Non-Linear Analysis of Arch Bridges Subjected To Ground Motion

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Abstract- *This paper deals with the Non-Linear Dynamic Analysis of Arch Bridge using STAAD.Pro V8i software subjected to Earthquake loading. In present, construction of Arch Bridges short and medium spans for by-passing the traffic is extensively happening due to its easily load bearing properties. Therefore it is a need to check its stability against strong earthquake. So the Non-Linear, Time history analysis of arch bridge modelled in STAAD.Pro is carried out in this research. For Time History analysis the Bhuj-2001 Earthquake data is used & for Reference the Rudramata Bridge which was failed during Bhuj Earthquake is studied. This study mainly focuses on the study of displacement, Time-Velocity, Time-Acceleration result of Arch Bridge against lateral loads. And results show that displacement in all three directions for arch bridge is lessthe for Rudramata bridge.*

Keywords- Arch bridge, STAAD. Pro V8i, Non Linear Dynamic analysis, Time history, Rudramata Bridge, Bhuj, Displacement, Time Velocity, Time Acceleration.

I. INTRODUCTION

The study of Arch Bridge's Behavior under the time history load is important for the areas which are prone to the earthquake. The STAAD.Pro V8i version software is also a leading software in the field of structural analysis. Nonlinear analysis allows us to account changes in stiffness with application of load. Depending on the nature of the problem, the loads should be applied in steps while the stiffness is adjusted multiple times within a load step to arrive at a converged solution.The objectives of damages field inspection of the bridge structure are to evaluate the structural performance, to identify the actual and potential sources of damage at the earliest possible stage, to explain the member state weather is in safe or unsafe, to classify the damaged parts in bridge members, and to identify any maintenance, repair, and strengthening that needs to be carried out. The deterioration of a bridge structure often appears in visible signs of damage. A detailed investigation provides information about the damages. Various test may be used to complement of the results of the visual investigation. Testing techniques and equipment should be determined relative to the amount and type of the deterioration and the importance of structure.

The purpose of evaluating the bridge structure damage is not only to determine the effect of damage to its remaining service life and load-carrying capacity, but also to determine the causes of defects. Generally, the damages occur in concrete bridges under unacceptable loads can be classified into cracks beneath the beam and slab. Additional settlement of bridge slab, extra vibration due to upcoming loads, corrosion of reinforcement, and spalling of concrete. (Sadeghi and Fathali 2007). In the present study, Rudramata concrete bridge is inspected for the Lateral loading in terms of Time-History Analysis. The objectives of this study are to investigate is there any kind of reduction in displacement, and to compare the results of Bridge by considering the full span and half span bridge models.

Many techniques used for assessment of arch bridges against lateral loading have been recognized as being highly conservative, i.e. predicting stability far lower than predicted by experience. At present, finite element analysis is usually considered too impractical for use in masonry arch assessment by civil engineering consultants, as it often requires input parameters that cannot easily be determined.

Amid the nineteenth century, the monetary material to assemble spans was timber because of its inexhaustible accessibility, cost, and simplicity of development. Thousands of timber covered bridges were built during the 19th and early 20th centuries, yet a relative small number remain today. The main four surviving timber connect types are the Burr curve, Town grid; Howe, Queen and lord kind of trusses. These types of bridges have many of the same characteristics, but each is uniquely different enough to cause concern when evaluating the structural behavior of each bridge. These differences add some complexity to accurately analyze these types of bridges. For example, there are several eccentric connections, various load paths, connection uncertainty between the subassemblies (trusses and arches), and interaction between the trusses and their housing. At the point when these are joined with material changeability, it is anything but difficult to scrutinize the utilization of streamlined truss investigation to outline these kinds of extensions.

This is recognized in the Federal Highway Administration's (FHWA) Covered Bridge Manual. The manual expresses that there are irregularities with the presumptions of conventional basic static examination of these secured spans utilizing straightforward investigation of trusses. This manuscript summarizes the results of using a simple but more accurate analytical technique for the analysis of historic covered timber bridges. The STAAD limited component program was used to achieve this goal by examining the Zacke Cox Burr Arch Bridge, and was approved utilizing the outcomes that are recorded in a report of the field study.

A good illustration of the conceptual method of design is in the design and construction of many of the 18th and the 19th century bridges in Venice." The construction of a these bridges is a combination of natural, (i.e. the situation in Venice in the 18th century, with the city being divided largely by the lack of bridges), scientific and social criteria all having effect on the final design. Movement of most materials therefore required the use of flat bottomed boats. To enable the use of boats required vaulted bridges structures. The arch was designed mainly for canal use, rather than any other design method, leading to the semicircular shape most commonly seen today.

A. Aim

Analysis and Design of Arch Bridge.

B. Objectives

- To study non-linear analysis of arch bridge.
- Comparative analysis of straight bridge and arch bridge for same span, same grade and same loading
- To compare effect change of span of arch bridge subjected to specified ground motion.
- To validate STAAD-Pro results with Maximum BMD and SFD for Bridge deck

II. METHODOLOGY

III. THEROTICAL CONTENT

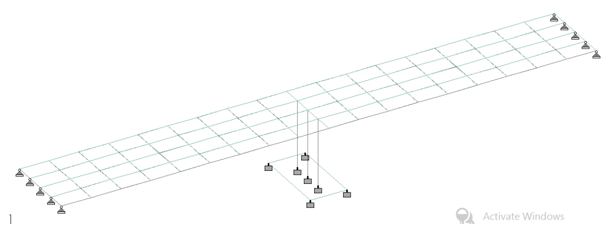
Available Data:-

- Total length of bridge: 80m
- Clear width of carriage way 10.5m (IRC 5: 1998 & IRC 6: 2010)
- Kerb width: 600mm (both side, pedestrians are allowed)
- Parapet: 1000 mm × 150 mm × 150 mm @ 1.5m c/c with 3-cast iron pipes as railing
- Camber: 1 in 100 (37.5 mm at center linearly varying to zero at kerbs)
- Wearing coat: 80mm
- Kerb height above pavement: 200mm (insurmountable type)
- Kerb type: full safety ensured
- Total kerb height above deck slab: 280 mm
- Clear depth of Longitudinal girders: 1400 mm
- Width of longitudinal girder: 400mm
- Width of cross girder: 300mm
- Clear depth of cross girder: 1400 mm
- Deck slab thickness: 250 mm
- Total overall depth of the super structure: 1800mm

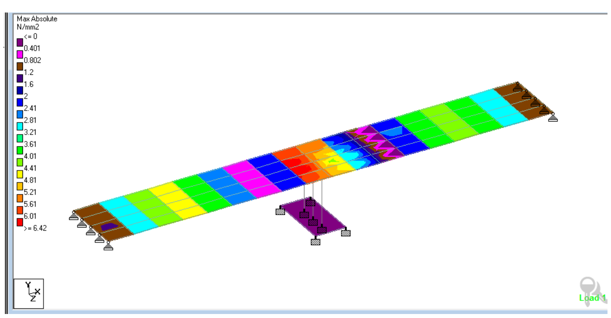
Super structure Available Data:-

- Total length of bridge: 80m
- Clear width of carriage way 8.6m (IRC 5: 1998 & IRC 6: 2010)
- Kerb width: 360mm (both side, pedestrians are allowed)

- Parapet: 1000 mm × 150 mm × 150 mm @ 1.5m c/c with 3-cast iron pipes as railing
- Camber: 1 in 100 (37.5 mm at center linearly varying to zero at kerbs)
- Wearing coat: 80mm
- Kerb height above pavement: 200mm (insurmountable type)
- Kerb type: full safety ensured
- Total kerb height above deck slab: 320 mm
- Clear depth of Longitudinal girders: 1800 mm
- Width of longitudinal girder: 600mm
- Deck slab thickness: 250 mm
- Total overall depth of the super structure: 1800mm
- c/c spacing of longitudinal girders: 2500 mm
- clear distance of cantilever span from face of girder: 1800mm
- Grade of concrete: M35
- Design strength: $f_{cd} = 0.67f_{ck}/\gamma_m$MPa (Annex – A2 of IRC 112: 2011)
- Grade of steel : Fe_{415} (IS 1786 : 2000)
- Design strength of steel : $f_y/1.15 = 0.87f_y$ MPa (clause-15.2.3.3 of IRC 112:2011)
- Poisson's ratio: μ = 0.2 (Annex-B; B-3-1 of IRC 112:2011)
- Analysis of deck slab: Piegaud's curve



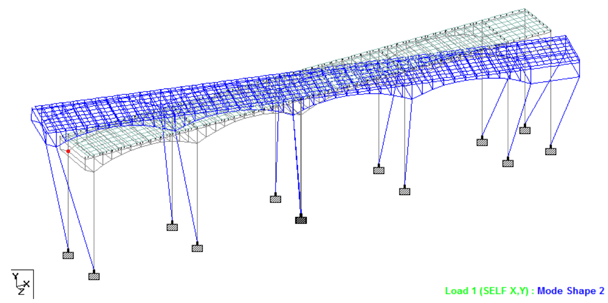
Modeling in Staad



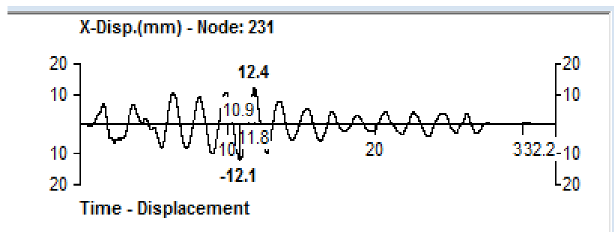
Stress Variation

IV. RESULT AND DISCUSSION

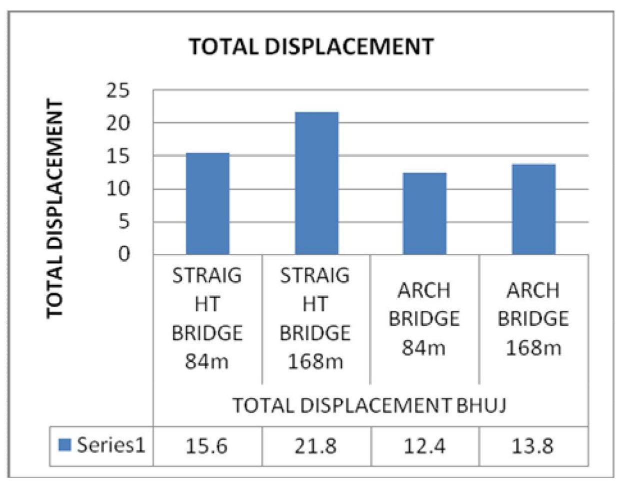
Mode shape of bridge



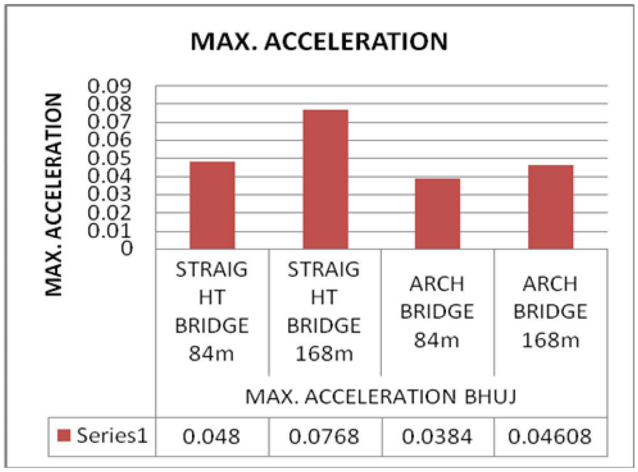
Various parameter result



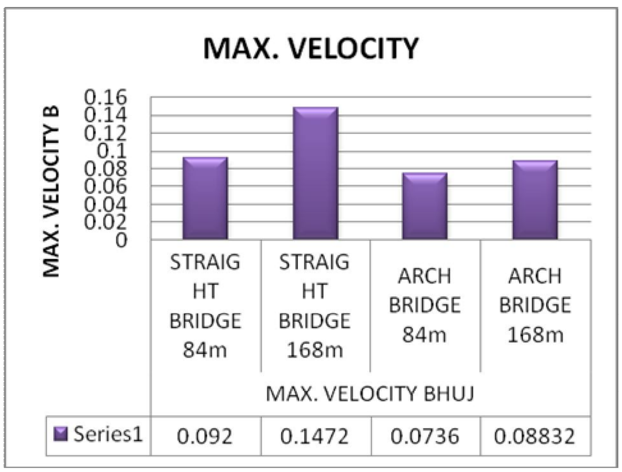
Total Displacement



Total Acceleration



Total Velocity



V. CONCLUSION

In this report non-linear analysis of bridge is carried out and report covers the every important aspect of the analysis. This study includes the analysis of time-displacement, time-velocity & time-acceleration results for the given models.

The results obtained in this study are representing that the arch bridge is having more stability if used with proper geometry. The models used in this study gives response for the given time history analysis proves that arch bridge is having more rigidity under dynamic loading condition.

1. After studying the bridge models for the results of the displacement it can be found that for given loading the straight bridge of 168m span shows the displacement in x-direction as 21.8mm, and the same result for equivalent arch bridge is found to be 13.8mm which shows that arch bridge is having more stability under earthquake loading than that for straight bridge.
2. For the various span of arch bridge it can be stated that as the span of bridge increases the values of displacement, velocity and acceleration also increases with respect to span in percentage.
3. It can be noted that, the smaller span size will have more stability regarding displacement, velocity and acceleration response of the structure.

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