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Structural and Impact Behaviour of Light Weight Self-Compacting Concrete

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***Abstract* – Self-Compacting Concrete (SCC) is one of the advanced type of concrete which is widely used in structures were congested reinforcements are provided. Generic self compacting concrete is found not to be suitable in certain cases and required modification needed is done by several researches. Once such modified SCC is Light Weight Self Compacting Concrete (LWSCC), in this research an attempt is being mode to produce LWSCC using various aggregates such as Pumice stone, Vermiculites and Perlite in the presence of synthetic super plasticizers. Initial test is to test the quality of aggregate were done as per Indian Standard Codes and results obtained were used in mix design. Preliminary sampling was done to check the suitability of the selected aggregates in producing LWSCC and it's found to be viable further studies will be done to obtain strength and impact behaviour of LWSCC using selected admixtures.**
***Keywords:* Self compacting concrete, Light weight self compacting concrete, Impact Behaviour of concrete, Flexural strength**

I. INTRODUCTION

A. Self-Compacting Concrete (SCC)

Self-Compacting Concrete is characterized by its high flow capacity and can therefore spreads through congested reinforcement, fills all open and confined corners of the form and consolidates only by its own self weight. It's usually higher in paste ratio and also it's contains some mineral addition such as natural pozzolan, slag, and silica fume. The integration of a high volume of fly ash had only a slight negative effect on workability, whereas a high Rice husk ash (RHA) volume tended to reduce both workability and segregation. RHA possibly will be used at a level of up to 25% and still gives satisfactory workability (Gritsada Sua-iam *et al.*, (2014)). SCC mixes containing 20% fine and coarse recycled concrete aggregates failed to satisfy the EFNARC requirements for SCC (Vinay Kumar, et al., (2017)).

B. Light Weight Concrete

Light weight concrete has recognized itself as a suitable construction material on every occasion savings the self weight of the structures and energy conservations are necessary, and whenever there is a large quantity of natural lightweight aggregates. They clarified the result of the bar diameter, embedded length in concrete, concrete strength, cover thickness and crack spacing on the bond strength. (Sancak, *et al.*, (2011)), reported lower bond strength for deformed bars in structural light weight concrete (SLWC) as compared with that of normal weight aggregate concrete (NWAC). They also observed that at the ultimate load the slip of ribbed bars for both NWAC and SLWAC specimens not very different. Field performance has demonstrated.

C. Aggregates Used In Concrete

Aggregates are the vital constituents in concrete. They supply suitable structure to concrete, reduce shrinkage and economically effective. in advance aggregates were measured as chemically inert substances however now it's been predictable that some of the aggregates are chemically lively and also that positive aggregates explicit chemical bond at the boundary of aggregates and paste. The easy truth that the aggregates occupy 70%-80% of the extent of concrete, there effect on various characteristics and houses of concrete is definitely large. To be acquainted with greater concerning the concrete it is very important that one have to know greater about the aggregates which constitutes important extent in concrete. Concrete can be considered as two component substances for ease paste part and combination element.

D. Light-Weight Aggregates

Lightweight aggregates able to be classified into two categories namely natural light-weight aggregate and artificial lightweight aggregates. Natural aggregates are not found in many places and aggregates are not of uniform quality. As such they are not used widely in making lightweight concrete. To avoid aggregates not to completely absorb the water needed for cement hydration and thus change the rheology of the concrete, it is necessary to pre-wet aggregates (dry). This quantity of water depending upon on the water absorbed by the dry aggregates 5 min after the immersion. The quantity of water depends on the aggregates moisture content.

E. Pumice Stones

Pumice is a mild and porous kind of pyroclastic igneous rock fashioned from the lava at some stage in the explosive volcanic eruptions. The pumice has a cell structure fashioned through the presence of molten lava flowing thru volcanoes, bubbles or air gaps while cooled (Kabay, *et al.*, (2015); Hossain, *et al.*, (2004)). Light-weight Pozzolanic substances may additionally have a few cementitious residences while made into very fine powder. At the equal time, its binding capacity increases at the same time as combined with cement and lime (Kabay, *et al.*, (2015); Sahin, *et al.*, (2008)).

F. Exfoliated Vermiculite

Exfoliated vermiculite is a mica-like mineral with shiny flakes which is one part of the phyllosilicate organization. It can be enhanced to 30 times its unique quantity while heated at 650–950◦C. The elevated vermiculite (EV) reveals prospective belongings as an example low thermal conductivity, low bulk density, persistence, chemical inertness and relatively excessive melting factor. The EV has density of only 60 to 130 kg/m^3. The concrete made with vermiculite as aggregate, therefore, will have low density and hence low strength. This concrete will be used for insulating purposes. It's also used for insitu roof and floor screeds or for the manufacture of blocks, slabs and tiles which are used for sound insulation. Vermiculite concrete products can be cut, sawn, nailed or screwed. This also to be used as a heat resistant material being non-inflammable. In india, mineral refining corporation at mysore produces vermiculite in many grades used for concrete industry.

G. Expanded Perlite

Perlite is a glassy volcanic rock that is considered a pozzolanic material due to its high SiO_2 and Al_2O_3 content (Rashad, (2016)). (Ramezanianpour, *et al.,* (2014)) exposed that calcined raw perlite rock play a role in increasing the durability of concrete. (Bektas, *et al.*, (2005)) showed with the use of both raw perlite rock and expanded perlite contains properties that can restrain the alkalie silica reaction. Though, (Yu *et al.,* (2003)) reported that natural perlite powder is characterized through its considerable pozzolanic effect for concrete. In accumulation, (Okuyucu *et al.,* (2011)) showed that natural perlite powder resulted in a considerable raise in the compressive strength of semi lightweight concrete mixtures as compared to the control mixtures.

II. MATERIALS

A. Ordinary Portland Cement

The specific gravity of Portland cement 3.15, standard consistency 30%, Initial and Final setting time 30 minutes and 1 hour, Fineness 1 g and Soundness test 1mm.

B. Fine Aggregate

The satisfactory mixture used in this research was fine river sand passing through 4.75 mm sieve with fineness modulus 3.69, particular gravity 2.60 and bulk density become 1.72

C. Coarse Aggregate

The specific gravity 2.8, crushing strength 6.7%, impact strength 29.6%, water absorption 2% were obtained from the test results.

D. Water

Potable water was considered throughout this test for diluting NaOH flakes, for manufacturing OPC concretes and for preparing destructive liquids.

E. Pumice Stone

Pumice is rich in silica, alkaline and has a significant sulfonium content. Among these aggregates, our choice focused on porous and mineral aggregates, pumice used directly in concrete, the value of the pumice density is 900 kg/m3. Pumice stone specific gravity is 2.3.

F. Vermiculite

Vermiculite is a mica-like mineral with shiny flakes which is one member of the phyllosilicate group. It can be expanded up to 30 times its original volume when heated at 650–950 C. EV in civil engineering field deals some potential advantages and some disadvantages. In this overview, the author summarizes the previous studies regarding to using EV as a construction material in traditional cementitious materials, geopolymers and other binders.(Rashad A M (2016)).Specific gravity of exfoliated vermiculite is 2.50.

G. Perlite

Different stages in the production of expanded perlite provide various types of waste by-products that could be used in the building industry, thus supporting a sustainable environment. In this study, the use of waste perlite powder (WPP) at a high content as a filler material in self-compacting concrete (SCC) was investigated (Ahmed, (2015)).Specific gravity of expanded perlite is 2.4.

III. METHODOLOGY

In this project initially we had done the basic tests for fine aggregate, coarse aggregate, cement, pumice stone, expanded perlite, exfoliated vermiculite. The tests like specific gravity, bulk density, fineness test were done for fine aggregate and the specific gravity, flakiness elongation, crushing value, water absorption, impact test, abrasion attrition, fineness modulus test were done for coarse aggregate and the specific gravity, consistency, initial setting time, fineness tests were done for cement. The mineralogical studies were analysed for pumice stone, expanded perlite, exfoliated vermiculite. And the specific gravity of pumice stone, expanded perlite, and exfoliated vermiculite also found.The conventional concrete was prepared for the mix design of M_{30} and the specimens like cube (9 no's), cylinder(9 no's), prism (9 No's), impact Specimen, (9 No's), Beam (9 No's) were moulded and allowed for curing in cold water.

In the fresh concrete Slum test, flow test, vee-bee consistometer, compaction factor tests were planned. Finally the Compression, Tension, Flexural test, for the specimens were analysed at 7th day, 14th day and 28th day. Then the self-compacting concrete was prepared for the mix design of M_{30} in which the coarse aggregate is replaced by pumice stone, vermiculate and perlite at various percentages like each 2.5%, 5%, 7.5%, 10%, 12.5% and 15%. In the fresh concrete Slum test, flow test, vee-bee consistometer, compaction factor tests were planned and the specimens like cube (9 No's), cylinder (9 No's), prism (9 No's), impact Specimen, (9 No's), Beam (9 No's) for each percentage were moulded and allowed for curing in cold water. Finally the Ultrasonic Pulse Velocity, Rebound hammer, Compression, Tension, Flexural test, Crack nature, Deflection, Durability for the specimens were analysed at 7th day,14th day and 28th day.

IV. RESULTS AND DISCUSSION

A. Tests on Fresh Concrete

1. Slump cone test

The mould for the slump test is a frustum of a cone, 30 cm of height. The base is 20 cm in diameter and it has a smaller opening at the top of 10 cm. The slump diameter obtained 6.0 to 6.5 cm for 2.5% to 15%.

2. Compaction factor Test

$$\text{Compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

The compaction factor value increases adding these aggregates in various percentage

3. Test on Hardened Concrete

Various tests on hardened concrete is done to find the strength and durability of concrete is achieved. A most hardened concrete tests are Compressive Strength Test, Split Tensile Strength Test, Flexural Strength test for prism

4. Compressive Strength

For cube compression tests, concrete cube size of 100mm was employed. The test was conducted as per IS 516-1959 provision.

Compressive strength = Load/Area in N/mm^2

B. Split Tensile Strength

The test was as per IS 5816-1999 codal provision. Split tensile strength is one of the basic and important properties of the concrete.

Split tensile strength= $2P/(\pi dl)$ in N/mm^2

Where, P - Crushing load in N, d - Diameter of the specimen in mm. l - Length of the specimen in mm

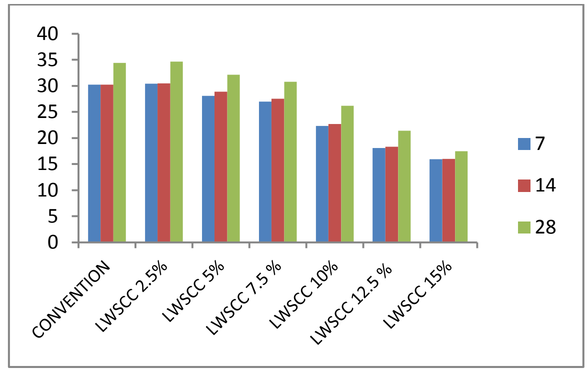

Fig. 1 compression test results of conventional and LWSCC

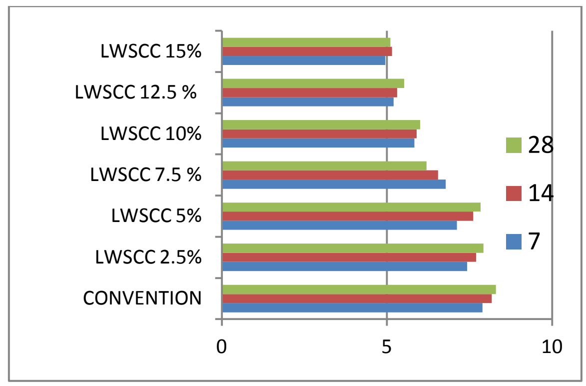

Fig. 2 Weight of cube

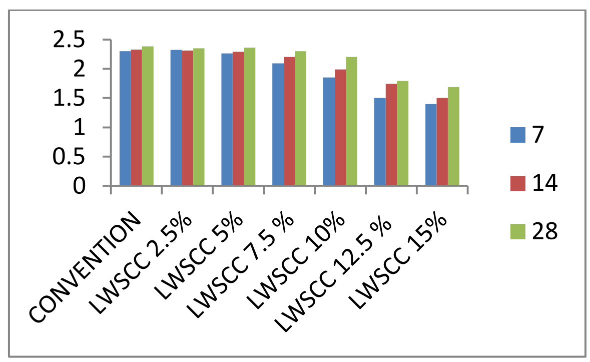

Fig. 3 Split tensile strength test results of conventional and LWSCC

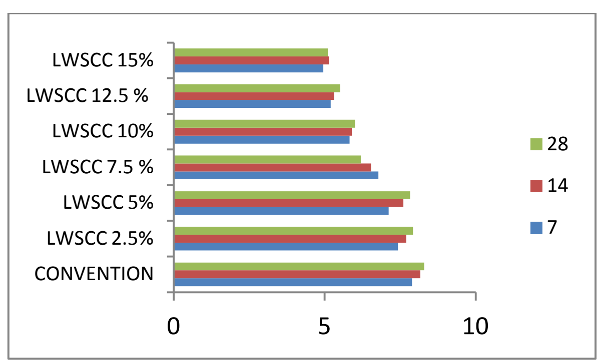

Fig. 4 Weight of cylinder

C. Flexural Strength on prism specimens

Flexural strength, also known as modulus of rupture or fracture strength. It is a mechanical parameter for brittle material and is defined as a material's ability to resist deformation under load. Flexural strength represents the highest stress experienced within the material at its moment of rupture. Test was as per IS 516-1959 codal provision.

Flexural strength $f_{cr} = Pl/bd^2$ in N/mm^2

Where, P – Ultimate load applied to the specimen in N
l – Length of specimen between supports in mm
b – Breadth of the specimen in mm.

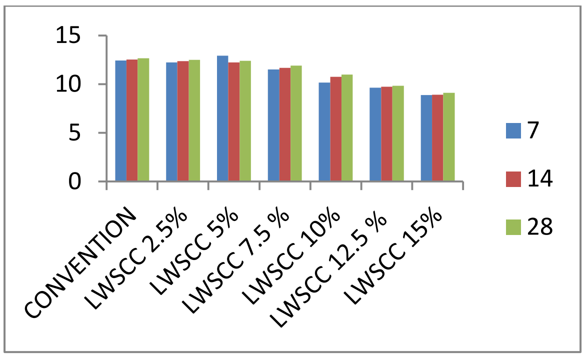

Fig. 5 Flexural strength test results for conventional and LWSCC

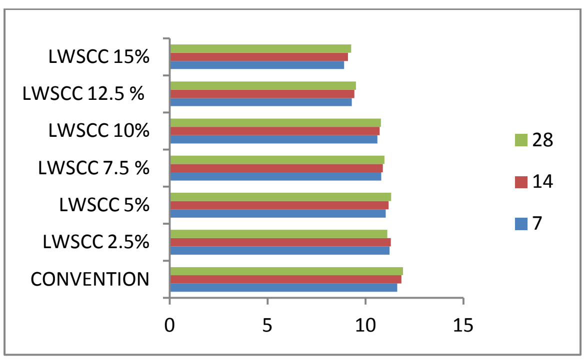

Fig. 6 Weight of prism

D. Impact test on cylinder

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force. Test measures the impact energy or energy absorbed prior to the fracture. Impact energy is a measure of the work done to fracture a test specimen. Cylinder mould of size 100 mm diameter and 64mm height is used for this study. The discs adopted to drop weight test following the guidelines of ACI committee 544.2R-89. The test conducted of repeated application of impact load in the form of blows, using a 44.5 N hammer falling from 457 mm height on the steel ball of 63.5mm diameter, placed at the centre of the top surface of disc. The impact energy was calculated for each concrete specimen using the following equations,

Impact energy $U = nMV^2/2$

Where n- Number of blows,
M- Mass of hammer,
V- Velocity of hammer at impact.
H- Falling height

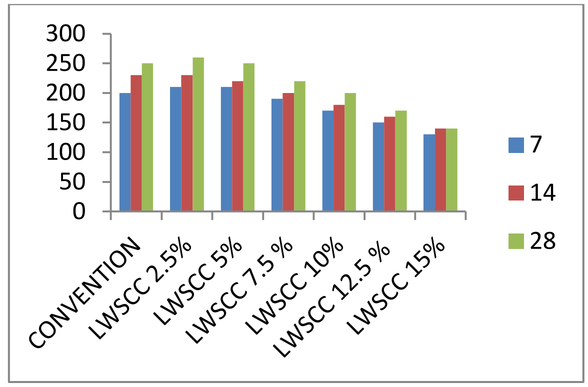

Fig. 7 Impact test on cylinder (Impact Energy in KNmm)

E. Flexural Strength on beam specimens

Flexural strength, also known as modulus of rupture or fracture strength. It is a mechanical parameter for brittle material and is defined as a material's ability to resist deformation under load. Flexural strength represents the highest stress experienced within the material at its moment of rupture. Test was as per IS 516-1959 codal provision. It is a measure of a reinforced concrete beam or slab to resist failure in bending. Flexure strength was measured by loading 150 mmx150mm x700mm concrete beams with a span at least three times the depth. Flexural strength was measured as modulus of rupture. Test specimen was cured for 28 days and tested for maximum load.

Flexural strength $f_{cr} = Pl/bd^2$ in N/mm^2

Where, P – Ultimate load applied to the specimen in N
l – Length of specimen between supports in mm
b – Breadth of the specimen in mm.

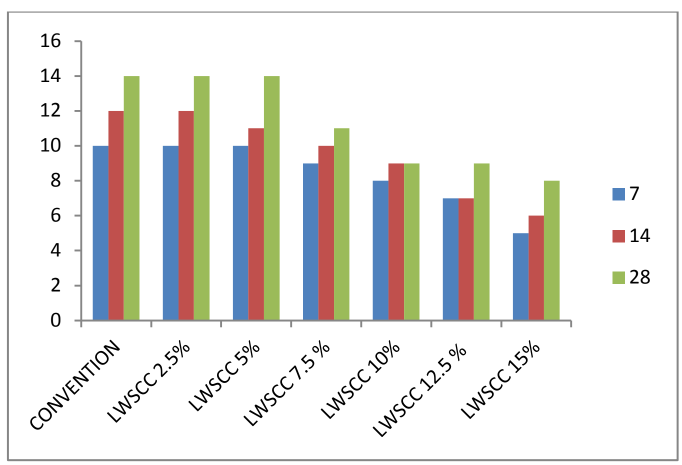

Fig. 8 Flexural strength of concrete beams

V. CONCLUSION

The experimental results of Light Weight Aggregates and super plasticizer as a admixture in concrete is presented in this work. The comparison of mechanical properties and behavior of the ordinary concrete and replacement of aggregates in concrete is discussed. The fresh and hardened concrete properties are analyzed and compared for all the trials.Use light weight aggregate replacement for course aggregate varying percentage like 2.5% to 15%. Up to 7.5 % replacement gave good results. Use light light weight aggregates produced light weight concrete. The 15% replacement produced light weight concrete but the hardened properties values are less.

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