Analytical Study on Conventional Concrete and Self-Compacting Concrete with Partial Replacement of Cement using Seashell Powder and Fly ash

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Abstract **- Self-compacting concrete, as the name indicates, it is a type of concrete that does not require external compaction, because it becomes levelled and compacted under its self- weight. The objective of the Analytical work is to study valuation of Conventional Concrete and Self-compacting concrete by statistical analysis containing with partial replacement of Sea shell Powder & fly ash as cement. Mix design for Self-compacting concrete was done based on IS 10262:2009 & "EFNARC guidelines". This project is about the exploratory study on the suitability of the Seashell powder and fly ash as partial replacement in concrete. The main objective is to encourage the use of these products as construction materials in low-cost building. In this research work, experiments have been conducted with collected materials and the preliminary data obtained by various physical tests. The test samples suitable to the experiment are selected. In this project, Cement is replaced with 3%, 6%, 9%, 12% of Seashell powder and replaced with Constant level of 15 % by Fly ash. Further the concrete is produced with various proportions and tested and compared with conventional concrete.**

Key Words: **Seashell Powder, Fly ash (Class F), Self-compacting concrete, Superplasticizer etc.**

1. INTRODUCTION

Self-compacting concrete (SCC) can be defined as fresh concrete that flows under its own weight and does not require external vibration to undergo compaction. It is used in the construction where it is hard to use vibrators for consolidation of concrete. Filling and passing ability, segregation resistance are the properties of self- compacting concrete. SCC possess superior flow ability in its fresh state that performs self-compaction and material consolidation without segregation issues. The materials, tests and properties of self-compacting concrete are explained in the below sections.

2. OBJECTIVE OF STUDY

[1] To study the fresh & mechanical properties of SCC.
[2] To investigate the performance of SCC with fly ash, sea shell powder & cement.
[3] Experimenting the concrete mix containing sea shell powder 3% ,6% ,9% and 12% as partial replacement of cement & 15% replaced fly ash of cement.
[4] Analyzing and studying the effect of varying percentages of seashell powder and fly ash and comparing the results with Conventional concrete.
[5] To obtaining the optimum percentage of sea shell powder & fly ash based upon the results.

3. LITERATURE REVIEW

Uchechi G. Eziefula , John C. Ezeh And Bennett I. Eziefula - Construction and Building Materials directed towards sourcing alternative sustainable materials for concrete in order to minimize over-reliance on natural resources. Many of the substitute materials used for producing green concrete are recycled materials obtained from industrial wastes and by-products. A promising solution to the challenge of seashell waste management involves utilizing seashells as construction materials in concrete. Experimental investigations have been carried out on the use of mollusk seashells such as periwinkle shell, mussel shell, oyster shell, cockle shell, crepidula shell, clam shell and scallop shell as aggregate replacement materials in concrete. The seashells were utilized as partial or total replacement of fine and coarse aggregates in concrete. Mollusk seashells have similar chemical composition with limestone-type aggregates but characteristically contain traces of chloride and sulphate salts. Although inclusion of seashell aggregate reduces the mechanical properties of concrete, utilizing some seashells as partial coarse aggregate at up to half substitution level can produce normal-weight concrete for non-structural and low-strength structural functions.

R. Yamuna Bharathi1, S. Subhashini, et.al-The percentage of seashell, is varied from 3% to 11%. Also the cement is replaced for 25% of fly ash. This reduces the construction cost by reducing the cost of cement and coarse aggregate and it also reduces the environmental pollution due to fly ash and seashell.

L. Senthil Nathan -Conducted an experimental study for increasing the compressive strength in concrete with partial replacement of cement in concrete by seashell powder. The cement is partially replaced with the seashell powder by 5%, 10%, 15%, and 20 % by weight of cement at the curing date 7, 14, and 28 days. Finally they concluded that as the curing date increases the strength of concrete increases and the maximum compressive strength is obtained when 20% replacement of cement by seashell powder.

Shivkumar Sahani Malik Mohammad Suhail, et.al-The fly ash has been used at 30% & 35% by mass of cementitious material. The production of Portland cement, the most commonly used cement in construction, is a significant source of carbon emissions. The use of fly ash as a replacement for cement in concrete reduces the carbon footprint of construction projects.

Monita Oliviaa Et. Al -In this study, the effect of replacing cement by ground seashell on the mechanistic properties of concrete was examined. In order to obtain the optimum cement replacement, the cement was replaced by 2, 4, 6 and 8% by weight with the ground sea shells. The optimum cement replacement of 4% was used to investigate the mechanical properties of the seashell concrete. The tensile and flexural strength of the seashell concrete were higher than the control concrete. The Young's Modulus of Elasticity of seashell concrete increased with the age of concrete.

Dr. P. Paramaguru, Mr. R. Uthirapathi, -Initially, conventional M25 cubes were cast and tested to compare the results of various replacements. The 10% replaced seashell powder concrete showed good results compared to other replacements. Partial replacement of wood ash with sand up to 15% is effective. From this, it is known that seashell powder and wood dust can be partially replaced for cement and sand and it can be considered as an alternative.

R.E. Philleo-studied fresh and hardened properties of fly ash in concrete and revealed that fly ash has a significant effect on the properties of fresh and hardened concrete the workability of the fly ash concretes was found to be much better, and the water requirement was lower, the rate and volume of the bleeding water were either higher or about the same, and the setting was slower, depending on the type and properties of the fly ash and the mix proportion.

Marthong C And Agrawal T.P- have stated that the normal consistency increases with an increase in the grade of cement and fly ash content. Setting time and soundness decreases with the increase in the grade of cement. The use of fly ash improves the workability of concrete and workability increases with the decrease in the grade of cement. Bleeding in fly ash concrete is significantly reduced and other properties like cohesiveness, pumping characteristics, and surface finish are improved.

M.L Gambhir - Compressive strength of concrete increases with the grade of cement. As the fly ash content increases in all grades of Ordinary Portland Cement (OPC), there is a reduction in the strength of the concrete. The rate of strength gain of concrete with age is almost similar in all three grades of OPC. Concrete with 20% fly ash content closer to that of ordinary concrete at the age e of 90 days. In all grades of OPC, fly ash concrete is more durable as compared to OPC concrete, and fly ash up to 40% replacement increases with the grade of cement. Shrinkage of fly ash concrete is like pure cement concrete in all grades of OPC.

4. MATERIALS USED

CEMENT- Selection of type of cement mainly depends on the specific requirements of concrete. It determines the strength and properties of fresh and hardened concrete. Cement used for all the specimens were ordinary Portland cement (53 grade).

FINE AGGREGATE-Among various characteristics, the most important for SCC is its grading. Fine aggregates used for SCC should be properly graded to give the minimum voids ratio and shall be free from deleterious materials like clay, silt content and chloride contamination. The fine aggregates used in SCC can be either natural aggregates or manufactured aggregates (M- Sand) with a uniform grade. The fine aggregates with particle size less than 0.125mm are generally employed.

COARSE AGGREGATE–The coarse aggregate is the strongest and least porous component of concrete. Some important properties of coarse aggregates like crushing strength, durability modulus of elasticity, gradation, shape and surface texture characteristics, percentage of deleterious particles and flakiness and elongation indices need special consideration while selecting the aggregates for SCC.

FLY ASH- Fly ash is the finely divided that results from the combustion of pulverized coal that is carried from the combustion chamber of a furnace by exhaust gases. Fly ash classifies as F, CL, or CH by its calcium oxide content. Type F refers to fly ash with CaO content less than 8%, Type C has a CaO content ranging from 8 to 20%. Higher CaO content generally denotes higher self-cementing properties. Two types of fly ash are produced and used: Type F and Type C.

Figure 1 Fly ash (Class F)

SEA SHELL POWDER - Seashell Powder is derived from natural sea shell. It is a rich source of calcium. Sea shell is a waste obtained near the seashore area as the result of disintegration of dead animals. Seashell consists of three layers outer, intermediate and inner layer. Outer layer is made up of calcite material whereas inner layer is otherwise known as nacre which is made up of calcium carbonate. Since 95% of calcium carbonate present in sea shell, it has the strength nearly equal to coarse aggregate.

Figure 2 Seashell Powder

WATER- Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrates cement gel. The requirements of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up only formation of undesirable voids in the hardened cement paste concrete.

SUPER PLASTICIZERS- Super plasticizer is a chemical admixture used in concrete to give workability to SCC. Different bases of New Generation Super plasticizers or High-Water Reducing Agents (HWRA) have different water reduction capacities. The advantage of this is water reduction which can be taken either to increase the strength as in High Strength Concrete or to obtain a better flow ability. The major mechanism was absorption of super plasticizer on the cement grain which leads to electro-static repulsion. Super plasticizer is a low-cost water reducer which can be used to get one or more combination of benefits.

5. FINITE ELEMENT MODELLING ABAQUS AND VALIDATION

ABAQUS 6.13 is software suitable for finite element analysis. It can be used for both static and dynamic problems. The Abaqus product suite consists of five core software products.

[1] Abaqus/CAE (Complete Abaqus Environment) – It is a software application used for both the modelling and analysis of components and assembling (pre- processing) and visualizing the finite element analysis result. A subset of Abaqus/CAE including only the post-processing module can be launched independently in the Abaqus/viewer product.

[2] Abaqus/standard – a general-purpose finite element analyzer that employs implicit integration scheme.

[3] Abaqus/explicit – a special purpose finite element analyzer that employs explicit integration scheme to solve highly non-linear systems with many complex contacts under transient loads.

[4] Abaqus/CFD – a computational fluid dynamics software application which provides advanced computational fluid dynamics capabilities with extensive support for pre-processing and post-processing provided in Abaqus/CAE.

[5] Abaqus/electromagnetic – a computational electromagnetics software application which solves advanced computational electromagnetic problems.

6. PROCESSING STEPS IN ABAQUS

Pre-processing- In this stage, the model of the physical problem is defined and an Abaqus input file was created. The model is usually created graphically using Abaqus/CAE.

Simulation- The simulation, which normally is run as a background process, is the stage in which Abaqus/Standard or Abaqus/Explicit solves the numerical problem defined in the model.

Post processing- The results can be evaluated once the simulation has been completed and the displacements, stresses, or other fundamental variables have been calculated. The evaluation is generally done interactively using the Visualization module of Abaqus/CAE or another postprocessor. The Visualization module, which reads the neutral binary output database file, has a variety of options for displaying the results, including color contour plots, animations, deformed shape plots, and X-Y plots.

7. MATERIAL PORPERTIES USED IN ABAQUS

S. No	Properties	Normal Concrete	Self-Compacting Concrete	Steel
1.	Grade	M25	M25	Fe500
2.	Density	2.5e-9 tone/mm^3	2.3e-9 tone/mm^3	7.85e-9 tone/mm^3
3.	Young's modulus	25000 N/mm^2	23750N/mm^2	210000 N/mm^2
4.	Poison ratio	0.2	0.2	0.3
5.	Yield stress	25 N/mm2	25 N/mm2	500 N/mm2
6.	Plastic strain	0	0	0

8. VALIDATION RESULTS OF CC BEAM MODEL

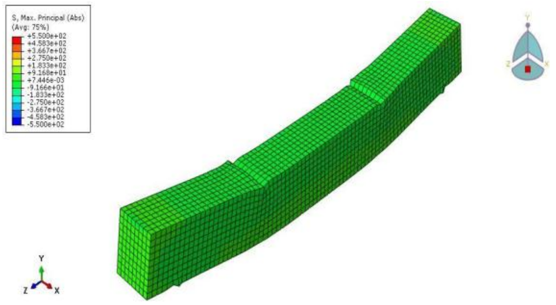


Fig. 3 Stress representation of CC beam

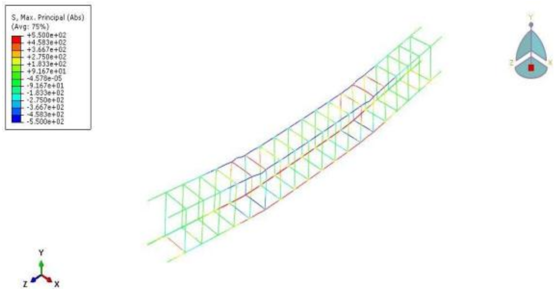


Fig. 4 Stress representation of CC reinforcement

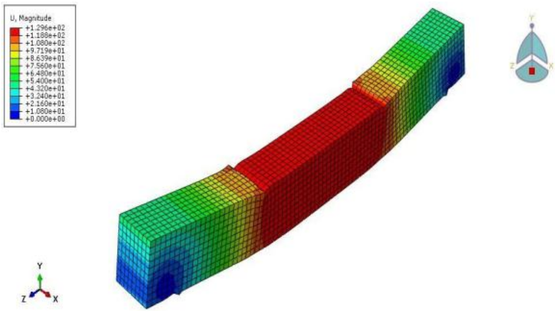
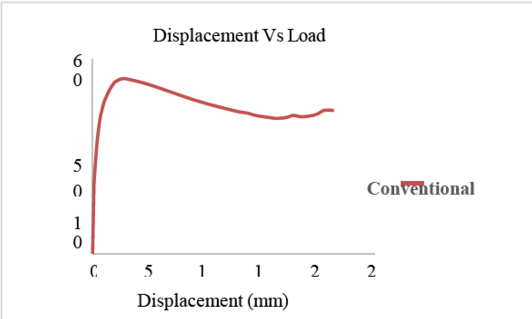


Fig. 5 Displacement representation of CC beam



9. VALIDATION RESULTS OF SCC BEAM MODEL

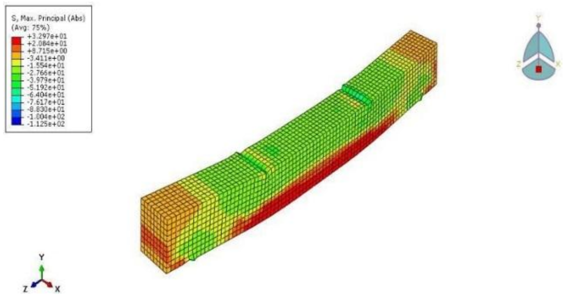


Fig. 6 Stress representation of SCC beam

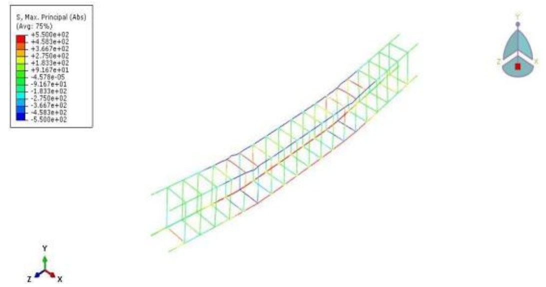


Fig. 7 Stress representation of SCC beam reinforcement

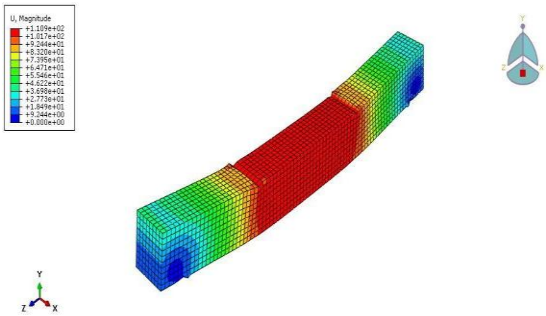
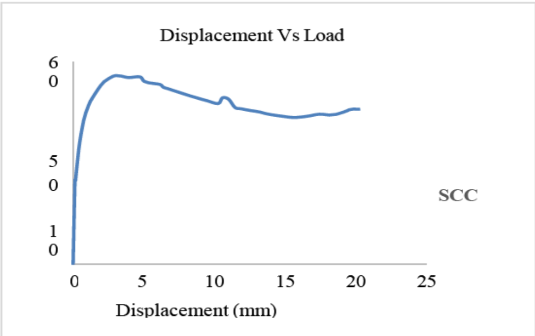


Fig. 8 Displacement representation of SCC beam



10. CONCLUSION

[1] The Numerical Analysis of both conventional concrete beam and self-compacting concrete beam with seashell as a partial replacement to cement of dimension 230mm x 300mm x 2400mm (b x d x l) has been analyzed by using ABAQUS software.

[2] The material characteristics are determined by laboratory tests and experiment, by using this test results the mix proportion for grade of concrete M25 has been arrived.

[3] For the numerical analysis validation is done. The variation is 2.5% to experimental work entitled as “An experimental study on flexural behavior of RC beams”. The numerical analysis results show the maximum ultimate load is 54.04 kn and displacement is 27.2 mm.

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