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SEISMIC ANALYSIS OF CURVE CABLE-STAYED BRIDGE

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Abstract - *Cable-bridges constructed in a more unique style for aesthetic and structural reasons. Curved cable bridges are not a common type of Highway Bridge in India, which are usually built at interchange which allows transportation of traffic from one highway to another. The current study presents the effect of horizontal curvature on the cable curved bridges as compared to straight cable-stayed bridges with changes in curvature. For this purpose, six models of cable-stayed bridge are selected with different radius of curvature. Linear time history analysis is performed on different combinations of models of varying curvature for the ground motion dataset. The outcomes are changes in displacement at different level of piers and deck and base shear.*

Key Words: Bridges, Curvature, Seismic analysis, linear time history

1. INTRODUCTION

In recent years, the Cable Bridge has become the world's most commonly used bridge system. Almost all existing long-span cable bridges are straight. There are only a few known cable bridge along the curved road. The number of cable bridges in modern style is growing worldwide. These bridges are now built-in a more unique style for structural and aesthetic reasons. Examples include Leirez Bridge, a single inclined tower bridge; Katsushika Harp Bridge, a single Pylon with two deck and S-shaped deck; Marian Bridge with an L-shaped pylon; Alamillo Bridge with a single scaled pylon; And Safti Link Bridge which has a curved deck and a single offset pylon [2].

Curved cable bridges are not a common type of Highway Bridge in India, which are usually built at interchange which allows transportation of traffic from one highway to another. Cable-bridges constructed in a more unique style for aesthetic and structural reasons. Also there is a more regular Symmetrical cable bridge up to 1 km of spans, small asymmetric designs have interesting dynamic features that return checks [3].

A cable-stayed bridge has one or more towers (or pylons), from which cables support the bridge deck. A distinctive feature are the cables or stays, which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines.

Link stayed and suspension spans are the biggest structure planned as a stage for conveying individuals and vehicles. Both the extensions are held up by the links, their methods of activities are altogether different. Link remained spans are more affordable speedier to construct and has grater solidness. These scaffolds are subjected to static and dynamic burdens causes' dynamic disappointment. The Cable stayed spans give an exceptional compositional view in light of their one of a kind link game plans and arch shapes [4].

2. BRIDGE DESCRIPTION

A regular three range straight cable-stayed bridge of 592m (1942 ft.) add up to length with mid-span of 350m long and both end spans are 121m (396 ft.) since quite a while ago utilized in this examination as appeared in Fig. Fig. 1(b) demonstrates the primary span of super-structure of the extension and Fig. 1(a) present the layout of pylon. The superstructure comprises of 0.225m (8 inch) persistent solid section upheld on supports. The profundity of the consistent solid brace is viewed as 1.75m (5.74 ft.). The substructure of bridge comprises of six inflexible piers at the both end sides of bridge at equivalent separation of 20m on two closures. Solid steel course are utilized beneath the solid supports with the targets of exchanging the superstructure burdens to the projections and obliging the flat distortions because of natural burdens. The precious diamond shape pylon is utilized.

The qualities received for investigation of configuration speed, maximum super elevation and coefficient of side friction are given below. Based on horizontal curvature, radius of curvature was changes. For 1^0 horizontal curvature, radius is 10340m, correspondingly for 2^0 shape, radius is 5170m, For 3^0, radius is 3447m, For 4^0, Radius is 2585m and For 5^0 radius is 2068m.

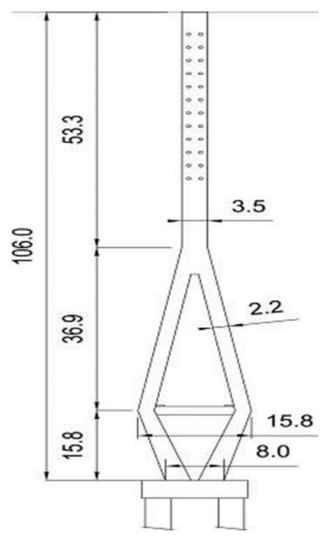

Fig. 1(a) Layout of Pylon

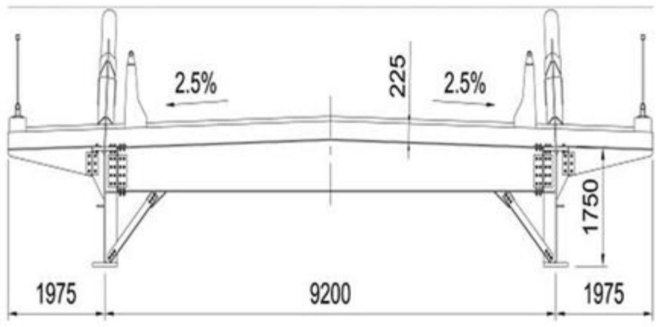

Fig. 1(b) Main Span of Super-structure

2.1 Properties of Bridge:

Cross-section of the Girder (m^2) = 0.3048 x 1.75

Cross-section of the Pier (m) (Circular Dia.) = 0.40m

Number of Girders = 60

Young's Modulus of elasticity of concrete (N/m^2) = $25x10^9$

Young's Modulus of elasticity of steel (N/m^2) = $2x10^{11}$

Translational stiffness along longitudinal and transverse direction (N/m^2) = $9853.8x10^6$

Translational stiffness along vertical direction (N/m^2) = $12.58x10^6$

Rotational stiffness along longitudinal and transverse direction (Nm/rad) = $31786.4x10^3$

Rotational stiffness along vertical direction (Nm/rad) = 81.1x103

Maximum Super-elevation = 0.10

Coefficient of side friction = 0.12

Design Speed (kmph) = 50

3. MODELLING IN SAP2000

The whole structure is drawn closer by a 3-D model utilizing SAP2000 as appeared in Fig. 2(a). All in all, the bridge deck is modelled as inflexible body demonstrate in seismic reaction investigation of bridge. It is surely knew, encounter that the presumption of rigid bridge deck does fundamentally impact on the seismic reaction of the extension, particularly when the bridge is subjected to seismic excitations longitudinal way. The bridge deck and pier are demonstrated as linear versatile shell components. The girder is modelled utilizing linear flexible components. Two joint connection components are utilized to demonstrate the orientation introduced between the pier top and the base of girders additionally on the pylon. The vertical interpretation and rotation of the deck about the longitudinal direction were controlled at the pier and pylon levels.

By using above procedure, cable-stayed bridge model with straight and curve horizontal curvature was made. The six models were made with different horizontal curvature like straight (0°), 1°, 2°, 3°, 4° and 5° horizontal curvature. The finite element model of cable-stayed bridge shows arrangement with all connection. By using grid pattern co-ordinate of bridge system were allocated. Defining the bridge elements using frames section properties and draw the elements by using the draw tool. The steel pier and pylon was connected with the deck girder by using the bearing i.e. the deck girder was resting on bearing above the pier. In the model, the bridge deck was connected by the two-joint link. Similarly, 1°, 2°, 3°, 4° and 5° curve cable-stayed bridge was modelled. The curve was drawn using Auto-CAD and curve imported in SAP2000.

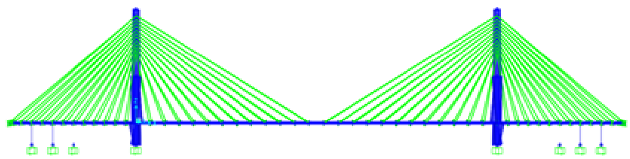

Fig. 2(a) 2D view of Straight Cable-Stayed

Fig. 2(b) 2D Top View of 5^0 Bridge

3.1 Linear Time History Analysis:

The direct integration technique leads the analysis forever arranges and the number or time stages is relative to the investigation/analysis time. Dynamic loads that change with time can be utilized in linear time history analysis. The time advance for time history analysis is distinctive for the direct technique and mode method. Time history analysis is the investigation of the dynamic reaction of the structure at each addition of time, when its base is presented to a specific ground motion. Static methods are applicable when higher mode impacts are not imperative.

3.2 Modelling in SAP2000:

a. The bridge co-ordinate data was defined to facilitate the geometry of the bridge and then the sectional and material properties are defined.

b. All the structural components are placed in the grid data system.

c. Various loads and load combinations are defined as per code specifications.

d. The bridge is analysed for the dynamic effect of the seismic force.

e. Later the bridge is checked for its response under the action of moving truck loads.

4. ANALYSIS AND RESULTS

4.1 Base Shear:

Table -1: Base Shear for Different Curvature of Bridges

Bridge Type	Base Shear (KN)
Straight	77912.977
1°	8061.26
2°	8400.609
3°	6324.446
4°	4572.204
5°	9141.729

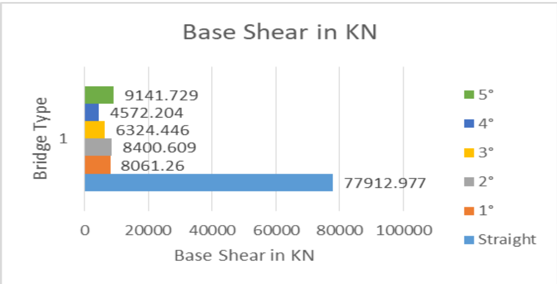

Chart-1: Base Shear for Different Curvature of Bridges

4.2 Displacement at Pier/Pylon at Deck Level:

Table -2: Displacement at Deck Level of Pier/Pylon

	Displacement (mm)					
Model	Straight (0)	1	2	3	4	5
Pier/Pylon						
P1	84.9	41.812	43.792	50.125	54.06	62.133
P2	84.5	41.457	43.879	49.823	52.37	62.723
P3	83.83	40.937	43.618	49.569	50.98	62.624
P4/PYLON	80.03	38.731	39.927	48.857	51.39	55.51

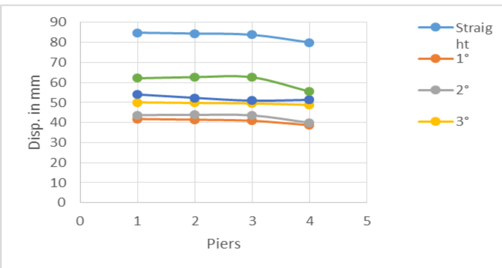

Chart-2: Displacement at Deck Level of Pier/Pylon

4.3 Displacement at Middle of Deck in X and Y-Direction:

Table -1: Displacement at Middle of Deck in X and Y-Direction

Bridge Type	Displacement (mm)	
	X	Y
Straight	26.091	480.3
1°	5.53	43.53
2°	0.1765	110.157
3°	0.3173	153.687
4°	0.4933	0.3917
5°	5.305	131.68

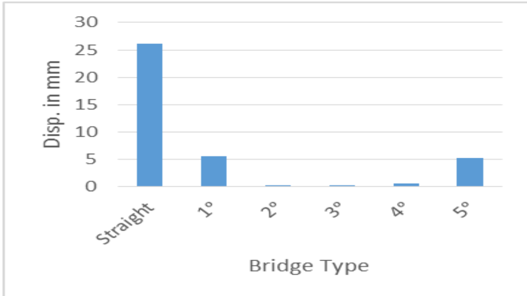

Chart- 3. (a): Displacement at Middle of Deck in X-Direction

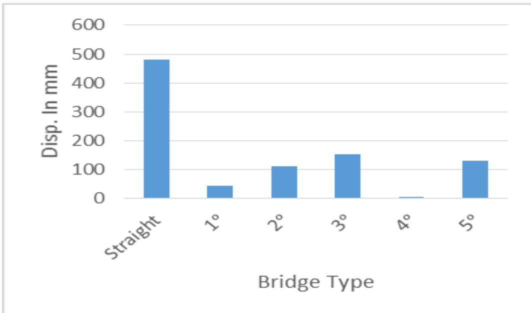

Chart- 3. (b): Displacement at Middle of Deck in X-Direction

4.4 Modes, Frequency and Time Period:

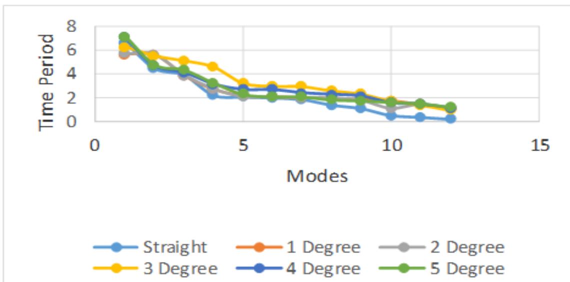

Chart -1: Modes with Time Period

5. CONCLUSION

Displacement at Deck Level of Pier/Pylon maximum at straight cable-stayed bridge however in the case of 1^0 Curve cable bridge the displacement is less than other bridges. The displacement of top of pylon is minimum for 5^0 curve cable stayed bridge. Displacement at middle of deck is minimum for 4^0 curve Cable Bridge. Base shear for the straight cable-stayed bridge is higher as compared to other bridges. Base shear from 5^0 horizontal curvature is increased slightly. Fundamental time period for 1st mode is minimum for 1^0, 2^0, and 3^0 curve and they become maximum for rest of the modes.

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