Study on Superstructure and Substructure of Cable-stayed Bridge

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***Abstract*: This paper includes study on cable-stayed bridge. For analysis 100 m, 150 m, 200 m, 250 m and 300 m spans are considered. The software used for study is CSIBridge software. This paper is concluded with study on various parameters of this of bridge. The parametric study includes study on deck moment, how response of bridge varies span wise, pylon height and span length to thickness of girder. The effect of superstructure changes on substructure is also studied.**

***IndexTerms* - CSIBridge, cable-stayed bridge, bending moment, shear force, deck moment, pylon height, girder depth.**

I. INTRODUCTION

Supporting a beam or bridge by inclined cable stays was the concept used in cable-stayed bridge, the inclined cables of the cable-stay bridge support the bridge deck directly with relatively taut cables. Morandi's Lake Maracaibo Bridge in Venezuela, constructed in 1962 is generally considered to be the first modern concrete cable-stayed bridge; however, it was preceded by two other tittle known concrete cable-stayed structures. The evolution of concrete cable-stayed bridges is traced from Torroja's Tempul Aqueduct in Spain, completed in 1925, to present day design concepts [6].

Figure 1: Maracaibo Bridge, Venezuela

II. LITERATURE REVIEW

Leonhardt and Zellner (1980) the author described cable-stayed bridge as a new type different from beam bridges. Many stay cables, closely spaced reduce the required depth and bending stiffness of longitudinal deck girders to a minimum, governed by the buckling safety and the allowed curvature of the deflection line. Pure tension and compression prevails, bending and shear becomes secondary. This leads to simple cross sections, simple cable anchorage, easy construction and superior dynamic behaviour, if one chooses high cable stresses. The new system allowed main spans upto 700 m for concrete and up to about 1,700 m for steel with considerable savings over suspension bridges.

Podolny (1981) had talked about the history, preferences, basic game plan, and stay-cable spacing of concrete cable-stay bridges. As late as 1970, the reasonable traverse restrain for steel cable-stayed structures was thought to be 1000 ft (300m). The idea of a concrete cable-stayed bridge had expanded the down to earth and competitive economic span range to the degree that concrete is a reasonable material option in the long-span bridge go. Supporting a beam or bridge by slanted cable stays was the idea used as a part of cable-stayed bridge; the slanted links of the cable-stay bridge bolster the extension deck specifically with moderately rigid cables. In spite of the fact that the cutting edge renaissance of cable-stayed bridges are said to have started in 1955, with steel as the favored material, over the most recent two decades various cable-stayed bridges have been built utilizing a strengthened or prestressed solid deck framework. Cable-stayed bridges had expanded the focused traverse scope of solid extension development to measurements that had beforehand been viewed as unthinkable and held for basic steel. With innovation of construction, prestressing, and segmental cantilever development, clearly cable-stayed bridges were broadening the focused traverse scope of solid scaffolds to measurements that had beforehand been viewed as unimaginable and in a range which had already been the area of basic steel. The mechanical means exist, they just require execution.

N. Krishna Raju (2009) a progressive way to deal with connect outline and development initially brought about by the German Engineer Dischinger in 1938 and later set in motion in the development of first present day link stayed connect is the Stromsund Bridge in Sweeden around 1953. This development made ready for the development of acclaimed Rhine family link stayed spans with ranges up to and surpassing 300m. As per Leonhardt, link stayed spans were actually, monetarily, stylishly and efficiently better than the traditional suspension spans for ranges in scope of 700 to 1500m. The mix of link remains with cell box support prestressed solid decks have fundamentally expanded the traverse scope of expressway spans. India's first link stayed connect was the Akkar Bridge in Sikkim finished in 1988 and reaching out finished a length of 157 m with a solitary arch stature of 57.5

Bannazadeh et al. (2012) in this article cable-stayed connect was examined from numerous perspectives, for example, number of spans, number of towers, number of cables and support composes. Cable-stayed bridges are auxiliary frameworks which are successfully made out of cables, principle girders and towers. Cable-stayed bridges are ordered in 3 classifications of harp, fan and radial. This ordering has been founded on a connection between the examples of cables and the width of spans. The principle worry of the investigation was to characterize the connection between the cable examples and the fundamental traverse length. By breaking down the outcomes it was inferred that the larger part of cases characterized were worked with harp designs. Notwithstanding this information it was reasoned that fan designs were utilized for actualizing longer spans. The principle reason was the superior of this example in directing powers.

Leonhardt (1987) had talked about the utilization of prestressed concrete in development of cable-stayed connect. The quantity of cable stayed bridges with cement or steel has expanded in the most recent decades. The greater parts of the bridges were comprised of steel. Actually by utilizing solid material the outline, auxiliary itemizing and development strategy can be disentangled, subsequently delivering a scaffold that is monetarily and tastefully unrivalled. The motivation behind this article was to introduce the most recent cutting edge on cable stayed bridges while expounding upon the basics and conceivable outcomes relating to such structures.

III. METHODOLOGY

The research work comprises a study of response of bridge deck for various different spans and 70R loading. The parametric study includes response of deck, deck moment, how the response of bridge varies span wise, pylon height and span length to thickness of girder ratio. Check the bridge analysed for class A and class AA loading. The model will be developed using CSI Bridge software.

IV. ANALYSIS USING CSI BRIDGE SOFTWARE

Present work involves parametric study on superstructure and substructure of cable-stayed bridge with fix common parameters. Analysis is done in computer aided software CSI Bridge as per Indian Standards. This bridge is analysed for span of 100m, 150m, 200m, 250m and 300m.

Fixed parameter of bridge and data taken for analysis are as following:
Deck type: Box girder
Width of bridge: 9.4 m (Two lanes)
Time variables: creep and shrinkage included.
Vehicle loading: IRC 70R-Wheeled loading (as per IRC)
Staged analysis done.
Bridge impact factor: 1.088 (as per IRC)
Concrete: M75
Steel: Fe1860

V. MODELLING

Following steps were followed while generating models for different spans:

- Selecting layout line.
- Selecting Frame Properties.
- Selecting Material Properties.
- Draw pylon.
- Select required deck section.
- Define Discretization points.
- Select Link properties.
- Draw rigid links.
- Select Cable properties.
- Draw cables.
- Define groups.
- Assign groups.
- Assign Supports.
- Define construction stages.

- Define lanes.
- Assign loads.
- Run.

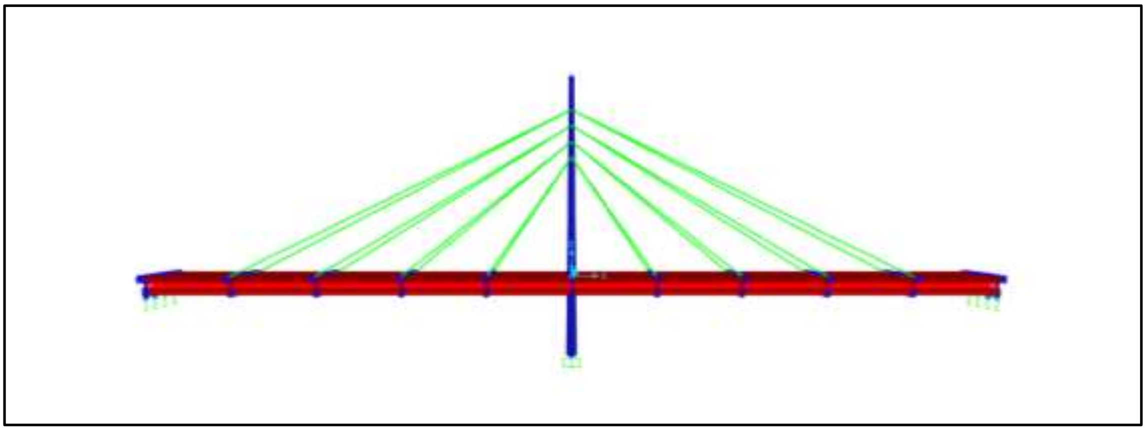

Figure 2: 3D model of cable-stayed bridge for 100m span.

VI. RESULTS AND DISCUSSION

6.1 Bending Moment

Dead load bending moment

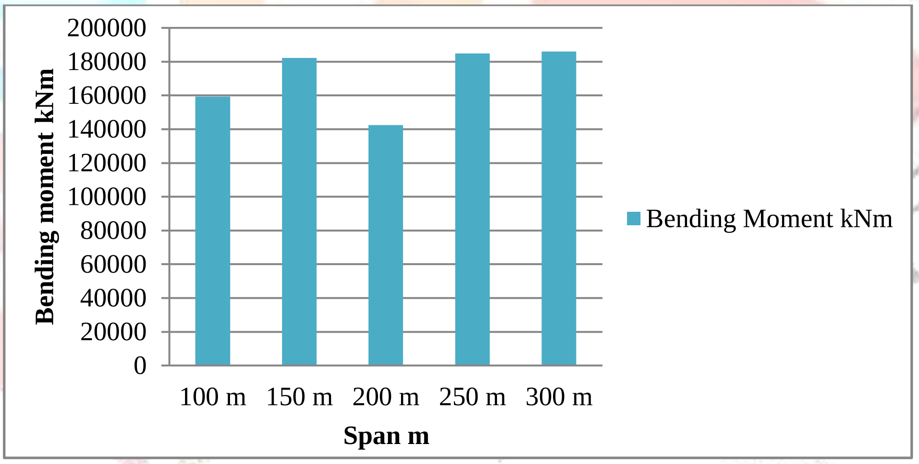

Figure 3: variation of dead load bending moment for cable-stayed bridge

Moving Load Bending Moment

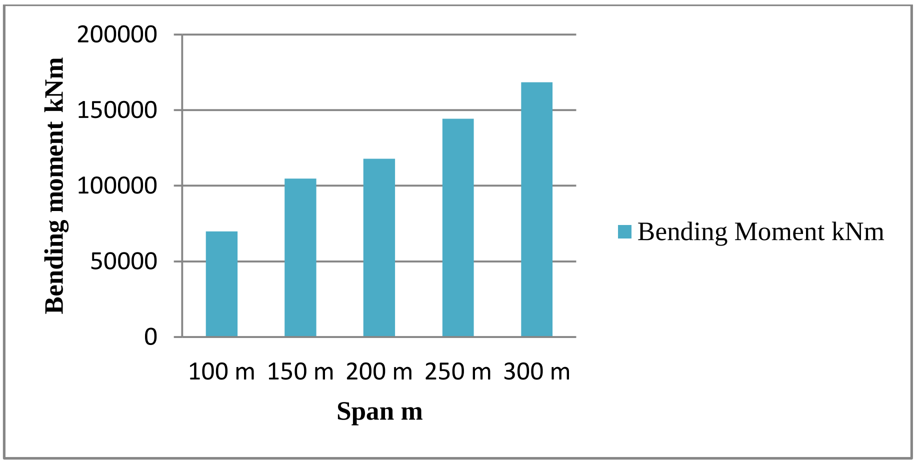

Figure 4: variation of moving load bending moment for cable-stayed bridge

6.2 Shear Force

Dead Load Shear Force

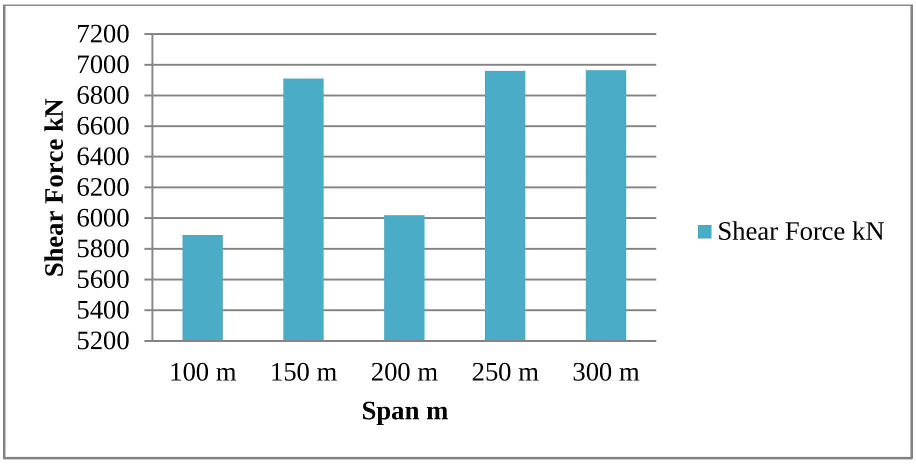

Figure 5: variation of dead load shear force for cable-stayed bridge

Moving load Shear force

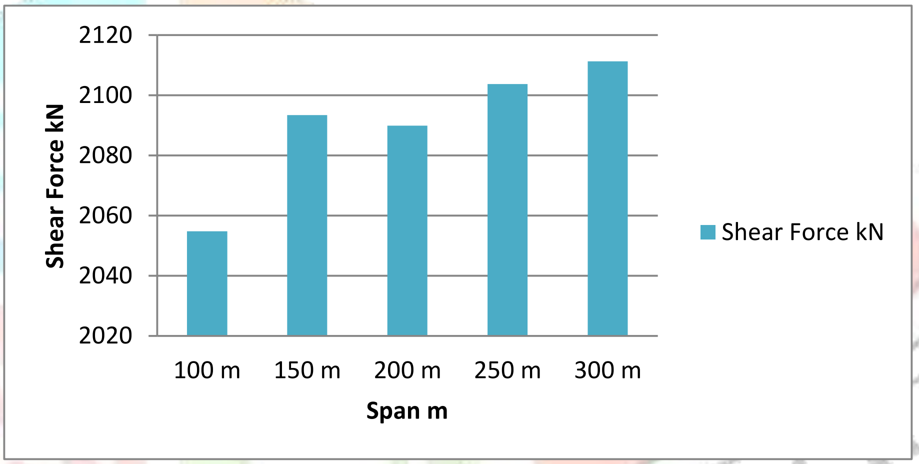

Figure 6: variation of moving load shear force for cable-stayed bridge

6.3 Pylon Height

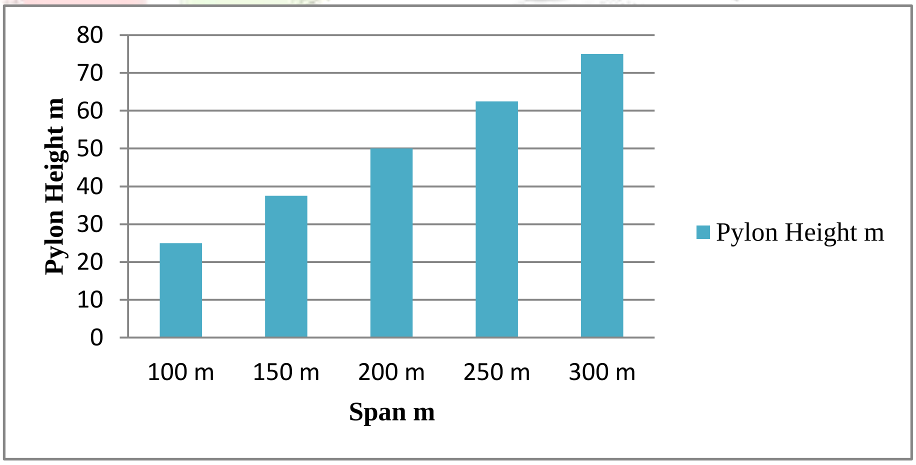

Figure 7: Variation of Pylon Height for cable-stayed bridge

6.4 Girder Depth

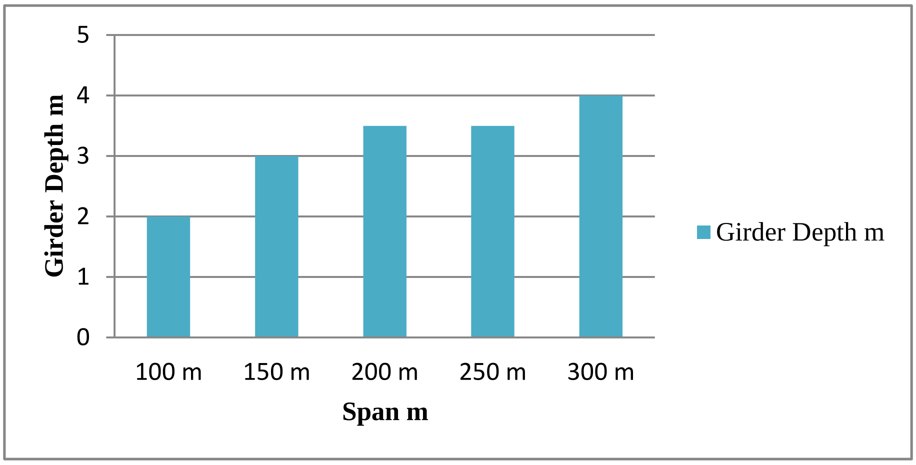

Figure 8: variation of girder depth for cable-stayed bridge

6.5 Number of Cables

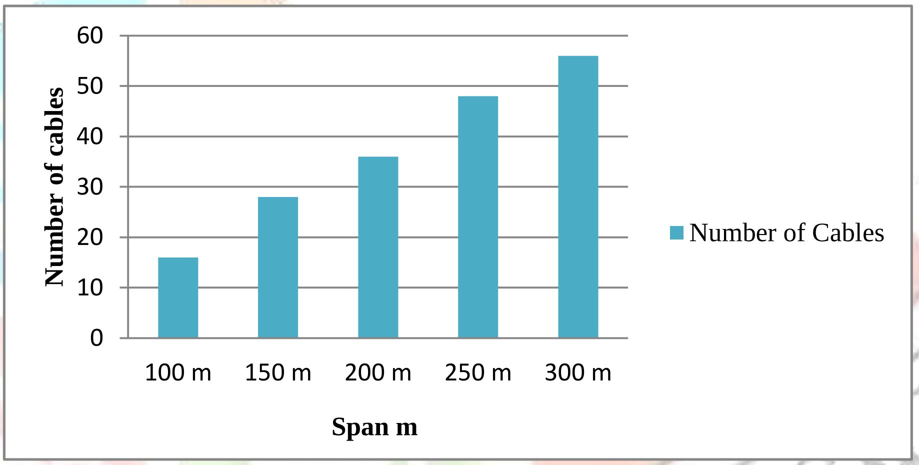

Figure 9: variation of number of cables for cable-stayed bridge

6.6 Effect on Pier

The effect of superstructure on substructure is studied form the joint reaction forces obtained at the end of pylon

F_1 = translation along layout line force
F_2 = translation normal to layout line force
F_3 = translation vertical direction force
M_1 = moment about layout line
M_2 = moment about normal to layout line

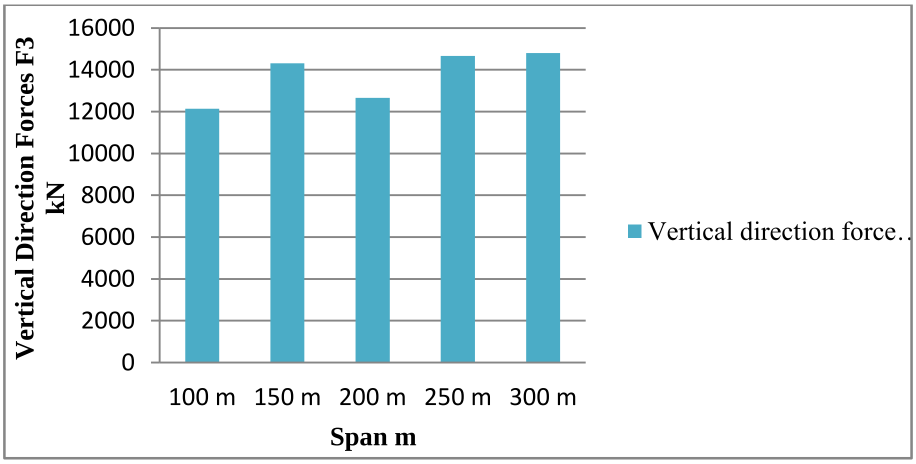

Figure 10: variation of dead load effect on pier for cable-stayed bridge

6.7 Effect on Abutment

The effect of superstructure on substructure is studied form the joint reaction forces obtained at the end of pylon

F_1 = translation along layout line force
F_2 = translation normal to layout line force
F_3 = translation vertical direction force
M_1 = moment about layout line
M_2 = moment about normal to layout line

Due to Dead Load

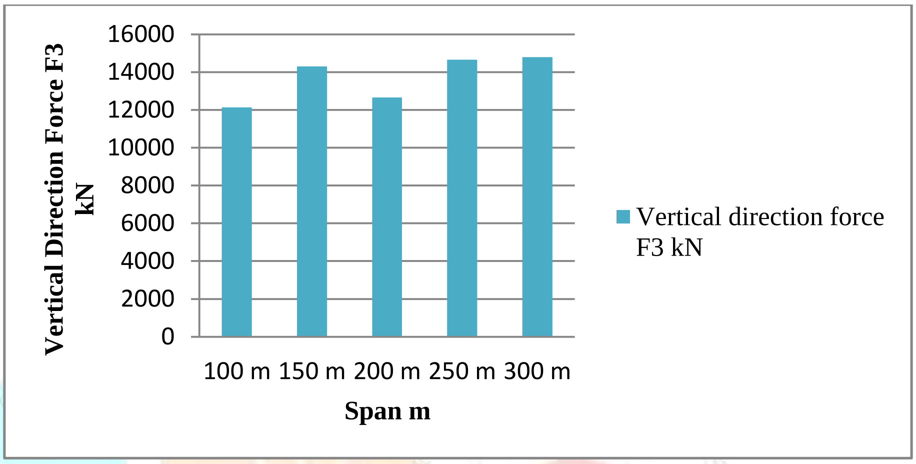

Figure 11: variation of dead load effect on abutment for cable-stayed bridge

Due to Moving Load

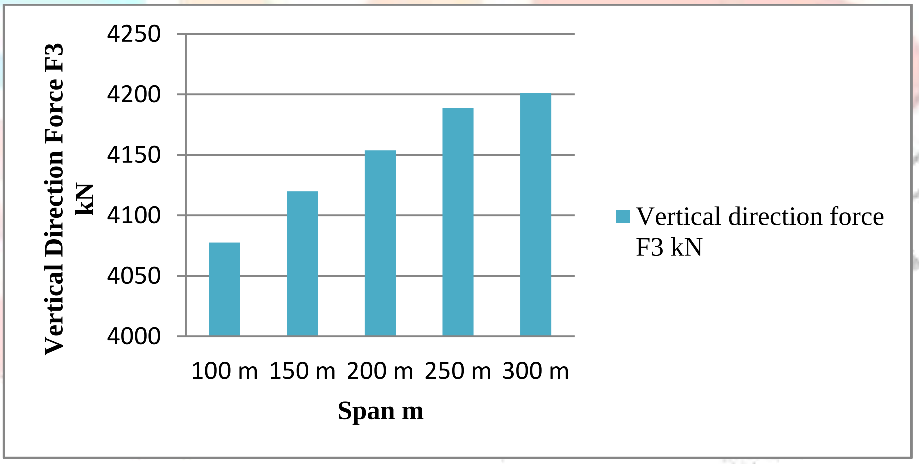

Figure 12: variation of moving load effect on abutment for cable-stayed bridge

- The dead load bending moment values are seen increasing by 12.55% (22867.6) from 100 m span to 150 m span. Further it decreases by 21.84% (39782.6) from 150 m span to 200 m span. For 250 m span it increases by 23.02% (42579) and for 300 m span it increases by 0.55% (1037.7) . This could be due to insufficiency of cables provided to carry the increased weight.
- The moving load bending moment values goes on increasing from 100 m span to 300 m spans by 33.42% (35022), 11.05% (13018.1), 18.33% (26443.2) and 14.37% (24215.9) respectively. This could be due to increasing span length.
- The dead load shear force values are seen increasing by 14.77% (1020.924) from 100 m span to 150 m span. It decreases by 12.88% (890.66) from 150 m span to 200 m span. From 200 m span to 250 m span it increases by 13.49% (939.471) and further increases by 0.06% (4.442) for 300 m span. This could be due to increase in self weight.
- The moving load shear force values are seen increasing by 1.84% (38.676), 0.16% (3.544), 0.65% (13.882) and 0.35% (7.538) from span 100 m to 300 m respectively.
- As the span increases the pylon height and girder depth increases. For increasing span length from 100 m to 300 m the pylon height increases by 33.33% (12.5), 33.33% (12.5), 20% (12.5) and 16.67% (12.5) respectively.
- Number of cables increases as span increases, the increase in number of cables from 100 m span to 300 m span is by 42.85% (12), 22.22% (8), 25% (12), and 14.28% (8) respectively.
- The vertical directional forces F_3 considered for studying the dead load effect on pier. The value increases by 15.16% (2170.37) from 100 m span to 150 m span, decreases by 11.55% (1652.88) from 150 m span to 200 m span. Further the value increases

by 13.68% (2007.47) and 0.92% (137.29) for span 200 m to 300 m. This could be due to insufficiency of provided cables to carry the increased weight.

- The vertical directional forces F_3 considered for studying the dead load effect on abutment increases by 15.56% (2227.69), 2.62% (385.46), 0.21% (30.87) and 0.92% (137.29) respectively from span 100 m to 300 m respectively. This could be due to insufficiency of provided cables to carry the increased weight.
- The vertical directional force F_3 considered for studying the moving load effect on abutment increases by 1.03% (42.48), 0.81% (33.65), 0.83% (35.02) and 0.29% (12.57) respectively from span 100 m to 300 m. This could be due to increasing forces transferred on the abutment in cable-stayed bridges.

VII. CONCLUSION

- The dead load bending moment values are seen increasing by 12.55% from 100 m span to 150 m span. Further it decreases by 21.84% from 150 m span to 200 m span. For 250 m span it increases by 23.02% and for 300 m span it increases by 0.55%.
- The moving load bending moment values goes on increasing from 100 m span to 300 m spans by 33.42%, 11.05%, 18.33% and 14.37% respectively.
- The dead load shear force values are seen increasing by 14.77% from 100 m span to 150 m span. It increases by 12.88% from 150 m span to 200 m span. From 200 m span to 250 m span it increases by 13.49% and further increases by 0.06% for 300 m span.
- The moving load shear force values are seen increasing by 1.84%, 0.16%, 0.65% and 0.35% from span 100 m to 300 m respectively.
- As the span increases the pylon height and girder depth increases. For increasing span length from 100 m to 300 m the pylon height increases by 33.33%, 33.33%, 20% and 16.67% respectively.
- Number of cables increases as span increases, the increase in number of cables from 100 m span to 300 m span is by 42.85%, 22.22%, 25%, and 14.28% respectively.
- The vertical directional forces F_3 considered for studying the dead load effect on pier. The value increases by 15.16% from 100 m span to 150 m span, decreases by 11.55% from 150 m span to 200 m span. Further the value increases by 13.68% and 0.92% for span 200 m to 300 m.
- The vertical directional forces F_3 considered for studying the dead load effect on abutment increases by 15.56%, 2.62%, 0.21% and 0.92% respectively from span 100 m to 300 m respectively.
- The vertical directional force F_3 considered for studying the moving load effect on abutment increases by 1.03%, 0.81%, 0.83% and 0.29% respectively from span 100 m to 300 m.

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