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Parametric Optimization of Composite Slab Subjected To Low Velocity Impact Load Using ANSYS

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ABSTRACT

This project involves parametric optimization of composite slab subjected to low velocity impact load using ANSYS. Modeling is done with ANSYS workbench 16.1. Type of analysis perfomed here is ANSYS explicit analysis.Here fourteen different models are analysed of this four models are with different shape of steel deck sheet ie,dovetail,rectangular, triangular and trapezoidal inorder to understand which shape of steel deck has better impact response.From this the better impact response is obtained for trapezoidal shape.Remaining four models are done in M20 grade of concrete with varying percentage of glass fibers ie,0,0.02,0.04,0.06% of fibers.From the analysis it is concluded that addition of glass fibers increases the impact response and impact response has got improved on increasing the percentage of glass fibers. And next four models are done with varying percentage of fibers in M30 grade of concrete .It is seen that on increasing the grade of concrete the impact resonse of composite slab also got improved.Next study is conducted to study the impact response of composite slab by replacing steel reinforcing with glass and carbon fiber reinforcing rods. After analysis the impact response of these two are found similar to steel reinforcing rod and that steel reinforcing rod could be used by considering both impact behavior and from the economical point of view.From the study the best model of composite slab is the one with trapezoidal shaped steel deck sheet,M30 grade with 0.06% of fibers and steel reinforcing rod.

Keywords: *— Explicit analysis, ANSYS,optimization*

I. INTRODUCTION

Impact is instantaneous application of load. Impact loading could occur in reinforced concrete walls and slabs in certain types of structures, struck by low speed objects accidentally**.** Low-velocity high mass impact loading conditions with velocities up to 10 m/s is the common impact scenarios for civil engineering. Typical low-velocity impact scenarios include transportation structures subjected to vehicle collisions, airport runways platforms during aircraft landing, and offshore structures subjected to ice and/or ship impact. A composite slab with profile steel decking has proved over the years to be one of the simple,faster,lighter,and economical construction in steel framed building systems. Estimating the response of composite structures to impact loading through full-scale tests is expensive in terms of providing the necessary test material, test equipment, and time to perform. Thus, this project describes the numerical modeling technique and investigations into the response of an composite slabs when subjected to impact loading in aspects of failure. In order to gain the better understanding of the behaviour of the structure, the Finite Element (FE) analysis has been carried out using ANSYS software.

II . OBJECTIVES

The main objectives of this study are

1. To find out which shape of steel sheet trapezoidal,triangular,rectangular or rectangular gives better impact response.
2..To find out the effect of adding fibers and changing grade of concrete on impact response of composite slab.
3.To study the impact response when Glass fibre reinforced polymer(GFRP) and Carbon fibre reinforced Polymer (CFRP)bars are used as reinforcement bars.

III. SCOPE

This project is to study the impact response of composite slab to impact loading by parametric optimization using ANSYS software. Response of composite slab by varying the shape of steel profile sheet, by varying the percentage of fibers in composite concrete and using GFRP and CFRP bars are studied. This project can be extended to study the impact response of composite slab by varying the angle of corrugation, or predict the impact response of composite slab with and without embossment in steel deck sheet

IV. DETAILS OF THE SPECIMEN

The composite slab is 1950x1950 mm square with continuose support.The depth of the slab is 140mm. The mass of drop weight is 515 Kg.The drop weight is 400mmx400 mm square.The design thickness of steel deck sheet is 0.86mm with effective area of cross section 1185 mm² and depth of sheeting 70mm

A. Models Considered for the Analysis

i. Composite slab with trapezoidal steel profile sheet(CSTP).
ii. Composite slab with rectangular steel profile sheet(CSRE).
iii. Composite slab with triangular steel profile sheet(CSTR).
iv Composite slab with dovetail steel profile sheet(CSDT).
v. Composite slab of M20 grade with 0% glass fibre(CSF1).
vi . Composite slab of M20 grade with 0.02% glass fibre(CSF2).
vii. Composite slab of M20 grade with 0.04% glass fibre(CSF3).
viii . Composite slab of M20 grade with 0.06% glass fibre (CSF4).
ix . Composite slab of M30 grade with 0% glass fibre (CSF5).
x . Composite slab of M30 grade with 0.02% glass fibre (CSF6).
xi . Composite slab of M30 grade with 0.04% glass fibre (CSF7).
xii Composite slab of M30 grade with 0.06% glass fibre (CSF8).
xiii. Composite slab of M30 grade with 0.06% glass fibre and CFRP reinforcing bars (CSCF).
xiv. Composite slab of M30 grade with 0.06% glass fibre and GFRP reinforcing bars (CSGF).

V. NUMERICAL STUDY

The numerical study was carried out for the following cases

A. Composite Slab with Different shape of Steel deck sheet

First four models are done with different shape of steel deck sheet.The following are the material properties of the specimen.

TABLE I

MATERIAL PROPERTIES OF THE SPECIMEN

Sl.No	Element Type	Material properties
1.	Reinforcement	Linear Isotropic Elastic Modulus $2x10^5$N/mm^2 Poisson's Ratio 0.3
2.	Concrete	Poisons ratio =0.1 Ec = 35355.33 N/mm^2 Grade of concrete M50 Fck =50 N/mm^2
3.	Steel decking	Linear Isotropic Elastic Modulus =210000N/mm^2 Poisson's Ratio 0.3

The ANSYS modeling of composite slab with different shapes is given in table below

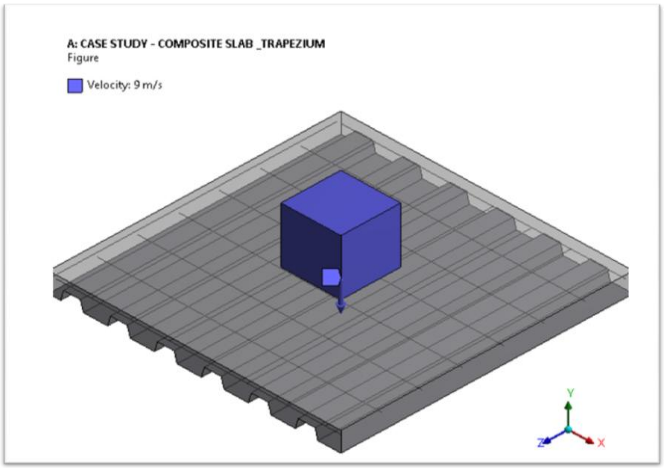

Fig. 1 ANSYS modeling of composite slab with trapezoidal shaped steel deck sheet. (CSTP)

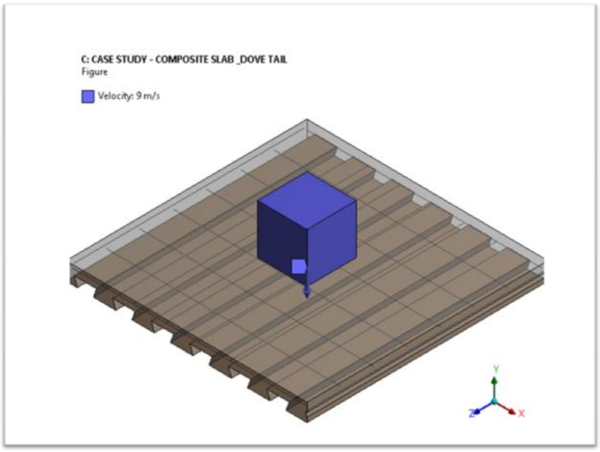

Fig. 2 ANSYS modeling of composite slab with dovetaiil shaped steel deck sheet. (CSDT)

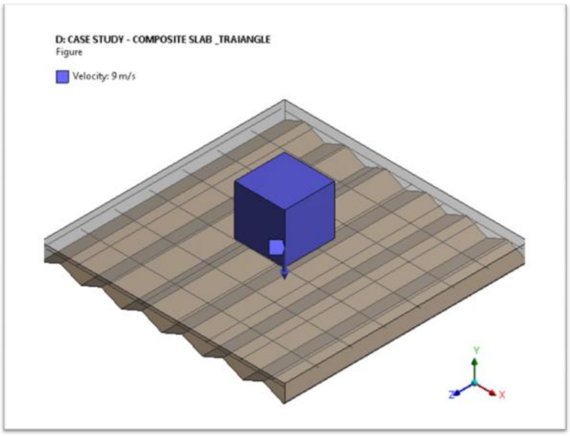

Fig. 3 ANSYS modeling of composite slab wit triangular shaped steel deck sheet. (CSTR)

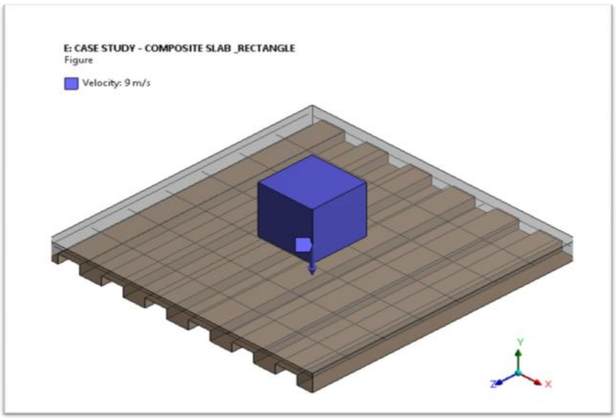

Fig. 4 ANSYS modeling of composite slab wit rectangular shaped steel deck sheet. (CSRE)

B. Composite Slab with Different percentage of glass fibers in M20 grade of concrete

Composite slab with no glass fiber and with three different percentage of glass fibers ie,0.02,0.04,0.06 in M20 grade of concrete is studied. Glass fiber–reinforced concrete (GFRC) is a type of concrete which basically consists of a cementitious matrix composed of cement, sand, coarse aggregate, water, polymer and admixtures, in which short length glass fibers are dispersed. the fibres provide reinforcement for the matrix and other useful functions in fiber-reinforced composite materials. Glass fibres have large tensile strength and elastic modulus but have brittle stress strain characteristics and low creep at room temperature

The following are the properties of glass fiber in M20 grade of concrete.

TABLE 2

PROPERTIES OF GLASS FIBER

Sl No.	Type	properties
1.	CSF1	Mean Tensile strength =3.20MPa Mean Compressive strength=26.16MPa
2.	CSF2	Mean Tensile strength =4.25MPa Mean Compressive strength=35.66MPa
3.	CSF3	Mean Tensile strength =5.05MPa Mean Compressive strength=38.73MPa
4.	CSF4	Mean Tensile strength =5.76MPa Mean Compressive strength=41.28 MPa

The ANSYS modeling of composite slab with different percentage of fibers in M20 grade of concrete is shown in figure 5

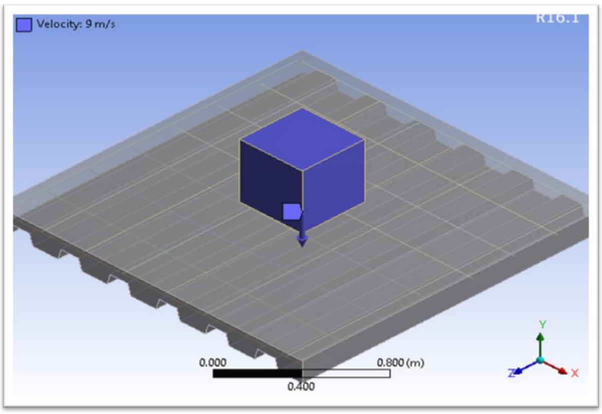

Fig. 5 ANSYS modeling of composite slab with different percentage of fibers in M20 grade of concrete.

C. Composite Slab with Varying Percentage of glass Fibers in M30 grade of concrete.

Composite slab with no glass fiber and with three different percentage of glass fibers ie,0.02,0.04,0.06 in M30 grade of concrete is studied. The following are the properties of glass fiber in M30 grade of concrete.

TABLE 3

PROPERTIES OF GLASS FIBER

Sl No.	Type	Material properties
1.	CSF1	Mean Tensile strength =34.19MPa Mean Compressive strength=37.80MPa
2.	CSF2	Mean Tensile strength =5.67MPa Mean Compressive strength=50.93MPa
3.	CSF3	Mean Tensile strength =5.91MPa Mean Compressive strength=55.73MPa
4.	CSF4	Mean Tensile strength =7.17MPa Mean Compressive strength=61.29 MPa

The ANSYS modeling of composite slab with different percentage of fibers in M30 grade of concrete is shown in figure 6.

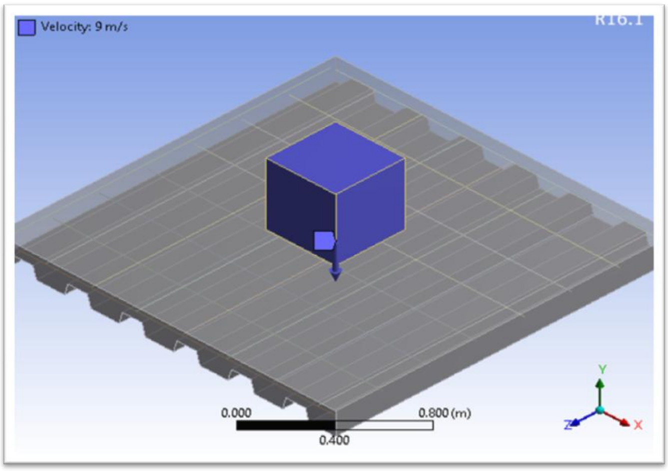

Fig. 6 ANSYS modeling of composite slab with different percentage of fibers in M30 grade of concrete.

D. Composite Slab by Changing the Steel reinforcing rod with glass and carbon fiber reinforced polymer rod

Effect of changing the steel reinforcing rod with CFRP and GFRP rod is studied. concrete grade of M30 and with 0.06% fibers and with trapezoidal shaped steel deck sheet is used. Fiber reinforced polymers (FRP) bars are non-corrosive and as such, they have higher strength than their steel counterparts. Also, they have been used in aggressive environments such as water treatments plants instead of steel .The following table shows the properties of CFRP and GFRP reinforcing bars.

TABLE 4

PROPERTIES OF GLASS FIBER

Sl No.	Type	Material properties
1.	CSF1	Mean Tensile strength =2136.9 Mpa
2.	CSF2	Mean Tensile strength =838.4MPa

The ANSYS modeling of composite slab with CFRP and GFRP reinforcing rods in M30 grade of concrete is shown in figure 7.

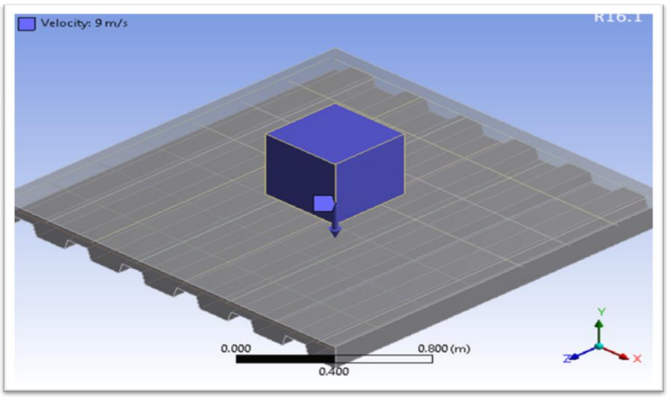

Fig. 7 ANSYS modeling of composite slab with CFRP and GFRP reinforcing rod.

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VI. RESULTS AND DISCUSSION

The results of ANSYS explicit analysis of different composite slab models are compared. Impact load carrying capacities of the structure are used to compare the performance of composite slab models . Following comparisons are done.

A.Comparison of Composite Slab with Different shape of Steel deck sheet

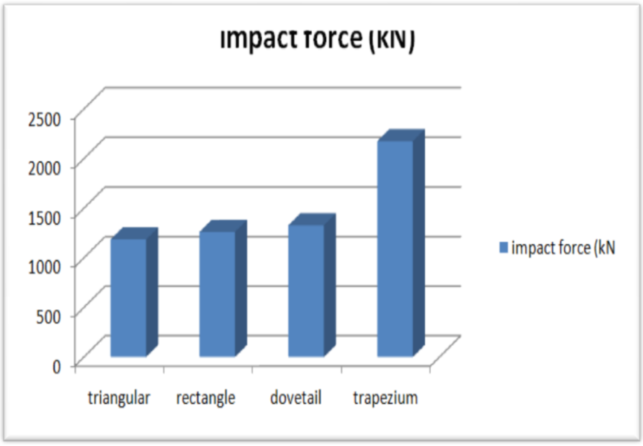

Fig. 8 Impact load of composite slab with different shape of steel profile sheet

From the above fig.8, it can be seen that trapezoidal section can resist maximum impact force with a value of 2176 kN and triangular section can resist least impact force with a value of 1184.96 kN.Rectangular and dovetail shape has impact force values of 1260.8kN and 1328kN respectively. is This means that more impact resistance occurs in trapezoidal section followed by dovetail ,rectangular and least impact resistance occurs in triangular shaped steel deck sheet it may be due to its special shape it prevent bending of the deck compared to other shapes

triangular < rectangular <dovetail < trapezium

B.Comparison of Composite Slab with Different percentage of glass fibers in M20 grade of concrete.

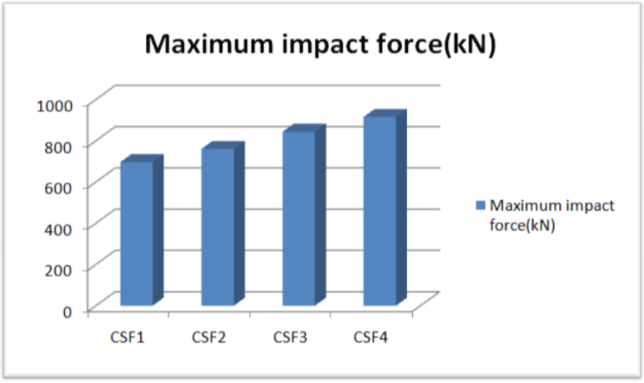

Fig. 9 Impact load of composite slab with different percentage of fibers

From the above fig 9, it can be concluded that composite slab maximum impact force is for composite slab with M20 grade and 0.06% glass fiber ,it has an impact force value of 696 kN.More impact force resistance shows more flexural capacity. The values of impact force for CSF2,CSF3,CSF4 are 760kN,843.2kN,915kN respectively, which shows that on increasing the fiber content impact force also gets increased. Addition of fibers to concrete increases the impact force value.It may be due to the fact that concrete is relatively weak in tension and may require some form of reinforcement to cope with tensile forces.So addition of fibers to increases the energy absorption ,it would appear that the dispersion of fibers throughout a concrete mix .

E. Comparison of Composite Slab with Different percentage of glass fibers in M30 grade of concrete.

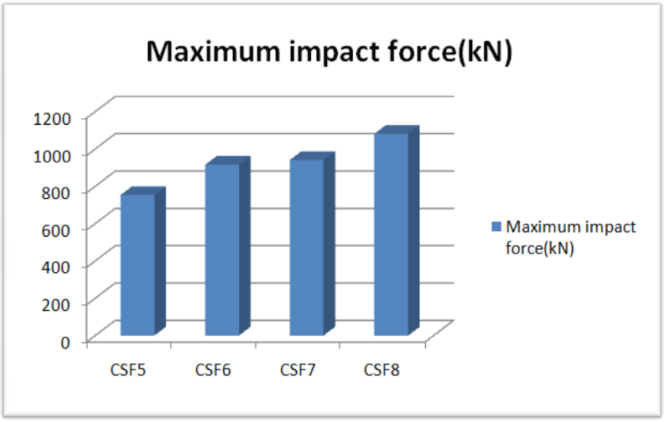

Fig. 10 Impact load of composite slab with different percentage of fibers

From the above bar chart it is clear that maximum impact force resistance is for CSF8,with 0.06% of fibers with a value of followed by CSF7,CSF6,CSF5.Addition of fibers to concrete increases the impact force value.It may be due to the fact that concrete is relatively weak in tension and may require some form of reinforcement to cope with tensile forces.So addition of fibers to increases the energy absorption ,it would appear that the dispersion of fibers throughout a concrete mix affords a degree of toughness between reinforcement bar spacing. The percentage increase in impact force values are shown in table as shown below.

C.Comparison of Composite Slab by Changing the Steel reinforcing rod with CFRP and GFRP

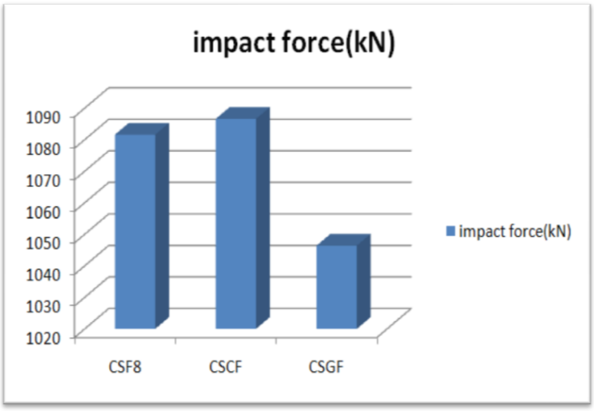

Fig. 11 Impact load of composite slab with different reinforcing rods

It is seen from the above that maximum impact force is for CSCF has an impact force value of 1086.4 kN. CSGF has an impact force value of 1046.4 kN.The impact force value for CSF8 is 1081.6kN. decreasing order of impact force is CSCF<CSF8<CSGF

CSCF has more impact force value this is due to the fact that ,CFRP rods have high strength to weight ratio ,low density as compared to steel reinforcing rods,high tensile strength.But the impact force value of CSGF is less as compared to CSF8 it may be due to its low modulus of elasiticity when compared to steel.

VII. CONCLUSIONS

The conclusions drawn from the present research are given below

- Best shape of steel deck sheet is trapezoidal as it has maximum impact force value when compared to other shapes.So trapezoidal shaped steel deck sheet is considered as the best shape and further analysis is done with this shape of steel deck sheet.
- On addition of glass fibers to composite slab with M20 grade,there is an increase in impact response and also on increasing the percentage of glass fibers better impact response is obtained.
- On addition of glass fibers to composite slab with M30 grade,there is an increase in impact response and also on increasing the percentage of glass fibers better impact response is obtained and also changing the grade
- It can be concluded from the above that as impact force of CSF8,CSCF and CSGF are almost similar. And due to the distinct properties of steel to use as reinforcement such as almost similar coefficient of thermal expansion for both concrete and steel. it is better to use steel reinforcement .
- From the research the best model is the composite slab with trapezoidal shaped steel deck sheet M30 grade,0.06% fiber and steel reinforcing rod as reinforcement.

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