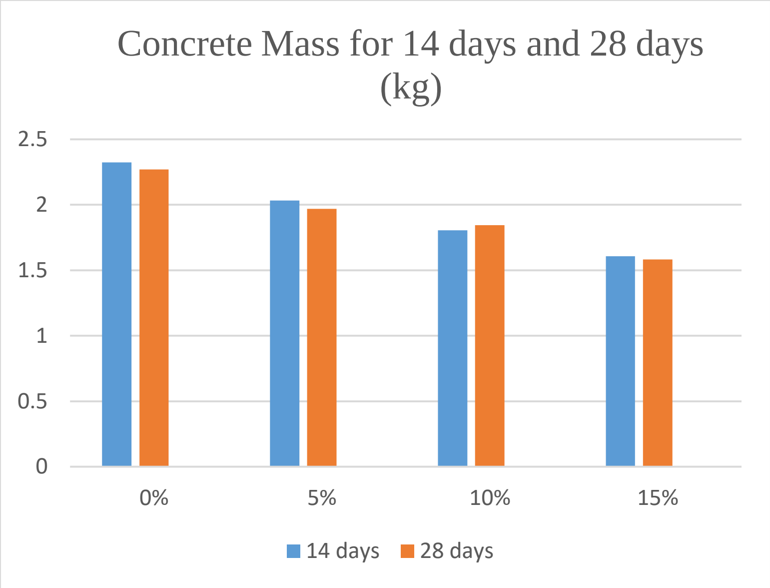

Figure 4: Concrete mass against percentage of substitute material for 14 days and 28 days

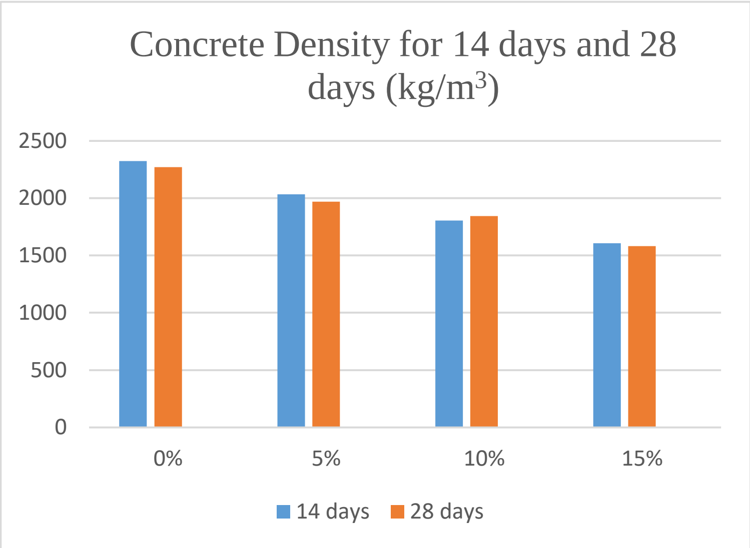

Figure 5: Concrete density against percentage of substitute material for 14 days and 28 days

4. Conclusion and Recommendation

Based on the study that has been conducted, it can be concluded that the level of workability of concrete increases with the increasing percentage of replacement materials. The value of the slump also increases as the percentage of replacement increases. The results for 0% and 5% replacement mixtures, both types are zero slumps while for 10% and 15% mixtures, the type of slump that has been recorded is shear slump with slump values of 75 mm and 145 mm respectively. Besides, the higher percentage of material replacement, the lower density, and mass of lightweight concrete. This is because lightweight concrete has a low replacement percentage uses of polystyrene and sawdust. Sample for 0% replacement mixture has higher density and mass compared to the sample of 5%, 10%, and 15% replacement mixture. However, as a recommendation to obtain lightweight concrete following the specifications in BS 1881: Part 116: 1983 [6], a compressive strength test should be conducted to determine the compressive strength of each lightweight concrete. This is because this test can determine the maximum amount of compressive load borne by the concrete before cracking occurs.

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