DETERMINATION OF OPTIMUM STYROFOAM CONTENT AND THERMAL PROPERTIES IN LIGHTWEIGHT CONCRETE

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ABSTRACT

Concrete is a composite material composed of fine and coarse aggregate bonded with cement that hardens over time. Lightweight concrete contains a lightweight aggregate that meets the requirements of ASTM-C.330 provision and has unit mass of dry air as determined by ASTM-C.567 which has a density of no more than 1900 kg/m^3[2]. Lightweight concrete is used widely in the construction industry, obviously due to reduction in weight. Builders and designers are looking for lightweight concrete to reduce the production cost. Reduction of self-weight load may result in reducing sizes of footings and lighter and smaller upper structures. Reduction in the dimensions of structural members results in larger space availability. Reduced dead load of the building by using lightweight concrete results in reduction of earthquake damages to structures. This experimental study was carried out to determine the optimum amount of Styrofoam of 20% of 3 mm in grade 30 concrete. The results were within the ASTM limits. Density is 1511 kg/m^3, slump value is 95 mm, compressive strength is 6.3 N/mm^2 and the flexural strength is 3.1 N/mm^2. Lightweight concrete will give high thermal insulation and enhanced fire resistance.

Keyword: - *Lightweight concrete1, Styrofoam2, Compressive strength3, Density4*

1. INTRODUCTION

Lightweight concrete is not a new material is back over three thousand years ago by Hindus that creating world famous towns of Mohenjo daro and Harappa [3]. It is a concrete containing lightweight aggregate that meets the requirements of ASTM-C.330 provisions and has unit mass of dry air as determined by ASTM-C.567 which has a density not more than 1900 kg/m^2 [2]. In manufacturing, lightweight concrete can be prepared with two methods. First method is to form a lightweight concrete using lightweight aggregates which have low density. The second method is to create a high porous concrete either by adding air to the concrete or vacuuming the concrete.

There are many concrete works, such as partition walls, benches for sitting and walkway fill, that can be made using light-weight concrete. It will save on the weight and the cost of the materials. Light-weight concrete with very low density has been an option for developed countries to construct buildings, bridges and offshore building. Buildings with lightweight concrete are as a filler to reduce the risk of damage or collapsed by the earthquake due to the light mass of construction. Light-weight concrete is also able to reduce budget costs as the volume of structural elements such as columns, beams, floor plate and the foundation which can be reduced due to a light load [4].

Styrofoam is widely used for manufacturing as packaging tools to absorb vibration during handling and transportation. Further, the Styrofoam is a disposal waste producing a considerable amount of waste. Due to its lightweight, it shows a potential to use as a replacement of coarse aggregates in the lightweight concrete.

Normally, crushed stone as coarse aggregates and river sand as fine aggregates are produced by sparing from rocks and river beds. These activities may cause to increase the scarcity of natural resources and in some countries, environmental limitations are imposed on mining of natural aggregates. By using alternative aggregates resources like Styrofoam, it is a need to check the capability of establishment an industry with export potential especially to countries where natural aggregates are depleted.

In previous studies, many researchers have investigated the physical, mechanical and durability properties of lightweight aggregate concrete incorporating different types of lightweight aggregates. This research study focuses on the lightweight concrete having Styrofoam. This research is to determine the optimum amount of Styrofoam foam balls and heat transfer properties by the process of conduction in lightweight concrete, for applications such as non-load bearing walls and filling and architectural purposes.

1.1 BACKGROUND STUDY

Determination of optimum Styrofoam content and thermal properties in lightweight concrete has been emphasized by several researches by considering some parameters such as relevant to the topic and time. Shahid Iqbal [12] stated using lightweight concrete is very important for reducing the self-weight of structures, especially in high rise buildings. It enables to decrease additional loads in case of renovation or strengthening of existing structures. Mochamad Solikin [19] used Styrofoam as partial substitution for fine aggregate and variation in mix proportion, which consisted of 0%, 30%, 40% and 50% fine aggregate replacement. Reduction in weight by the use of lightweight aggregate is preferred especially for structures built in seismic zones [5]. Reduced dead load of the building by using lightweight concrete results in reduction of earthquake damages to structures.

In most of the previous researches which were studied in the literature, pumice, Styrofoam waste, polyurethane foam and polystyrene foam were used as lightweight aggregate to produce the lightweight concrete. Due to its lightweight, it seems that the Styrofoam has potential to use as aggregates replacement of coarse aggregates in the lightweight concrete.

P. Mounanga, [13] did an experimental study concerning the incorporation of polyurethane (PUR) foam wastes into cementitious mixtures in order to produce lightweight concrete. Seven concrete mixtures containing various PUR foam volume fractions (from 13.1% to 33.7%), and two reference concrete mixtures (without PUR foam) were prepared and characterized. In particular, their thermal and mechanical properties were determined.

This research will be carried out to determine the optimum Styrofoam content in the lightweight concrete. Specially, the study will focus on compressive strength, flexural strength and thermal conductivity since previous research studies did not focus all these parameters in one research to design a lightweight concrete

2. METHODOLOGY

The research study based on experiments focuses on analyzing compressive strength, flexural strength and heat transfer by experimental analysis. The experimental proportion employed three specimens for compression test, five specimens for dimensional uniform check and water absorption, and two specimens for flexural strength. All the specimens were tested at the age of 14 days.

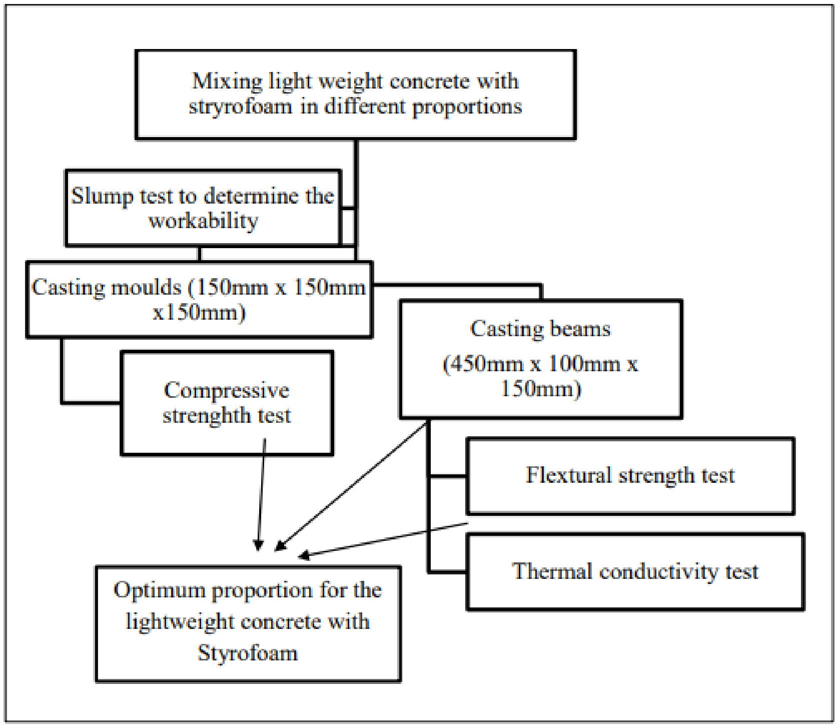

Fig -1 Methodology

3. RESULTS AND DISCUSSION

The data analysis is important for the gathering the results from the data. Experimental data will be analyzed statistically to regression analysis, sensitivity analysis and correlating parameters. Preliminary laboratory experiments on casting the cubes. Any variation in the casting procedure will significantly affect the characteristics of concrete. Same water is using for all experiments. The casting purpose two cube were casted and results were calculated average. Cement bags not opened to the atmosphere.

3.1 Compressive strength test

Table -1 Compressive strengths of different lightweight concrete and grade 30 concrete

	3mm	5mm	10mm	15mm
Grade 30	43.880	43.880	43.880	43.880
5%	19.015	15.111	14.27	13.96
10%	9.642	6.755	10.16	9.60
15%	7.233	6.344	6.35	6.02
20%	6.333	5.444	5.02	5.16
30%	2.800	1.911	1.85	1.75

3mm diameter 20 % and 3mm 15 % are selected for flexural tests

3.2 Flexural strength test

Two-point loadings were applied to test beam dimension of 450x150x100 mm^3. The formula for calculating the flexural strength was taken from the (BS 5628-1, 1992) as follows:

Flexural strength (3mm 15%) $= \frac{P.l}{b \times h^2}$

$$= \frac{26.83 \times 1000 \times 300}{100 \times 150^2}$$

$= 3.577\ N/mm^2$

Flexural strength (3mm 20%) $= \frac{P.l}{b \times h^2}$

$$= \frac{23.51 \times 1000 \times 300}{100 \times 150^2}$$

$= 3.134\ N/mm^2$

More than 3 Nmm^{-2} is sufficient. Hence, **20% of 3mm** mix were selected as optimum Styrofoam lightweight concrete.

Table -2 Quantity of dry materials per 1 cubic meter in Kg

3 mm Styrofoam	Mix designs	Quantity of dry materials per 1 cubic meter in Kg				
		Cement	**Water**	**Fine aggregate**	**Coarse aggregate**	**Styrofoam**
	20%	320.26	160.00	635.67	812.00	16.74

3.3 Thermal conductivity test

3mm, 20% mix were selected for thermal conductivity analysis.

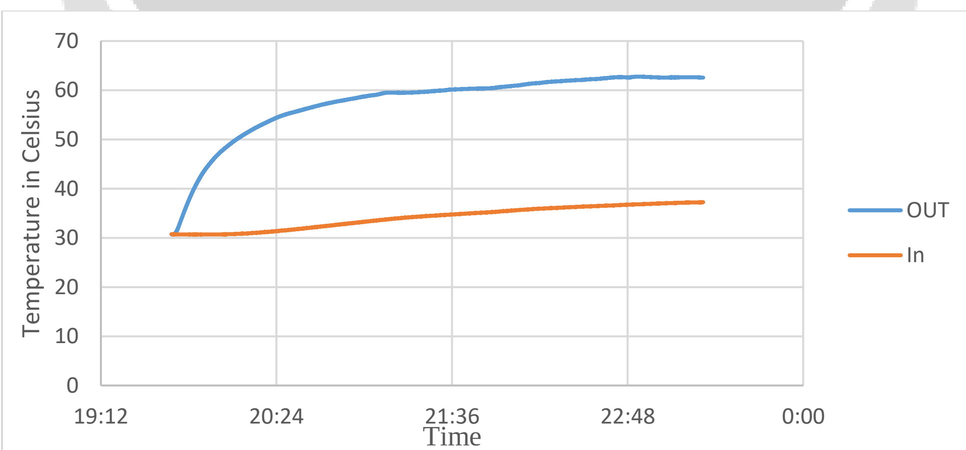

Fig -2 Thermal conductivity analysis

Thermal comfort primarily depends on the temperature of the indoor environment, humidity and the heat supply to the indoor environment which in turn will affect the indoor temperature. Styrofoam lightweight concrete is also a potential substitute. Since heat transfer in the Styrofoam lightweight concrete is very slow and effective.

4. CONCLUSIONS

Lightweight concrete usage is gaining widely in construction industry, obviously due to reduction in mass. Reduced dead load of the building by using lightweight concrete results in reduction of earthquake damages to structures. Normally, crushed stone as coarse aggregates and river sand as fine aggregates produced by sparing from rocks and river beds. This will destroy the beauty of natural resources and in some countries, environmental limitations are imposed on mining of natural aggregates. By using alternative aggregates resources like Styrofoam, it is capable to establish an industry with export potential especially to countries where natural aggregates are depleted.

This experimental study determined the optimum amount of Styrofoam of 20% of 3 mm in grade 30 concrete. Density is 1511.1 kg.m3, slump value is 95 mm, compressive strength is 6.333 N/mm^2 and the flexural strength is 3.134 N/mm^2. Builders and designers are looking lightweight concrete to reduce the production cost. Reduction of self-weight load may result in reduced sizes of footings and lighter and smaller upper structure. Reduction in the dimension's sizes of structural member results in larger space availability. Lightweight concrete will give high thermal insulation and enhanced fire resistance.

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