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Free Vibration Analysis of Horizontally Curved Composite Concrete-Steel I-Girder Bridges

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Abstract: The presence of a crack in civil structures has a significant effect on their vibrational characteristics. The objective of the current research is to investigate the effect of crack on vibrational characteristics of bridges using FE simulation. The CAD modeling and modal analysis are conducted using ANSYS software. The natural frequencies are computed and mode shape is generated for each frequency. Then I shaped a girder with the crack that has lower natural frequencies as compared to bridge design without crack. The deformation obtained for bridge deck with cracked I-shaped girder beam is higher than bridge deck design without cracks.
Key Words: Bridge, vibration, natural frequency

I. INTRODUCTION

A bridge is a structure that allows people to pass over an obstacle without blocking the path below. A railway, a road, a canal, a pedestrian, or a pipeline may all require passage. A road, a river, a railway, or a valley may be the obstacle to be traversed. A bridge is a structure that carries the transportation of loads across an incline or over a barrier, such as a canal, road, or railway. Nowadays, many different types of bridges are being constructed.

Continuous bridge

Simply supported bridge

The bridge is simply supported. A bridge's length is usually broken into several separate spans. The load-bearing element is simply supported at both ends of each span. Where neighboring spans are inevitably varied in-depth & length, or Where adjacent spans have significantly disparate designs and layouts of the beams that do not provide continuity, such as different beams spacing or splayed framings, the bridges are merely supported should be used to maintain structural integrity. Simply supported bridges can be desired if the bridge is a component of the facility, like an interchange, where phases will in the future need to be removed or added to one or more spans. T-beam bridges account for the majority of bridges built on highways. IRC codes are created and utilized regularly based on research conducted all across the world. It is built to allow passage over an impediment, which is usually anything that can be crossed by an object. There are many various sorts of designs, each of which serves a certain purpose and may be used in a variety of scenarios. Bridge designs are determined by the bridge's function, the terrain in which it is built, the materials used to construct it, and the cash available to construct it. A bridge is a structure that is built over an obstacle and hence providing a passage without obstructing the object. The passage may be for a railway, a road, a pipeline, a valley, or a canal. The physical obstacle can be a road, railway, water bodies like a river or a valley. The T-beam Bridge is best suited when the span ranged is between 10 to 25 m. T-beam is so-called because the longitudinal girders and deck slabs are cast simultaneously to form a T-shaped structure. The Superstructure consists of the longitudinal girder, cross girder, deck slab, cantilever portion, footpath handrails, and wearing the coat. A T-beam is a load-bearing structure made from a T-shaped cross-section in reinforced concrete. The top of the T-shaped cross part is known as a flange or compression part in order to resist compression loads. The bridge superstructure and another component of the bridge are subjected to a set of loadings conditions that the component must withstand. The design of the bridge is based on these loadings.

II. LITERATURE REVIEW

Mahantesh. S.Kamatagi, (Sep2015), [1] worked on a simple T-beam bridge span that was examined with staad pro. The study found that when class 70R cars are loaded, the maximum bending moment is obtained. Following the results, the T-beam bridge is designed using both methods. It should be noted that the findings obtained using the finite element approach are smaller than those produced using the working stress method. It should also be highlighted that the design of a bridge using IRC 112-2011 is more cost-effective than using IRC 21. It should be noticed that the area of steel required in IRC 112-2011 is less than in IRC 21. The modeling and analysis of an RC T-beam bridge superstructure may be done quickly and efficiently with staad pro. Because the design is based on a probabilistic technique of design, IRC:112-2011 provides an affordable design with a dependable safety margin for concrete bridges. When compared to IRC:21-2000, designing girders utilizing IRC:112-2011 saves longitudinal space.

Abrar Ahmed (July 2017) [2] conducted an IRC specification study of T-beam girders and found that the findings generated using the FEM method are more cost-effective than the one-dimensional analysis. The outcome of comparing the Team and Box Girder designs for spans up to 25 meters or less demonstrates that the T-Beam Girder is the more cost-effective component, but the Box Girder is always appropriate for spans higher than 25 meters. Because box girders have a closed section, the torsional rigidity is higher in them, according to the results. According to the study, a comparative design of the I-Section and Box Section indicates that the Box girder is more expensive for 16.3 m spans but less expensive for 31.4 m spans. Because the shear force and bending moments for PSC T-beam girder are smaller than for RCC T-beam girder bridge, it is always better to use PSC sections rather than RCC, which is more cost-effective and suitable for spans of 24m and higher. Prestressed concrete structures have a much longer life expectancy than reinforced concrete and steel structures.

Anushia K Ajay (June 2017),[3] In this study, a single-span two-lane bridge is subjected to IRC class AA monitored loading while the span is varied, and the results are examined with software. Parametric analyses on several bridge superstructural elements are carried out in this project. The study is primarily concerned with the cost-effective depth of a longitudinal girder for various bridge spans. T-Beam Bridge graphs and diagrams are also created, which can be utilized as a useful aid in the design process. The optimal effective length to the effective depth (I/D) ratio for the economical design of longitudinal girder using LSM is obtained as 14. The cost of the girder will be increased if there is an increase in the grade of concrete and decreases when it is increasing in thickness of the deck slab so It is preferable to keep the thickness between 170 mm and 200 mm.

David A.M. Jawad (2010), [4] According to the paper, The dynamic behavior of vehicle load bridges was extensively investigated for both analytical and experimental purposes. A special committee of the ASCE produced the first significant report on the subject in 1931. The committee's recommendations, These criteria, which were based on data obtained during a series of field tests, are the foundation for American design specifications. This was proposed that the live load due to cars be enhanced by an Impact Fraction in particular (I0/, where L is the burdened length in feet and I is limited to 0.25). Major experimental research was developed and funded in 1962 by the American Association of State Highway Officials to assess the dynamic effects of driving automobiles on short-span highway bridges. The AASHO standard standards for highway bridges specify a variant on the impact percentage given by the equation, specifying that I should not exceed 0.3. In 1981, the ASCE Committee on forces & loads recognized AASHTO's present practice regarding live load impact, with the exception that the term effect is replaced with the more descriptive phrase dynamic allowance for traffic loading whenever applicable in current design requirements.

P. Veerabhadra Rao (Aug 2017) [5] The study conduct simply supported RC T-beam Bridge Rational technique and method for the finite element using staad Pro. This study concluded that when it is compared with the Guyon Masssonet method Courbon's Method gives The average result for longitudinal girder bending moment values in the longitudinal girder. The study also concludes that the bridge deck is an analysis by both method grillage analogy as well as by finite element method. This study concluded that grillage analysis is easy to use and comprehend but analysis by finite element method, it is found that as compared to IRC the load per meter run of IRS loadings was increased by 210%, The Bending Moment due to IRS 25t Loading-2008 load combinations increased on an average of 4.6 times to the Bending Moment due to the IRC loading and Shear force and due to the IRS, 25t Loading-2008 load combinations increased on an average of 3.2 times to the Shear force due to IRC load.

Cornwell et al. [6], Farrar et al. [7], Peeters et al. [8, Kim et al. [9], and Ni et al. [10] all done research on the effects of temperature on the bridges dynamic properties. They attempted to link modal features to temperature, as well as to create models of system identification that could distinguish between influences of temperature and genuine damage indicators on dynamic modal parameters.

III. OBJECTIVES

The objective of the current research is to investigate the effect of crack on vibrational characteristics of bridges using FE simulation. The CAD modeling and modal analysis are conducted using ANSYS software. The natural frequencies are computed and mode shape is generated for each frequency.

IV. METHODOLOGY

The bridge deck with I shape girder is modeled in ANSYS design modeler. The extrude, sketch, and pattern tool is used to develop the CAD design of the bridge. The developed CAD model is shown in figure 4.1 below. The elliptical shape crack is also modeled on one side of the I girder.

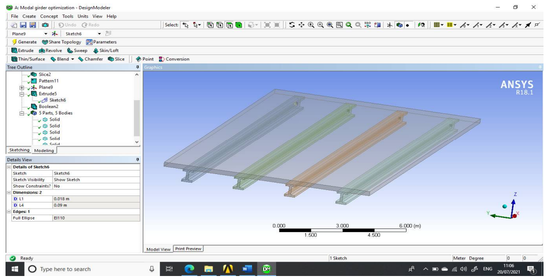

Figure 1: CAD design of bridge deck

The developed design is imported in ANSYS mesher where it is meshed using hexahedral and tetrahedral element types. The element size is set to default and layers are set to 5. The growth rate is set to 1.6. The developed meshed model is shown in figure 3.

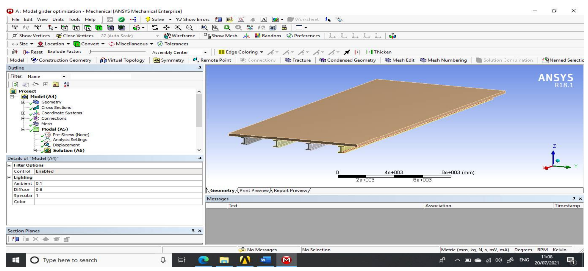

Figure 2: Imported CAD design in ANSYS mesher

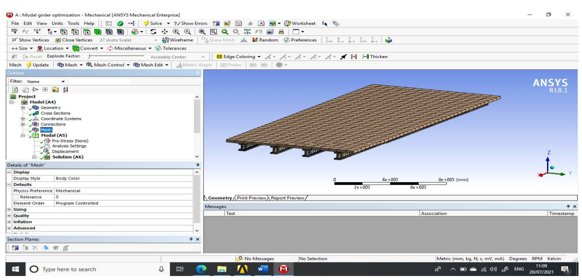

Figure 3: Meshing of the bridge deck and I shaped girder

The loads and boundary conditions are applied on the girder as shown in fig. 4 below. The left face and the right end face of the bridge deck are applied with displacement support wherein all the movements in 3 directions are restricted.

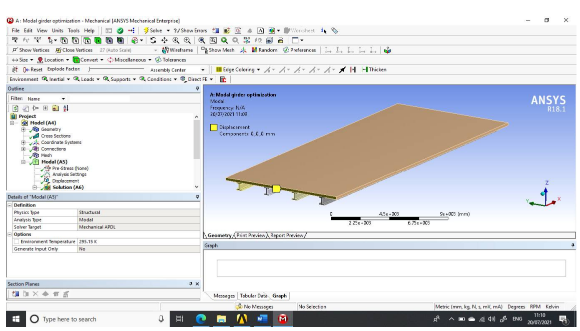

Figure 4: Loads and boundary condition

After applying loads and boundary conditions, the block lancoz method is set for conducting modal analysis. The number of frequencies to extract is set to 5 and the number of frequencies to expand is also set to 5. The solution is run and results are generated.

V. RESULTS AND DISCUSSION

The natural frequencies are computed for the bridge deck with I shaped girder. The 1st mode shape of the bridge is shown in figure 5 below.

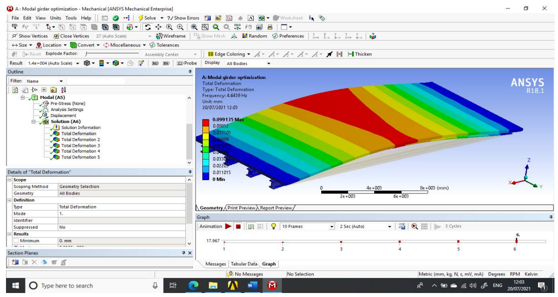

Figure 5: Mode shape of first natural frequency

The maximum deformation is observed at the center zone of the bridge deck and minimum deformation is observed at the fixed support ends of the bridge. The vibration is along the transverse vertical direction with a magnitude of more than .07mm.

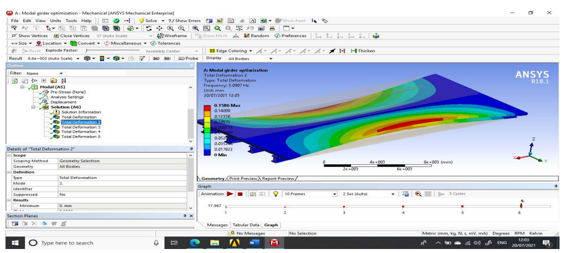

Figure 6: Mode shape of second natural frequency

For the 2nd mode shape, the maximum deformation is observed at the corners (along the transverse direction) of the bridge deck as shown in the red-colored region. The deformation is minimum at the longitudinal center region of the bridge which is represented in dark blue color. The mode shape obtained from the analysis is rotational type.

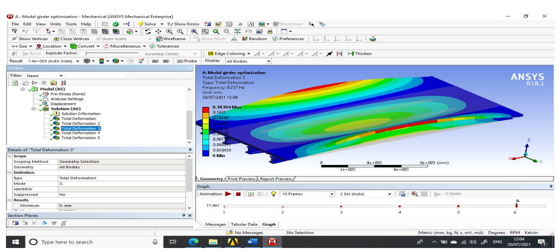

Figure 7: Mode shape of third natural frequency

For the 3rd mode shape, the maximum deformation is observed at the corner edges and at the center of the bridge deck as represented in yellow color. The maximum deformation in the 3rd mode shape is more than .172mm.

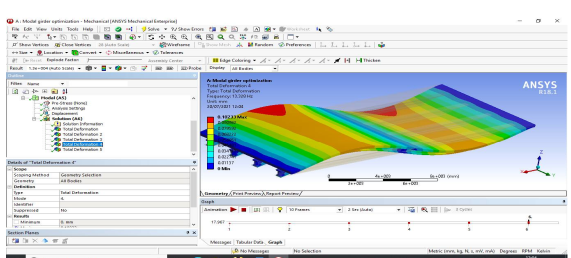

Figure 8: Mode shape of fourth natural frequency

For the 4th mode shape, the maximum deformation is observed at the two locations which have more than .10mm deformation. The location of maximum deformation is at corners. The maximum deformation, in this case, is also nearly .10mm.

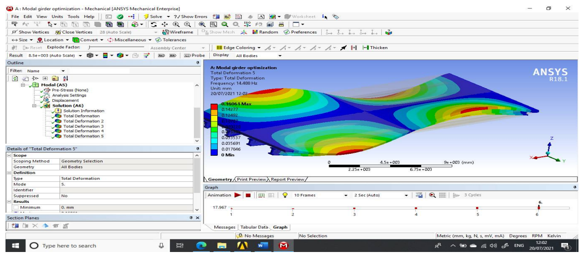

Figure 9: Mode shape of fifth natural frequency

The mode shape corresponding to the 5th natural frequency is shown in figure 9 above. The maximum deformation is obtained at mid-corner regions represented in red color. The frequency obtained from the simulation is torsional with the magnitude of maximum deformation as .16mm.

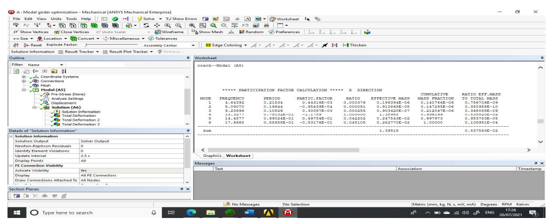

Figure 10: Mass participation along the x direction

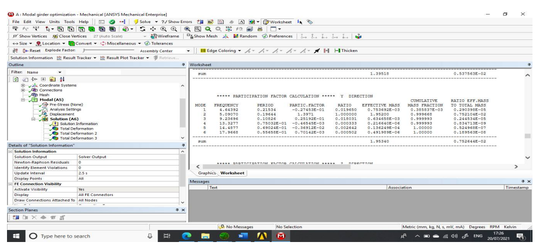

Figure 11: Mass participation along x direction

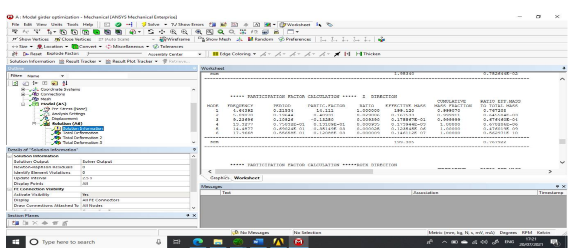

Figure 12: Mass participation along x direction

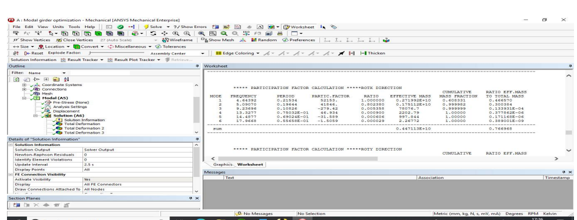

Figure 13: Mass participation along x-direction

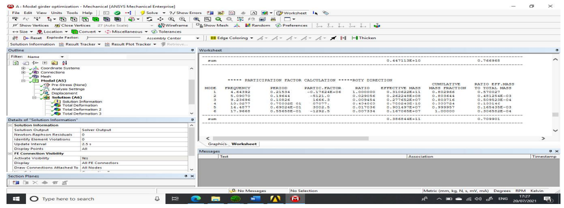

Figure 14: Mass participation along x-direction

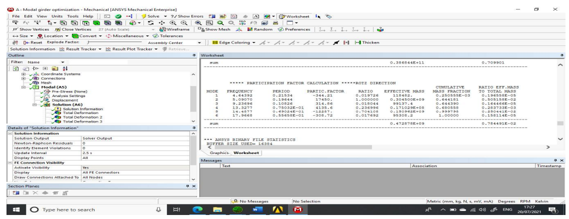

Figure 15: Mass participation along x-direction

The mass participation factors are evaluated for each direction and are shown in figure 10 to figure 15. The maximum mass participation is observed along translational z-direction with a magnitude of .76. This signifies that any external excitation conducted along this direction would cause resonance which would lead to amplitude build-up. The minimum mass participation factor is observed along the longitudinal x-direction. The frequency comparison of cracked I-shaped girder is made with the uncracked design of the bridge. The frequencies obtained for the uncracked bridge are lower than that of the cracked I-shaped girder bridge. The 1st natural frequency of uncracked bridge design is 4.44Hz and 1st natural frequency of cracked bridge design is 4.64Hz.

VI. CONCLUSION

The FE simulation is a viable tool in determining the vibration characteristics of the bridge deck. The simulation packages are time-saving and cost-effective as compared to experimental testing. Then I shaped the girder with a crack that has lower natural frequencies as compared to the bridge design without crack. The deformation obtained for bridge deck with cracked I-shaped girder beam is higher than bridge deck design without cracks. The maximum mass participation is observed along translational z-direction which signifies that any external excitation conducted along this direction would cause resonance which would lead to amplitude build up. The minimum mass participation factor is observed along the longitudinal x-direction.

REFERENCES

[1] Mahantesh.S. Kamatagi, (Sep 2015), Worked On "Comparative Study of Design of Longitudinal Girder Of T-Beam Bridge'' Volume: 02 Issue: 06| Sep-2015 (IRJET)
[2] Abrar Ahmed, (Jul 2017), ''Comparative Analysis and Design Of T-Beam and Box Girders'' Volume 6, Issue 8, August-2015 IRJET
[3] Anushia K Ajay (June 2017), ''Parametric Study On T-Beam Bridge'' Volume 8, Issue 6, June 2017, pp. 234–240, Article ID: IJCIET_08_06_027
[4] David A.M. Jawad (2010), Study On ''Analysis of the Dynamic Behavior of T-Beam Bridge Decks Due to Heavyweight Vehicles'' Emirates Journal for Engineering Research, 15 (2), 29-39 (2010)
[5] P.Veerabhadra Rao(Aug 2017), Study On "Analysis Of Girder Bridge With IRC And IRS Loadings – A Comparative Study' Vol. 6, Issue 8, August 2017 IRJET.
[6] Cornwell P, Farrar CR, Doebling SW, Sohn H. "Environmental variability of modal properties", Experimental Techniques;45–8. 1999
[7] Farrar CR, Cornwell PJ, Doebling SW, Prime MB, et al. "Structural health monitoring studies of the Alamosa Canyon and I-40 bridges", Los Alamos National Laboratory report LA-13635-MS. 2000.
[8] Peeters B, De Roeck G." One-year monitoring of the Z24-bridge: Environmental influences versus damage events", In Proc. of the 18th IMAC. p. 1570–76. 2000
[9] Kim JT, Park JH, Kim WJ. "Vibration-based structural health monitoring under uncertain temperature conditions", Safety and reliability of engineering systems and structures, ICOSSAR 2005. Rome (Italy); June, p. 19–23. 2005
[10] Ni YQ, Hua XG, Fan KQ, Ko JM. "Correlating modal properties with temperature using long-term monitoring data and support vector machine technique", Engineering Mechanics, 27:1762–73. 2005