STRUCTURAL BEHAVIOUR AND DESIGN CRITERIA OF CABLE-STAYED BRIDGES WITH CURVED PYLONS UNDER LIVE LOAD CONDITION

Imperial College London

Minyi Lu **Supervisor: Dr Ana M Ruiz-Teran**

Department of Civil and Environmental Engineering, Imperial College London

INTRODUCTION

Cable-stayed bridge with curved pylons is an unconventional type of bridge and the pylon shape brings additional aesthetic value to the structure. The curvature of the pylon can be designed to eliminate most of the bending moments along the pylon under permanent load. However, it is not realistic to eliminate the pylon bending moments under live load. The key objective of this project is to perform structural analysis of a typical cable-stayed bridge with curved pylon and apply variations on the selected structural properties to seek potential improvements, in terms of the efficiencies of the main cables and the bending moment control along the curved pylon, for this type of bridge structure under live load.

BENCHMARK MODEL

Table 1: Parameters of the benchmark model

Bridge length (m)	180
Main span (m)	160
Pylon height (m)	118
Number of forestays	29
Spacing of the forestays (m)	5
Number of backstay	1
Length of the backstay (m)	110
Pylon bottom inclination to the horizontal	40°
Pylon top Inclination to the horizontal	90°
Forestay inclination to the horizontal	26°

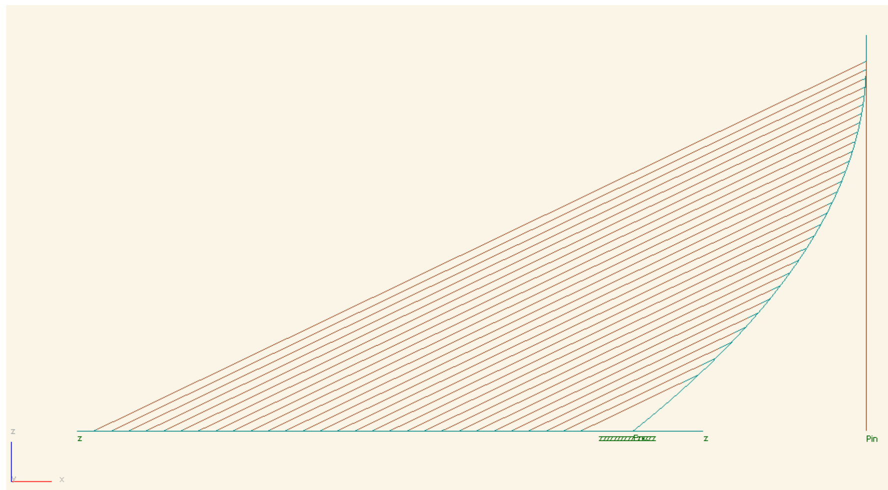

Figure 1: Benchmark bridge model

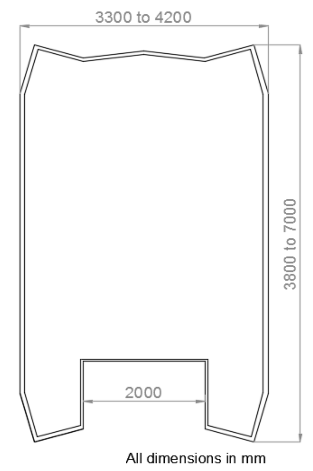

Figure 2: Pylon section

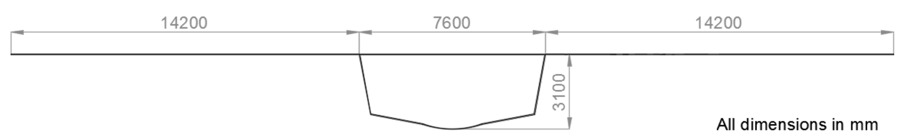

Figure 3: Deck section

BENCHMARK MODEL RESULTS

Table 2: Results of the benchmark model analysis under a live load of 100 kN/m

Cable moment efficiency	71.5 %
Cable loading efficiency	48.8 %
Negative maximum pylon bending moment (kNm)	- 63020
Positive maximum pylon bending moment (kNm)	+ 23890
Absolute maximum pylon bending moment (kNm)	63020

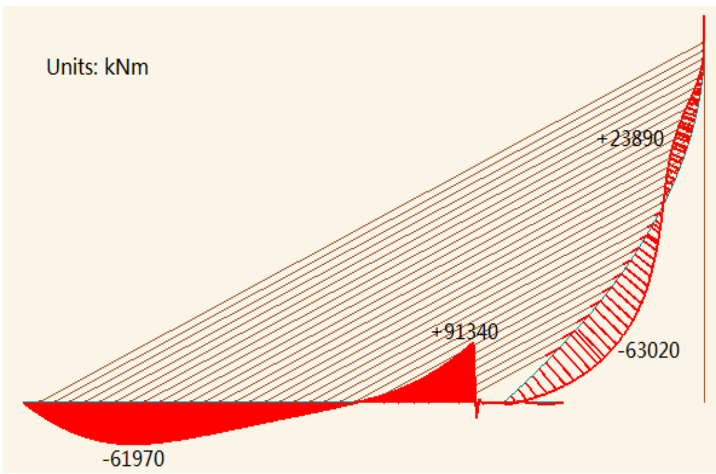

Figure 4: Bending moment distribution of the benchmark model under a live load of 100 kN/m

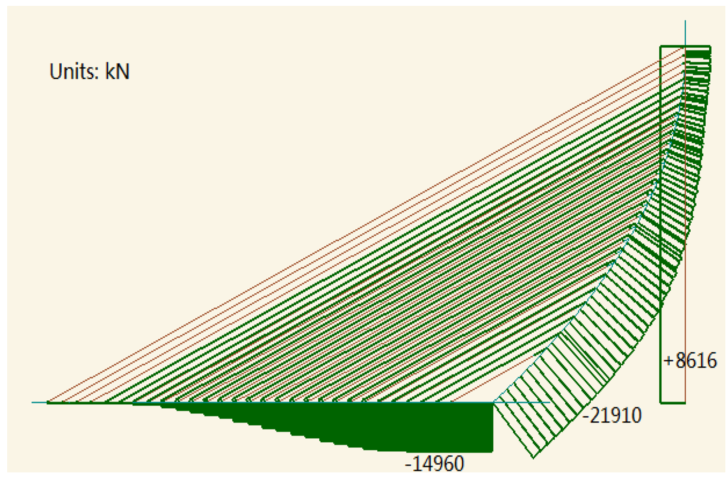

Figure 5: Axial force distribution of the benchmark model under a live load of 100 kN/m

PARAMETRIC ANALYSIS METHOD AND RESULTS

Modifications to the key structural parameters, i.e. the cable sizes as well as the deck and pylon section properties, in the benchmark model are applied to seek ways to improve the structural performance of the bridge under live load.

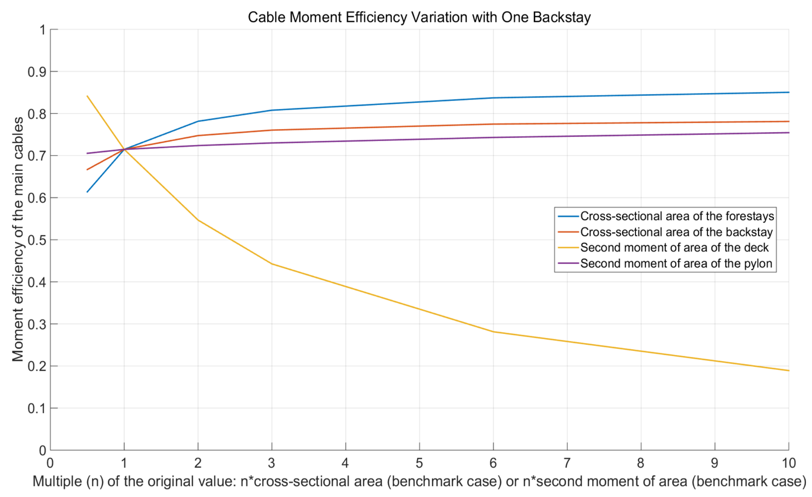

Figure 6: Cable moment efficiency variation

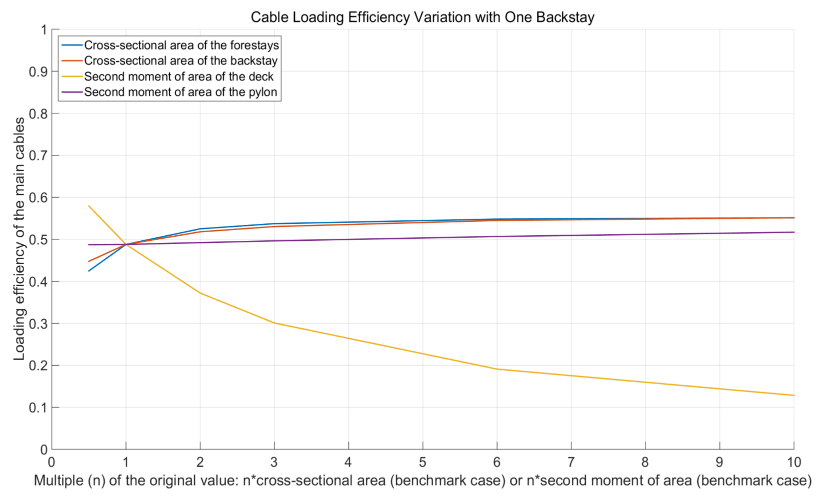

Figure 7: Cable loading efficiency variation

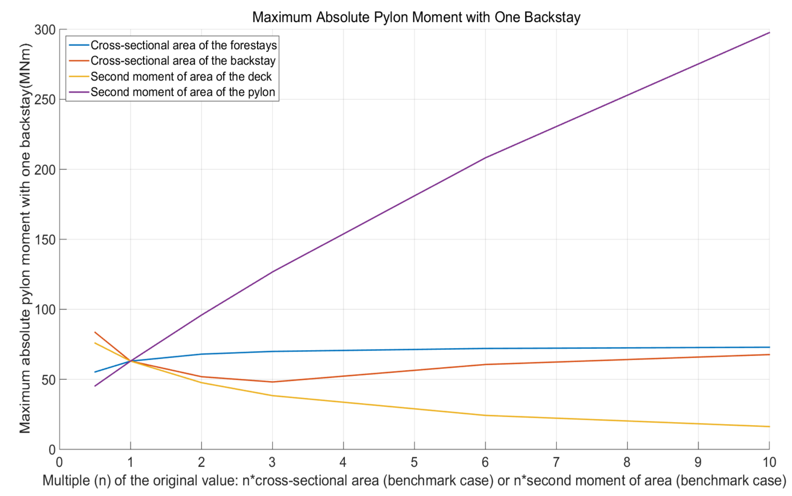

Figure 8: Pylon bending moment variation

The impacts of increasing the number of backstays are also analysed. Having multiple backstays will increase both the cable efficiencies and the pylon bending moments. As a result, evidences are not enough to prove the resultant improvement in the overall structural performance of the bridge under live load.

Identified effective methods of improvement under live load:

- Increasing the forestay section sizes
- Increasing the backstay section size to no more than three times the benchmark value
- Reducing the second moment of area of the deck or the pylon

FEASIBILITY CHECK RESULTS

The identified methods of improvement are examined in terms of the moment capacities of the deck and pylon sections as well as the deflections along the deck and pylon to confirm their feasibilities.

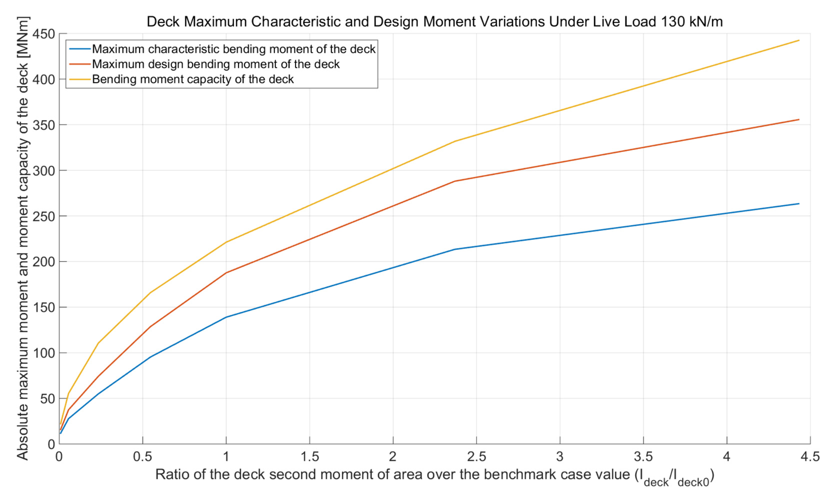

Figure 9: Moment capacity check for the deck

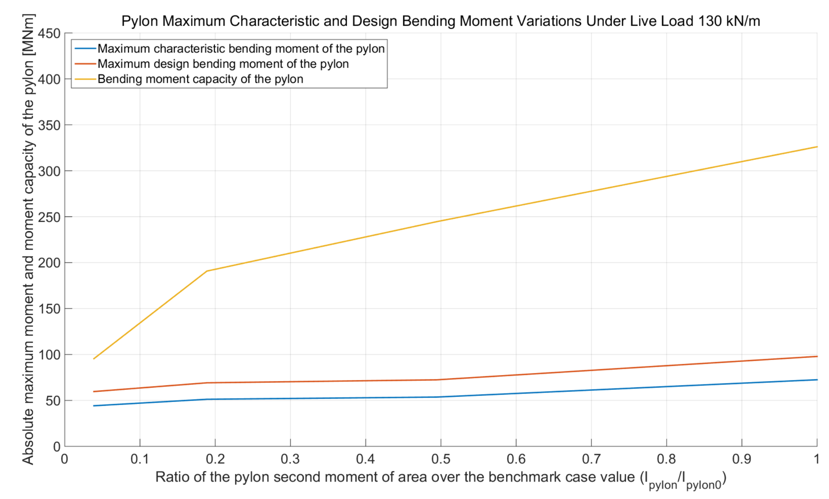

Figure 10: Moment capacity check for the pylon

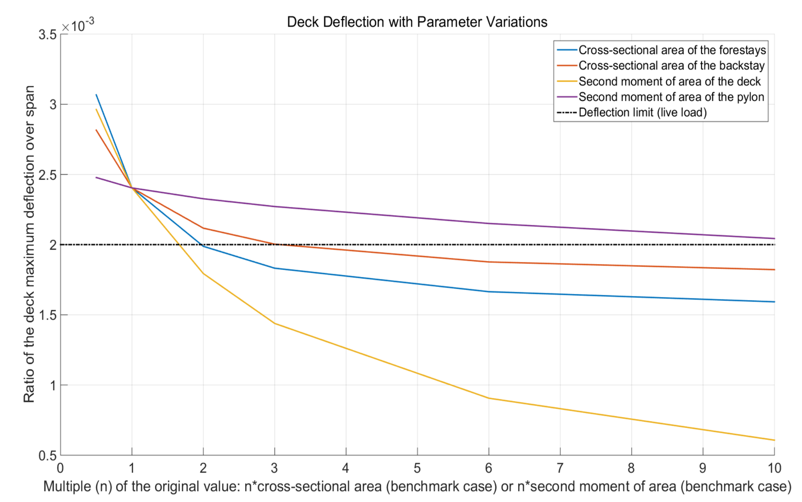

Figure 11: Deck deflection control

CONCLUSIONS

The improvement methods that are both effective and feasible under live load are listed below:

- Increasing the forestay section sizes to more than twice the benchmark value to ensure sufficient deflection control along the deck
- Increasing the backstay section size to approximately three times the benchmark value to ensure reductions in the pylon bending moment as well as sufficient deflection control along the deck

ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr Ana M Ruiz-Teran for her continuous guidance and support throughout the project.

REFERENCES

Oasys Limited (2015) *GSA Suite* (Version 8.7) [Software] Oasys Limited. Available from: http://www.oasys-software.com/products/engineering/gsa-suite.html.