International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 3, May-Jun-2023, ISSN (Online): 2395-566X

Effect of Different Cable Arrangements on Collapse Behaviour of Cable Stayed Bridge

M.Tech Scholar Manish Saxena, Prof. Pawan Dubey
Department of Mechanical Engineering,
People's University,
Bhopal

Abstract- A suspension bridge is similar in that it too features towers and a deck held in place by cables, however this one's cables support the deck by linking it directly to the towers. Pedestrians, bicyclists, drivers, and passengers in automobiles, vans, and even light rail trains often use it. It is commonly utilised in places where a suspension bridge would be too costly owing to its length, but where the span is too short for a cantilever bridge to be practical. In this study, the collapse behaviour of cable stayed bridge has been done using STAAD PRO.

Keywords- Cable arrangements, collapse behaviour, cable stayed bridge.

I. INTRODUCTION

Stability, economy, beauty, and optimal use of structural materials are only few of the benefits of cable-stayed bridges. Because of this, these bridges are gaining popularity and are often chosen over suspension bridges for spanning long distances. The bridge deck of a cable-stayed bridge is suspended from cables that connect many towers. "In terms of cable configuration, the most popular kinds of cable stayed bridges are fan, harp, and semi-fan bridges." The length and nonlinear structural behaviour of such bridges make them trickier to analyse than shorter, more conventional bridges. However, the cables within those spans are primarily responsible for their nonlinear properties. Building a cable-stayed bridge that meets all of the required performance metrics while still keeping costs down is no easy task.

"The deck of a cable-stayed bridge is supported by inclined people extended from the towers;" these tension members bear the pressure from traffic crossing the bridge and distribute it to the bridge's foundation below. "In 1823, the French engineer navier published the first description of the cable-stayed bridge." With regards to the bridge deck and the wrought iron chains that hold it up, he has done extensive research.

Still, wrought-iron chains add further rigidity to the bridge deck. Nonetheless, navier work persisted as paper work because nobody used it in class. Similarly to navier's work, dischinger researched cable stayed bridges in 1938. In this design, the cable at the top of the tower attaches the longitudinally outside section of the bridge deck to the tower below. However, he made a few modifications on the deck and towers of the bridge's central span, which uses cables to connect the two.

Notably, this technique was never put to use in building because of the many inconsistencies it displayed in structural behaviour and visual appearance. Therefore, dischinger suggested a new system, which is now commonly known as the pure cable stayed bridge system. When this method is used to build the Stromsund Bridge, dischinger earns the title of "the father of modern cable stayed bridge." Construction of the Stromsund Bridge, the world's first modern cable-stayed bridge, was completed that year, in 1955. A second contemporary cable-stayed bridge, the leonhardt-designed Rhine River Bridge in Dusseldorf, was constructed after the Stromsund Bridge.

The bridge, which was given its current name in honour of Theodor Heuss in 1957, was opened to the public in style. Both of these bridges had proven extremely sturdy, aesthetically pleasing, economically viable, and straightforward to set up. The door has opened for further widespread and effective use.

II. REVIEW OF PAST RESEARCH

Mycherla Chaitanya (2018) [17] developed a model of a Girder Bridge and a Cable Stayed Bridge, and investigated how they would fare under varying loads. For analytical reasons, they consider dead load, live load, and combined load. Finally, the author did a comparison study based on internal forces, stresses, and deformation of the structure under different load effects.

Krunali Mavani (2017) [15] conducted simulations of Cable Stayed Bridges with a variety of pylon configurations. The author came to the conclusion that research into the dynamic response to the influence of pylon form was necessary. Additionally, he made alterations to the pylon design and height while keeping all other performance criteria for the bridge the same in order to make accurate assessments.

Pravin Malwiya (2017) [20] used SAP2000 to perform linear and nonlinear static analysis. For the purpose of analysing cable-stayed bridge behaviour, it compares and contrasts investigations into cable tension, deck deflection, and base shear.

Pawan Patidar and Sunil Harne (2017)[19]validated the economic health of Plate Girder Bridges (Railways) across a range of spans by holding a one variable constant while altering the others.

Praveen Kumar et al (2017)[20]The deck and pylon displacements of the cable-stayed bridge were computed while considering the traffic loads and seismic loads. These pylons first bear the weight, but eventually the foundation underneath them takes over. Author also takes care to ensure that the pylons can support all the various loads by carefully selecting their design and cable arrangement.

Poornima and Bharath (2017)[15]have analysed cable stayed bridges with varying cable configurations in their studies. The author used FEM software to analyse the various pylon forms and make educated guesses about which cable and tower layout would be optimal. There are 4 distinct pylon shapes: a "A," "Y," and "H," as well as a circular pylon with a single axial layer of supports. Pylon range in size and shape, each with its own distinct cross section. The author finds that there are primarily four types of cable arrangements, distinguished by the method used to attach the cables to the deck and the tower.

Guru prasad (2016)[7] author compares two bridges to see which one is better suited to carrying six lanes of traffic both financially and logistically. A wider and more cost-effective three-plane cable design of cable stayed bridges was something he saw.

Shivanshi and Pinaki (2016)[22]fan type, semi-fan type, and harp type cable configurations, among the most frequent, were taken into account. Using STAAD Pro, the author created and analysed the bridge using this cable configuration. The author then analyses each bridge model and recommends the one with the fewest faults and the highest efficiency. According to the findings, the fan configuration is the most effective of the three investigated options.

Savaliya (2015)[4]have analysed the cable-stayed suspension Hybrid Bridge's temporal history and nonlinear statics. The author further verifies their findings. In order to do all of the necessary analyses, SAP2000 was used. In order to connect the findings of the study paper to the functionality of the SAP 2000 software, the duration of the bridge for each mode shape was calculated and made available for examination.

Deep Gupta (2016)[24] The author of this study drew up plans for a bridge to span the gap between NH-58 and Kaliyar Road. In addition to preventing pedestrian-vehicle collisions, the author claims this would put an end to traffic congestion and delays on the roadway. A solar power generating system also was incorporated into the design in order to assist the green construction goal of College, which has seen increased interest in solar energy in recent years owing to environmental concerns.

III. OBJECTIVES

- In this study, we compare the performance of four popular cable configurations for Cable Stayed Bridges, including fan, star, radial, and harp configurations, as well as two phylon configurations (the "A" and "H") for each.
- Shear force, bending moment, and displacement will be compared across the various configurations.
- STAAD Pro will be utilized for all of the analyses. Then, based on our case studies, we'll recommend the best setup.

IV. RESEARCH METHODOLOGY

1. Methodology Used:

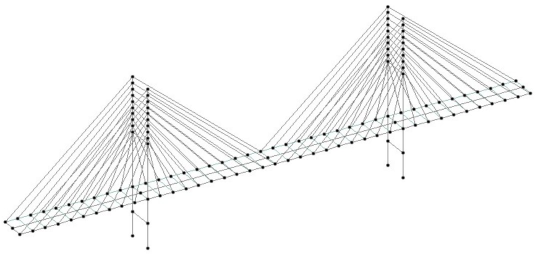
- We begin by reviewing the relevant literature in the field before diving in.
- The next step is to assign member and material attributes to the model in STAAD Pro according on the design specifications.
- The 200-meter-long bridge is described in detail. The deck is 10 metres wide. The 65 m tall bridge.
- Dead weight, imposed loads, and wind forces are all taken into account in our work.
- Lastly, we'll evaluate the situations side by side..

2. Description of Bridge:

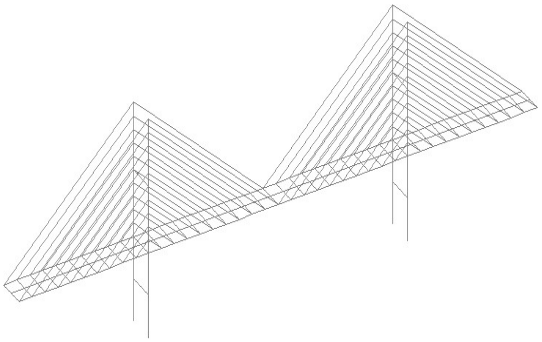
The feasibility of cable-stayed bridges is analysed. The bridge stretches a total of 200 metres in length. The deck is 10 metres wide. See Figure 6-8 for a bridge diagram. There are a total of 65 metres of bridge height. This pylon is unique in its design. Different bridge designs, such as the fan, radial, star, and harp, are depicted in the next chapter.

Table 1. Description of Structure.

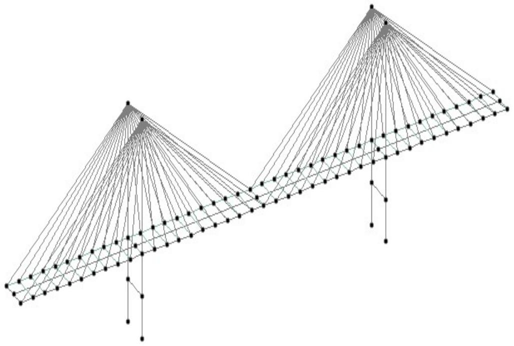
Description	Value
The total span of the bridge	200 m
total width of the deck of the bridge	10 m
Total height of the bridge	65 m
Dia. of column	0.3 m
Beam size (1)	0.5 x 0.45 m
Beam size (2)	0.5 x 0.5 m
Deck thickness	0.3 m
Support type	Fixed support



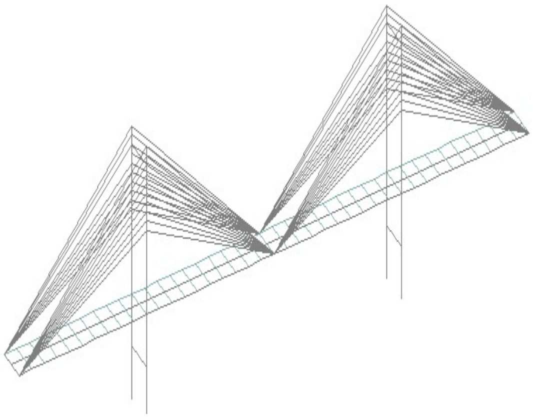
(a) Fan arrangement of cables.



(b) Harp arrangement of cables.

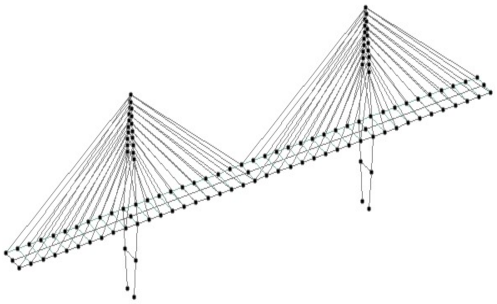


(c) Radial arrangement of cables.

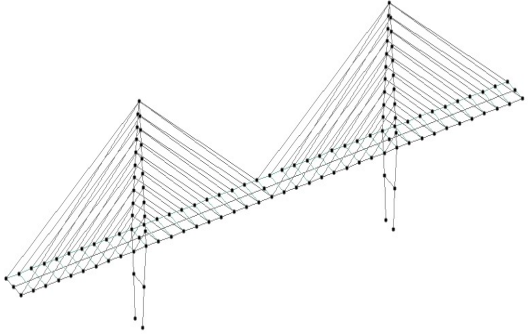


(d) Star arrangement of cables

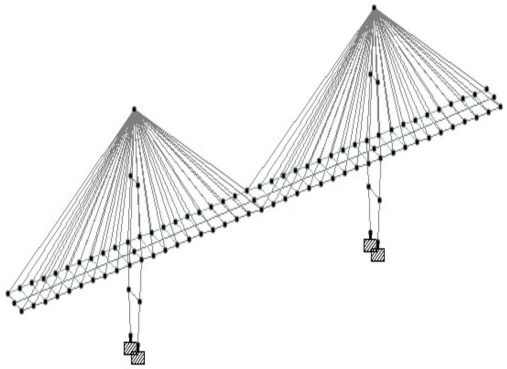
Fig 1. H-shape tower with different cable arrangement.



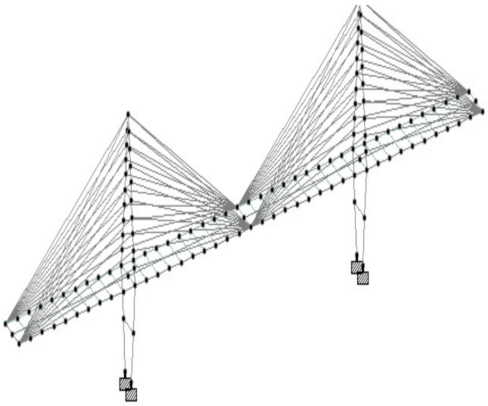
(a) Fan arrangement of cables



(b) Harp arrangement of cables



(c) Radial arrangement of cables



(d) Star arrangement of cables

Fig 2. A-shape tower with different cable arrangement.

V. RESULTS AND DISCUSSION

Here, we give the effective design findings for the four cable-stayed bridge configurations: star, fan, radial, and harp.

1. Shear Force And Bending Moment:

Figures 5.1–5.6 illustrate the maximum shear force and bending moment for different cable configurations, respectively; from this, it can be deduced that the maximum shear force and max. There is a star design to the bending moments, whereas a harp pattern suggests a minimum shear force and a minimum bending moment value, leading to a balanced section.

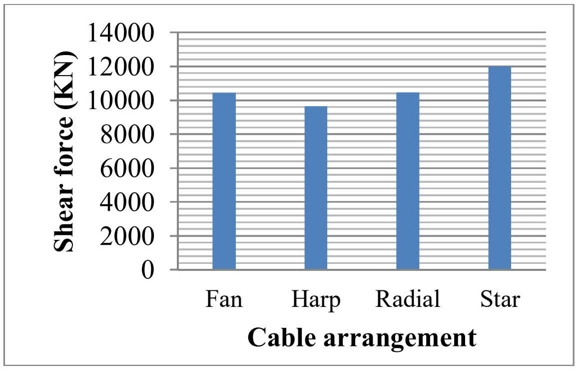


Fig 3. Shear force for H shape.

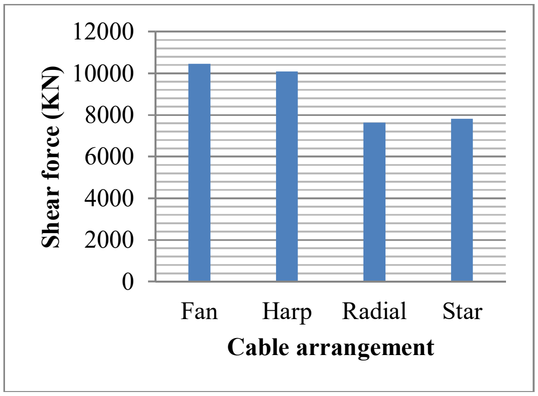


Fig 4. Shear force for A shape tower.

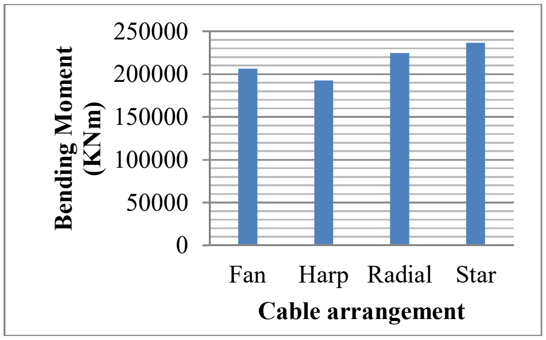


Fig 5. Bending moment for H shape tower.

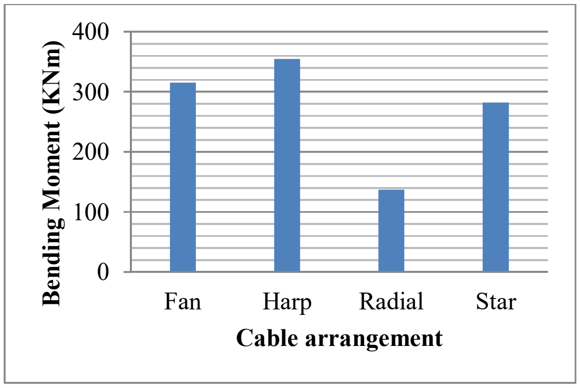


Fig 6. Bending moment for A shape tower.

2. Deflection:

Figure 16 shows a comparison of the maximum displacement for different types of truss, in which the deflection is found to be greatest again for star cable arrangement and smallest for the harp cable arrangement. *"This finding suggests that the star cable arrangement will necessitate more supports than the other cases."*

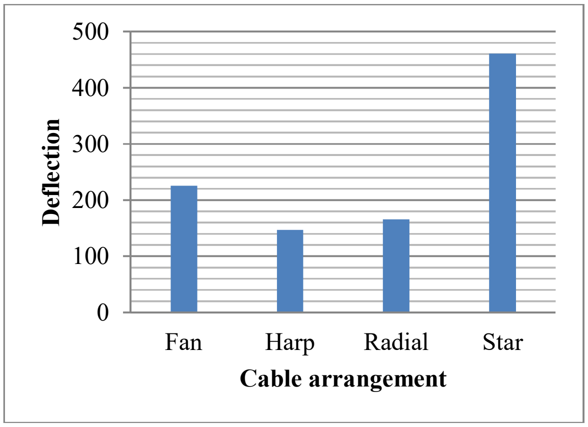


Fig 6. Deflection with different cable arrangement for H shape tower.

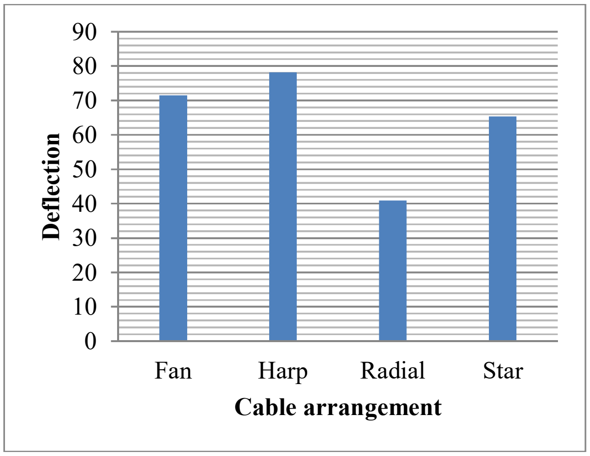


Fig 7. Deflection with different cable arrangement for A shape tower.

VI. CONCLUSION

With the help of Staad-Pro, they have analysed several scenarios, including dead load and live load, for a selection of cable configurations on a tower of both H and A shapes. The outcomes of this investigation are as follows-

1. Based on cable configuration to the tower and the deck:

H shape tower

- There is a greater shear force in a star configuration and a lower shear force in a harp configuration.
- The star configuration produces the highest bending moment, whereas the harp configuration produces the lowest.
- More deflection occurs in the star configuration, and less in the harp.
- According to the findings, the harp arrangement is the most productive of the four possible configurations.

A shape towers

- Fan designs have higher shear forces than radial ones.
- In a radial configuration, the bending moment is smaller than in a harp configuration.
- More deflection occurs in a harp configuration, and less in a radial one.
- The findings showed that the radial configuration was the most effective of the four tested options.

2. Based on Shape of the Tower:

Compared to a circular tower, which now has homogeneous members, we found that an H-shaped pylon exhibits less sag and moment in its cables and deck. This is because the H-shaped pylon has more joints, making it less homogeneous. This means that the cables' stress and tension carrying capacity are not distributed evenly throughout the towers.

REFERENCES

[1] Aishwarya Kulkarni, Priyanka Kumbhar, Pooja Mandge, Sarita Khot (2016), "Materials for Footover Bridges", International Research Journal of Engineering and Technology, Volume: 03 Issue: 04, PP: 2701-2703.

[2] Atul K. Desai (2013), "Seismic Time History Analysis for Cable-Stayed Bridge Considering Different Geometrical Configuration For Near Field Earthquakes", International Journal of Engineering and Technology, 5(2), 1-10.

[3] Aye Nyein Thu (2014), "Long Span Cable-Stayed Bridge with H-Shaped Tower", International Journal of Science, Engineering and Technology Research, Volume 3, Issue 6, PP: 191-202.

[4] G. M. Savaliya, A. K. Desai, S. A. Vasanwala (2016), "Static And Dynamic Analysis Of Cable-stayed Suspension Hybrid Bridge & Validation ", International Journal of Advanced Research in Engineering and Technology , Volume 6, Issue 11, PP: 91-98.

[5] G.Lakshmi Poornima, R.Bharath (2017), "Optimization and Analysis of Cable Stayed Bridges", International Research Journal of Engineering and Technology, Volume 4, Issue 8, PP: 2307-2312.

[6] Ghanshyam M. Savaliya (2013), "Analysis of Differently Configured Cable Supported Bridges and its Validation", International Journal of Engineering Research & Technology, Vol-2, Issue-7, PP: 1741-1745.

[7] Guruprasad D (2016), "Comparison of Two Planes and Three Planes Cable Configuration Of Cable Stayed Bridge", International Research Journal of Engineering and Technology, Volume: 03 Issue: 09, PP: 1029-1031.

[8] Hussain Hararwala (2016), "Effect of the Different Shapes of Pylons on the Dynamic Analysis of Cable Stayed Bridge using SAP 2000", International Journal for Scientific Research & Development,Volume 4, Issue 11, PP: 17-22.

[9] IRC: 18-2000, "Design criteria for pre-stressed road bridges".

[10] IRC:21-2000, "Standard specifications and code of practice for road bridges".

[11] IRC:6-2000, "standard code and specifications for road bridges, Loads and stresses".

[12] IRC. SP. 054, "Project preparation manual for bridges".

[13] IRS-CBC, "code of practice for plain, reinforced & pre-stressed concrete for general bridge construction".

[14] IS: 800-2007, "General construction in steel-Code of practice".

[15] Krunali Mavani (2017), "Dynamic Analysis of Cable Stayed Bridge for Different Pylon Configuration", International Journal of Advance Engineering and Research Development, Volume 4, Issue 11, PP: 586-592

[16] Mohammed Yakub Ali, Gugulothu Swarna (2016), "Design and Analysis of Pedestrian Bridge", International Journal of Advance Technology in Engineering and Science, Volume 4, Issue 10, PP: 323–331.

[17] Mycherla Chaitanya (2018), "Modelling & Comparative Analysis of Cable Stayed & Girder Bridges using SAP2000", International Journal for Research in Applied Science & Engineering Technology,Volume 6, Issue 2, PP: 464-468.

[18] Nikhil R (2017), "Comparative Study on the Effect of Structural Configuration on Seismic Analysis of Cable Stayed Bridge Using SAP 2000", International Journal of Engineering Research and General Science Volume 5, Issue 2, PP: 116-121.

[19] Pawan Patidar, Sunil Harne (2017), "Parametric Study of Plate Girder Bridge", Journal of

Mechanical and Civil Engineering, Volume 14, Issue 6, PP: 01-08.

[20] Praveen kumar M, M Rame gowda, Arjun B (2017), "Analysis of Cable Stayed Bridge under the Action of Vehicular and Seismic Loads", International Journal of Scientific Development and Research, Volume 2, Issue 10, PP: 17-22.

[21] Pravin Malwiya (2017), "Effect of Cable Arrangement on Nonlinear Static Analysis of Cable-Stayed Bridge", International Research Journal of Engineering and Technology, Volume 4, Issue 4, PP: 2105- 2108.

[22] Shivanshi, Pinaki (2016), "Analysis of the behaviour of Cable stayed bridge with different types of cables arrangement", International Journal of Innovative and Emerging Research in Engineering Volume 3, Issue 5, PP: 125-134.

[23] T. Pramod Kumar and G. Phani Ram (2015), "Analysis and Design of Super Structure of Road cum Railway Bridge across Krishna River", International Journal of Engineering & Science Research, Vol-5, Issue-7, and PP: 830-838.

[24] Deep Gupta (2016), "Analysis of Cable Stayed Bridge", International Journal of Engineering, Vol-2, Issue-3, and PP: 112-118.

[25] Mohammed.Yakub Ali, Gugulothu.Swarna, (2016), "Design and Analysis of Pedestrian Bridge", Vol.4, Issue No 10, P.20-30.

[26] Mohammed.Yakub Ali, Gugulothu.Swarna, (2016), "Design and Analysis of Pedestrian Bridge", Vol.4, Issue No 10, P.20-30.