EXPERIMENTAL AND COMPARITIVE STUDY ON FLEXURAL BEHAVIOUR OF COMPOSITE BEAM

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Abstract

This project deals with the flexural behavior of composite beam. The composite beams consist of steel section, concrete slab or beam and shear connectors or epoxy adhesive bonding agent for the connection between steel and concrete. The steel section used in this project is Indian Standard Medium Beam [ISMB] section. The shear connectors used are headed stud for the connection between steel section and concrete slab and beam. Epoxy bonding agent also used for the connection for the replacement of shear connectors.

The experimental investigation on the flexural behavior of composite beam is carried and gave good results. From the results, the composite beam [I section with concrete slab] has good rapport compare to that of composite beam [I section with concrete beam]. The composite beam connected with connectors able to withstand more weight compare to epoxy bonded composite beam.

1. Introduction

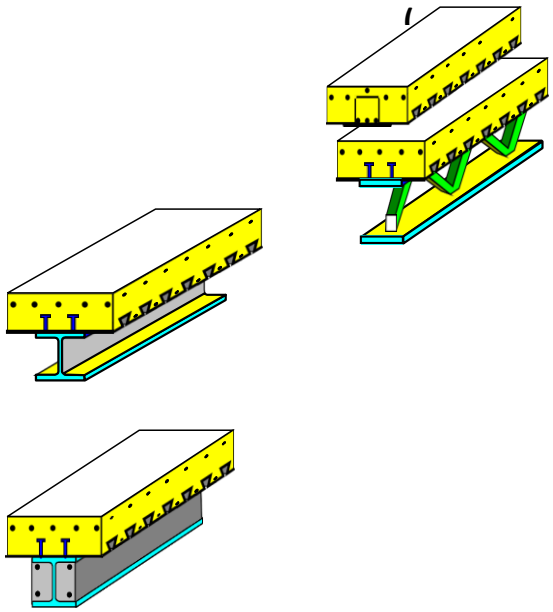
Concrete structural system incorporates a composite steel beam has been widely used around the world to build and bridge members structures. A composite is formed when components of steel, such as I beam, attached to concrete components, such as a floor or deck slab bridge. Composite structures have a low cost level compared to steel and RCC. Also the structure of resisting the fire components.

Composite beams

Composite beams which are composed of RC floor plate and steel beam or bridge floor and steel beam with shear connector and epoxy adhesive. composite development exists when two unique materials are bound together so emphatically that they demonstration all together unit from an auxiliary perspective. At the point when this happens, it is called composite activity. One regular model includes steel radiates supporting solid floor chunks.

In a composite shaft the elastic part of the power pair brought about by twisting is conveyed by the steel profile while the compressive segment that is likewise because of bowing is conveyed by either fortified plate or by the strengthened solid plate and steel profile collaboration framework. Composite shafts are consistently lighter than strengthened solid pillars. In the composite bar, less steel is utilized than in strengthened solid bars which have a similar tallness.

1.1 Types of composite beams
a. I-Girder, **b.** encased section, **c.** helical shaped girder**, d.**stiffened plate.



COMPOSITE BEAM

In concrete composite relative systems acts together with metal to create a rigid, lightweight structure is much less expensive. Shallow beams can be used which may reduce the build up high. Increased range of decent span length. The weight of structural metal frame can be reduced to reduce the cost base. Reducing the burden of live load deflection. They include a large living room without the need for any intermediate columns.

SHEAR CONNECTOR;

Shear connectors are also called studs or shear studs in the field of composite construction methods.

Depending on the welding cycle is used, the end of the shear connectors may be inserted into the ferrule pottery (circular shield segment) during welding to hold the weld. shear connectors make a solid connection between the steel bar and section a solid floor is poured on the head of metal decking. comprising a composite development provides a solid activity between pre-assembled units such as steel or pre-emitting projected enriched specimen or pre-focused on a solid bar and concrete cast-in-situ, with the aim that the two will go on as one unit.Shear connector also called to keep the vertical partition part of the steel support in the contact surface.

Functions and Shear connection;

There are two main functions of shear studs;

- Conveying their longitudinal shear along circuitry.
- separation b/w the reinforced beam and concrete slab.

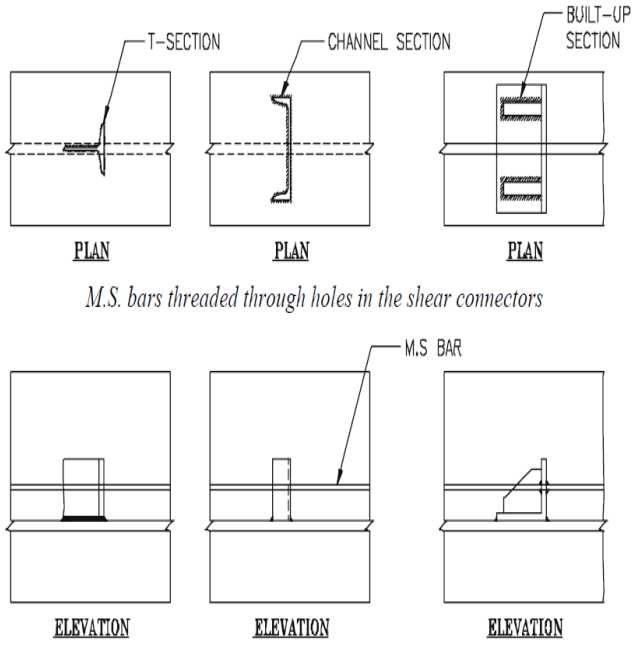
Shear connection:

shear studs set after the decking is in the area. shear connectors can be installed through the steel erection contractor or installer expertise shear connector. Welding equipment required for installation are provided with the aid of a sliding connector installer**.**

Rigid type connector:

This kind connector is designed to be a proof of the strength inherent bent a little deformation. Types of shear studs can be of various forms, but the most common type is the short length of the bar, angle or tee welded to a steel girder in conduct.

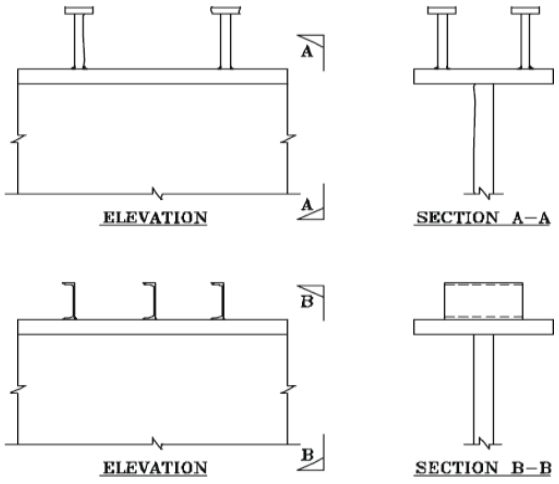
This are the stud connectors arrives their strength from the bearing pressure of the concrete, its equally spreads their loads evenly over the surface because of the rigid consistency of the connectors.



Flexible type connectors:

Flexible shear connectors consisting of studs or angles or channels or tees welded on the flange on the flange plates of prefabricated units.

This type of connectors such as studs, welded channels to the reinforced steel beams gets their strength respectively. Essentially over the bending of the flexible connectors.



T-RIB CONNECTOR

Shear connector Perfobond T-type composite metal bridges concrete is recommended, and a chain thrust ratings and expulsion are performed several parameters as well as the length and thickness of the ribs, the diameter and wide variety of holes in the ribs, the number of transverse reinforcing bars made of metal, and the energy of the concrete. Given the consequences of control, the effect of each parameter is analyzed. Furthermore, an electricity assessment form shear is suggested for a long rib Perfobond shear connector type T. Four hundred millimeters. Comparison and confirms that the recommended system rationally evaluates the effect to take into account systems.

Shear strength and Merits

Types of steel used in shear connectors are given below they are;

a. Cross sectional dimensions of connector.
b. Compressive Strength of concrete in the slab.

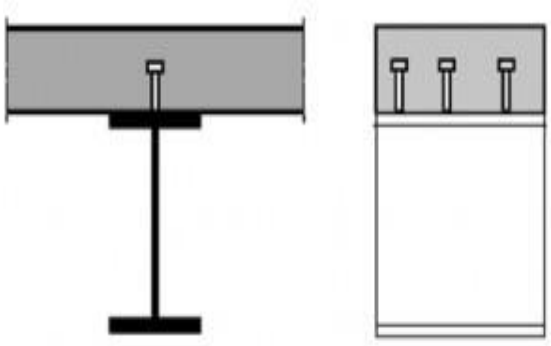
Merits

a.Easy to use.
b.Economical.
c.Very fast installation as compared to conventional processes.
d.Minimum human intervention.

Merits of Composite Structures of Shear Connectors

i.Reduction in concrete as well as steel.
ii.Greater strength of the structure.
iii.Greater speed of construction.
iv.Lesser floor sections.

Typical Shear connector composite beam



EPOXY ADHESIVE

Epoxy

a. It's a term used to derive the basic components of structure then its cured on its end products by using epoxy resins.Then it is called as a chemical structure.
b. Epoxy resins, also called as polyepoxides are a class of active prepolymers and polymers which having epoxide contents.

The characteristics are
i.better moisture resistance,
ii.low shrinkage,
iii.good adhersion.

Epoxy adhesive, Components & Merits

Epoxides are done by polymerizing its a mixture of double compounds such as resin and hardener. When the resin is mixed with a specific catalyst its curing begins. Curing is the process by which the molecular chains react chemically active sites, giving as good result an exothermic action. Epoxy adhesives adhere to a different kind of materials and their properties based upon the specific chemistry of the groups and the nature of cross available. Some of the most underrated special events gives their requirements are given below they are;

a.Without chemical and fire resistance,

b.Its good in adhesive and water resistance as known
as full-fillment and cobination of mechanical and electrical insulating properties.

Components

As mostly effected epoxy adhesive used in structural components in the composite construction they are;

- single-component

- double-component

Merits

Epoxides are the most commonly used in the component adhesive. The advantages are high in strength and gives excellent resistance to chemical and environment.Its capable to resist creep under sustained load. They easily fills holes and gives good excellent filling bonding properties and exactly against hard chemicals.They are often results used as alternatives to welding and rivets.

Objective

The composite structures are most economic and time control construction in civil constructions. The composite beam is an unique results for building slabs or bridge decks due to the rapid speed of construction. To determine the comparitive behavior of composite beams with shear studs and epoxy adhesive bonding agent.

Literature survey

GENERAL

This units consists of fully based on the form of literature collected. And the selected chapters that have been abstracted from every literature for getting knowledge about the composite beams.

Earlier study

Shear Connector Survey

Giovanni Fabbrocino and Marisa Pecce , **Experimental tests on steel – composite concrete beams under (-ve bending)**,

This chapter is an experimental investigation on composite beams under (–ve bending). The behaviour of the composite cross sections is quite different depending on the type of loading.

In the sagging moment zone the optimal use of the composite element occurs, since the concrete is in compression and the steel in tension but when the negative moment stresses the composite cross section, the concrete is under tension and the steel under compression; thus the development of the slab cracking and the local buckling of the steel profile influence the strength and the ductility of the beam.

The steel component of the cross section is a standard HEB 180 profile, characterised by the following geometrical dimensions: Profile height 180 mm; Flange width 180 mm; Flange thickness 14 mm; Web thickness 8.5 mm. The concrete slab is 800 mm wide and 120mm thick, four steel reinforcing bars F14 mm are provided. Transverse reinforcement has been also used to reduce local damages due to the action of the shear connectors.

Strain behavior of shear studs in composite component structures;

The importance of this case study was to know about the deformation substance of shear studs that are used in steel-concrete composite structure, Its plays better numerical analysis of

experimental investigations. In the experiment, putting strain gauges along the length of the shear studs.

In a very tiny intervals rather obstracles. On the other hand, In the analatical analysis, the strain can be easily formulated at each node with a very small time interval to develop an appropriate analatical model. To analyse with different geometric conditions is a time consuming matter, whereas the numerical analysis can easily check the effect of any difference.

Epoxy adhesive survey

The study is accomplished based totally on reliability- based totally layout optimization technique (RBDO). Mechanical homes of used materials and the implemented load are taken into consideration as unsure parameters. This units presents a reliability-based totally optimization method approach of adhesive bonded steel–concrete composite beams with both probabilistic and non- probabilistic uncertainties. The actual reliability-based method gives an alternative method for the optimization layout of adhesive binding composite beams challenge to both stochastic and bounded differentiations.

Summary on survey

Design of Composite beams

The design of composite beams is carried out under Eurocode 4 and IS 11384- 1985 and also it involves the following aspects.,

Moment capacity
The section is designed in such that the moment capacity is higher than they wants.

Shear capacity
To enclose the extra capacity, this based on the steel section alone.
Shear connector capacity
To enable high composite reaction to be winned, these must be designed to be adequate.
Longitudinal shear capacity
Check to prevent possible splitting of the concrete along the length of the beam.
Serviceability checks
Checks such as deflection and stresses are to be determined and the value should be within the permissible limit.

Steel Section and shear connector standard

From the literature survey, the steel section and the shear connectors for composite beams is mainly carried with American, European standards. In this research programme, the steel section and the shear connectors for composite beam will be carried according to Indian standard steel section.

Epoxy adhesive property

The mechanical conduct of the reinforced composite bar relied firmly upon the sticky material properties. The versatile modulus of sticky material properties. The elastic modulus of adhesive material is 1000mpa. In the ideal exhibition steel solid composite bars.

MIX DESIGN & MATERIAL PREPARATION

GENERAL

The various strength properties of concrete are dependent on cement content, water-cement ratio (W/C), compaction level and aggregate gradations and quality.

MATERIALS USED

Cement

Ordinary Portland cement 53 Grade sample was tested to obtain the following characteristics:

i. Specific gravity test.
ii.Standard consistency test.
iii.Initial setting time test.
iv.Final setting time test.

Properties of cement

S.No	Description	Result
1	Specific gravity	3.12
2	Fineness (by sieve analysis)	2%
3	Consistency	32%
4	Initial setting time	52 minutes
5	Final setting time	372 nutes

Coarse aggregate

Hard granite crushed stones of much less than 20mm length have been used as coarse combination. The Specific gravity, Fineness modulus, water absorption and bulk density of the coarse aggregate have been examined.

Properties of coarse aggregate

S.No	Description	Values
1	Specific gravity	2.75
2	Bulk density	1648.73 Kg/m3
3	Water absorption	1%
4	Fineness modulus	4.67
5	Average impact value	15.79%

6	Average crushing value	20.8%

FINE AGGREGATE

F.A size < 4.75 mm sieve were used as fine aggregate. The tests for fine aggregate such as Specific Gravity, Fineness modulus, Water absorption and Bulk density.

Properties of fine aggregate

S.No	Description	Values
1	Specific gravity	2.61
2	Bulk density	1632.19 Kg/m3
3	Water absorption	1%
4	Fineness modulus	2.72

Water

Potable water avails in lab's with pH value of not less than six and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well.

Target mean strength

The target mean strength is determined by using the relation $\mathbf{f_t = f_{ck} + kS}$

Where $\mathbf{f_t}$ **-** target mean compressive strength at 28 days $\mathbf{f_{ck}}$ – characteristic compressive strength at 28 days **S –** Standard deviation.
k – Statistical coefficient
$\mathbf{f_t = 25 + 4.0\ (1.65) = 31.6\ N/mm2}$

Water-cement ratio

In while mean strength, the w/c ratio is read from the appropriate curve in IS10262. Hence a w/c ratio of 0.44 is accepted. The water content is 186 litres/m3. The cement content works out to be 186/0.44 = 423 kg/ m3.

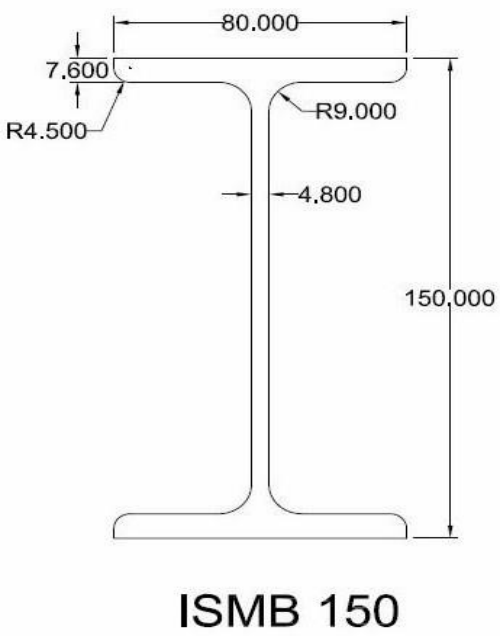
Mix proportion details

WATER (litres/m3)	CEMENT (kg/m3)	FINE AGGREGATES (kg/m3)	COARSE AGGREGATES (kg/m3)
186	423.00	601.47	1176.93

0.44	1	1.42	2.78

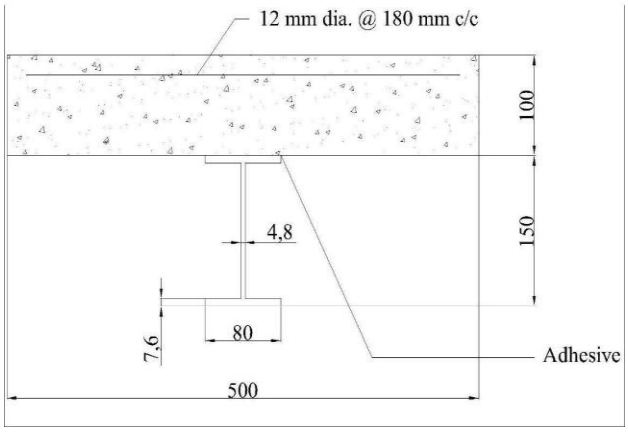
STEEL PROPERTIES

The steel section for the composite beam used is medium weight and of Indian standard steel section. The steel section used is ISMB 150. The following are the properties of the steel section taken from steel table,



ISMB 150

Properties,



Depth of the section -150mm
Thickness of flange -7.6mm
Thickness of web -4.8mm
Width of flange -80mm

Weight per metre -146.1N

MARKING IN STEEL FLANGE & WELDING OF CONNECTORS.

The following figures shows the marking and welding of connectors in the steel flange,

MOULD PREPATION, CASTING & CURING

MOULD PREPARATION

The mould for the composite beam [I section with concrete slab and beam] is as shown;

BEAM MOULD

SLAB MOULD

TESTING & FINAL REMARKS

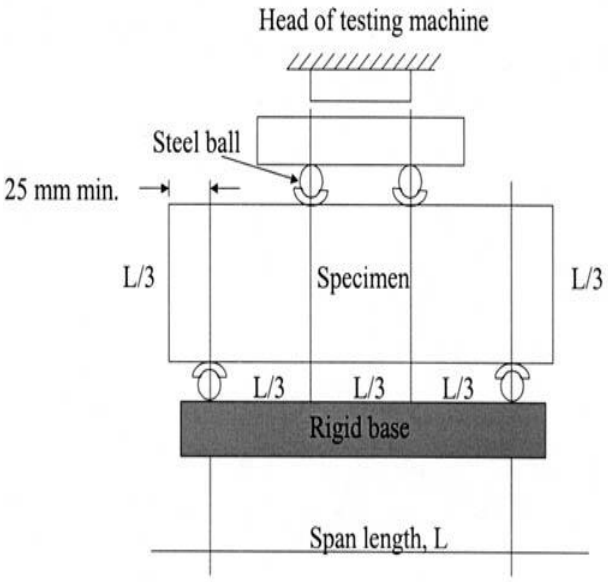
TESTING

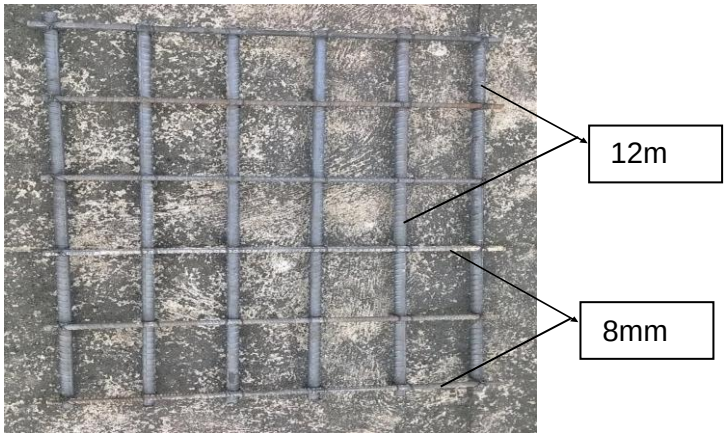
The two-point load test setup for the flexural behavior of composite beam is as shown,

Load in kN	Def.Centre in mm	Def. under Point mm	Slip in mm
0	0	0	0
40	0.72	0.42	0.13
80	1.26	0.87	0.17
120	1.64	1.25	0.22
160	1.80	1.31	0.26
200	2.04	1.43	0.28
230	2.37	1.61	0.35
240	2.52	1.69	0.35
250	2.70	1.69	0.35

Testing of shear connector welded composite beam [I section with concrete slab] {S1}
The shear stud welded composite beam tested on with the setup includes the dial gauge and LVDTs are used to measure the deflection and slip values. The setup is as shown.

Load in kN	Def. at Centre in mm	Def. under point in mm	Slip in mm
0	0	0	0
50	0.13	0.16	0
100	0.28	0.33	0.01
150	0.37	0.45	0
170	0.41	0.47	0.03
178	0.43	0.48	0.01


Head of testing machine
Steel ball
25 mm min.
L/3
Specimen
L/3
L/3
L/3
L/3
Rigid base
Span length, L


12m
8mm


SELF STRAINING
LOADING FRAME
100 Ton Capacity
GET GLOVES

The following are the readings of the shear connector welded composite beam (I section with concrete slab) is as shown in tabular and the failure load of specimen is as shown in fig given below with the results.
Crack attained load =230kN
Ultimate load =250kN
Maximum slip value =0.35mm
Deflection =1.69mm and 2.7mm under point and at Centre.

Testing of shear connector welded composite beam [I section with concrete beam] {S2}

The shear stud welded composite beam tested with the setup includes the dial gauge and LVDTs are used to measure the deflection and slip values. The setup is as shown.,

The following are the readings of the shear connector welded composite beam (I section with concrete beam) is as shown in fig. and the failure load of specimen with the results.

Crack attained load =170kN
Ultimate load =178kN
Maximum slip value =0.03mm
Deflection =0.48mm and 0.43mm under point and at Centre
respectively.

Testing of epoxy bonded composite beam [I section with concrete slab] {E1}

The shear stud welded composite beam tested with the setup includes the dial gauge and LVDTs are used to measure the deflection and slip values. The setup is as shown.,

The following are the readings of the shear connector welded composite beam (I section with concrete slab) and the failure load of specimen is as shown in abovefig, with the results.

Load in kN	**Def.at Centre in mm**	**Def. under point in mm**	**Slip in mm**
0	0	0	0
50	0.04	0.19	0.17
100	0.06	0.19	0.13
150	0.07	0.25	0.22
200	0.09	0.31	0.36

Ultimate load =200kN
Maximum slip value =0.36mm
Deflection=0.31mm and 0.09mm under point and at Centre respectively.

Testing of epoxy bonded composite beam [I section with concrete beam] {E2}

The shear stud welded composite beam tested with the setup includes the dial gauge and LVDTs are used to measure the deflection and slip values. The setup is as shown.,

The following are the readings of the shear connector welded composite beam (I section with concrete beam) and the failure load of specimen is as shown in fig with the results.,

Load in kN	**Def. at Centre in mm**	**Def.under point in mm**	**Slip in mm**
0	0	0	0
40	0.13	0.15	0.01
80	0.24	0.28	0.01
100	0.29	0.34	0
120	0.32	0.40	0
130	0.33	0.43	0

Crack attained load =100kN
Ultimate load =130kN
Maximum slip value =0.01mm
Deflection =0.43mm and 0.33mm under point and at Centre respectively.

FINAL REMARKS

From the experimental study, the following remarks had been made.,

i.The composite beam gave the strength equal to the theoretical calculations as per designed with Indian standard code.

ii.All the composite beams deflect very well and the deflection value of tested is less than theoretical value.

iii.The composite beam [S2, E2] doesn't slip while compare to that of composite beam [S1, E1].

iv.The shear welded composite beam attains more strength compare to epoxy bonded composite beam.

v.The epoxy bonded composite beam may be used for quicker strength compare to shear welded composite beam.

vi.There is no peel off concrete from the I section which is bonded with epoxy adhesive, also no crack in the composite beam [E1].

CONCLUSION

The steel - concrete composite beam is increasingly used in the field of construction for their flexibility. Also the steel-concrete composite beams can be used in the situations where they can be subjected to the simultaneous actions of flexure and axial forces. The steel-concrete composite beam is experimentally tested and the result of the shear connector welded composite beam is compared with the epoxy bonded composite beam. The epoxy adhesive bonding can be preferred if the shear connector availability is no more. Also, the epoxy bonded composite beam gives equal strength compare to the shear connector welded composite beam. Both the composite beams can be preferred in future based on their requirement in the construction industry.

APPENDIX

Grade of Concrete	Assumed standard deviation (N/mm2)

M10, M15	3.5
M20, M25	4.0
M30, M35, M40, M45, M50	5.0

Nominal max., size of aggregate (mm)	**Max., water content (kg)**
10	208
20	186
40	165

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