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Structural Analysis of Akkar Cable Stayed Bridge byUnknown Load Factor Method

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Abstract With the advent of computer-based optimization techniques, cable stayed bridges are becoming a more and more relevant solution for long spans. Not only this but because of them being a suspended structure they can be easily installed in places where provision of multiple foundations or piers is rather difficult. This study has worked to find pre tensioning forces of the cables of AkkarBridge in Sikkim. Computer based optimization is used to create an ideal moment diagram under dead load (self- weight) by Unknown load factor using MIDAS Civil.

Key Words: Cable Stayed Bridge, Computer Based Optimization, Pretension, Unit Load Method, Unknown Load Factor.

1.INTRODUCTION

An Unknown load Factor

A cable stayed bridge is an indeterminate structure. So, to achieve a reasonably efficient design computer-based optimization is necessary. One such method is the Unknown load factor method also known as Unit Load Method. It is a numerical way to minimize the number of iterations while trying to deduce number of stressing operatives for cables.

For applying this method, a basic bridge system should be chosen before optimizing can be performed. In cable stayed bridges, to minimize the deck moments, the cable angles are preferred to be kept within the range of 25 to 55 degrees. Neither during construction stages nor in its design life should a cable observe compression force. Keeping that in mind a basic configuration of cables is chosen which is later checked for stability by optimization.

There is not a certain fixed way for selection of unit load groups. The structural designer is free to choose unit load groups according to his requirement. This flexibility is useful in construction stages as well for optimization of cables.

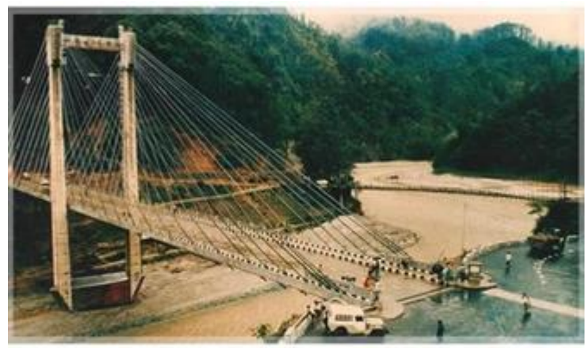

Fig. B Akkar Bridge

Akkar Joherthang Bridge in Sikkim over is one of the 1st cable bridges constructed in India. In this study with the help of software and unit load method, pretension forces are calculated for each cable. Cross section area of each cable is kept constant. In the existing bridge there are 34 cables in each plane i.e. 17 cables on each face of the tower in one plane. An anchorage zone is also provided where the cables rest on the deck.

Pretension force is nothing but the axial force experienced by cables of the bridge.

In this method generally these two conditions are defined:

1.A unit shortening or unit tensioning to make the axial force cause cable shortening.

2.A restriction of support or an element. A unit movement, which changes moment in deck.

As much the numbers of fixed moments same number of unit load cases are a must to be defined

Following equations are simultaneously solved:

$\sum|Wiyi|$ as a sum of the absolute values

$\sum (Wiyi) 2$ as quadratic values sum

$\max |W_i y_i|$ as the maximum absolute values

Where, W_i is the weight to be applied at the unknown load condition which is taken as 1KN in this study and y_i

is the unknown load factor, in this case the pretension force in each cable.

2.DESIGN PARAMETERS OF PROJECT

1.Pylon
Pylon Type = H type Pylon
Pylon Height Total = 54.6 m
Pylon height above deck = 33.9 m
Top cross section = 1.6*1.6 m^2
Bottom cross section = 2.5*2.5 m^2
Grade of Concrete = M45

2.Deck
Span of the bridge = 160 m
Total width of deck = 10 m
Number of lanes = two lanes 7.5 m

3.Girder
Longitudinal Girder = 0.6*0.8 m^2
Cross Girder = 0.45*0.8 m^2

4.Cable
Cable Arrangement = fan type
Number of cable planes = 2
Number of cables in each plane = 34
Area of Cable = 1423.9 mm
37 H.T. E450 wires.

3.MODELLING

MIDAS Civil is used for analysis procedure. It is a well-known powerful tool for structural analysis and design of all kinds of bridges. It also performs construction stage analysis of bridges. Both the static and dynamic, linear and non-linear analysis can be performed through the software. It uses Unknown load factor method as an optimization technique to figure out unknown forces.
Cables are modelled as General Beam elements and Truss or tension-truss cable elements. Various others like shell and plate element exist too. Optimization is limited to linear analysis only. Initial pretension forces are calculated in ideal state by unit load method by Unknown Load Factor function.

4.RESULTS AND DISCUSSION

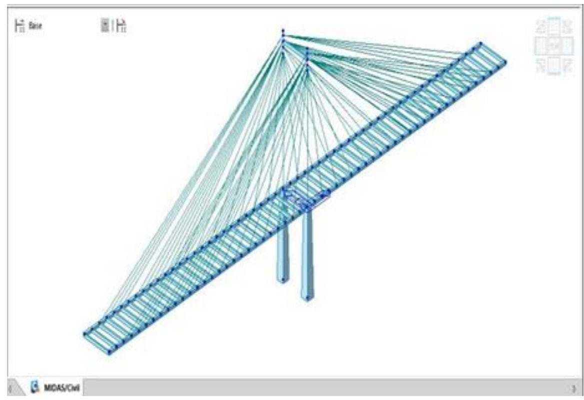

Fig.4.1 Rendered Model of Akkar Bridge in MIDAS Civil

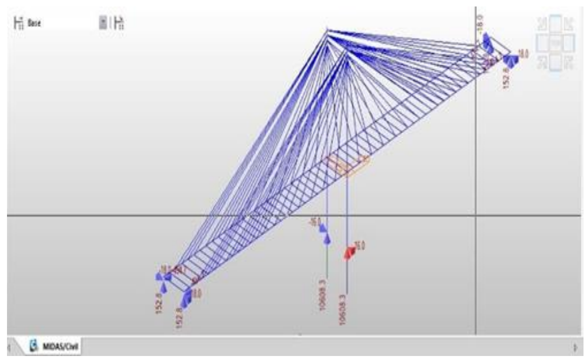

Fig. 4.2 Support Reaction

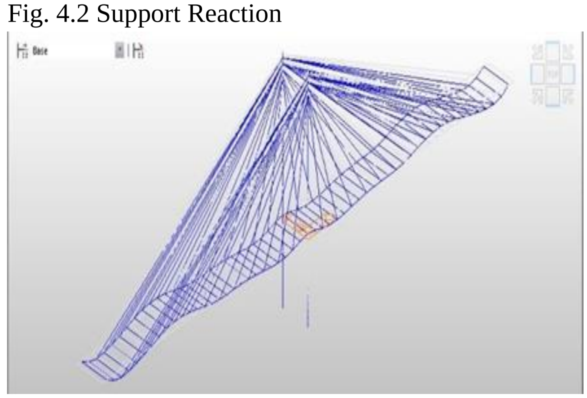

Fig.4.3 Deformed Shape

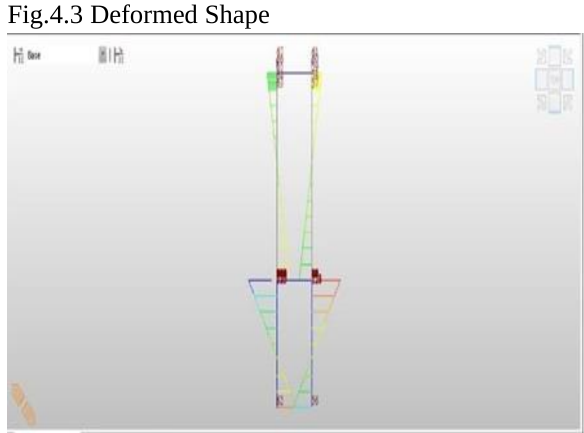

Fig.4.4 Pylon Force Diagram

Table 4.1 Pretension Force

Cable	Pretension Force in KN
Tension 1	174.5627394
Tension 2	281.9491181
Tension 3	358.4476587
Tension 4	400.6196622
Tension 5	374.4999732
Tension 6	337.4995101
Tension 7	298.5524581
Tension 8	271.6781496
Tension 9	261.4042431
Tension 10	267.9269449
Tension 11	288.9875878
Tension 12	332.7413063
Tension 13	351.0808951
Tension 14	326.4862613
Tension 15	268.6138141
Tension 16	186.0411271
Tension 17	67.96517937

5.CONCLUSIONS

From above case study on Akkar cable stayed bridge by unknown load method, we can conclude that this method gives desirable results of pretension forces in cables for considered cable arrangement. It reduces the human error and efforts in calculation of design engineer by minimizing the number of iterations for optimum cable pretension force.

Compression forces in cables and unacceptably high stresses in deck and pylon can cause failure of cable stayed bridges, but presence of these forces can be easily detected by unknown load method.

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