PARAMETRIC INVESTIGATION OF CABLE STAYED BRIDGE USING MACRO BASED PROGRAM

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Abstract

In this paper, effects of various parameters such as geometric properties of deck and pylon and number of cables on the behaviour of cable stayed bridge were observed. For this purpose, analysis of 240 m long fan type cable stayed bridge having single plane of cables is carried out with the help of software facilities. To save time in modelling of bridges manually, a programming tool has been developed in excel software with the help of visual basic macro for the purpose of parametric study of Cable stayed bridge. With the help of this tool, number of models of cable-stayed bridge can be automatically generated in software SAP-2000. From the analysis of number of models, comparison of bending moments in pylon and deck is done.

Keywords: *VB program, Form control, Class 70R, Class A, Cable stayed bridge, parametric study, SAP2000, Interactive Database.*

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I. INTRODUCTION

Road transportation system is the basic infrastructural facility needed for any country to achieve self sufficiency by having a smooth flow in demand and supply chain. India is a developing country where technological boom arouse in the field of infrastructure for past 20 years. As one of the most competitive bridge in modern times, the cable-stayed bridge is usually a hub for transportation projects. Cable stayed bridge has a fine-looking appearance and fits in with most surrounding environments. Cable-stayed bridges are large and sophisticated structures which may greatly benefit from the use of structural optimization techniques for preliminary design improvement.

In the past studies, Pao-Hsii Wang investigated effects of parameters on cable-stayed bridge for investigating the individual influence of different sources of nonlinearity in such bridges which include large deflection, beam column and cable sag effects. Wei-Xin Ren showed that the geometric nonlinearity has a much smaller effect on the cable stayed bridge behaviour than material nonlinearity. From these studies, it has been concluded that for more accurate analysis of cable stayed bridge, some other parameters also require to be considered such as depth of stiffening girder, stiffness of pylon and length of central panel in addition to number of cables and pylon height.

II. DESCRIPTION OF STRUCTURE

For the purpose of parametric study a fan type cable stayed bridge having single plane of cables has been investigated. Total length of bridge is 240.0m having three spans 50m + 140m + 50m as shown in Fig 1. Box girder of 15.0m width is provided as deck carrying four lanes of traffic. For superimposed dead load, 4.0 T/m uniformly distributed load is considered over entire length of bridge. Live load combinations with class 70R and class A vehicles as per IRC:6-2014 are considered. For worst combinations of dead load, superimposed dead load and live load, bridge model is analysed. Various parameters considered in the study are pylon height and width, depth of box girder, length of central panel and number of cables. Values of these parameters are shown in Table 1. The effect of parameters is studied through comparison of bending moments at following critical locations.

- Maximum sagging moment at midspan of central panel of deck
- Maximum hogging moment in deck at pylon location
- Maximum moment in Pylon at deck level.

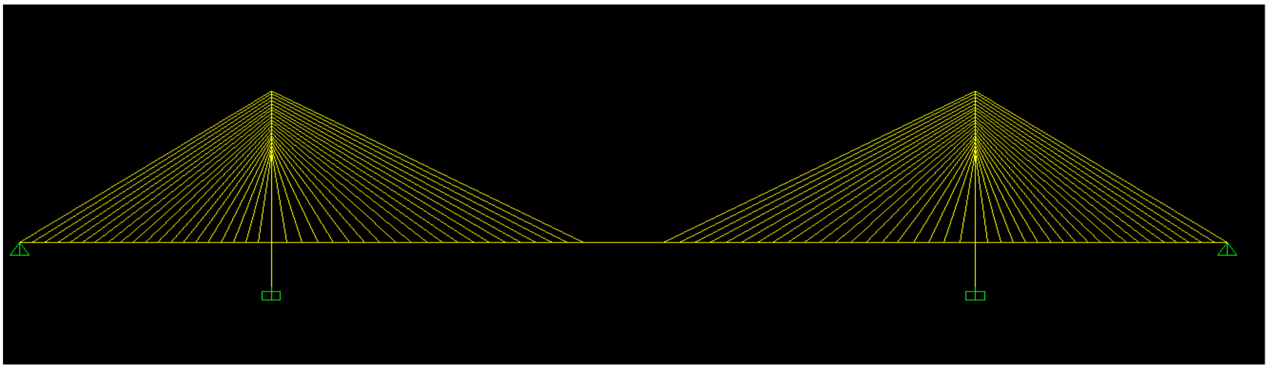


Fig 1 Cable stayed bridge Model in SAP2000

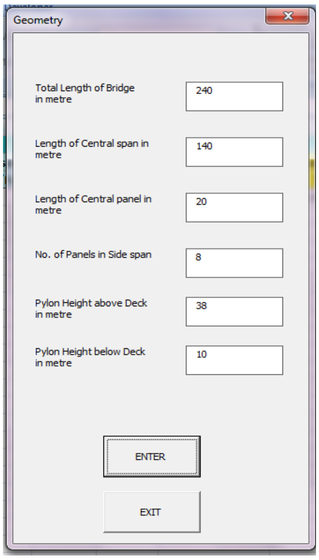
Table 1. List of parameters considered in program

No.	Parameter	Values considered						
1	Pylon Height (m)	26.0	28.0	30.0	32.0	34.0	36.0	38.0
2	Pylon Width (m)	1.00	1.25	1.50	1.75	2.00	2.25	2.50
3	Girder Depth (m)	1.00	1.25	1.50	1.75	2.00	2.25	2.50
4	Length of Central Panel (m)	8.0	10.0	12.0	14.0	16.0	18.0	20.0
5	Number of cables	8	10	12	14	16	18	20

III. DEVELOPMENT OF PROGRAM

The structure in this study is analysed in software SAP2000. A program in Visual Basic macro has been developed such that it works as the interface between SAP2000 and Excel. The model input is written in excel files using 'Interactive Database' format which is a special feature of SAP2000. After importing the excel file to SAP2000, model is generated and can be analysed. Also desired result output after analysing the model in SAP2000 can be transferred to Excel format. With the programming tool, by putting few parameters, model of cable stayed bridge is automatically generated in SAP2000. Imported excel file implements following functions of SAP2000.

- Generation of joints and frame elements of cable stayed bridge
- Generation of boundary conditions – restraints and constraints
- Assignment of material properties to components of bridge
- Assignment of sectional properties to components of bridge
- Generation of static loads such as DL and SIDL
- Generation of moving loads such as Class 70R and Class A
- Combination of desired loads as per IRC:6-2014



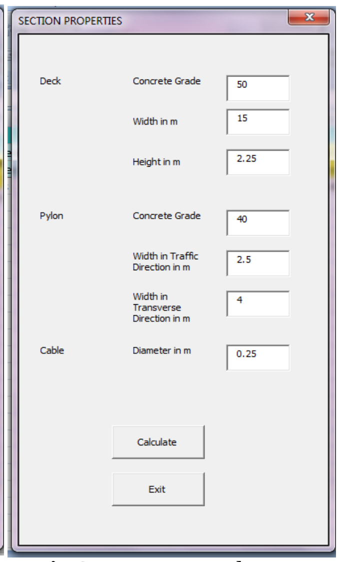


Fig 2. Form control - Geometry **Fig 3.** Form control - Sectional Properties

The program is written with the help of two form controls namely 'Geometry' and 'Sectional Properties' as shown in Fig.2 & Fig.3 respectively. As the program runs, form controls will appear on screen and ask for certain parameters of the bridge which need to be specified for purpose of modelling. After putting values of various parameters, program is executed. Then this excel file is imported to software 'SAP2000'. After analysing the model, result output is exported to excel format. Typical flow chart of program is shown in Fig.4.

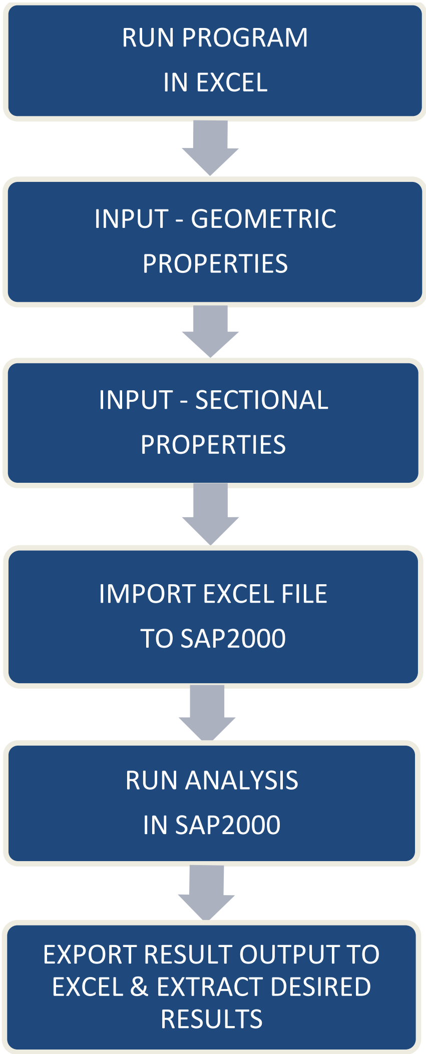


Fig 4. Flow Chart

IV. RESULTS AND CONCLUSION

In the analysis of 240.0m long cable stayed bridge, change in parameters such as stiffness of deck, pylon and number of cables have significant effect on the bending moments in the structure. Bending moment in the box girder at midspan of central panel and at pylon location and bending moment of pylon at deck level will change as the stiffness of these members change. For comparing bending moments at these critical locations, results of three sets have been studied as shown in Table 2.

Table 2. Sets of Parameters

	A	B	C	D	E
Set 1	30.0	2.00	1.50	12.0	10
Set 2	34.0	1.75	1.25	16.0	16
Set 3	38.0	2.50	2.25	20.0	8

Where,

A = Pylon Height in metre
B = Pylon Width in Traffic direction in metre
C = Depth of Girder in metre
D = Length of Central Panel in metre
E = Number of cables in each side span

In each set, default values for all five parameters are considered. Further in each set, value of one parameter changes while other four parameters remain same and program is executed for purpose of modelling the bridge. In this way, number of models are analysed in all three sets. In each case, graphs are plotted for bending moment at critical locations in the structure against each parameter keeping four other parameters fixed. Graphs plotted for first case are presented from Fig.5 to Fig.9.

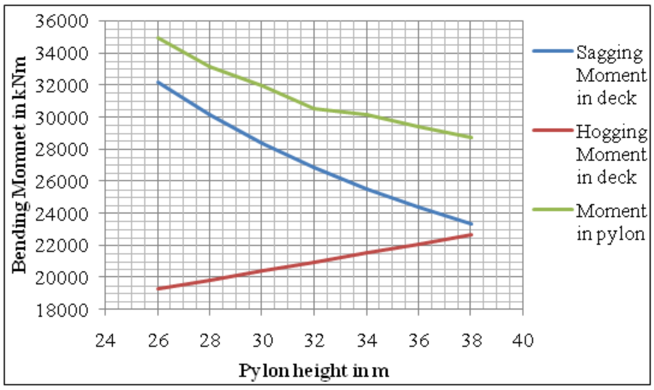


Fig 5. Graph- Pylon height vs Bending Moments

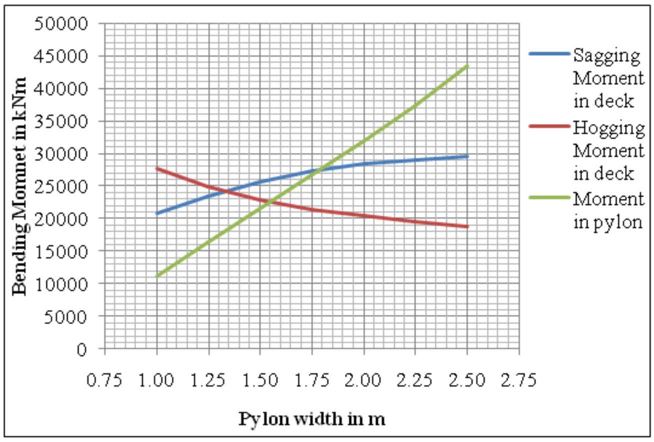


Fig 6. Graph- Pylon width vs Bending Moments

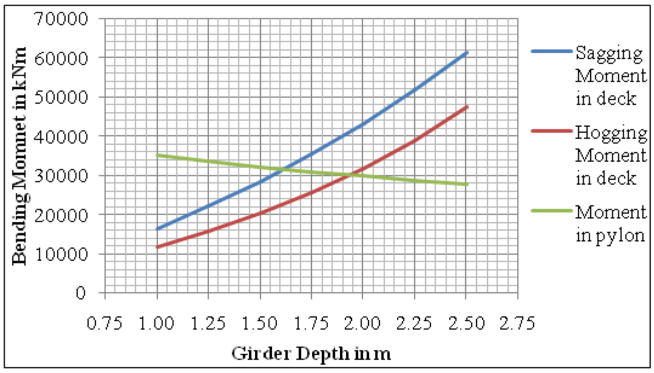


Fig 7. Graph- Girder Depth vs Bending Moments

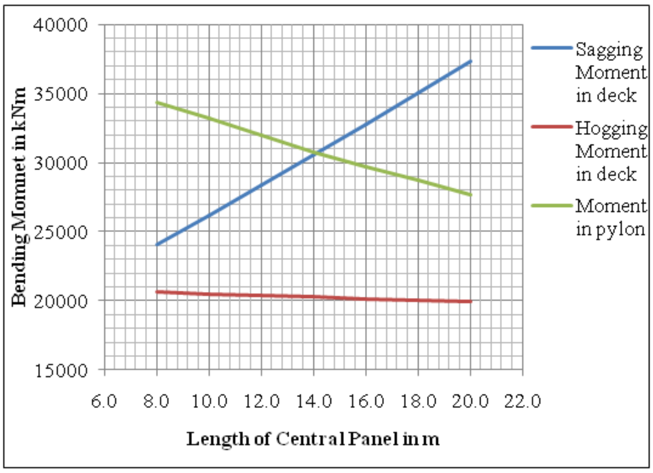


Fig 8. Graph- Length of central panel vs Bending Moments

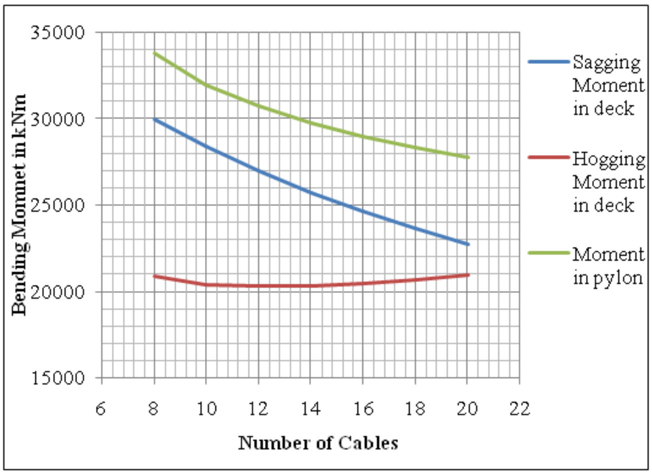


Fig 9. Graph- Number of cables vs Bending Moments

By comparing graphs in all three sets, various effects on maximum moments in deck at midspan of central panel and at pylon location and maximum moment in pylon at deck level were observed in governing load combinations which are as follows.

- Due to increase in pylon cross sectional properties, moment in pylon at deck level tend to increase drastically. But this has less significant effect on moments in deck.
- With increasing height of pylon, sagging moment in central panel of deck and moment in pylon at deck level tend to reduce whereas hogging moment in the deck at pylon location tend to increase.
- With increasing number of cables, sagging moment in central panel of deck and moment in pylon at deck level tend to reduce whereas hogging moment in the deck at pylon location tend to increase.
- With increasing depth of deck, moments in deck tend to increase as more stiff deck attracts more forces whereas moments in pylon at deck level tend to reduce.
- If length of central panel is increased, then it is obvious that there will be significant increase in the moment at midspan of central panel. Also increase in moments in pylon at deck level can be seen. Hogging moments in deck at pylon location do not alter much.

From all these observations, it is seen that stiffer sections of deck and pylon will produce more bending moments. It is preferable that slender sections should be used for deck and pylon so as to achieve economical solution. Further, use of more number of cables reduces bending moments in overall structure.

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BIOGRAPHIES

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