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PREVAILING PARAMETERS IN THE ANALYSIS OF HIGH SPEED RAILWAY CABLE STAYED BRIDGES- A REVIEW

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Abstract- Railway bridges play a crucial role in the speedy and flexible communication and transport between cities of the country. It plays an important role in the economy and infrastructure development of any nation. High speed rails are the most effective and sustainable mode of travelling. India is quite unique along all developing nation for not having high speed rail corridor but by introducing Mumbai-Ahmedabad high speed rail project Indian government opens up research directed towards the same field. Several research studies are attributed to HSR Bridges such as experimental research, numerical modeling, bridge-vehicle interaction and fatigue. Evaluation of the useful life, reduction of vibrations. In addition, the effects of collision, impact and Seismic loads on railway bridges are studied from the existing literature. This article tries to summarize the existing research in the field of railway cable stayed bridges for practicing engineers and Researchers. Extracts of this study can be used to evaluate the dynamic performance of nearby rail bridges with more refinement.
Keywords – Rail Model, High Speed Rail Transport, Dynamic Analysis

1. INTRODUCTION

Railway bridges are an important part of national economy and serve as Foundation for Infrastructure Development. Railway Bridges play an important role in the construction of a rapid communication system between cities and across the country. However, damage to bridges, induced by earthquakes or other hazards can interrupt the means of continuous transport as well as the emergency evacuation routes.

Bridge dynamics refers to deflections and stresses in bridges caused by the moving wheel load and several dynamic load. Parameters which influencing the stresses in the bridges are firstly due to the characteristics of bridge structures, characteristics of the vehicles and secondly damping of bridges and in vehicles, speed of vehicle traffic, etc. Vehicles affect associate not only the vertical forces but also by Movements which generate longitudinal and transverse Horizontal forces. Increment or decrement in deformation of bridge are compared with static forces. In the bridge design practice, these effects are considered by dynamic Coefficient or dynamic impact factor. However, this only indicates how often the static effects should be multiplies to cover the additional dynamics effect. The dynamic coefficient cannot characterize the effect of all the above mentioned parameters. Because of its simplicity, but generally guarantees the safety and reliability of bridges. The assessment of bridge fatigue assumes the magnitude and number of constraint cycles generated in the bridge by the passage of all vehicles during its service life for estimation of fatigue life and for determination of inspection intervals.

In this paper a sincere effort is made to summarize the existing research on experimental research, numerical modeling, Vehicle-bridge interaction, estimation of fatigue life, vibration reduction and suppression of railway bridges. The current state of the art on the effects of the collision load, the impact load and the seismic load on railway bridges are cataloged. The substantial results of the study may be useful for researchers in the field of railway bridges.

2. ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS

The railway bridges response under dynamic loading is one of the vital problem which has to be solved in railway bridge design and maintenance. Therefore, inordinate efforts have been continuously spent to the matter of dynamic interaction of vehicles and bridges. There is a long research history for more than one hundred years. Especially in the last two decades, increasingly sophisticated analytical models have been successfully developed by researchers. In 1849, Stokes presents one analytical solution for simply supported beam with the circulating moving mass. Afterwards, Timoshenko has done a remarkable research, which is a basis for many subsequent studies. The author studied the case of a simply supported beam subject to harmonic loads moving at constant speed, which simulated the effects of a multiple axle train circulation. Later on, Inglis presented an innovative approach which characterizes the circulation of a system formed by a suspended and a non-suspended mass, rolling on a simply supported beam. Detailed set of analytic solutions which allow the computations of accelerations, displacements and bending moments along a beam with an Euler-Bernoulli behavior to diverse loading cases, which could vary randomly on time, with the consideration of different support conditions and span lengths. [1] The beam vibration functions are developed for the analysis of multi-span beams under moving loads. Based on Hamilton's principle, the modified beam vibration functions satisfy the zero deflection conditions at all the intermediate point supports as well as

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the boundary conditions at the two ends of the beam. Based on these models, vertical and lateral dynamic interactions of the train–bridge system have been studied and many useful results applied to practical bridge engineering. There are so many papers published on the dynamic behaviors of articulated trains [2-4] researcher developed numerical model of rail model with 10 DOF to 30 DOF for the most accuracy in response prediction.[5] The analytical work's results were validated by the experimental set up. This is the accurate estimation of behavior of structural component under high speed rail impact. Different sensor to be used for strain measurements [5] nondestructive monitoring system used for the more efficient results. [6-8]

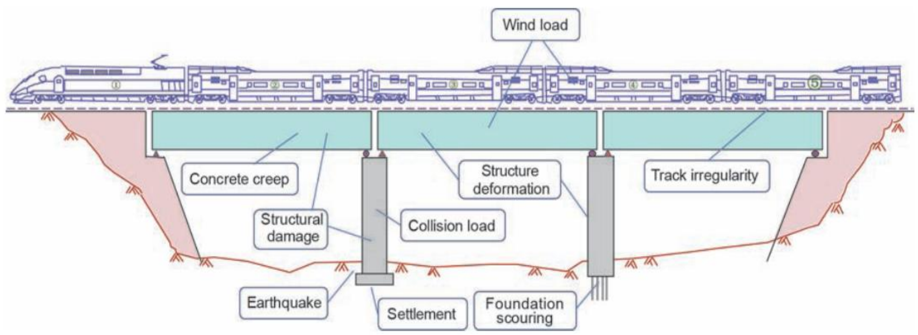

Figure 1 Train-bridge dynamic interaction system [24]

3. VEHICLE-BRIDGE INTERACTION

Many researchers have studied the interaction problems of the dynamic vehicle bridge since the middle of the 19th century. Due to the limitation of computing capacity at the initial stage, only simplified models of vehicle systems could be considered. For example, a moving vehicle was modeled as a moving load regardless of the effect of the inertia force, then a moving mass model was used instead of a moving load for include the effects of the force of inertia.[10] with the time passes modified model approaches have been used like moving spring damper model, moving exle load model, 4-axle moving force model, 4-axle moving mass model, 4-axle 2-d.o.f. moving vehicle model, 2-axle 2-d.o.f. moving vehicle model. [10] Today, the volume of traffic and the speed of vehicles have increased considerably, as has the configuration of vehicles. Therefore, computerized approaches are needed. To study the 3D vibrations of the bridge systems between vehicles, the stiffness matrix, the mass matrix, the damping matrix and the force vector of the vehicles and the bridge must be previously formed. Then, the points of contact between the bridge deck and the vehicles couple the two components. Most of the previous investigators have addressed the problem using two sets of differential motion equations, one for the bridge and one for the vehicle, and then considering the iterative contact conditions. In the iteration, the displacements of the contact points are assumed first. The interaction forces between the vehicles and the bridge are calculated by solving the equations of movement of the vehicle. The improved displacements of the contact points are obtained by solving the equations of motion of the bridge using the calculated interaction forces. The iteration process will only be completed eventually if the displacements of all contact points of the two consecutive iterations are close enough. The set of differential motion equations for vehicles can only be established if the type of vehicle is specified. When the vehicle type is changed, the movement equations must be redefined. [11-18]

4. FATIGUE LIFE ESTIMATION

This research presents a generic fatigue assessment method for riveted railway bridges based on finite element analysis of a typical short-span riveted railway bridge, which is quite common in the United Kingdom. The overall fatigue analysis was first performed for the structure, then estimates of fatigue life were obtained by the S-N method. Classification of fatigue details, modeling uncertainty and load evolution were it is crucial to estimate the remaining fatigue life of older bridges. The next step in the method was to analyze the constraints of a finite element detailed model of the fatigue critical connections mentioned above. This step can provide information about the place of fatigue more prone to cracking. The TCD method provides more appropriate fatigue results than the S-N method, which can ignore 3.5 times the number of damages, which emphasizes the need to strengthen inspection and management plans. The results of the current study require authentication via Field observations due to associated uncertainties. [19]

5. IMPACT LOADS

A two decade before most of researchers had done dynamic analysis of CS Railway Bridge with very simplified approach; they were not considered the impact load generation due to high speed train application. [2, 11, 12]. But due to high axle generated through rail and road surface roughness formed a high impact load on adjacent structure. This realization leads to high research on this area.

Damping has a significant impact on the impact factors but depends on the type of load effect considered and the location. Impact effects based on deck bending are generally high in the shorter side spans as compared to the longer span. Impact effects on the tower and shorter cables are moderate. Depreciation is usually effective in reducing the impact. When the effect of the impact is moderate to high, the impact factor generally increases when the quality of the railway is lower. However, the impact factor is not proportional to the magnitude of the roughness. When the impact factor is relatively low, no trend is observed. Then, the effects of the initial vertical movement of the vehicles of the train before climbing on the bridge were studied. The vertically induced motion can be induced by random rail irregularities or nonrandom focus irregularities. In both cases, the effects decrease with distance from the abutment. [20-23]

6. EARTHQUAKE LOADS

The seismic resistance of bridge structures is a subject of great concern in many countries, particularly those located in earthquake-prone regions. With respect to railway bridges, it is possible that the bridge itself may remain safe during an earthquake, but it may not be safe enough for trains to travel there due to excessive vibration. Obviously, the safety of moving the trains on the bridge under the effect of seismic excitation is a subject of great concern for railway engineering. This problem is becoming increasingly important because of the frequent use of raised bridges as railway support structures and the increasing speed of passenger trains. However, to the knowledge of the authors, rather limited efforts have been devoted to this problem in the past.

The vehicle-bridge interaction system with seismic loading must satisfied the following characteristics: the relative movement between the wheel and the rail is much greater; therefore, the wheel-rail interaction hypothesis should be operative in case of significant deformation. The seismic force between the wheel and the rail can be quite large, so the time step of the numerical integral must be much smaller to guarantee the convergence of the temporal iterations. The requirement of driving comfort in railway vehicles can be ignored in the event of an earthquake. Subsequent dynamic analysis performed for different time histories for the safe assured journey. [24-30]

7. CONCLUSION

Railway bridges subject to a dynamic load may experience deflections, stresses and vibrations resulting from the moving train load, impact load, seismic load or collision load. Since railway bridges play a very important role in ensuring smooth and timely communications and transportation across the country, damage to railway bridges under extreme load conditions can have adverse consequences. As a result, experimental research, numerical modeling and structural performance evaluation of railway bridges are of paramount importance around the world. This paper attempts to summarize existing experimental and analytical research on bridge-to-vehicle interaction, low collisions, shocks and seismic loads, vibration reduction and suppression techniques, and estimating the service life of railway bridge structure. This research work can be a first step for beginners interested in exploring the field of railway bridges.

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