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Design and Deflection Analysis of Deck Slab using Staad Pro Software

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Abstract – **Bridges are the lifelines and supporters for the improvisation of the road network. Not only do the bridges help in traffic flow without any interference but also maintain the safety of roads. Due to this reason the bridges design has gained much importance. This paper is basically concerned about the analysis and design of Deck Slab Bridge by STAAD Pro using IRC Loading. Which contains a span of 100m X 16m and has a 4-girder system? The objective is to check the result for particular input design, properties and parameters and the approach has been taken from IS standard design. We also compared of two different materials like as EPS and Steel in deck slab design. The output contains analysis results such as moments, axial forces, shear forces, deformations, Deflection and design results such as reinforcement detailing of bridge structure. From the research it can concluded that the analysis can be done for any span of bridge, grade of concrete and grade of rebar. Hence, this article may help the structural engineer to analyze and design EPS simple span bridges.**

Keywords – **GUI, Simple Span Bridges, Solid Deck Slab Bridge, T-Beam Deck Slab Bridge, Finite element method.**

I. INTRODUCTION

A Deck Slab bridge is a structure having a total length above 6m between the inner face of the dirt walls to carry the traffic loads above the natural obstruction (streams, rivers etc.) or artificial obstructions. The superstructure of the bridge comprises of the deck slab and supports. On the simple span bridge, the deck slab lay specifically on bearings through which forces and moments are transferred to the sub-structure. The deck slab bridge comprises superstructure as deck slab and supports as abutments. Fig. 1.1 shows the typical sections of the solid deck Slab Bridge which contains components such as deck slab wearing coat, abutment and footing. The solid deck slab casting is up-front with simple, and the concrete moulds are extremely easy to build. Solid volumes might be expanded. The T-beam deck Slab Bridge include deck slab sections supported by longitudinal girders are supported by abutments. The girders give the stiffness and strength essential for the length, and empower the section to be moderately thin and inexpensive to build. The details are required for the design of the abutment and substructure is span of bridge.

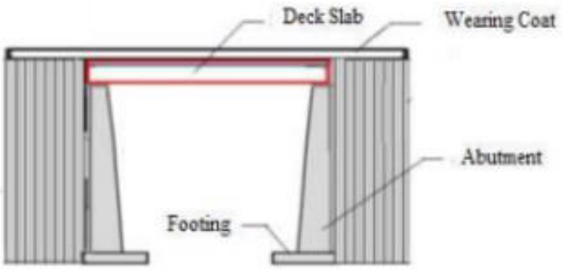

Fig.1.1.Longitudinal section of Solid Deck Slab.

Fig-1.1 shows the typical sections of the T-beam deck slab bridge, which contains components such as, deck, slab, three longitudinal girder, wearing coat, abutment and footing. The required number of girders used is needy upon a few aspects, for example, the depth of the slab deck and the slenderness of the girder. Modulus for cast in-situ girder and section of slab deck are more convoluted than that essential for solid concrete slab decks. The requirements for the analysis and design of the superstructure and substructure are span, carriageway width and reduced levels etc.

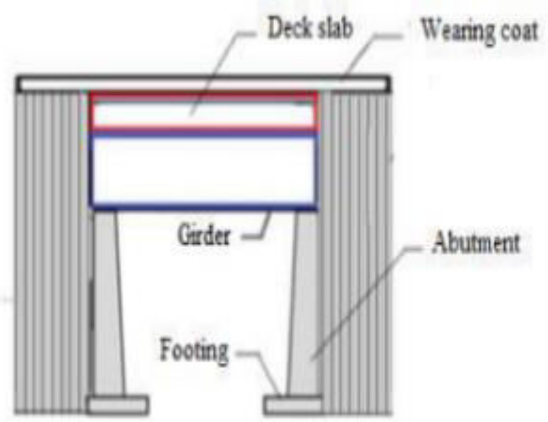

Fig.1.2.Longitudinal section of Solid Deck Slab Bridge.

II. OBJECTIVES AND PROBLEM FORMULATION OBJECTIVES

The primary objective of the present Research is, "To develop software to analyses and design an EPS material and RCC solid slab and T-beam culvert/bridge". To achieve the above primary objective following steps are followed:

Generation of graphical user interface (GUI) in STAAD PRO for input of geometric and material property data on bridge/culvert under study.

Coding in STAAD PRO for analyses of bridge "slab/culverts" structural components using finite element method for the data given in GUI.

Coding in STAAD PRO for the design of "slab/culverts" structural components using Indian standard specifications for the data given in GUI.

Extracting the analysis result obtained from STAAD PRO pictorially in the form of figures and tables.

Extracting the design result obtained from STAAD PRO pictorially in the form of figures and tables.

Also we comparison of Two material like as EPS and RCC all parameters like as total weight, Deflection, movement force etc.

III. PROJECT MOTIVATION

The Project motivation of the study deals with the stress analysis of deck slabs used with integral abutment bridges due to truck loads.

The considered superstructures consist of a concrete slab on several composite steel beams. The loading is composed of two side-by-side HS20 trucks, in accordance with the AASHTO's Load Factor Design provisions (Standard 1996).

The transverse location of the trucks is based on maximizing the positive moment between the beams and the negative moment at the location of the beams. The linearly elastic finite element method is used to analyze the three-dimensional bridge system. The main objectives of this investigation are to:

1. Study the transverse stresses (perpendicular to the centerline of the bridge) in the deck slab in the positive and negative bending moment regions near and away from the abutments
2. Investigate the longitudinal stresses (along the centerline of the bridge) in the positive and negative bending moment regions near and away from the abutments
3. Compare the obtained results for integral abutment bridges with the corresponding values for simply supported bridges, as well as with the AASHTO method.

IV. DESIGN CRITERIA

STAAD. Pro. in space is operated with units Meter and Kilo Newton. The geometry is drawn and the section properties are assigned. Fixed Supports are taken. Quadrilateral meshing is done followed by assigning of plate thickness.3D rendering can be viewed for the geometry. Loads are defined by the loads and definitions. By Post processing mode, Nodal displacement, Max. Absolute Stress distribution for the bridge can be viewed. Run analysis is operated. Max. Response by the IRC Class 70R loading is done by STAAD. The deck is created in bridge deck processor, this being the first step of STAAD. In STAAD. Roadways, curbs, vehicular parameters are provided. Lastly transfer of load is done into STAAD Pro. For further analysis and design. All the Max. Response criteria are checked Mx, M,Mz stresses etc for different member's elements. The load positions and reactions, beam forces and moments, etc. are determined. The concrete is designed as per IS Code.

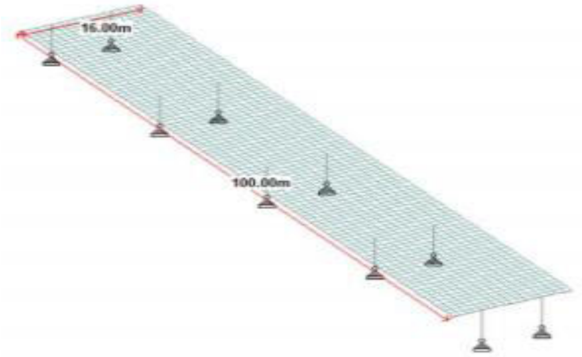

Fig. (4.1) Geometry.

V. DESIGNING THE SLAB

Method 1: As mentioned, this method involves specifying design parameters such as Steel and concrete strength (FYMAIN, FC), Clear cover for the bars, etc. and the "DESIGN ELEMENT" command from the Design page of the STAAD Modeling mode. Those instructions, called parameters and design commands, will then get embedded into the STAAD input file along with the geometry, properties, supports, loads and such data that you specified while creating the model. You will then have to run the analysis again. At that time, the program executes the instructions for designing individual elements of the slab.

This method is just an approximate way to find out if the thickness of the slab is sufficient to carry the loads. It does not include checks such as one way and punching shear, bond, reinforcement bar details, etc. In the Application examples section, example 9 illustrates this method. It is something similar to a "code check" for individual elements comprising the slab. It does not do a full-scale RC detailing of the slab in its entirety.

Method 2: Using the Concrete Design item that is available from the Modeling Mode. After the analysis is completed, enter the Concrete Design mode. Once inside that mode, the elements that constitute the slab have to be selected and you have to form a slab which subsequently have to be designed using the facilities of this mode. This is also called the "RC Designer" mode. For help on designing a slab using this method, go to Help-Contents-Graphical Interface Help- Concrete Design Mode-Examples-BS8110 British Code Examples-Slab Design

Method 3: Using RAM Concept - a powerful slab design software offered by Bentley. This is a program exclusively for designing slabs - elevated floor slabs (RC

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and post-tensioned) and foundation slabs. You will require a license for this program to use this feature. The procedure for designing a slab using this method, go to Help-Contents-Graphical Interface Help-Advanced Slab Design Mode Elsewhere in this forum, you will find numerous discussions on designing slabs using RAM Concept.

So, using this method, the slab in the STAAD. Pro model is exported to RAM Concept and the design of that slab is done by RAM Concept.

VI. RESULT AND DISCUSSION

1. Staad. Pro V8I. Analysis:

The output data for the IRC Class 70R bogie loadings are considered which include nodal displacement, nodal displacement summary, beam forces, beam end displacements, beam end displacement summary, reactions, reaction summary, axial forces, beam moments, live load effect and many more by STAAD. Pro V8i. As all of them cannot be described in this paper, the data result tables being very large, some of the glimpse of the output results in the tabular forms is provided in this paper.

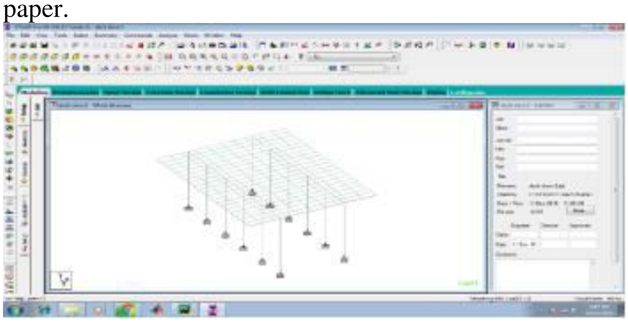

Fig.(6.1). Design domain Implementation of deck slab.

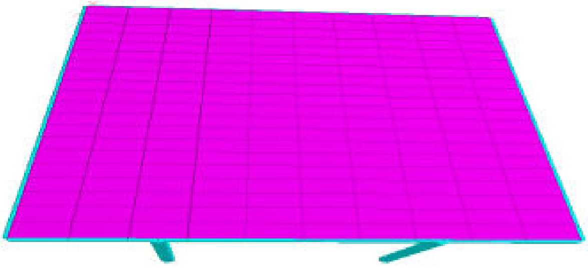

Fig.(6.2).Design domain top view.

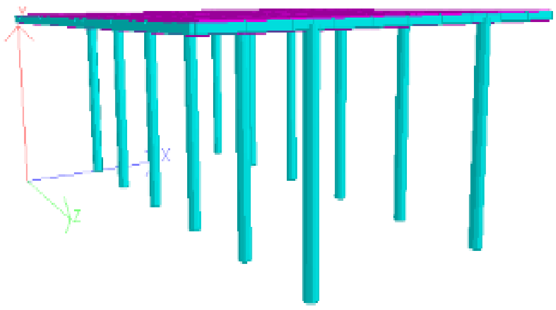

Fig. (6.3)Design domain side view.

2. Modeling of the Bridge Deck:

The present study is related to the Part 4 slab of the bridge. For analysis and design check of the Part 4 of the curved bridge, a finite element model of the slab of the Part 4 of the existing bridge was developed using Structural Analysis and Design Software STAAD Pro.

The Part 4 of the slab bridge is supported on six pot bearings spaced at varying distances on the North-East abutment and eight pot bearings on the South-West abutment as shown in the Figure 6.1.

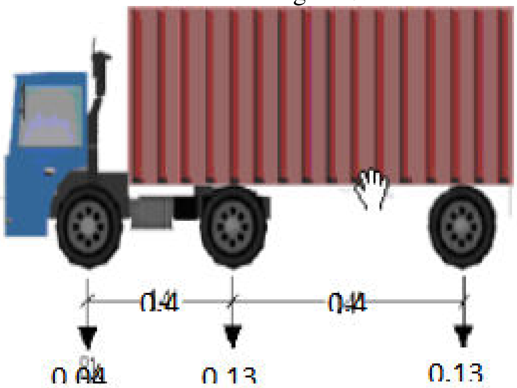

Fig. (6.4) Location of bearings (Support) on the Abutment.

The finite element model of the slab is shown in Figure 6.5. The finite element mesh is 0.08m x 0. 08m in size. The aspect ratio of the elements is 1 or less. The lines parallel to the roadway in the mesh indicates the boundary of the walkway and the barrier line. These lines have been placed to apply the barrier loads and the walkway loads on the slab. The finite element model comprises 976 elements and 992 nodes. Plate elements are used for modeling the slab and the thickness of the plate is assigned as 0.1 m.

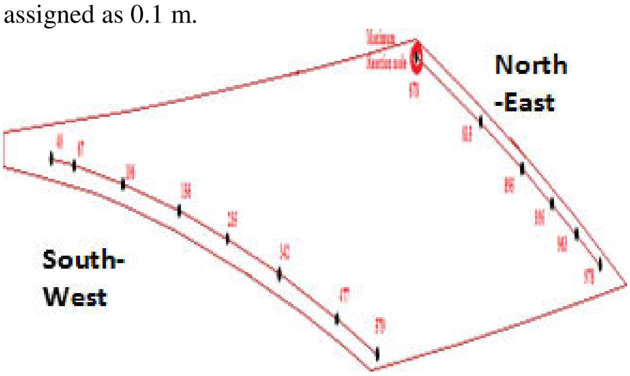

Fig. (6.5). Finite element mesh of the Part 4 of the slab bridge.

- **Loads on the Slab Deck:**

1. Dead Load

- Self-weight of 1m reinforced concrete slab has been scaled 1/10 to be 0.1m.
- Self-weight of 0.3 m x 1.75 m edge beam has been scaled to 1/1000.
- New Jersey barrier weight = 0.31 m2 has been scaled to 1/1000.

- Weight of the walkway dead loads = 25 kN/m3 x 0.25 m = 6.0 kN/m2 has been scaled to 1/10, which is equal 0.60 kN/m2.

1. Live load on walkway = 5.2 kN/m2 has been scaled to 1/10, which is equal 0.52 kN/m2
2. By calculating the dead loads, the total dead loads when scale down was 1.22 kN/m2
3. The total loads = 1.22 + 0.52 = 1.74 kN/m2 which was used in FEM work.

2. Live Load

A scaled walkway live load of 0.52 kN/m2 is considered for the analysis of the deck slab. The truck load considered in the design is the standard truck as per Ministry of Communication, Saudi Arabia recommendations. The scaled live load for the MOC truck consists of a leading load of 0.04 kN/wheel followed by two loads at 0.43 m spacing with a scaled value of 0.13 kN/wheel. The concentrated truck loads are shown in Figure 6.6 and the MOC truck is shown in Figure 6.4 and 6.5. The live load can be placed on any location of the deck slab. A typical live load position of the trucks is shown in Figure 6.6.

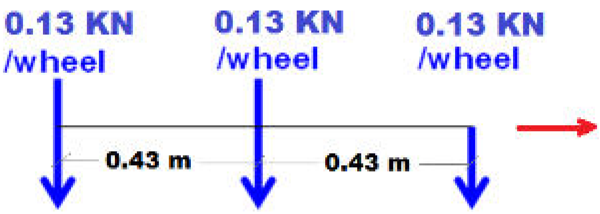

Fig.(6.6) Loading configuration of MOC truck (Truck Loads).

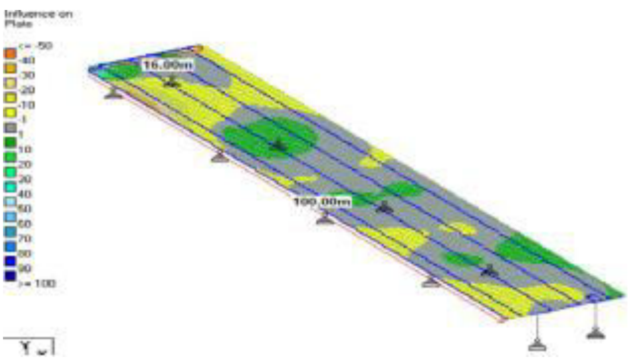

Fig.(6.7) MOC truck (Truck Load).

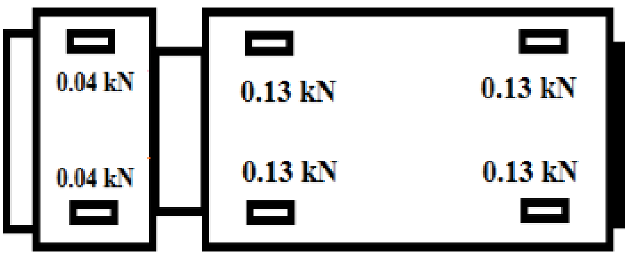

Fig. (6.8) Plan view of MOC truck (Truck Load).

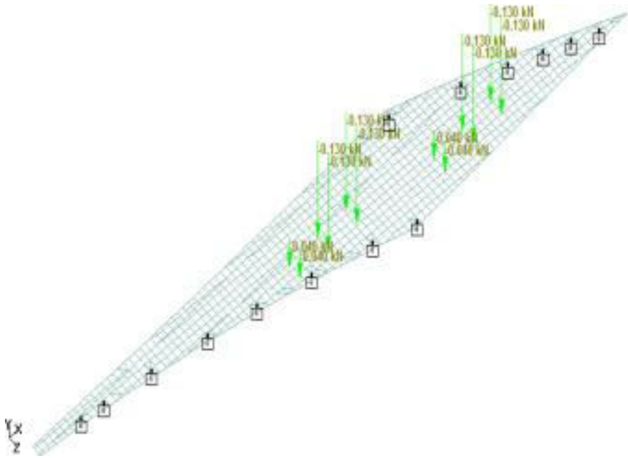

Fig.(6.9) Typical Live load Position on the Deck (Truck Load).

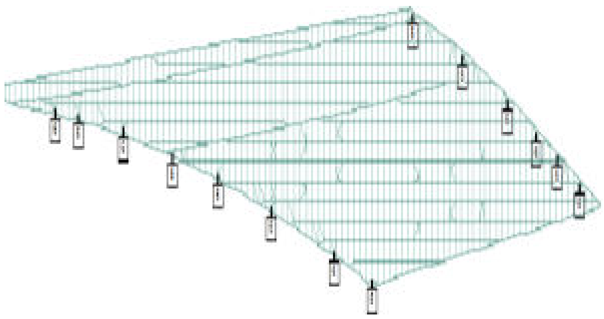

Fig.(6.10) Plate Stresses.

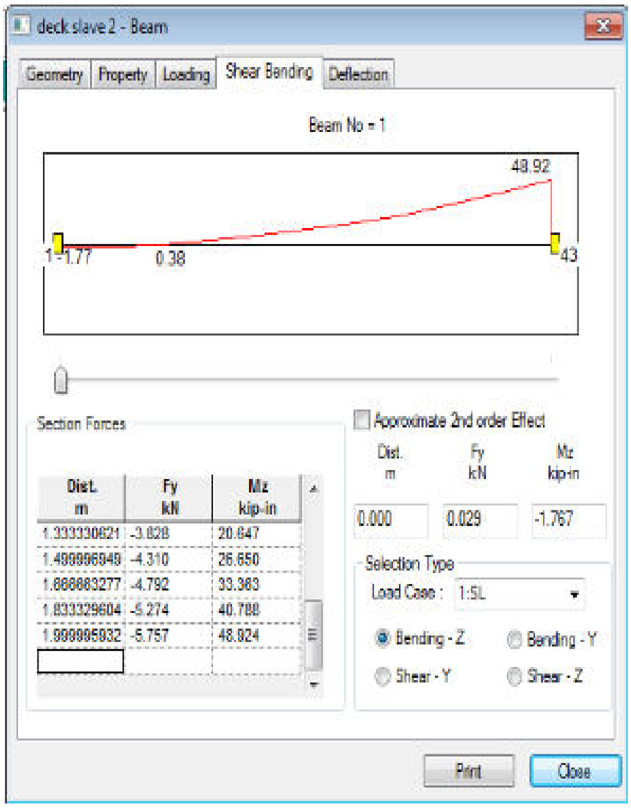

Fig.(6.11) Share bending EPS.

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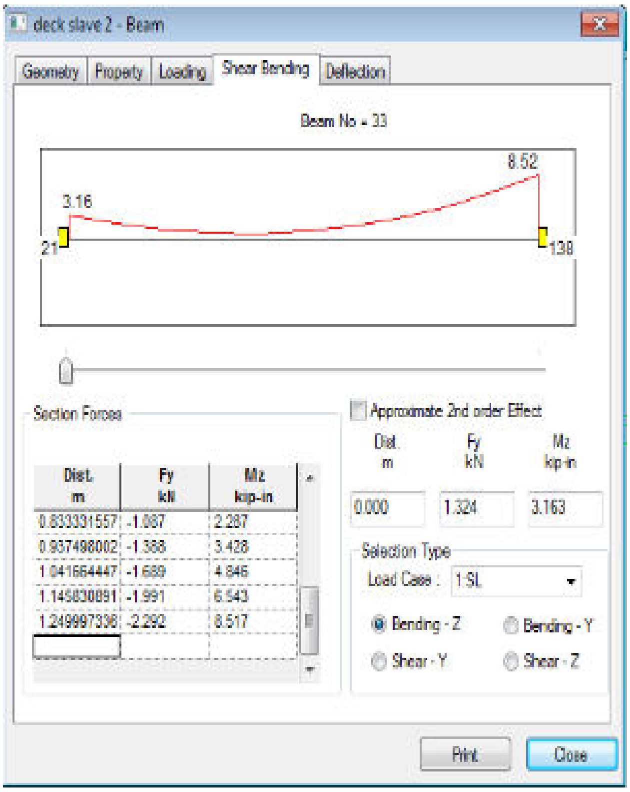

Fig. (6.12) Share bending of steel material.

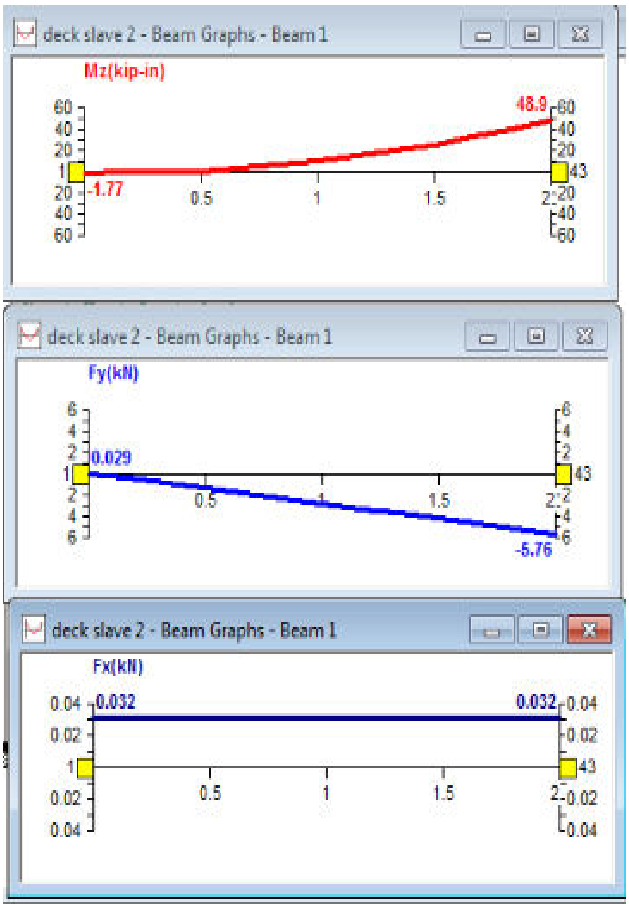

Fig.(6.13) Movement force Fx,Fy EPS.

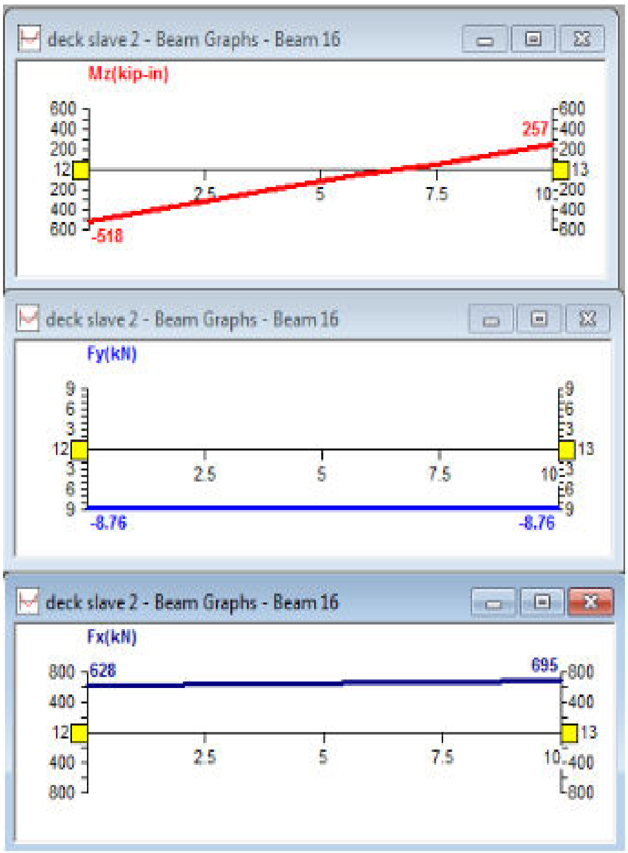

Fig. (6.14) Movement force Fx, Fy steel deck slab.

VII.CONCLUSION

1. Analysis and design of the Deck Slab Bridge as per IRC codes (here IRC 70R loading) can be easily done by STAAD. Pro. in connection with STAAD.vi8. Mechanism is well understood.
2. The maximum resultant nodal displacement is for node 1529; 0..015mm in x, -51.203mm in y and -.287mm in x.
3. The maximum and minimum values for beam maximum forces by section property are computed for axial, shear and bending.
4. The effect of vertical loading for 6 traffic lanes showing width, front clearance, rear clearance, no. of axles, positon in x, and position in y with orientation can be determined. The orientation varies from 0 to 1.5708.
5. The concrete design for element 61 gives the top and bottom longitudinal reinforcement is 0.540 and 0.545. The top and bottom transverse reinforcement are 0.540 and 0.780 for element 61. Similarly, for other element, it can be found out.
6. It is must for today's engineers, designers, research scholars to make an effective contribution to what is the purpose of each high quality design and for the improvement of quality of environment in which we all are residing. Thus evolution of software must be properly used so that it meets the beneficiary needs.

A linear elastic analysis of the skewed deck slab was carried out using a finite element modeling of the slab and all applicable loadings and was carried out using a scaled model too. Based on the findings of this study, the following conclusions are drawn.

1. The skewed slab geometry has contributed to the development of high torsional moment throughout the deck slab. This, in combination with the bending moments in two orthogonal directions, has resulted in high principal moments.
2. The computed load deflections of the slab correspond reasonably well with the deflection of the scaled model measured in the lab. The maximum load deflection is at the same location through FEM results and experiment work which is at 2.0 m from the point of maximum reaction of the long span 5.2 m.
3. A reasonably good correlation between the experimental results and the theoretical results of the model was noted. The agreement was much closer with respect to deflection. The measured reaction at the N-W corner also matched reasonably well with the theoretical values. With respect to stresses, the correlation was not as good as expected.

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