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EXPERIMENTAL STUDY ON MECHANICAL BEHAVIOUR OF COMPOSITE BEAM

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ABSTRACT
This project focuses on an experimental study in order to predict the structural performance of composite beam. The composite beam was referred to a structural member in which concrete is sandwiched between two steel plates. The steel plates are interconnected by headed stud and J hook shear connectors with 100mm and 120mm spacing in order to develop a composite beam action between the plates and concrete core. The concrete core consists of super absorbent polymer as internal curing represents normal weight concrete. For the normal strength of the self curing concrete grade of M25.Mix proportion accordance with IS10262:2000.Trial dosage of 0.3% and 0.4% weight of cement is used for normal strength concrete core. In SCS the normal curing is not applicable because of corrosion of steel plate and shear connectors which occurs due to the interaction of water. So, keeping importance to this an attempt has been made to develop self cutting concrete by using super absorbing polymers as self curing agents. The strength of concrete containing self curing agent is tested and compared with conventionally cured concrete. Providing mild steel plate of 4mm thickness in both the faces of composite beam. The composite beam size to be tested in this project is 450x150x150mm of 8nos of varying spacing of shear connectors. The composite beam is loaded and tested under the two point bending systems

CONTENTS:

1.INTRODUCTION

Modern civilization relies upon the continuing performance of civil engineering infrastructure ranging from industrial building to power station and bridges. For the satisfactory performance of the existing structural system, the need for strengthening is inevitable. Commonly encountered engineering challenges such as increase in service loads, changes in use of the structure, design and/or construction errors, degradation problems, changes in design code regulation and seismic retrofits are some of the causes that lead to the need for new techniques to upgrade the performance of the structures

Steel-Concrete-Steel (SCS) sandwich comprises a central concrete core which is sandwiched between two steel skins to form a composite unit whose behaviour is greatly influenced by the interfacial bond between the two materials. During the past 30years there have been many research and development in SCS sandwich construction. cohesive bonding material (e.g. epoxy) and different types of mechanical shear connectors such as headed stud, J hook, Bi - steel connectors, angle shear connectors, plate connectors etc., was proposed to bond the steel plate and the concrete core.

Considering the existing SCS system, commonly used shear connectors is headed stud and J hook connectors were investigated experimentally in the researches. Light weight concrete (LWC) and high performance Ultra Lightweight Cement Composite (ULCC) materials were used as a core material.

2.OBJECTIVE AND SCOPE OF THE INVESTIGATION

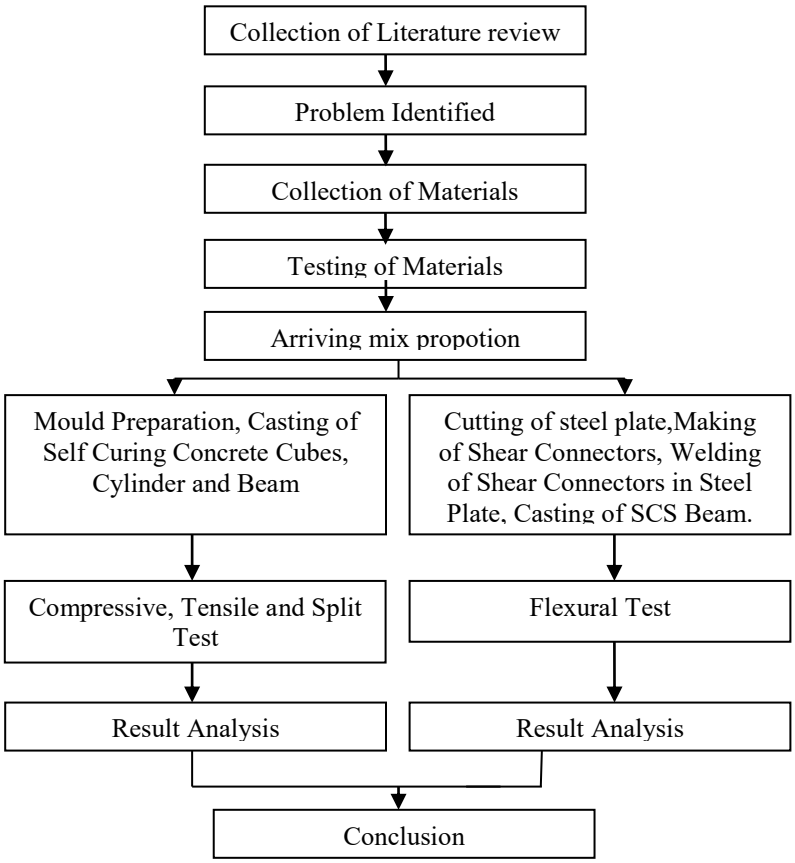
- To increase the compressive strength of the self curing concrete method.
- To improve the process of hydration of concrete by using self curing agents by Super absorbent polymer.
- To determine the strength of concrete by using internal self curing agent of trial dosage of 0.3% and 0.4%.
- To examine the flexural behaviour of sandwich steel beam using headed stud and J hook shear connectors with 100mm and 120mm spacing

SCOPE

- To study the compressive strength, split tensile strength, flexural strength of self curing concrete of varying dosage of super absorbent polymer and compare them with the normal concrete.
- To study the structural performance of SCS sandwich steel beam

3.METHODOLOGY:

In this study initially the preliminary tests for cement, fine aggregate, coarse aggregate, and the properties of the materials are determined. A concrete mix design for M-25 grade of concrete was developed by Indian Standard codes IS 383-1970, IS 10262-1982, IS 15658: 2000. Test on Flexural Strength of concrete for M25grade at 28 days curing were conducted.



4.MATERIALS COLLECTION:

CEMENT

Portland pozzalana cement of 53 grade available in local market is used in this project. Table 3.1 shows the physical properties of cement The Cement used has been tested for various proportions as per IS 4031-1988.

Table 1Physical Properties of cement

S.No	Properties	Results
1.	Standard Consistency	36 %
2.	Initial Setting Time	30 minutes
3.	Fineness Modulus	8.33
4.	Specific gravity	3.14

FINE AGGREGATE :

The fine aggregate used is clean dry river sand. The sand is sieved to remove all pebbles. The grading should be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of SCC will be sensitive to such changes. The properties of the fine aggregate are

Table 2

S.No	Properties	Results
1.	Specific gravity	2.62
2.	Fineness modulus	3.17

COARSE AGGREGATE:

Hard granite broken stone are used as coarse aggregate. the maximum size of aggregate is generally limited to 20mm.Aggregate size of 10mm-12mm is desirable for structures having congested reinforcement.

Table 3 Physical properties of coarse

S.No	Properties	Results
1.	Specific gravity	2.76
2.	Water absorption	0.5%
3.	Impact value	13.16%
4.	Fineness modulus	6.02%

SUPER ABSORBENT POLYMER (SAP)

The super absorbent polymer particles can be absorb a very large amount of water during concrete mixing and form large inclusions containing free water, thus preventing desiccation during cement hydration. Self curing provides extra curing water uniformly throughout the entire microstructure of the concrete.

Table 4 Properties of SAP

Form dry	Crystalline white powder
Form wet	Transparent gel
Particle size	125-250µm
PH of absorbed water	Neutral

Figure 1:Super Absorbent Polymer

STEEL PLATE

Normal mild steel plate with 4mm thickness was used to fabricate the steel skin plate. The Steel coupon test was prepared and test under tension accordingly to ASTM to obtain the material properties.

Figure 2:Steel plate

5.EXPERIMENTAL PROCEDURE

CASTING OF SPECIMEN

a) Cube = 150mmx150mmx150mm.
b) Cylinder = diameter 150mm and height 300mm.
c) Beam = 450mmx75mmx75mm.

Figure 3:Casting of selfcuring concrete specimen

MAKING OF SANDWICHED COMPOSITE BEAM

1. Cutting mild steel plate
2. Welding of shear connectors in the mild steel plate
3. Casting of sandwiched beam

Cutting of mild steelplate:Mild steel plate size of 850x1150x4mm, where cutted in to 16 numbers, Gas cutting is used to cutting the specimen, following images showing the specimen cutting.

Welding of shear connectors in the mild steel plate

Shape of shear connectors used in this project is headed stud and J hook. Provided with 100mm and 120mm spacing. Following are the figures shows the shape of shear connectors used in composite beam.

Figure 4:Welding of shear connectors in steel plate

Casting of sandwiched beam

The beam specimen were casted with two steel plate of sizes 4mm to which they headed stud and J hook are welded as shown infig. the steel plates are properly such that it maintain the depth of 150mm.the end of the steel plates

Figure 5: Casting of Beam

6.TESTING

TEST ON FRESH CONCRETE : Workability of concrete describes the ease or difficulty with which the concrete is handled, transported and placed between the forms with minimum loss of homogeneity. Workability of concrete mixture is measured by Slump test, Compaction Factor test, Vee-bee Consistometer test.

SLUMP CONE TEST: Slump test is the most commonly used method of measuring consistency of concrete.

Table 5 Slump value for Self curing concrete for M_{25}

Weight of cement (g)	Water cement ratio (w/c)	Vol. of water added (ml)	Slump in mm
3710	0.50	1855	0
3710	0.55	2040	20
3710	0.60	2226	43
3710	0.65	2411	115

Figure 6 : Slump Cone Test

COMPACTING FACTOR TEST

Compacting factor test is more precise and sensitive than slumptest and is particularly useful for concrete mixes of very low workability.

Table 6 Compaction factor test for self curing concrete

Mix	Slump in mm	Compaction Factor
M_{25}	115	0.95

Figure 7 :Compaction factor

TEST ON HARDENEDCONCRETE

1.CompressiveStrengthTest

2.Flexural Strength Test

3. Split test or tensile test

Compressive Strength Test

Figure 8 :Compressive tests for cube

Table 7

SPECIMEN	FOR 7 DAYSUSING 0.3% OF SAP		FOR 28 DAYS USING 0.3% OF SAP	
	Load (kN)	Stress N/mm^2	Load (kN)	Stress (N/mm^2)
A1	$36.4x10^4$	16.2	$64.20x10^4$	28.53
A2	$35.6x10^4$	15.82	$69.17x10^4$	29.95
A3	$36.0x10^4$	16	$66.54x10^4$	29.57
AVERAGE		**16.01**		**29.35**

Split Test or Tensile Test

Figure 9: Split tests for cylinder

Table 8

SPECIMEN	FOR 7 DAYS USING 0.3% OF SAP		FOR 28 DAYS USING 0.3% OF SAP	
	Load (kN)	**Stress N/mm^2**	**Load (kN)**	**Stress (N/mm^2)**
B1	15.6x 10^4	2.203	20.5x10^4	2.90
B2	15.01x 10^4	2.12	24.6x10^4	3.46
B3	14.9x 10^4	2.107	23.6x10^4	3.34
Average		**2.14**		**3.23**

FLEXURAL TEST FOR CONCRETE

Figure 9:Universal testing machine

Table 9

SPECIMEN	MODULUS OF RUPTURE(7 DAYS) USING 0.3% OF SAP		MODULUS OF RUPTURE(28 DAYS) USING 0.3% OF SAP	
	Load (kN)	**Stress N/mm^2**	**Load (kN)**	**Stress N/mm^2**
C1	2.3x10^3	2.45	5.6x10^3	5.9
C2	2.6x10^3	2.77	5.26x10^3	5.6
Average		**2.61**		**5.75**

TESTING OF SANDWICHED COMPOSITE BEAM

The composite beams were simply supported over an effective span of 450mm and tested under two point loading system. Loading was applied by using hydraulic jack of capacity 100tons. The load applied on the beam was measured using a load cell. The deflection at the mid-span was measured by using Linear Variable Differential Transformers (LVDT). Static load was applied incrementally at a rate of 5kn/min. To visually observe the cracks in the concrete core records all data such as load, deflection while testing. The first crack and the first yielding of concrete and steel were closely observed. After testing the concrete core was removed to observe the deformation of the shear connectors. The experimental setup for testing the beam is shown in

Figure 9:Universal testing machine

Fgure 10: Universal testing machine

RESULT

The composite beams were tested under two point loading and the results were discussed. The ultimate load carrying capacity and deflection of the specimens for concrete cores was in Table

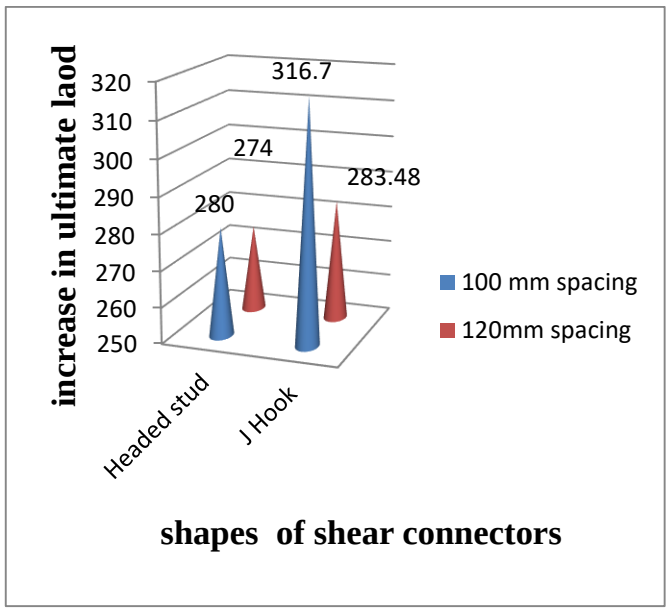
Table 10 Average of Experimental test results of ultimate load, Ultimate stress and maximum deflections

SNO	TYPE OF SHEAR CONNECTORS	ULTIMATE STRESS(kN)	ULTIMATE STRESS (N/mm^2)	DEFLECTION (mm)
1	Headed stud with 100mm spacing	280	37.33	11.31
2	Headed stud with 120mm spacing	274	36.53	13.95
3	J Hook with 100mm spacing	316.70	42.12	6.70
4	J Hook with 120mm spacing	283.48	37.78	8.72

Ultimate load capacity

The ultimate load carrying capacity of self curingconcretesandwich beam is shown in chart

Chart 1:

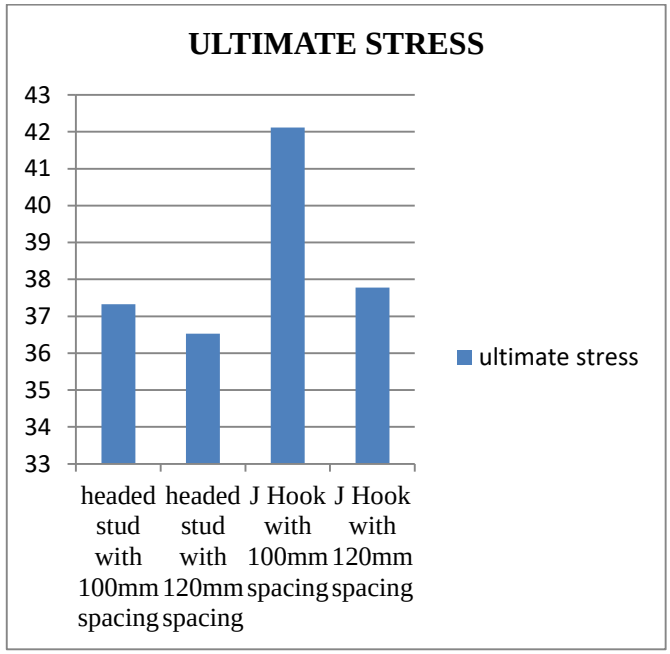


From this chart it can be seen that the ultimate load carrying capacity of self curing concrete with J hook is higher than headed stud beam.

Effect of self curing concrete core Strength

The strength of the concrete core has a direct effect on the ultimate load carrying capacity of the composite beam. It was observed from the chart that the strength of the J hook concrete core increased from 37.33 to 42.12MPa. It was found that there was 12% increase in the ultimate load carrying capacity of J hook composite beam.

Chart 2:



Load deflection behaviour

The load deflection graph for headed stud and J Hook composite beams are shown in chart

Chart 3:

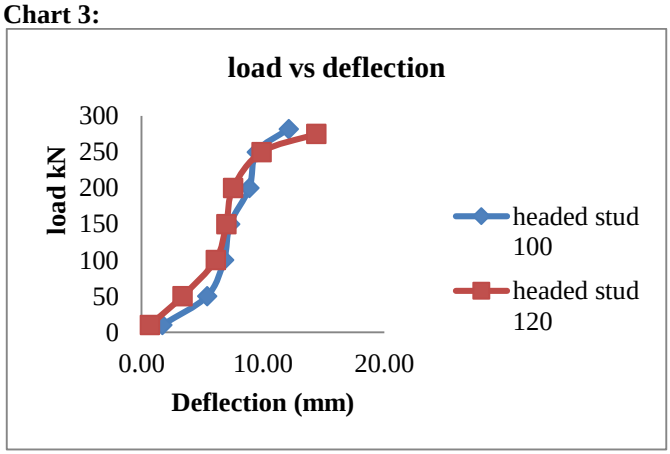


Chart Load vs Deflection for Headed stud

From the chart, it was observed that the composite beam with headed stud of 100mm spacing has higher load carrying capacity when compared to 120mm spacing.

Chart 4

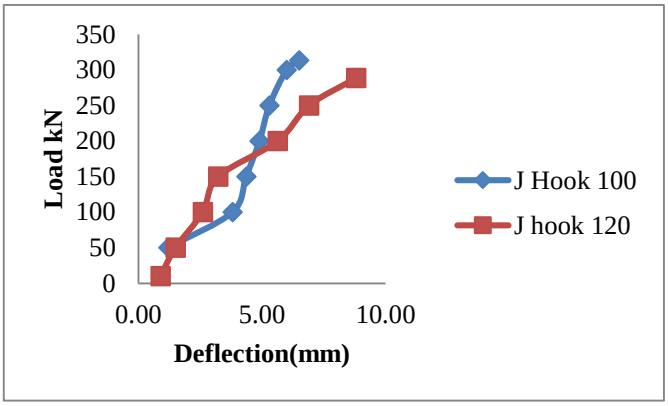


Chart Load vs deflection for J hook

From chart it can be seen that the initial crack load for the beam JHB 120 is higher when compared to the JH 100beams.

Failure mode and crack pattern

The failure of all the beams initiated with yielding of steel plates and formation of cracks in the concrete core at initial loading. At ultimate state the beams were failed by formation of more cracks in the concrete core and bending of shear connectors. The failure modes and crack pattern of headed stud beams and J hook beams are shown in fig .

Figure 11 : Failure of the headed stud beam

Figure 12: Failure of the J hook beam

Figure 13 :Shear failure of the beam at ultimate stage

From fig and fig, it was observed that there was lesser number of cracks formed in the concrete core. This was due to the connectivity of Jhook shear connectors in the concrete which delayed the formation and propagation of cracks as a result of which the beam has higher load carrying capacity when compared to headed stud shear connectors. concrete core failure was observed to be ductile and not brittle due to the presence of shear connectors which prevents the formation of cracks and delays the failure of the beams.

7.CONCLUSION

1. Using of SAP in concrete the compressive strength, split tensile strength, modulus of rupture and modulus of elasticity values are remarkably increased So, the optimum percentage of addition of SAP in SCC for internal curing is 0.3%.This extends the hydration and thereby increases the strength of concrete. Therefore self-curing concrete with SAP is recommended for field application where curing is difficult and water scarcity areas.

2. The experimental study shows that the load carrying capacity of the self curingconcrete of J hook shear connectors beam was 12% higher than the headed stud composite beam.

3. The shear resistance of the self curing concrete core increased because of the presence of j-hook connectors than the headed stud.

4. The strength and stiffness of the beam JHB 100 and HSB 100 were found to be maximum when compared to HSB 120 and JHB 120

5. The concrete core failure was observed to be ductile and not brittle due to the presence of fibres which prevents the formation of cracks

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