ANALYTICAL AND EXPERIMENTAL STUDY ON LACED STEEL CONCRETE COMPOSITE BEAM

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Abstract : Laced steel concrete composite (LSCC) beam comprises of thin steel cover plates provided with apertures/perforations, through which reinforcements in the form of lacing are introduced and held in the position with the help of transverse/cross rods, after which concrete is filled in between the cover plates. This paper presents the results of an Analytical and Experimental study on the laced steel concrete composite beams. A Finite Element Model (FEM) has been developed using ANSYS to analyses beam with steel concrete composite by providing lacings and the Experimental study was carried out by applying two point loading. Thus the flexural behaviour of both the results are compared and analysed.

***IndexTerms* - LSCC beam, FEM.**

I. INTRODUCTION

Steel–concrete–steel (SCS) sandwich composite system consists of steel cover plates connected to concrete core by shear connectors. SCS system, in general, finds application in structures requiring high strength and ductility as well as high energy absorbing capability. Use of continuous shear reinforcement or inclusion of steel and other fibres as micro reinforcements were found to improve the ductility of structural members. Laced steel–concrete composite (LSCC) system is a new type of SCS system .It consists of two thin steel cover plates connected using lacings and infilled with concrete. LSCC system does not involve welding due to the particular arrangement of lacings and cross rods. The anchorage requirements of the lacing around the cross bar ensures no slip condition in LSCC beams. Under transverse load, top cover plate experiences compression and bottom cover plate experiences tension. Lacings are found to be always in tension and the vertical concrete struts carry compression.

In the elastic range, the compressive forces in concrete above neutral axis and the top cover plate combine and form a couple with the tensile force in the bottom cover plate to resist the applied moment. In the fully plastic range, forces in top and bottom cover plate's together act as a couple to resist the applied moment. Lacings together with concrete struts transfer the shear. In the entire response range, concrete remains in a confined state. In order to understand the basic behaviour of LSCC system, experimental investigation and Analytical investigation on LSCC beams was carried out. Hot rolled steel (HRS) is the common term for products made by rolling or pressing thin gauges of sheet steel into goods. Hot Rolled steel goods are created by the working of sheet steel using stamping, rolling or presses to deform the sheet into a usable product. The worked products are commonly used in all areas of manufacturing of durable goods like appliances or automobiles but the phrase Hot Rolled steel is most prevalently used to describe construction materials.

It consists of steel beam over which a reinforced concrete slab is cast with shear connectors. In conventional composite construction, concrete slabs are simply rested over steel beams and supported by them. These two components act independently under the action of loads, because there are no connection between the concrete slabs and steel beams. When a shear connector is provided between concrete slab and steel beams the slip between them is eliminated and steel beam and concrete slab act as a composite beam. The basic concept of composite beam lies in the fact that the concrete is stronger in compression than steel and steel is stronger in tension.

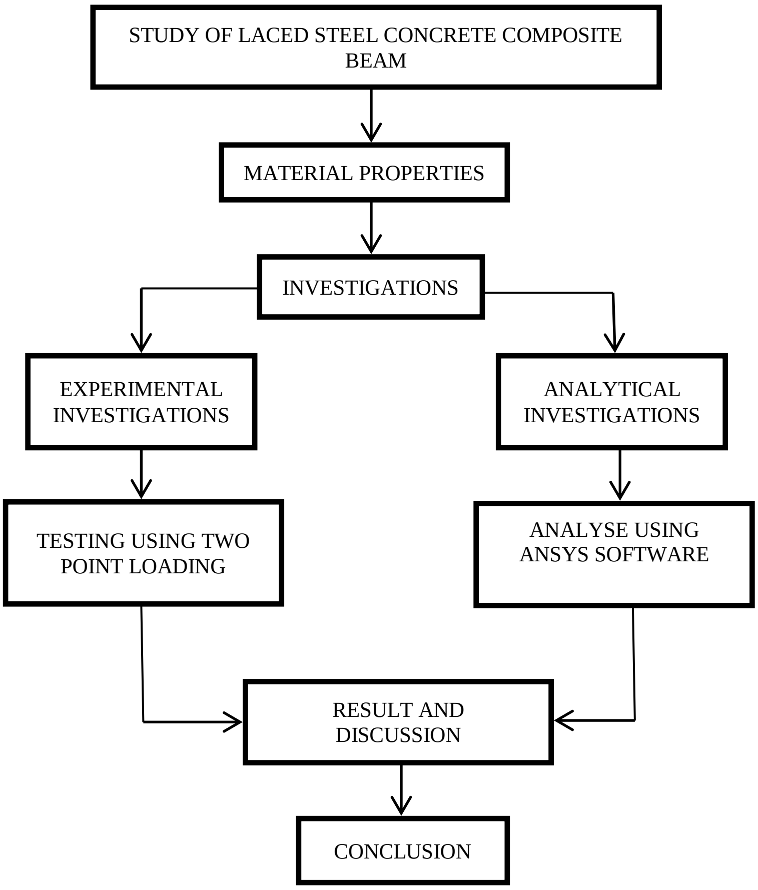
II. UNIQUE FEATURE

Simple structural elements made of commonly used materials integrated to devise new configuration for effective performance. Optimized material usage to result in enhanced strength, deformation and rotational capabilities. Highly suitable to resist suddenly applied dynamic load.

III. SUMMARY OF THE LITERATURE

The LSCC beams are found to perform better Flexural behaviour than compared with SCC, RC and LRC beams. In LSCC beams, steel cover plates prevent the spalling of concrete and Lacings helps in effectively confining the concrete between the top and bottom cover plates. Hot rolled steel has been increasing considerably in structural applications due to their light weight, high strength to weight ratio, ease of fabrication, erection, economy. The specimens with lacing reinforcement are more ductile than beams without lacing.LSCC system is found to possess the essential properties, namely high ductility, and structural integrity for resisting suddenly applied dynamic loading. The results are concluded that the shock load are resisted more by LSCC(Laced Steel Concrete Composite) compared to LRC(Laced Reinforced Concrete),RC(Reinforced Concrete) and SCC(Steel Concrete Composite)The software used to analyze the laced steel concrete composite beam are ANSYS, ABAQUS.

IV. METHODOLOGY



V. EXPERIMENTAL INVESTIGATION

The objective of experimental investigation is to assess the feasibility of strengthening of Laced steel concrete composite beam to determine the flexural behaviour of LSCC Beam.

5.1 Mix Design

For experimental investigation M30 mix design are considered for both normal beam and LSCC Beam

Table 1: Mix Design of concrete

Water	Cement	Fine Aggregate	Coarse aggregate
160	380 kg	711 kg	1283 kg
0.42	1	1.87	3.38

5.2 Compressive Strength test

Cube of size 150x150x150 mm were cast. Three specimens were made and tested for 28 days.

Fig.1 Compressive strength of concrete

The compressive strength test results of three specimens are mentioned below.

Table 2: Compressive strength test results

Specimen no's	Compressive strength(N)
1	32
2	31.5
3	33
Average	32.1

5.3 Normal Beam

Normal beam is developed of length 1000 mm and cross section of the beam is 300 x 150 mm. Where the mix design of M30 are used concrete as per IS: 456-2000 and IS 10262-2009.The concrete are mixed with the mix ratio of 1:1.87:3.38.where all the side of the beam are moulded properly to prevent concrete from leakage. After mixing, the concrete is poured immediately inside the beam. Concrete is filled in three layers, and each layer is compacted well by using a tamping rod of standard size, so as to avoid entrapped air inside the concrete beam and honey combing effect on the sides. Compaction of concrete is the process adopted for expelling the trapped air from the concrete. The lower the workability, higher is the amount of air trapped. Hand compaction was done by using a tamping rod. The consistency of concrete is maintained at a higher level. Concrete was filled in layers and each layer was compacted well using the compacting rod. Test cube specimens are demoulded after 24 hours from the process of moulding. Care should be taken not to damage the specimen during the process because, if any damage is caused, the strength of the concrete may get reduced. The test specimens after compaction were kept as such for a period of 24 hours. After that period of time the moulds were removed and the specimen are cured using gunny bags. The beam was tested under two point loading. Where the load applied is 50 kN.

Fig.2 Normal Beam

The normal beam test results are mentioned below:

Table 3: Normal beam results

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	10	5
3	20	10
4	25	15
5	35	20

5.4 LSCC Beam

Hot rolled steel plate was used for channel section where two channel sections are made of dimension 300x150 mm and thickness of 3mm.Yield strength of steel was 310 N/mm^2. Two sizes of steel rod was used of dimension of 8mm and 10mm.where 8mm rods were been used for lacing and 10 mm rods were been used for cross rods. Yield strength of rods was 415 N/mm^2.Where the two cannel sections are connected using lacing and cross rods are used at the top of the beam to connect the two sides of lacing together. Where welding are used for the connection of lacing. Welding is done to connect the lacing in the beam. Where the shop welding is done for the beam.

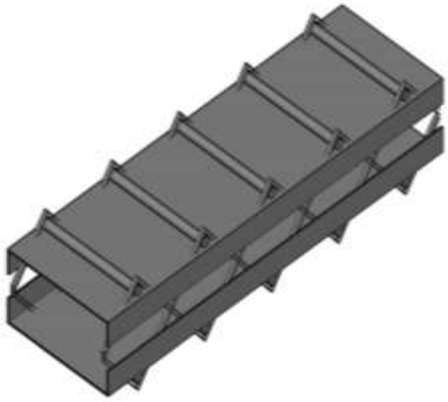


Fig.3 Isometric View of the LSCC Beam

Concrete of M30 grade was used to fill the beam. The mix design is done for M30 concrete as per IS:456-2000 and IS 10262-2009.The concrete are mixed with the mix ratio of 1:1.87:3.38.where all the side of the beam are shuttered properly to prevent concrete from leakage. After mixing, the concrete is poured immediately inside the beam. Concrete is filled in three layers, and each layer is compacted well by using a tamping rod of standard size, so as to avoid entrapped air inside the concrete beam and honey combing effect on the sides.

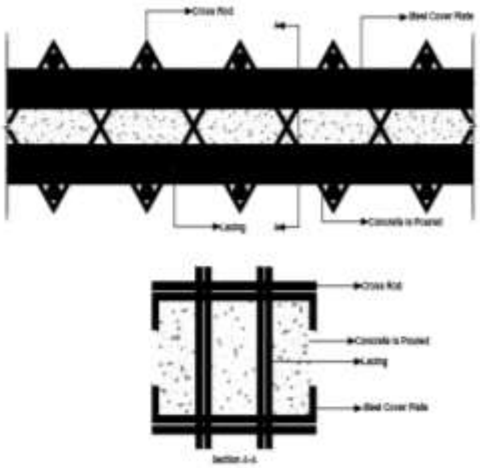


Fig.4 Cross section of LSCC Beam

Compaction of concrete is the process adopted for expelling the trapped air from the concrete. The lower the workability, higher is the amount of air trapped. Hand compaction was done by using a tamping rod. The consistency of concrete is maintained at a higher level. Concrete was filled in layers and each layer was compacted well using the compacting rod. Test cube specimens are demoulded after 24 hours from the process of moulding. Care should be taken not to damage the specimen during the process because, if any damage is caused, the strength of the concrete may get reduced. The test specimens after compaction were kept as such for a period of 24 hours. After that period of time the moulds were removed and the specimens were kept in ordinary curing tank and allowed to cure for a period of 14 days. The beam was tested under two point loading. Where the load applied is 50 kN.

Fig.5 LSCC Beam

The LSCC Beam test results are mentioned below:

Table 4: LSCC Beam results

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	10	1
3	15	3
4	35	5
5	50	7

5.5 Comparision Of Normal And LSCC Beam Experimentally

The graph comparison are made for normal and LSCC Beam

Fig 6: Graph for Normal Beam

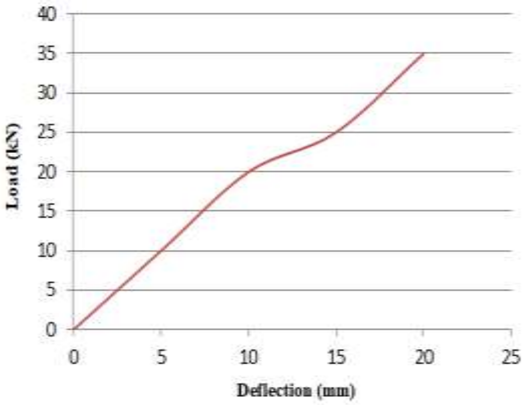
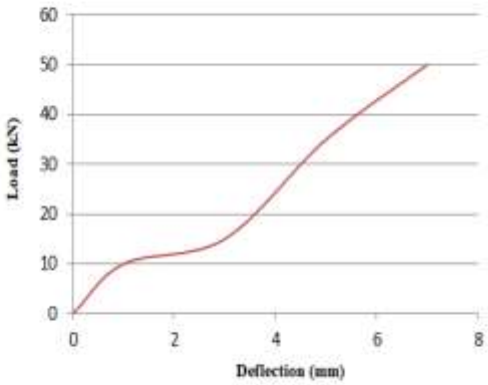


Fig 7: Graph for LSCC Beam



The comparison of normal and LSCC beam experimentally shows that the LSCC Beam is more efficient than the normal beam.

VI. ANALYTICAL INVESTIGATION

The ANSYS Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and Design Modeller. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The class focuses on geometry creation and optimization, attaching existing geometry, setting up the finite element model, solving, and reviewing results. The class will describe how to use the code as well as basic finite element simulation concepts and results interpretation.

6.1 Normal Beam

Normal beam are analysed using ANSYS Software. Where two point loading is applied of 50 kN for conventional beam. The beam of 1000 mm length and cross section of 300x150 mm were developed.

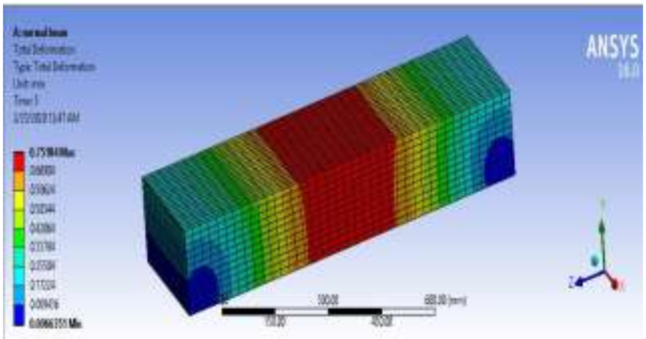


Fig.8 Normal beam using ANSYS

The normal beam test results are mentioned below:

Table 5: Normal beam results

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	15	5
3	26	7
4	31	9
5	40	18

6.2 LSCC Beam

LSCC beam are analysed using ANSYS Software. Where two point loading is applied of 50 kN for LSCC beam. The beam of 1000 mm length and cross section of 300x150 mm and thickness of channel section is taken as 3 mm were developed. Where the lacing rod of 8mm and cross rod of 10 mm was taken.

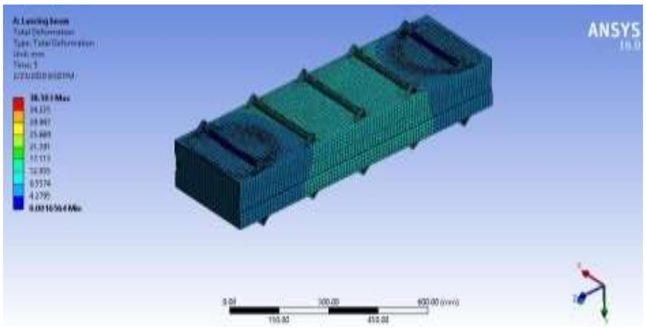


Fig.9 LSCC beam using ANSYS

The LSCC beam test results are mentioned below:

Table 6: LSCC beam results

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	10	1.75
3	25	3
4	36	4.5
5	50	6

6.3 Comparision of Normal and LSCC Beam using ANSYS

The graph comparison are made for normal and LSCC Beam using ANSYS

Fig.10 Graph for Normal Beam

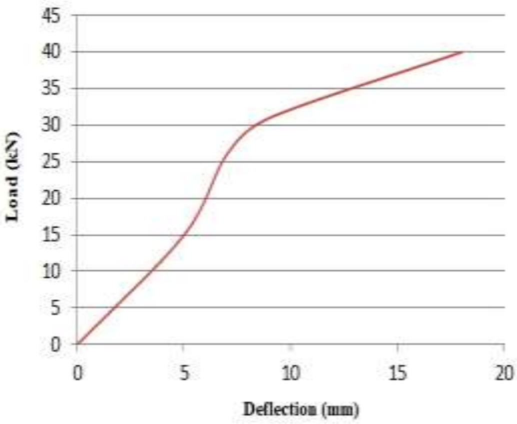
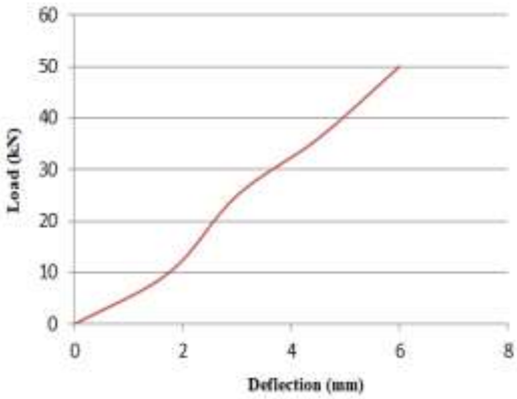


Fig.11 Graph for LSCC Beam



The comparison of normal and LSCC beam experimentally shows that the LSCC Beam is more efficient than the normal beam.

VII. CONCLUSION

Based on these extensive experimental and analytical investigations, important conclusions have been arrived at and they are as follow:

- In experimental and analytical results, the flexural strength is maximum at 50 kN for LSCC Beam compared to the Normal beam.
- Where by using channel section of thickness 3mm and lacing angle of 45 degree gives more efficient result for LSCC Beam compared to the Normal Beam.
- Comparing experimental and analytical investigations, the load carrying capacity are efficiently analysed in analytical investigation compared to experimental investigation.
- The load carrying capacity is more of 60-70 % for LSCC Beam compared to Normal beam.

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