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Comparative Study On The Strength Of Lightweight Foamed Concrete Prepared Using Different Reagents

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Abstract: This project presents the results of the investigation conducted on a lightweight foamed concrete using different reagents; Sodium Lauryl Sulphate (SLS) and Lithofoam, with a view to determining its potential as a construction material in Nigeria. The properties investigated on the foamed concrete having target density of 1800kg/m^3 were: workability, bulk density and compressive strength. The foamed concrete was developed using a w/c ratio of 0.5 and a mix ratio of 1:3:0.0025. Concrete specimens were produced using two different fine aggregate grades. Specimens were cured in water for 7, 21 and 28 days. The results revealed that the curing ages significantly affected the strength and that suitable strengths can be achieved using SLS as a foaming agent. The 28th day strengths for the concrete specimens were 11.27N/mm^2 and 11.04N/mm^2 respectively. These strengths were about 23.2% and 25.8% less than that achieved using the Lithofoam as the reagent.

Keywords: Cellular concrete, Compressive strength, Reagents, Sodium Lauryl Sulphate.

1. Introduction

Foamed concrete is a type of lightweight concrete that can be produced by creating pores in the concrete through the addition of a foaming agent to the mix that will react with cement to produce air voids. It is also well known as a cellular concrete. This type of concrete is produced with about 20% or more air by volume in the concrete. It is produced with only fine aggregates so that its unit weight is approximately two-third of the unit weight of conventional concrete. Due to the absence of coarse aggregate and the introduction of larger pore spaces, cellular concrete has some improved characteristics; like lighter weight, better insulation properties, good fire-proof performance, good seismic performance and durability. It has a very broad application.

The introduction of the pores are generally achieved through mechanical means either by;

- Pre-formed foaming, or
- Mix foaming.

The pre-foaming method comprises of producing a base mix and stable preformed aqueous foam separately and then thoroughly blending the foam into the base mix [1]. The foam is made using a foam generator. In the foam generator, the foaming agent is diluted in water to make a pre-foaming solution and then the pre-foaming solution is expanded with air into foam. The mix foaming method involves the addition of a quantity of foaming agent to the slurry & whisking the mixture into a stable mass with the required density. There are generally two (2) types of foaming agents; Protein-based foaming agent and Synthetic-based foaming agent [2]. The protein-based foaming agents can be gotten from natural sources like animal proteins (horn, blood, bones of cows, pigs & other remainders of animal carcasses). Synthetic-based foaming agent on have densities of about 40g/litre with an expansion of about 25 x using portafoam. They are very stable at concrete densities above 1000kg/m^3 and give good strength.

2. Materials and mix proportions

The basic raw materials for the production of foamed concrete are cement, fine aggregate, foaming agent and water.

2.1 Cement

The binder that was used for this experiment was a greyish powdered Portland Limestone Cement (PLC).

2.2 Fine aggregate

Two fine aggregate samples with different grades were used. The first sample was hauled from a dump site. The grading shows a zone 3 sand as it had about 15-34 percentage passing through the 0.5mm sieve. The second sample was hauled from a different dump site, showing a grading of zone 1 sand sample as it had about 15-34 percentage passing through the 0.6mm sieve.

2.3 Foaming agent

The foaming agent that was employed in this research was a white powdered synthetic-based foaming agent with trade name Sodium lauryl sulfate (SLS).

2.4 Water

Water used for the mixing and curing process was clean potable water, which was free from any amount of oil, acids, salt, alkalis, organic materials or any other substances that may be harmful to concrete. The mix design was conducted by weight targeting a density 1800kg/m^3.

3.1 Results and discussions

3.2.1 Sieve analysis result

The results of the sieve analysis test performed on the two fine aggregate samples revealed the following; For the first aggregate sample, the fineness Modulus (FM), which is a single figure that expresses the grading of the aggregate, was calculated to be 1.40, which indicated a very fine sand. The

Coefficient of Uniformity (CU) gave 1.73 while the Coefficient of Curvature (Cc) gave 0.86, thus, showing that the aggregate sample was poorly graded. For the second aggregate sample, the fineness Modulus (FM) was calculated to be 3.11, which indicated a coarse sand. The Coefficient of Uniformity (CU) gave 2.22 while and the Coefficient of Curvature (Cc) gave 1.09, showing that the aggregate sample was well graded.

3.2.2 Moisture content test result

The moisture content test revealed that the first fine aggregate sample had about 2.94% moisture present while the second sample had about 3.28% moisture present and hence, the mass of water required for the mix were reduced to maintain the water cement ratio**.**

3.2.3 Workability test result

Subsequent slump test carried out showed that the average value of slump for the two concrete specimens produced were 265mm and 240mm respectively. Because Foamed concrete generally does not require compaction, vibration or leveling, a collapsed slump was formed. The Protein based foamed concrete on the other hand, had an intermediate slump value of 250mm.

3.2.4 Bulk density

The average bulk density of the foamed concrete at the 28th day was found to be 2074.07kg/m^3 for the first concrete sample. The value of the bulk density was not within the acceptable tolerance, and the coefficient of variability was more than 10% which indicated a non-satisfactory foamed concrete using a target density of 1800kg/m^3. Available literatures [3], and [4] revealed that foamed concrete have densities ranging from 1400kg/m^3 to 2000kg/m^3. The bulk density value exceeded the acceptable range of lightweight foamed concrete. This is particularly important if the results of this investigation were to be considered valid for lightweight concrete. The second concrete sample gave a bulk density value of 1975.31kg/m^3. This value of density was within the acceptable tolerance, and the coefficient of variability was less than 10%, which indicated a satisfactory foamed concrete with a target density of 1800kg/m^3. This bulk density value fell within the acceptable range of lightweight concrete.

Table 1: *28th Day Bulk Density Values*

Concrete sample	*Average weight of sample (kg)*	*Average density of sample (kg/m^3)*	*Coefficient of variability (%)*
1	7.00	2074.07	15.2
2	6.67	1975.31	9.74
Protein based foamed concrete	6.40	1889.29	4.96

3.2.5 Compressive strength test result

The compressive strength test conducted on the first concrete sample brought about the results in Table 2 below;

Table 2: *Compressive Strength Results for Sample 001*

Age	*Average load (kN)*	*Average stress (N/mm2)*
7	180.8	8.04
21	216.8	9.64
28	253.6	11.27

From the table above, it is evident that there is a gradual increase in compressive strength with a corresponding increase in curing age. Table 3 below represents the compressive strength of concrete sample 002 which also shows a gradual increase in compressive strength with a corresponding increase in curing age.

Table 3: *Compressive Strength Results for Sample 002*

Age	*Average load (kN)*	*Average stress (N/mm^2)*
7	155.8	6.92
21	204.5	9.09
28	248.5	11.04

Figure 1 below represents a plot of the compressive strength against the corresponding age for the two concrete samples produced. The plot showed a converging trend in their strengths

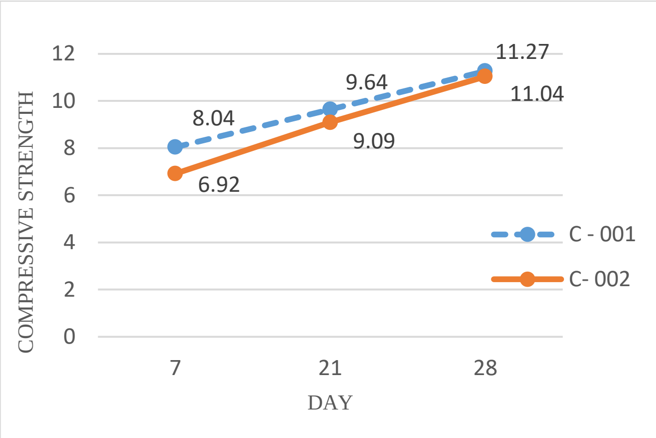

Figure 1*: Variation of Compressive Strength with Age for C– 001 and 002*

For structural applications, compressive strength at 28 days of curing is considered to be the index of concrete quality. The 28th day compressive strengths produced using the SLS as a reagent were compared with that produced using the Lithofoam as the reagent. Figure 2 below represents a plot of their 28th day compressive strengths which revealed that the foamed concrete produced using Lithofoam as the reagent had a higher strength when compared with those produced using SLS. The strength values all fell within the acceptable range for structural lightweight concrete according to both [5] and [6] classifications.

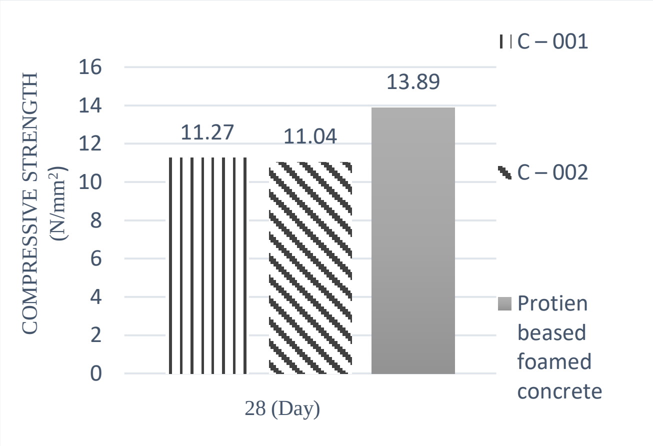

Figure 2: *Variation of Compressive Strength with Age for C– 001, C– 002 and the Protein Based Foamed Concrete.*

4. Conclusion

From the results obtained;

- C – 001 had a higher compressive strength than C – 002. Although they were both produced using a synthetic based foaming agent, Sodium Lauryl Sulphate (SLS), and the same mix design ratio was used, the discrepancy in their strengths can be traced to the type of aggregate used and the foam generation method. Thus, we can conclude that aggregate samples with a higher fineness modulus and a mixed foam method of foam generation produces concrete with a lower strength.
- C – 001 generally had a higher bulk density than C– 002. This can be linked to the relationship between the method of foam generation and the void ratio. Hence, we can then conclude that because C– 002 was a much lighter sample, it had much bigger voids than those produced in C– 001 and thus had a lesser bulk density.
- The use of the synthetic based foaming agent, Sodium Lauryl Sulphate performed satisfactorily in the production of foamed concrete that fell within the range of structural foamed concrete.
- There was a general increase in compressive strength with progressive increase in curing age for the synthetic based foamed concrete.
- The protein based foamed concrete had a higher compressive strength than the concrete samples produced using a synthetic based foaming agent. This could be traced down to the chemical components of the foaming agents and how they reacted with the cement.

5. Recommendation.

The synthetic based reagent used in the comparative study of the strength of the lightweight foamed concrete performed satisfactorily in the production of a structural foamed concrete. Although it had a lesser compressive strength than those produced with a protein based reagent (Lithofoam), it is recommended that it can be used in the production of foamed concrete. For the productions of a more satisfactory and higher compressive strength, it is recommended that;

- A well graded fine aggregate sample with a low fineness modulus is used
- The preformed method is used for the foam generation
- A protein based reagent rather than a synthetic based one is used in the mix

The lesser compressive strength in the synthetic based foamed concrete can also be linked to the water used for curing.

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