EXPERIMENTAL STUDY OF FIBRE REINFORCED COMPOSITE SLAB BY ADDITION OF FLY ASH

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Abstract *:* A structural member composed of two or more dissimilar materials joined together to act as a unit is referred as composite structure.These essentially different materials are completely compatible and complementary to each other; they have almost the same thermal expansion. The two complementary materials, structural steel and reinforced concrete are introduced and it is shown how composite action is achieved in the case of composite. Attention is drawn to the effect of this form of composite construction on other more general problems such as fire resistance rating, speed of construction, flexibility and final fitting out. The most important and most frequently encountered combination of construction materials is that of steel and concrete, with applications in multi-storied commercial building and factories, as well as in bridges. Composite structure have an ideal combination of strengths with the concrete efficient in compression and the steel in tension. The use of profiled deck composite slab in the construction industry has many advantages including the simplicity in construction compared to other flooring system. The profiled sheeting serve's as shuttering by shouldering wet concrete during construction stage. This composite construction method gained popularity for eliminating time-consuming erection and subsequent removal of temporary forms. Cost effective highly flow able green engineering cementitious composite made of locally accessible materials could yield better composite activity between the profiled steel sheeting and the concrete.In composite slab by addition of polypropylene fibre and fly ash gives more flexural strength than reinforced concrete slab.Shear connector join the I-section beam and reinforced concrete slab and stud connector takes more load carrying capacity than channel connector

IndexTerms - Steel Profiled Deck sheet, Shear connectors, Ibeam, composite slab.

I. INTRODUCTION

To introduce steel-concrete composite members and construction; to explain the composite action of the two different materials and to show how the structural members are used, particularly in building construction. Composite design is when a structural member composed steel and concrete material joined together and acts as a single unit. The use of steel in construction industry is very less in India as compared to many developing countries. The experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially in the current development needs in India. Steel is an alternative construction material and not using it where it is economical is a heavy loss for the country. Also, it is evident that now-a-days, the composite sections using Steel encased with Concrete are economic, cost and time effective solution in major civil structures such as bridges, industrial sheds and high rise buildings. The most important and most frequently encountered combination of construction materials is that of steel and concrete, with applications in multi-storey commercial buildings and factories, as well as in bridges. The composite slab have almost the same thermal expansion; they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension.[8]

1.1 Composite slab

It consist of profile steel decking with an in-situ reinforced concrete topping. The decking not only acts as permanent formwork to the concrete, but also provides sufficient shear bonds with the concrete so that, when the concrete has gained strength, the two materials act together compositely. Composite slabs are regularly used to extend between 3 m and 4.5 m onto supporting beams or walls. The ability of the decking to help the construction loads, without the requirement for temporary propping, generally dictates such spans. At the point when the solid has increased adequate quality, it acts in combination with the tensile strength of the decking to frame a 'composite' slab. It can be considered as a reinforced concrete slab, utilizing the decking as external reinforcement. The load conveying capacity of composite slab is typically directed by the shear bond, upgraded by interlock, between the decking and the concrete, rather than by yielding of the decking.[9]

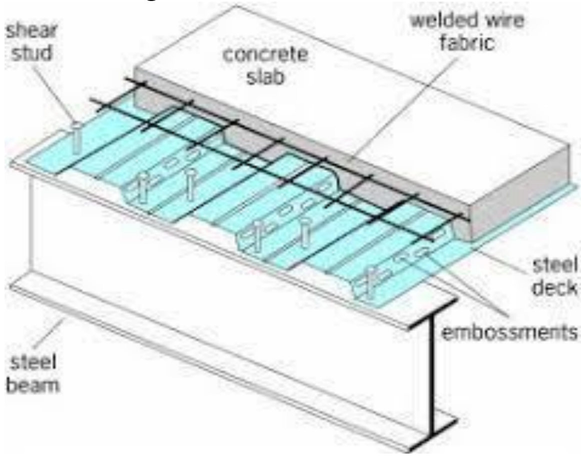

Fig.1 Composite slab

2 LITERATURE REVIEW

These studies relate to the behavior of conventional concrete slab over a steel I – beam. The concrete frame construction has until recently been traditionally undertaken using plywood formwork for all structural elements and no any advantages have been achievable during the construction phase. This has been overcome by the development of composite slab which employ a permanent formwork system consisting of profiled sheeting for concrete framed construction.

Josef Holomek.et.al (2016) has studied Composite slab consists of the layer of concrete above the trapezoidal sheeting. The sheeting serves as a lost formwork as well as a tension bearing member after the hardening of concrete.
K.M.A.Hossain.et.al (2016) has presented the development and performance evaluation of a new high performance composite flooring system incorporating emerging green cost-effective engineered Cementitious Composites. Thirty full-scale composite slabs were fabricated and tested under simply supported four-point loading conditions. The variables in the tests included: two types of concrete Engineered Cementitious Composites.
A Hamoda.et.al (2017) has investigated the behavior of composite girders made of high performance concrete slab connected to steel I-beam through stud shear connectors subjected to hogging moment. Such girders are widely used in bridge construction. Reinforcing steel bars in the negative moment region contribute significantly to the moment resistance and is found to be ineffective due to cracking of ordinary concrete. This research proposes the use high performance concrete precontaining fibres with better crack resisting.
S. P. Siddh,et.al (2017) has invistigated the midspan deflection and end slip of the composite slabs is presented in this paper. The deflection of composite slabs depends on the shear stiffness of the connection between profiled sheet and concrete. Results of the experimental investigations of a composite slab with profiled sheeting trapezoidal type and concrete are presented in this paper.

3 MATERIAL AND METHOD

3.1 Shear Connectors

Commonly used types of shear connectors according to IS: 11384 – 1985: Code of practice for composite construction in auxiliary steel and concrete. Stud and angle connector will used to interface concrete slab and steel beam. The yield stress is 660 MPa and tensile strength is 830 MPa of the shear connector. Stud shear connectors used 16 mm diameter and 75 mm height as per IS: 11384 - 1985. Material is Fe 540 -HT having tensile strength and yield stress 540 MPa and 350 MPa connectors are invariably used in composite floors.Stud shear connectors are welded through the sheeting on to the top flange of the beam. Angle shear connectors used 75x40x5 mm size as per IS: 11384-1985 material is Fe 58- HT having tensile strength and yield stress 568 mpa and 353 mpa. These connectors are very stiff and they sustain only a little deformation while opposing the shear force. [6]

3.2 Profiled deck sheet

The profiled deck steel sheet will used for test of trapezoidal profile of 1.2 mm thickness. Trapezoidal profile with web indentations Profiled deck shaped are chosen based on the ability to enhance the bond at the steel-concrete interface and providing stability while supporting wet concrete and other construction loads. The steel deck is normally rolled into the desired profile from 0.70 mm to 1.6 mm galvanized coil. It is profiled such that the profile heights are usually in the range of 40 – 60 mm whereas higher depth of 85mm is also available. The typical trough width lies between 150 to 350 mm. Generally, spans of the order of 2.5m to 3.5m between the beams are chosen. [12]

3.4 Steel beam

The steel beam used for test will ISMB 100 @ 8.9 kg/m. The modulus of elasticity, yield stress and tensile strength is 200 GPa, 450 MPa and 500 MPa, respectively. [5]

3.5 Concrete

The concrete slab for the push-out test was constructed similarly as the concrete slab used for the composite beams.Accordingly, the thickness of the concrete slab was set at 50 mm. Due to the small thickness of the concrete slab;maximum size of the coarse aggregates was selected as 7 mm. The water cement ratio for the concrete was 0.45.The width of the concrete slab were 400 mm. The concrete slab was cured for 28 days by covering with gunny bags. Also, three concrete cube were casted to determine the compressive strength of the concrete. [4]

Table 1. Design mix proportion for M30 grade concrete

Design Mix proportion for M30 grade concrete (1:1.25:2)	
Particulars	Quantity
Cement	281.67 kg
Sand	472.84 kg
Aggregate	782.55 kg
Fly ash	93.88 kg

3.6 Fly ash

Class F fly ash 25% substitution of ordinary Portland cement utilized. Good performance and environment friendliness, fly ash based construction materials have incredible potential as options in contrast to ordinary Portland cement. To acknowledge sustainable development and helpful use in the constructional industry. It improves workability as the spherical shaped particles act as miniature ball bearings within the concrete mix, thus providing a lubricant effect. This equivalent impact also improves concrete pumpability by reducing frictional losses during the pumping procedure and flat work finishability. Fly ash decreased water request by replacement of cement reduces the water demand for a given slump. At the point when fly ash is used at around 20% to 30% of the total cementitious, water demand is reduced by approximately 10 percent. Higher fly ash contents will yield higher water reduction. Decreased heat of hydration replacing cement with a similar measure of fly ash can decrease the heat of hydration of concrete. This decrease in the heat of hydration does not sacrifice long term strength gain or durability. The diminished heat of hydration reduces heat rise issues in mass concrete placements. [11]

3.7 Polypropylene fibre

Polypropylene fibre recron 3 S triangular polyster of 12 mm length was mix in concrete, 0.75% content of cement. Polypropylene fibres diminishes the water permeability, increases the flexural strength because of its high modulus of elasticity. Polypropylene fibres have hydrophobic levels, which protect against wetting with bond cement paste. The hydrophobic nature of polypropylene has no impact on the amount of water required for concrete. The Compressive strength and splitting tensile strength increments proportionately.[3]

3.8 Design Considerations

Composite floors are designed based on limit state design philosophy. Since IS 456:2000 is also based on limit state methods, the same has been followed wherever it is applicable. Provided main steel of 8 mm bar center to center 300 mm spacing and distribution steel of 8 mm bar center to center 330 mm spacing

Beam size**:** ISMB 100 @ 8.kg/m

Depth of section (D):100 mm Width of flange (b): 50 mm Thickness of flange (tf):7 mm Thickness of web (t): 4.7 mm Depth of web (dw):h1:64.8 mm Ixx: 183x 10^4 mm Zp:36.6x 10^3 mm^3 Number of beams: 9 nos

Composite slab size **:** 2000 x 400x100 mm Depth of slab=50 mm+50 mm=100mm Clear cover of composite slab = 15 mm

4 Casting process:

A) Material collection

Fig.2 Profiled decking sheet

Fig.3 Steel I Beam

B) Welding Process

Fig.4 Ctting and welding process on profiled deck sheet

C) Concreting Process

Fig.5 Concreting process on composite slab

D) Curing process

Fig.6 Curing process on composite slab

E) Test set up

Fig.7 Test set up

F)Flexural testing process

Fig.8 Flexural Testing Process

5. Result and discussion

1.Steel concrete composite slab with profiled deck sheet, the first crack was developed at the top layer of the slab and at this load one minor crack was developed at the center portion of the slab. As the load increased, new cracks developed while the existing ones near the line load enlarged. After that gradually applied load major cracks were developed below the concentrated load.

2.During testing have used one point central loading condition and observed that central deflection in composite slab was less than normal concrete slab.

3. The end slip was developed in corner portion of slab and vertical separation between two materials was also observed before failure.

4. Compressive strength of concrete cube in 7 days curing in Table 2.

Table 2. Result of compressive strength Test

Details	Sample		
	Trail 1 (1:1.46:2.57) mix proportion	Trail 2 (1:1.25:2) mix proportion	Trail 3 (1:1:1) mix proportion
Compressive Load(KN)	1)410 KN 2)415 KN 3)420 KN	1)446 KN 2)451 KN 3)456 KN	1)375 KN 2)380 KN 3)385 KN
Compressive strength (N/mm^2)	=18.22 N/mm^2 =18.44 N/mm^2 =18.66 N/mm^2	=19.82 N/mm^2 =20.04 N/mm^2 =20.06 N/mm^2	=16.66 N/mm^2 = 16.88 N/mm^2 =17.11 N/mm^2
Compressive strength 20.04 N/mm^2	1:1.25:2 proportion used for casting		

The compressive strength of specimen having mix proportion was 1:1.46:2.57, 1:1.25:2, 1:1:1.For the 1:1.25:2 mix proportion have more compressive strength than other two. Therefore this proportion was used to casting.

Table.3 Results of flexural tests

Results of flexural tests				
Sr.No.	**Slab Specifications**	**1^{st} Crack load (in kN)**	**Ultimate load (in kN)**	**Center Deflection (in mm)**
1	RCC Slab(RS)	7.9	11.78	33.38
2	RCC Slab + PP Fibres (0.75%)(RSP)	8.2	12.37	42.97
3	RCC Slab + PP Fibres(0.75%) + Fly ash(25%)(RSPF)	8	12.1	38.7
4	I Beam + Deck Sheet + RCC Slab+ Stud connector(IDRS)	69.5	80.24	20.6
5	I Beam + Deck Sheet + RCC Slab + Stud connector + PP fibres (0.75%)(IDRSP)	72.9	84.35	28.66

6	I Beam + Deck Sheet + RCC Slab + Stud connector + PP fibres(0.75%) + Fly ash(25%)(IDRSPF)	70.8	82.5	25.1
7	I Beam + Deck Sheet + RCC Slab +Channel connector(IDRC)	60.4	71.67	22.80
8	I Beam + Deck Sheet + RCC Slab +Channel connector + PP fibres (0.75%)(IDRCP)	63.42	75.1	40.26
9	I Beam + Deck Sheet + RCC Slab +Channel connector + PP fibres (0.75%)+Fly ash(25%)(IDRCPF)	61.60	73.7	33.7

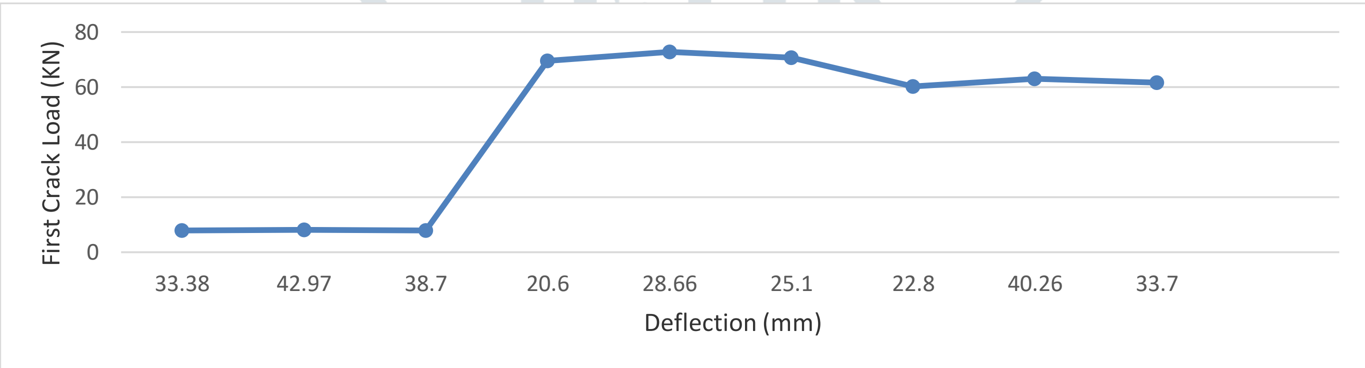

Fig.9 First crack load v/s Deflection

In above **Fig.9** shows the First crack load vs Deflection. First crack load vs Deflection.First crack load was found in normal concrete slab was 7.9 KN. IDRSP increased by 4.8% than control specimen due to addition of PP fibre (0.75%) and IDRSPF increased by 2% than control specimen by addition of PP fibre strength increased but due to fly ash strength get reduced than control specimen. In IDRC first crack load was found at 60.4 KN. In IDRCP first crack load increased by 4.3% than control specimen and IDRCPF increased by 2% than control specimen i.e. composite profile deck was more effective than RS slab.

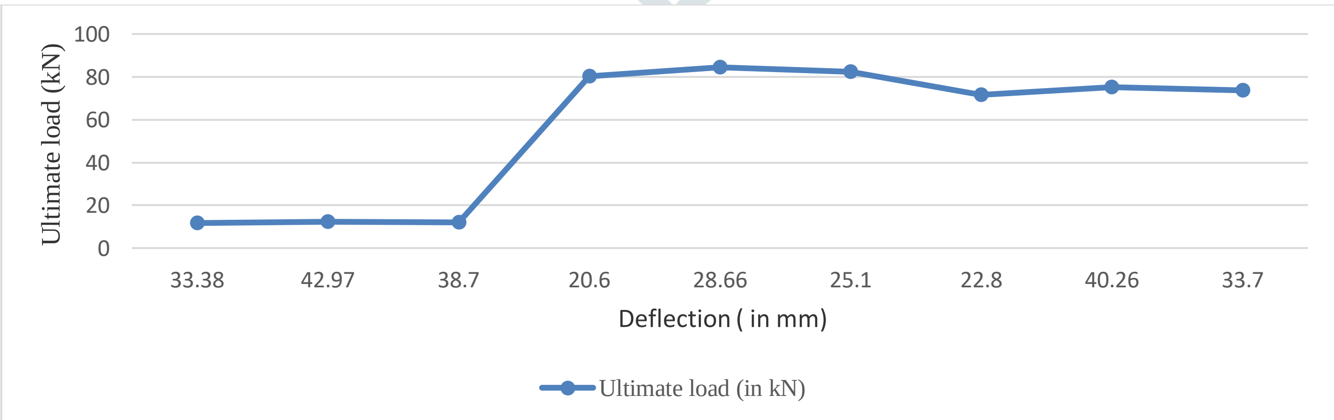

Fig.10 Ultimate crack load v/s Deflection

In above **Fig.10** shows the Ultimate load vs Deflection. Ultimate load was found in normal concrete slab was 11.78 KN. IDRSP increased by 5.2% than control specimen due to addition of PP fibre (0.75%) and IDRSPF increased by 2.8% than control specimen In IDRC ultimate load was found at 71.67 KN. In IDRCP ultimate load increased by 4.7% than control specimen and IDRCPF increased by 2.8% than control specimen i.e. composite profile deck was more effective than RS slab.

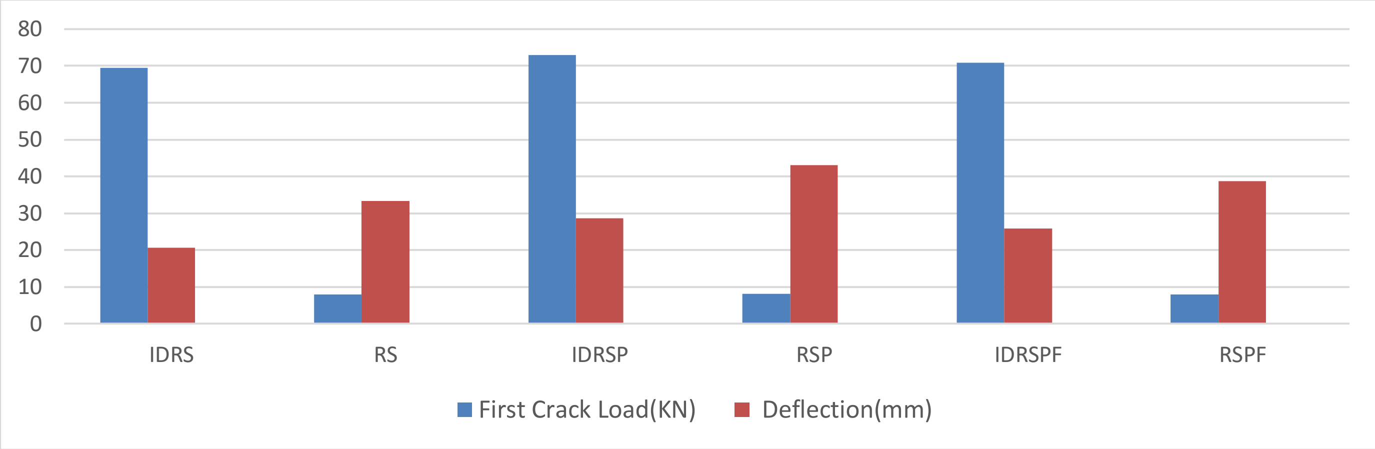

Fig.11 First Crack Load v/s Deflection of IDRS & RS

In above **fig.11** shows the 1st crack load v/s Deflection. First crack load was found in normal concrete slab was 7.9 KN but deflection more. First Crack Load of IDRS was maximum and deflection minimum but in case of RS it is reverse i.e. deflection was maximum and first crack load minimum. Composite profile deck was more effective than RS slab.

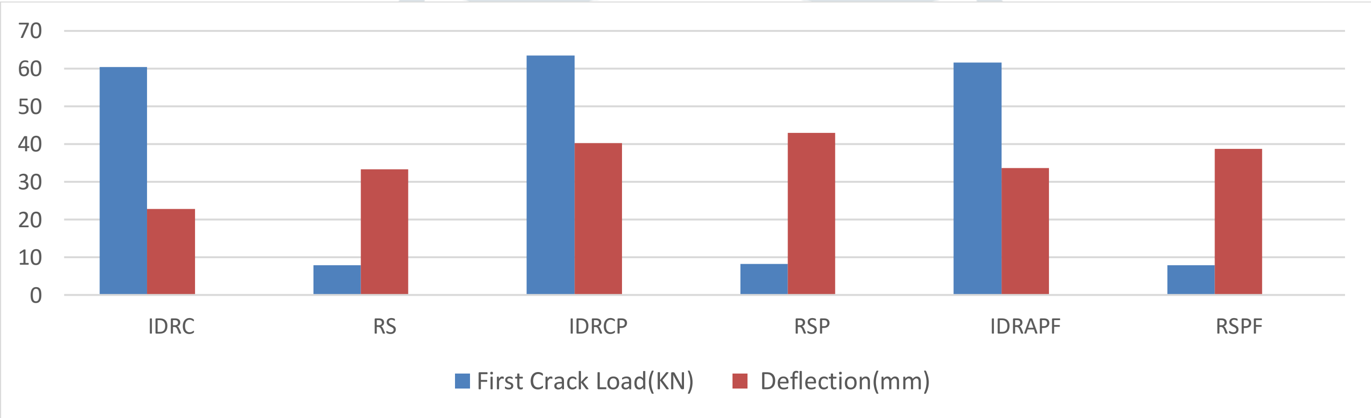

Fig.12 First Crack load v/s Deflection of IDRC & RS

In above **fig.12** shows the 1st crack load and Deflection. First Crack Load of IDRC was maximum and deflection minimum but in case of RS it is reverse i.e. deflection was maximum and first crack load minimum. Composite profile deck was more effective than other normal slab.

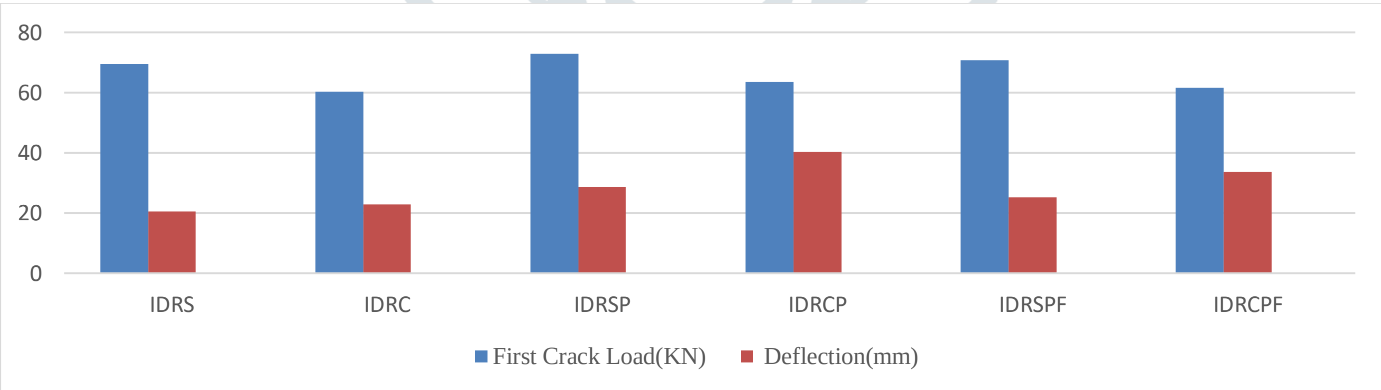

Fig.13 First Crack Load v/s Deflection of IDRS & IDRC

In above **Fig.13** shows the 1st crack load and Deflection. IDRS carrying maximum load than IDRC. It shows the stud connector having maximum load carrying capacity and minimum deflection than the channel connector.

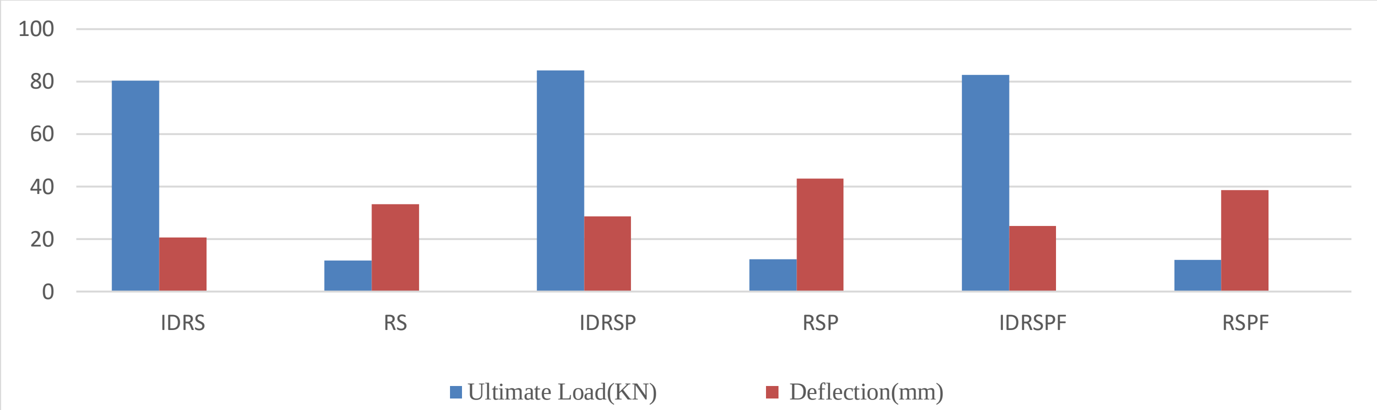

Fig.14 Ultimate Load v/s Deflection of IDRS and RS

In above **Fig.14** shows the Ultimate load and Deflection. Ultimate Load of IDRS was maximum and deflection minimum but in case of RS it is reverse i.e. deflection was maximum and ultimate load minimum. Composite profile deck was more effective than other normal slab.

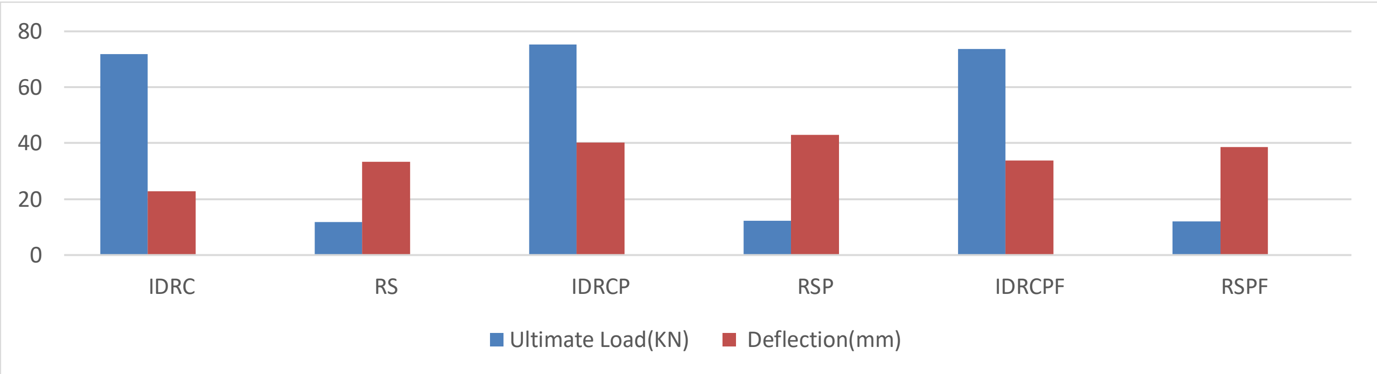

Fig.15 Ultimate Load v/s Deflection of IDRC & RS

In above **Fig.15** shows the Ultimate load and Deflection. Ultimate Load of IDRC was maximum and deflection minimum but in case of RS it is reverse i.e. deflection was maximum and ultimate load minimum. Composite profile deck was more effective than other normal slab.

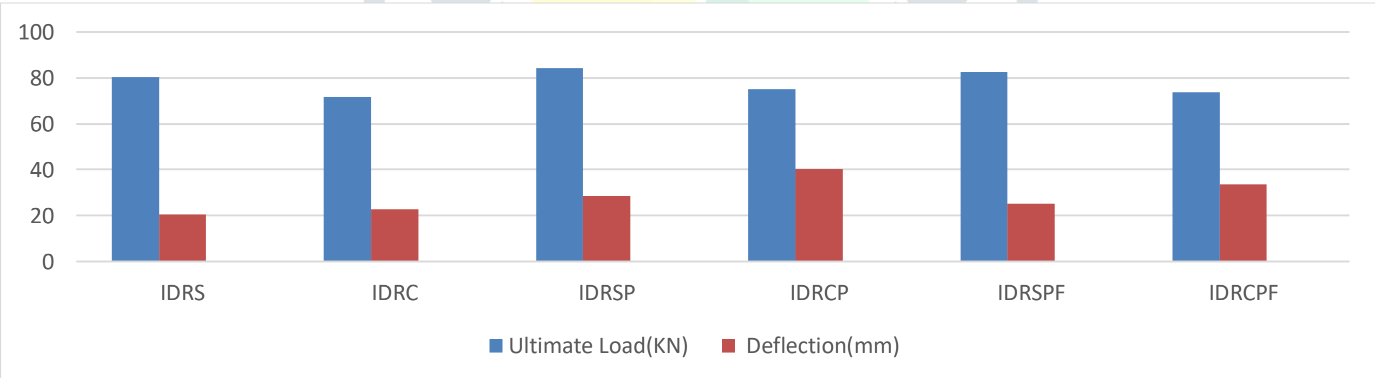

Fig.16 Ultimate Load v/s Deflection of IDRS & IDRC

In above **fig 16** shows the Ultimate load and Deflection. IDRS carrying maximum load than IDRC. It shows the stud connector having maximum load carrying capacity and minimum deflection than the channel connector.

CONCLUSION

1) The 1st crack load carrying capacity of the composite slab using stud connector is 7.8 times increased than RCC slab.
2) The 1st crack load carrying capacity of the composite slab using channel connector is 6.7 times increased than RCC slab.
3) The ultimate load carrying capacity of the composite slab using stud connector is 5.8 times increased than RCC slab.
4) The ultimate load carrying capacity of the composite slab using channel connector is 5.08 times increased than RCC slab.
5) The steel reinforcement required in composite construction is less than RCC slab.
6) In composite slab by using profile deck sheet, then the depth of composite slab reduced.

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