A Comparative Study of a Suspension Bridge, A Cable-Stayed Bridge, And A Hybrid Cable-Stayed Suspension Bridge

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Abstract: *A suspension bridge is a form of bridge in which the deck is sustained by suspension cables as well as vertically suspenders. Stiffening girders/trusses, main suspension cables, main towers, as well as cable anchorages at either end of the bridge are the essential system components of a suspension bridge system. The main cables, that are tension elements constructed of high-strength steel, are the principal load-bearing components. The main cable's complete cross-section is particularly efficient at moving weights, therefore buckling is not a problem. As an consequence, the bridge's deadweight can be significantly reduced, allowing for a larger span. In terms of presentation, suspension bridges are superior than other forms of bridges.Examining the behavior of three scenarios cable-stayed bridge, a suspension bridge, and a cable-stayed suspension hybrid bridge—under identical loading conditions is the primary focus of this study.*

Keywords: *Cable Stayed Bridge (CSB); Suspension Bridge (SB); Cable Stayed Suspension Hybrid Bridge (CSSHB),Pylon, Seismic Analysis ,CSi Bridge.*

I.INTRODUCTION

James, an American innovator, is credited with creating the contemporary cable bridge. In order to secure this chain along either side of the bridge structure, two cables are employed over the tops of numerous towers. Despite having many similarities, suspension bridges and cable stayed bridges differ most significantly in the manner in which the deck force is transmitted to the cable in a suspension bridge. A cable-stayed bridge has a direct cable connection to the deck. Cable stayed bridges have become more well-liked due to its light weight, enhanced aesthetics, and long span designs. This study focuses primarily on three separate cases: suspension bridges, cable-stayed bridges, and hybrid cable-stayed suspension bridges.Vertical hangers that are attached to the main catenary wires in a suspension bridge support the deck. These principal catenary cables are cradled by pylons as well as anchored at an anchor point located at the end of the span. Modern suspension bridges are more compact, aesthetically appealing, and sturdy compared to any other style of bridge, allowing them to span longer distances.
On a cable-stayed bridge, one or maybe more towers (sometimes referred to as pylons) suspend cables that maintain the bridge deck. Whatever gives it its different character are the cables or supports that constantly run from the tower to the deck, usually generating a fan-like design or a number of parallel linesContemporary suspension bridges, in contrast, feature support cables for the deck that hang perpendicular, connect here across towers, and are attached at both ends of the bridge. The cable-stayed bridge is the ideal choice for spans that are simultaneously short than suspension bridges as well as longer as compared to cantilever bridges. The pylon-supported slanted cables are sufficiently extended to give the deck the necessary lateral stability. The primary catenary wires' suspension sustained the deck under vertical directed forces. Therefore, by including both cables within the same bridge system, the benefits of the both cable-stays as well as suspension cables may be realized. The suspension's length is shortened by the hybrid system. There are new additions like "on-deck pylons" as well as diagonally existing cable remains. Pylon responses are transferred to the main supports through the "on-deck pylons" supports and the main towers, compressing the deck girder system.

II. RELATED WORK

Many writers have conducted independent study on suspension or cable-stayed bridges, but there is little information accessible on hybrid bridge structures. The following is a summary of a few research papers written by authors from different countries.
RajniVerma and RashmiSakalle's research paper, Girder, published in 2022 For dynamic loading conditions, a comparison analysis between a bridge and a cable-stayed bridge was done. Bridges were compared for dead load, live load, and combined load. To determine internal forces, stresses, and deformation of the structure under various load impacts, structural analysis was performed. SAP 2000, an analytical program, was used to model and analyze both cases. the group Priyanka Singh (2021) In this research study using STAAD Pro, the bridge design, model, and analysis for several types of pylons were described. Pylons of the H-type, A-type, and inverted Y-type types are among those that are taken into consideration.Comparing shear force and bending moment in terms of self weight for three scenarios allowed us to identify the type of pylon design that is the most effective. The findings can be applied to lessen the drawbacks of

different kinds of pylons. A. K. Desai and J. H. Gabra (2019) A dynamic analysis of the effects of pylon geometry (shape) on Modulation Times Period(s) for various time histories studies was attempted in the study report using SAP2000. The 1400 m span CSSHB underwent the similar procedure. The fan-type cable layout was considered in the investigation.A dynamic research (Time History) of CSSHB was conducted using 7 different pylon forms to investigate the effects of pylon shapes. The findings indicated that the double diamond, inverted Y, and A shaped pylons are the stiffest, whereas the H and hexagonal shaped pylons are the most flexible.

Ali L. Abass et al (2018) For the study paper, a cable-stayed bridge was modeled and examined using Ansys using the finite element method. The damping effect was investigated in the vertical and inclined directions as an earthquake effect was applied to the cable-stayed bridge in the longitudinal and lateral directions with adjustments to the number, direction, and value of the damping coefficient (c) of the dampers. The findings showed that modifications to inclined dampers' damping coefficient and number were more effective than changes to vertical dampers in longitudinal and lateral earthquakes. Rajesh A. K. and Almas M. (2017) The study investigated the seismic response of a cable-stayed bridge in relation to pylon form.Only the pylon shape—specifically, the A type, H form, and inverted Y shape—was changed; all other variables, including the span dimension, remained same. In their 2017 study, Bilcilintan Patel et al. evaluated the seismic behavior and various vibration modes of cable-stayed bridges.

G. M. Savaliya et.al (2015) Dynamic analysis of a hybrid cable-stayed suspension bridge was done in a research work, taking into account the suspension component's and the main cables' cable sag. The analysis was finished utilizing the principal mode shape time period of the bridge's lateral, vertical, longitudinal, and cable mode forms. Dr. T. Rahman and Kumudbandhu Poddar (2015) This research article focused on the computational analysis of suspension bridges, cable-stayed bridges, and two different types of composite bridges. The Quincy Bayview Bridge served as a model for the cable-stayed bridge. The effects of loads, both static and dynamic, are included in the analysis of these bridges. The analysis was performed using the MIDAS CIVIL Software.

III. METHODLOGY

The approach used to design and analyze Case I, a suspension bridge, Case II, a cable-stayed bridge, and Case III, a cable-stayed suspension hybrid bridge, is presented in this section. Using the analytical tool CsiBridge andsimilar loading circumstances, modeling is done for all three scenarios.

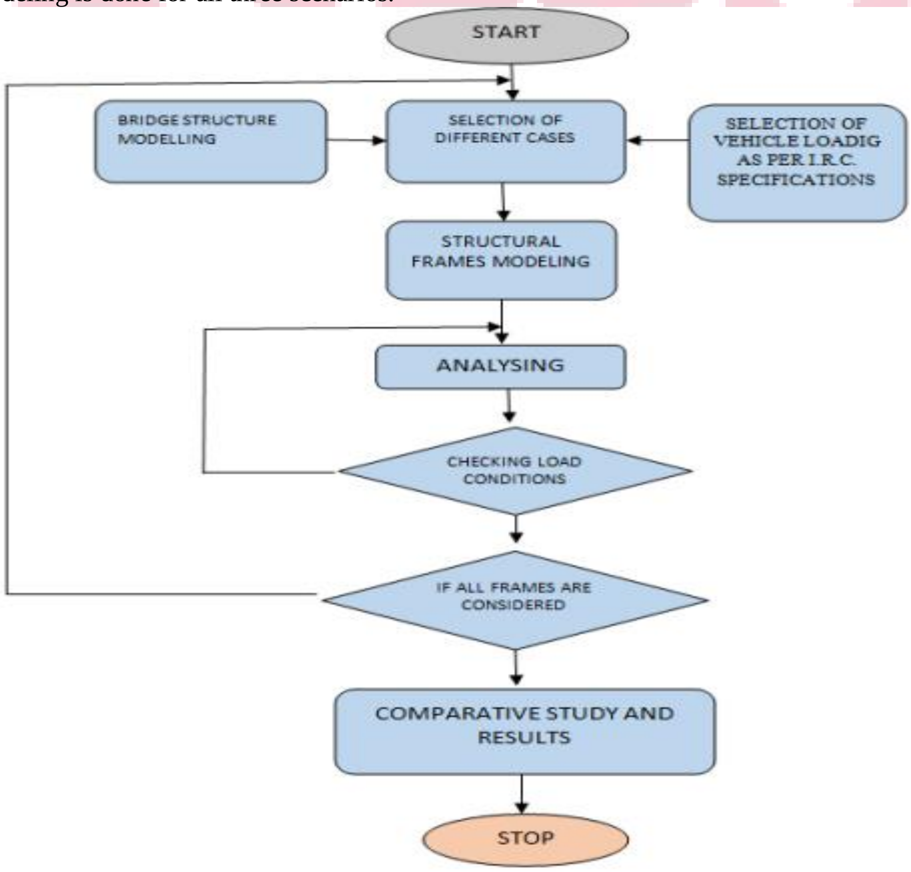

Figure 1: Flow Chart

A. Case I Suspension Bridge

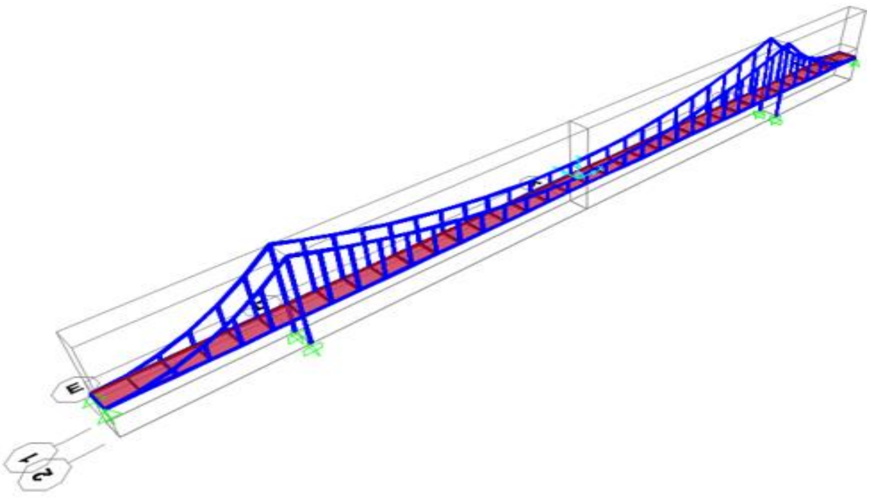

Figure 2: Suspension Bridge

B. Case II Cable Stayed Bridge

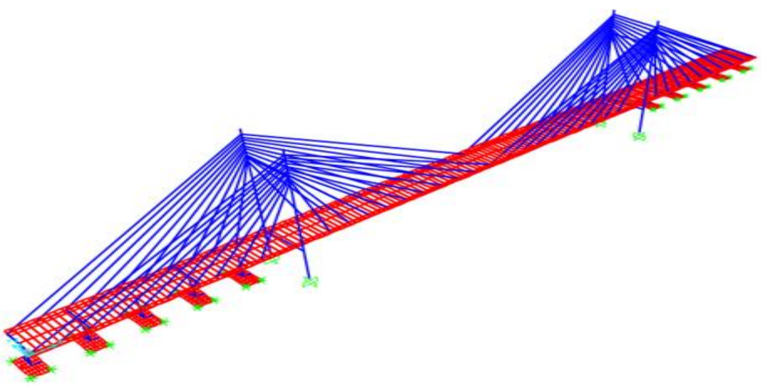

Figure 3: Cable Stayed Bridge

C. Case III Cable Stayed Suspension Hybrid Bridge

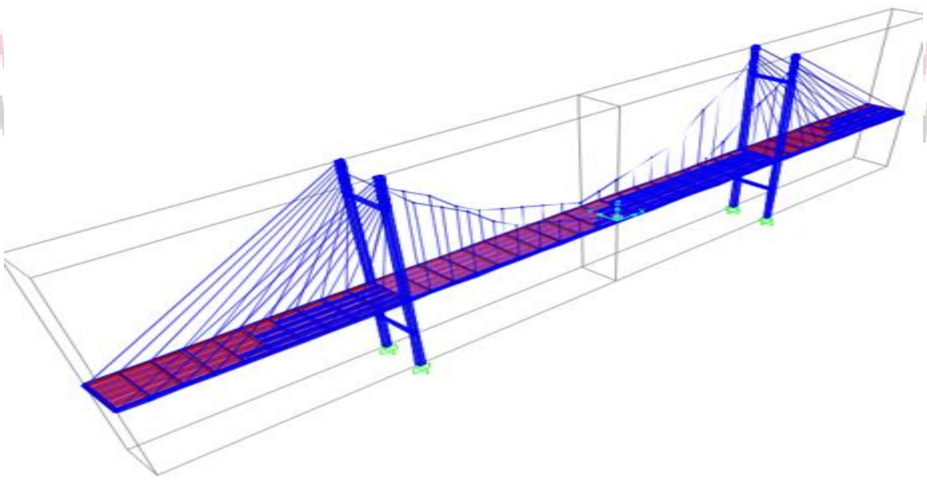

Figure 4: Hybrid Bridge

IV. RESULTS AND DISCUSSION

The results of three separate models of cable-stayed, suspension, and hybrid bridges are presented on the basis of shear force, bending moment, displacement, and axial force. These outcomes are examined in light of the interaction of seismic, live, and dead loads. The table and figures below show a comparison of the three models.

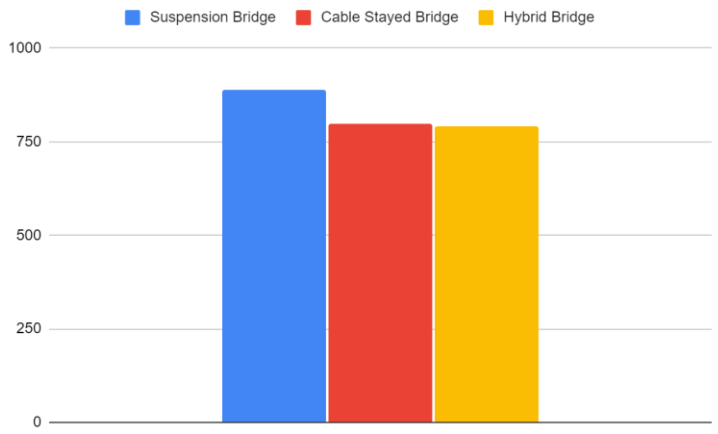

Figure 5: Shear Force in kN

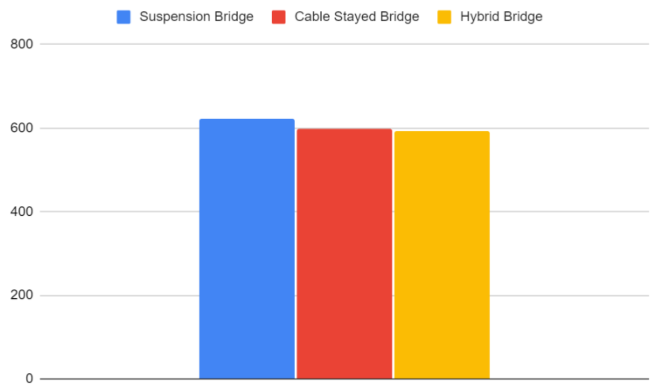

Figure 6: Displacement in mm

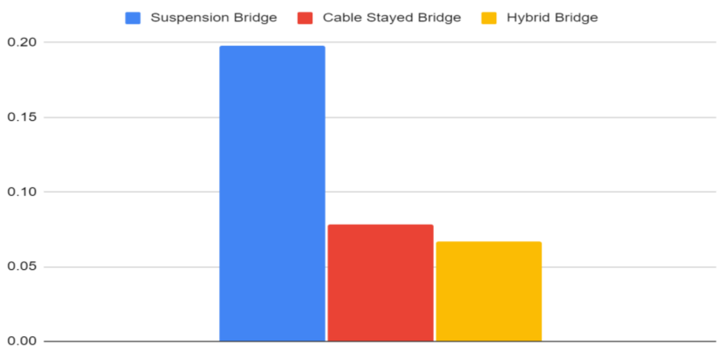

Figure 7: Torsional Values

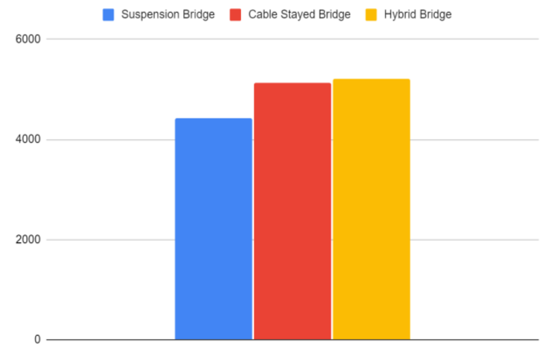

Figure 8: Support Reaction in kN

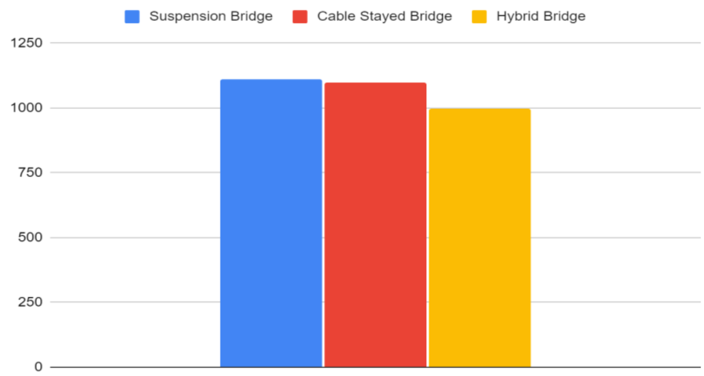

Figure 9: Maximum Moment in kN-m

V.CONCLUSION

In this study, three distinct cases—a bridge, a cable-stayed bridge, and a hybrid cable-stayed suspension bridge—are largely examined. The modelling and analysis was performed using analytical application CSI bridge including vehicular loading and seismic loads.

- ❖ The shear force in this situation was 791.007 kN for the hybrid bridge and 890.394 kN for the suspension bridge. The shear force of a hybrid bridge was 5 and 11% less than that of a cable-stayed bridge and a suspension bridge, respectively.
- ❖ The suspension bridge's maximum deflection in this example was 621.098 mm, the cable-stayed bridge's maximum deflection was 598.768 mm, and the hybrid bridge's maximum deflection was 593.909 mm.
- ❖ In contrast to the other two situations, suspension bridge had the highest level of torsion. For instance, torsion must be carefully considered by engineers who build suspension bridges.
- ❖ Since the joint with fixed support has no degrees of freedom, six support responses are applied from the fixed support to the structure. Here, a hybrid bridge had a higher support reaction than a cable-stayed or suspension bridge by a margin of 6% and 9%, respectively.

The greatest instant occurs when the shear force is zero or changes sign (positive to negative or vice-versa). The Suspension bridge showed the greatest moment, but the Hybrid bridge showed the least.

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