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Impact Resistances of Hybrid Steel Truss Beams

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Abstract - *This study investigate the impact resistances of hybrid steel trussed concrete beams (HSTCBs) under three-point loading with span 1000 mm. HSTCB is constituted by a prefabricated steel truss installed within the concrete core. The truss usually is composed by a system of a steel rebars welded to form the diagonals of the truss with diameter 6mm and the main bars used to form the upper and bottom chords with diameter 10mm using Fe 415 grade steel. Truss was filled with M30 concrete to form a composite beam. Steel reinforcement in reinforced concrete beams is to handle the bending and shear stresses that develop within a beam. The horizontal longitudinal bars designed to carry the bending stresses and vertical stirrups to carry the shear force. Alterations in the reinforcement pattern within the beam affect the flexural as well as shear carrying capacity of the beams. impact resistances of beams is studied through numerical analysis using finite element analysis (ANSYS) by varying the truss configuration with different velocity.*

Key Words: **Hybrid steel truss concrete beam, steel plate, confinement, shear reinforcenment, impact force, ultimate loads**

1. INTRODUCTION

1.1 General Background

When concrete and steel are combined together they form a composite member. The composite construction has gained importance due to its ability to combine the advantage of steel and concrete. Concrete is best utilized in compression and steel in tension. As concrete is incapable of resisting tensile load and steel section that are slender are most likely to undergo buckling under critical load. But when combined together to form composite member their individual weakness are overcome both their strength are utilized fully to increase the strength, stiffness and durability of the structure. Reinforced concrete beams are used to transfer the imposed loads from slabs and walls to columns. A beam must have adequate safety margin against bending and shear stresses

A special steel-concrete composite beam called Hybrid Steel Trussed Concrete Beams (HSTCBs) was appeared recently in the construction industry, in which prefabricated truss reinforcement is embedded within the concrete. The truss structure is usually made with or without steel plate or a precast concrete slab, which represents the bottom chord. A system of ribbed or smooth steel bar is welded in order to form the diagonals of the truss. HSTCBs represent a structural typology of composite beams typically employed as efficient structural solution for light industrialization and constituted by prefabricated steel truss embedded within a concrete matrix cast in situ. HSTCBs are typically constituted by a steel truss embedded in a concrete core. The truss is usually made up of a steel plate or a precast concrete slab, which represents the bottom chord, a system of ribbed or smooth steel bars welded to form the diagonals of the truss, with some single or coupled rebars constituting the upper chord.

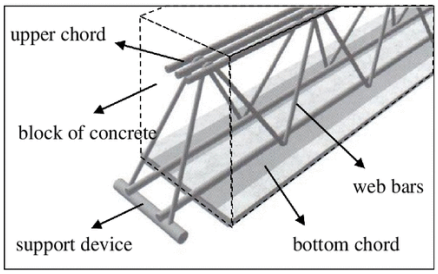

Fig -1: Hybrid steel truss beams

2. NUMERICAL INVESTIGATION USING ANSYS WORKBENCH 16.1

2.1 Base Model

Numerical modelling of Steel plate with patterns of slit models were done using ANSYS 16.1 WORKBENCH, a finite element software for mathematical modelling and analysis. The dimensions of all the 9 specimens are same. Width of beam is 150 mm, depth is 260 mm and the length is 1000mm. The hybrid beams were given with cover plate 3mm, different confinement and different velocity. Also the hybrid beam were given with 500Kg load.

Table -1: impact velocity for different Height

Height(mm)	Velocity(m/s)
100	4.42
2000	6.26
500	9.90

The beam were tested in three point bending. The finite element models were loaded at the same locations as

the full-size beams. The Analysis requires input data for material properties are as shown in Table 1.

Table -2: Material Properties of Steel.

Young's modulus of Steel (Gpa)	200
Poisson's ratio of Steel (ν)	0.3
Density of Steel, (kg/m^3)	7850
Yield Stress (Mpa)	415

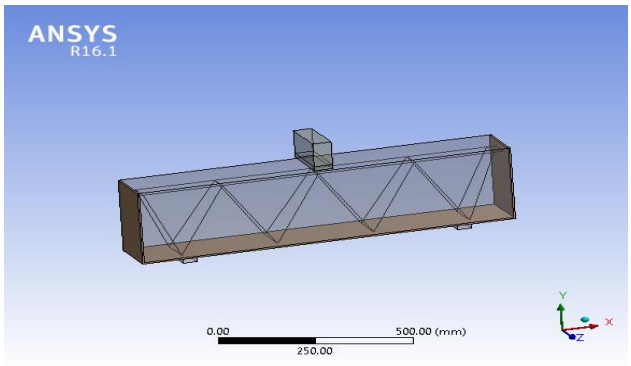

Fig -2: Modelled view of Trapezoidal HSTCB with cover plate no-confinement

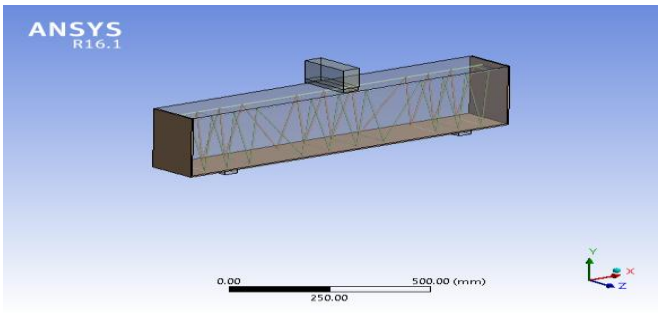

Fig -3: Modelled view of Trapezoidal HSTCB with cover plate, shear and flexural confinement

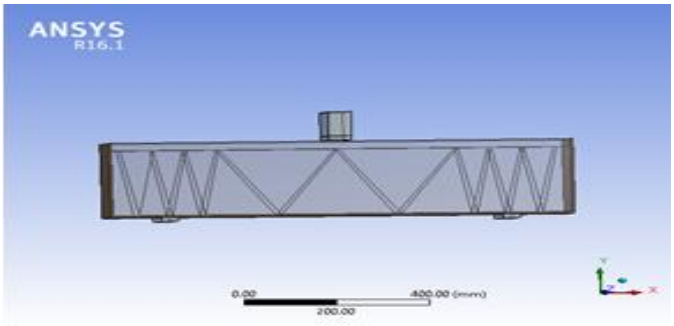

Fig -4: Modelled view of Trapezoidal HSTCB with cover plate and shear confinement

The HSTCB was modelled with dimension 150x260mm and length 1000mm.Three plates were provided. Two of the plate act as supporting plate and other act as loading plate. The loading plate and support plate dimensions were approximately 150 mm x 50 mm x 25 mm. Hinged supports were provided at both ends. The supports were provided at a distance of 110mm from both sides. Three point loading were applied at a distance of 475mm from the edges.

3. RESULTS AND DISCUSSIONS

The finite element analysis of hybrid steel trussed concrete beam specimens were carried out for studying the impact resistances. Nine different specimen models were analysed for this. The result of the present study are given below.

3.21Load Deflection Analysis

From the graph show in chart 7-9 represents the Load Deflection for different velocity impact. It is observed from that the chart with velocity=4.42m/s, from that models the lower displacement value is13.216mm (TZ-HSTCB-CP-NC).The chart with velocity=6.26m/s, from that models the lower displacement value is 20.017mm (TZ-HSTCB-CP-SC&FC). The chart with velocity=9.90m/s, from that models the lower displacement value is 39.473mm (TZ-HSTCB-CP-SC&FC). Lower displacement increase the stiffness of the beams.so the model with cover plate and no-confinement is the best .Figure 5 to Figure 13 shows the total deformation in different velocity impact.

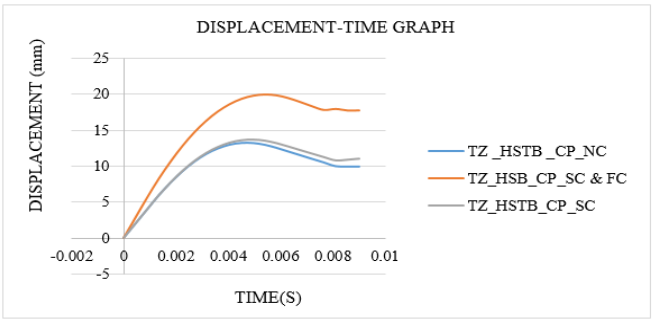

Chart -7: Load-Deflection graph with velocity 4.42m/s.

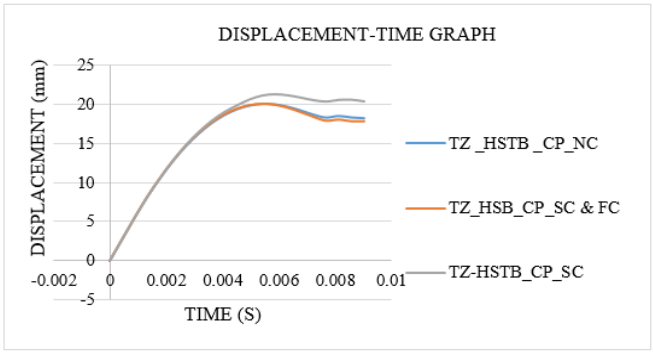

Chart -8: Load-Deflection graph with velocity 6.26m/s.

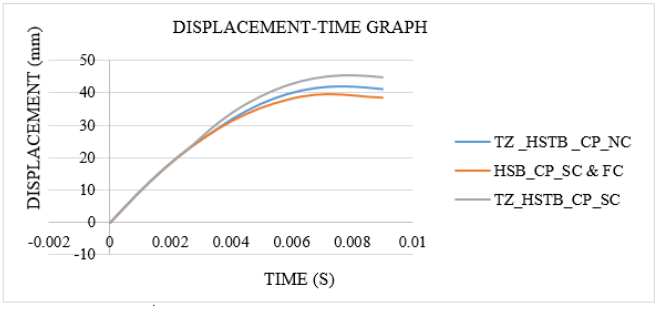

Chart -9: Load-Deflection graph with velocity 9.90m/s

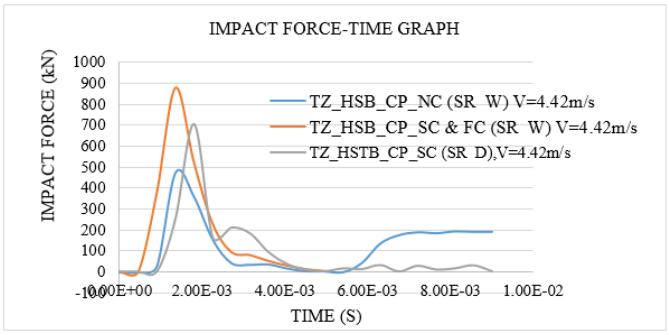

Chart -10: impact force-time graph with velocity 4.42m/s

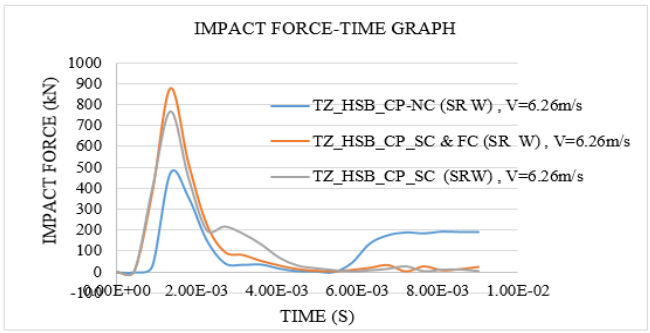

Chart -11: impact force-time graph with velocity 6.26m/s

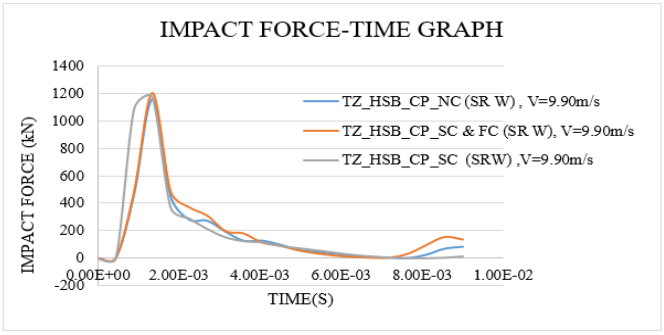

Chart -12: impact force-time graph with velocity 9.90m/s

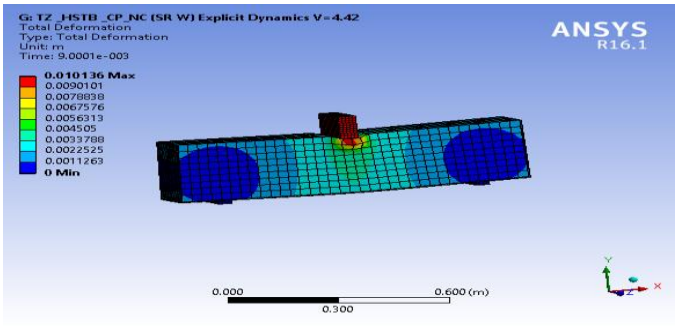

Fig -5: Total deformation for TZ-HSTCB-CP-NC with velocity=4.42m/s

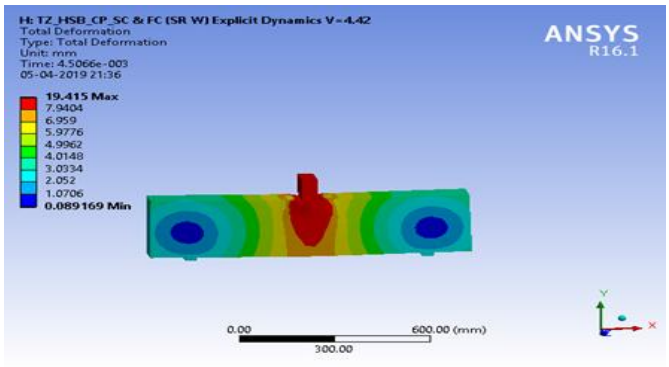

Fig -6: Total deformation for TZ-HSTCB-CP-SC&FC with velocity=4.42m/s

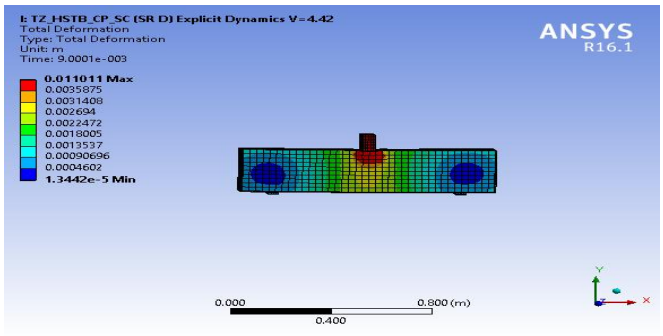

Fig -7: Total deformation for TZ-HSTCB-CP-SC with velocity=4.42m/s

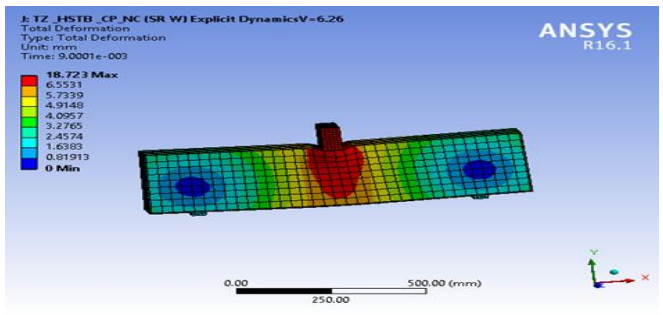

Fig -8: Total deformation for TZ-HSTCB-CP-NC with velocity=6.26m/s

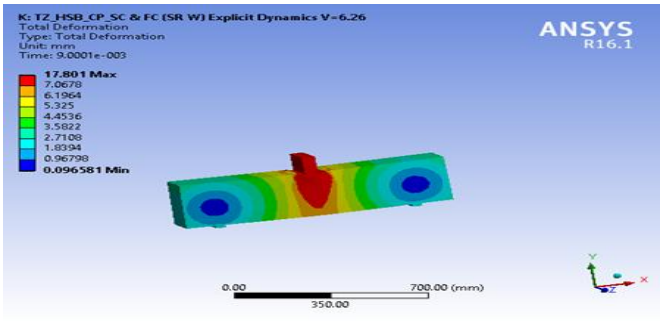

Fig -9: Total deformation for TZ-HSTCB-CP-SC&FC with velocity=6.26m/s

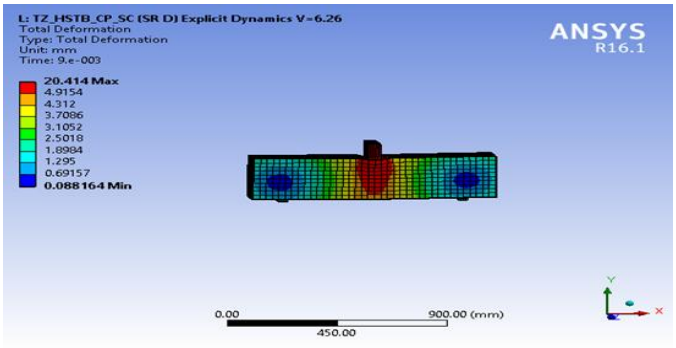

Fig -10: Total deformation for TZ-HSTCB-CP-SC with velocity=6.26m/s

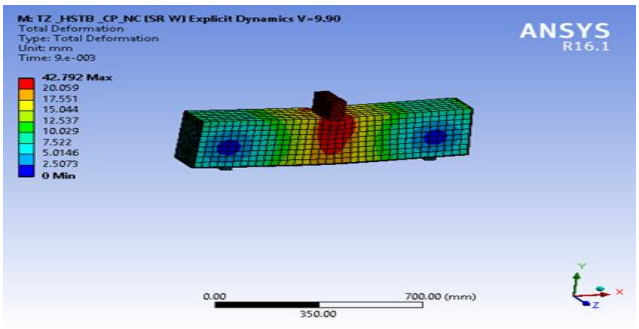

Fig -11: Total deformation for TZ-HSTCB-CP-NC with velocity=9.90m/s

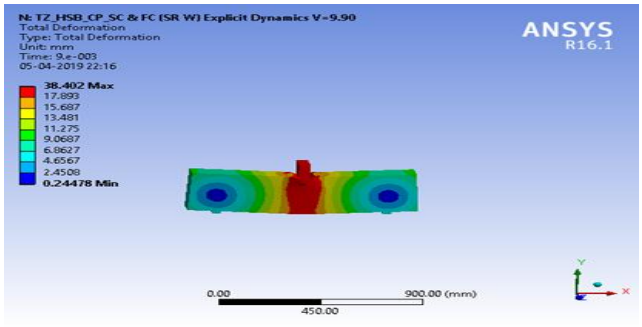

Fig -12: Total deformation for TZ-HSTCB-CP-SC&FC with velocity=9.90m/s

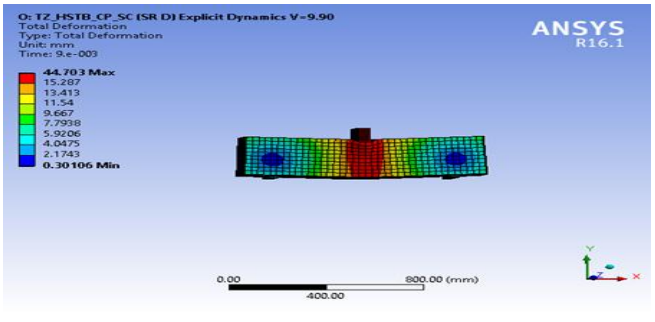

Fig -13: Total deformation for TZ-HSTCB-CP-SC with velocity=9.90m/s

3.3 Comparison of results

Non-Linear dynamic analysis is conducted to observe the impact resistances of beams in different impact velocity. Table 2 shows the comparison of test results for each model. Parameters like impact force, displacement corresponding to time interval is observed for the comparison of results. By comparing the displacement value of each model, the model with cover plate and no- confinement shows lower displacement. Lower displacement increase the stiffness of beams. Stiffness increase the impact resistances of the beam.

Table -3: Comparison of result for each model.

VELOCITY (m/s)	MODEL	TIME (s)	DISPLACEMENT (mm)	TIME (s)	IMPACT FORCE (kN)
4.42	CP-NC	0.0045002	13.216	0.0018	573.971
	CP-SC&FC	0.003	20.017	0.00135	877.506
	CP-SC	0.0049501	13.664	0.0018	706.843
6.26	CP-NC	0.0054001	20.05	0.00135	471.335
	CP-SC&FC	0.0054001	20.017	0.00135	877.506
	CP-SC	0.0058501	21.331	0.00135	768.036
9.90	CP-NC	0.0076501	41.866	0.00135	1198.865
	CP-SC&FC	0.0072002	39.473	0.00135	1206.671
	CP-SC	0.0076501	45.292	0.00135	1177.978

The table shows the impact force on beam with velocity 4.42m/s,6.26m/s and 9.90 m/s. The best model from the above table is TZ-HSTCB-CP-NC with velocity 4.42m/s. Because the displacement value is 13.216mm. If the displacement of the beam is decreased, the stiffness of the beam will be increased. So the impact resistances of the beam will be increased.

4. CONCLUSIONS

The finite element analysis of hybrid steel trussed concrete beam specimens were carried out for studying the impact resistances. Nine different specimen models were analysed for this. From the result of the present study, the following conclusions were made.

- The displacement and impact force for TZ-HSTCB-CP-NC, TZ-HSTCB-CP-SC& FC and TZ-HSTCB-CP-SC with velocity=4.42m/s is 13.206mm and 573.971kN, 20.017mm and 877.506kN, 13.664mm and 706.843kN.
- The displacement and impact force for TZ-HSTCB-CP-NC, TZ-HSTCB-CP-SC& FC and TZ-HSTCB-CP-SC with velocity=6.26m/s is 20.05mm and 471.335kN,20.017mm and 877.50kN,21.331mm and 768.036kN.
- The displacement and impact force for TZ-HSTCB-CP-NC, TZ-HSTCB-CP-SC& FC and TZ-HSTCB-CP-SC with velocity=9.90m/s is 41.866mm and 1198.865kN,39.473mm and 1206.671kN,45.292mm and 1177.978kN.

Among this nine models TZ-HSTCB-CP-NC with velocity=4.42m/s is good. Because the displacement value is 13.216mm. Lower displacement will increase the stiffness and impact resistance. So the stiffness and impact resistances of this beam is high as compared to other models.

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