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Transient Analysis on Bridge Deck Slab under the Action of Moving Load and Wind Load

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Abstract
Bridges are the structures which gains international importance as they are essential part of any road and railway network. Transient analysis of bridge is essential to ensure over all structural performance and stability during severe ground shaking. In this paper transient analysis is done considering wheel load and wind load,. This repeated type loading causes fatigue, fatigue is the progressive deterioration of a structure by crack growth. So bridge deck must withstand one of the most damaging types of live loads (wheel load).
Wind action, besides earthquake make large horizontal effect on structure .the significance of these actions will vary with time and intensity. Wind load on bridge deck slab is treated as a quasi –static .Quasi- static transient analysis is the load changes with the time, but if this change is slow compared to the period of the first natural frequency of structure.
This paper present transient load analysis on bridge deck slab subjected to the moving load and also effect of wind load. Here considered as bridge deck slab situated in a category 3 area and also determined time varying deformation and stress on slab. This study reveals that finite element method is applicable and reliable tools for bridge analysis. The main aim of this study to evaluate damage by considering stress and deformation, and this nonlinear analysis is carried on ANSYS workbench
Keywords: Keywords: Transient, Quasi static, Dynamic, Wind load, Bridge deck slab, Finite element method
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I. INTRODUCTION

Bridges are the structure which undergoes several type of transient analysis. Transient structural analysis is used to determine the dynamic response of a structure under the action of any general time dependent loads. It is used to determine the time varying displacement strain, stress and forces. In general, an analysis is to be transient if the load is variable with the time.

A transient analysis is however not necessarily dynamic. Static transient analysis is performed if the load changes with the time but if this change is slow compared to the period of the first natural frequency of the structure. In this study the bridge is analyzed using both moving load and wind load as transient analysis. Wind action, beside earthquake makes large horizontal effect on structure. The significance of this action will vary in time and intensity. This variation depends upon meteorological and seismological character of certain area. Wind load on bridge deck slab is treated as aquatic static ,so there is no need for considering dynamic response procedure .EN 1994-1-4 gives guidance on the determination of wind action for the structural design .this is applicable to bridges with span of up to 200m,except cable support bridges. Wind action is represented by a set of pressure or forces .The effect of this force is equivalent to extreme effect of turbulent wind

In this paper, analysis of wind action on a bridge deck slab is conducted .wind force acting on bridge deck situated in category 3 area and also determined time varying deformation and stress on slab. The main aim is to evaluate damage by considering stress and deformation and this nonlinear analysis is carried on ANSYS software.

1.1 Literature review

One of the most crucial structural analyzes for bridge design is dynamic analysis. Static analysis is a state that does not change over time. This is because it ignores the effect of time and analyzes the state of equilibrium of forces in an object or system. For problems on static analysis, the shear force, moment, and deformation inside the member are determined by the size of a given load. Dynamic analysis can be said to be an analysis of the behavior of objects or systems, including changes over time (considering time or frequency). Dynamic analysis applied to the design of bridges includes dynamic moving load analysis of railway bridges and seismic design. The effective design of bridge superstructure is a prerequisite to achieve ultimate strength and overall structural performance .transient analysis of bridge are essential to ensure overall structural performance and stability during severe ground shaking motion. A transient analysis is however not necessarily dynamic, as it could be quasi static .quasi static transient analysis is the load changes with time. In transient analysis load is the function of time, in the mechanical application, transient analysis can be done on flexible structure or a rigid assembly. Generally transient analysis is used to determine the dynamic response of a structure under the action of any general time dependent loads. Through this analysis time varying displacement, strains, stresses and forces in a structure can be determined .the time scale of the loading is such that the inertia or damping effects are considered to be very important .if the inertia and damping effects are considered as not important, then static analysis ids done.

In transient analysis, analysis by moving loads done by applying motion load. A motion loads are the component of a test and measurement system that provides motion to a load or load in a one or many direction.. A motion system is made up of a set of linear and rotational stages. A linear stage moves in a straight line, while rotation stage moves in circle. A stage can either controlled by manually with knob control or with automated motion control. Through these analysis strength structure can be easily determined

1.2 wheel load

Load is calculated by IRC class A as per IRC 6-2000. This transient analysis is carried out by using ANSYS software, by placing load On one specified set of nodes at a time. Vibration due to moving load has large effect on bridge deck slab. It is very difficult to identify the significant parameters that govern the response due to variation changes in stress strain and deflection etc. Hence finding dynamic behavior is very much important in the field of bridge engineering. In this research we are finding stress and deformation behavior correspond to different depth. The vehicle load considered from IRC class A is along the depth in the direction parallel to span. Slab with young’s modulus 2500Mpa, poisons ratio 0.15, density 2549 is used.

Here the damping is ignored in both the bridge and vehicle and also the vehicle is assumed to in contact with the bridge deck slab.

Loading representation:-

- IRC class A as per IRC 6-2000 (for moving load or a vehicle)
- In this program –divides the axle weight in half and applies two –wheel loads at a distance equal to half of vehicle width on either side of a centerline of vehicle travel

Cumulative number of standard axels computed as per IRC 37(2001)

- Axle loading will be used for the calculation of stress ranges as per IRC class A loading
- For simplifying number of cycle per vehicle will be assumed equal to one cycle per truck
- The value of average daily truck traffic (ADTT) was assumed less than 5228 truck/day
- Growth factor is 6-7.5%

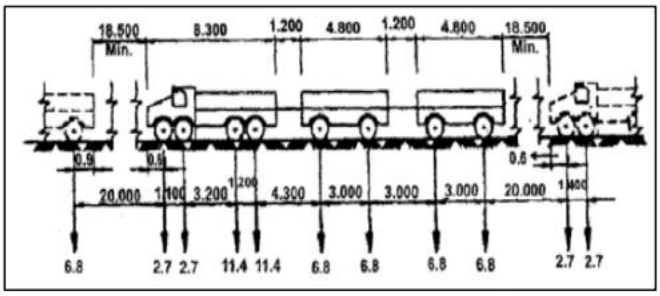

Fig 1: truck wheel load
Source:IRC 37(2001)

Cumulative standard axle $= \frac{365 \times (N \times F[1+r]^{m+n} - 1)}{r}$

Table 1:Deck slab details

Span(m)	Width(m)	depth	depth	depth	depth
6	15	0.3	0.36	0.42	0.48
4	15	0.3	0.36	0.42	0.48

1.3 WIND ACTION

Wind action, besides earthquake make large horizontal effect on structure. The significance of these action will varies in time and Intensity. This variation depends upon meteorological and seismological characteristics of certain area.Wind load on bridge deck slab is treated as a causes static, so there is no need for consideration dynamic response procedure.

The indain roads congress (IRC) bridge code section two specifies loading for which the bridge have to be designed. As per IRC all bridge structuresnshould be designed for the wind forces as below .through the wind forces are dynamic in nature ,the forces can be approximated as equivalent static loads.these forces are considered to act horizontally and in such a direction as to cause the maximum stresses in the member under consideration.

The intensity of wind force is Taken from table 3.2 these values are to be doubled for the Kathiawar peninsula and the coastal region of west Bengal Orissa.it may be noted that the velocity and wind pressure non linearly with the height above ground or water level .

Table 2:Wind velocity and pressure

H(m)	V(km/h)	P(kN /m^2)
0	80	0.40
2	91	0.52
4	100	0.63
6	107	0.73
8	113	0.82
10	118	0.91
15	128	1.07
20	136	1.19
25	142	1.30
30	147	1.41
40	155	1.57
50	162	1.71
60	168	1.83
70	173	1.93
80	177	2.02
90	180	2.10
100	183	2.17
110	186	2.24

H is the average height in meters of the exposed surface above the mean retarding surface (ground or bed level or water level).V is the horizontal velocity of wind in kilometers per hour at height H.P is horizontal wind pressure at height H

The area on which the wind force is assumed to act is determined as below:
For a deck structure: The area of the structure as seen in elevation including the floor system and railing, less area of perforations in the railings or parapets.

For a through or half-through structure: The area of the elevation of the windward truss, plus half the area of elevation above the deck level of all other trusses or girders.

The wind load acting on any exposed moving live load will be assumed to act at a height of 1.5 m above the roadway and to have a value 3 kN per linear meter. For the purpose of this calculation, the clear distance between the trailers of a train of vehicles should not be omitted. When the wind velocity at deck level exceeds 130 km/h, no live load need be considered to be acting on the bridge. The total assumed wind force shall not be less than 4.5 kN per linear meter in the plane of the loaded chord and 2.25 kN per linear meter in the plane of the unloaded chord on through or half-through truss, latticed or similar spans and not less 4.5 kN per linear meter on deck spans. A wind pressure of 2.4 kN/m² on the unloaded structure shall be used if it produces

1.4. Transient analysis

Two type bridge deck slab is modeled in ANSYS with Optimize variation in depth. Bridge deck slabs having span 15x4 and 15x6 and thickens of 0.3,0.36,0.42,0.48 are modeled in ANSYS. the material properties provided are young's modulus 25000 Mpa, poisons ratio of 0.15,density 2549 kg/m^3.The width of slab is given as 15m and span of 4 and 6.Meshing is developed as per accuracy ,and the boundary condition is one end is fixed and other end is pinned

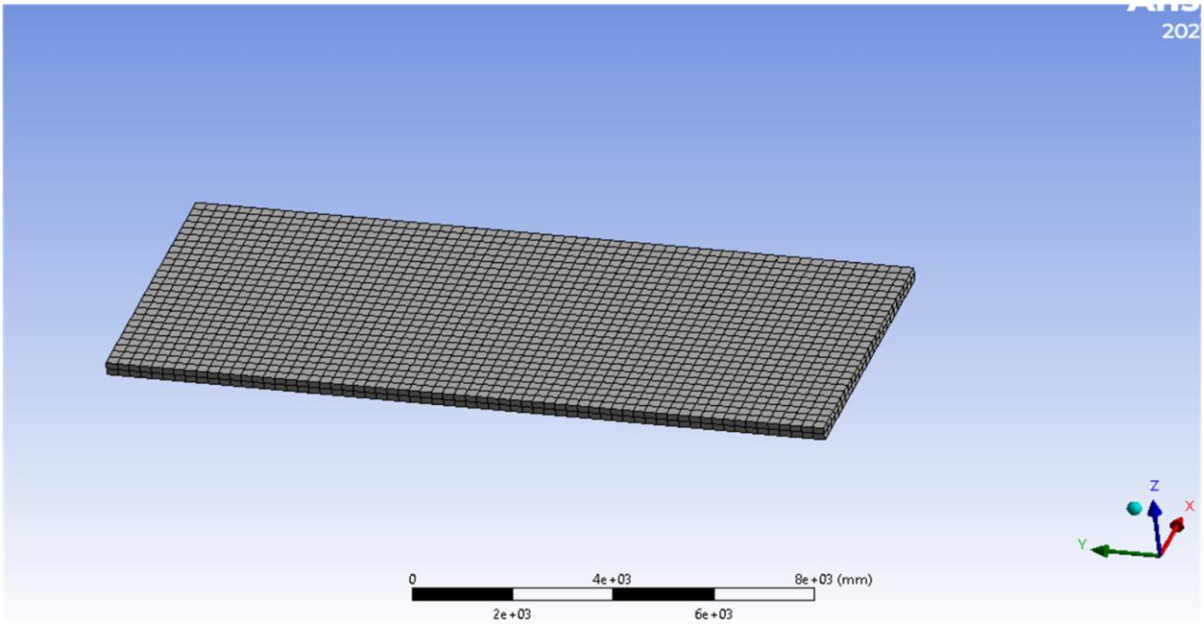

Fig 1 : Mesh on slab

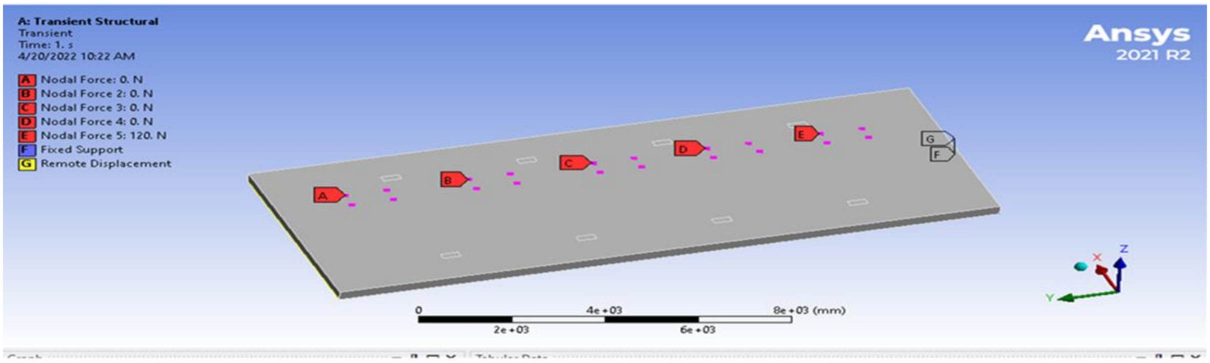

Fig 2: Nodal force on slab

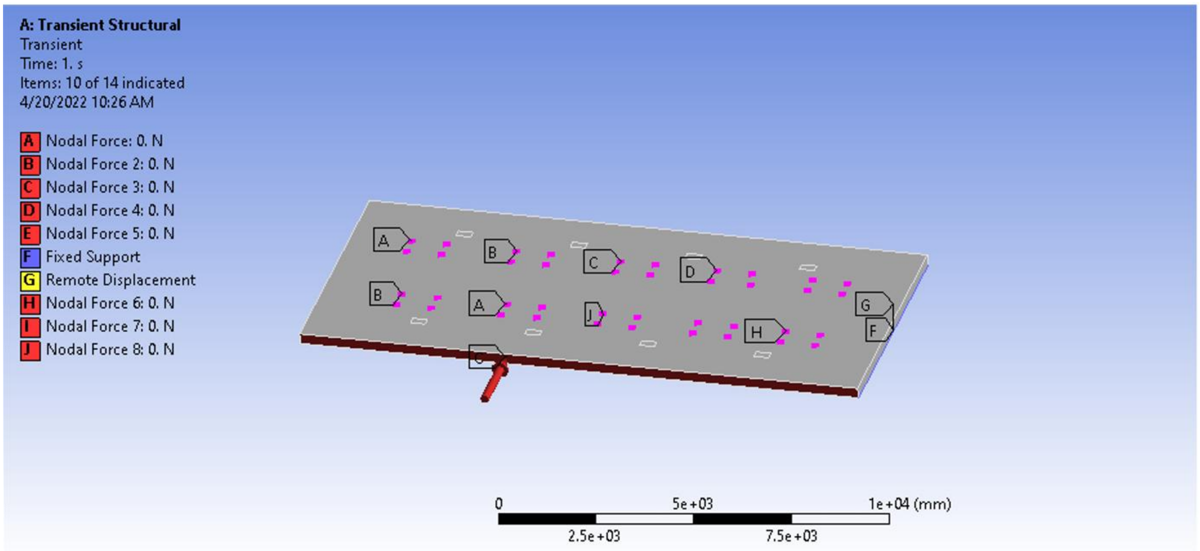

Fig 3: wind load on slab

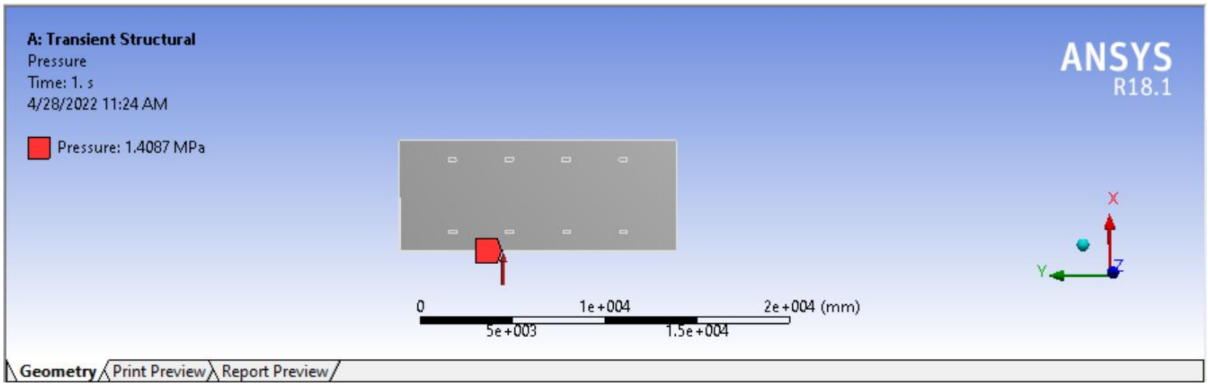

Fig 4: wind load applying

II. RESULT AND DISCUSSION

The results obtained are as discussed below

1.3.1 stress values on slab 6x15x0.30

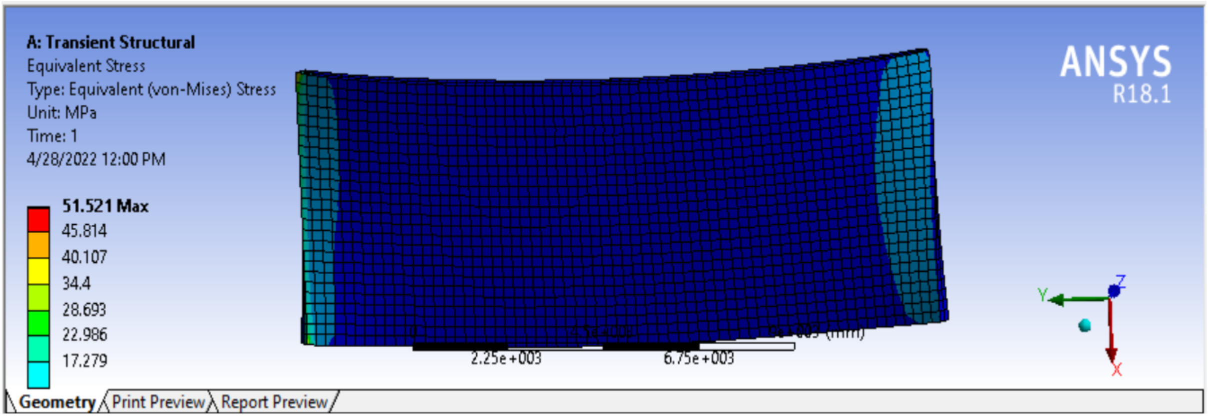

Fig 5: stress variation

Equivalent (von mises) stress obtained after running the analysis. The stress in figure shows that stress values are more on support region. It is because the maximum normal stress occurs at the point of connection of the steel beam with concrete slab ,due to greater rigidity and it will decreases as it moves to center.

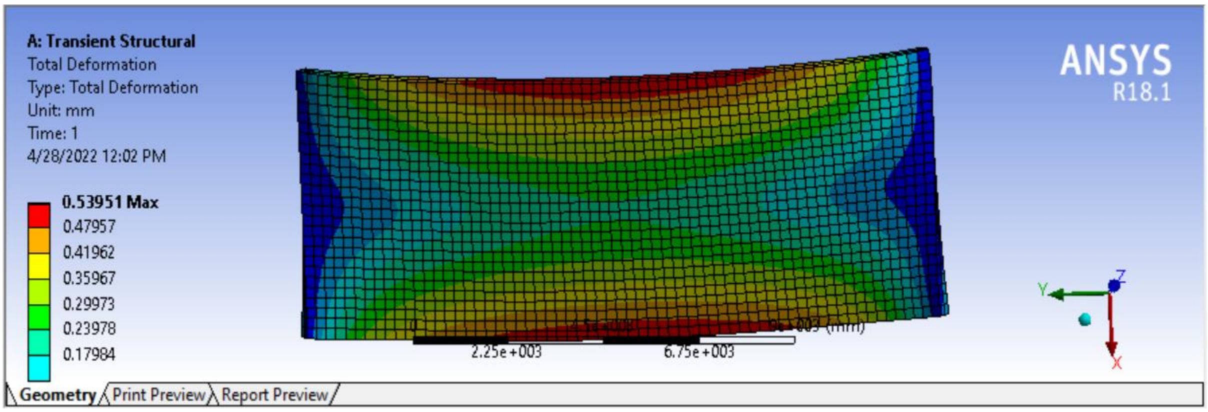

Fig 6: deformation

From the contour figure obtained, maximum deformation values are at center region of span. And its values decreases towards the end.

The result obtained from the analysis is shown in table 1.the wind force acting on bridge deck in the xdirection is calculated

Table 3:stress and deformation values on slab

Span	Depth	Stress	deformation
6x15	0.3 0.36 0.42 0.48	51.52 52.85 53.744 69.677	0.53951 0.4626 0.41172 0.3876
4x15	0.3 0.36 0.42 0.48	93.074 94.923 95.881 125.65	0.78811 0.71438 0.66976 0.66779

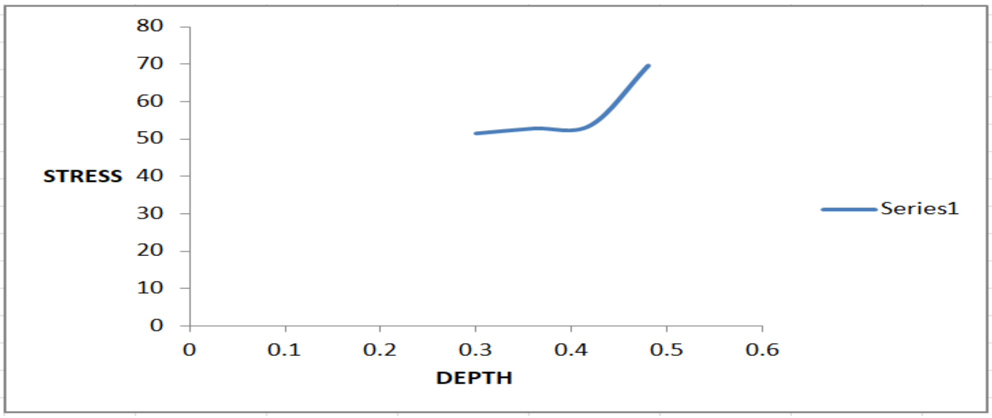

Fig 7: The wind force in terrain category 3,stress variation dependence on depth of slab with span 6x15

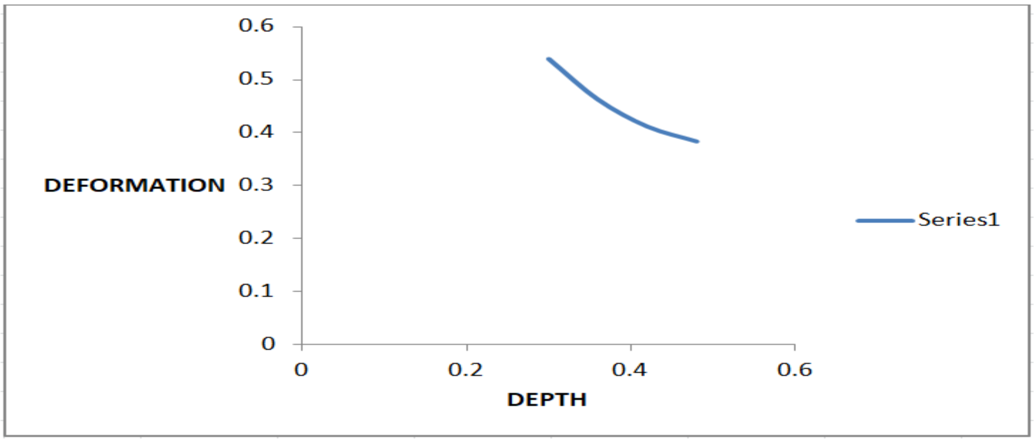

Fig 8: The wind force in terrain category 3,deformation variation dependence on depth of slab with span 6x15

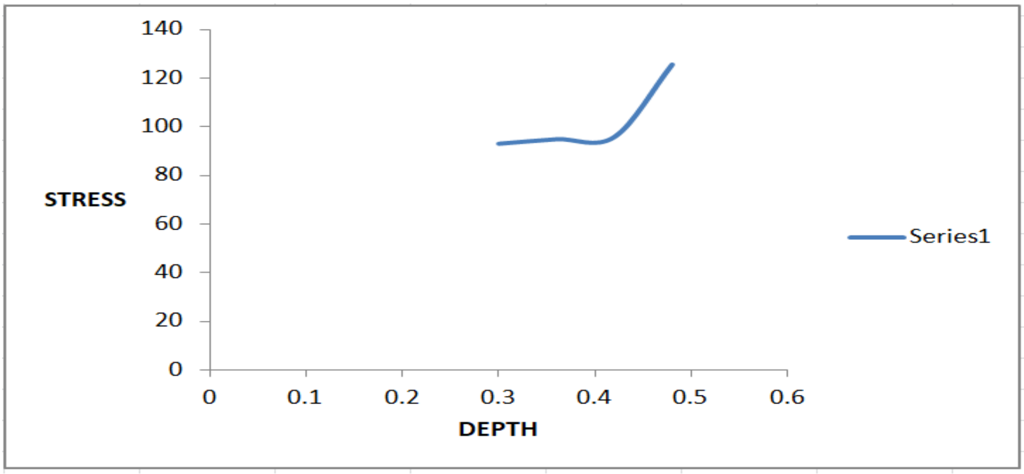

Fig 9: The wind force in terrain category 3,stress variation dependence on depth of slab with 4x15

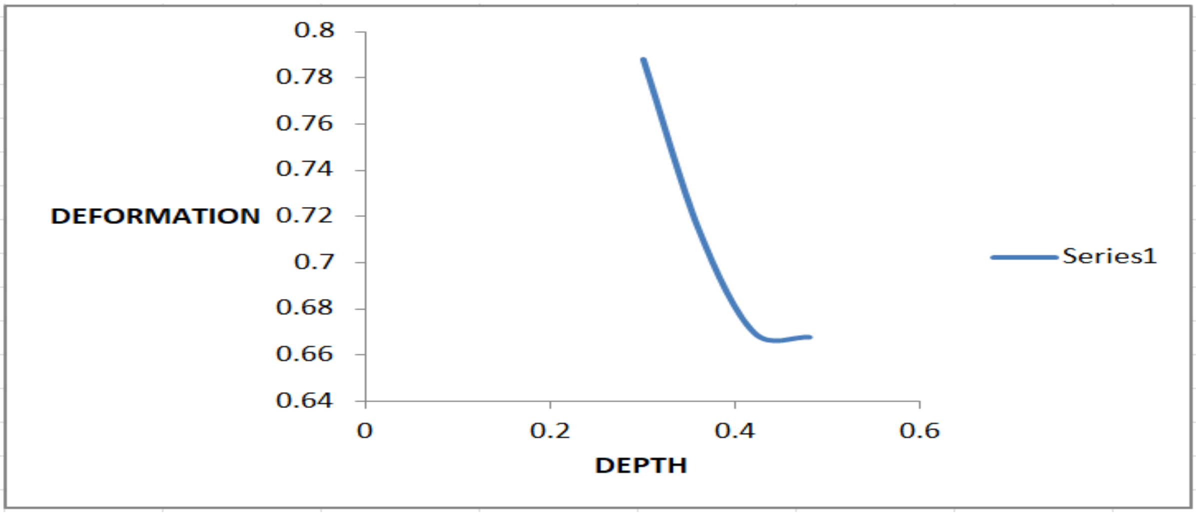

Fig 9: The wind force in terrain category 3, deformation variation dependence on depth of slab with 4x15

III. CONCLUSION

Dynamic response of bridge deck to moving vehicle is studied and it measured in terms of stress and deformation. Following conclusion area made on the basis of result obtained from this study of simplified model of bridge and vehicle.

1. Deformation decreases when depth of slab increases because when depth increase tendency of buckling decreases due they will try to take more loads

2. That stress values are more on support region. It is because the maximum normal stress occurs at the point of connection of the steel beam with concrete slab, due to greater rigidity and it wills decreases as it moves to center

3. When span increases stress value and deformation values increases because when span increases effect of stress and deflection are more

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