



Article Title: Study of Earthquake Loading On the Analysis of Cable Bridge Structure Using Staad Pro

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ABSTRACT

To overcome the obstacles like crossing of river, Dam, Heavy Traffic flow in the way of journey Bridges were the part of our day-to-day life. Construction of such kinds of Bridges were being much challenging. Construction of bridge works are making the life complicated. Much efficient and quick construction of bridges are very important. Cable stayed bridges are visualized for their less construction time, Higher Efficiency. In the construction aspect cable stayed bridges have less supporting points to the ground when compared with traditional Bridges. By thus it is having higher sensitivity to natural calamities like Seismic activity like Earthquakes. Because of supporting long length by pylons the response of these kind of structures should be analyzed for safe construction and better serviceability. The complicated analysis procedure makes the structure safer. The complicated analysis can be simplified by the software's like Staad Pro. In the software we can create earthquakes in various intensities and the real-time response can be found out. This paper describes more about the cable bridges and their response for the Seismic activity. The analysis procedure is done in Staad Pro and the response of a model cable stayed bridge is figured out for gaining the safety standards for safer construction of Cable Stayed Bridge.

1 Introduction

For the basis of aesthetics and in technically faster construction & less cost of construction the cable stayed bridges are most preferable. The usage of cables for suspending bridges were in practice from ancient times. From the construction of first modern cable stayed bridge (Swedish Stralsund Bridge) the concept attracts the structural engineers. The cable stayed bridges are much useful by reducing the construction materials. Since they use minimum support the blocking of piers underneath the way considerably reduced. The construction method of cable stayed bridges is the most challenging phase for the engineers. Since there are many kinds on cable bridges selection of any kind is important. The most common types of cable bridges are side-spar cable-stayed bridge, cantilever spar cable stayed bridge, multiple span cable stayed bridge, extra dosed bridge, and cable stayed cradle-system Bridge. These kinds are categorized by the arrangement of cables to the main pylon. E.g. Side- spar cable stayed bridge have the cable arrangement that connect the pylon to any one side of the bridge deck. The type of cable stayed bridge analyzed in this paper is cable stayed cradle-system Bridge. It is the most common type of cable stayed bridge. It has less construction complications in compared with other types. In thus the stay cables are connecting the pylon to both sides of the Bridge Deck.



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The cable stayed cradle-system bridge by itself have three types based on the cable arrangement they are Harp arrangement, Fan arrangement, Semi-fan arrangement.



Figure 1: *Side-spar cable-stayed bridge*



Figure 2: *cable stayed cradle-system Bridge*

The Harp arrangement is not suitable for large span bridge because of requiring taller pylon and large forces in stay cables. The Fan arrangement require considerably higher number of stay cables and also require higher weight of anchorage. Therefore, the semi-fan arrangement is much suitable for modern spans with less stay cables and have high aesthetic values. The main difference between these kinds are the connection of stay cables to the pylons. In the Harp arrangement, the stay cables are attached to the Pylon evenly from top to bottom. In opposite to that the Fan type contains the stay cables attachment to the singular spot on the top of the pylon. The Semi-fan arrangement is the combination of Harp type and Fan type arrangements.



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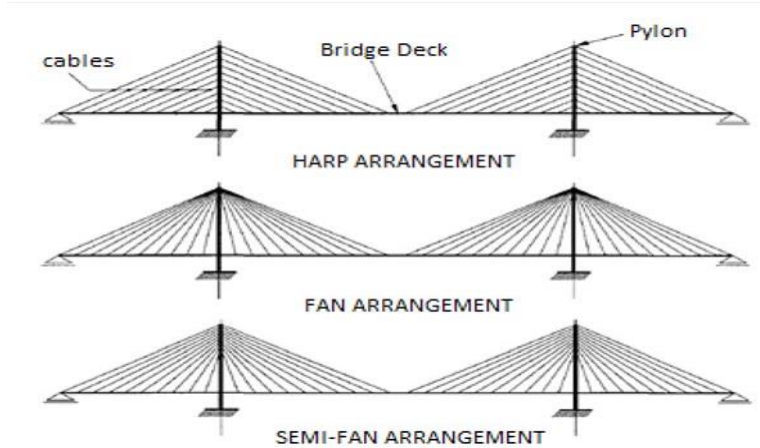


Figure 3: Cable arrangements

Components of Cable Stayed Bridges

The cable stayed bridge have 4 major components they are, Pylon, Stay Cables, Deck and the Foundation. The load transferring will be from Deck through the cables to the Pylon which transfer the load to the Foundation. The cables here are the tension members and the Pylon is the compression member. The selection of suitable members is much important for the better and safe construction. Here stay cables are the cables—of strand, wire or carbon which are used for transferring structural load and for supporting the bridge deck without having piers underneath. Since stay cables act like supporting members the use of piers can be reduced. There are three kinds of stay cables they are parallel steel strand, wire and carbon. Wire stay cables are generally prefabricated and strand stay cables are more commonly assembled in site using strand-by-strand installation method. The carbon type stay cables have comparatively less self-weight than others so thus it is more useful in construction of long span bridges. The use of stay cables which have elastic properties are useful in the reduction of strain energy caused by earthquakes. Generally, the steel used as stay cables have yield strength up to 1180 MPa and Tensile strength up to 1570 MPa.

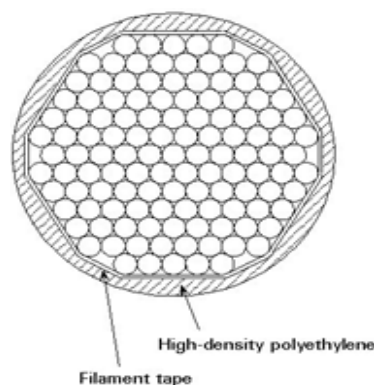


Figure 4: Parallel strand stay cable



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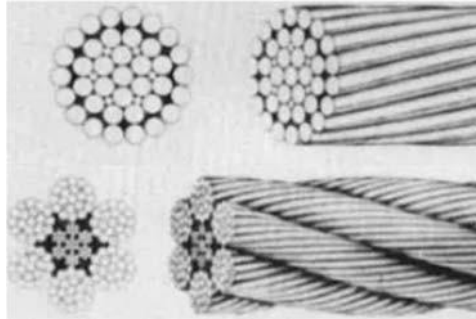


Figure 5: wire strand stay cable

There are many types of towers in cable stayed bridge based on the arrangement of pylons some are single tower, Twin tower, A-frame tower, Diamond tower. In thus the diamond tower is more attractive. Due to the changes in the shape of towers each kind have its own advantages and disadvantages. Some are efficient in transferring heavy loads some make the construction procedure more complicated. For a safe construction of cable stayed bridge to withstand the earthquake pressure suitable tower arrangement can be selected.



Figure 6: Types of tower arrangements

The substructure performs two main functions one is transferring vertical load from the super structure and resisting the horizontal forces acting on the bridge. Based on the soil type and according to the amount of load from the pylon suitable foundation type should be selected. A cable stayed bridge requires large lateral capacity, a high capacity of soil or rock anchor system, a group of driven piles, or a group of large diameter drilled shafts. The most common type of footing used is the pile group covered by both pylons with suitable pile cap.



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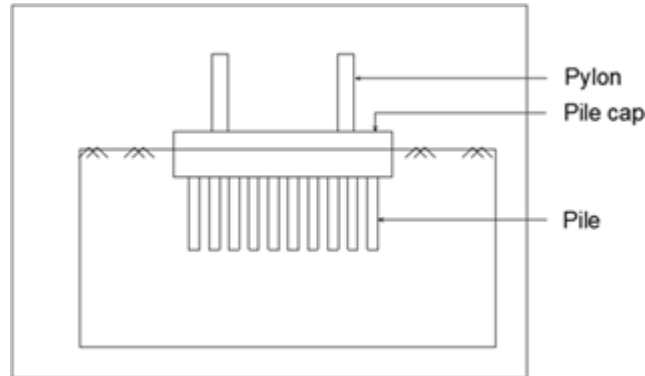


Figure 7: *cross section of foundation model*

Seismic forces can weaken the structure easily, in order overcome that a well analyzed construction type should be proposed. Seismic analysis allows us to visualize the response of a bridge during an earthquake, which enables us to obtain the additional forces or deformations that would generate because of an earthquake. We can reduce the impact of seismic forces by introducing some structural elements like seismic dampers etc. Analytical model of cable stayed bridge: Analytical procedure including modelling, designing and analyzing provides the impact of loads on the particular structure. The procedure can be kept in software's for the ease of work, which can reduce the risk factor on the construction. The loads to be considered are the self- weight, live load, wind load, seismic load and thermal load. And the combination cases proposed by suitable standers should be considered. For the steel structure implantation of thermal load is a must. Thus the analysis can provide the effect of thermal stress ant it can be reduced with suitable connections.

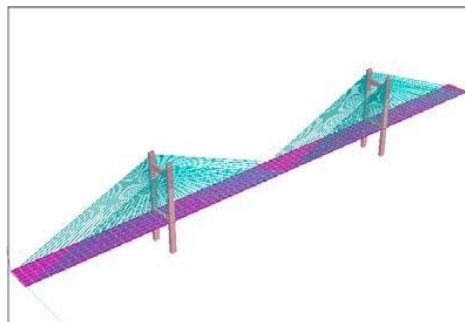


Figure 8: *Rendered view of Staad model*



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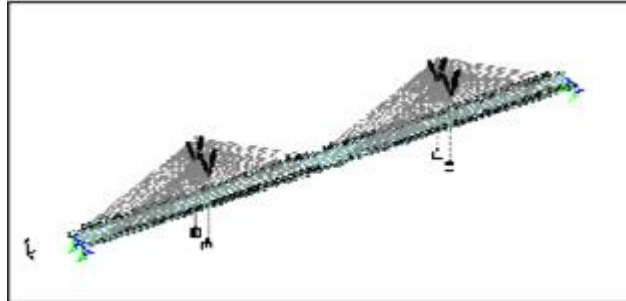


Figure 9: Staad Model

The Staad model is developed for finding the response of seismic forces. Total length of the model is 474m and width of 22m. The deck used for the analysis is of steel frame type. In this buildup steel sections are assigned throughout the frame and the concrete deck is placed above this. Cable members are assigned in the end sides of cross beams to the pylon. Self-Weight of the structure assigned by Staad pro itself. And the seismic load is generated in both two direction of the model as shown in the fig 10 and fig.11. The load can be assigned in any one direction (positive direction) to find the maximum response since the model is symmetrical.

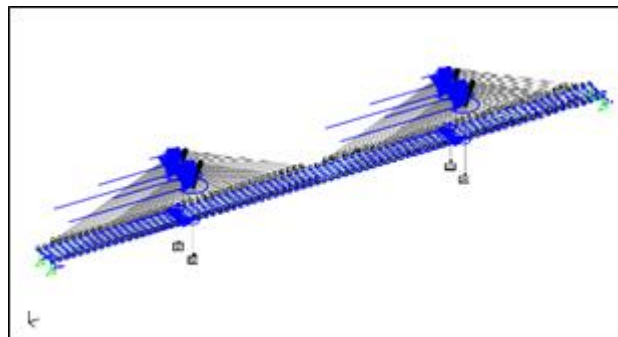


Figure 10: seismic load assigned in x direction

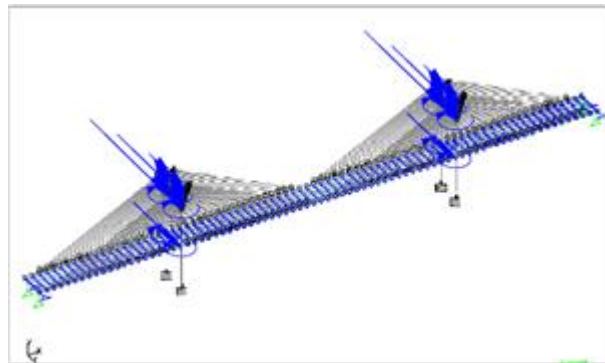


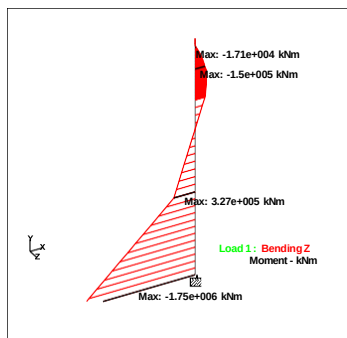
Figure 11: seismic load assigned in z direction



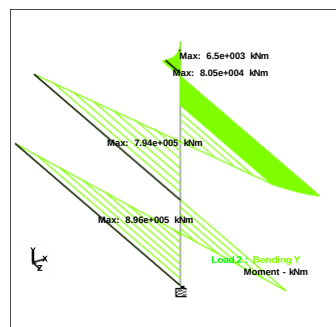
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Response of Analytical model

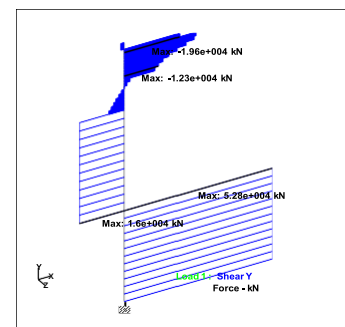
The maximum bending moment occur in the pylon for the generated seismic force along x direction is 1.744×10^6 kNm. Which is at the bottom of the pylon. And along the z directional force the maximum bending moment is 8.9×10^5 kNm. Which occur in the bottom of the pylon. The maximum shear force for x directional seismic force is 2.4×10^4 kN. Which is at the connecting points of cables to the pylon. And for the z directional seismic force the maximum shear fore is 1.9×10^4 kN. The maximum Axial Fore along x direction is 2.75×10^3 kN. And for z direction 2.03×10^5 kN. (BMD – Bending Moment Diagram, SFD – Shear Force Diagram, AFD – Axial Force Diagram)



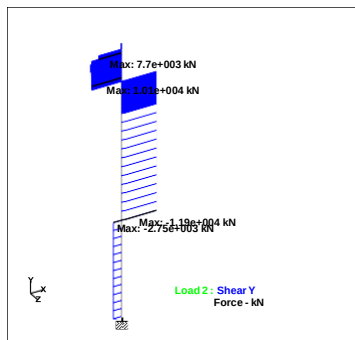
BMD (seismic x Direction)



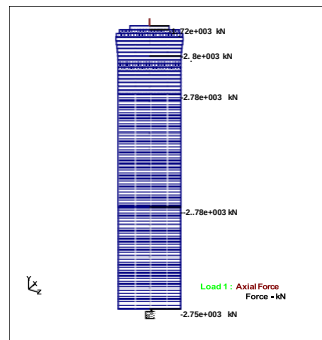
BMD (seismic z Direction)



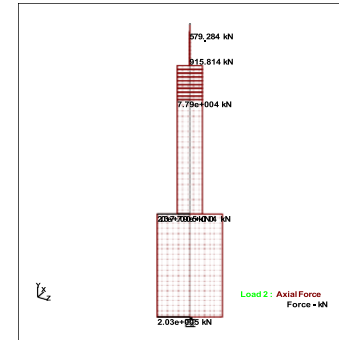
SFD (seismic x Direction)



SFD (seismic z Direction)



AFD (seismic x Direction)



AFD (seismic z Direction)

2 Result

The study of effect of earthquake load on a cable stayed bridge model is done using the Staad Pro software. The study shows that the maximum bending moment due to seismic forces assigned occur in the bottom of the Pylon. A suitable foundation method should be proposed for resist the seismic forces. This study shows that the maximum bending occur in bottom of the pylon and maximum shear occur in connection between pylons and stay cables. The suitable connection between pylon and stay cable may reduce the seismic force in the cable bridge structure.



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3 Conclusion

For a safe construction of bridge structures analytical procedures gives an assurance of the service life. The staad pro analysis of model cable stayed bridge provide the necessary details about the impact of seismic force along the two directions of the model. The maximum bending moment value generated and the position of the bending moment occur gives the necessary data for the future analysis. Required systems for preventing the maximum forces can be employed. For example elastic properties added to the stay cables reduces the strain energy. Especially thermal releases in the connection of long length of bridge decks reduces the thermal load occur in the structure. In order to reduce the impact of seismic force multiple combinations of member design and connection can be choose. The reduction in the self-weight also reduces the impact. Usage of seismic dampers and suitable bearings can help to prevent accidental damages. By understanding the impact forces, trial and error method in analytical procedure improves the serviceability of the structures and reduces the risk factors. This study employs the impact of seismic force in model cable bridge structure for better understanding and design.

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