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Study on Interfacial Shear Properties of Concrete Reinforced Stone Arch Bridges Using Staad.pro A Review

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ABSTRACT

Bridges are the structural components that are required for the efficient movement of Trains and locomotives and under earth embankment for crossing of water course like streams across the embankment as road embankment cannot be allowed to obstruct the natural water way. Bridges can be of different shapes such as arch, slab and box. These can be constructed with different material such as masonry (brick, stone etc.) or reinforced cement concrete. Since bridge pass through the earthen embankment, these are subjected to same traffic loads as the road carries and therefore, required to be designed for such loads. The cushion depends on rail profile at the bridge location. For analysis relevant IRCs are required to be referred. The structural elements are required to be designed to withstand maximum bending moment and shear force. In this study we are reviewing latest researches and publications on analysis of bridge structures, stone bridges and vehicular loading conditions.

Keywords : Analysis, Bridge, Staad.Pro, IRC, Structure, Forces, Displacement, Stone Masonry.

I. INTRODUCTION

Bridges are an important component of all type of modem transport system. In the half of the past decade technical knowledge of earthquake engineering increased considerably. Performances of bridges have vital importance before and after an earthquake event. Hence it must remain functional even after dissipation of seismic event to endure relief as well as security purpose. Substructure of the bridge is more susceptible to damage and its performance must be good during ground motion because substructure connect superstructure to the foundation. Hence failure of substructure leads to collapse of entire bridge which may turn m to disaster. There are many design codes and guidelines available worldwide for the seismic design of bridges. These guidelines are helpful for improving the seismic capacity of the bridges. Despite of many advances made in design of earthquake Resistance Bridge some gaps still remain in many areas due to unpredictable nature of ground motion. For the analysis of bridges under seismic excitation simplified method (response spectrum method) or time history analysis and pushover analysis are used

The main focus of this study is to review the design criteria and effect of variation in various parameters to improve the performance of arch bridge against traditional bridge with seismic excitation and review the various theories, experimental investigations and numerical findings in the analysis and design of retaining wall so as to give a quick overview to the researchers. To provide a detailed review of the literature related to Bridge analysis in its entirety would be difficult to address here. Although there has been a lot of work modeled on bridges and culverts - none provide in-depth understanding of the RC bridges contributions related to I.R.C. loading and hydraulic calculation is seen in past efforts most closely related to the needs of the present work. A brief review on finite element analysis, comparison of different bridges and code provision of previous studies is presented here. This literature review focuses on Analysis method, bridges and tools for analysis and some code provisions will be addressed by area.

II. LITERATURE SURVEY

Yutao Pang and Li Wu (2018) the research paper investigated the effect of aftershocks on seismic responses of multispan reinforced concrete (RC) bridges using the fragility based numerical approach. For that purpose, a continuous girder RC bridge class containing 8 bridges was selected based on the statistical analysis of the existing RC bridges in China. 75 recorded mainshock-aftershock seismic sequences from 10 well-known earthquakes were selected for the investigation. In order to account for the uncertainty of modeling parameters, uniform design method was applied as the sampling method for generating the samples for fragility analysis. Fragility curves were then developed using nonlinear time-history analysis in terms of the peak curvature of pier column and displacement of bearings. Finally, the system fragility curves were derived by implementing Monte Carlo simulation on multi-normal distribution of two components.

Results stated that for the RC continuous bridges, the influence of aftershocks can be harmful to both bridge components and system, which increases both the component fragility of the displacement of bearings and seismic curvature of pier sections and system fragility. Additionally, it is better to evaluate the vulnerability of bridge system, rather than only assess the effect of aftershock based on a single component.

Luca Pelà et.al (2009) the research paper presented practical methodology in order to evaluate the seismic safety level of existing masonry arch bridges. Two particular cases were considered namely a stone masonry bridge with brick-made vaults and a stone masonry bridge with concrete-made vaults. The structural analysis was carried out by making use of a simplified inelastic procedure: the structural capacity, obtained by a nonlinear static (pushover) analysis, was directly compared with the demand of the earthquake ground motion described by an inelastic response spectrum, in order to estimate the seismic performance of the bridges.

The methodology defined in the present work seems to be suitable for a careful seismic assessment of existing bridges without resorting to specialised packages. In particular, the seismic safety of the S. Marcello Pistoiese Bridge and the Cutigliano Bridge was demonstrated by ascertaining that their displacement capacities are higher than the seismic demands of the sites in which they are located, for the whole range of the masonry material properties that bound the actual ones.

Rahul Gangwar et.al (2020) This paper gives the comparative study of R.C.C.(Reinforced Cement Concrete) Girder and P.S.C.(Prestressed Concrete) Girder, which include the design and estimates of R.C.C. and P.S.C. Girder of various spans. The aim of this work is to study R.C.C .girder as well as P.S.C.

girder and then compare the results. The idea is to succeed in a superior conclusion regarding the prevalence of the 2 techniques over each other. R.C.C members are commonly used for residential as well as commercial structures and are generally short span. In R.C.C. depth of girder increases with the increase in span due to deflection limitation. To surmise, R.C.C girder shall be suitable for small to medium span however the prevalence of prestressed concrete girder is undeniable for extended spans.

The conclusion derived from the results stated that Reinforced concrete beams are generally heavy. They always need shear reinforcements besides the longitudinal reinforcement for flexure. Prestressed concrete beams are lighter. By providing the curved tendons and the pre-compression, a considerable part of the shear is resisted. In reinforced concrete beams, high strength concrete is not needed. But in prestressed concrete beams, high strength concrete and high strength steel are necessary. Reinforced concrete beams being massive and heavy are more suitable in situations where the weight is more desired than strength. Prestressed concrete beams are very suitable for heavy loads and longer spans. They are slender and artistic treatments can be easily provided. Cracks do not occur under working loads. Even if a minute crack occurs when overloaded, such crack gets closed when the overload is removed. The deflections of the prestressed concrete beams are small. Prestressed concrete sections are thinner and lighter than RCC sections, since high strength concrete and steel are used prestressed concrete.

Melika Naderi and Mehdi Zekavati (2018) the aim of research was to investigate the seismic behavior of the bridge. Nonlinear dynamic analysis was used for simulation of seismic behavior of the bridge. Regarding the complexity in mechanical features and geometry of the bridge, precise evaluation of seismic behavior is a difficult task. Therefore, experimental analysis was used to increase the modeling precision. Bridge numerical modeling was used by combination of FEM and DEM. This combinational method is a powerful tool for crack and failure simulation. Friction was also used to increase the precision of analysis for accurate simulation of Osmanli Bridge seismic behavior, combination of FEM and DEM was used. After 5.7 s from the earthquake the creation of cracks started in both lateral walls. At the end of the earthquake, cracks were created in the arch which is about 1 cm. due to the applied acceleration. The blocks would be thrown away. Discrete simulation was used for simulation of Senyuva Bridge. A part of right lateral wall was destroyed during the earthquake. The left lateral wall also damaged but was not destroyed. The blocks of the right wall were thrown along z direction. The growth of arch cracks increased during the earthquake and the maximum crack had the side of 4.5 cm.

According to the results of numerical studies, combination of FEM and DEM is an efficient technique. Seismic capacity of both bridges was determined based on the results of numerical studies. It is recommended to reinforce both bridges against the earthquakes.

Wei-Xin Ren et.al (2010) the research paper presented a beam-arch segment assembly procedure for the dynamic modelling and analysis of arch bridges. It is demonstrated that the proposed beam-arch segment assembly procedure is efficient with the advantages of less element numbers and enough accuracy. It is expected that this methodology can be an effective approach for the further dynamic response analysis of arch bridges under all kinds of dynamic loads such as earthquakes, winds and vehicles.

Both natural frequencies and mode shapes of the Jian bridge calculated from the proposed beam-arch segment assembly procedure agree well with those obtained from the commercial finite element analysis package ANASYS and field dynamic testing under operational vibration conditions. It is demonstrated that the proposed beamarch segment assembly procedure is suitable and reliable for the dynamic analysis of arch bridges with the advantages of less element numbers and enough accuracy. It is expected that this methodology can be an effective approach for the further dynamic response analysis of arch bridges under all kinds of dynamic loads such as earthquakes, winds and vehicles.

Hayder Ala'a Hasan et.al (2012) the primary objective of the research was to investigate the damage in the typical reinforced concrete bridge pier under seismic loads of intensity same as that happened in the area around Iraq and see whether it will support such an earthquake or not. The whole bridge substructure and the surrounding soil were modeled using ANSYS. The case under study was modeled using the SOLID65 concrete element, which is used for modeling three dimensional solid models with or without rebars. The soil model is 18m long, 9m width and 17m depth. The distances between center to center of piles are equal to 4.5m. Since the diameter of piles is 1.5m, therefore distances between the centers of piles and the edges of soil volume is 4.5m which is equal to three times the diameter of piles.

The results stated that the deflections are small and within allowable limits, but the stresses in the concrete were higher than the limits of the structural concrete design limits of the general codes of practice, keeping in mind the earthquake load applied was not severe compared to earthquake happened near Iraq area. It is highly recommended to force bridge designers in Iraq to use and depend on the special provisions for earthquakes in codes to cover such deficiencies in pier design.

L. Di Sarno et.al (2012) the research project aims at studying the seismic behaviour of existing R.C. bridges together with the analysis of the effectiveness of isolation systems. The research program focuses on the assessment of an old R.C. viaduct with frame piers through PsD test. The experimental program will be performed at the European Laboratory for the Assessment of Structures of Joint Research Center at Ispra (Italy). In particular, two of the twelve piers will be built in scale 1:2.5 whereas the remaining part of the viaduct will be numerically simulated.

A refined numerical model has been used for preliminary simulation of the seismic response of the entire viaduct; the model has been calibrated using literature results and experimental data coming from a test campaign carried out at the University Roma Tre on R.C. frame piers. This allowed to select a couple of piers to be physically tested during the experimentation. All the key aspects of the problem have been here addressed: the most suitable test rig configuration, the integration scheme to be adopted during the PsD test, the selection of input, the numerical model for both isolated and non-isolated case.

Lina Ding et.al (2012) in the research paper, the nonlinear finite element analysis, incorporating the model updating technique was used to predict the behaviour of a 30-year-old slab-girder bridge. The original finite element model based on the design drawings is updated by modifying the stiffness parameters of the girders, slab, shear connectors and bearings so that the vibration properties of the model match the field vibration measurement data. The updated model represents the present condition of the bridge better than the original model that is based on the design blueprints. The load carrying capacity of the bridge was calculated using the original and updated finite element models, respectively, with consideration of nonlinear material properties. The influence of the shear connectors on the load carrying capacity is specially investigated.

The analysis carried out on the original model shows that the load carrying capacity of the bridge is 1.67 times the ultimate load specified in the design code and 20% higher than the capacity calculated according to the empirical formula. This indicates that the empirical formula underestimates the load carrying capacity of bridges. The finite element model is then updated based on the field vibration tests. The nonlinear analysis on the updated model indicates that the bridge ultimate load carrying capacity is about 1.49 times the nominal load, implying the bridge is still safe under the present traffic condition, whereas 12% less than that estimated from the design model. This exercise demonstrates that the updated model can represent the actual condition of the bridge better and the load carrying capacity based on the updated model can provide a more realistic condition of the bridge.

S.Basilahamed and A.R.R.Kalaiyarrasi (2018) the research paper analyzed a single span two lane t-beam bridge by varying the span of 25m, 30m, 35m and 40m where the width was kept constant. The bridge models are subjected to the IRC class AA and IRC class 70Rtracked loading system in order to obtain maximum bending moment and shear force. The problem in continuum mechanics was approximated by FEM (finite element method) in STAAD Pro, which is general method of structural analysis.

From the analysis it is observed that with the increase in the span, Courbon's method and finite element method have no significant variation. Courbon's method gives the average result with respect BM values in the longitudinal girder as compared to Guyon Massonet method. The results were analyzed and it was found that the results obtained from the finite element model are lesser than the results obtained from one dimensional analysis, which means that the results obtained from I.R.C. loadings are conservative and FEM gives economical design.

Xiaoke Li et.al (2012) the research paper introduced main dimensions and drawings and further discussed the static analytical results of the bridge. The numerical model was built by the integrated solution system for bridge and civil engineering- MIDAS/Civil. The piles, pile caps, piers, bent caps, deck slabs and connections between two contiguous reinforced concrete hollow slabs were all simulated. The forces and displacements of arch under the given loads and load combinations can be calculated close to the actual values.

The distributions of bending moment, axial force, shear force and vertical displacement along the arch axis prove that sedimentation displacement of arch toe and arch temperature are the key factors and need to be considered seriously during design process.

Ravikant and Jagdish Chand (2019) in the research of bridge girder design, three same models were prepared in the STAAD pro and then there loadings are changed according to IRC codes, Euro codes and AASHTO specifications respectively. The span of the bridge is taken as 25m in which girders are constructed. The size of longitudinal girders is taken as2000x500 mm and cross girders is 1500x250 mm. There are three longitudinal girders are considered having spacing 2600 mm c/c and cross girders are considered as 5000mm c/c. The design of girders is carried out using the software STAAD Pro. The comparative parameters of the study were the shear force, bending moment and area of steel in the design of bridge girders i.e. longitudinal girders and cross girders due to the application of different loading according to IRC codes, Euro codes and AASHTO specification.

The conclusion derived from the results stated that In comparison of all three codes, Euro code designs are over reinforced as compare to the other two i.e. IRC codes and AASHTO specifications. In design of bridge girders with Euro codes shear forces, bending moment and deflection are almost double as compare to the other two i.e. IRC codes and AASHTO specifications. Design of bridge girders (up to 25m) using IRC codes are most economical and safer as compare to the other two i.e. AASHTO specifications and Euro codes. IRC codes have the best combination of loading and design methods as compare to the other two i.e. AASHTO specifications and Euro codes. Since the design of bridge girder using IRC codes acquire minimum value of deflection and bending moment so therefore IRC Class A loading is the most economical and optimum loading for the design of bridge girder in INDIA.

Alessandro Rasulo et.al (2020) the research paper presented a finite element model for assessing the nonlinear behavior of RC bridge piers under combined axial, shear, and bending moment. The model explicitly takes into account the response caused by the shear capacity deterioration due to the interaction with flexural deformation.

This important effect has been introduced through the incorporation of a zero-length shear spring in series with a flexural column element and a rotational slip spring. A phenomenological curve for the shear response has been proposed and calibrated, realistically capturing the monotonic and cyclic response of columns, including the pinching, the stiffness softening, and the strength deterioration due to deformations and cyclic load reversals. A good agreement between the numerical prediction and experimental data was observed.

S.Basilahamed and A.R.R.Kalaiyarrasi (2018) the research paper analyzed a single span two lane t-beam bridge by varying the span of 25m, 30m, 35m and 40m where the width is kept constant. The bridge models are subjected to the IRC class AA and IRC class 70Rtracked loading system in order to obtain maximum bending moment and shear force. The analysis was carried out using IRC codal provisions. T-beam bridge decks are one of the major types of cast in situ concrete decks which consist of a concrete slab integral with girders. The problem in continuum mechanics is approximated by FEM (finite element method) in STAAD Pro, which is general method of structural analysis.

The results were analyzed and it was found that the results obtained from the finite element model are lesser than the results obtained from one dimensional analysis, which means that the results obtained from I.R.C. loadings are conservative and FEM gives economical design.

B. Ozden Caglayan et.al (2012) the research paper presented assessment of a monumental concrete arch bridge with a total length of 210 meters having three major spans of 30 meters and a height of 65 meters, which is located in an earthquake-prone region in southern part of the turkey. Three-dimensional finite element model of the bridge was generated using a commercially available general finite element analysis software and based on the outcomes of a series of in-depth acceleration measurements that were conducted on-site, the model was refined. By using the structural parameters obtained from the dynamic and the static tests, calibrated model of the bridge structure was obtained and this model was used for necessary calculations regarding structural assessment and evaluation.

The outcomes of the load rating procedure show that the bridge has the capability to withstand proposed train loads with considerable safety. However, due to historical heritage status of this massive structure, maximum care must be taken in operation as well as maintenance of this bridge.

J. Kiyono et.al (2012) dynamic behaviors of several stone arched bridges are simulated using the 3-dimentional DEM in the research. Firstly, by inputting a impulse wave to the models as an input ground motion, their first natural frequencies in three directions are computed, and their vibration characteristics was investigated. Secondly, seismic behaviors are computed and the failure occurrence mechanism is investigated. Effects of the material properties of the backfill and the span length on seismic behaviors and failure patterns are also investigated and finally, effectiveness of reinforcement by inserting mortar between stones was verified.

All models except the single arched ring model avoided collapsing, and it is found that the analyzed stone arched bridges with backfill have the seismic resistance. However, as the number of spans increases or if the boundary condition is free in the side, or if soils are packed inside the bridges, there is a possibility that some stones fall down because the out-of-plane deformation increases. Therefore, to assess the seismic performance, appropriate modeling of the boundary conditions in the sides and the material properties in the backfill is found to be important. Seismic behaviors of reinforced models by inserting mortar between stones are also computed and the effectiveness was confirmed.

S. De Santis and G.de Felice (2012) A modelling approach based on fibre beam elements was used to represent masonry arches under seismic loads. Non-linear dynamic simulations under a set of natural accelerograms are performed on circular arches and compared to push-over analyses revealing that a good agreement is found provided that a load distribution is used that includes both horizontal and vertical loads proportional to the product of masses and first mode displacements, to account for the presence of non-null displacement components in both vertical and horizontal directions in the modal shape. Thus, this appears to be an adequate representation of the inertial forces arising in the actual response of a masonry arch under earthquake motion to be used within push-over based seismic assessment procedures.

Push-over analyses on arches built on pillars show that the seismic capacity decreases with the pier slenderness, except when the pier is so stiff that the collapse mechanisms does not even involve it. The effect of both classical and innovative strengthening techniques, such as steel tie-bars and externally bonded composite material strips applied on the arch extrados, is evaluated. The former prevents the relative movement of the arch springers, while the latter does not allow the crack opening on the arch extrados. As a result, the weakest failure modes are constrained and a significant capacity improvement was achieved.

III. CONCLUSION

The literature review has suggested that use of a finite element modeling of the Arch Bridges with various material. So it has been decided to use STAAD.Pro for the Finite Element Modeling. With the help of this software study of bridge structure has been done considering Vehicular loading. STAAD.Pro also helps in Finite Element Modeling in view of that different type of forces can apply to get the actual results. In this literature review it is revealed that live project work to implement the same at site and to develop a relation between software and practical work implementation.

IV. REFERENCES

[1]. Yutao Pang and Li Wu, [Seismic Fragility Analysis of Multispan Reinforced Concrete Bridges Using Mainshock-Aftershock Sequences], Hindawi Mathematical Problems in Engineering, Volume 2018, Article ID 1537301, 12 pages.

[2]. Luca Pela, Alessandra Aprile and Andrea Benedetti, [Seismic assessment of masonry arch bridges], Engineering Structures 31 (2009) 1777_1788.

[3]. RAHUL GANGWAR, ANKUR PRATAP SINGH and T.N.PANDEY, [Comparative Study of RCC and PSC Girder], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 04 | Apr 2020.

[4]. Melika Naderi and Mehdi Zekavati, [Assessment of seismic behavior stone bridge using a finite element method and discrete element method], Earthquakes and Structures, Vol. 14, No. 4 (2018) 297-303.

[5]. Wei-Xin Ren, Cong-Cong Su and Wang-Ji Yan, [Dynamic Modeling and Analysis of Arch Bridges Using Beam-Arch Segment Assembly], CMES, vol.70, no.1, pp.67-92, 2010.

[6]. Hayder Ala'a Hasan, Ammar A. Abdul Rahman and Hani Aziz Ameen, [Finite element analysis of reinforced concrete bridge pier subjected to seismic loading], AMERICAN JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, 2012, 3(2): 94-98.

[7]. L. Di Sarno, G. Della Corte, R. De Risi, M. Erdik , C. Yenidogan, A. Marioni, M. Sartori, F. Taucer, P. Pegon and R. Ceravolo, [Seismic analysis and retrofitting of an existing R.C.highway bridge: investigation through pseudo-dynamic], 15 WCEE Lisboa 2012.

[8]. Lina Ding, Hong Hao, Yong Xia and Andrew J. Deeks, [Evaluation of Bridge Load Carrying Capacity Using Updated Finite Element Model and Nonlinear Analysis], Advances in Structural Engineering,Volume 15 No. 10 2012.

[9]. Ravikant and Jagdish Chand, [Design and Analysis of Bridge Girders using Different Codes], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 8 Issue 07, July-2019.

[10]. Alessandro Rasulo, Angelo Pelle, Davide Lavorato, Gabriele Fiorentino, Camillo Nuti and Bruno Briseghella, [Finite Element Analysis of Reinforced Concrete Bridge Piers Including a Flexure-Shear Interaction Model], Appl. Sci. 2020, 10, 2209; doi:10.3390/app10072209.

[11]. S.Basilahamed and A.R.R.Kalaiyarrasi, [COMPARATIVE ANALYSIS AND DESIGN OF T-BEAM BRIDGE DECK BY RATIONAL METHOD AND FINITE ELEMENT METHOD, Proceedings of National Conference on Sustainable Construction Materials, March 27-28, 2018.

[12]. B. Ozden Caglayan, Kadir Ozakgul and Ovunc Tezer, [Assessment of a concrete arch bridge using static and dynamic load tests], Structural Engineering and Mechanics, Vol. 41, No. 1 (2012) 83-94.

[13]. J. Kiyono, A. Furukawa and K. Toki, [Seismic Assessment of Stone Arched Bridges], 15 WCEE LISBOA 2012.

[14]. S. De Santis and G.de Felice, [Seismic Analysis of Masonry Arches], 15 WCEE LISBOA 2012.

[15]. Xiaoke Li, Lixin Liu, Shiming Liu and Shunbo Zhao, [Static Analysis of Reinforced Concrete Arch-deck Bridge with Archaized Connective Corridors], Applied Mechanics and Materials Vol. 238 (2012) pp 738-742.

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