Technical Note:

EFFECT OF INCORPORATING EXPANDED POLYSTYRENE AGGREGATE GRANULES IN CONCRETE MATRIX

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Abstract

Incorporating expanded polystyrene granules in concrete matrix can produce lightweight polystyrene aggregate concrete of various densities. Workability which is an important property of concrete, affects the rate of placement and the degree of compaction of concrete. Inadequate compaction leads to reduction in both strength and durability of concrete. In this research work, the effect of incorporation of expanded polystyrene aggregate granules in concrete was studied. The polystyrene aggregate granules was used to replace 0-40% of coarse aggregates. A mix proportion of 1:1.8:3.7 with water cement ratio of 0.47 were used. Concrete cubes of 150mm $\times$ 150mm $\times$ 150mm of coarse aggregate/polystyrene granules were cast and cured at 3, 7, 28, 60 and 90 days respectively. At the end of each hydration period, the three concrete cubes for each hydration period were crushed and their average compressive strength recorded. A total of ninety (90) concrete cubes were cast. The result of the compressive strength tests for 5-40% replacement of coarse aggregates with polystyrene granules ranges from 5.05-31.75N/mm\textsuperscript{2} as against 23.59-36.08N/mm\textsuperscript{2} for the control test. The workability for 5-40% replacement of coarse aggregates with polystyrene granules ranges from 15-63mm as against 10mm for the control test (0% replacement). The incorporation of the expanded polystyrene aggregate granules as concrete matrix results in the decrease in strength of concrete produced.

Keywords: polystyrene aggregate granules, coarse aggregates, compressive strength, workability

1. Introduction

Lightweight concrete can be produced by partially replacing the normal weight coarse aggregate particles with expanded polystyrene granules. The particle and bulk densities for the polystyrene aggregate used are 62 and 20kg/m$^3$ respectively. The expanded polystyrene aggregate is commercially available with suitable chemical coating, which is necessary to achieve a uniform dispersion in the fresh concrete mixture and to avoid segregation during mixing and handling of concrete. The polystyrene has negligible water absorption due to its closed cellular structure. [1] reported that the standard workability tests are not suitable for the polystyrene aggregate concrete since they are sensitive to the unit weight of concrete. [2] made similar observation when working with some materials together with polystyrene granules. The incorporation of polystyrene granules in concrete manufacture may provide a satisfactory solution to the problems posed by concrete production [3]. Finally, the incorporation of polystyrene granules should not impair concrete durability. Traditional assessment methods must therefore be adapted to evaluate this material [4].

This study contributes to the development of a methodology for assessing concrete manufactured from polystyrene granules. The methodology is based on the study of concrete containing this material.

The durability and the environmental impact of concrete are closely connected to its transport properties which control the kinetics of the penetration of water and aggressive agents into concrete [5]. The movement of chemical species within the material and the leaching of certain chemicals are also closely linked to concrete diffusivity [6].

Finally, the strength characteristics of concrete containing increasing levels of polystyrene granules were studied to identify the influence of the granules on concrete produced with it [7].
2. Methodology

Concrete mixtures with six levels of polystyrene granules ranging from 5, 10%, 20%, 30% and 40% and concrete mixtures with no polystyrene granules were investigated to determine their effect on the strength of concrete. The mixtures were labeled M0, M5, M10, M20, M30 and M40 with the different polystyrene granules replacement percentages of coarse aggregates represented by the final digits in the label. The mixtures were proportioned for a target cube strength of 43N/mm² and had a cementitious material content of 340kg/m³, a fine aggregate content of 627kg/m³, a coarse aggregate content of 1273kg/m³ and a water cement ratio of 0.47.

Crushed expanded polystyrene granules angular in shape with a non toxic chemical coating and having a mean diameter of 3.5mm were used in the concrete mixtures. The fine aggregate used was clean river sand, free from deleterious substances with a specific gravity of 2.62 and bulk density of 1533kg/m³. The coarse aggregate was obtained from a local supplier with a maximum size of 20mm, specific gravity of 2.65 and bulk density of 1467kg/m³. Both aggregates conforms to [8] and [9] respectively for coarse and fine aggregates. The cement used was Ordinary Portland Cement (Ibeto) which conforms to [10].

2.1. Compressive strength test

Tests to determine density, workability and compressive strength were carried out in this study. For the compressive strength test, polystyrene aggregate granules was used to replace 0 to 40% of coarse aggregates by weight. For the compressive strength test

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150mm cube specimens were used. A total of 90 specimens were cast and cured in water at room temperature in the laboratory for 3, 7, 28, 60 and 90 days. At the end of each hydration period, three specimens for each were tested for compressive strength and the average recorded.

### 2.2. Workability test

For the workability, a standard slump cone measuring 300mm x 200mm x 100mm was used. The compaction was also in three layers as carried out in a compressive strength, that is one third of its height, two-third of its height and filled up completely. Each layer was compacted using a tamping rod.

### 3. Results and Discussion

Table 1-6 shows the result of the compressive strength of concrete with 0-40% replacement of coarse aggregate with polystyrene aggregate granules. The result shows that strength development increases with increase in hydration period. The result of the compressive strength for 5-40% replacement of coarse aggregate with polystyrene granules ranges from 5.05-31.75N/mm² as against 23.59-36.08N/mm² for the control test. The result shows that there is a decrease in the strength of concrete produced as the percentage replacement level of coarse aggregates with polystyrene granules increases.

Table 7 shows the result of workability of concrete produced when polystyrene granules are used in a certain replacement level of coarse aggregates. The result of workability for 5-40% replacement of coarse aggregates with polystyrene granules ranges from 15-63mm

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Table 4: Result of compressive strength obtained with 20% replacement of coarse aggregates with polystyrene granules.

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Table 5: Result of compressive strength obtained with 30% replacement of coarse aggregates with polystyrene granules.

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Table 6: Result of compressive strength obtained with 40% replacement of coarse aggregates with polystyrene granules.

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Table 7: Result of workability of concrete produced with 0-40% replacement level of coarse aggregates with polystyrene granules.

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as against 10mm for the control test. The result shows that the higher the workability of concrete produced, the lower the strength of concrete.

4. Conclusion

The conclusion of the study can be summarized as follows:

1. The incorporation of polystyrene granules in the production of concrete will reduce the strength of concrete produced.

2. The strength development in the concrete produced increases with the increase in hydration period.

3. The strength of concrete decreases with the increase in workability.

References


