Effect Of Damper Position On The Behavior Of Suspension Bridge Subjected To Dynamic Loading

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Abstract- *Suspension bridges are most probably the most extraordinary form of bridges that can span a very extensive canyon and waterway. Suspension bridge is the one in which the weight of deck is supported by the vertical suspenders and these cables are suspended further from main cables. Wind included vibrations have been the primary concern in the analysis of suspension bridge, but in the recent decades, earthquake effects have also gained the importance. The main aim of this paper is to evaluate the behavior of suspension bridge under dynamic loading. The analysis is carried out by SAP 2000 software. Moreover, the effect of damper position on the structure behavior of suspension bridge under dynamic loading has been evaluated. The influence of water level of suspension bridge located on river and sea has also been incorporated in the dynamic analysis of suspension bridge.*

Keywords- Suspension bridge, wind load, water pressure, wave impact, dynamic analysis.

I. INTRODUCTION

Suspension bridges are remarkable for long span dynamic beauty. Suspension bridge is the one in which the weight of the deck is supported by vertical suspenders and this suspenders are further suspended from the main cable, which are catenary in shape. The main steel cables of the suspension bridge are supported by high towers.

In the earlier times, suspension bridges were constructed with iron chain cables. Later on, a rapid expansion of the central span length took place in the 19th century triggered by the invention of steel. At present, suspension bridges represent 20 or more of all the longest span bridges in the world. The span range usually varies from 70 to 2000 metres. Presently, Akashi Kaikyo bridge in Japan is the longest suspension bridge in the world (Total length: 3911 m).
M.-F. Liu [1] observed that the deformation of the cable produced more oscillations due to the flexible property of the cable. Moreover, it was also concluded that the interaction of moving loads and seismic forces amplify the response of the long-span suspension bridge.

Meng-Gang Yang [2] concluded that MR damper is an effective imitation of the damping force as compared to other dampers. In addition to this, it was also observed that the passive control with optimum input current performs better than the other control systems.

I.F. Lazar [3] compared the performance of Tuned Inerter Dampers with that of the Viscous Dampers. The results showed that TID (Tuned Inert Damper) can be considered as a viable alternative to VDs (Viscous Dampers) when used to limit unwanted cable vibrations.

Xing Shen [4] proposed a novel seismic system in which the Transverse Steel Dampers(TSDs) were combined with conventional sliding bearings. The seismic behavior of this system was carried out by Quasi-static tests. The results concluded that the proposed TSD seismic system proves to be beneficial for long span bridges.

Christopher Bradner [5] measured the dynamic response of the bridge specimen using strain gauges, displacement sensors and accelerometers. The experimental results showed that the wave load has great impact on the bridges.

Fig -1: **Akashi Kaikyo Bridge (Japan)**

1.1 Dynamic Analysis Method

Basically dynamic analysis is a simple extension of static analysis. The response of a structure to earthquake motion and wind load is evaluated with help of dynamic analysis. This can be achieved by applying several analytical techniques. Moreover, the effect of various damper position on displacement, vibration and velocity can be carried out. Response spectrum analysis method has been used for the dynamic analysis. Response spectrum analysis is basically the statistical type of analysis for the determination of likely response of a structure to seismic loading. In addition to this, the water pressure and wind load calculations are carried out with respect to IRC codes while the wave force of sea are calculated on the basis of SPM charts. The analysis is also been carried out for with and without damping.

II. RESEARCH SIGNIFICANCE

It is very important to design the structure after understanding its behavior under moving, seismic and wind loading. The Structural designer has several alternatives to choose from while defining a structural system that fit the architectural layout. For bridge structure there are three main parts which are as below:

1. Super structure(bridge deck)
2. Sub structure(bridge piers)
3. Foundation(pile or well foundation)

Earthquake is the worst among the natural disasters. Moreover, in case of suspension bridges, wind force also play a significant role. Therefore, it becomes important to find out the convenient damper position for stabilization of bridge under dynamic loading. Moreover, the water wave forces of river and sea are different. So it is important to study the effect of water wave forces on the piers of suspension bridge. Also, the design considerations will be checked. Moreover, its stability will be checked under dynamic loading.

III. BEHAVIOUR OF SUSPENSION BRIDGE SUBJECTED TO DYNAMIC LOADING

In the present study, suspension bridge has been analysed for different load combinations. The variables incorporated are wind load and water pressure; in case of river, while in case of sea, wind load and wave force are used as variables.

The loads considered for the analysis are dead load, live load, earthquake load, wind load, water pressure (in case of river) and wave impact (in case of sea).The load combinations are taken according to the criteria of Limit State of Serviceability as per IRC:6.

The different damper position considered are as follows:

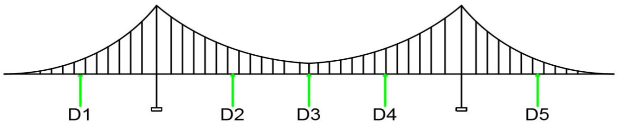

Fig -2: Various Damper Position

Small span bridge data:

Left span length: 97.6m
Middle span length: 244m
Right span length: 97.6m
Deck width: 23.6m
Column height H1: 20m
Column height H2: 50m
Minimum middle sag: 6.10m

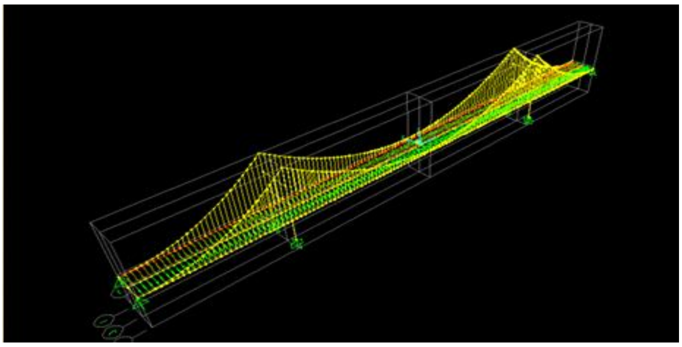

Fig -3: Geometry Of Small Span 3D View

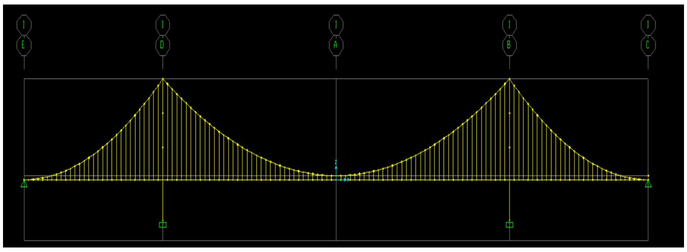

Fig -4: Geometry Of Small Span 2D View

Long span bridge data:

Left span length: 255m
Middle span length: 500m
Right span length: 255m
Deck width: 23.6m
Column height H1: 30m
Column height H2:70m
Minimum middle sag: 9.15m

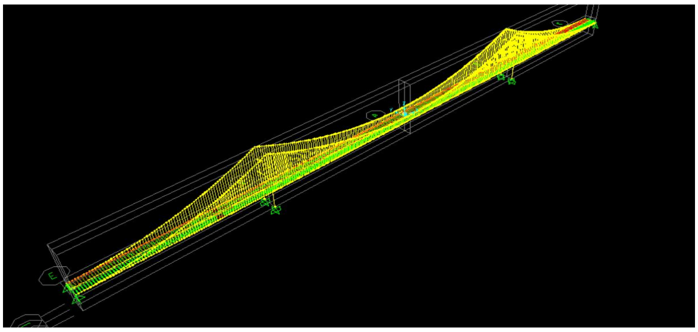

Fig -5: Geometry Of Long Span 3D View

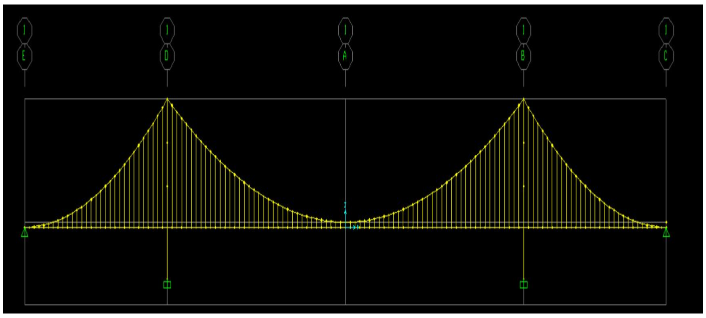

Fig -6: Geometry Of Long Span 2D View

IV. ANALYSIS RESULTS

4.1 Small Span

In accordance, to the similar data of small span, different damper positions are compared. The results are extracted in form of spectral displacement, spectral velocity and spectral acceleration.

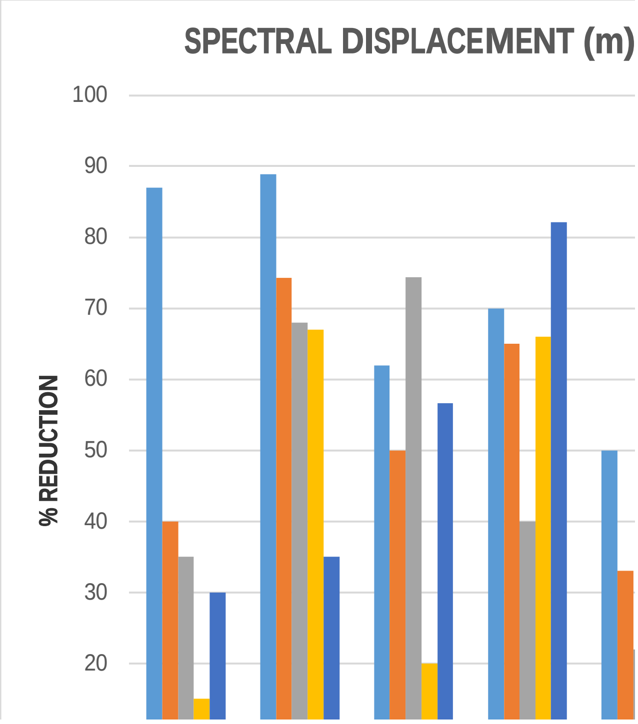

Chart -1: % Reduction In Spectral Displacement

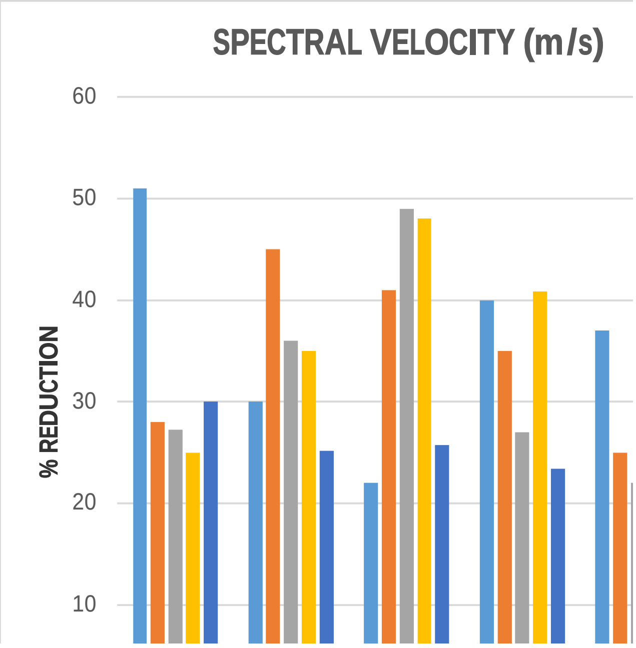

Chart -2: % Reduction In Spectral Velocity

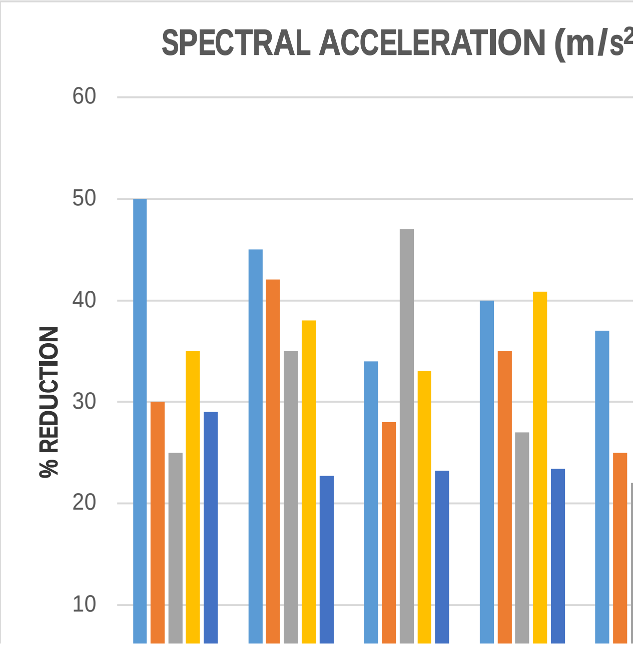

Chart -3: % Reduction In Spectral Acceleration

4.2 Long Span

In accordance, to the similar data of long span, different damper positions are compared. The result are extracted in form of spectral displacement, spectral velocity and spectral acceleration.

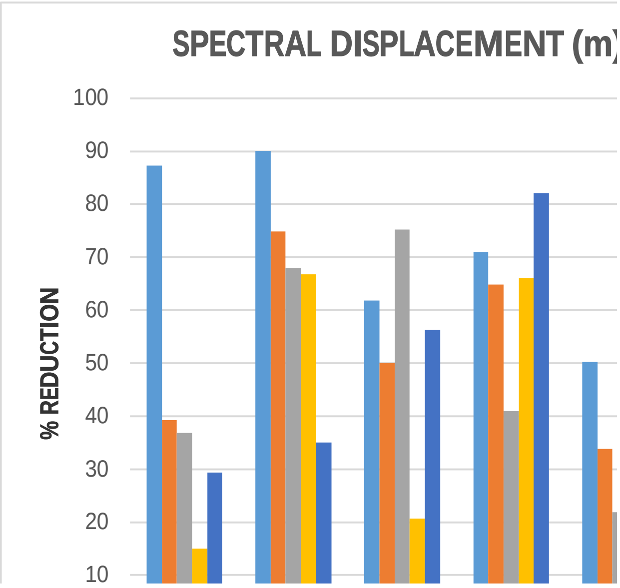

Chart -4: % Reduction In Spectral Displacement

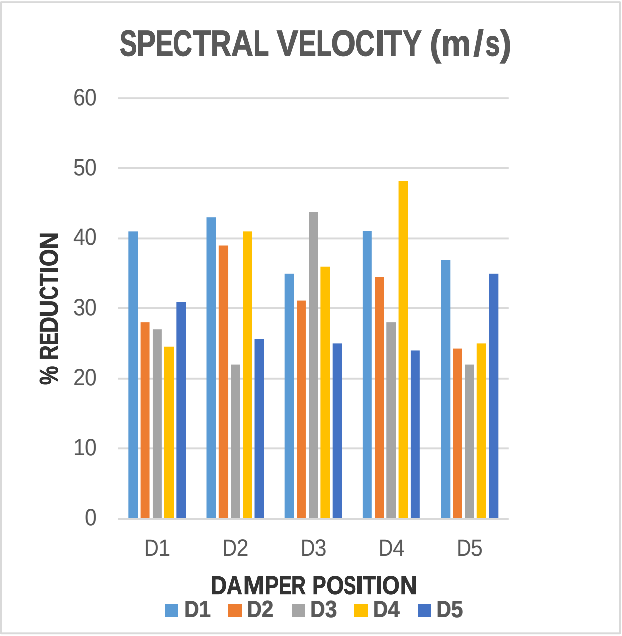

Chart -5: % Reduction In Spectral Velocity

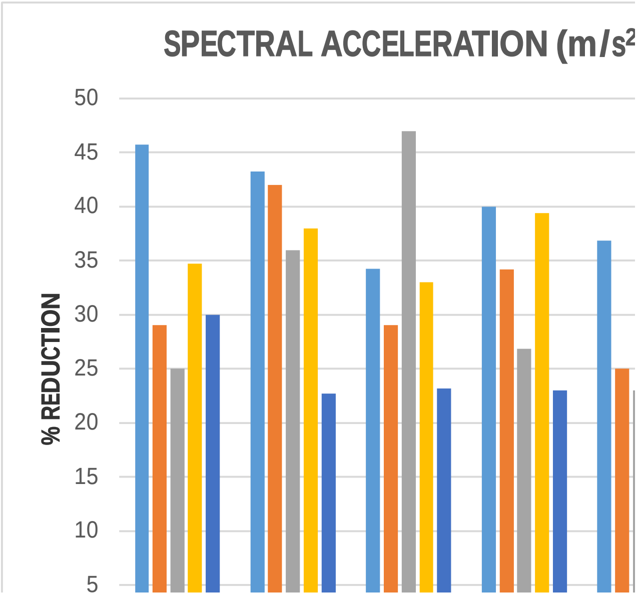

Chart -6: % Reduction In Spectral Acceleration

V. INFLUENCE OF WATER LEVEL ON SUBSTRUCTURE IN PRESENCE OF WIND LOAD:

Table -1: Different Water Depths:

Case	Depth (m)
Case 1	12
Case 2	15
Case 3	17

As the water level increases, the exposed height subjected to wind loading decreases. Due to this, the value of base shear decreases with the increase in water level.

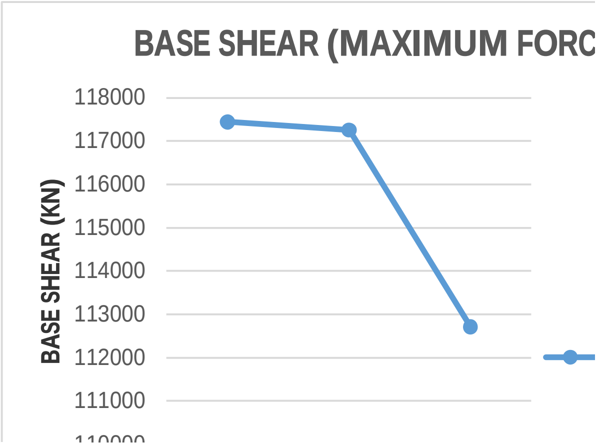

Chart -7: Base Shear (Maximum Force)

VI. CONCLUSION

The behavior of the suspension bridge varies with the variation in the damper position when subjected to dynamic loading. Moreover, based on the results of spectral displacement, spectral velocity and spectral acceleration ;it can be concluded that the dampers placed on the central span are more effective than those placed at the left span and right span.

With the increase in the water level, the value of base shear decreases as the exposed height decreases with the increase in water level. Thus, it can be concluded that water level has great impact on the substructure of bridge

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