Performance Analysis of Steel Concrete Composite Section

Prof. Y.P. Pawar[1], Mr.Ganesh S. Mali[2]
[1]Assistant Professor, Dept of Civil Engineering
[2]Dept of Civil Engineering
[1, 2] SKN Sinhgad College of Engineering, Korti, Pandharpur 413304

Abstract- *In present work, an attempt is made to investigate the behavior and design of composite members used in composite sections for different configurations under the load. The main purpose of this research work is to analyses the structural performance of steel – concrete Composite sections, comparative analysis of the steel – concrete composite section and RCC members under flexural performance. The finite element method (FEM) is the most popular simulation method to predict the physical behavior of systems and structures.*

This work is intended to show a summary of ANSYS capabilities to obtain results of finite element analyses as accurate as possible. The target of this research is to demonstrate a better analytical understanding of double steel-concrete composite beams. Thereby, the focus should be set on the performance analysis of existing composite section with composite action. Therefore, the principal purpose is the nonlinear finite element analysis of steel-concrete composite beams containing double composite action and head studs shear connectors.

Keywords- Steel –concrete composite section, head studs shear connectors, slip-strain value, beam-slab interface

I. INTRODUCTION

The use of composite structures is increasingly present in civil construction works. Steel-concrete composite beams, particularly, are structures consisting of two materials, a steel section located mainly in the tension region and a concrete section, located in the compression cross-sectional area, both connected by metal devices known as shear connectors. The main functions of these studs are to allow for the joint behavior of the beam-slab, to restrict longitudinal slipping and uplifting at the elements interface and to take shear forces. steel-concrete composite beam is a new structural system developed on the basis of single steelconcrete one, in which there is also a bottom reinforced concrete slab connected to a steel profile in the negative moment regions through the head studs. Comparing with the traditional single steel-concrete composite beam, its advantage is that effectively limits the crack width of the negative moment area, and also improves the stress state of section, so that it is suitable to the composite continuous beam with a larger span.

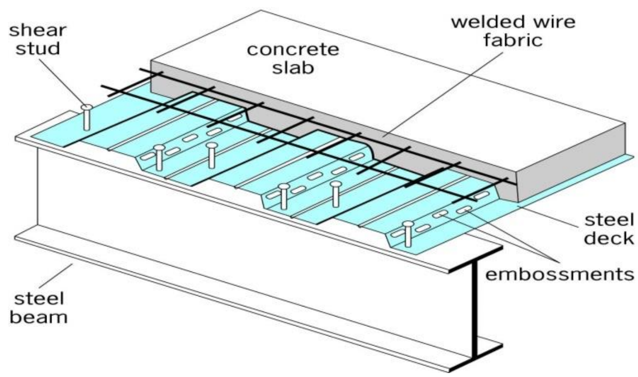


Figure 1 Illustrative sketch of composite section

The mechanical properties of the double composite beam obviously depend on their respective properties and interactions. In the negative bending moment area, the concrete slab cracks under tension and then the interface slip occurs between steel profile and concrete slab, with non-linear features, it makes great impact on the structure of the internal forces and deformation. Therefore, it is necessary to present a finite element model to study the mechanical properties of the double steel-concrete composite beam in negative moment regions.

Behavior and design aspect of composite slab

composite slab is defined as a slab system comprising normal weight or lightweight structural concrete, placed permanently over cold-formed steel deck in which the steel deck performs dual roles of acting as a form work for the concrete during construction and as positive reinforcement for the slab during service.

1) Complete interaction between steel and concrete: No global slip at the steel-concrete interface exists. The horizontal transfer of the shear force is complete and the ultimate load P is at its maximum, the composite action is complete. The failure can be brittle, if it

occurs suddenly or ductile if it happens progressively.

2) Zero interaction between concrete and steel: Global slip at the steel-concrete interface is not limited and there is almost no transfer of shear force. The ultimate load is at its minimum and almost no composite action is observed. The failure is progressive.
3) Partial interaction between concrete and steel: Global slip at the steel-concrete interface is not zero but limited. The shear force transfer is partial and the ultimate values lies between the ultimate loads of the previous cases. The failure can be brittle or ductile.

Shear Connector

Shear connectors or mechanical connectors are one type of connectors that are used to connect concrete and steel in composite structure. These types of connector are more prevalent and widely used in composite construction due to easy availability and enough research data proving their effectiveness and ensuring their connecting ability. One of the most important factors in case of composite structures is the interaction of the bonding layer. This is why it is important that the shear connectors provide interaction as close to full interaction as possible.

The shear connectors must fulfill the following criteria's:

They must be able to transfer the direct shear at the base.

The link created by these connectors inside concrete should be a tensile link

It is also very necessary according to the modern norms that these connectors are feasible, economical and eco- friendly.

The total shear force at the interface between concrete slab and steel beam is approximately eight times the total load carried by the beam. Therefore, mechanical shear connectors are required at the steel-concrete interface. These connectors are designed to

(a) Transmit longitudinal shear along the interface, and
(b) Prevent separation of steel beam and concrete slab at the interface.

II. PROBLEM STATEMENT

ANSYS computer program has been used to develop a three dimensional nonlinear finite element model in order to investigate the behavior of steel- concrete composite section, with emphasis on the beam slab interface. Three beam models with varying in size of shear connector have been addressed. The associated constitutive results such as the, the maximum deformation, the principle strain and stress, Normal stress, elastic stress and strain, shear stress values are presented.

Aim: –

The main aim of the project is to study the design and analysis of composite members used in composite sections for different configurations under the loading conditions

Objective: –

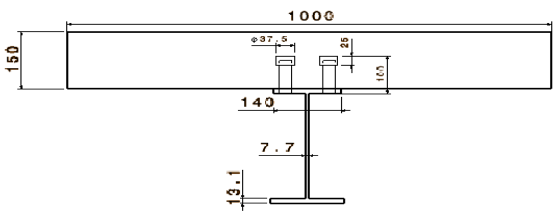
The main objectives of the present research work may be summarized as follows:

1) To analyze the structural performance of steel – concrete Composite sections.
2) To investigate the failure pattern of the members for different parameters.
3) To study the comparative analysis of the steel – concrete composite section and RCC members under flexural performance.

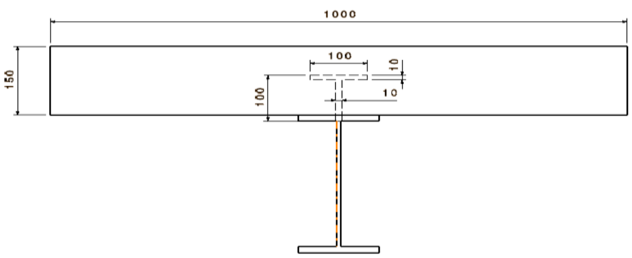
III. METHODOLOGY

This work uses model of composite section, for analysis purpose. The finite element model presented here developed by ANSYS.16 the model implementation started with the definition of the geometry of the composite beam. Secondly, finite elements available in the ANSYS computer program library were chosen to represent the composite materials. Thirdly, the properties and constitutive relations of the materials involved were introduced. Finally, the mesh, couplings and linkages between the elements were added, taking into consideration the symmetry condition and the consequent restriction of degrees of freedom, and also the beam support conditions and the applied load. The first simulation was done vis-à-vis the unique characteristic of the beam, to validate the model. Then, to analyze the connectors influence on the structural behavior of the composite beam, several alternatives for connectors were analyzed, with changing shapes of connector. The details of composite beam which is used further is as shown in below figures

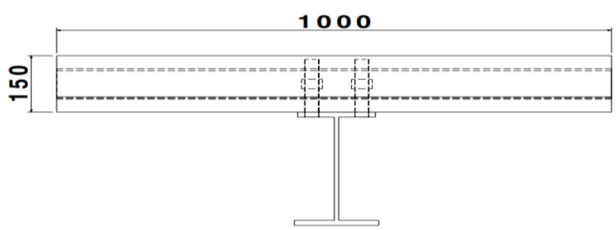
1) Beam with Headed stud shear connector



2) Beam with T shape shear connector



3) Beam with Headed stud and metal sheet



Parameters of model

For our project, we made a composite section by using ISMB 300 section and concrete.

There are 3 models,

1) Composite section with headed stud shear connector is provided on I section by weld.
2) Composite section with T shape shear connector is provided on I section by weld.
3) Composite section with headed stud shear connector and MS metal sheet is provided.

A. Steel beam - ISMB 300

Depth of section (d) – 300 mm
Width of section (b) – 140 mm
Thickness of web (tw) – 7.70 mm
Thickness of flange (tf) – 13.10 mm
Area of section (A) - 58.6 cm2
Moment of inertia (Ixx) – 8990 cm4
Sectional modulus (Zp) – 599 cm3
Radius of gyration (rx) – 12.4 cm

B. Concrete

Grade of concrete (Fck) – M40
Depth of slab – 150 mm
Size of specimen – 3000 X 1000 mm
RCC beam size – 230 X 450 mm
Reinforcement – 8mm @ 120mm c/c in longitudinal direction
8mm @ 120mm c/c in transverse direction

C. Shear connector

M8 High strength (Grade 8.8)
Yield stress – 660 Mpa
Tensile stress – 830 Mpa
Headed stud shear connector
Diameter – 25 mm
Height - 100 mm
Design strength of head stud connector for M40
Concrete – 113 KN
T shape stud shear connector
Size – 100 x100 x10 mm
Size of flange – 100 x 10 mm
Size of web – 90 x 10 mm
Depth – 100 mm
Design Load per connector for M40 concrete – 211 KN

D. MS Metal sheet

Thickness - 0.5 mm
Weight (Kg/Sq. meter) – 3.14

Figure of ANSYS Models

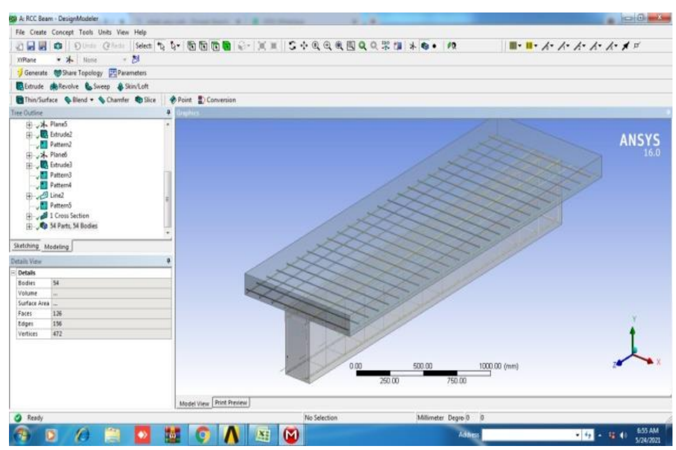


Fig.2 ANSYS model of RCC Beam

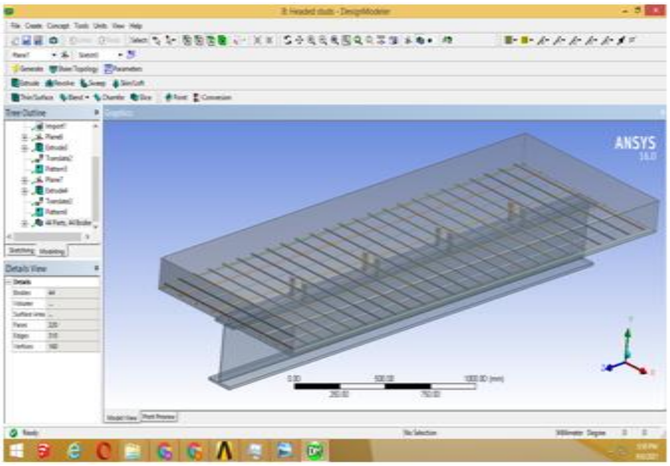


Fig.3 ANSYS model of Beam with Headed Stud shearconnector

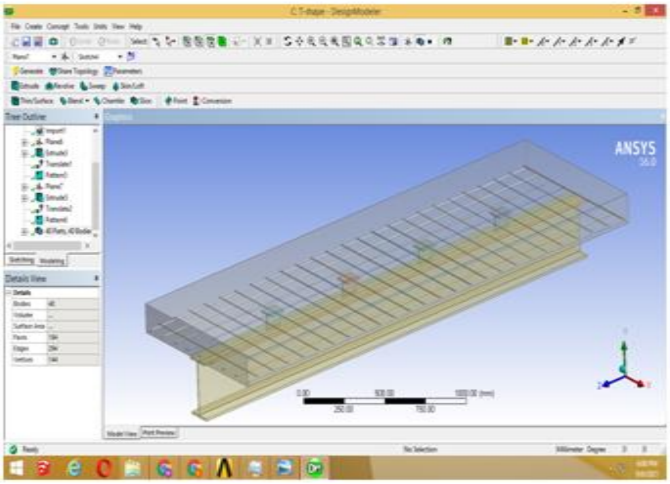


Fig.4 ANSYS model of Beam with T Shape Stud shear connector

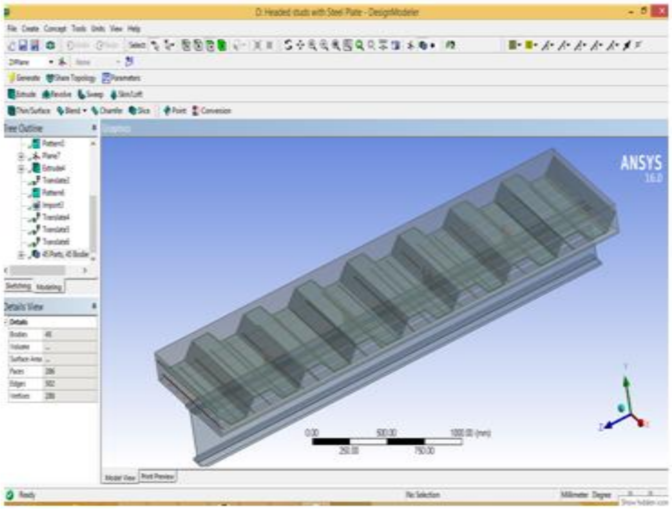


Fig. 5 ANSYS model of Beam with Headed stud connector and metal sheet.

Materials and workmanship specifications:-

Steel – concrete composite structure was designed by limit state method.

For structural steel, the materials and workmanship is according to IS 800-2007.

For concrete and reinforcing steel, the materials and workmanship is according to IS 456-2000.

For composite construction in structural steel and concrete, the materials and workmanship is according to IS 11384- 1985.

Materials properties :

The characteristics of the beam and the real properties of materials are presented in Table 3.1. It is may be noted that this study considered other configurations for the connectors, as number, height and diameter. Materials properties of composite beam were as follows,

Sr. No	Material	Property	Value
1	Structural steel	Yield stress f_{sy} (MPa)	265
		Ultimate strength f_{su} (MPa)	410
		Young's modulus E_s (MPa)	205×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain e_t	0.25
2	Reinforcing bar	Yield stress f_{sy} (MPa)	250
		Ultimate strength f_{su} (MPa)	410
		Young's modulus E_s (MPa)	200×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain e_t	0.25
3	Concrete	Compressive strength f_{sc}(MPa)	40
		Tensile strength f_{sy}(MPa)	3.553
		Young's modulus E_c(MPa)	32920
		Poisson's ratio μ	0.15
		Ultimate compressive strain e_s	0.045
4	Stud shear connector	Spacing (mm)	600
		Number of rows	2
		Numbers of connectors	8
		Yield stress f_{sy}(MPa)	660
		Ultimate strength f_{su} (MPa)	565
		Young's modulus E_s(MPa)	200×10^3
		Poisson's ratio μ	0.15
		Ultimate tensile strain e_t	0.045

Table 1 : Material Properties

Results and Discussion :

We found the results of composite beam, they are given below

Sr.No	Parameter	RCC Beam	Beam with headed studs	Beam with T Shape Shear Connector	Beam with headed studs and Metal sheet
1	Total Deformation(mm)	15.38	5.64	1.45	0.56
2	Maximum principle stress(M pa)	0.3680	2.549	2.138	2.550
3	Normal Stress(Mpa)	0.0603	0.8761	0.489	0.8764
4	Maximum principle elastic strain	0.0120	0.00196	0.00129	0.000193
5	Normal elastic strain	0.00249	0.00104	0.000256	0.000104
6	Equivalent elastic strain	0.0136	0.00564	0.00236	0.000564
7	Equivalent stress(Mpa)	0.4095	1.1152	4.6283	1.1162
8	Maximum shear elastic strain	0.01668	0.007764	0.003312	0.000777
9	Shear stress(Mpa)	0.02265	0.7558	0.5610	0.7557

Table 2 : Observed Results

IV. CONCLUSION

Based on the finite element numerical study and the available results, the following main conclusion can be extrapolated.

1. The FEA ANSYS program can be used as a very useful tool in predicting performance of steel concrete composite beam. It can provide detail information for the distribution of stresses and strain in composite section.
2. From result, it concludes that composite sections are not vulnerable to principle elastic and normal strain. Its performance is very impressive in case of equivalent elastic strain.
3. The thickness of metal sheet has very little effect on behaviour of steel concrete composite section. The deflection in composite slab is less than as compared to RCC slab. Total deformation with shear connector is very less as compared RCC section.
4. Due to structural integrity and bonding it shows very less value of shear stresses. Based on this study, it is seen that the shear connection of simply supported beams effects on the overall system response.
5. In further investigation the influence of shear connectors are studied, from that work it can be concluded that the shape, diameter and height values of for shear connectors wereused, it is observed that shape of cross section of shear connector also matters in behavior of composite beam.
6. After observing overall result, Beam with headed stud shear connector and beam with metal sheet shows excellent performance.
7. The finite element model used in the present work is able to simulate the behavior ofsteel-concrete composite section. These results reveal the accuracy and efficiency of the developed computer program (ANSYS 16) in predicting the behavior composite steel-concrete beams.

V. FUTURE SCOPE

1. Evaluation of the performance of members, connection and connector under severe cyclic and dynamic loading including shakedown behavior is another field which may be of interest to the researchers.
2. The earthquake response of steel and composite building structures is a subject of much interest, therefore there is much scope for research on the use of composite structure in seismic areas. The use of fully and partially encased steel section in reinforced concrete is particularly beneficially for earthquake resistant design is highly recommended.
3. Fire resistance of composite structure is desirable to maximize their potential use and to clearly understand steel concrete progressively lose strength and stiffness at elevated temperatures.
4. The use of fiber reinforced concrete, high strength concrete, self -compacting concrete instead of the conventional concrete may be explored in steel concrete composite construction.
5. Little wind analysis of multi- storied composite structure can be carried out and charts can be prepared for various wind pressure.
6. Design rules for composite construction have been developed gradually over the years and have been undergoing improvements and updating till today. These progressive changes results in more efficient use of constituent materials and led to better, less expensive structures. There is no doubt that the research for further improvement in this field will be certainly beneficial because it has very wide scope for further development.

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