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Configuration Analysis of a Self-Anchored Suspension Bridge

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Summary

A mono-duo self-anchored suspension bridge is in construction for the crossing of the highway and the railway line between Seoul and the new airport. Contrary to a typical suspension bridge, large axial force is introduced in the stiffening truss of a self-anchored suspension bridge under the dead load state. An algorithm is developed to consider the initial forces of frame members in establishing the initial equilibrium state of a self-anchored bridge. This algorithm utilizes an auto-iterative technique. Based upon an application, it is found that the initial-force-included configuration analysis is necessary for a self-anchored suspension bridge for the proper control of the construction.

1. Initial Configuration of a Self-anchored Suspension Bridge

Contrary to a typical suspension bridge, large axial force is introduced in the stiffening truss of a self-anchored suspension bridge due to the dead load. Consequently the cable anchorages and the tower tops of a self-anchored suspension bridge go through displacement along the bridge axis in the nonlinear equilibrium state analysis under dead load (see fig 1). For this reason, it is difficult to form the aiming configuration of a self-anchored suspension bridge with only the conventional method for an earth-anchored suspension bridge. In order to control the changes of the boundary conditions of the main cable, it is necessary to consider initial axial forces in calculating the unbalanced force caused by the bridge self-weight.

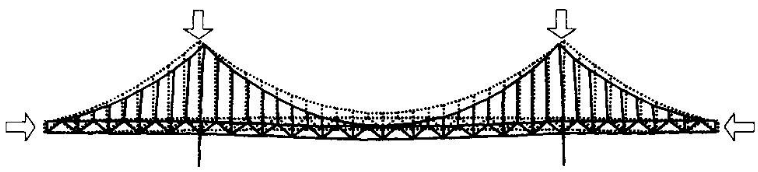

Fig. 1 Dead load deformation due to large axial force

2. Auto-iterative Nonlinear Configuration Analysis

As a prerequisite to the final configuration analysis, strict configuration analysis has been carried out only for the cable net system including the main cables and hangers. The three dimensional elastic catenary cable element has been used in the mathematical modeling of the bridge. The exact configuration of the main cable can be defined by suggested auto-iterative trial-and-error method based on the given design parameters.

An auto-iterative algorithm is developed to consider the initial forces of the frame members in establishing the initial configuration of a self-anchored bridge. This algorithm is based on the geometric nonlinear analysis using Modified Newton-Raphson method and an iterative trial-and-error algorithm is added for the convergence of the final configuration of the total bridge.

3. Application and Effectiveness

The nonlinear configuration analysis has been performed for a self-anchored suspension bridge in Korea which is in construction. It consists of 3 spans of 125m-300m-125m. It has A-shaped towers and a mono-duo cable system sagged horizontally as well as vertically (see fig 2). The mathematical modeling of the bridge is shown in fig 3.

Table 1 shows the importance of the initial-force-included configuration analysis. It can be easily found that the suggested algorithm reduces the difference considerably between the design (target) and the final (result of configuration analysis) configuration.

The determined mathematical model can be used effectively not only for the nonlinear live load analysis or dynamic analysis but also for the nonlinear backward-step construction stage analysis for the prediction of the unstrained member length or the camber control.

Table 1 Result of the configuration analysis

	Description		Design (a)	Conventional Method (b)	Presented Method (c)	Relative Error (%)*
Displ. (cm)	End Link	Δx	0	5.253	0	0
	Top of Tower	Δx	0	8.295	0	0
		Δz	0	6.748	0	0
	Main Cable Anchorage	Δx	0	5.512	0	0
		Δz	0	-0.451	0	0
	Sag of Main Cable	f_z	60	60.207	60	0
		f_y	13.576	13.573	13.579	-
Tension (ton)	Main Cable (Horizontal)	max.	4842	4453	4840	0.5
		min.		4459	4840	0.5
	Hanger (mid-span)	max.	322.3	293.2	326.8	15.5
		min.	307.6	273.0	307.6	0
	Hanger (side-span)	max.	323.7	295.7	328.0	15.4
		min.	308.8	272.3	308.1	1.9

*) Relative Error = $|\{(c)-(a)\}/\{(b)-(a)\}| \times 100\%$

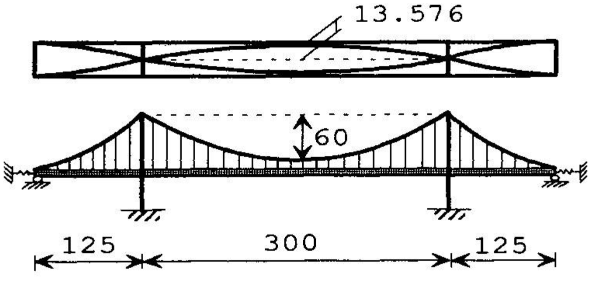

Fig. 2 A Self-Anchored Suspension Bridge

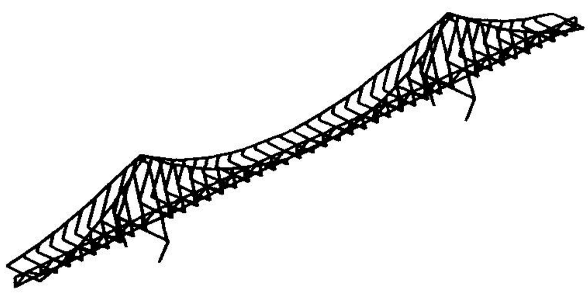

Fig. 3 Mathematical Model