Progressive Collapse of Cable Stayed Bridge Using SAP2000

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Abstract- *Progressive collapse is a major threat causes the more demolitions of structure and leads to the loss and damage of lives. The main causes of the progressive collapse are earthquake and severe wind which results in gradual and successive failure of number of elements of the structure. The present paper includes linear static analytical procedures. For linear static analysis loading is considered as per the Post Tensioning Institute (2001) recommendations and GSA (2003) progressive collapse guidelines. Alternate path (AP) method is used for progressive collapse analysis of the cable stayed bridge. The cable stayed bridges are modeled in SAP 2000 with various cable arrangements and studied the deflection of girder under static loading condition. also studied the axial forces developed in the cables under the cable loss. The results are taken with respect to the various cable arrangement and number of cable lost.*

Keywords- Cable stayed bridge, SAP2000

I. INTRODUCTION

Cable-stayed bridges have been known since the 16th century and cast-off broadly from the 19th.Cable stayed bridges have only become an established solution for long span structures over the last 60 years. This recent domination is due to the progress of consistent high strength steels for the cables and perhaps more decisively, the beginning and widespread use of computers to analyses the intricate mathematical simulations. A cable-stayed bridge has 1 or more *towers* (or *pylons*), from which cables sustenance the bridge deck. A distinctive feature is the cables which run nonstop from the tower to the deck, generally forming a fan-like shape or a series of parallel lines. This is in distinction to the modern suspension bridge, where the cables backup the deck are suspended vertically from the main cable, anchored at both ends of the bridge and running between the towers. The cable-stayed bridge is optimal for spans longer than cantilever bridges and shorter than suspension bridges.

A. Cable-Stayed Bridges

A typical cable stayed bridge is a deck with one or two pylons established above the piers in the mid of the span. The cables are close slantways to the girder to arrange for supplementary supports.

Cable-stayed bridges may look alike to suspension bridges together have roads that hang from cables and together have towers. But both the bridges support the load of the road in very unlike ways. The variance lies in how the cables are linked to the towers.

Cable stayed spans are basic frameworks which are adequately made out of links, primary braces and towers. A scaffold conveys vertical loads mostly by the support. The staying links give transitional backings to the brace with the goal that it can cover a significant distance. The fundamental basic type of a link stayed connect incorporates a progression of covering triangles containing the arch (or the pinnacle), the links, and the brace. Every one of these individuals are under prevalently pivotal powers, with the links under strain and both the arch and the support under pressure. Pivotally stacked individuals are commonly more effective than flexural individuals.

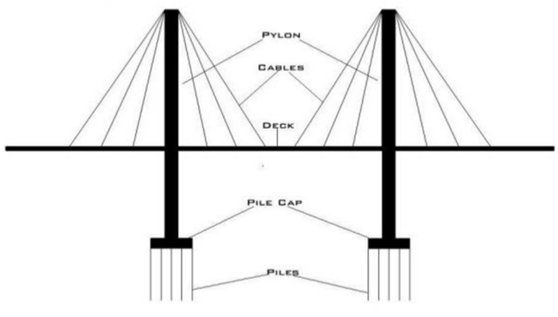


Fig 1.Components of Cable Stayed Bridge

B. Classification based on arrangements of the cables

1. Radial pattern
2. Harp pattern
3. Fan pattern

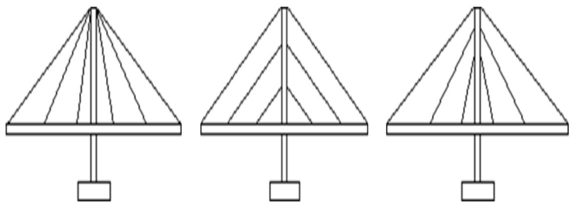


Fig 2 Cable Arrangements a) Radial b) Harp c) Fan

C.Objectives

1. To perform the progressive collapse analysis along with blast load for the cable stayed bridge having different cable arrangements and pylon geometry.
2. To compare the absolute displacements of girder and axial cable forces under progressive collapse mechanisms
3. To calculate the demand to capacity ratios for the cables to find out the structural stability against the progressive collapse mechanism
4. To find out the most suitable cable arrangement and pylon geometry against the progressive collapse

II. PROPOSED CONCEPT

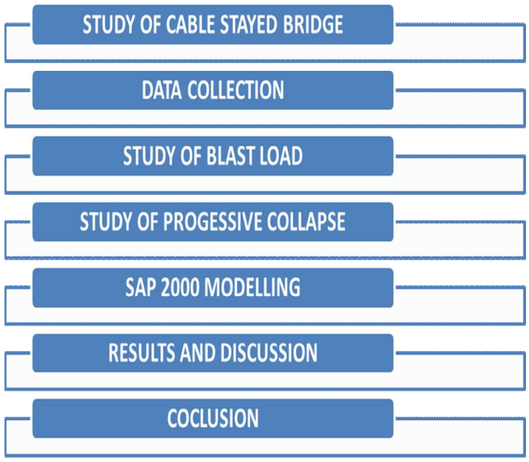
A comparative study of progressive collapse of cable stayed bridge using SAP2000 by considering various cable arrangement system and pylon geometry

Table 1. Combinations of cable arrangement and pylon type

Sr.No.	Cable Arrangements	Pylon
1	Harp Arrangement	A – Type
2		H – Type
3		Y – Type
4	Fan Arrangement	A – Type
5		H – Type
6		Y – Type
7	Radial Arrangement	A – Type
8		H – Type
9		Y – Type

III. METHODOLOGY

As the bridge with two pylons, three spans i.e. two end spans and one middle span, is quite difficult to analyze. So here bridge with two end spans with single pylon is finalized. The geometrical data is arrived by study of several cable stayed bridges built in India and Abroad.



A. Materials Properties.

Ser.No.	Material	Property	Value
1	Structural steel	Yield stress f_{sy}(MPa)	265
		Ultimate strength f_{su}(MPa)	410
		Young's modulus *Es*(MPa)	205×× 10^3
		Poisson's ratio µ	0.3
		Ultimate tensile strain e_t	0.25
2	Reinforcing bar	Yield stress f_{sy}(MPa)	250
		Ultimate strengthf_{su} (MPa)	350
		Young's modulus Es(MPa)	200×× 10^3
		Poisson's ratio µ	0.3
		Ultimate tensile strain e_t	0.25
3	Concrete	Compressive strengthf_{sc}(MPa)	42.5
		Tensilestrengthf_{sy}(MPa)	3.553
		Young's modulus E_c(MPa)	32920
		Poisson's ratio µ	0.15
		Ultimate compressive strain e_s	0.045

4	Stud shear connector	Spacing (mm)	110
		Number of rows	2
		Numbers of connectors	68
		Yield stress f_{sy}(MPa)	435
		Ultimate strength f_{su} (MPa)	565
		Young's modulus E_s(MPa)	200×× 10^3
		Poisson's ratio μ	0.15
		Ultimate strain *e*	0.045

IV. RESULT AND DISCUSSION

A.Modeling of the bridges

SAP2000 is the easiest most productive solution for structural analysis and design needs. It can analyse simple 2D frames as well as the complex 3D structures. It is the most suitable finite element tool for modelling and progressive collapse analysis of cable- stayed bridges. The three types of cable arrangements i.e. Harp, Fan and Radial has modelled by using SAP2000 as shown in following Figures.

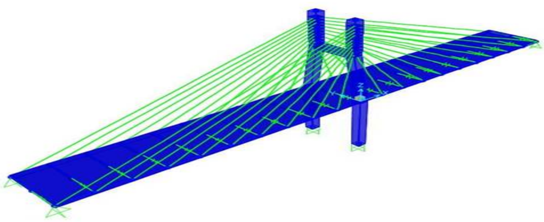


Fig 3. Fan Cable arrangement with H-type pylon

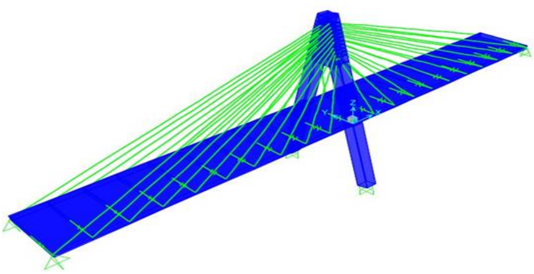


Fig 4. Fan Cable arrangement with A-type pylon

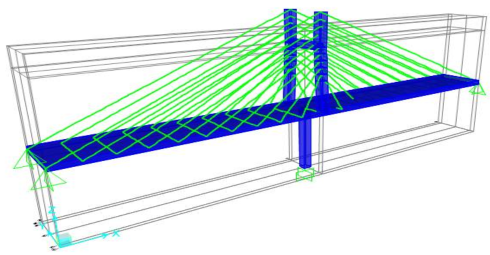


Fig 5 Fan Cable arrangement with Y-type pylon

B. Deflection of Girder for FAN cable arrangement with A- type pylon

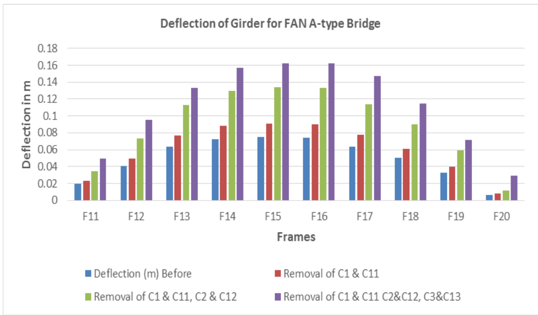


Fig 6 Deflection of Girder for FAN A-Type Bridge

C. Deflection of Girder for FAN cable arrangement with H- type pylon

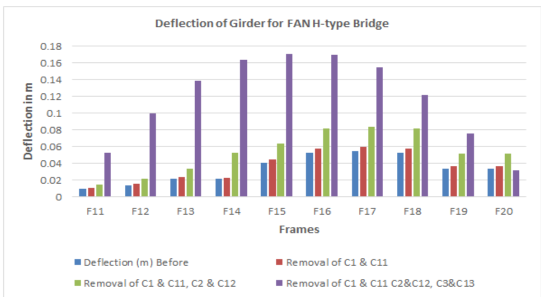


Fig 7 Deflection of Girder for FAN H-type Bridge

D. Deflection of Girder for FAN cable arrangement with Y- type pylon

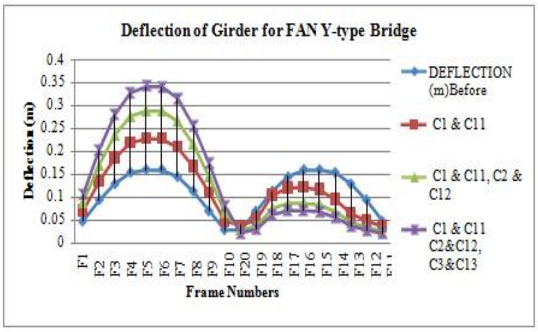


Fig 8 Deflection of Girder for FAN Y- type pylon

VI. CONCLUSION

The deflection of girder at the other side of the pylon cannot be considered as negligible under the loss of outside cables. The vertical deflection at the other side of the pylon decreases as the location of the lost cable approaches the pylon.

After two critical cable losses deflection obtained is minimum on the cable loss side and maximum deflection on the other side as compared to the four and six critical cable losses. For six cable losses the deflection on the cable loss side is maximum and the deflection on the other side is minimum
The cables adjacent to the ruptured cable do not reach the tension yield and the maximum nodal vertical displacement decreases when the lost cables are near the pylon.

When only Cable arrangement is considered the maximum deflection obtained is 0.4714m in HARP cable arrangement with H-type pylon whereas the FAN cable arrangement with A-type pylon gives least deflection0.3317m.

In case of cable arrangement with pylon geometry, the FAN cable arrangement with A-type pylon gives best results against progressive collapse. HARP cable arrangement with H-type pylon gives worst results progressive collapse.

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