MECHANICAL PROPERTIES OF LIGHT-WEIGHT CONCRETE BLOCK USING EXPANDED POLYSTYRENE FOAM

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ABSTRACT

The purpose of this research is to find out the effect of Styrofoam or EPS (expanded polystyrene) as a partial and total replacement of aggregate in concrete blocks. The concrete block production from polystyrene wastes can be an alternative to brick in non-structural elements to reduce the emission of PM (Particulate Matter), CO_2 from brick kilns. Styrofoam concrete has lower thermal conductivity compared to normal concrete and can be used as green material. Two types of mixing ratios were maintained for this experimental study. In one mix, Cement to EPS ratio was kept at 1:8 and in another mix river sand was also used alongside the EPS in a ratio of 1:4:8. The water to binder ratio was maintained at 0.5 for all the samples. Three samples with a dimension of 10" × 5" × 3" from each batch were tested for 28 days compressive strength and water absorption capacity. It was observed that the compressive strength of the specimen with fine aggregate and EPS was 7.16 MPa whereas the compressive strength of another specimen where only EPS had been used was 6.32 MPa. It is obvious that samples with cement and only EPS will show lower compressive strength and higher absorption, and that exactly happened in this test. Both the samples showed plastic behavior at the failure. The addition of 30% by weight of fine aggregate reduces the water absorption capacity of the block by 12.5%. Concrete block with a total replacement of aggregate with Styrofoam decreases the weight by 32.5% compared to that of cement, sand, and EPS mixture. Concrete with EPS can be categorized as non-structural lightweight concrete. It can reduce the dead load of the structure to some extent. Styrofoam blocks reduce the unit cost by nearly 50% compared to burnt clay brick.

Keywords: *EPS, light-weight, compressive strength, absorption, aggregate*

1. INTRODUCTION

Expanded polystyrene (EPS) wastes are generated from packaging industries. They are non-biodegradable and they pollute the environment after being disposed of by burning or landfilling (Adeala & Soyem, 2020). The large volume of wastes is produced for the abundant use of Styrofoam in mainly packing goods and products (Ahmad et al., n.d.). The possibility of using Styrofoam as a partial replacement for fine aggregates in concrete has been a research interest in recent times. Though the physical and mechanical properties of EPS are different from those of conventional fine aggregates, several studies were conducted on this topic (Adeala & Soyem, 2020). Styrofoam, pumice stone, and perlite as lightweight materials are beneficial to reduce the self-weight of structures if these materials are used in concrete as a replacement of aggregates. Solikin & Ikhsan used Styrofoam as a partial substitution for fine aggregate. It was observed that the utilization of Styrofoam up to 50% as a partial replacement of fine aggregate provides better mechanical properties (Solikin & Ikhsan, 2018). Styrofoam improves fresh concrete's workability and decreases unit weight but reduces mechanical strength. For higher dosages of Styrofoam as a replacement of fine aggregate, granules in concrete mass are not uniform and tend to flow. The application of Polystyrene granules in non-structural elements can reduce environmental pollution, construction cost, and dead load (Cadere et al., 2018). Polystyrene concrete comprises polystyrene waste shredded aggregates, cement, and sand. Kulkarni used the polystyrene waste shredded to replace 40% of natural aggregates in nine trial mixes with varying proportions. Studies revealed that the expanded polystyrene foam can be effectively used to make lightweight concrete and is suited for non-load bearing structures such as partition walls and facades (Kulkarni, 2021).

2. METHODOLOGY

This study used Styrofoam, river sand, and PCC (Portland Composite Cement). All of the materials are locally available.

2.1.1 Materials Collection

Styrofoam beads were obtained from the cork sheets used in the packaging of different products. Figure 1 shows the collecting procedure of the EPS granules. Cement and sand were purchased from the local market.

Figure 1: Collection of Styrofoam granules

2.1.2 Preparation of Molds

To prepare the samples, we prepared six molds made of wood & steel. The nominal size of the molds (shown in Figure 2) is 10" × 5" × 3".

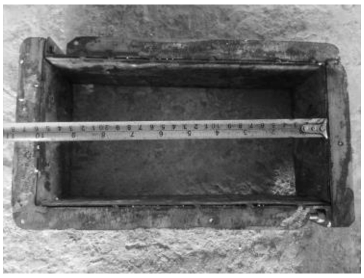

Figure 2: Moulds

2.1.3 Mixing

We cast two different mixes. One of the mixes (Mix-1) contains cement and Styrofoam beads with a proportion of 1:8 and another mix (Mix-2) was prepared from cement, sand, and Styrofoam with a ratio of 1:4:8. For this study 0.5 water-cement ratio was maintained.

The required volumes of materials were measured and thoroughly mixed to ensure homogenous mixtures. Cement and river sand were mixed with Styrofoam granules first and then water was added slowly. The mixture was poured into the wooden frame and a wooden handle trowel was used to smooth the block. Then, the sample was kept at room temperature and after 24 hours gunny sacks were used for curing up to 28 days. Figure 3 shows the preparation of the samples from the mixtures and figure 4 shows the curing of the sample after 24 hrs. of mixing.

Figure 3: Sample Preparation

Figure 4: Curing

2.1.4 Testing of the Samples

The samples were collected at 28 days of curing and kept in the UTM for the compressive strength test. The samples were tested according to ASTM C 140. The absorption capacity and unit weight of both types of samples were also determined. Figure 5 shows the testing procedure of the half-block (cut lengthwise).

Figure 5: Compressive strength test of the sample.

2.1.5 Comparison of Compressive Strength

The compressive strength of the block of Mix-1 was 6.32 MPa and that of Mix-2 was 7.16 MPa. Total replacement of aggregate with the Styrofoam reduced the strength, but 30% replacement of aggregate with Styrofoam increased the strength. Figure 6 shows the comparison between the compressive strength of the samples.

2.1.6 Comparison of the Water Absorption Capacity

The water absorption capacity of Mix-1 and Mix-2 was found at 11.9% and 10.41% respectively. Water absorption capacity increased with the increasing percentage of Styrofoam. Figure 7 shows the comparison of the absorption capacity of the two mixes.

2.1.7 Comparison of Unit Weight

Due to the lightweight of the EPS, the unit weight of both Mix-1 and Mix-2 was less than that of any burnt clay brick. Figure 8 shows the comparison among the two mixes and bricks. Unit weight decreased with the increasing percentage of Styrofoam.

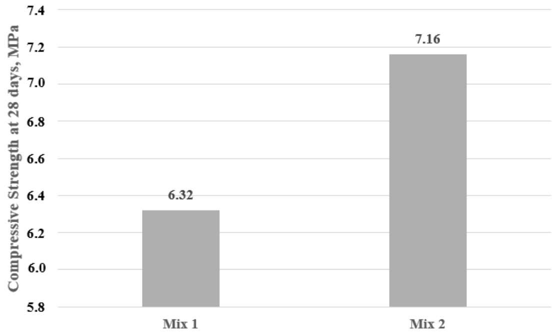

Figure 6: Comparison of compressive strength of two different mixes

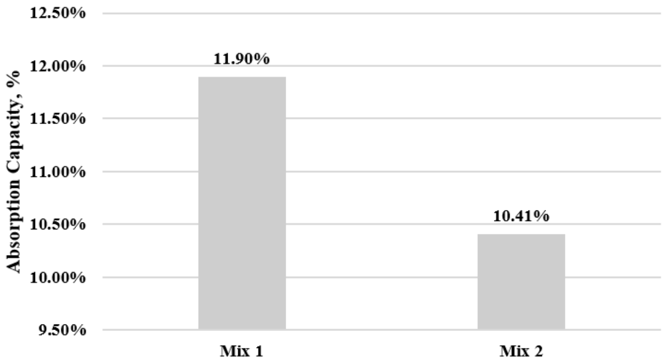

Figure 7: Comparison of absorption capacity of two different mixes

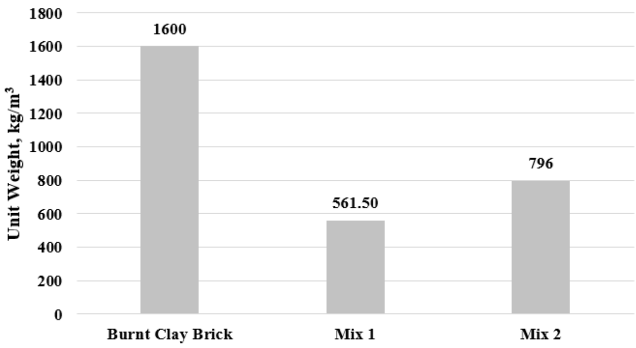

Figure 8: Comparison of unit weight

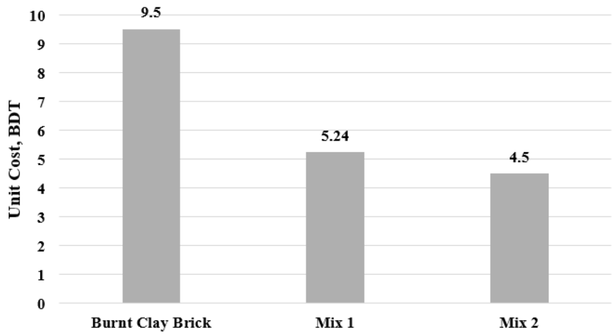

Figure 9: Comparison of unit cost

2.1.8 Comparison of Unit Cost

In Bangladesh, the unit price of 1st class brick is around 9.50 BDT. Including all the costs related to the production of the block of Mix 1, the unit price was calculated as 4.5 BDT and that of the second mix is 5.24 BDT. Figure 9 shows the comparison of the unit cost.

3. CONCLUSIONS

EPS granules can be incorporated into the concrete mixture to make lightweight concrete. Styrofoam concrete block has low compressive strength and can be used as an alternative to brick only for non-structural elements. It can reduce about 50% of the dead load of the partition wall. The application of recycled Styrofoam in the concrete block can indirectly reduce environmental pollution and brick-kiln emissions. Block comprising cement, Styrofoam, and sand has lower water absorption capacity and better strength than the mixture of total replacement of sand with EPS. Total replacement of aggregate by Styrofoam decreases the strength to some extent but 30% replacement of fine aggregate with EPS increases the strength. Production cost is also relatively less than that of bricks. Considering the mechanical properties, unit weight, economic and environmental aspects of such a block can draw more research interest.

ACKNOWLEDGMENTS

We would like to express our gratitude to Md. Abu Hurairah for his assistance in cutting the sample and conducting the experimental program.

REFERENCES

Adeala, A. J., & Soyem, O. B. (2020). Structural Use of Expanded Polystyrene Concrete. International Journal of Innovative Science and Research Technology, 5(6), 1131–1138. https://doi.org/10.38124/IJISRT20JUN849

Ahmad, M. H., Loon, L. Y., Noor, N. M., & Adnan, S. H. (n.d.). STRENGTH DEVELOPMENT OF LIGHTWEIGHT STYROFOAM CONCRETE. 6.

Cadere, C. A., Barbuta, M., Rosca, B., Serbanoiu, A. A., Burlacu, A., & Oancea, I. (2018). Engineering properties of concrete with polystyrene granules. Procedia Manufacturing, 22, 288–293. https://doi.org/10.1016/j.promfg.2018.03.044

Kulkarni, A. A. (2021). Strength and Durability of Polystyrene Concrete. International Journal of Recent Technology and Engineering, 9(5), 166–171. org/10.35940/ijrte.E5254.019521

Solikin, M., & Ikhsan, N. (2018). Styrofoam as partial substitution of fine aggregate in lightweight concrete bricks. 030041. https://doi.org/10.1063/1.5042961