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Design and Analysis of 3D Bridge Truss Using Steel and Concrete Materials

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***Abstract*— Today truss structures that are simple to assemble and more economical are used for many purposes such as crossing area, rail road and other transportation bridges. These structures are composed of members that are connected to form a rigid frame of steel and arranged in a triangular manner resulting in the loads carried to become either in tension or compression. In this paper, a 3D bridge truss were designed and analysed in (ANSYS Workbench) with the real time boundary conditions by using steel for the whole structure to determine the static analysis like: axial force, stress , shear stress and deformation. The floor's material of the Bridge was changed from steel to concrete in order to find which combination of materials will give better performances. The results show that using concrete floor can reduces axial force and stress up to 0.64515N and 0.0001233Mpa, respectively while using steel material will reduce bridge's shear stress and deformation up to 7.9015e-21Mpa and 3.4888e-8mm, respectively.**

***Keywords*— Floor, chord, Bridge, Steel, Concrete, ANSYS workbench**

I. INTRODUCTION

Road traffic accidents *have become* one of the *most important* problems worldwide. One of the main reasons for this problem is supposed to be because the lack of separate ways for pedestrian crossing and imbalance between the sizes of the roads, vehicle numbers and pedestrian number [1]. As such, the separate ways for the pedestrians will be needed in order to reduce this problem and to facilitate the movement of vehicles. This paper facilitate and smoothies the movement of vehicles by designing pedestrian crossing truss bridge in the roads that are congested with vehicles and pedestrians via the methods of finite element analysis, modeling and simulating software such as CATIA and Ansys Workbench. This truss bridge permits the vehicles to have smooth and safe paths by avoiding the interference of the pedestrians since it lets them use a separate crossing way.

A truss can be classified based on the configuration of members into different types; Bailey truss, Howe truss, Boll man truss, Long truss, Bowstring arch truss, Warren truss, Brown truss, and Pratt truss [2].

II. FINITE ELEMENT ANALYSIS OF 3D TRUSS BRIDGE

Figure 1 shows the dimensions of the 3D bridge truss. In this paper the Pratt truss configuration type was selected. This structure has been employed within bridge over the past two centuries as an effective truss technique. In which the diagonal members are in tension while the vertical ones are in compression [2-4]. This design produces a more efficient structure since the steel in the diagonal members can be reduced. This decreases the self-weight and eases the structure. It would also reduce the cost of the construction. This type of structure is most suitable for horizontal spans, where the force is in the vertical direction [2]. Finite element analysis (FEM) of Bridge truss was used for observing the structure behaviour by the structural static analysis [5-6]. This is only to show the behaviour of bridge in the form of stress and displacement analysis.

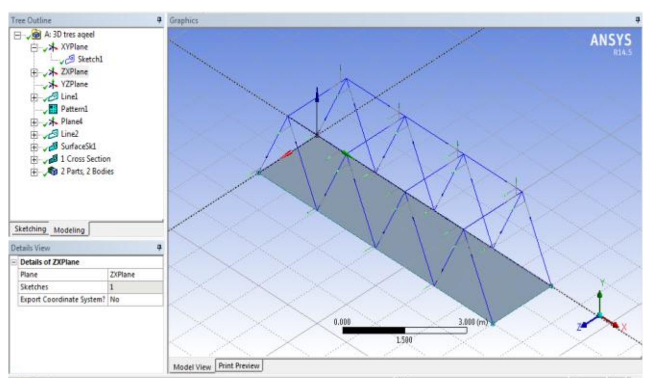

Fig.1: Model of 3D Truss Bridge in Ansys Workbench

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A. Meshing

The meshing is very significant for the analysis at all the structural object or body. Meshing is the method of discretization of a body into smaller parts for precision of the results and the set of nodes and elements is known as mesh [7-8]. Figure 2 shows the bridge after applying meshing process.

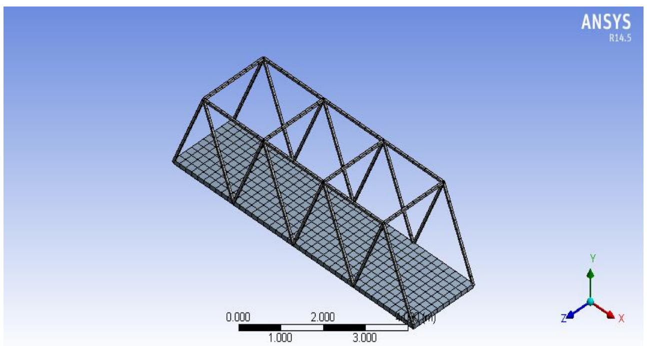


Fig.2: Meshing Model

B. Material Properties

Two types of materials (steel and concrete) are selected and used to build the structure of the bridge. Table 1 demonstrates the materials' properties. Then the bridge truss is analysed to find out which one will give high strength to weight ratio.

TABLE I
MATERIAL PROPERTIES FOR STEEL AND CONCRETE

	Steel	Concrete
Young's Modulus (Mpa)	$2e^{11}$	$3e^{10}$
Passion's ratio	0.3	0.13
Density (Kg\ m^3)	7850	2300

C. Loads and Boundary Conditions

Pressure (0.2 Pa) was applied on the floor of the bridge; Figure 3 shows the load and boundary conditions on the bridge.

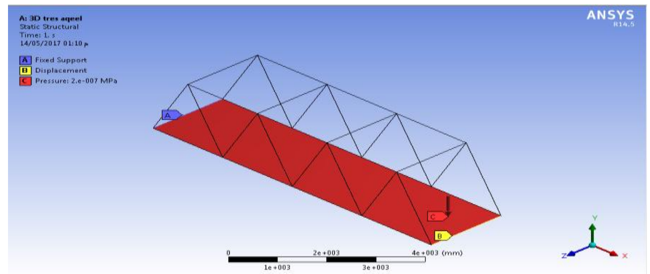
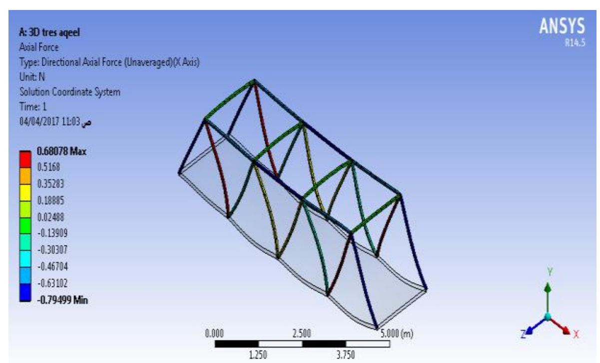


Fig.3: Boundary conditions on Model

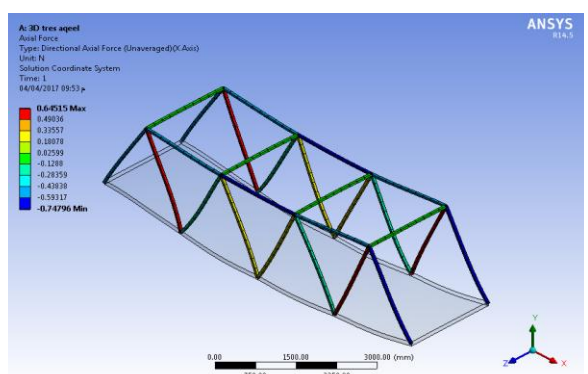
III. STATIC ANALYSIS RESULTS

A. Axial Force of Bridge by using two Materials (Steel, Steel-Concrete

Figures 4A and 4B show the axial force of bridge using two materials: Steel and Steel-Concrete; respectively. From the results of axial force above we can see steel-concrete materials in Figure 4B have less axial force compare with the steel in Figure 4A (see Table 2 and Graph 1).



(A)

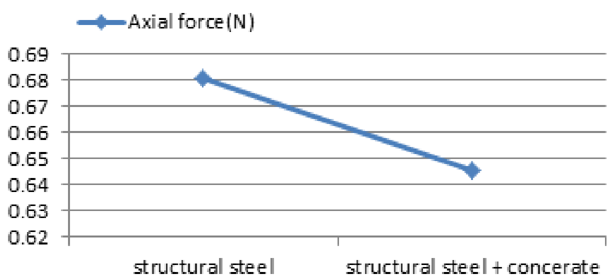


(B)

Fig.4: Axial Force A) Steel B) Steel-Concrete

TABLE 2
THE STATIC RESULTS FOR (STEEL AND STEEL-CONCRETE)

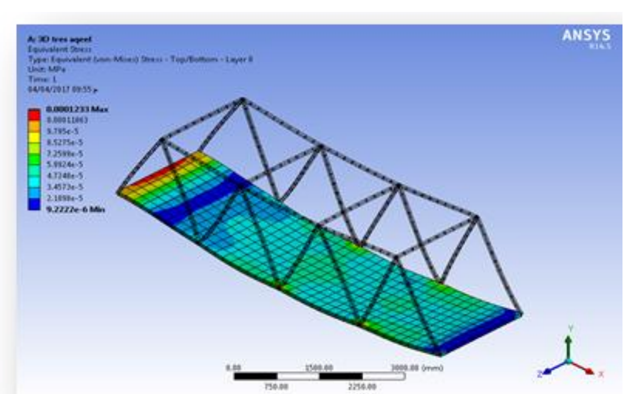
	Axial force (N)	Stress (Mpa)	Shear stress (Mpa)	Deformation (mm)
Steel	0.68078	94.795	$7.9015e^{-21}$	$3.4888e^{-3}$
Steel-Concrete	0.64515	0.0001233	$1.642\ e^{-20}$	1.6239e-5



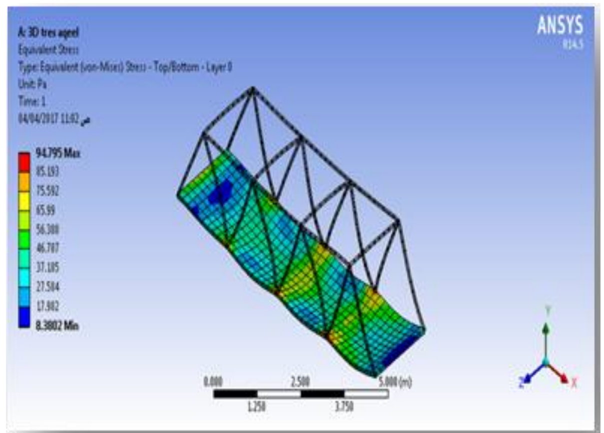
GRAGH1: AXIAL FORCE

B. Stress Plot of Bridge by using two Materials (Steel and Steel-Concrete)

Title As shown in Figures 5A and 5B by using steel, the stress is extremely high in comparison with steel-concrete materials because it reduces the stress up to 0.0001233Mpa (see also Table 2 and Graph 2 for comparison).

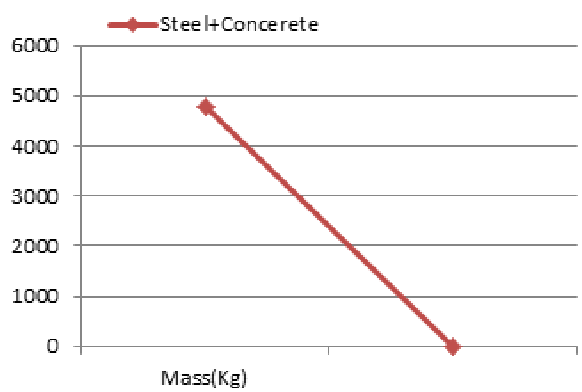


(A)



(B)

Fig.5: The stress using A) Steel and B) Steel- Concrete



GRAGH2: STRESS

C. Shear Stress Plot of Bridge by using Steel and Steel-Concrete

In Figures 6A and 6B, the shear stress for steel material is (7.9015e-21Mpa), while it will be double of this value when Steel + Concrete materials were used (see Table 2 for comparison).

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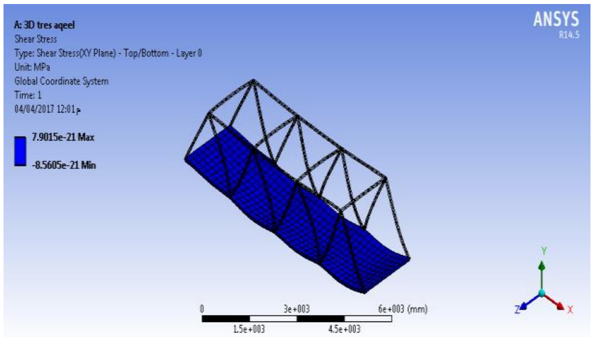
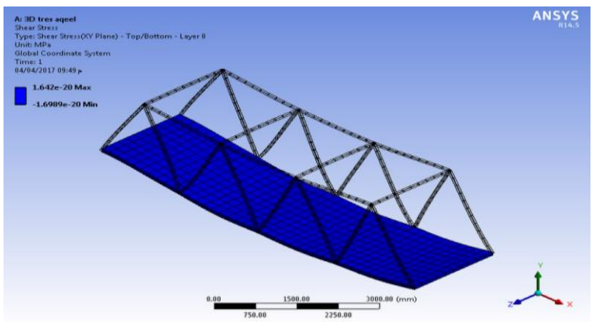


(A)

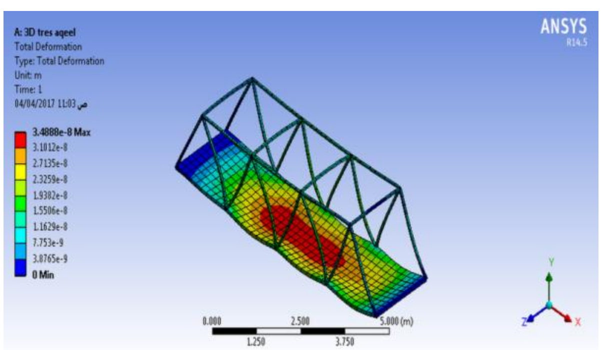


(B)

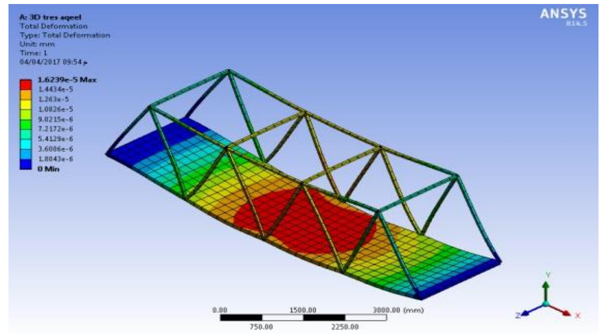
Fig.6: Shear Stress using A) steel and B) Steel-Concrete

D. Displacement Plot of Bridge Using Steel and Steel-Concrete.

Figures 7A and 7B demonstrates the bridge deformations when the steel and steel-concrete materials were used. Table 2 and Graph 3 show that the bridge deformation is reduced from 1.6239e-5mm within steel-concrete to 3.4888e-8mm when the steel was used.

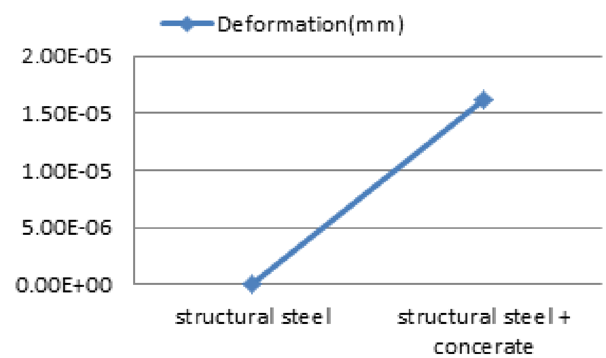


(A)



(B)

Fig.7: Bridge deformation using A) Steel and B) Steel + Concrete

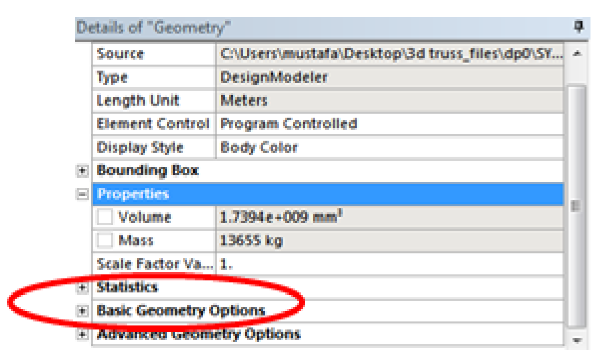


GRAGH3: THE BRIDGE DEFORMATION

E. Weight of Bridge by Using Steel and Steel-Concrete

Figure 8 shows the mass of steel bridge and steel-concrete Bridge. When Steel Material was used the mass value of model is 13655 kg while when the material was changed to steel-concrete, the mass value will be reduced up to 0.33 (see Table3 and Grap4).

Mass for Steel



Details of "Geometry"

Source	C:\Users\mustafa\Desktop\3d truss_files\dp0\SY...
Type	DesignModeler
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Properties	
Volume	1.7394e+009 mm³
Mass	13655 kg
Scale Factor Va...	1.
Statistics	
Basic Geometry Options	
Advanced Geometry Options	

(A)

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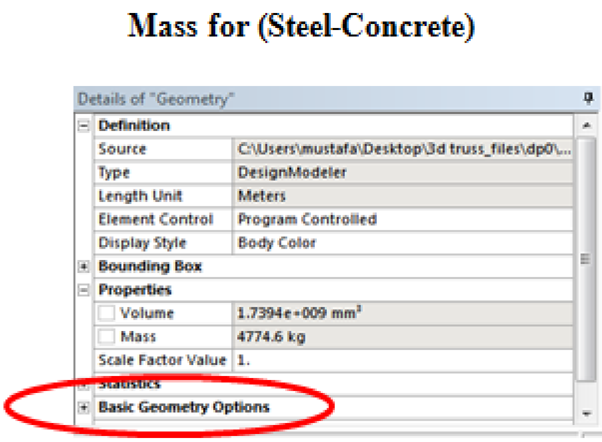
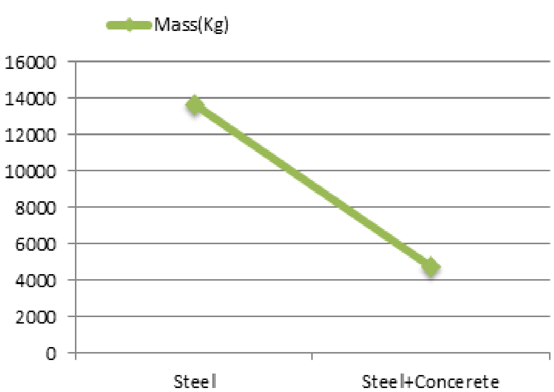


(B)

Fig.8: Bridge weight using A) Steel and B) Steel-Concrete

TABLE 3
MASS OF MATERIALS (STEEL, STEEL +CONCRETE)

	Steel	Steel + concrete
Mass(Kg)	13655	4774.6



GRAPH4: MASS OF MATERIALS

IV. Conclusion

In this project, the 3D bridge truss was designed and analysis in (Ansys Workbench) within two states: in the former steel is used for the whole model while in the latter steel is employed for chord while concrete is used for the floor of the bridge. Then the static results: axial force, Stress, Shear Stress and deformation were determined. The weight ratio of the materials in both states was found. It was concluded that:

- The lowest axial force and stress values are occurred within floor's concrete material in comparison with the floor's steel material.
- The lowest shear stress and deformation values are occurred within floor's steel material compared to floor's concrete material.
- By using concrete material within the bridge's floor, the bridge weight is reduced nearly 33% in comparison with the bridge within the steel floor.

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