Analysis of a Steel Bridge Connected with Tunnel Considering Live Project Data Using SAP2000 A Review

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ABSTRACT

Majority of the truss bridges in India and abroad are either structurally deficient and/or functionally obsolete. There is a desperate need to enhance the performance of these existing bridges by an appropriate technique which should be economical and with minimum disturbance to the traffic. The aim of the present analytical work is to know the effect of Pre-stressing on the member forces, deflections and total weight of steel of a statically. In this paper presenting review of literature related to analysis of steel bridge and tunnels.

Keywords : Bridges, Truss, Pre-stressing, Cable, Member forces, Deflections and SAP 2000.

I. INTRODUCTION

Bridge is a structure which permits the section of people on foot or vehicles worked over any hindrance or water body. There are several bridge designs that serve an appropriate purpose. Depending on the behavior of bridge.

There are various types of bridges

1. Timber bridge
2. Concrete bridge
3. Steel bridge
4. Composite bridge

Bridge has mainly two sections the superstructure and the substructure. The superstructure has deck slab, I-Girder and shear connectors though substructure has of the footer, stem and the cap. Composite construction consists of two unique materials which are strongly bound to form a solitary unit.

"Composite" implies that the concrete portion of the deck is associated with the steel portion of the bridge by shear connectors. Shear connectors are fundamentally fixed on steel beams and then they are embodied in the concrete slab. Shear connectors can be associated by welding, or utilizing nut and bolts.A steel beam which is assembled composite by utilizing the shear connectors and concrete which is more strong and stiff as compared to beam.

II. LITERATURE REVIEW

Historically, the principle of „prestressing' was employed long before the word was coined, and this principle is used today subconsciously in some everyday objects. The Romans countered the problem of arches tending to overthrow piers, by putting a large weight on to the pier in order to counteract the tensile stresses due to the arch thrust. This principle was even exploited architecturally, and gave rise to the typical Roman decoration of statues on piers. Materials such as cast iron, which are strong in compression but weak in tension, require compressive prestressing to make them more effective. In the 15th century, Leonardo Da Vinci suggested that cast-iron cannons would burst less frequently when fired if the barrels were tightly wound with iron wire; centuries later, the idea was adopted in wire-wound guns. This section presents summarized reports from research papers of numerous authors.

Nitin Indulkar et.al (2022) research paper investigate the factors that causes the seismic forces in the system. A simplified analysis methodology is put forward based on IRC SP 114; 2018. It is applicable for seismic design of bridges with a design service life of 100 years, considering Design Basis Earthquake (DBE). It has covered the seismic map and spectral acceleration graphs as specified in IS: 1893-Part-I- 2016. It also adopts the method prescribed for evaluation of liquefaction possibility, as specified in IS: 1893-Part-I-2016. For the evaluation of seismic forces, Elastic Seismic Acceleration method, Elastic Response Spectrum method and Linear Time History method are specified. The IRC Guidelines describe the various types of special investigations to be carried out for bridges to be constructed in near field zones, skew, and curved bridges and so on. For loads and load combinations, IRC 6-2017 provides the guidelines and specifications. The objective of this code is to provide common procedure for design of bridges. It deals with the various loads such as vehicular loads, braking forces, wind load, water current forces and their combinations. Results stated that the maximum resultant force in zone III increased by 112% in Zone V and the maximum and minimum resultant moment in zone III was increased by 123.6% and 128.8% respectively in Zone V.

Pratik Soni et.al (2022) research paper investigated three types of sections (i.e. Warren truss, Pratt truss and Howe truss). Two span lengths was analyzed, 40 m and 80 m, with a height of 7 m and a width of 6 m, and was simply supported at the ends. The suitable locomotive loading for broad gauge (1.676 metre wide) railway track was considered as per IRS Bridge regulation while the railway bridge was examined. These bridges were analysed for comparing node displacement, beam forces, and response at the supports due to movement load of locomotives with seismic zone 5 being considered. STAAD.Pro V8i was used to conduct the analysis on parameters of node displacements, beam end forces, and support responses were used to interpret the results.

Results stated that for a 40-meter-long truss bridge, the Warren truss exhibits less node displacement and support response than the Pratt and Howe trusses. Overall, one can claim that the Warren truss is the finest piece of truss for a 40- meter span truss bridge. The Pratt truss or Howe truss may be utilised as the superstructure for an 80 metre span bridge with no alteration in member cross-section, while the Warren truss behaves the worst of the three types of truss for the same.

A Jayaraman et.al (2021) research paper aimed to resist the seismic force/ vibration force in railway steel truss bridges using splice connection. Using the Warren type of railway truss bridges Analysis and designed by Indian standard railway code (IRC) and IS 800 -2007. The connection of the railway truss bridge is bolted with splice connection. Same cross sectional area has been carried for both theoretical and experimental investigation.

Results stated that the splice connection has high load carrying capacity, low deflection and high level seismic resistance. The members designed with splices show greater reduction in the structural weight. Experimental evaluation shows increase in the load carrying capacity and decrease in the deflection while using members with splices by 24% Splice connection best seismic performance compared to the other type of connection.

Baokui Chen et.al (2021) research paper evaluated the effects of seawater and site conditions on the seismic response of the isolated continuous girder bridge are evaluated in this study. The seawater-muddy soil-isolated bridge coupling model is built in the dynamic analysis software ADINA, and the external seismic wave input is realized by the seismic wave motion analysis program. The influences of seawater and muddy soil on the seismic response of isolated continuous girder bridges are determined by comparing different offshore site models.

The results indicated that the seawater and the muddy soil magnify the displacement of the seabed. The existence of seawater increases the longitudinal relative displacement of piers by 20%–40% but has limited influence on the bending moment and shear force of piers. The muddy soil can increase the longitudinal relative displacement and internal force of the piers remarkably. Moreover, the displacement of bridge bearings increases significantly under the combined influence of muddy soil and seawater. In the seawater muddy soil-isolated bridge coupling model, the seawater and site condition can influence the seismic performance of sea-crossing bridges obviously.

Daihai Chen et.al (2020) in the research paper, finite element analysis of a 122-meter concrete-filled steel tube arched chord truss bridge was performed using ANSYS to obtain the natural vibration characteristics of the bridge, both before and after reinforcement. In addition, the response spectrum and dynamic time history methods were used to analyze and compare its seismic performance.

The results show that the transverse stiffness of the bridge's main truss was relatively low. After the reinforcement, the vertical and the torsional frequencies of the bridge significantly increased by 24% and 32%, respectively. under the same condition, the axial force at the fixed end of the top chord of the strengthened bridge was reduced by roughly 29%, and the transverse and the vertical displacement at the middle of the top chord span were reduced by roughly 10% and 20%, respectively. Thus, the reinforcement measures significantly improved the vertical stiffness of the bridge.

Kuihua Mei et.al (2020) The Chengdong Hanjiang Bridge in Ankang City is a multi-span continuous beam-arch combination system bridge of (75+2×125+160+2×125+75) m, and its site is located in the earthquake zone. A calculation model based on Midas / Civil finite element software process analysis method is applied to seismic response analysis using power. At the same time, in order to influence the travelling wave effect and the seismic isolation system on the internal force of the bridge structure, corresponding finite element models were established and calculated with time history analysis. The finite element model under non-uniform excitation uses the "Large Mass Method" (LMM) for analysis and calculation under different wave velocity multi-point excitations.

The results show that after considering the traveling wave effect, the displacement and bending moment of the control section of each hole increase, and the internal force of the fixed pier increases. When the wave velocity is 600m/s, the traveling wave effect strengthens the seismic response of the structure the most. With the increase of the wave velocity, the seismic response of the structure gradually approaches the seismic response under uniform excitation. After the friction pendulum seismic isolation support is used, it is fixed. The bending moment of Pier No.32 has been reduced by 80%, the stiffness of the whole bridge is more balanced, the forces of each pier are relatively close, and the isolation effect is good.

Mohd Waseem and Mohammad Saleem (2019) objective of the research paper to evaluate and examine multi-span seismic output with up to five spans of 100 meter long Girder Bridge frame designed and analyzed using CSiBridge v 21.1.0. Box Girder Bridge's seismic performance is very complex and the performance is based on the intensity of peak ground motion and ground motion acceleration. The three dimension model and the data of Bhuj earthquake used for dynamic characteristics and showing the maximum response of box girder deck.

Results stated that the value of the acceleration, displacement, velocity, and base shear with respect to time in the x-direction is higher than the acceleration, displacement, velocity and base shear with respect to time in both directions, while the base moment with respect to time in the y-direction is higher than the remaining two directions. The base shear has played a significant role in the bridge deck's seismic response which provides resistance to lateral load.

Purevdorj Sosorburam and Eiki Yamaguchi (2019) research paper presented a parametric study on the seismic behaviour of the truss bridge with BRD was conducted by changing the length, the cross-sectional area, the location and the inclination of BRD. The safety of the existing truss bridge under a large earthquake was assessed by nonlinear finite element analyses.

The performance-based verification proves that the BRD is applicable for the existing truss bridge to sustain its resistance against large earthquakes. Results indicated that the axial compressive and tensile stresses of damaged members could be reduced by BRDs with different design parameters that are shown to be effective.

Heena Dewangan and Kaushik Majumdar (2018) the research paper presented the vibration analysis of steel truss bridges under moving loads by using STAAD Pro Software. The proposed bridge is pratt, warren, howe and K type where the bridge length was 250ft. The considered loadings on the bridge were dead loads, live loads, wind loads, seismic effects and temperature effects. Design calculations of structural steel members were considered according to the design criteria of AISC-ASD Specifications.

Results stated that maximum deflection was observed in Pratt bridge whereas least in howe, which indicates that in terms of deflection howe was more stable than pratt. In terms of unbalance, forces warren type truss bridge was more stable showing less shear forces, whereas the maximum was observed in pratt truss. The bending moment was more in pratt than warren type bridge.

Mehmet F. Yılmaz and Barlas Ö. Çaglayan (2018) research paper presented a seismic assessment of multi-span steel railway bridges in the Turkish railway system. The main concept was to determine bridge seismic behavior and safety under seismic conditions. Bridge PSDMs were obtained for the example the Alasehir bridge from 60 nonlinear time history analyses, and bridge component demands were used to derive component and overall bridge fragility curves.

Component and system fragility curves were derived considering individual element buckling and fracture capacities. Truss piers elements were identified as the most vulnerable bridge components, whereas superstructure elements were the safest. Since truss piers significantly affect fragility, the system upper and lower fragility bounds were very narrow, and the overall bridge fragility curve was close to the lower bound, showing good correlation between component demands. Component fragility curve gave information about the individual performance of bridge component. Retrofitting strategy could be illustrated considering the most fragile component. Truss piers elements were critical components in the bridge and strongly affected the system fragility curve. System fragility curve derived using Monte Carlo simulation was between upper and lower bound.

Jayakrishnan. T J and Lekshmi Priya. R (2017) research paper presenetd seismic behavior analysis of composite bridge without cross girders using ANSYS. From the Modal Analysis, it was found that 3 Girder bridges suffer less deformation than 5 Girder Bridges. On Response Spectrum Analysis, the deformation value of 3 Girder Bridge is slightly higher than 5 girder bridge is seen. The equivalent stresses formed in both the bridges are observed to be within the permissible limit.

Mohamed Ghannam et.al (2017) research paper presented the effect of post-tensioned cables in strengthening double-span steel trusses considering different truss's systems namely (Warren and N truss system). Different techniques using post-tensioned cables were used in strengthening different truss systems. The main difference between these techniques was the profile and the locations of the post tensioned cables. Comparisons between these techniques was made in order to determine the suitable post tensioning technique for each truss system. The analysis and results were obtained by using ANSYS program.

Results concluded that post-tensioning was an effective method in strengthening different types of steel trusses. Strengthening trusses using post-tensioned cables can reduce the internal force in both tension and compression members. However, the reductions of the internal tension forces was more significant than the compression forces.

Vipin A. Saluja and S. R. Satone (2016) research paper presented seismic analysis of foot over bridge for different soil conditions highlights the effect of different soil conditions in different earthquake zones with Response Spectrum analysis using Staad-Pro.

Conclusion stated that lateral displacement of the building reduced as the percentage of irregularity increased. As the percentage of vertical irregularity increases, the story drift reduces and goes on within the permissible limit as clause no. 7.11.1 of IS 1893-2002 (Part I). It was found that mass irregular building frames experience larger base shear than similar regular building frames.

Ebrahim Amirihormozakia et.al (2015) research paper proposed an efficient and accurate simplified modelling approach for primarily horizontally curved steel girder bridges.The accuracy and validity of the proposed models were verified against 3D FE counterparts. The analysis time that is required for nonlinear response history analyses was reduced by 80%, making the modelling approach especially appropriate for studies that require substantial number of analyses such as fragility curve development.

The proposed modelling approach was used to model the experimentally recorded response of a 2/5 scale model of a curved bridge which involved one of five highly nonlinear configurations. The preliminary comparison of experimental vs. analytical response verifies the efficiency and accuracy of the proposed approach.

E. Bhargavi and G.V.Rama Rao (2015) research paper aimed to present analytical work to understand the effect of Pre-stressing on the member forces, deflections and total weight of steel of a statically determinate three types of trusses such as Pratt type (Type A), Warren truss (Type B), Lattice Truss (Type C).Pre-stressing technique has been adopted to upgrade the performance of the truss. The truss is pre-stressed with high tensile steel cable and the profile of the cable is straight. The truss was analysed for member forces and deflections using STAAD PRO Software.

Results stated that there was a noticeable improvement in the performance of the structure. Member forces have been reduced significantly in the entire truss members and there is a reduction in deflection at the centre and material requirement after pre-stressing.

E. Tapia-Hernández et.al (2014) research paper presented seismic analysis of a 24 m (80 feet) simple span steel bridge capable of carrying two traffic lane. The bridge was designed through the free interactive design software developed by the Short Span Design Standards (SMDI), which adopts the current AASHTO LRFD Specifications (2010). The superstructure comprises built-up girders with ASTM A507-50W steel in composite action with a normal-weight reinforced concrete slab. The structure was supposed located in Mexico, and so the vehicular conditions (i.e., loads and lengths) were adapted to the local requirements. Nonlinear dynamic analyses were carried out in OpenSees in order to study the inelastic response under the most unfavorable local seismic records (artificial and historical) in at least one of its components (e.g. longitudinal, transversal and/or vertical).

Results recommend the development of a second research phase, which is the seismic analysis of a 40 meters (140 feet) simple span steel bridge, the maximum bridge span that can be designed with the eSpan140 tool. It is expected that a longer span bridge have a larger fundamental period, which will be more exciting under a new set of artificial and recent historical records. So, these results could confirm that the seismic demands do not have a significant influence on the design of short span steel bridges in Mexico.

Li Yuanming and Zhou Zhixiang (2014) research paper investigated the seismic performance of a steel truss-concrete Combination continuous rigid frame bridge. A dynamic spatial finite element model of Qingqiyong Bridge, which is a long span bridge, was created using MIDAS. Its natural frequency and vibration mode can be calculated,the seismic performance and structure stiffness were presented and analyzed on the basis of calculated results. Design response spectrum and time-history method was used to calculate the bridge seismic performance.

Results stated that natural frequency of the bridge was small, its period was long, and this kind of bridge was a new kind of earthquake resistant and energy-saving structure. Seismic effect has some effect on the bridge, especially the bending moment along the bridge. The natural frequencies of Qingqiyong bridge are mainly concentrated in the scope that arranges from 0.H7z～5Hz. In the first 10 order vibrations, when subjects to load, first few order vibrations may be stimulated simultaneously, therefore, when mode superposition method is adopted to calculate the bridge dynamic response, multiple vibration modes should be considered simultaneously.

Jiandong Zhang et.al (2014) research paper proposed a simplified seismic evaluation method for the thin-walled stiffened box steel pier to predict its strength and ductility. In this method, two modified bilinear material models for the fiber-beam element were suggested to include the local buckling of the base stiffened plate. An experiment validated a shell element based model, which was selected for comparison with the proposed fiber-beam based model. Twelve numerical cases were then simulated by the shell element based model and the fiber-beam element based model, respectively, and their accuracies were compared with each other.

Numerical results showed that the proposed pushover method, employing the amended bilinear kinematic material model for the fiber beam element, is of good accuracy. If the maximum strength is taken as the ultimate point, the bilinear material model, replacing the yield point by the buckling stress, is recommended. If 95 percent of the maximum strength after the peak is regarded as the ultimate point, the elastic-perfectly plastic material model was suggested.

Mohamed Abdel-Basset Abdo (2010) research paper was concerned with parametric study of the effect of rectangular web openings on the response of steel bridges with cross frames and bottom lateral bracings. The research included analyzing the deflections of steel bridges as an important factor of static response and the frequencies of steel bridges as an important factor of dynamic response.

Results stated that the ratio of each reinforcement area to flange area should not less than 0.15 and it is preferable to be 0.3; with anchorage length = 15 cm beyond the edges of the opening. Results further stated that existence of more than one square or rectangular web opening leads to great increase in the deflection at mid span and considerable decrease in frequencies. An increase in the ratio of web opening height to web height leads to great increase in the maximum deflection of the bridge model.

III. CONCLUSION

Here Authors examined various bridges and methods of analysing bridges considering different vehicular loading condition. Authors also concluded that utilizing analysis tool for designing bridges is more precise and accurate as compared to general methods.

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