STUDIES ON ANALYSIS OF BEAM USING MECHANICAL PROPERTIES OF SELF-COMPACTING CONCRETE WITH FOUNDRY SAND AND BASALT FIBRE

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Abstract - The paper represents a studies on mechanical properties of self-compacting concrete with foundry sand and basalt fibre. Foundry sand consists of silica sand, burnt carbon, residual binder and dust. It increases the strength and durability properties of concrete. In this study, foundry sand is fully replaced with fine aggregate and varying percentage of calcite powder and quartz powder is partially replaced with cement by addition of 0.75% of basalt fibre. Mix-1 (2.5% C.P +15% QP), Mix-2 (2.5% C.P +20% QP), Mix-3 (5% C.P +10% QP), Mix-4 (10% C.P +10% QP).Sika Viscocrete 20HE is used as superplasticizer. Total 8 number of cubes and cylinders is casted for M30 grade of concrete. The specimens are tested for 7days and 28 days after curing. The slump flow test, V-funnel test, L-box test and U-box test were conducted. The results, shows that it holds good parameter on fresh property test and also increases the strength of harden property. The investigation shows reduction in segregation resistance as it holds to be homogeneous and carbon dioxide emission is also reduced. In addition to this, An ANSYS modelling of concrete beam is done in order to determine the analysis of the structural member.

***Key words* - Self-compacting concrete, spent foundry sand, basalt fibre, calcite powder, quartz powder, ANSYS modelling.**

1. INTRODUCTION

Concrete can be considered as the most widely used material in the construction industry. Concrete is a construction substance consisting of cement, aggregate, water, and admixtures. The use of large quantity of cement results in carbon dioxide emission and greenhouse effect. The use of environmentally friendly technologies, such as supplementary materials, is expected to increase the quality of concrete mixtures. Self-compacting concrete or self-consolidating concrete is the recent innovative development of conventional concrete. In 1983, while investigating the durability of concrete structures in Japan, a major problem arose. The issue is that skilled labour is needed for adequate compaction in order to produce a durable concrete. So, in 1986, Okamura invented self-compacting concrete and he is known as the father of "SCC" technology. SCC is a non-segregating, highly flowable special concrete that can settle into formworks and encapsulate heavily reinforced, narrow and deep parts using its own weight without the use of any external vibrating equipment.

2. OBJECTIVE

- To study the mechanical properties of self-compacted concrete in its fresh and harden state.
- To study the different strength properties of self-compacted concrete using spent foundry sand as full replacement of F.A.
- To determine better flow-ability, filling ability and passing ability of self-compacting concrete.
- To analyses the concrete beam specimens using ANSYS software.

3. SCOPE

- Conventional fine aggregate usage can be avoided by using spent foundry sand.
- Increases flexural properties of SCC by using basalt fibres.
- Conventional fine aggregate usage can be avoided by using spent foundry sand.
- Emission of carbon di oxide can be reduced.

4. MATERIALS USED

4.1 CEMENT

Ordinary Portland cement of 53 grade is used in this project for casting all the specimens. As the concrete hardens, the cement and water combine to form a paste that binds the other materials together. The physical properties of cement are shown in Table 1

Table-1: Physical Properties of Cement

Properties	Values
Specific gravity	3.15
Bulk density	14440 Kg/m^3
Initial setting time	30min
Final setting time	600min

4.2 COARSE AGGREGATE

Coarse aggregate conforming to EN 12620 are appropriate for the production of SCC. When compared to normal vibrated concrete, the amount of coarse aggregate used in self-compacting concrete is much lower. In this study, coarse aggregate of 10mm size is used for Self Compacting Concrete in accordance with standard specifications. To prevent aggregate blocking and to ensure the SCC mix's flow-ability and passing ability. The physical properties of coarse aggregate are shown in Table 2

Table-2: Physical Properties of Coarse aggregate

Properties	Test results
Specific gravity	2.94
Compacted bulk density	1.5kg/l
Loose bulk density	1.37kg/l
Water absorption	11.11%
Impact factor	24.18%

4.3 QUARTZ POWDER

Quartz is a hard, crystalline chemical compound made up of one silicon atom and two oxygen atoms joined together in a SiO2 silicon-oxygen tetrahedral structure. Quartz, also known as silica powder, is used to make float glass, fibre glass, automotive glass, and other forms of glass. Quartz is used extensively in the electronic industry. The specific gravity of quartz powder is 2.61. The chemical composition of quartz powder is shown in Table 3

Table-3: chemical composition of quartz powder

Composition	Quartz (%)
SiO_2	99.4%
Al_2O_3	0.07%
TiO_2	0.04%
CaO	0.01%
MgO	0.01%
L.O.I.	0.28%
Alkalies	0.28%
Fe_2O_3	0.04%
MESH	100M

4.4 CALCITE POWDER

Calcite is the most stable polymorph of calcium carbonate and a carbonate mineral (CaCO3). The filler content calcium carbonate powder enhances the hydration rate of the cement compound and thus increases the strength at an early age. Calcite powder has a beneficial effect on sulphate resistance. Calcite prevents concrete from bleeding when the cement content and the susceptibility is low. Chemical composition of calcite powder is shown in Table 4

Table-4: chemical composition of calcite powder

Composition	Calcite (%)
$CaCO_3$	93% - 96%
MgO	1.52%
Silica	1% - 2%

4.5 FOUNDRY SAND

Foundry sand is a by-product of the production of both ferrous and nonferrous metal castings. It is high-quality silica sand with uniform physical properties. Metals are casted into specific shapes using the foundry sand casting process by melting into a liquid and then pouring it into the mould. After the metal has solidified as it cools, the mould material is removed. It is essentially a fine aggregate that can be used in a variety of applications such as natural sands as well as manufactured sands. In the current study, fine aggregate is totally replaced with Foundry sand to increase mechanical strength parameters while maintaining good flow-ability, passing ability, filling ability, and segregation resistance. The physical properties and chemical composition of spent foundry sand are shown in Table 5 and Table 6

Table-5:Physical Properties of spent foundry sand

Properties	Test results
Specific gravity	2.32
Fineness modulus	4.31

Table-6: chemical composition of spent foundry sand

Component	Percentage
O (SiO_2)	70.58%
Na (Albite)	1.56%
MgO	1.290%
Al_2O_3	5.20%

SiO_2	15.75%
Ca(Wollastonit)	0.62%
Fe	3.97%

4.6 BASALT FIBRE

Basalt fibre is made from a single material, crushed basalt, and has better physical and mechanical properties than fibre glass. Its characteristics vary depending on the source of the lava, the rate of cooling, and its historical exposure to the elements. Basalt fibre is used in Fibre Reinforced Polymer and Structural Composites, both of which have a high potential and are receiving a lot of attention. The chemical composition of basalt fibre is shown in Table 7

Table- 7: chemical composition of basalt fibre

Composition	Basalt (%)
SiO_2	50.6%-60.3%
Al_2O_3	13.6% - 19.3%
TiO_2	0.8% - 2.24%
CaO	5.8% - 9.5%
MgO	3.0% - 5.3%
$FeO + Fe_2O_3$	9.0% - 15.0%
$Na_2O + K_2O$	0.8% - 2.26%
Others	0.09% - 0.13%

4.7 SUPER PLASTICIZER

Sika Viscocrete 20HE is a third-generation High Performance super plasticizer that is ideal for the manufacture of concrete and mortar mixes. It has a strong early strength growth, a powerful water reduction, and excellent flowability.

5. MIX PROPORTION

Replacement ratio of calcite powder and quartz powder with cemen are shown in Table 8

Table-8 mix proportion of self-compacting concrete

Percentage Replacement of Calcite	Percentage Replacement of Quartz	Cement (kg)	Calcite Powder (kg)	Quartz Powder (kg)
2.5%	15%	6.65	0.22	1.33
2.5%	20%	6.875	0.22	1.77
5%	10%	7.5	0.5	0.97
10%	10%	7.08	0.97	0.97

6. RESULT AND DISCUSSION

6.A. FRESH PROPERTIES OF SCC

SCC containing 100 percent foundry sand was tested for Slump flow, V-funnel, L-Box, and U-box. The fresh properties of self-compacting concretes with foundry sand are shown in the Table 9.

- Flow times in the V-funnel ranged from 6 to 10 seconds.
- The investigation's test results revealed that all SCC mixes met the permitted flow time criteria.
- The L-box ratioH2/H1 for the mixes in the above results was greater than 0.8, which is in accordance with EFNARC guidelines.
- There was a U-box difference in the height of concrete in two compartments in Properties of Self-Compacting Concrete.
- In terms of slump flow, all SCCs demonstrated satisfactory slump flows within the prescribed range, indicating good deformability.
- For the flow-ability and passing ability, all of the fresh properties of concrete values were in good alignment with the European guidelines' values.

Table 9 fresh properties of scc

S. NO	COMBINATIONS	SLUMP FLOW (sec)	V-FUNNEL (sec)	L-BOX	U-BOX (cm)
1	SCC	5	6	0.9	31
2	MIX 1	6	7	0.85	32
3	MIX 2	8	6	0.91	32
4	MIX 3	9	10	0.93	34.5
5	MIX 4	11	11	0.91	35.5

6.B. HARDEN PROPERTIES OF SCC

1.COMPRESSIVE STRENGTH TEST

Compressive Strength of M30 grade concrete mixes with 100% replacement of fine aggregate using foundry sand and 0.75% of basalt fibre. Mix-1 (2.5% C.P +15% QP), Mix-2 (2.5% C.P +20% QP), Mix-3 (5% C.P +10% QP), Mix-4 (10% C.P +10% QP) at 7th and 28th days strength are given in Table 10

Table 10 compressive strength test results

S. N O.	Combination	Compression Test	
		7 Days Result (N/mm²)	28 Days Result (N/mm²)
1.	Mix–1	23.65	31.80
2.	Mix–2	25.82	35.10
3.	Mix–3	21.5	31.9
4.	Mix–4	19.7	29.01

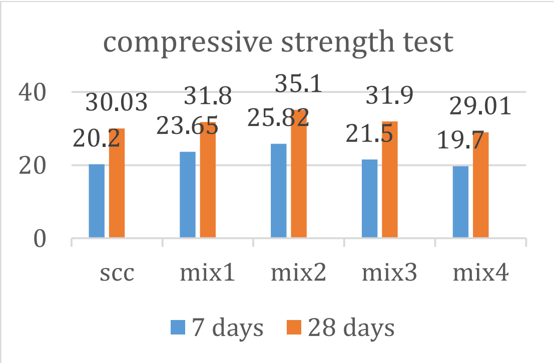

Chart-1: shows compressive strength test results

2.SPLIT TENSILE STRENGTH TEST

Split Tensile Strength of M30 grade concrete mixes with 100% replacement of fine aggregate using foundry sand and 0.75% of basalt fibre. Mix-1 (2.5% C.P +15% QP), Mix-2 (2.5% C.P +20% QP), Mix-3 (5% C.P +10% QP), Mix-4 (10% C.P +10% QP) at 7th and 28th days strength are given Table11.

S. NO.	ombination	Split tensile strength Test	
		7 Days Result (N/mm²)	28 Days Result (N/mm²)
1.	Mix–1	2.2	3.45
2.	Mix–2	2.42	3.71
3.	Mix–3	1.62	3.34
4.	Mix–4	1.40	2.89

Table -11: split tensile strength test results

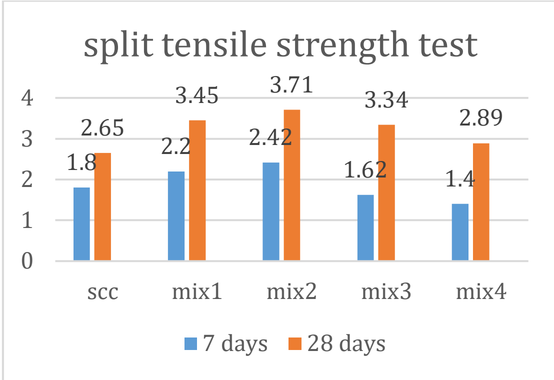

Chart-2: shows split tensile strength test results

7. FINITE ELEMENT ANALYSIS

For numerical analysis, ANSYS workbench finite element software were used. Column of 150mm x 200mm with length 1500mm was designed. Material Properties were taken and the acting force reaction was applied. The acting internal force reaction is considered for the effect of displacement on the analysis of the structure. In concrete structures, the displacements are small when compared to the dimensions of the structure. The following figure shows the analysis of beam.

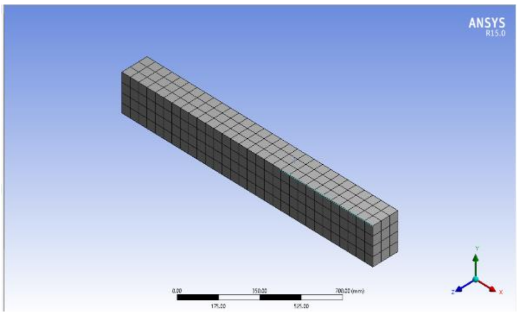

Fig-1: shows the modelling of beam

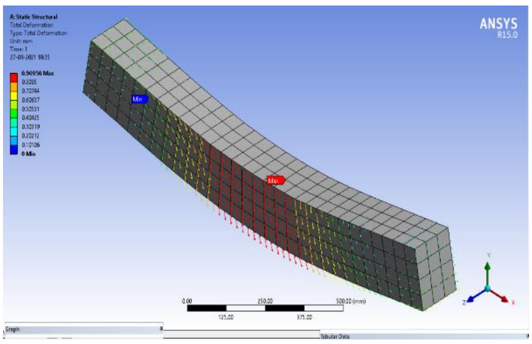

Fig-2: shows the loading pattern of beam

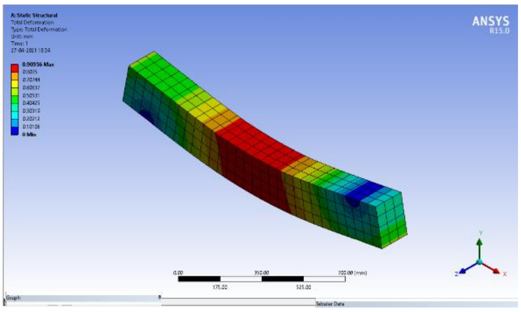

Fig -3: shows the total deformation of beam

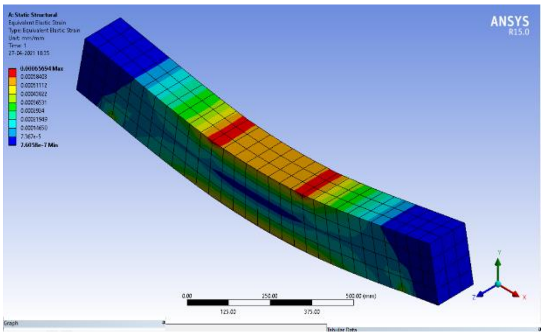

Fig-4: shows the equivalent elastic strain

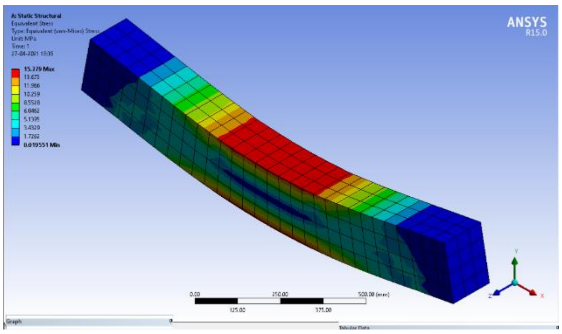

Fig-5: shows the equivalent stress

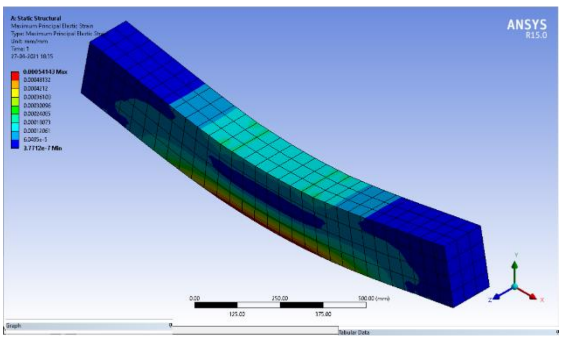

Fig -6: shows the maximum principal elastic strain

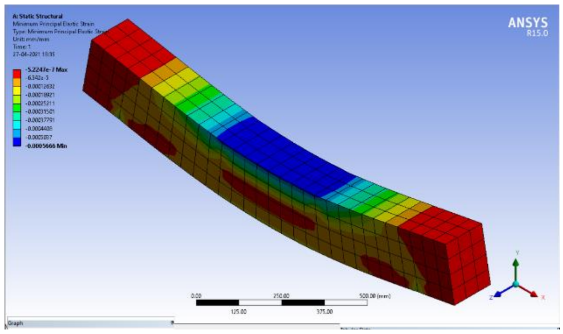

Fig -7: shows the minimum principal elastic strain

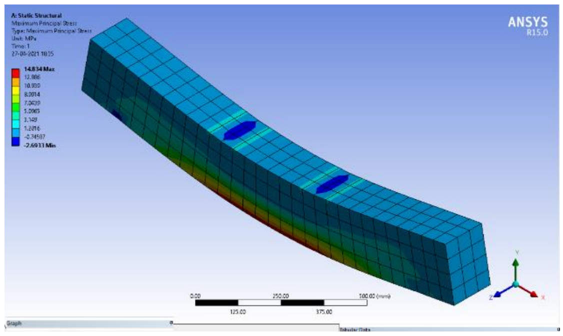

Fig -8: shows the maximum principal stress

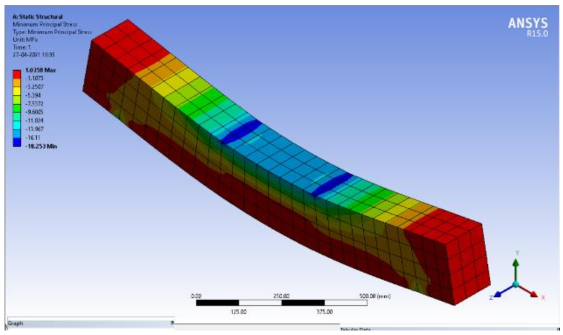

Fig -9: shows the minimum principal stress

8. CONCLUSIONS

Based on the experimental investigation results, the following conclusions were drawn for self-compacting concrete.

1. The compressive strength and split tensile strength is increases at 100% replacement of spent foundry sand with 0.75% of basalt fibre.

2. The maximum compressive strength and split tensile strength at 7 days is observed as 25.82(N/mm^2) and 2.42(N/mm^2) and in 28 days the maximum compressive strength and split tensile strength is observed as 31.5(N/mm^2) and 3.71(N/mm^2) at 2.5% of calcite powder and 20% of quartz powder.

3. On further increasing the percentage of calcite and quartz powder will results in decrement of the strength of the self-compacting concrete.

4. The replacement of spent foundry sand with fine aggregate will give better result when compared with ordinary self-compacting control mix.

5. ANSYS workbench finite element software was used for the analysis of beam.

6. The total deformation, equivalent elastic strain, maximum and minimum principal elastic strain, equivalent stress and the maximum and minimum principal stress were obtained.

9. REFERENCES

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