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Analysis of Composite Beam with Shear Connectors Using FEA Software (ANSYS)

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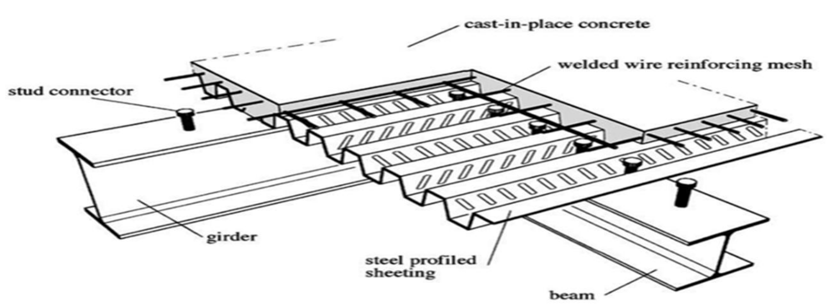
Abstract: The Composite structures made of concrete slabs and rolled steel profiles are widely used components in bridges and High buildings. Composite effects are created by connecting concrete slabs and steel profiles with chemical anchors. In this paper, I analyze three types of shear connectors (Headstud, T shape, Channel section) with different grade of concrete M-20, M-30, M-40 based on design strength given by the code book IS: 11384-1985. Based on their performance under static load, find the best connector for a particular composite beam while maintaining the stress and amount of steel in the connector as a common aspect.
Keywords: Composite beams, Ansys Software, Shear Connectors.

I. INTRODUCTION

Composite beams, which are constructed by laying concrete slabs on concrete beams and connecting them with steel or shear connectors, are structural elements that are commonly used in structures such as bridges and skyscrapers. Bridges and buildings frequently use plate and beam structures. Plate girder interaction is enabled by shear connectors welded to the top of the steel girder flange. You can eliminate slippage between the beams and the concrete slabs by using proper connections. As a result, the steel beam and plate behave as a "composite beam," similar to a monolithic T-beam.

Steel-concrete composite structures, particularly multi-layer steel frames, have a significant market share in a number of European countries, as well as the United States, Canada, and Australia. This is primarily due to decreased construction depth, reduced steel weight, and rapid construction programmers. By combining structural elements to form a single compound section, the compound action improves structural efficiency. By reducing materials, slimming floor depth, and speeding up the structure, composite beam construction offers significant cost savings. Furthermore, this system is known for its increased stiffness and strength when compared to non-composite solutions. Composite beams are structural members made of two or more different materials that are connected in some way to function as a single unit.

A reinforced concrete composite beam is a simple example of a composite beam in a building structure. Wide steel shapes like I and W are fixed in the laboratory's concrete floors. Reinforced wood, concrete wood, and plastic concrete are all examples of composite beams. The composite beams shown here differ from the fibre reinforced polymer beams shown in the figure below.



Typical composite floor system

II. OBJECTIVE

The goal is to test the effect of the number, size, and height of shear connectors in composite beams. These verifications were accomplished through the investigation of longitudinal slip in the slab beam interface, vertical deformation at mid span, and composite beam bearing capacity. The results were compared to standards and other dates identified in the examined literature.

III. LITRATURE REVIEW

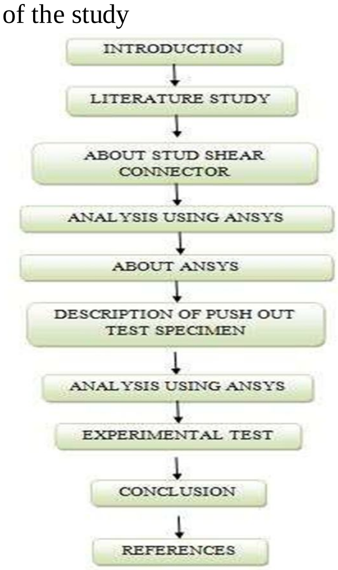
1) *Sandatmanesh et al. [1989]* **-** Prestressed with high-strength steel tendon and investigated the behavior of steel girders bonded to concrete slabs. Bradford and Gilbert [1992] developed a theoretical model of the time-dependent response of simply supported reinforced concrete composite beams. In 2000, Ayoub and Filippou developed inelastic beam elements for studying partially bonded reinforced concrete beams under monotonous and repeated loads.
2) *Chung and Wang (2006)* **-** Shear connection flexibility can affect the structural behavior of continuous composite beams not only in terms of load deflection behavior, including initial stiffness, but also in terms of load bearing capacity. I understand. .. This work also investigated the effect of the flexibility of the shear connection of semi-continuous beams on both global and local operating elements.
3) *Lee et al. (2005)***-** They did examine at the conduct of massive shear stud connectors utilized in metal concrete composite bridges. Since too many small length connectors like 19 mm and 22 mm length are required in regions of excessive shear in composite bridges. That reasons longer welding time and different problems. It turned into discovered that the protection elements used for ordinary length studs ought to be elevated for massive length studs, and fatigue energy discovered in massive studs is little decrease than ordinary studs.
4) *Smitha. K (2015)* **-** Finite elment analysis of composite beams with shear connectors Composite structures made of concrete slabs and coiled steel profiles are widely used components in bridges and skyscrapers. Composite effects are created by connecting concrete slabs and steel profiles with chemical anchors. In this paper, we analyze four types of shear connectors and, based on their performance under static load, find the best connector for a particular composite beam while maintaining the stress and amount of steel in the connector as a common aspect.
5) *Lam and El-Lobody (2005)***-**They did study on composite beam using headed studs. Lam first did experimental work using shear studs in push-off test. The result obtained are then validated with the finite element model developed by him for the same push-out test in ABAQUS. Lam concluded that ABAQUS can be used for modeling composite beams and can replace the costly experimental work.

IV. PROBLEM OUTLINE

There has been little research into using ANSYS to model partial interaction of steel concrete composite beams. ANSYS is appropriate for engineering simulation programmes because it is based on the finite element method and can solve relatively simple linear analyses as well as nonlinear simulations. ANSYS has a large library of elements that allow us to model almost any type of geometry. It also includes a large number of material models that allow us to simulate the behaviour of various materials such as metals, polymers, and rubber composites, reinforced, crushable, concrete, and resilient foams. ANSYS provides a wide range of simulation capabilities for linear and nonlinear problems. The geometry of each component is defined with appropriate material models and component interactions to model problems with many components. ANSYS automatically selects load increments and continuously adjusts convergence and tolerances during a non-linear analysis to ensure the correct solution is obtained.

V. METHODOLOGY

The below flowchart shows the methodology of the study



VI. RESEARCH APPROACH

Finite element model has been created using ANSYS. Data from different published experimental results were collected and modelling has been developed. Behaviour of shear connectors in composite beam has to be found out. The objective was achieved by carrying out analysis of composite beams as follows.

1) A detailed literature study.
2) Modelling of steel concrete composite beam in ANSYS.
3) Validation of the FE model in ANSYS with the published experimental results.
4) Generating results for different type of connectors so that it can be used instead of doing the experimental work.

VII. SHEAR CONNECTORS

Composite construction provides monolithic action between pre-fabricated units such as steel beams, pre-cast reinforced concrete, pre-stressed concrete beams, and cast in-situ concrete, allowing two elements to act as a single unit. Although there is some natural bonding between the concrete slab and the steel beam in the early phases, this connection cannot be relied on because it is likely to erode due to use and over load. Mechanical shear connectors are thus given to assist the steel and concrete elements in acting in a composite manner without ignoring the contribution offered by the inbuilt natural bond. Shear connectors are primarily recommended to resist horizontal movement between the concrete slab and the steel beam and to spread horizontal shear between the concrete slab and the steel beam. Shear connectors are also utilised to prevent the slab from vertically separating from the steel gurder at the contact surface. As a result, shear connectors must be constructed to provide integral action of the composite structure under all load circumstances, as follows: a) Without slip, transmit longitudinal shear along the surface in contact. b) To prevent vertical separation of in-situ RC slabs from pre-fabricated steel beams.

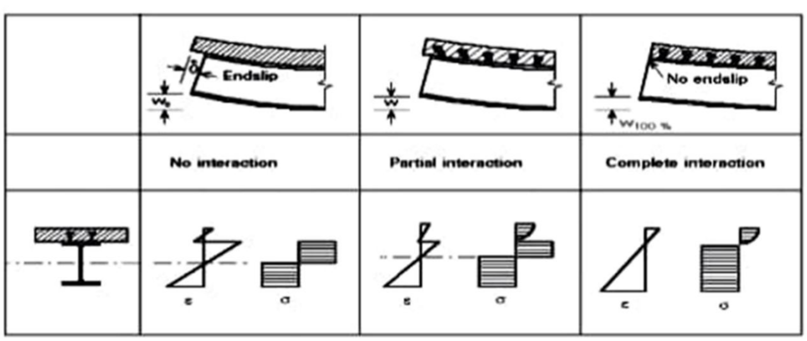
VIII. PARTIAL INTERACTION

In reality, it is expected that there is no slide at the interface of a steel-concrete composite beam when using a stiff form of shear connector. However, research over the years have revealed that even when utilising a rigid form of connector in a composite beam, there is always some slide at the interface. As a result, it is not possible to create a completely firm link. The flexibility of the connector also improves the ductility of the connection.

The connectors are expected to resist the longitudinal shear force even when deformed to determine the shear resistance and shear capacity of the connection. The resistance of the beam is determined by the shear resistance of the connections. The slip that happens at the interface as a result of the deformations has a significant impact on the stiffness of the composite beam.

Types of Interactions:-

1) *No Interaction:* It means there is no connection between concrete slab and steel beam. The concrete slab and steel beam act individually.
2) *Full Interaction:* A beam where the connectors are infinitely stiff is said to have "full interaction". In this type of connection there is no slip between concrete slab and steel beam.
3) *Partial Interaction:* A beam where the connection is relatively flexible is said to have "partial interaction". In this type of connections there is slip between concrete slab and steel beam. The shear connector deforms in this case.



Composite steel beam – concrete slab interaction

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IX. ANSYS MODELS

A. *Simply Supported Composite beam*

DATAS

Thickness of slab- 125 mm

Partition load – 1.5 KN/m2 Floor finish load – 0.5 KN/m2

Imposed load- 3 KN/m2

fck – 30 N/mm2

fy – 415 N/mm2

Density of concrete – 24 KN/m3

Sectional properties:- ISMB 450

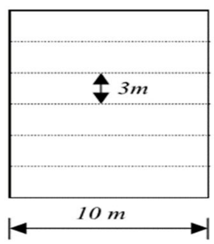
D – 450 mm Zx – 1350 x 103 mm3

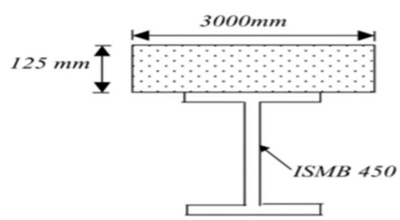
tf – 17.4 mm ry – 30.1 mm

tw – 9.4 mm

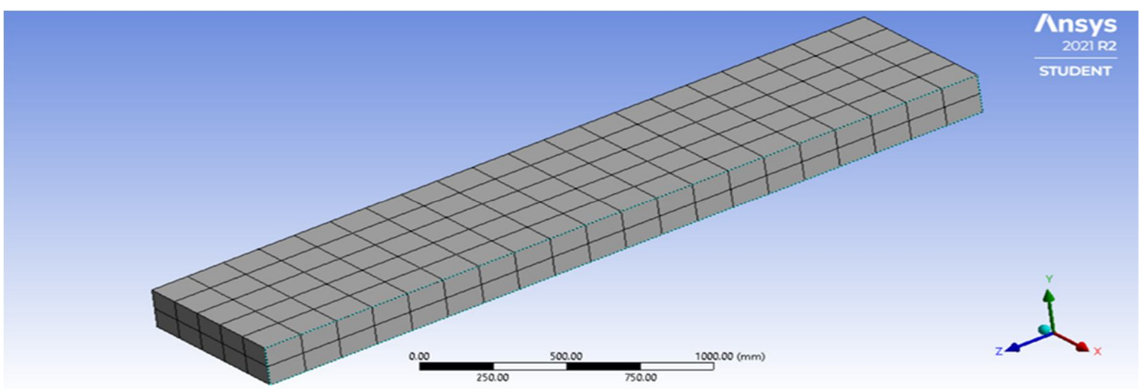
Ix – 303.9 x 106 mm4

Iy – 8.34 x 106 mm4

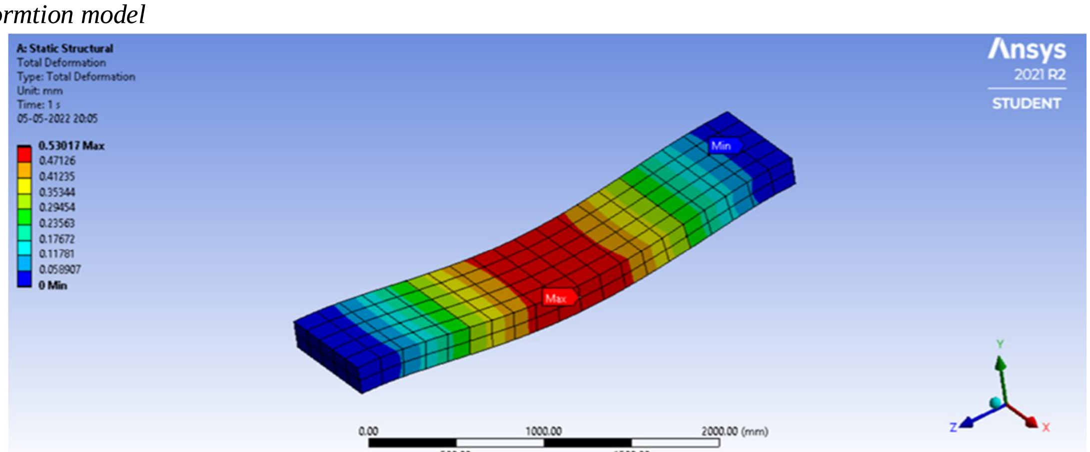




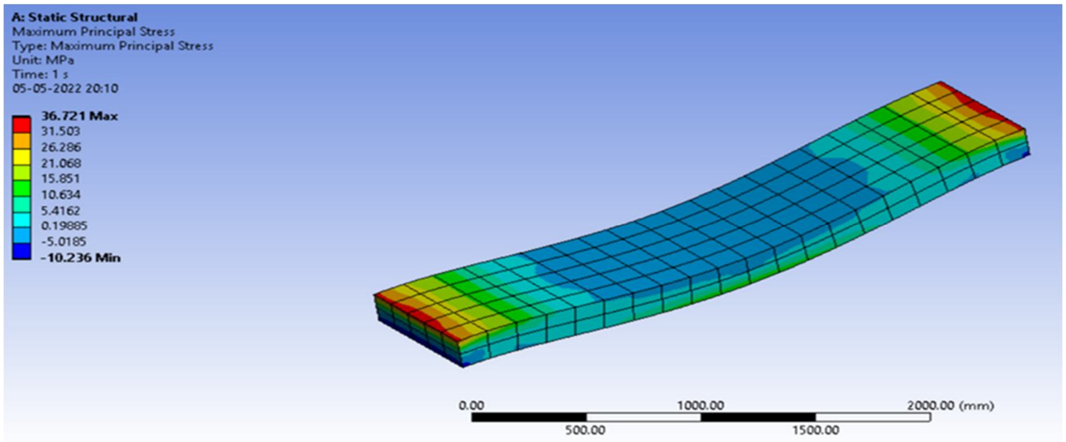
1) *Finite Element Mesh model*



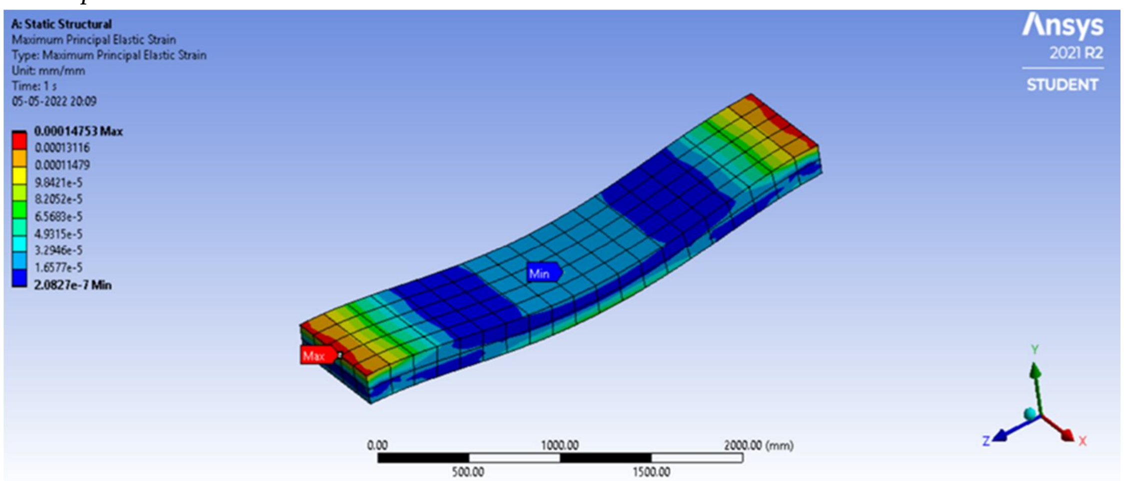
2) *Total Deformtion model*



3) Maximum Principle Stress model

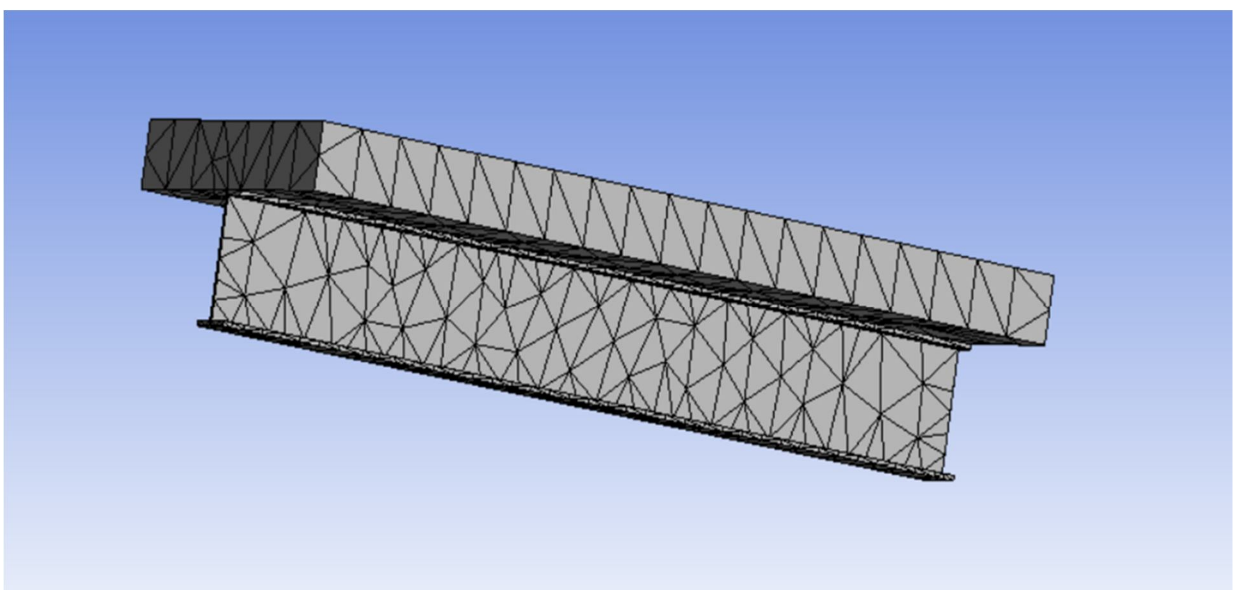


4) Maximum Principle Strain model

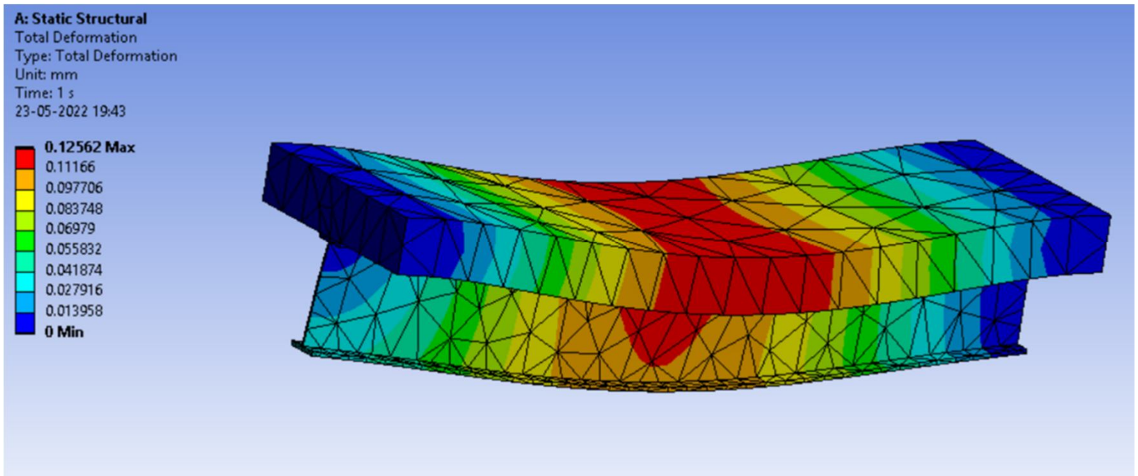


B. Steel Concrete Composite Beam

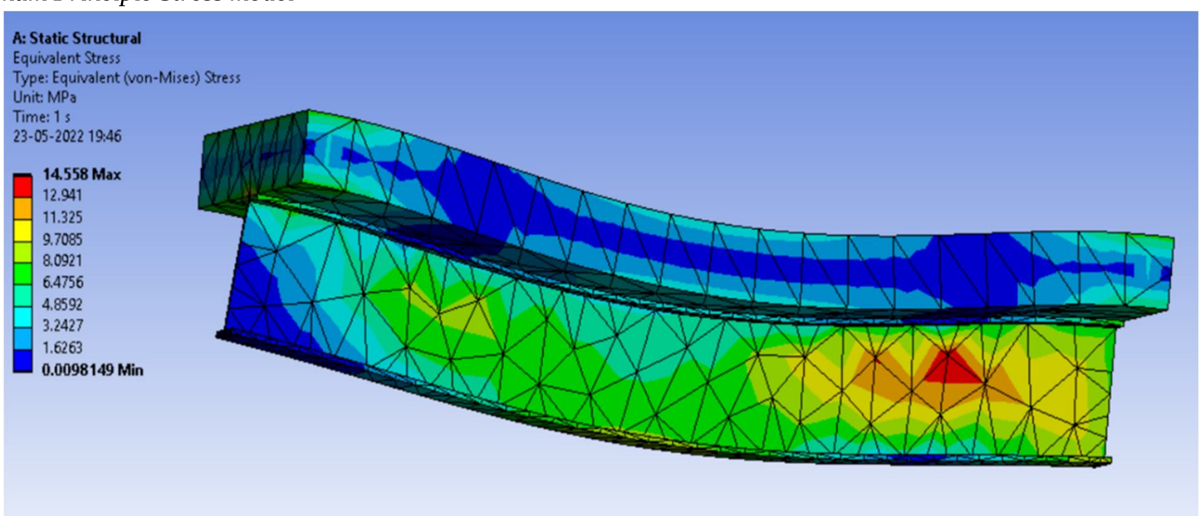
1) Finite Element Mesh model



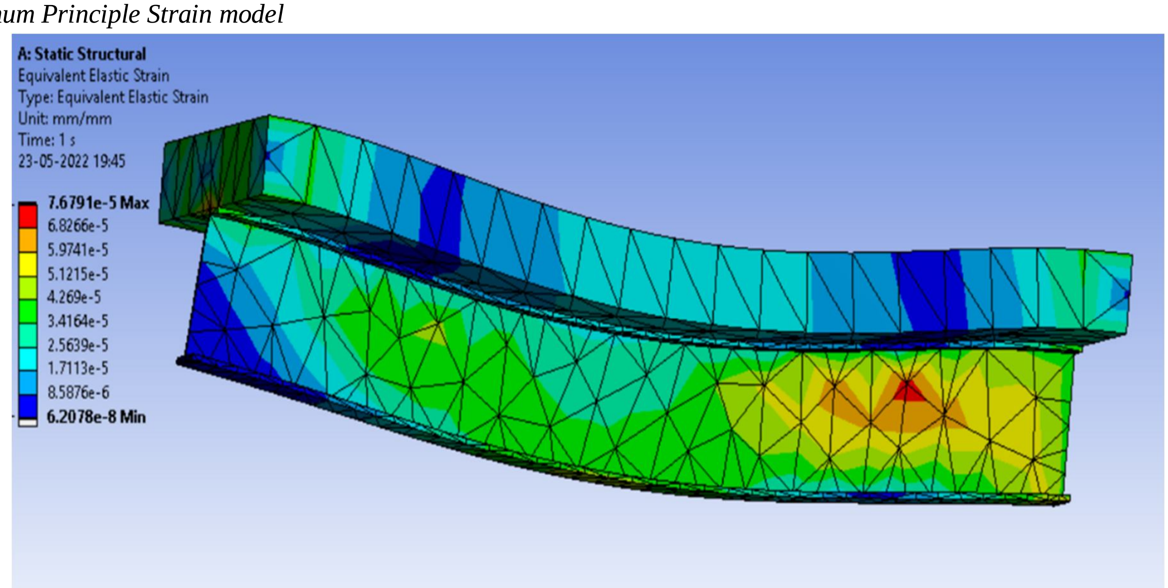
2) *Total Deformtion Model*



3) *Maximum Principle Stress model*



4) *Maximum Principle Strain model*



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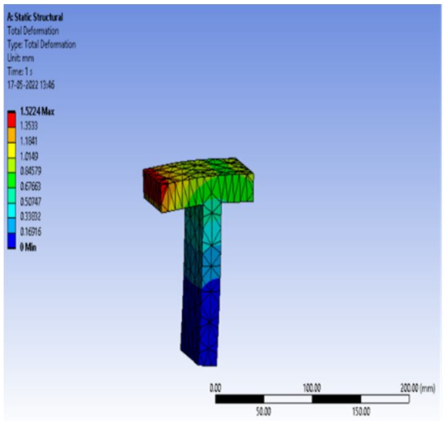
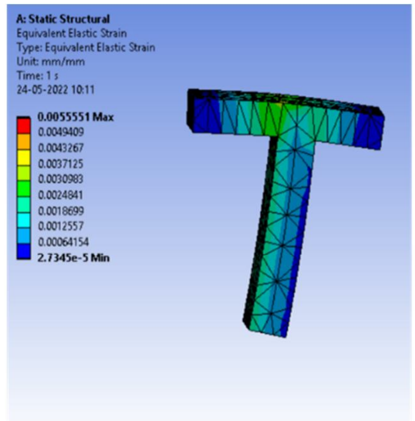
X. SHEAR CONNECTORS BY ANSYS SOFTWARE

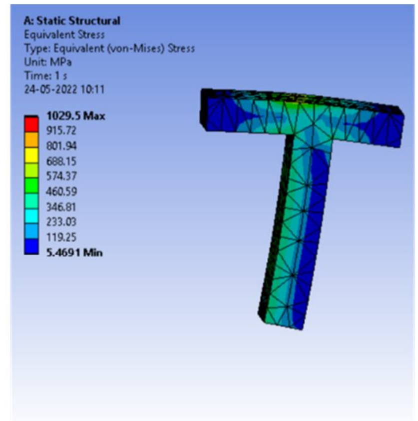
A. Analysis Of Tee Connector



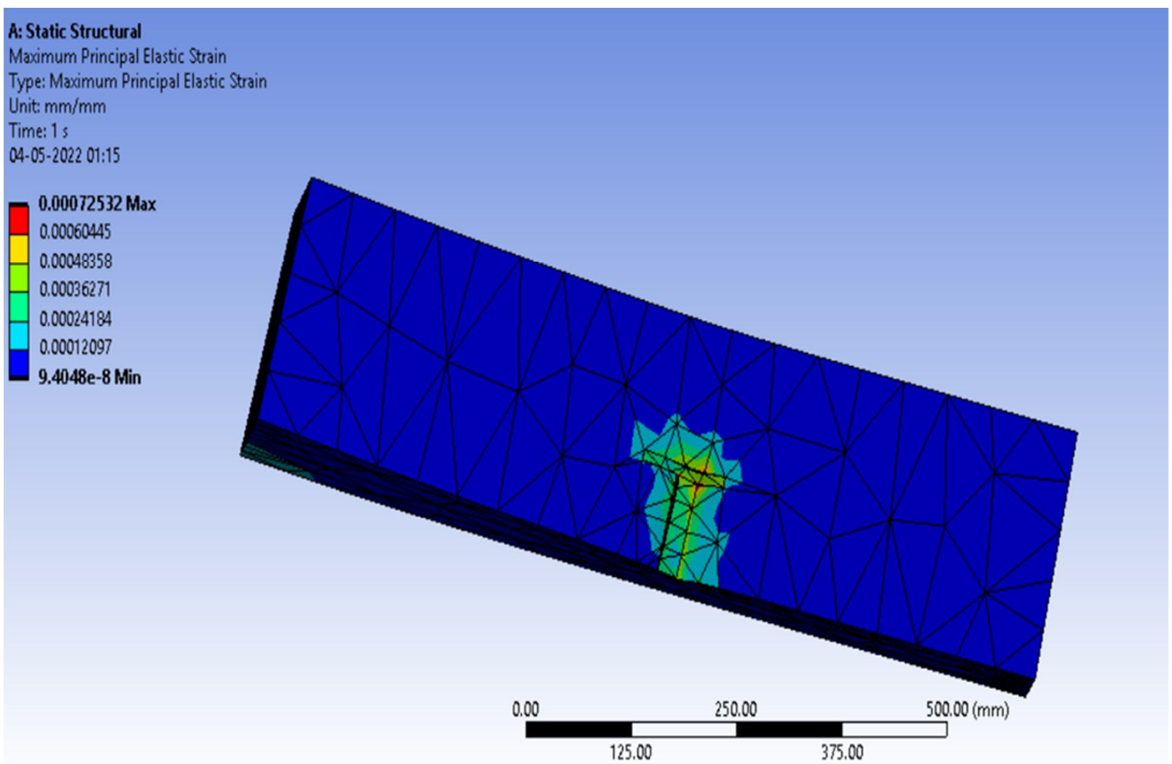
deformation



equivalent strain



equivalent stress

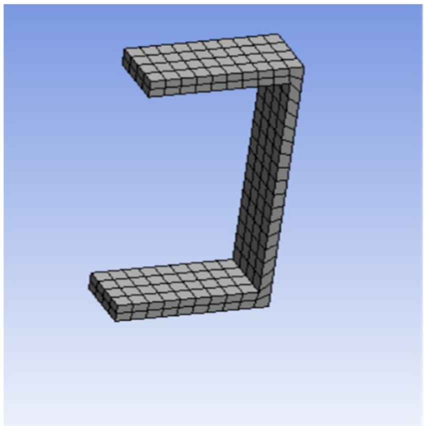


Deflected shape of T shape (100 x 100 x 10)

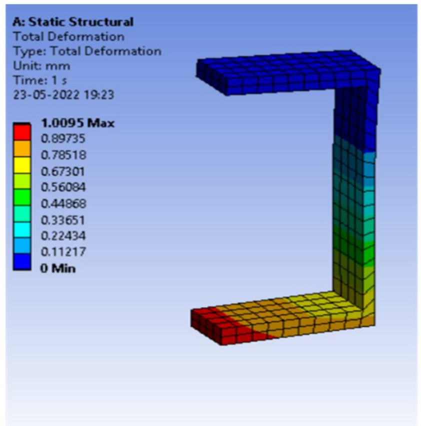
Tee Connector Analysis Result

ANALYSIS OF TEE SHEAR CONNECTROR			
	M-20 GRADE	M-30 GRADE	M-40 GRADE
TOTAL DEFORMATION	1.2858	1.5224	1.6644
EQUIVALENT STRESS	795.3 Mpa	941.48 Mpa	1029.5 Mpa
EQUIVALENT STRAIN	0.0042913	0.0050812	0.0055551

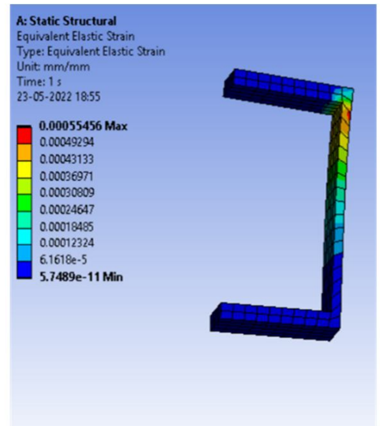
B. Analysis Of Channel Connector



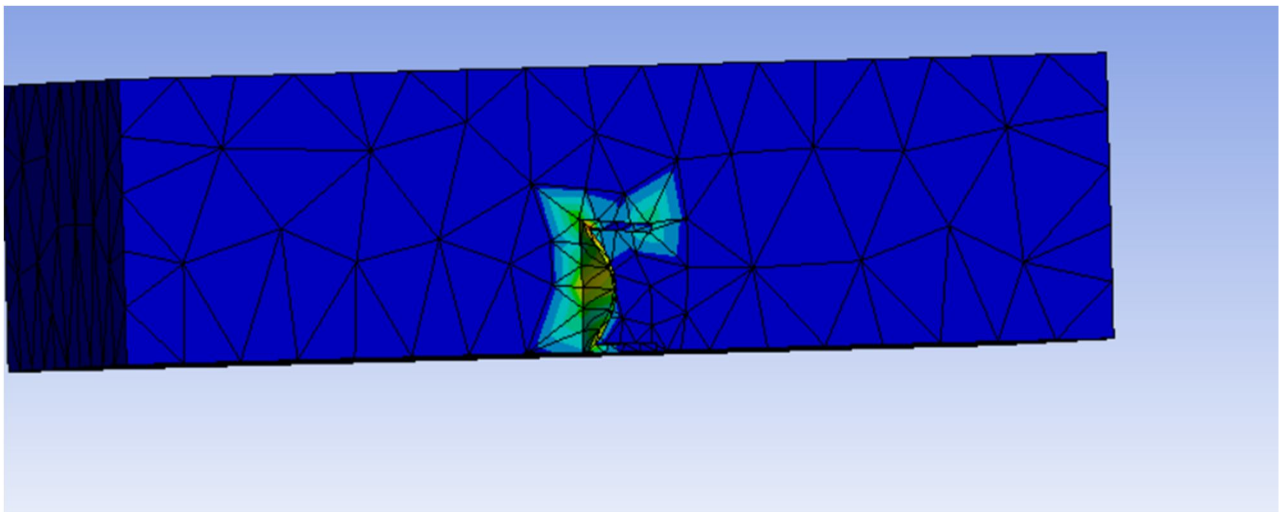
Finite element Mesh in ANSYS



Total deformation model in ANSYS



Equivalent Elastic Strain model in ANSYS



Deflected shape of complete model after analysis ISMC 125

Channel section Analysis Results

CHANNEL SECTION	CONCRETE GRADE	D	B	t_f	t_w	LOAD	DEFORMATION (mm)	STRESS (Mpa)	STRAIN
ISMC 75	M-20	75	40	7.3	4.4	159	0.6639	169.33	0.000847
	M-30	75	40	7.3	4.4	193	0.8059	205.54	0.001029
	M-40	75	40	7.3	4.4	218	0.91032	232.14	0.0011614
ISMC 100	M-20	100	50	7.5	4.7	169	0.42671	67.992	0.0003021
	M-30	100	50	7.5	4.7	204	0.51472	82.073	0.00041064
	M-40	100	50	7.5	4.7	228	0.57528	91.738	0.0004587
ISMC 125	M-20	125	65	8.1	5	184	0.76441	83.958	0.00041992
	M-30	125	65	8.1	5	219	0.90982	99.928	0.000492
	M-40	125	65	8.1	5	243	1.0095	110.08	0.0005542

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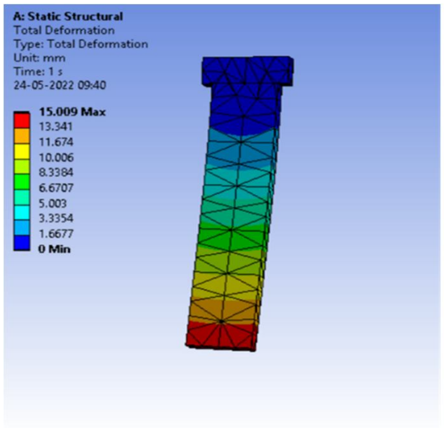
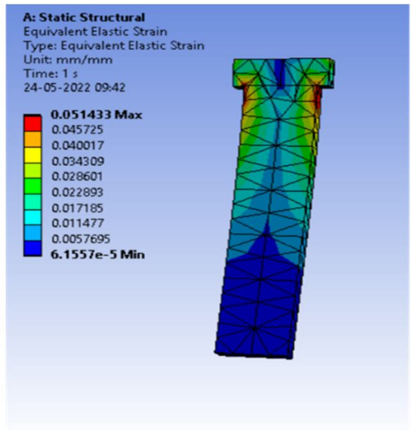
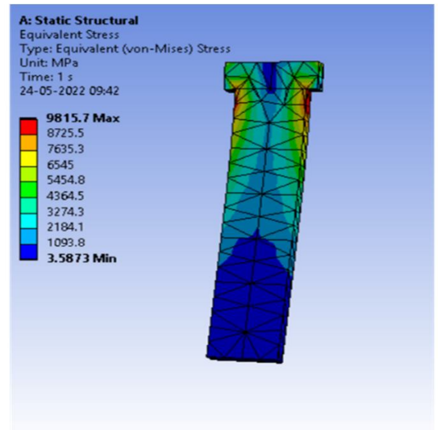
C. Analysis Of Headed Stud Connector



deformation

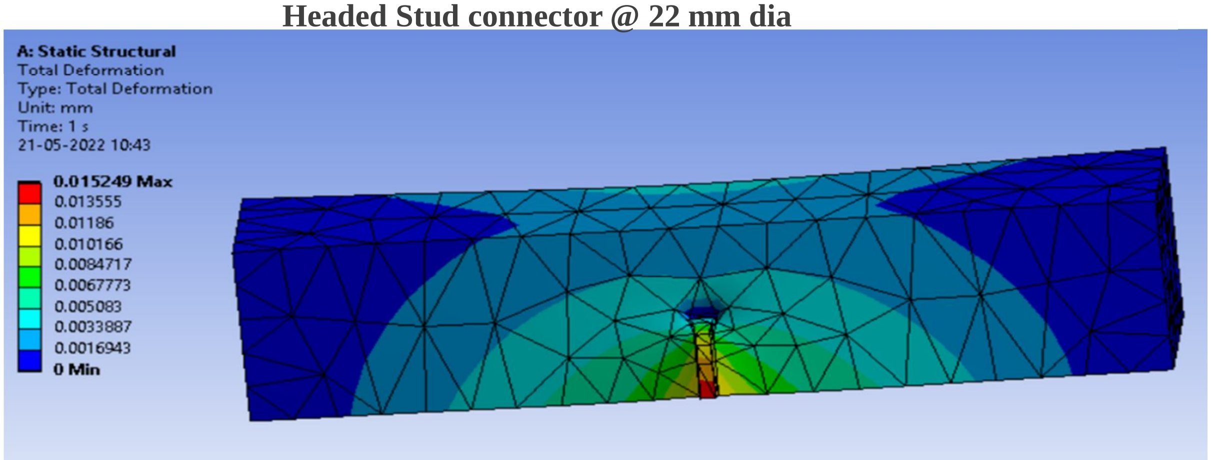


equivalent strain



equivalent stress

Headed Stud connector @ 22 mm dia



Deflected shape of complete model after analysis HEADSTUD WITH DIA 22mm

Headed Stud Connector Results

DIAMETER	HEIGHT	CONCRETE GRADE	LOAD (KN)	DEFORMATION (mm)	STRESS (Mpa)	STRAIN
13mm	62mm	M-20	23	0.8265	1750.1	0.0091
13mm	62mm	M-30	28	1.0013	2103.6	0.01101
13mm	62mm	M-40	31	1.1106	2358.3	0.01225
16 mm	75 mm	M-20	47	4.411	4359.1	0.02193
16 mm	75cmm	M-30	49	4.5988	4544.9	0.02286
16 mm	75 mm	M-40	54	5.068	5008.3	0.0252
20mm	100mm	M-20	57	7.3381	7506.3	0.03982
20mm	100mm	M-30	68	8.7542	8754.9	0.04975
20mm	100mm	M-40	75	9.6554	9856.2	0.0524
22mm	100mm	M-20	70	11.17	7309.2	0.0383
22mm	100mm	M-30	85	13.572	8875.9	0.04657
22mm	100mm	M-40	94	15.007	9815.7	0.0514

XI. CONCLUSIONS

1) The FE model developed considers the linear and nonlinear material parameters of the shear stud and concrete.
2) The ANSYS model results have been validated and are extremely close to the published results. According to the convergence study, when the mesh size drops, the results tend to increase and are significantly different from the findings obtained from the large meshing size described in the literature.
3) As stud diameter grows, so does load carrying capacity.
4) Based on the finite element analysis results, it can be determined that the channel type shear connection has less deformation than the other types and the headstud type connector has the most deformation for the given load.
5) The FE model developed considers the linear and nonlinear material parameters of the shear stud and concrete.
6) The ANSYS model results have been validated and are extremely close to the published results. According to the convergence study, when the mesh size drops, the results tend to increase and are significantly different from the findings obtained from the large meshing size described in the literature.
7) As stud diameter grows, so does load carrying capacity.
8) Based on the finite element analysis results, it can be determined that the channel type shear connection has less deformation than the other types and the headstud type connector has the most deformation for the given load.

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