Finite Element Analysis of Arch Bridge Truss Structure: A Review

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Abstract- *This study presented a literature review of the state of practice for the use of innovative prefabricated systems and elements in bridge construction, rehabilitation, and re placement. In addition, the experience gained in the rail road industry, as well as international experience on the use of prefabricated systems and methods to minimize traffic disruption, is summarized. New systems that are current under evaluation are also presented. The primary intention of this investigation is focused on alerting structural engineers to the possible distortions, associated to the steel and composite bridge's service life when subjected to vehicle's dynamic actions. In this paper effort has been made to design and optimize such bridge structure analysis. The basic emphasis has been given to minimize the total deformation of the structural member by optimizing the cross sections, material properties and weight. The crust of our review focuses on the analysis of truss bridge structure, complex or simple because truss is the most widely used in steel bridges used in railways and pedestrian crossings.*

Keywords- Bridge structure, Steel truss, design of bridge, Arch Bridge structure, FEM.

I. INTRODUCTION

Steel is broadly used around the world for the development of bridges of various sizes. It is a flexible and powerful material that offers green and sustainable answers. Steel has long been known as the financial option for a variety of bridges. It dominates the markets for long-span bridge structure, railway bridges, footbridges, and medium span dual carriageway bridges. It is now increasingly more the selection for shorter span dual carriageway systems as properly. Society receives in many ways from the profits brought with the aid of metal bridge answers. Landmark metal bridges embody right design, they're rapid to construct and have inspired the regeneration of many former commercial, dock and canal facet regions. The connected elements (usually directly) can be pressured from tension, compression, or now and again each in response to dynamic loads [4]. These trusses can be made from wooden, steel or can be composite shape. Steel has higher strength, ductility and durability than many different structural materials inclusive of concrete or wooden. However metallic should be painted to prevent rusting. Like other bridge sorts, there is each simple and continuous truss bridge. In a true arch, the dead load produces mainly axial stress, and most of the bending stress comes from live load acting over a part of the span. Live load over the entire span causes very little bending moment. True arches are generally two-hinged, three-hinged or hingeless. The two-hinged arch has pins at the end bearings, so that only horizontal and vertical components of force act on the abutment. The hingelessarch is fixed at the abutments so that moment, also, is transmitted to the abutment. The three-hinged arch has a hinge at the crown as well as the abutments, making it statically determinate and eliminating stresses from change of temperature and rib shortening.

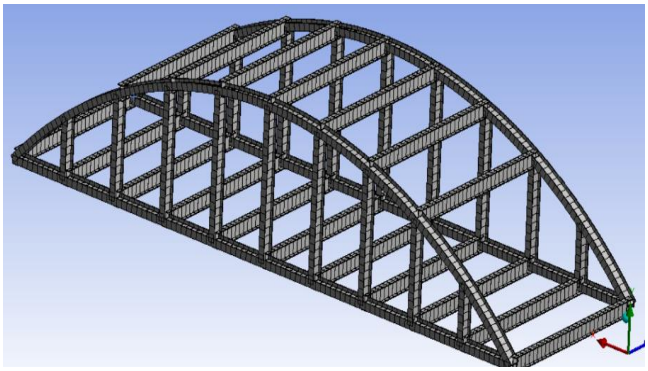

Figure 1: Arch Bridge Truss structure

II. TYPES OF TRUSS BRIDGE

According to the configuration of members a truss can be classified in to different types and in this paper the Bailey truss configuration type was selected. Classifications of truss type according to their member configuration are listed below [4].

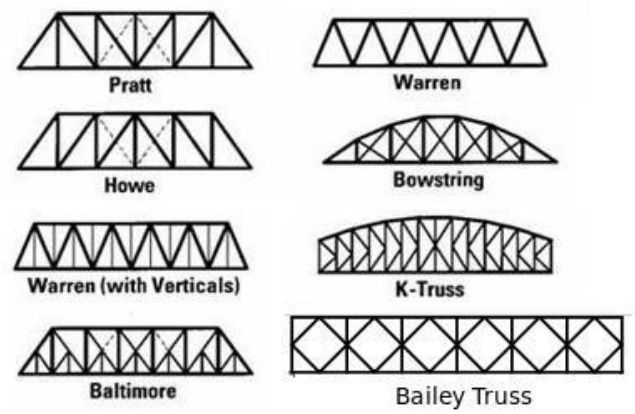

Figure 1:Example of Common truss configuration

III. FINITE ELEMENT METHOD

The FEM approach is a effective tool to achieve the numerical solution of extensive variety of engineering applications. The approach is general sufficient to handle any complicated form or geometry, for any substance under various boundary and loading circumstances. The generality of the finite element method suits the evaluation necessity of today's complicated engineering structures and designs wherein closed form answers of governing equilibrium equations are usually not obtainable. In addition, it is an efficient drawing tool through which designers can carry out parametric design studies through allowing for various design cases, (different shapes, substances, loads, etc.) and investigate them to select the optimal design.

IV. LITERATURE REVIEW

Doungporn et. al. (2019)analyzed the load deflection behaviour of the superstructure elements of beam bridges under two different beam–beam connection designs. They present a mathematical model for beam–bridge structural analysis and apply the finite element method to solve the problem. they investigate the effects of beam–beam connection design on the response and behaviour of the bridge system. they also present the effect of live-loads and dead-loads on structural deformation, stress, and internal strain energy. performed computer modelling of the beam bridge using ANSYS 19.2. The results indicated that the model with half-full beam–beam connection design leads to higher values of bridge deformation, (von Mises) stress, and total strain energy compared with the bridge model with half beam–beam connections.

Rahul Vyas et. al. (2019) The Purpose of this investigation is focused on alerting structural engineers to the possible distortions, associated to the steel and composite bridge service life, when subjected to vehicles dynamic actions. In this study, effort has been made to analyze two types of bridge structure i.e. Pratt truss & lattice truss with two different sections ('I' Section & 'C' Sections) by applying various loads at the nodes of the frame of two trusses. The basic emphasis has been given to check the total deformation and direct stresses between two types of bridge structure with 'I' Section and 'C' section. The modal analysis in Ansys is completed to attain the total deformation and mode shapes of bridge structure to stay away from the failure of the bridge. As per study, we found out that, the major variations in truss structures. Pratt truss have less deformation and stresses as comparison to lattice truss.

Ozmen et. al. (2018) In this study, it is aimed to investigated dynamic linear analysis of a masonry arch bridge. For this purpose, historical Musapalas masonry arch bridge is selected as a case study. As a result of the analysis, dynamic response of the bridge such as displacements and maximum-minimum principal stresses are obtained and seismic response of the bridge is examined. The bridge was modelled with ANSYS software using macro modelling approach. Maximum and minimum principal stress contours and time history graphs of the bridge were achieved. As a result of the linear dynamic analysis, it can be seen that the possible damages will initially start upper part of the spandrel walls.

Pipinato et. al. (2018) presented a study of a typical 1·1 km bridge in the north of Italy against a background of new infrastructure development. The bridge is composed of five network steel arches. The design solution represents a lightweight alternative if compared to traditional arch bridges. The deck is a steel–concrete composite section resting on precast slabs. Before the final structural design, parametric studies were developed in order to optimize the material grade, the structural shape and the structural detailing. The parametric studies illustrated and developed could be considered a time-consuming procedure, but as demonstrated, they are very useful in order to keep control of the weight design alternatives. The increased design time is certainly balanced by a more efficient and lighter solution.

Rohit Gakre et. al. (2018) studied about four different steel truss section are considered they are howe bridge, pratt bridge, warren bridge and k-type bridge sections are considered with 50 metre length supports at the end of the geometry. In this comparative study, it is concluded that K-type and Pratt type truss bridge shows comparatively more stiffness and stability to resist load whereas in cost comparison Howe type truss bridge is more economical; thus, it can be concluded from our study that in resisting load K and Pratt type are more effective and in terms of cost Howe type is more economical whereas K

type is second best economical type. Therefore, it can be justifying that K-type truss bridge will be overall more suitable than other cases.

Y Q Cai et. al. (2018) In order to inspect mechanical behaviour analysis of long-span steel truss arch bridge, the spatial finite element model was established to analyze the mechanical behaviour of the structure under static load and mobile load. Static load test of three span continuous steel truss arch bridge was carried out. The strains, deflection and the tension of the slings were measured. Comparison of testing data with the theoretical values obtained from finite element analysis was carried out. The results showed that the strength and stiffness of the bridge met the design requirements, and the static load test results were basically consistent with the theoretical analysis, which verified the mechanical characteristics of the bridge.

Ajmi Junoob et. al. (2017) presented the analytical dynamic analysis of a concrete-filled steel tubular (CFST) half-through arch bridge by ANSYS 16. Based on ANSYS for model analysis of bridges, the basic steps include: building up the FEM model, applying the load and solving the model, expanding the mode, observing the results and so on. A three-dimensional finite element (FE) model of CFST arch bridge and solid steel tubular arch bridge is developed and an analytical model analysis is carried out to obtain deformation.

Darius Bačinskas et. al. (2017) Experimental investigation of structural behaviour of glass fiber reinforced polymer (GFRP) space truss bridge model subjected to static loading is discussed in this study. Bridge prototype was assembled using GFRP profiles produced by Fiberline Composites Ltd, steel bolts and GFRP brackets. Flexural behaviour of the truss structure was monitored at every loading stage. In order to perform the comparison analysis of truss structural behaviour, numerical model was created employing finite element software Solidwork. Comparative analysis has shown good agreement between experimental and numerical results. The obtained results show, that designed and tested bridge model has a sufficient reserve of structural stiffness.

Jin Cheng et. al. (2017) real coded/ integer-coded method is used to realistically represent the values of the design variables. Three GA operators consisting of constraint aggregate selection procedure, arithmetic crossover, and non-uniform mutation are proposed. The finite element method (FEM) and the first order reliability method are used to compute the value of the probabilistic and deterministic constraint functions. The results reported herein are limited to the particular cases presented. This reduced problem required considerable computational effort, and it is recommended that future work in this area be directed toward reducing these costs. Such a reduction may also allow the inclusion of additional design options, such as shape optimization, multiple reliability constraints, instability constraint, as well as the potential for system reliability analysis.

Yong-sheng Song et. al. (2017) A structural safety evaluation is also conducted by comparison with the provisions recommended by design codes and by analysis of absolute stress. It is concluded that three types of members present different dynamic behaviours and that the value of the impact factor for chords B exceeds the provision recommended by the design codes. Chords C present the greatest ratio of bending stress versus axial stress. Based on the monitoring strain data and calibrated FE simulation, the impact factors of three typical types of members are calculated and obtained. In addition, the axial bending behaviours under the action of running trains are obtained for three typical types of members.

Wei He et. al. (2017) In this investigation the finite element software ANSYS is used to analyze the main arch hinge of the project, mainly analyses the stress state under the most unfavourable load condition. bearing steel truss arch bridge design, take the finite element software ANSYS on the main arch hinge is locally analysed, the arch at the junction of reliable performance test. Studies have shown that half through steel truss arch bridge should be adopted by reasonable cylindrical arch hinge, and Hertz theory is in the analysis of the arch hinge contact does not apply. From the finite element analysis results show that, under the most unfavorable combination of loads conditions.

Alika Koshi et. al. (2016) This study presented the behavioral aspects of through arch bridge with different arch positions and to compare them with the real structure by using 3D bridge model in Finite Element Analysis software – ANSYS. Maximum deformation is showed by the bridge having its arch positioned below the deck level and the maximum deformation is found at the center portion. The positioning of arch at deck level shows lesser deformation compared to the other cases. But as the arch is positioned be-low the deck level, the deformation exceeds thus making it unstable. Arch height has a great significance in the support forces and stresses.

Douglas Rammer et. al. (2016) This study focused on recent field work and analysis of four Burr Arch through-truss-type covered bridges located in Lancaster County, Pennsylvania. An overview of field evaluation methods, loading testing, and structural modelling procedures are included along with a comparison of field measurements and structural model prediction of bridge behaviour. The final step in the process is

performing a load rating for the subject bridges using the calibrated finite element (FE) model developed for that structure from live load testing results. The basic procedure for performing the load rating via the calibrated FE model. based on the findings and recommendations from the previous section, create a FE model of the structure. calculate the ratio of the member capacity to the member forces output from the FE model to determine the load rating factor. A load rating factor greater than or equal to 1 is desired.

Siddhartha Ray et. al. (2016) A stress ribbon bridge of 45-meter span is modelled and analyzed using Ansys version 12. For simplicity in importing civil materials and civil cross sections, Civil FEM version 12 add-on of Ansys was used. A 3D model of the whole structure was developed and analyzed and according to the analysis results, the design was performed manually. The basic objective of this study is to elaborate on what a stress ribbon bridge is, its types and its advantages over conventional pedestrian bridges. This study elaborates on the various parameters essential before the actual design or analysis and the sources from which they are obtained. It also briefly explains the process of modelling, loading and analysis of a stress ribbon bridge in ANSYS. The critical conditions were identified and designed for manually.

V. CONCLUSION

Although, there are several researches have been made to correlate the behavior of Bridge Structure, it is at just research level or educational level. Arch bridges are a type of structure primarily intended to withstand compression force, causing studies regarding stability to be very important. If a deck arch bridge tilts and becomes unstable, vertical column will tilt as a result of restraints of the girder. The horizontal component force produced thereby will accelerate the tilt of the bridge. negative effect produced by non-directional force onarch bridge stability. Increasing vertical rigidity of arch can effectively increase overall structural stability, increasing the lateral rigidity of arches can increase overall structural stability, but the impact is insignificant once a certain value is reached.

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