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***Research Paper***

# STRUCTURAL BEHAVIOUR OF CABLE STAYED BRIDGE SYSTEM USING VARIOUS TYPE OF DECK-PROFILES

Dr. G. Srikanth (Professor) [1] . Lanka Viswanatha Dutta. M Tech[2] Department of Civil Engineering, Siddhartha Institute of Technology & Sciences (SITS) Narapally village, Hyderabad, Telangana 500088

***ABSTRACT***

The prime objective of the present work is to study the structural behaviour of cable stayed bridge with different types of deck profiles by by modelling and analysing them under static and dynamic loadings, ensuring that the same span to depth ratio is maintained in all cases. A comparison of their behaviour under static and dynamic analyses was made. The complete work consists of conducting a static and dynamic analysis using commercial software (MIDAS civil) by modelling a 4 lane cable stayed road bridge with main span of 150m and having side spans of 75m on either side supported on two pylons. The deck width at the road surface is considered 23.5m. Single axial layer of stay cables, with 6 nos. on either side of pylon, totalling to 24 nos. are anchored in the median of the road bridge. The total focus has been given to study the performance of the Cable Stayed Bridge with commonly used deck profiles, i.e., PSC- contiguous I girder , PSC-contiguous T beam, PSC-Box girders with single and multi-cells. Parametric study will be to work out the axial and bending stresses in deck and stay cables, displacements and deflections under static analysis. Dynamic analysis is conducted to study the seismic response of cable stayed bridge by using Linear Time History Analysis (THA). Parameters like axial and bending stresses, stresses in stay cables and displacements in the deck, base shears were studied. The study also considers providing a Triple friction pendulum isolator (TFPI) damper at lower girder position of abutments in the bridge for improving dynamic behaviour of bridge. The displacements at the abutments with and without TFPI for all the four deck profiles were studied and compared. Further, a comparison of time periods of the bridges with and without TFPI damper for all the four deck profiles were also made. The results of the study enable engineers in selecting the better performing deck profiles for cable stayed road bridges designed using IRC guidelines for static and dynamic loadings.

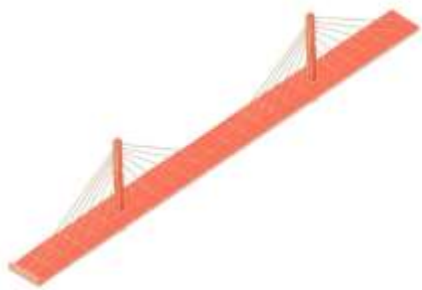

**Fig 1 Cable Stay bridge Model in MIDAS civil**

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## INTRODUCTION

The history of cable stayed bridges dates back to 1595, found in a book by the Venetian inventor (Bernard et al., 1988). Many suspension and cable-stayed bridges have been designed and developed since 1595 such as the Albert bridge and the Brooklyn bridge (Wilson and Gravelle, 1991), (Bernard et al., 1988). Cable-stayed bridges have been later constructed all over the world. The Swedish Stromsund bridge, designed in 1955, is known as the first modern cable-stayed bridge (Wilson and Gravelle, 1991). The total length of the bridge is 332 m, and its main span length is 182 m. It was opened in 1956, and it was the largest cable-stayed bridge of the world at that time.

***Static Analysis***

Static analysis is used to study the behavior of a structure under critical combination of dead and live loads. The parameters evaluated are the axial and bending stresses, deflections in deck and stresses in stay cables.

***Dynamic Analysis***

The Seismic response of the cable stayed bridge is evaluated by calculation of the response of the bridges structure to earthquakes. The parameters evaluated are the axial and bending stresses, deflections, displacement, time period and base shears. It is required to conduct dynamic analysis for structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent. [29]

**Linear Dynamic Analysis**

Static procedures are appropriate when higher mode effects are not significant. This is generally true for short, regular buildings. Therefore, for tall buildings, buildings with torsional irregularities, or non-orthogonal systems like cable stayed bridges, a dynamic procedure is required. In the linear dynamic procedure, the building is modelled as a multi-degree-of-freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix.

1. The seismic input is modelled using either modal spectral analysis or time history analysis (THA) but in both cases, the corresponding internal forces and displacements are determined using linear elastic analysis. The advantage of these linear dynamic procedures with respect to linear static procedures is that higher modes can be considered. However, they are based on linear elastic response and hence the applicability decreases with increasing nonlinear behavior, which is approximated by global force reduction factors. [29]
2. In linear dynamic analysis, the response of the structure to ground motion is calculated in the time domain, and all phase information is therefore maintained. Only linear properties are assumed. The analytical method can use modal decomposition as a means of reducing the degrees of freedom in the analysis. [29]

**Time History Analysis (THA) Method**

The complete time history of response to an earthquake can be obtained by calculating the response at successive discrete time, with the time step (interval between calculation times) sufficiently short to allow extrapolation from one calculation time to the next., where linear analysis is involved, the time step should not exceed a quarter of period of the highest structural mode interest. This solution method in the time domain is further discussed by Clough and Penzien (1993).

**Triple friction pendulum isolator (TFPI)**

The primary function of a TFPI (Fig. 2) is to uncouple the structure (bridge deck or building) from the ground during an earthquake, thus reducing the seismic forces transmitted to the superstructure.

It dissipates seismic energy through friction, a form of inherent damping. The movement of sliding surfaces within the isolator generates friction, which converts the kinetic energy of the earthquake into heat, effectively reducing the structural response.

The Triple Pendulum bearing offers better seismic performance, lower bearing costs, and lower construction costs as compared to conventional seismic isolation technology.

The properties of each of the bearing's three pendulums are chosen to become sequentially active at different earthquake strengths. As the ground motions become stronger, the bearing displacements increase. At greater displacements, the effective pendulum length and the effective damping increase, resulting in lower seismic forces and bearing displacements

**Fig 2 TFPI** seismic isolator

**Objectives of the study:**

(1) To study the structural behavior of following types of deck-profiles that are adopted in cable stay bridges by keeping the same span to depth ratio in all the cases :

1) Multi-cell Box Girder
2) Single Cell Box Girder
3) Multi-cell PSC T Girder
4) Multi-cell PSC I Girder

(2) To study the effect of design of the above types using the Triple Friction pendulum Isolator (TFPI) as damper to control the seismic effect of the cable-stayed bridge.

(3) Compare the results and evaluate better performing deck-girder system and its cost-economics with respect to :

1) load carrying capacity and self-weight,
2) load carrying capacity and required material.

**REVIEW OF LITERATURE**

Fernando Madrazo-Aguirre, Ana M. Ruiz-Teran, M. Ahmer Wadee (2015) Published a paper "Dynamic Behaviour of Steel-Concrete Composite Under-Deck Cable-Stayed Bridges Under The Action of Moving Loads." in Journal of Engineering Structure(ELSEVIER). In this paper, Fernando Madrazo-Aguirre proposed to reduce the maximum acceleration of steel-concrete composite under-deck cable stayed bridge due to earthquake force and also conducted cost optimization.

**4.0 CONCLUSIONS**

The main objective of the study is to analyze a static and dynamic behaviour of cable stayed bridge system using different type of PSC deck-profiles, (i.e, 1-cell box girder,4-cell box girder, multi-T type girder, multi-I type girder). To optimized structural behaviour of cable stayed bridge system using various type of deck-profiles under the load combination of dead load, secondary dead load and moving load (static loading) and linear time history analysis (dynamic loading) as per IRC Criteria. For Optimization of cable stayed bridge system span to depth ratio of deck-profiles/girders were keeping constant.From the result of analysis, the following conclusions were carried out:

**Static analysis:**

1. By keeping span to depth ratio constant for the analysis of various deck profiles under the load combination stress, force and bending moment are within the permissible limits as per IRC based codal criteria.
2. By keeping constant span to depth ratio cable diameter is changing significantly, but pylon dimensions are same.
3. By performance based analysis in the term of cable stress and girder stress, PSC multi- cell box girder is giving better performance.
4. In the terms of girder bending moment result of PSC multi-I girder and PSC multi-T girder are giving better performance under combination of dead load, secondary dead load and moving load respectively.
5. According to overall performance based analysis, PSC multi-cell box

girder for four lane road in cable-stayed bridge system is proposed.

**Dynamic analysis:**

To study of behaviour of the bridge during earthquake using time history analysis, the BHUJ earthquake time history acceleration data is applied in lateral component in both X and Y direction for cable stayed bridge analysis.

1. From results of stress and cable stress at various positions it indicates that under seismic loading girder stress and cable stress both were in permissible limits of criteria of seismic effects. By keeping constant span to depth ratio, the cable diameter is changing significantly, but pylon dimensions are same.
2. From the table of TFPI deformation at abutment, it indicates that TFPI gives better performance under the seismic loading in both direction X and Y for all type of deck- profiles.
3. In vibration mode analysis, the different type of deck-profiles using in cable stayed bridge system with TFPI time period of $1^{st}$ mode shape is increase significantly and for $2^{nd}$ and $3^{rd}$ mode shape time period is changes more hence, the fundamental time period for isolation system is increased.
4. According to Eigen value analysis, PSC-T type and PSC-I type girders gives better performance under seismic loading in cable stayed bridge system.
5. But according to the overall analysis, PSC 4-cell box girder is structurally better performing for four lane road.

**Future Scope:**

Further to this study, research is needed to study the behavior of the cable stayed bridge with various deck profiles considering the following aspects: non-linear effects from stay cables, performance under wind and non-linear effects of earthquake loading.

**REFERENCES**

[1] Chun S. Cai, Yin Zhang, Jianguo Nie (2015), “Composite Girder Design of Cable- Stayed Bridges”, Practice Periodical on Structural Design and Construction(ASCE) Department of Civil, Nanyang University, China

[2] Do Dai Thang, Min-se Koo, Asif Hameed (2009), “Optimum Cost Design of Steel Box-Girder by Varying Plate Thickness”, KSCE Journal of Civil Engineering Department of Civil Engineering Inha University, Incheon 402-571.

[3] Fernado Madrazo- Aguirre, Ana M. Ruiz-Teran, M. Ahmer Wadee (2015), " Dynamic behaviour of steel-concrete composite under-deck cable-stayed bridge under the action of moving loads", Journal of Engineering Structure(ELSEVIER) Department of civil and Environment Engineering, Imperial College of Science, Technology & Medicine, London.Uk.

[4] L.M.C Simoes, J.H.J.O Negrao (2000), " Optimization of Cable Stayed Bridge With Box Girder Deck", Advance in Engineering Software(ELSEVIER).

[5] Phani Kumar.Ch, S.V.V.K. Babu and D. Aditya Sai Ram (2016)," Analysis and Design of Prestressed Box Girder Bridge by IRC : 112-2011", International Journal of Constructive Research in Civil Engineering, Civil Engg. Department, Andhra Pradesh, India.

[6] Xialin Yang And Yaping WU and Guoxiang WEI, (2010), " Analysis of Stress Influence of Top Deck Thickness on Main girder With box cross section used in cable stayed bridge", Logistics for Sustained Economic Development(ASCE) Civil

Engineering College,
[7] Lanzhou University, Lanzhou 730070, China.
[8] Yasir I. Musa and Manuel A. Diaz (2008), " Design Optimization of Composite Steel Box Girder in Flexure", Practice Periodical on Structural Design and Construction(ASCE). Engineer in Training, Federal Highway Administration, Harrisburg, PA 17107.
[9] M. C. Constantinou, I. Kalpakidis, A. Filiatrault and R.A. Ecker Lay (2010) , published paper "Lrfd-based analysis and design procedures for bridge bearings and seismic isolators"
[10] Sachi parekh, Dr. M. kumar, Dr. V.R. Panchal (2016), published paper "Seismic response of cable stayed bridge isolated with triple friction pendulum system (TFPS)" in journal of innovative research in science and engineering (IJRSE).
[11] Tony S. Vader, Cole C McDaniel (2005),"Influence of Dampers on Seismic Response of Cable Supported Bridge Towers", Department of Civil and Environmental Engineering, Washington State University, Pullman.(ASCE- Journal of bridge engineering)