EXPERIMENTAL INVESTIGATION AND ANALYSIS ON SELF COMPACTING CONCRETE USING INDUSTRIAL WASTES AND HYBRID FIBRES

Pooja S[1], Vennila A[2], Sree Vidya V[3]

[1]S. Pooja, Student, Department of Civil Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India..
[2]Mrs. A. Vennila, Assistant Professor, Department of Civil Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India.
[3]Mrs. V. Sree vidya, Professor, Department of Civil Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India

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***ABSTRACT* -** Over the past few decades, building activity has risen dramatically in almost all developing countries around the world. Because of its ever-increasing demand, cement is becoming a scarce product around the world. It's time to look for some substitute materials that can partially or completely replace cement and sand in concrete without compromising its consistency, strength, or durability and other characteristics. Self-Compaction Concrete (SCC) is used to save time and increase the filling ability of extremely congested structural members through its own weight without using vibration. The parameters of SCC strength were investigated. The use of foundry sand in concrete reduces the amount of natural river sand and M-sand used. Metakaolin provides strong concrete properties and decreases the amount of cement used. The reduction in usage of OPC cement reduces CO2 emissions, resulting in a more stable environment. By replacing fine aggregate with treated foundry sand and OPC with metakaolin, four different mixes were created in this project. OPC was replaced by metakaolin, and conventional fine aggregate was replaced by processed foundry sand (40 percent and 80 percent) (20 percent and 25 percent) Polypropylene fibre and glass fibre have been added to the mix. The properties of fresh concrete, such as flow capacity, filling ability, passing ability, and segregation resistance, were tested on those mixes, and the results were obtained. The properties of hardened concrete, such as compressive strength and split tensile strength, were also tested, and the results were obtained. Additional beam element analysis is carried out in ANSYS and ABAQUS.

Keywords: self compacting, concrete, fresh concrete, treated foundary sand, metakaolin, OPC, Polyrpopylene fiber, Glass fiber, ANSYS, ABAQUS.

I. AIM AND OBJECTIVE

This research looks at the possibility of using treated foundry sand and Metakaolin as a replacement for fine aggregate and cement with the addition of hybrid fibres. It also leads to decrease in the amount of river sand and cement used in self-compacting concrete.

II. INTRODUCTION

All of the building materials, such as cement, sand, and coarse aggregate, come from natural sources. There is a huge need to meet demand due to infrastructure growth. Concrete, as the most used building material, is used in a wide range of industries, contributing to the depletion of natural resources. Cement development is increasing, which has been depleting the environment. Self-compacting concrete (SCC) is a significant advancement in the building industry. The concrete, as the name implies, flows under its own weight without using any vibration. Where congested reinforcement is used and higher mechanical compaction is needed, this concrete type is commonly used.

SCC was first developed in Japan in the late 1980s and is primarily used in seismic regions for highly congested reinforced structures. Since the durability of concrete structures has become a major concern in Japan, proper compaction by skilled labourers is necessary to achieve long-lasting concrete structures. This requirement prompted the development of SCC, which was first published in 1989.

SCC provides several benefits to the Precast, Pre-stressed concrete, and Cast-in-Situ building industries.

Designing a suitable mix proportion and testing the properties of the concrete thus obtained are the most important tasks in producing SCC. In practise, SCC has a high fluidity, self-compacting efficiency, and segregation resistance in its fresh state, all of which contribute to reducing the risk of honey combing of concrete. With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures.

SCC also performs well in compression and can meet other building needs because its manufacturing meets structural design specifications. SCC has a higher degree of workability than IS 456:2000's "very high" degree of workability. If a concrete mix has the following features, it is known as Self-Compacting it has the following characteristics

- Filling ability
- Passing ability
- Segregation resistance

III. MATERIAL PROPERTIES

a) *Treated foundry sand*

Foundry sand is a high-quality silica sand that is bonded to form moulds for ferrous and nonferrous metal castings. The physical and chemical properties of foundry sand are largely determined by the form of casting process used and the industry sector from which it comes. It can be reused in foundries many times, but after a certain period of time, it becomes a waste material referred as used or spent foundry sand. It's a fine aggregate that can be used in a variety of ways, such as natural and processed sands. The sand was known as moulded sand until it became spent foundry sand. The moulded sand splits and becomes a treated sand after being treated with silica oil and carbon dioxide gas.

b) *Ordinary portland cement (opc)*

Cement is a bonding agent with cohesive and adhesive properties that allows it to bind together various construction materials and form a compacted assembly. This project makes use of OPC 53 Grade.

c) *Fine aggeregate (m – sand)*

In concrete building, manufactured sand can be used instead of river sand. Crushed hard granite stone is used to make manufactured sand. Crushed sand is cubical in form with grounded sides, cleaned, and graded for use as a building material. Manufactured sand (M-Sand) has a particle size of less than 4.75mm. IS 383:1970 has been verified for the sand used in this project.

d) *Coarse aggregete*

Aggregate sizes are usually limited to 20mm in diameter. For structures with congested reinforcement, a 10 mm aggregate is preferred. Aggregates with a scale greater than 20 mm should be used whenever possible. It is preferable to use cubical or rounded aggregate that has been well graded. Aggregates must be of consistent consistency in terms of shape and grading. The substance that passes through IS sieve no. 4.75 is termed as a coarse aggregate.The aggregate used in this project has a maximum size of 10 mm. IS: 383- 1970 should be used to measure the aggregates.

e) *Metakaolin*

The anhydrous calcined form of the clay mineral kaolinite is known as metakaolin. Metakaolin has a particle size that is smaller than cement but not as fine as silica fume. When used to replace cement at a percentage of 5 to 25% by weight, the resulting concrete is more cohesive and less likely to bleed. Pumping and finishing processes require less effort in pumping and finishing processes .The compressive strength of hardened concrete is also increased at this level of replacement.

f) *Polypropylene fiber*

Polypropylene is a 100% synthetic textile fibroid made up of approximately 85% propylene. Propylene is the monomer in polypropylene. Propylene is a chemical by-product. This project used a fibrillated polypropylene fibre with a length of 12mm and a diameter of 34 micron, as well as a low density of 0.9 KN/m3 was used in this project.

g) *Glass fiber*

Glass fibre is a substance made by allowing molten glass to pass through orifices before solidifying and being flexible enough to be used as a fibre. It has a diameter of 5 to 24 μmetres and its length is 6 milimeter.

h) *Water*

Generally, portable water that is suitable for use in concrete.

i) *Superplasticizer*

VMA (Sika viscocrete 20 HE) is a viscosity modifying agent. All Portland cements, including SRC, are compatible with Sika ViscoCrete Premier. It significantly enhances workability as a superplasticizer without adding water or increasing the chance of segregation. It can reduce water by up to 40% and improve 28-day strength by up to 40.

IV. EXPERIMENTAL INVESTIGATION

1. *Fresh concrete test*

Slump flow, V-funnel, U-Box, and L-box were checked using SCC containing different proportions of Treated Sand, Metakaolin, and the same proportion of Glass Fibre, Polypropylene Fibre. The table below shows the fresh properties of all Self-compacting concretes with treated foundry sand and metakaolin. In terms of slump flow, all SCCs had appropriate slump flows in the 3-6 second range. This indicates a high degree of deformability. EFNARC considers an SCC to be satisfactory if it lasts between 6 and 12 seconds. The V-funnel flow times ranged from 6 to 10 seconds. According to the findings of this investigation, all SCC mixes meet the criteria for allowable flow time. The L-box ratio H2/H1 for the mixes was greater than 0.8, as required by EFNARC.

Table 4.1 Fresh Concrete Properties

COMBINATIONS	SLUMP FLOW	L-BOX	V-CHANNEL	U-BOX
NOMINAL	4	0.8	5	30.5
MIX-1	7	0.8	6	32.5
MIX-2	9	0.78	7	33.3
MIX-3	11	0.75	9	34.6
MIX-4	13	0.71	11	36

2. *Hard concrete test*

a) *Compressive strength test*

The hardened properties of concrete are determined for different replacement percentages of treated sand and metakaolin. The following tests are completed at 7 and 28 days to assess the material properties of concrete.

- Compressive strength test
- Split tensile test

Compressive strength checks are performed on 150 mm x 150 mm x 150 mm cubes. The results are compared to the outcomes of a control combination of specimens. MIX-1 (TFS-40%, MK-20%, GF-0.125%, PF-0.125%), MIX-2(TFS-40%,MK-25%,GF-0.125%,PF-0.125%), MIX3(TFS80%,MK-20%, GF-0.125%, PF-0.125%), MIX-4(TFS-80%,MK-25%,GF-0.125%,PF-0.125%) at the age of 7, 28days are tabulated below.

Table 4.2 Compressive strength of Concrete

COMBINATIONS	COMPRESSIVE STRENGTH 7 DAYS STRENGTH (N/mm^2)	COMPRESSION STRENGTH 28 DAYS STRENGTH (N/mm^2)
NOMINAL	21	30
MIX-1	19	28
MIX-2	19.6	28.5
MIX-3	21	32.2
MIX-4	24	34

b) *Split tensile strength*

Concrete cylinder specimens with a diameter of 150 mm and a height of 300 mm were cast to determine the split tensile strength. The compression test results were used to cast the cylinders for the best results. The experiments were carried out on cylinders that were 7 and 28 days old. The effect of M30 Grade concrete mixes on split tensile strength MIX-1 (TFS-40%, MK-20%, GF-0.125%, PF-0.125%), MIX-2(TFS-40%,MK-25%,GF-0.125%,PF-0.125%), MIX3(TFS80% ,MK-20%, GF-0.125%, PF-0.125%), MIX-4(TFS-80%,MK-25%,GF-0.125%,PF-0.125%) at the age of 7, 28days are tabulated below.

Table4.3 Split Tensile Strength Test Results

COMBINATIONS	SPLIT TENSILE STRENGTH 7 DAYS STRENGTH (N/mm^2)	SPLIT TENSILE STRENGTH 28 DAYS STRENGTH (N/mm^2)
NOMINAL	1.8	2.7
MIX-1	1.52	2.2
MIX-2	1.7	2.5
MIX-3	1.9	3.6
MIX-4	2.5	3.9

V. ANALYTICAL RESULTS

a) *ANSYS analysis*

The finite element method is a numerical analysis technique for obtaining approximate solutions to a broad range of engineering problems that can be performed using a variety of tools. The basic idea behind this research is that the structure is divided into a finite number of elements with finite dimensions, reducing an infinite degree of freedom structure to a finite from an infinite degree of freedom to a finite degree of freedom ANSYS workbench finite element software was used for numerical analysis. The load was applied as point loads and the material properties were taken into account. The effect of displacement on the structure's study is taken into account by the acting internal force reaction.

The following figure shows the result of beam analysis.

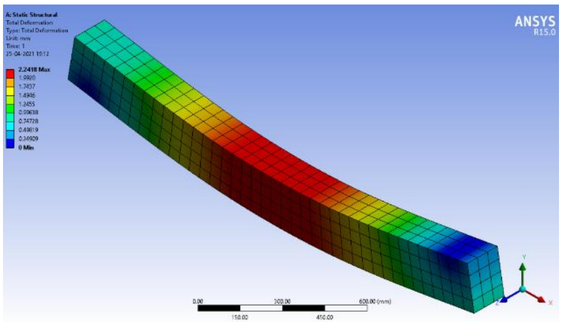

Fig 5.1 TOTAL DEFORMATION

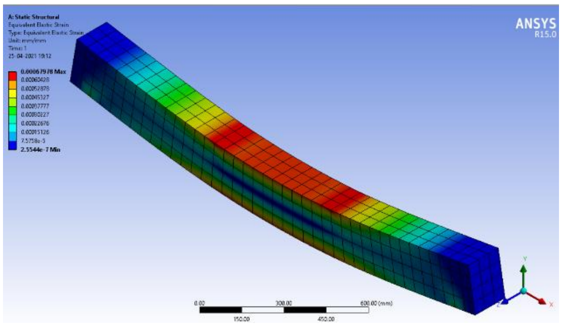

Fig 5.2 EQUIVALENT ELASTIC STRAIN

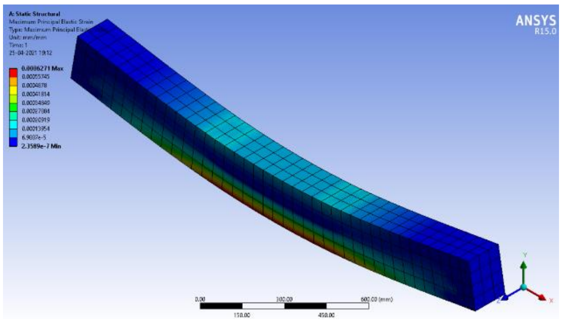

Fig 5.3 MAXIMUM PRINCIPAL ELASTIC STRAIN

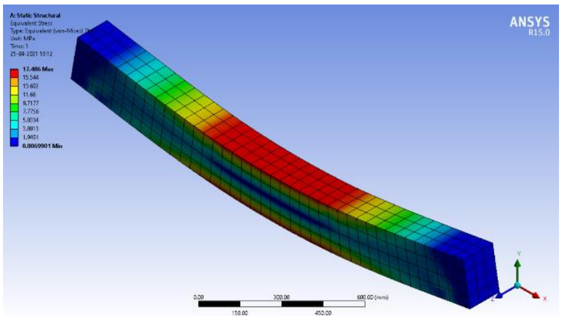

Fig 5.4 EQUIVALENT STRESS

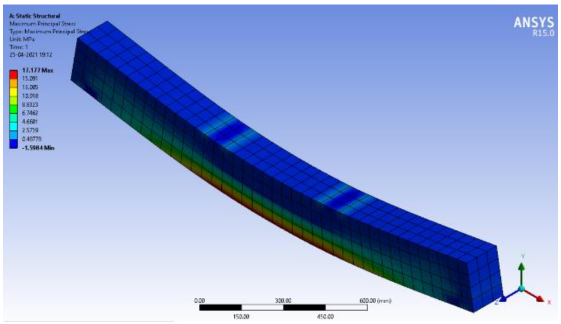

Fig 5.5 MAXIMUM PRINCIPAL STRESS

b) Abaqus analysis

ABAQUS workbench finite element software was used for numerical analysis. ABAQUS is a nonlinear finite element analysis programme that can be used to solve problems in mechanical, structural, civil, biomedical, and other engineering fields. It includes geometry modelling, material properties, meshing, boundary conditions, and other topics in order to provide a full engineering forecast. ABAQUS/CAE is an ABAQUS setting in its entirety. The load was applied as UDL and the material properties were taken into account. The effect of displacement on the structure's study is taken into account by the acting internal force reaction.The following figure shows the analysis of beam.

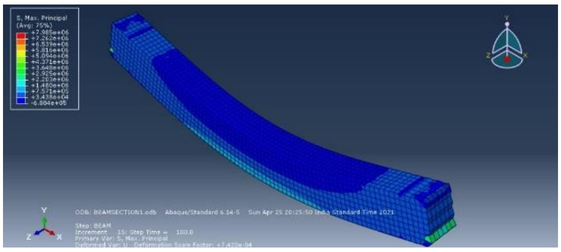

Fig 5.6 MAXIMUM PRINCIPAL STRESS

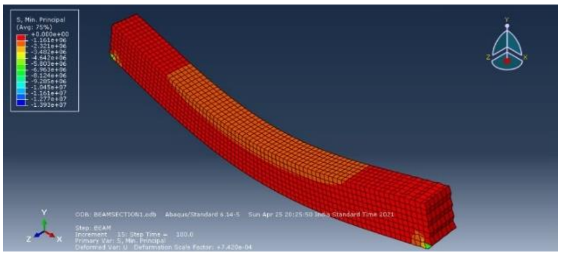

Fig 5.7 MINIMUM PRINCIPAL STRESS

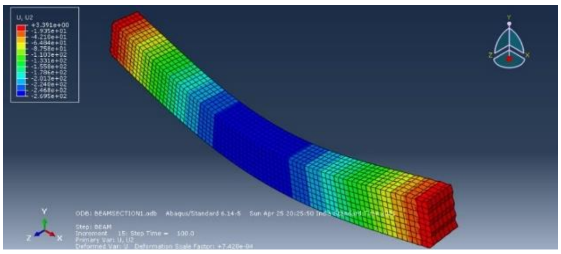

Fig 5.8 MAXIMUM DEFORMATION

VI. CONCLUSIONS

- Four separate self-compacting concrete mixes using treated foundry sand and metakaolin as fine aggregate and cement substitutes.
- MIX -4 has the highest strength of the four mixes.
- MIX-4 has a higher compressive strength than other combinations.
- As compared to other combinations, MIX-4 has a higher split tensile strength.
- M – sand replaces 80 percent of treated foundry sand, resulting in increased strength.
- When 25% of the metakaolin is replaced with cement, the strength increases.
- In self-compacting concrete, treated foundry sand and metakaolin can be used as a substitute.

BEAM ANALYSIS

- ANSYS programme was used to build a finite element model of a beam with a point load condition.
- ABAQUS programme was used to build a finite element model of a beam with UDL condition.
- The maximum deformation, equal elastic strain, maximum principal stress, maximum principal elastic strain, and equivalent stress are all shown in the ANSYS finite element analysis data.
- The finite element analysis results from ABAQUS shows the maximum deformation, maximum principal stress and minimum principal stress.
- The UDL deformation in ABAQUS is greater than the point load deformation in ANSYS.
- In ANSYS, the minimum principal is less than the amount calculated in ABAQUS.
- In ANSYS, the maximum principal is less than the value examined in ABAQUS.

REFERENCE

[1] Abbas H, Shukla A (2017), "a comparative study of the performance of selfcompacting Concrete using glass fibres", International Journal of Mechanical And Production Engineering, **5** (10), 2320-2092.

[2] Anjali D, Vivek S S, Dhinakaran G (2015), "Compressive Strength Of Metakaolin Based Self-Compacting Concrete", International Journal of ChemTech Research, **8** (2), 622-625.

[3] Deepa Balakrishnan S., Paulose K.C., "WORKABILITY AND STRENGTH CHARACTERISTICS OF SELF-COMPACTING CONCRETE CONTAINING FLY ASH AND DOLOMITE POWDER", American Journal of Engineering Research (AJER), Volume-2, 2013.

[4] Deepthi C G, Shindon Baby, "STUDY ON COMPRESSIVE STRENGTH OF CONCRETE WITH DOLOMITE POWDER AND CRUSHED TILES", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 9, September 2016.

[5] EFNARC (European Federation of National Associations Representing Concrete), Specifications and Guidelines for self-compacting concrete, Hampshire, U.K., February 2002.

[6] Eknath P.Salokhe, Desai D B, "APPLICATION OF FOUNDRY WASTE SAND IN MANUFACTURE OF CONCRETE", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 2011.

[7] Kiran K. Shetty, Gopinatha Nayak, Rahul Shetty K, "SELF COMPACTING CONCRETE USING RED MUD AND USED FOUNDRY SAND", International Journal of Research in Engineering and Technology (IJRET), Volume: 03, Special Issue: 03, May-2014.

[8] Kishor S. Sable, Madhuri K. Rathi, "COMPARISON OF NORMAL COMPACTED CONCRETE AND SELF COMPACTED CONCRETE IN SHEAR & TORSION",