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AN EXPERIMENTAL STUDY ON LIGHTWEIGHT CONCRETE USING KOTA STONE SLURRY WASTE

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Abstract—*Light weight cellular concrete is a type of foamed thermal insulated light weight concrete consists of cement, water and sand with air volume more than 30%. Structure applications of cellular lightweight concrete include precast units such as concrete bricks, partitions etc. Structural application of cellular concrete includes void and trench filling, thermal and acoustic insulation by making partition wall. The cellular concrete was designed to have a density targeted between 401-500 kg/m3. It has been found that the utilization Kota stone waste in cellular concretes leads to the higher strength. Experimental study was conducted to determine the factors influencing LWC strength its use as non-structural and non-load bearing elements of building. Various mechanical tests were conducted on the prepared specimen to quantify its properties and understand its use as a cheap non-load bearing structural element. Moist curing was done for 28 days at room temperature. Various factors influence the mix design and strength of cellular foamed concrete, such as ksslw/cement ratio (k/s), water/cement ratio (w/c) and design target density. It was found that k/s ratio influence the water demand of the concrete mix. However, the concrete density is the factor that influences the strength most.*

1. Introduction

In general, there are two ways to achieve a low density concrete; first by using a low density aggregate, such as pumice or other lightweight rock, and second by introducing a gas or foam into the concrete mix. However, the use of lightweight aggregate material is not always feasible due to unavailability of lightweight material in many locations. The use of cellular concrete overcomes the supply problem associated with the use of lightweight aggregate, and further it allows an increased degree of control of the density of the finished product. Stone is a most common building material of ancient times. In the recent years, a sustainable growth in the consumption of stones is observed in all over the world.

In general, there are two types of waste named as quarrying /cutting /sawing from in –situ stone site and polishing waste from construction sites. At present country's 25 lakh hectare area is under mining lease conditions, out of which ninety percent area is subject to opencast mining techniques. Lightweight aggregate of low specific gravity is used in this lightweight concrete instead of ordinary concrete. The lightweight aggregate can be natural aggregate such as pumice, scoria, all of those of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate.

The main requirement for this type of concrete is that should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking (Samidi, 1997).

2. Scope of study

The primary use of structural lightweight concrete is to reduce the dead load of a concrete structure. The structure lightweight concrete mixture can be designed to achieve similar strengths as normal weight concrete. The same is true for other mechanical and durability performance requirements. The Structural lightweight concrete provides a more efficient strength-to-weight ratio in structural elements. In most cases, the marginally higher cost of the lightweight concrete is offset by size reduction of structural elements, less reinforcing steel and reduced volume of concrete, resulting in lower overall cost. Structural lightweight concrete provides a higher fire-rated concrete structure in buildings.

3. Light Weight Concrete

Foamed concrete is a lightweight concrete that is versatile and have some attractive characteristics such as its flow-ability, self-compacting and self-leveling nature, low dimensional change and ultra–low density. The material can be designed to have controlled low strength, exceptional thermal insulation properties and good load-bearing capacity and be easily excavated, if necessary. Foamed concrete was generally used for application for ground works such as high volume void fills road sub-base, soil stabilization and grouting tunnel walls. This development in the use of foamed concrete has attracted many researchers throughout the word to explore new ideas and opportunities in its application.

The project study involves experimental studies on the CFC-Block of density 401 and 500 kg/m3 developed using stone waste. Various tests: compressive strength, flow table test for workability, water absorption etc. were carried out to know the effect of incorporating KSSLW as filler. To find out the mix – proportional corresponding to two densities which use the maximum utilization of ksslw (kota stone slurry waste).

4. Materials Required

4.1 Cement

The cement taken was Ordinary Portland Cement (OPC) of 43 grade of uniform consistency, conforming to IS 8112-1989. The test for specific gravity, standard consistency, initial and final setting time and 28-day compressive strength have been conducted.

4.2 Fine Aggregate

The main type of aggregate used in this study was solani river sand of very fine grade, collected from the local site Roorkee. The fineness modulus of solani sand was 1.07, which fulfill the requirement of fine aggregate to make CFC-block. Sand conforming to IS 2185 (IV): 2008 and to suit the final product density was used. It should be fine with 2 mm maximum size and 60-90% passing through a 600-micron sieve as per British Cement Association (1994). The sand was air–dried in the laboratory to surface dry condition. Only finer aggregates were used, because coarse aggregate may settle in the lightweight mix and causes collapse of the foam during mixing (Such and Seifert, 1999; Jones, 2000).

4.3 Kota stone slurry waste

Kota stone is fine-grained variety of limestone, quarried at different district of Rajasthan, India. Many hundreds of mines are located in on near the town of Ramganjmandi (Fig.3.8) and Kota district. As an example: in Hadoti (Bundi district), there is more than 5000 cutting and 300 polishing units are producing dimensional Kota stone.

Figure 1: Kota stone slurry waste

4.4 Surfactant

One of the moist important ingredients required for foamed concrete is the foaming agent. There are several types of surfactants available in the market. The surfactant used in this study was commercially available natural protein –based surfactant. Properties of surfactant are shown in table no.1

Table no: 1 Properties of Surfactant

S. No.	Characteristics	Value/Observation
1	Name	Natural protein based foaming agent
2	Appearance	Dark brown liquid
3	Specific gravity	1.16
4	pH	6.97
5	Use of foaming agent	1 ltr (diluted in 20 part of water)
6	Chloride content (IS:6925-1973)	Nil
7	Chemical action (IS;2185(iv)-2008)	Completely harmless, nontoxic, non-Flammable

4.5 Water

Fresh and clean tap water from the laboratory was used for mixing and curing the specimens in present study. Water used in this study was usually normal tap water of pH within the range 6.8-7.5.

5. Result and Discussion

Detailed experimental investigation was carried out to study the properties of pumice, a lightweight aggregate as partial replacement of normal weight coarse aggregate in concrete. On prepared specimens, different types of tests were done such as compressive strength, tensile strength, water absorption

5.1 Workability

After doing flow table test, water –cement ratio which have value of 130,150 and 170 was selected from each phases for density (Table 2) and further calculation was done according to these water-cement ratios.

Table no:2 Flow value v/s water-cement ratio

No.	w/c ratio	D_i	D_S	Flow value
1	0.50	10	230	130
2	0.52	10	250	150
3	0.68	10	270	170
4	0.58	10	230	130
5	0.63	10	250	150
6.	0.66	10	270	170

5.2 Wet Density

For all mixes targeted plastic density was 500kg/m3.Stability of foam was found to be affected by „free" water content, ksslw content and sand quantity. Foam bubble can come upward due to more free water as ksslw absorbed more water then it may be that due to lack of water it can take water from bubble by breaking them. In stability in foam concrete cases the density to vary and this may cause segregation, unpredictability collapse. So to overcome this effect, some extra foam by weight of ksslw was added with the designed foam quantity in the mortar base mix to achieve the targeted consistency.

5.3 Water Absorption

Water absorption is the indication of the durability; more is the absorption lesser is the durability. Also water absorption indicates the transportation and handling properties of material. According to IS 6598:1972 the value of water absorption is limited to 12.5%, but in above specimen value obtained is 33.07.

Table no: 3 Calculation of water absorption

Dry weight b	Wet weight A	Percentage water absorption
260	340	33.07

5.4 Compressive strength

The strength characteristics of block were determined on 1000kn Shimadzu Universal testing machine. The compressive strength was carried out on the foam concrete in accordance with the provision of Annex D of IS 2185(iv): 2008. While The flexural strength and split tensile strength was carried out as per IS 516:1959 and IS 5816:1999 respectively.

Total specimens used for compressive strength test are three. Sizes of the specimens are (100x100) mm no compaction effort has given to specimen. compressive strength of foam concrete mixture with different kota stone contents and most densities are in Table from the data it is clear that in case of foamed concrete, strength has no significance because strength depends of density.

Table No:4 Compressive strengths as a function of w/c ratio for density 500 Kg

Phases	(Avg.) Kg/	w/c ratio	Compressive strength (Mpa)		
			3 days	7 days	28 days
X1	403.34	0.50	0.25	0.50	1.01
	475.45	0.52	0.34	0.59	1.05
	450.52	0.68	0.38	0.52	1.13
X2	471.11	0.58	0.35	0.56	1.11
	495.52	0.63	0.37	0.66	1.14
	535.54	0.66	0.39	0.64	1.15

6. Conclusions

The lightweight thermal insulated form concrete blocks in the material and construction technology have led to the sign can't resulting in improved performance, wider and more economical use. As a result, lightweight thermal insulated block has the concrete which serves both economic and environmental concerns. The Kota stone slurry waste acts as filler for both cement as well as sand because of matching of particle size distribution with both i.e. sand OPC-43G.

The conclusion based on the work carried out in this project is given as follows:

1. The initial water-cement ratio was taken 0.50 for the control mix. However, reduced water/cement ratio caused an increase in strength of the foamed concrete but at the expense of reduced workability.
2. Though compressive strengths are not comparative to conventional concrete still it holds lot of potential to be used as a non-load bearing element in low cost residential structures.
3. High water absorbtion is obtained because Fly ash consumes calcium hydroxide that formed when water reacts with alite and belite which makes C-S-H gel. The formation of hydrate calcium silicate makes the foam concrete micro structure denser and more crystalline as compare to that when ksslw was used which does not react with CH and also and also does not makes extra C-S-H gel.

The study suggests in accordance to the above described tests and their results that light weight concrete made using kota stone slurry has potential to be used in low cost residential structures. Further scope of the study would include to study thermal insulation properties of the LWC for its use in mountainous regions.

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