ANALYSIS OF ARCH BRIDGE-REVIEW

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Abstract: The structure and mechanics of arch bridge is very different than other bridge. The equal distribution of load over the abutment is uniform so it have significant advantages than other bridges. There are so many techniques in construction technology and software which are capable to determine the various parameters and economic cost which gives fast results, by using software and 3-D models. Nowadays limit state Ring-3 is latest version of software which is popular in masonry arch bridge analysis. By using algorithm technique, the aim to demonstrate a methodology to find minimum cost for designing in terms of material consumption by volume finding the optimal profile. Finally the new method of analysis and design of arch bridge are discussed.

Keywords: Optimal profile, Algorithm techniques, Rehabilitation, Sustainability, Finite Element Analysis

1. INTRODUCTION

Bridge structure is design to provide continuous passage over an obstacle,An Arch bridge is a bridge shaped as an upward convex curved arch to sustain the vertical loads. An arch bridge is a bridge with abutments at each end shaped as a curve arch. Arch bridge work by transferring the weight of bridge and loads to the entire span similarly. Bridges are important structures in modern highway and railway transportation systems, and generally serving as lifelines in the social infrastructure systems. Bridge components (superstructure, bearing, substructure, etc. The arch bridge are used for their durability, rigidity, economy and beauty concrete bridges are many types such as arch bridge, rigid frame bridge. The arch bridges allow the weight to transfer along the entirety of structure, even when that action occur right along the top of the arch, Bridge is a typical structure, there are number of bridges which are used since ancient papers and researches In fact the development in bridge technology is also the most important factor to measure the development of human life, Today arch bridges can be built very fast with advanced technologies and advanced materials recently developed. With help of this now it has been possible to achieve economy during construction of arch bridges. Today arch bridges can be built for longer spans. There are several methods and software used to determine various factor regarding construction of arch bridges.

2. LITERATURE SURVEY

"Performance Comparison of Through Arch Bridge at Different Arch Position" *Alika Koshi, Dr Laju Kottalil (2016)*

Through arch bridge is a special-shape arch bridge and through-type arch bridge, is a bridge made from materials such as steel or reinforced concrete in which the base of an arch structure is below the deck, but the top rises above it, so the deck passes through the arch. Cables or beams in tension suspend the central part of the deck from the arch. Its structure and mechanics are significantly different from normal arch bridges because of its single arch rib skewing across the girder and its arch rib being subjected to massive axial compression force, torque, and shear stress. He was discuss about behavior of through arch bridge in deformation by changing the position of arches and checked the stability of arch bridge.

"Rehabilitation of arch bridges with lithely arch method" *Saurabh Vilas Joshi, G. N. Kanade*

Today arch bridges can be built very fast with advanced technologies and advanced materials. With help of new construction techniques now it has been possible to achieve economy during construction of arch bridges. Also these new arch bridges are durable and withstands in natural calamities due to advanced materials. Today arch bridges can be built for longer spans. Lithely Arch is a precast, modular, concrete arch bridge system. The bridges constructed using Lithely Arch technology are purely compressive in nature. Lithely Arch technology can be used for replacing, widening and strengthening old arch bridges. In this paper the rehabilitation of old arch bridge by lithely arch technique done safely.

"Development and application of concrete arch bridges in China" *Baochun CHEN*; Jiazhan SU; Shangshun LIN; Guodong CHEN; Yizhou ZHUANG; and Habib (2017)*

China is a country with vast mountainous areas that cover 69 % of the country's land area, and is thus well suited for the construction of arch bridges. China has a long history of application of arch bridges as one of its main bridge types. Thanks to its relatively high compressive strength, concrete can be used economically in an arch bridge, which is primarily subjected to compressive forces. Concrete arch bridges in China first appeared in railway applications in the 1940s. In 1965, the Hong-du bridge in Du-an county of Guangxi province reached the longest span of 100 m. According to Chen and Ye [1], there were 199 concrete arch bridges built or under construction with spans of no less than 100 m at the end of August 2007, with 56 of those structures having spans of no less than 150 m. The construction of concrete arch bridges continued thereafter, especially for the high-speed railway networks. With their great development, concrete arch bridges in China have achieved acclaim and prestige worldwide for their structural innovations and construction methods. In this paper, results of an investigation on concrete arch bridges in China are presented. Some typical concrete arch bridges are briefly introduced. New technologies and research on concrete arch bridges in China are summarized, and potential future developments are discussed.

"Analysis of dynamic stiffness of arch bridges by means of the first natural frequency" *Slawomir Karas, Radoslaw Wrobel (2017)*

Even in terms of statics, arch bridge design, regardless whether for the purposes of railways or roads, may face numerous problems in stresses distribution. In practice, a numerical analysis is indispensable. Dynamics is much more complex. Here, the modal analysis as implementation of FEM is applied. At present, the Fourier's harmonic analysis is rarely in use. In case of dynamics, apart from examining limit states, i.e. ULS and SLS in relation to strain/stress amplitudes, deformations and accelerations, also damping vibrations and possible excitations are important. In the face of such complexity, it is necessary to look for a relatively simple measure for purposes of preliminary assessment of a model of bridge to be designed. Most often, the measure is the shape and value of the first natural vibration frequency [2-4]. Such an approach is to be found among the European standards, where it is a simplified criterion for simple (non-complex) structures, simple beams [5]. Even the best design cannot replace a proofing test load performed on a constructed bridge, both in static and dynamic terms. Nevertheless, it is assumed that results of the numerical model analysis should be consistent with in situ measurements.

"Stability Analysis of Special-Shape Arch Bridge*" Wen-Liang Qiu, Chin-Sheng Kao, Chang-Huan Kou, Jeng-Lin Tsai and Guang Yang (2010)*

With continuous improvements in the aesthetics of bridges, bridges with traditional and simple designs can no longer satisfy demands of visual appeal. Consequently, some new special-shape arch bridges have gradually been presented to the world. Special-shape arch bridges differ from normal arch bridges in that, in special shape arch bridges, arch ribs are configured askew across the main girders, and hangers are configured at different angles, thereby creating a unique dynamic effect. The stability problem is an important issue in the field of mechanics and is a problem often encountered in bridge engineering; the stability problem is of equal importance to the strength problem. The stability problems associated with askew configuration of arch components in special-shape arch bridges is a subject of even greater concern. Structural stability analysis theory has gradually developed and formed since Euler introduced the Euler Formula for dealing with the buckling of slender struts *Tamkang Journal of Science and Engineering, Vol. 13, No. 4, pp. 365_373 (2010) 365* over two centuries ago. Timoshenko and Gere (1961) and Ziegler Hans (1968) have made comprehensive expositions of structural stability theory. Early research on steel arch in-plane buckling mainly employed classical buckling theory Austin and Ross (1976) studied the impact of the rise-span ratio of two-dimensional parabolic arches and circular arches on in-plane buckling loads, and found that the parabolic arches had lager buckling loads than catenary arches and circular arches. In a study on in-plane buckling of parabolic arches, Harrison (1982) found that the buckling load limits of local loads are significantly smaller than overall loads . In researches on in-plane inelastic buckling, Mirmiran and Amde (1993) studied inelastic buckling of prestressed arches. Pi and Trahair (1996) studied the impact of many factors such as arch slenderness ratio, obliquity, initial bending, and residual stress on the inplane inelastic buckling strength of circular steel arches This paper uses the eigenvalue method to perform detailed study on the stability problem in a special shape Arch bridge, taking into account the impacts of different loads, restraint conditions, stiffness of arch rib, stiffness of deck and rise-span ratio of arch rib.

"Structural optimization of concrete arch bridges using Genetic Algorithms*" Mostafa Z. Abd Elrehim, Mohamed A. Eid, Mostafa G. Sayed (2019)*

In recent years, Artificial Intelligence (AI) techniques show wide applications to facilitate human life. These techniques (such as Evolutionary Algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Tabu Search, Fuzzy Optimization and Artificial Neural Network-based methods) have been applied individually or coupled to solve the life problems. Genetic Algorithms technique, which is one of AI branches, is used for solving complex engineering optimization problems. The Genetic Algorithms (GAs) have been started in 1975 by John Holland. GAs have been widely used in most engineering fields such as: chemistry and physics, mechanics, aerodynamics, robotics, networks, architecture and civil engineering. In civil engineering, GAs have been used in almost all branches;

for example: reinforced concrete flat slab buildings, optimization of tunnel profile in different ground conditions, determining the optimal cross-section of steel beamsand the design of water distribution networks. Few structural optimization researches investigated the optimal design of arch bridges. In 2008, there was an attempt for bending moment reduction in arch using a specific arrangement sequence for hangers. Two years later, an optimal design of steel truss arch bridges using a Hybrid Genetic Algorithm was presented. A comparison between circular and parabolic arch was presented in the same year and it was observed that the parabolic arch has lower internal forces, more economic than the circular arch and it is more efficient for open bridges. Nowadays, Genetic Algorithms are being applied to widespread application in business, scientific and engineering specializations. Finite Element Analysis (FEA) is a numerical technique that can be used to get the accurate solution for complex engineering problems. It started since several centuries back as an idea of replacing the complicated problem by a simpler one. The main concept of FEA is considering the origin solution as built up of many small interconnected sub regions. It has been used for solving many structural analysis problems. Today, the Finite Element Method is considered one of the most important analysis tools for engineers and scientists. The arch bridges have a main advantage over other crossing structures; the economy. In order to increase their economy superior, some attempts were introduced to find the optimal design for these bridges. In 1999, the optimality criteria method was used to develop a recursive relationship for the design variables (mainly, the depth at the crown and at the support) The current research deals with the concrete arch bridge optimization problem by developing a new analysis tool that comprises both Finite Analysis and Genetic Algorithms using MATLAB programming platform. In this methodology, the arch is modelled numerically as a continuum structure divided into 2D Constant Strain Triangular (CST) elements joined together at corners. The joints coordinates are the design variables for the optimization process which aims to minimize the arch weight. The developed Finite Element Analysis program is used to check the structural safety issue.

“Aesthetic and Sustainbility of arch bridges*” Jure Radić, & Marija Kušter (2013)*

Bridges are significant structures. Comparing with buildings and other infrastructures, bridges are dominant in the environment not only by their dimensions, but also by their service life and the number of users during it. They serve to community and can be seen from different location (on/under the bridge, from close up, faraway, from other roads) and in different conditions (standing, moving: at varying speed and in a variety of vehicles). Consequently, it is not surprising that bridge engineering is often exposed to public judgment, more than other professions. Therefore, it is necessary to design not only reliable, durable and economical bridges, but also aesthetically pleasant structures.

Key factor at the beginning of bridge design process is understanding of natural, built and community context and identifying significant constraints. Context sensitive design has been applied for the first time during construction of first historical bridges, built by local labor and made of local material as a matter of natural choice. Great example of that sustainable method in more recent past is the reconstruction of the bridge across Krka River near Skradin (Fig. 1), led by the greatest Croatian bridge builder Kruno Tonković (1911-1989), professor at Faculty of Civil Engineering – University of Zagreb. The old bridge with steel arch trusses above the roadway was demolished in the II World war. All usable parts were incorporated into the new composite structure (the two steel arch tubes filled with high grade concrete). New bridge is much more economic than the old one, has a higher navigation clearance and wider roadway and is more logical and beautiful [1]. Design sensitive to context is valued by communities. Structures and landscapes that fit and enhance context are good for community pride and local identity, they are often more sustainable and self-reliant [2]. One type of structure may be acceptable or beautiful in one location while unacceptable or ugly in a different location.

“Comparative Study of Arch Bridges with Varying Rise to Span Ratio” *Tauhidur Rahman and Arnab Kumar Sinha (2015)*

It has been years that bridge designers and engineers are not only concerned about stability of bridge structures but being concerned about their efficiency, economy and aesthetic as well. Arch bridges are often selected as solution over girder bridges to cross over deep George in mountain area when greater span ranging from 40 to 550m is required. As of today most bridges in this range of span are used in countries like United States, Japan, China and Australia are tied-arch and truss bridges. The reason for this is that arch bridges are aesthetically pleasing as well as economically feasible and are very popular and widely used since ancient times. Many researchers have worked on Arch Bridge based on design, load carrying capacity, creeping effect, seismic response, in plane and out of pane behavior, the stability of the structure, arrangement of its structural components, vibration control, out of plane problems, lateral load effects etc. and there have been an continuous improvements in the development of Arch bridges. From the literature review it is seen that most of them have focused on the buckling of the arches as buckling is a common criteria of a curved beam or arch when it is loaded in its plane and the beam buckle by deflecting laterally out of its plane and twisting. However the important aspect in designing any structure is to ensure its safety, structural stability and economy of the structure etc. which can be achieved by designing the structure for the optimum dimensional parameter of the structure. In case of an arch bridge the rise to span ratio is an important geometrical parameter and it has relatively large impact on the structural behavior of the bridge. Moreover the increase in the dimensional parameters also increases the self weight of the structure leading to increase in the cost of construction. Thus the aim of our present study is to investigate the structural behavior of different arch bridges considering different rise to span ratio, when they are subjected to static, wind and traffic loading and to study their economical potential, their efficiency and finally obtaining an optimum value of rise to span ratio for different spans.

3. CONCLUSIONS

Arch bridges are very high in compression due to stability and it is important. In mountaineous areas, the long span arch bridge are adopted for the transporting of high speed railway. If deck arch bridge changes there direction it becomes unstable then vertical column tilts. The horizontal component force which was produced on the bridge increases the tilting, which was a negative effect. The hangers which are placed diagonally improves the stability of the structure and it's the negative effect. For single arches, as large deformations will cause arch axial compression to be reduced and will also stability coefficients to be larger than the results of linear elasticity stability analysis, just performing linear elasticity stability analysis is sufficient for single arches with lateral effects. For increasing the substantiality of the bridge height of the main girder is increased.

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