Study of Cable Stayed Bridge Subjected to Ground Motion using Time History Method

Munot Vaibhav[1] Dr. Shelke Nagesh[2] Deosarkar Manoj[3]
[1,3]Student [2]Professor
[1,2,3]Dr. D.Y. Patil School of Engineering & Technology CharholiBudru, Lohegaon, Pune-412105, India

Abstract— Cable Stay type bridges have been around a lot longer than a lot of people think and can be traced back more than four centuries. Many early bridges using cable stays incorporated both cable stays and suspension cables. One very famous example of this is the Brooklyn Bridge in New York City, which was completed in 1883Early examples often combined features from both the cable-stayed and suspension designs, including the famous Brooklyn Bridge. The design fell from favor through the 20th century as larger gaps were bridged using pure suspension designs, and shorter ones using various systems built of concrete. Cable stay Bridge is analyzed through Staad pro.

Key words: Cable-Stayed Bridge, Pylons, Dynamic Interaction, Galvanized Wires

I. Introduction

Cable-stayed bridges may appear to be similar to suspension bridges, but in fact they are quite different in principle and in their construction.

In suspension bridges, large main cables (normally two) hang between the towers and are anchored at each end to the ground. This can be difficult to implement when ground conditions are poor. The main cables, which are free to move on bearings in the towers, bear the load of the bridge deck. Before the deck is installed, the cables are under tension from their own weight. Along the main cables smaller cables or rods connect to the bridge deck, which is lifted in sections. As this is done, the tension in the cables increases, as it does with the live load of traffic crossing the bridge. The tension on the main cables is transferred to the ground at the anchorages and by downwards tugs on the towers. In the cable-stayed bridge, the towers are the primary load-bearing structures which transmit the bridge loads to the ground. A cantilever approach is often used to support the bridge deck near the towers, but lengths further from them are supported by cables running directly to the towers. This has the disadvantage, compared to the suspension bridge that the cables pull to the sides as opposed to directly up, requiring the bridge deck to be stronger to resist the resulting horizontal compression loads; but has the advantage of not requiring firm anchorages to resist the horizontal pull of the main cables of the suspension bridge. By design all static horizontal forces of the cable-stayed bridge are balanced so that the supporting towers do not tend to tilt or slide, needing only to resist horizontal forces. Accurate prediction of the dynamic response of long-span cable-supported bridges is dependent predominantly upon the knowledge of their dynamic properties, including natural frequencies, mode shapes, damping values, participation factors, and a description of dynamic excitation. With their crease of clear span of cable-stayed bridges and increasing use of slender deck system, the dynamic interaction among cables, the deck and towers becomes evident, which may significantly affect the modal properties and the seismic response cables have been found to have more significant participation ratios than those of the shorter cables. Experimental investigations also confirmed the coupling of vibrations between cables and deck/towers however, the conventional equivalent modulus approach by modeling bridge cables as single truss elements cannot appropriately account for the effects of cable vibrations. The use of multiple elements for cables was strongly recommended in the dynamic analysis of cable-stayed bridges.Q. Ni, J. Y. Wang et. al. studied modal analysis of the cable-stayed Ting Kau Bridge was carried out by using a three dimensional finite element model with hybrid-element-cable system. S.V.NIT et.al.focus is given on the effect of shape of pylon on the seismic response of cable stayed bridge, for this, the bridge span dimension and other parameters are kept constant, and only the pylon shape is varied viz. A type, H type, portal frame, spread pylon and pyramid shapes. Yukari Aoki et. al.did finite element (FE) model for a cable-stayed bridge designed according to Australian standards is developed and analyzed statically and dynamically for this research purpose.

II. Objectives

- To analyses& design cable stayed bridge fan & harp type including bridge pier.
- To determine natural frequency, time period of natural cable stayed bridge using staad pro.
- To perform non-linear dynamic analysis of fan & harp type cable stayed bridge subjected to various ground motion.
- To perform comparative study of fan & harp type Cable Bridge for deflection, principal stress, bending stress, shear stress.

III. Methodology

A. Introduction

Three models are employed in this study to investigate the effects of the rigidity of brace end connections on the behavior of a transmission tower. In Model A, all of the main braces are assumed to be rigidly connected to the horizontals and the legs. In Model B, the connections of the main braces are assumed to be in-plane pin-connected and out-of-plane rigid-connected. In Model C, the connections of the main braces are assumed to be pinned in both in-plane and out-of-plane. In all three of the models, the secondary members are assumed to be pin-connected. Dynamic analysis using the time history analysis calculates the building responses at discrete time steps using discretized record of synthetic time history as base motion. If three or more time history analyses are performed, only the maximum responses of the parameter of interest are selected. Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion. Static techniques are applicable when higher mode effects are not important. This is for the most part valid for short, regular structures. Thus, for tall structures, structures with torsional asymmetries, or no orthogonal frameworks, a dynamic method is needed. In linear dynamic method, the structures is modeled as a multi degree of freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix.

1) Ground Motions and Linear Time History Analysis

The seismic input is modeled utilizing time history analysis, the displacements and internal forces are found using linear elastic analysis. The playing point of linear dynamic procedure as for linear static procedure is that higher modes could be taken into account. In linear dynamic analysis, the response of the building to the ground motion is computed in the time domain, and all phase information is thus preserved. Just linear properties are considered. Analytical result of the equation of motion for a one degree of freedom system is normally not conceivable if the external force or ground acceleration changes randomly with time, or if the system is not linear. Such issues could be handled by numerical time-stepping techniques to integrate differential equations.

a) Material Modeling

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elasto-plastic materials, and fully incompressible hyper-elastic materials.

2) Ground Motion Records

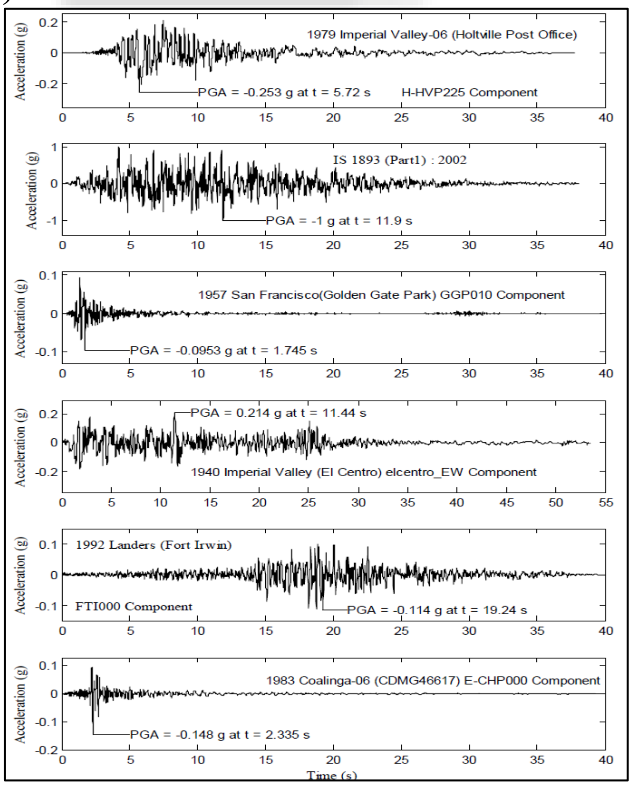

Fig. 1: Ground motion acceleration versus time with PGA value of 1979 Imperial Valley-06 (Holtville Post Office) H-HVP225 component, IS 1893 (Part1): 2002

Buildings are subjected to ground motions. The ground motion has dynamic characteristics, which are peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), frequency content, and duration. These dynamic characteristics play predominant rule in studying the behavior of RC buildings under seismic loads. The structure stability depends on the structure slenderness, as well as the ground motion amplitude, frequency and duration.

IV. PROBLEM STATEMENT

Parametric Study of Submerged Pier of Bridge includes the study of following parameters.

– Water level: For different levels of water like, H=0, H=h/2, H=h/4, H=3h/4. We can calculate the maximum and minimum stresses at the base of the pier.

A. Hydraulic Particulars

1) Design discharge through the bridge= 9.903Cumecs
2) Effective linear water way @ FSL= 13.45M
3) Maximum mean velocity of flow @ FSL V= 0.64 m/sec
4) Full Supply Level FSL = 445.605 m
5) Scour level = 443.375m
6) Founding levels of pier = 442.455m
7) Safe bearing capacity of soils = 350KN/m^2
8) Number of spans = 2Nos
9) Span c/c of bearings = 10.37m
10) Full Supply Level FSL = 445.605m
11) Bottom of deck = 449.53m
12) Road level = 450.42m
13) Height of deck = 0.790m
14) Thickness of wearing coat = 0.1m
15) Canal bed level CBL = 443.955m
16) Top of RCC footing = 443.055m
17) Thickness of footing =0.60m

Scour level = 443.375m

Superstructure & loadings & type of structures:

1) Span length c/c of bearings= 10.37m
2) Total width of decking = 7.5m
3) Carriage way width = 7.5m
4) Thickness of Uniform wearing coat cc M30= 0.1m
5) Type of structure Piers= RCC

1) Design Loadings

– Unit weight of dead loads: As per IRC:6-2000
– Unit weight of RCC = 25KN/m^3

2) Type of Live Loads:

– One lane of Class -70R
– Two lane of class –A
– Unit weight of PCC = 24KN/m^3

V. RESULTS & DISCUSSION

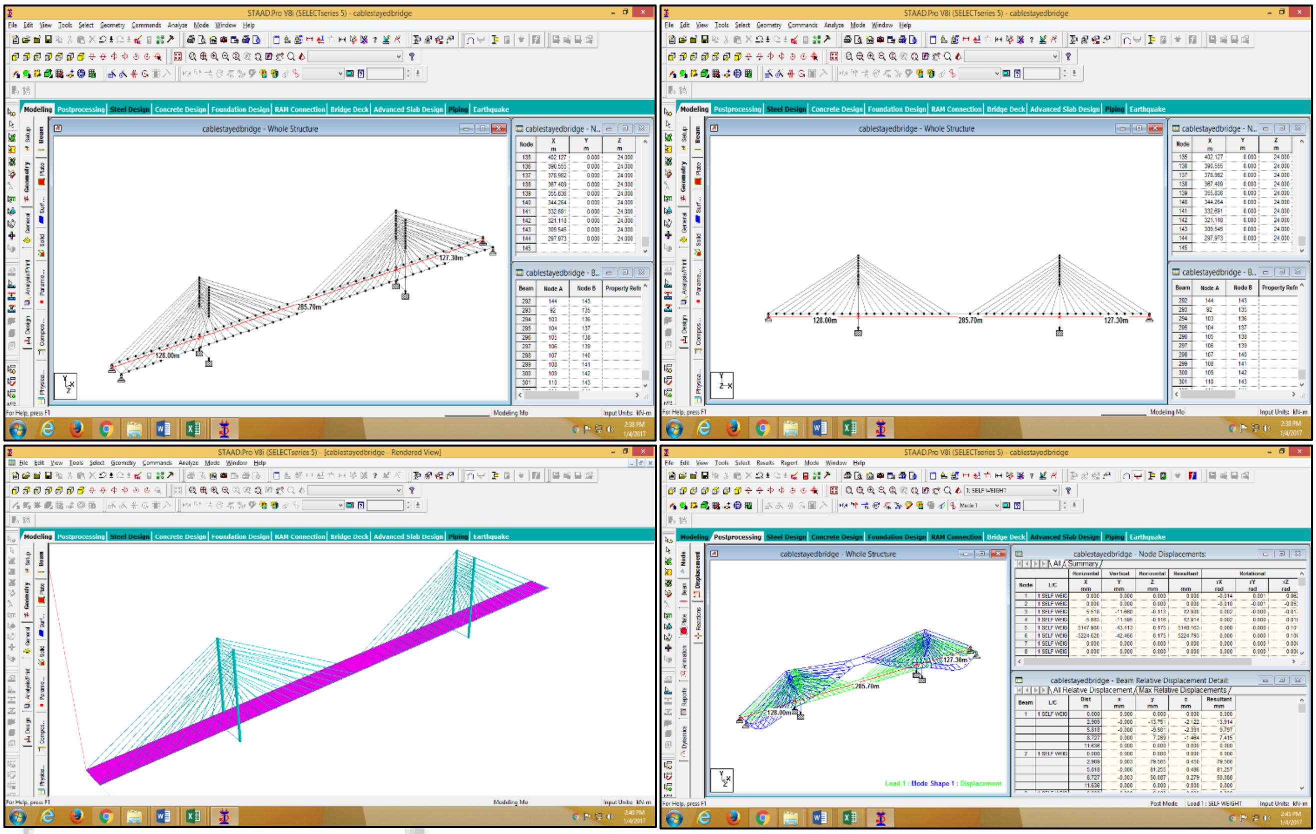

Fig. 2: Results

L/C		FxkN	FykN	FzkN	MxkNm	My kNm	MzkNm
1	Loads	0	-1.81E+05	0	2.17E+06	0	-4.90E+07
	Reactions	0	1.81E+05	0	-2.17E+06	0	4.90E+07
	Difference	0	0	0	0	0	0.649

Table 2: Results

VI. CONCLUSION

1) In this study linear analysis of cable stayed bridge is done using FEA tool Staad-Pro
2) In this study literature review various ground motion data collected sanfrancisco, IS1893.1979 imperial valley1940 imperial value etc. to perform tie history analysis of cable styed bridge.
3) Harp type cable stayed bridge is modelled containing 40 cables 541.8m span, ht 87m.
4) Reaction done to self wt. found is 1.81x105 resultant , then natural frequency & time period observed maximum at model no.1

REFERENCES

[1] S.V.NIT, Effect of Pylon Shape on seismic response of Cable stayed bridge with soil structure interaction INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 1, No 3, 2010
[2] Yukari Aoki Analysis of the Performance of Cable-Stayed Bridges under Extreme Events April 2014
[3] Dr. Atul K. Desai Seismic time history analysis for cable-stayed bridge considering different geometrical configuration for near field earthquakes 2011
[4] G. M. Savaliya Static and dynamic analysis of cable-stayed suspension Hybrid Bridge & validation.
[5] G. M. Savaliya International Journal of Advanced Research in Engineering and Technology Nov 2015.
[6] HussainHararwala Effect of the different shapes of Pylons on the Dynamic Analysis of Cable Stayed Bridge using SAP 2000.
[7] Ki-du kim large displacement of in-elastic analysis of concrete cable stayed bridge using xfinas-3 fem system and gid 2011.

