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Review on Analysis of Free Vibrational Horizontally Curved Bridges

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Abstract: Curved I-girder concrete bridges give an outstanding answer to urban congestion, traffic, and pollution concerns, but the combined flexibility and torque responses of the bridges make their behavior exceedingly complex. That is why structural design parameters for simplified design procedures are in high demand, as measured by empirical equations. To analyze the effect on the free vibrational reaction of curve composite steel-concreteI-girder bridge with varying vibration parameters, this research employs a sensitivity analysis. To learn the fundamental frequency and the geometric configuration of the model forms, a parametric investigation is performed. Finite element Modelling of composite steel/concrete frameworks, deformable shear model, fine element formula, finite element mounting, finite element calibration, and finite element modeling, etc. Modeling finite element. Sensitivity research to draw the fundamental frequencies for the evaluated bridges. The parametric research outcomes. The results. Curved I-girder bridges of composite steel with single span or multi-span lengths are presented.
Keywords: bridges,concrete,grinder.

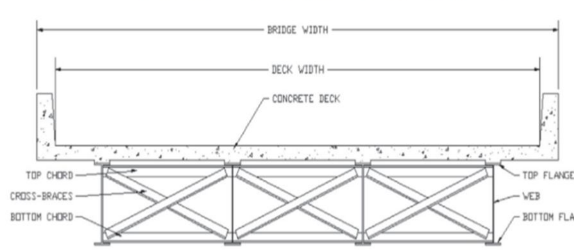
I. INTRODUCTION

There are many advantages of curve bridges, rarer visually, seamless transitions, economic benefits, decreased pollutants resulting from idle pollution, fewer traffic jams, short portions, and generally efficient designs, are becoming more and more popular. However, conduct is exceedingly complex due to the interconnected nature of curved bridges.

Bending and twisting of the bridges,Because of its practicality, economy, and ease of construction, the composite slab-on-girder bridge is the engineer's top option. However, as the open-section I-girders supply limited torsional strength, cross-braces become an important design part, making the entire engineer's design process considerably more complicated. Figure 1 shows the schematic of theUse steel girders with a rectangular cross-section and uses curved girders with a circular cross-section.

The behavior of curved or bending beams is not a novel idea. The research on the design of a horizontal curve bridge with 202 references has been comprehended in a very detailed way. Most of them come from Japan. The Highway Federal Administration established the CURT Consortium the same year to examine the behavior of horizontal bridges. As a consequence, 2003 AASHTO's Horized Curved Highway Bridge Guide Specifications have been issued. It covers both the historical point of view and the state of the art of the curved I-girder design. Many researchers have worked on analytical solutions for straight and curved bridge dynamic analysis issues. A detailed solution to the free vibrations of horizontally curved double symmetrical beams supported on fundamental elements was offered. To manage the free vibration of bridges which are only supported by a single prismatic beam, they derived ideal solutions for differential equations that govern the vibrational motion of such structures. To forecast,They developed formulas using the Rayleigh-Ritz approach and the Lagrange multiplier notion for calculating the natural frequencies of curved multi-span bridges.The beam vibrates freely as long as it has a cubic equation, which regulates its free vibration. The prediction made by the Culver equation for the component's paired natural frequencies turned out to be correct, as seen in the equation's first two roots. In order to include the effects of shearing deformation and rotational inertia, an analytical method for the dynamical analysis of curved bridges was revisedBilling.

R. Wodzinowski et al. / Journal of Constructional Steel Research 140 (2018) 47–61



(a) Cross-section of the composite concrete on steel I-girder bridge

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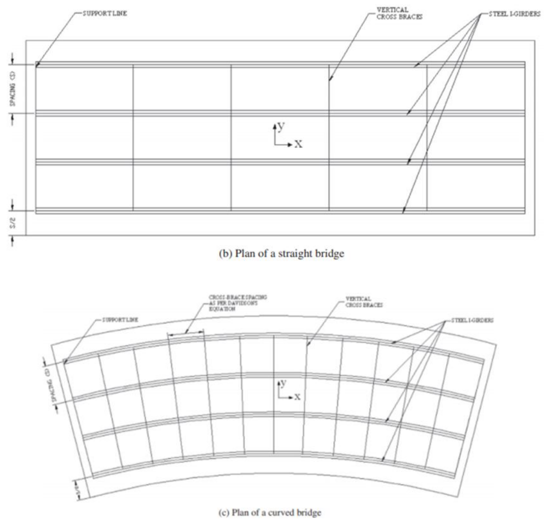

Fig.no.1 plans& cross-section of the studies curved &straight simply-support bridges.

A. *Intorduction of Vibration*

Vibration is a time-dependent shift of a particle or a particle system to a position of equilibrium. If these displacements with respect to the balance position are repeated at identical time intervals, the resulting move is said to be periodical. Engineering Vibration offers natural frequencies as one of its primary benefits. The frequencies of each structure are distinct, allowing for a diverse spectrum of dynamic modes. At that point, both large-scale deflections and catastrophic failures are highly likely.

B. *Classification of Vibration*

Vibration can be classified in several ways. Some of the significant classifications are as follows:

1) *Free & Forced Vibrations:* Free vibration occurs when a system is left to vibrate on its own following an internal disruption. The system is at rest since there is no outside force affecting it.
2) *Undamped& Damped Vibration:* There are no Undamped vibration occurs when energy is lost or dissipated during oscillation owing to friction or other resistance.
3) *Linear And Nonlinear Vibration:* When all three of the vibratory system's basic elements spring, mass, and linear actuator linearly, that is called linear vibration.

II. FINITE-MODELING-ELEMENT-OF-CONCRETE-STEEL FRAMESCOMPOSITE

A. *Beam Model with the Deformable Shear Connection*

An interconnected composite beam and an individual-coupled Euler-Bernoulli beam are both depicted in figure 1 from Newmarket al., 1951.The orthogonalX,Y,Z frame is introduced locally.The 'Z' axis is perpendicular to the beam's axis &horizontal. In Figure 1, the YZ cross-sectional symmetry plane represents the geometric and material cross-sectional symmetry. Since the YZ plane charges are symmetric, similar charges in that plane are also presumed to be symmetric. A material location on the beam's beamline is known as the displacement field u of that point.

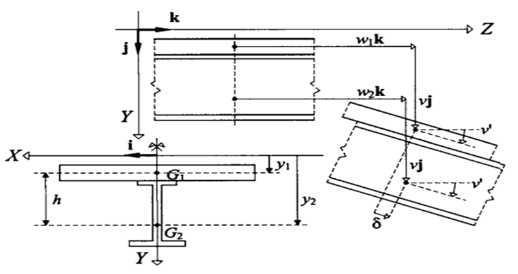

Figure no.2 two-dimensional kinematicreference system&composite beam model

Domain shifts when w axial shifts A reference point, whose order is "y" equals 1: concrete plate, = 2: steel beam; The vertical cross-section shifts. The vertical component of the cross-section is referred to as "v." As well as the vectors "j" and "k," the units "y" and "z" have unit vectors that point along the Y and Z axes, respectively. The equality in transverse shift and rotation of the dome and the steel beam can be seen as a result of the enforced contact between the two pieces.The axial stress z and interface slip are the two non-zero pressure components.

$$\varepsilon_{z\alpha}(y,z) = w'_{\alpha}(z) + (y_{\alpha} - y)v''(z) \quad \text{on } A_{\alpha} \ (\alpha = 1,2)$$

$$\delta(z) = w_2(z) - w_1(z) + hv'(z)$$

Where h=y2−y1distance in Fig. 2 of the two components between G1 and G2. At the length reinforcement sites, Eq. 2 additionally supplies reinforcing strain because the steel and concrete are connected in an ideal fashion.

B. Finite-Element Formulations

In this work, a "simple and effective two-dimensional" ten-degree-of-freedom ‘SCC’ mechanical frame element has a deformable connectionshear. In total, there are eight DOFs located exteriorly: Four DOFs per terminal node, two DOFs for each transverse beam, and one DOF for each of the concrete slab's axial movements.While the other two are internal, namely, the concrete slab's axial movement and the steel beam's axial displacement Picture 2. Each SCC beam end can provide an internal limitation that will maintain zero applied steel beam slip on the concrete plating component.A valuable feature incorporated inside the adopted frame element. The correct results of the free-locking element were proved provided an adequately refined mesh is chosen.

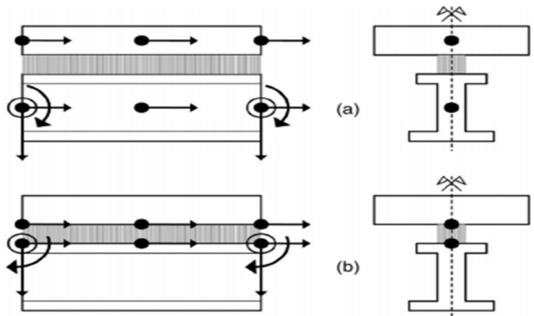

Figure no.3 reference is defined at the slab-beam centroid, while another is defined at the slab-beam interface.

The same elements for the ‘SCC’ structures, monotonic and cyclic load circumstances were also used in finite-element sensitivity analyses. However, the results and observations of this document are not confined to the particular finite element utilized.

C. Finite-Element Assembly

Using two formulations for composite beam elements (one conventional and one-dimensional formulation with three column elements of a DOF per end node) and columns for beam-column elements (both conventional and three-column elements of a DOF per end node) presents unique issues. Different assembly configurations relating both to common and less common scenarios.They have been explored and applied in this work. Rigid connections of the beam-to-column are examined solely. However, it is feasible to extend to semi-rigid connections by introducing unique components with predefined constituent behavior.

D. Element-material & Representation Characteristics

The linear shell elements were used to create the concrete deck slab, girder flanges, and the web.This 6-DOF element has three rotations and three displacements: Φ1, Φ2, and Φ3, and U1, U2, and U3. Bridges can be formed with a curved profile because the shell components are designed as true curved shell parts. Across the concrete slab overhangs, the numbers of shell components in the deck slab were 4 for all FEA models employing the radial direction and 2 for all FEA models employing the tangential method. It is also important to note that, for the girder web, the numbers of shell elements and flanges used were 4 and 2, respectively. While working to gain a finer degree of control, the number of shell components would vary from 36 to 72. On this side of the bridge, the tangential number varied from 36 to 72 pieces, ranging from the length of the bridge span.

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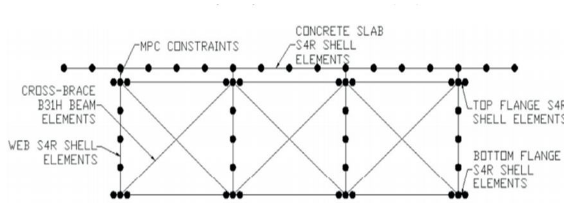
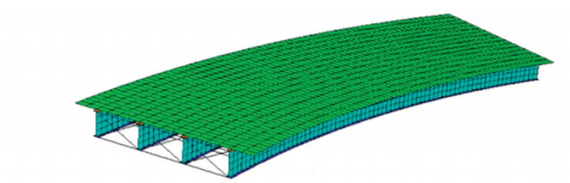
E. Calibration of the Finite Element Model

To calibrate the finite element models, a basic, 25-meter long, three-girder bridge was built with various levels of shear interaction between the concrete deck slab and the steel girders. The bridge was 7.5 m in width, the gardens were 2.5 m apart, and the slab was 1.25 m above sea level. In order to gauge the adequacy of the bridge models, stresses and deflections were examined on the middle-bottom portions of the jackets, in contrast to what would be predicted using beam theory. the inherent frequency of the original construction was close to that of the bridge

$$f_1 = \frac{\pi}{2L^2}\sqrt{\frac{EI}{m}}$$



(a) Typical finite element model for bridge cross-section



(b) FEA model for a curved bridge

where; L=the length of the bridge, $f1$=the first flexural frequency, m = the weight of the bridge per meter,EI = the flexural stiffness of the composite section.

The models have been calibrated by using a mechanism that has an additional shear interaction amongst a concrete plate and a stainless steel surface, increasing it from 33% to 100%, and then by increasing the number of shear pinions.

III. SENSITIVITY ANALYSIS

A sensitivity analysis was done to investigate the effect of a wide variety of parameters on basic frequencies of curved bridges. The study's objective was to discover variables that impact the free vibration response, which enables the parametric analysis and equation proposal to be implemented.The research involved particular conditions, such as the number of braces, the length of the belt, and the curvature radius, as well as lengths of the rods, curtain spacing, depth of girders, the rigidity of the cross braces, and vertical bracing systems. This summarises the ramifications of all the above settings in great detail.Thus are determined the essential parameters that determine the free vibration reaction.

A. Boundary Conditions & Effects

The fundamental frequency of curved bridges has been examined in order to investigate boundary conditions on the resulting frequency, and support bearings have been used. Where in every instance, the bridge is limited to all support bearings in the gravity direction. In this case, two approaches to the design were applied, such as the tangential method & the chord methods. The global x, y, and z directions of all evaluated bridges were covered by the secant methodology. All the coatings have been lined up to meet the bridge curvature or, in terms of tangential process, have been placed in local directions. All six examples have been labeled "SA, SB, SC," since they apply to global roller bearings, which have the designation "SA," "SB," or "SC," and local roller bearings, which have the designation "TA," "TB," or "TC."Various more factors which are affected are

1) Effect of cross-braces
2) Effect of curvatureradius
3) Effect of girders
4) Effect of flange-thickness
5) Effect of cross-brace-stiffness

6) Effect of horizontal-bracing systems
7) Effect of span length
8) Effect of girder spacing
9) Effect of depth of girders
10) Effect of endplate diaphragms

IV. LITERATURE OF REVIEW

HamdyMahy El-Din Afefy[1]proposed in this paper studies the free vibration response of the I-girder bridges with curvature and with steel rebar embedded in concrete. Complex research that incorporates 336 of the bridge models is carried out in order to identify the fundamental frequency and related modes of the models under investigation.ABAQUS software suite was used to numerically simulate the fundamental frequencies of these bridges to provide these measurements. From the results of the parametric analysis, the basic frequency of the I-girder bridges of the curved, composite concrete-stael is predicted by simple equations. The established equations are demonstrated to be equally applicable to single-span or multi-spans I-girder curved composite steel bridges of similar span lengths.

Zureick.et.al.[2]proposed in this paper explains the broad program of experiments and analyses that the Federal Highway Administration (FHWA) has undertaken, with a view to producing new rational design recommendations on horizontally curved bridges in steel. There are also analysis and experimental attempts to measure the size of the whole components, which are being tested in the context of a whole three-sided bridge system.

Magdy Samaan.et.al.[3] said that ,Finite element modeling is used to study the natural frequencies and mode shapes of continuous, curved, multi-girder composite bridges made from composite materials. Two identical, permanent twin-box girder models are built to serve as check and validation models. The model is then examined and certified. In these research projects, the empirical data used to calculate the fundamental frequency of the bridges serves as an important reference. The length of the range, the number of lanes, and the number of boxes are all adjustable parameters. In addition to those listed above, there are several more considerations: the curvature ratio, the span-to-radius ratio, the span-to-depth ratio, the thickness of the end of the fillet, and the number of crosses bracing.

Khaled Sennah&j,b, kennedy[4] propose that this paper describes a parametric analysis that examines 120 prototypes in order to examine their inherent frequencies and modes. Everything under discussion was included in the study: all of these come with the above information, with the exceptions of design type and construction method. The three-cell model of variable curvature has the most accurate findings in comparison to four different types of linear-scaled bridge models.A straight bridge is identified based on characteristics that also apply to curved ones. The parametric study findings served as the starting point for the calculations of the initial flexural frequency and dynamic charge allowance.

Imad EldinKhalafalla&khaledsennah[5]said ,When designing a horizontal bridge, it is a good idea to assume that the bridge will curve horizontally but will stay in line with the terrain.Specifications and standards of design of the bridge have placed some restrictions on the treatment of horizontally curved bridges as direct. These limits are, however, no different from the precise estimation of the structural response between the bridge cross-section configurations. In addition, these criteria have been mainly created for girder bending time calculations. For the accuracy of the limitations, three-dimensional finite-element models were used for the analysis of their behavior under dead loads to explore I-girder and slabs-on-concrete I-girder-bridges,which have horizontal curvatures of the bridge's structure. Now we know how much stress we can expect to see in the internal components: In all feasible curvature locations, To calculate the stress on the turning gear, including its longitudinal bending stresses, vertical deflections, vertical supporting responses, and fundamental bending frequencies, we looked at the span length, bridge width, and bridge length continuity.

RadekWodzinowski.et.al[6] proposed that the aim of this study is to examine the link between the design parameters of I-girder bridges composed of concrete-steel composite and the free vibration responses of those structures. This study of 336 straight and curved bridges includes a parametric investigation of the fundamental frequency and several harmonic mode configurations. The numerical simulation for these bridges was done using the ABAQUS software suite.From the results of the parametric analysis, the basic frequency of the I-girder bridges of the curved, composite concretesteel, is predicted by simple equations. The established equations are demonstrated to be equally applicable to single-span or multi-spans I-girder curved composite steel bridges of similar span lengths.

Alessandro Zona.et.al.[7]proposed that the generated finite-element model's simulation of the quasi-static cycle test confirms the result of the test. Once the simulation assumptions have been verified, the researchers will use the computer to do a numerical simulation of characteristics and seismic response for a genuine five-story, two-story, two-story steel frame with SCC beams and steel columns. Because of these assumptions, the outcomes of the model are subject to variation. A significant impact was had on the dynamic global response of the SCC frame structures when the deformation of the heart connection was included in the finite-element model. Precise modeling of the shear-related boundary conditions is required to perform an accurate simulation of this structure using composite beams with deformable shear connections.

Hoang-Nam Nguyen.et.al.[8]proposed that Inthis research article explains how plate theory and finite element method (FEM) leverage the first-order shear deformation to find oscillator equations for the shell structure while being loaded dynamically. In the MATLAB environment, the writers design and verify the accuracy of the established software. Based on this technique, we explore the impacts on the shell's dynamic reactions of several geometrical and physical characteristics.

Davood Younesian.et.al.[9] proposed that based on this study, we now know about several novels and useful ways to use structural mechanics, nanotechnology, biotechnology, composite structures, and mechanical systems that are available thanks to aerospace technology.Researchers can select the relevant type of foundation/structural for their dynamic systems by using the information offered in this study article. This research concludes with a new concept of intelligent foundations that can be used both for energy and self-powered sensing applications in future intelligent cities.

Carlo Rainieri[10] This study outlines some of the explicative uses of the OMA and Structural Health Monitoring (SHM) for bridges carried out throughout the years by the authors. This case study discusses the aforementioned components of OMA development in the last decade, which includes topics like non-destructive evaluation and bridge monitoring, as well as serviceability issues and catastrophic events.

Jean-Jacques Sinou[11]This examination of several fail-diagnosis approaches, such as those for civil engineering and rotating machinery, that are based on linear and nonlinear vibration data is an attempt to cover the entire topic. A fragment can be detected developing in the region of fracture detection over time.

V. CONCLUSION

Due tohorizontally vibrational curved bridges & its high significance during natural catastrophes, the vulnerability assessment of vital infrastructures has attracted much attention in recent decades. The risk assessment represents a vital step in adjusting and enhancing the resilience to hazardous events on roads. The purpose of the presentation of the methodologies was the literature review. Based on the sensitivity analysis, the following items should be included in the design: boundary conditions, number of crossbreds, bridge length, curvature radius, girder separation, bucket number, body depth, buckle thickness, solid final plates, and horizontal bracing systems. Furthermore, the research was performed.

This paper examines the impact of various vibrational parameters on the vibration-free reaction of the I-girder bridges of curved cement-structure composite. Detailed parametric research is carried out to establish their fundamental frequency and mode forms. Modeling of finite elements of stainless cement composite frames, models with deformable shear connection, finite element formulations, finite element mounting, and also finite element calibration.

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