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Comparative Study on Modelling Techniques of Cable-Stayed Bridges

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Abstract: **-- The analysis of cable-stayed bridges is much more complex than that of conventional bridges (such as truss and girder bridges) due to their huge size and complicated nonlinear structural behaviour. Over the years, researchers have proposed different methods and software to model and analyse cable-stayed bridges but each has their own drawbacks. This paper concerns with the comparison of modelling techniques of the cable-stayed bridge in MIDAS Civil and Staad Pro software. The cable-stayed bridge chosen was symmetrical with cables having a semi-fan configuration. The bridge had H-shaped pylon and the span cantilevered 50 metres on both sides. The bridge was analysed for gravity loads and the results obtained from both the software were presented. It was inferred that all analysis cases need to be considered to arrive at most desirable solution and MIDAS civil might be the preferable tool.**

Index Terms **- Cable-stayed bridges, gravity loads, Midas civil, modelling, Staad Pro.**

I. INTRODUCTION

A characteristic feature of the cable-stayed bridge is that the cables run directly from pylon to deck, normally forming a fan like pattern or a series of parallel lines. Cable-stayed bridges are preferred due to their aesthetic appearance and are more economic in terms of materials for medium span bridges. A cable-stayed bridge has one or more pylons, from which cables support the deck of the bridge and its analysis has to be done very carefully. In the past, disasters have occurred due to incorrect analysis and negligence. Even though we have more advanced softwares and programs, idealization and method of analysis lie at designer's discretion and his/her knowledge on the subject. At present, the largest cable-stayed bridge in terms of length of main span is Rusky Bridge, Russia (1104 m). As the demand for better looking and lengthier cable-stayed bridges is increasing, more research and studies are being done to improve the span, structure, design, and maintenance of these bridges.

II. BRIDGE DATA

The data for the analysis is taken from [1]. The cable-stayed bridge is symmetrical with cantilever span of 50m on both sides. The deck is concrete box girder having width = 9m, depth = 2m, flange and web thickness = 0.5m. It has pylons with 'H-shape' having concrete section of 1m x 1m. The height of pylon above deck is 30m and below deck is 10m. The pylon's concrete top cross beam has B = 1m, D = 1.5m, and concrete bottom cross beam has B = 1m and D = 2m. Cable properties: cable 1 and 2 have area = 40000mm2 and are anchored 1.5m below pylon top, cable 3 and 4 have area 30000mm2 anchored 2m below cables 1 and 2, cable 5 and 6 have area 20000mm2 anchored 3m below cables 3 and 4 at pylons. The cables are anchored at deck as shown in Fig. 1. Modulus of elasticity of cables is 210 GPa and grade of concrete used is M45.
The soil below the bridge is considered as hard.
The sectional elevation of cable-stayed bridge is shown in the Fig. 1 and cross section is shown in Fig. 2.

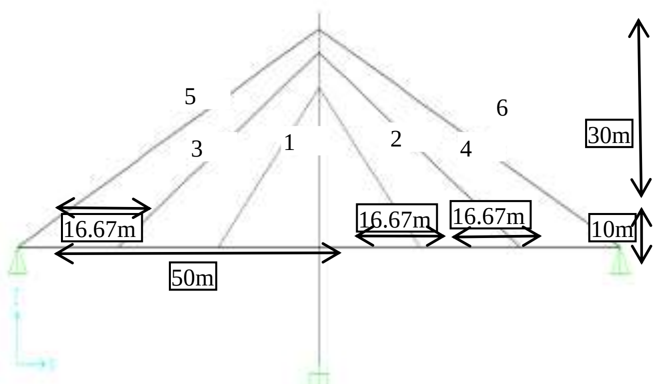

Fig. 1 Sectional elevation of bridge

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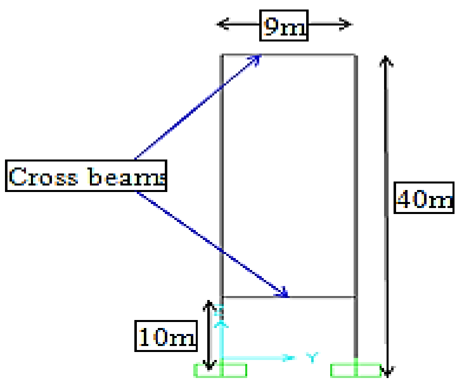

Fig. 2 Cross section of bridge

III. MODELLING

A. Modelling in Staad Pro

The idealization is same as that in MIDAS Civil. Here, the rigidity at points where cables are attached to the deck is ensured using Master and Slave node command. The bridge is modelled in Staad Pro as shown in the Fig. 3.

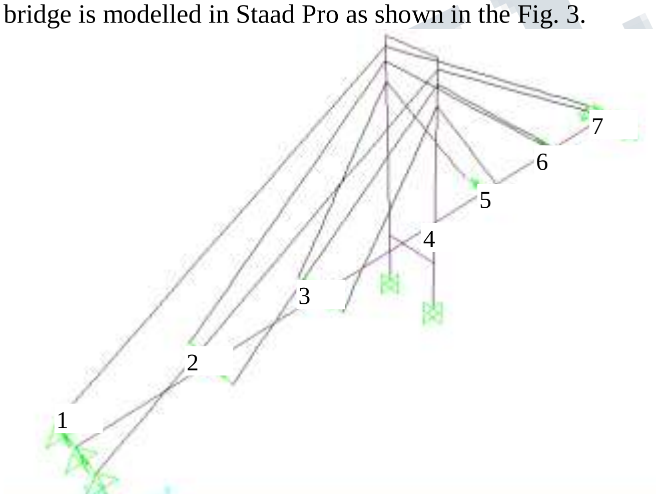

Fig. 3 Bridge model in Staad Pro

B. Modelling in MIDAS Civil

The deck of the bridge i.e. concrete box girder is idealized as a beam element, connected laterally by the rigid links (using rigid link command) at the points where cables are attached to the deck. The pylons, cross members (top and bottom) are idealized as beam elements and the cables as cable elements i.e. they undergo only tension. The support condition for pylons is considered as fixed. The cable-stayed bridge is modelled in MIDAS Civil as shown in the Fig. 4.

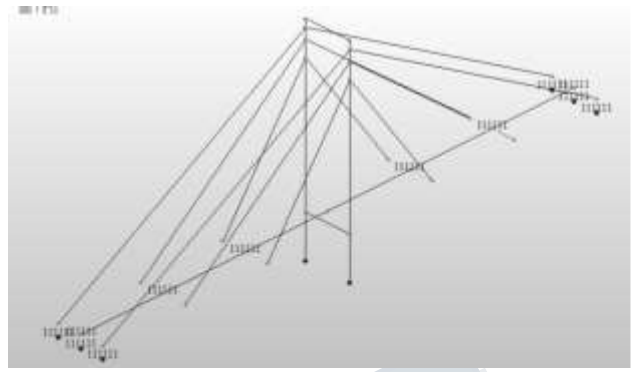

Fig. 4 Bridge model in MIDAS Civil

IV. ANALYSIS AND RESULTS

The self-weight of each component i.e. cables, pylons and girder is applied and the bridge is analyzed for linear static case only. The deflections obtained at various points on the girder from MIDAS Civil and Staad Pro are compared and are presented in Table I.

Table I Displacement at various nodes

Node no.	Displacement (m)	
	MIDAS Civil	Staad Pro
1	0.052	0.051
2	0.046	0.047
3	0.027	0.029
4	0.010	0.012
5	0.027	0.029
6	0.046	0.047
7	0.052	0.051

A. Analysis in MIDAS Civil

The procedure followed is similar to as given in [2]. When the bridge is analysed as a whole structure, the bending moments and deflections obtained from MIDAS civil at various points on the girder are presented in Table II.

Table II Bending moment and deflection at various nodes

Node No.	Bending Moment (kNm)	Deflection (m)
1	0	0.052
2	4420	0.046
3	-3870	0.027
4	-36740	0.010
5	-3870	0.027
6	4420	0.046
7	0	0.052

The bridge is constructed stage by stage and for each stage, corresponding time-dependent properties such as creep and shrinkage have to be considered. Their effects are

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cumulative with respect to time and if the bridge is analyzed as a whole this cumulative effect cannot be considered effectively. However, this drawback is easily overcome in MIDAS Civil by using the command Construction stage analysis.

By using Construction stage analysis, the bridge is also analysed in the following 4 stages:

1st stage:

The Pylon is constructed upto its full height. The bottom cross beam and top cross beam are constructed at this stage. The construction stage is shown in Fig. 5.

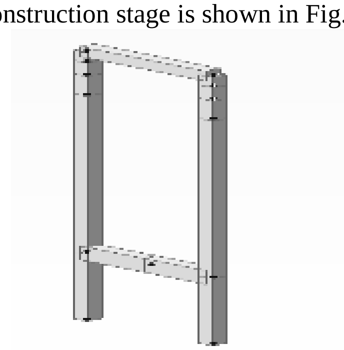

Fig. 5 Construction stage I

2nd stage:

The first cantilever portion on both the sides of the pylon are constructed. Cables 1 and 2 are connected rigidly to their respective places. The stage is shown in Fig. 6.

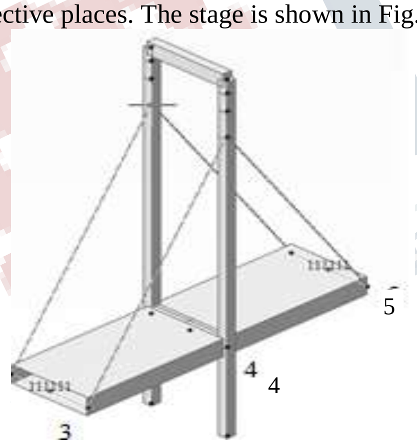

Fig. 6 Construction stage II

The analysis results of the stage are shown in Table III.

Table III Bending moment and deflection at various nodes

Node No.	Bending Moment (kNm)	Deflection (m)
3	-3870	0.037
4	-36740	0.018
5	-3870	0.037

3rd stage:

The second cantilever portion on both the sides of the pylon are constructed. Cables 3 and 4 are anchored to their respective places. The construction stage is shown in Fig. 7.

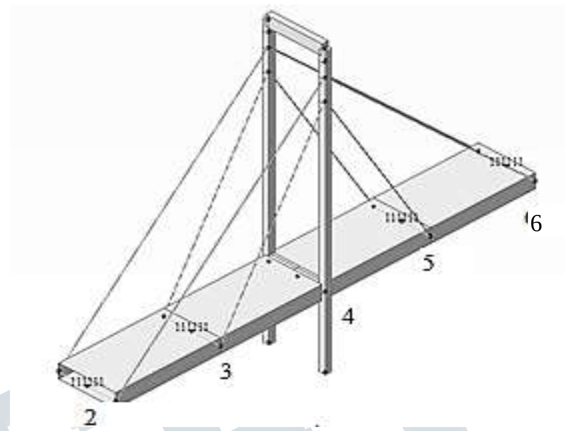

Fig. 7 Construction stage III

The analysis results of the stage are shown in Table IV.

Table IV Bending moment and deflection at various nodes

Node No.	Bending Moment (kNm)	Deflection (m)
2	0	0.071
3	-1680	0.093
4	-12810	0.032
5	-1680	0.093
6	0	0.071

4th stage:

The third cantilever portion on both the sides of the pylon are constructed. Cables 5 and 6 are anchored to their respective places. The construction stage is shown in Fig. 8.

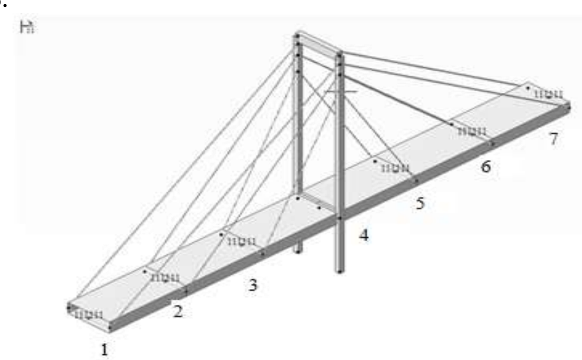

Fig. 8 Construction stage IV

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The analysis results of the stage are shown in Table V.

Table V Bending moment and deflection at various nodes

Node No.	Bending Moment (kNm)	Deflection (m)
1	0	0.100
2	-3190	0.150
3	-1330	0.135
4	-17460	0.045
5	-1330	0.135
6	-3190	0.150
7	0	0.100

V. CONCLUSION

From Table 1, it could be seen that the deflections obtained at various points on the girder using MIDAS Civil are almost same as that of results obtained from Staad Pro software. The results shown in Table II to Table V convey that the girder in the example considered which undergoes hogging moment during construction stage experienced sagging moment during service stage. Also, the deflection and bending moment obtained when the bridge was analysed as a whole did not yield maximum deflection. The deflection was found to be maximum during construction stages. So, it can be concluded that there is possibility that construction stage might govern the design criteria in certain cases. So, all cases have to be considered for analysis to arrive at most desirable solution.

REFERENCES

1. Sharath, R. (2014). “Study of cable-stayed bridges”. M. Tech. Dissertation Report, Visvesvaraya National Institute of Technology, Nagpur, India.

2. Tao Zhang, and ZhiMin Wu (2011). “Dead load analysis of cable-stayed bridge”. International conference on Intelligent building and management, volume 5, Singapore, 270-274.

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