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NUMERICAL INVESTIGATION OF BRIDGE STRUCTURES SUBJECTED TO GRAVITY, SEISMIC AND MOVING LOADS

Alfiya Hakkim[1], Muneera B[2]

[1]M.Tech student, Dept. of civil Engineering, Younus College of Engineering and Technology, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, Younus College of Engineering and Technology, Kerala, India

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Abstract - : *Bridges are very important in the modern roads and railway transportation system, generally serving as social infrastructure system. The main objective of this study is to match the structural members capability between the differing types of piers with U- beam girder under gravity, seismic and vehicle loading. This study investigates efficiency of piers with U- beam as girder on seismic as well as structural analysis and design of integral bridges by using finite element analysis software ANSYS 16.0 version. The structure of the bridge will be design in CAD model software called CREO PARAMETRIC. The investigation mainly analyzes the structural member capability between girder shape (U- beam) and piers (hammer head pier, multi column bent, solid wall type pier) by applying different loading conditions.*

Key Words: *ANSYS, CREO, Seismic load, Bridge, Pier*

1. INTRODUCTION

Bridges structures are momentous and proficient civil structures and they contains on different types of structural members. These members can be divided into two groups. The first group is called superstructure and it includes the bearings, girders (beams), deck (including sidewalks), joints, asphalt pavement layer, security barrier, and drainage system. The second group is known as substructure which is contained on the foundations (piles and piles cap), piers, and pier caps. In general, bridges are important part of the transportation engineering system. It presents the connection way over urban congestion, waterways, and valleys. The bearing capacity of bridges controls the weight and the volume of traffic loads which are passed by the transportation system.

[1] The objective of the study is to compare the structural members capacity between different types of bridges structures under seismic load using CSI bridge. Bridges structures models are box girder bridge, solid girder bridge model, Precast I girder bridge, Slab bridge, Precast T girder bridge, U steel girder bridge. The result showed that models of box girder, precast T, and U steel girder bridge had the higher values of natural frequency comparing with other structures

[2] This study deploys simulation of nonlinear analysis of bridge using DRAIN 2DX. Paper presents details seismic analysis of RC multicolumn bridge bents and four seismic rehabilitation schemes. These schemes included steel dowels from the pile cap to the piles, a reinforced grade beam joining the pile caps and carbon FRP jackets for columns and joints

[3] The bridging activity is as old as human civilization. Innumerable bridges of various kinds and of various materials have been built from times immemorial. Design of medium span highway bridge system requires careful selection of structural element in preliminary stage. The motive behind the study is to prepare some useful interface for preliminary design of bridge system. There is no unique form of design which would be always most economical. It is only by comparing a few designs that the economic design can be found in a particular set of conditions. Economy can be achieved by separately or simultaneously considering one or more of the following factors: span, superstructure cross section, cost of prestressing steel and concrete consumption. The study includes parametric study on prestressed concrete girder bridge superstructure.

1.1 Objectives

- To determine deformation, stress, ultimate load and moment of U- beam girder with piers such as hammer head, multi column bend and solid wall type piers under loading conditions (gravity, seismic and moving loads).
- To validate and check the possibilities of finite element programming using ANSYS software for bridge analysis.

1.2 Scope of the Project Work

- Mercalli scale is considered
- Damping the generated vibrations using elastomers
- Effect of gravity is considered
- Vehicle loading as per IRC – Class AA tracked vehicle loading
- Optimization of bridge structures

2. METHODOLOGY

The whole project is divided into sequential steps. The following chart represents the methodology of the work

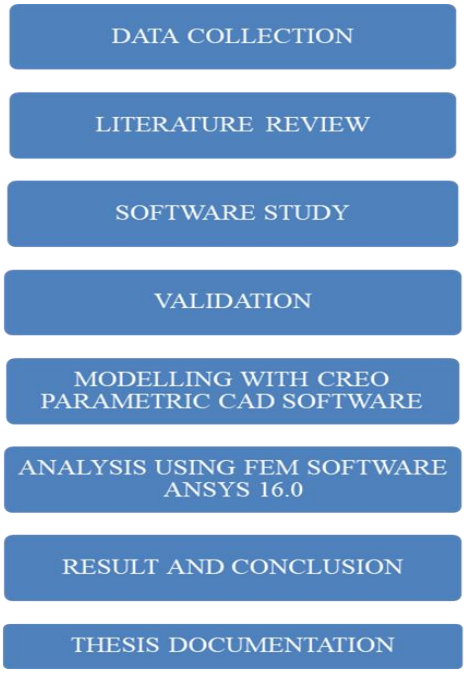

Fig -1: Flow chart showing methodology of the study

3. BRIDGE INPUT AND ANALYSIS

3.1 Model

Modelling of 20 m span bridge using CREO PARAMETRIC CAD modelling software. Specimen and model details were shown in Table – 1 and Fig – 2 to 4 represents models of bridge.

Table -1: Specimen and Model Details

Type Superstructure	Deck slab
Carriageway width	7.5 m
Kerbs	600 mm on each side
Foot Paths	1.20 m wide on each side
Thickness of wearing coat	80 mm
Lane of bridge	Two lane
Span	20 m
Width of deck	11 m
Thickness of deck	300 mm
Concrete	M40
Steel	Fe415

MODEL NAME	MODEL ID
U- beam girder with hammer head pier under gravity loading	UG – HHP G1
U- beam girder with hammer head pier under seismic loading	UG – HHP S1
U- beam girder with hammer head pier under vehicle loading	UG – HHP D1
U- beam girder with multi column bent under gravity loading	UG – MCP G2
U- beam girder with multi column bent under seismic loading	UG – MCP S2
U- beam girder with multi column bent under vehicle loading	UG – MCP D2
U- beam girder with solid wall type pier under gravity loading	UG – SWP G3
U- beam girder with solid wall type pier under seismic loading	UG – SWP S3
U- beam girder with solid wall type pier under vehicle loading	UG – SWP D3

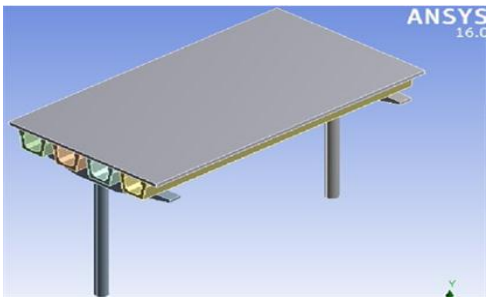

Fig -2: Model of U- beam girder with hammer head pier

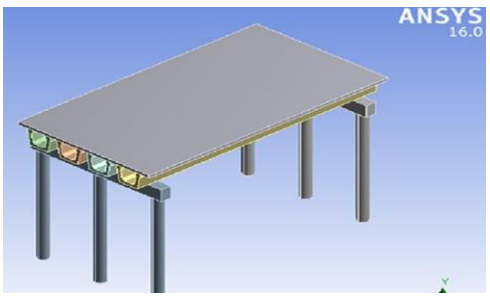

Fig -3: Model of U-beam girder with multi column bent

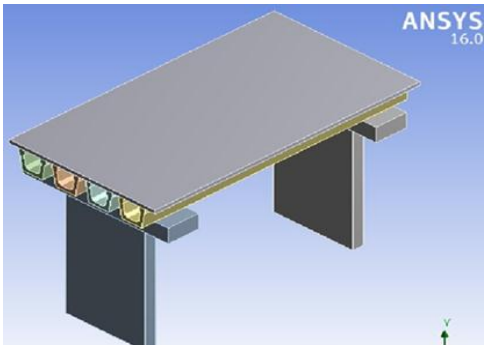

Fig -4: Model of U-beam girder with solid wall type pier

3.2 Loading

The loads assigned to the bridge are as follows,

Dead Load:

It includes the self-weight of the structure including the components attached to the structural members such as crash barrier, etc.

Live Load:

This is entered in the software in form of moving load. For two numbers of lanes, as per IRC (Indian Road Congress) class AA type vehicle loading is considered.

Seismic Force:

seismic analysis is being analysed in Mercalli scale. Magnitude of vibration is being converted to acceleration in Mercalli scale reading and hence analysis is being done. Acceleration is taken as 7 m/s^2**.**

4. ANALYSIS

The present study includes two different analysis namely static structural and transient analysis.

For analysis of bridge, bridge structures such as U- beam girder with different types of pier such as hammer head pier, multi column bent pier, solid wall type pier are examined under different loading conditions.

Fig -5 represents deformation of U- beam with different pier under gravity loading.

Fig -6 represents deformation of U- beam with different pier under seismic loading.

Fig -7 represents deformation of U- beam with different pier under vehicle loading.

Table -2: Results of analysis of U beam girder

MODEL ID	DEFORMATION (mm)	STRESS (MPa)	FORCE (kN)
UG – HHP G1	0.928	6.176	$1.08x10^3$
UG – MCP G2	0.925	5.967	$2.73x10^3$
UG - SWP G3	0.753	4.283	$1.05x10^4$
UG – HHP S1	1.189	8.605	$1.10x10^3$
UG – MCP S2	1.193	13.031	$2.78x10^3$
UG - SWP S3	0.851	9.497	$1.08x10^4$
UG – HHP D1	0.550	1.898	$4.91x10^2$
UG – MCP D2	0.524	2.324	$6.38x10^3$
UG - SWP D3	0.352	0.937	$2.58x10^3$

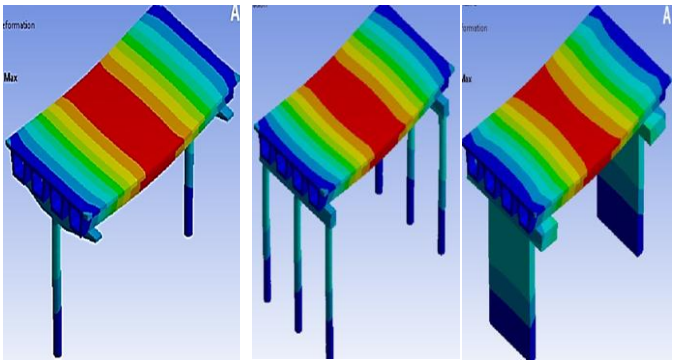

Fig -5: Deformation of U-beam girder with different piers under gravity loading

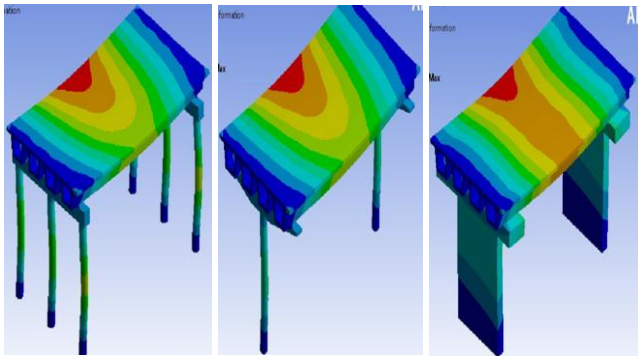

Fig -6: Deformation of U-beam girder with different piers under seismic loading

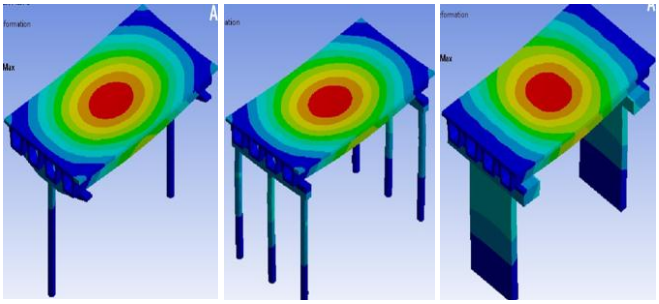

Fig -7: Deformation of U-beam girder with different piers under vehicle loading

Table -3: Comparison of results of U beam girder

MODEL ID	% INCREASE IN DEFORMATION	% INCREASE IN STRESS
UG - SWP G3	0	0
UG – MCP G2	18	28
UG – HHP G1	18	30
UG - SWP S3	0	0
UG – MCP S2	28	27
UG – HHP S1	28	10
UG - SWP D3	0	0
UG – MCP D2	32	60
UG – HHP D1	36	50

5. CONCLUSIONS

- Modelling and analysis of bridge using finite element program such as ANSYS is possible
- Solid wall type pier with U- beam girder shows less deformation as compared to multi column bent and hammer head pier under different loading
- While considering longer spans and elevated structures solid wall type pier cannot be taken as an optimized section. Hence multi column bent is taken

6. SCOPE FOR FUTURE WORK

- This study can be continued for different shapes for girders and pier columns i.e. rectangular, square etc.
- The column base has been assumed to be fixed at its bottom in this research. However, the soil-structure interaction between piles that support the columns can be researched.
- All the columns of the bridge considered in this study have the same height. Bridge having columns of varying heights may be studied.
- The bridge in this study consists of 20m span length. The number of spans and their lengths can be varied in further researches.

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