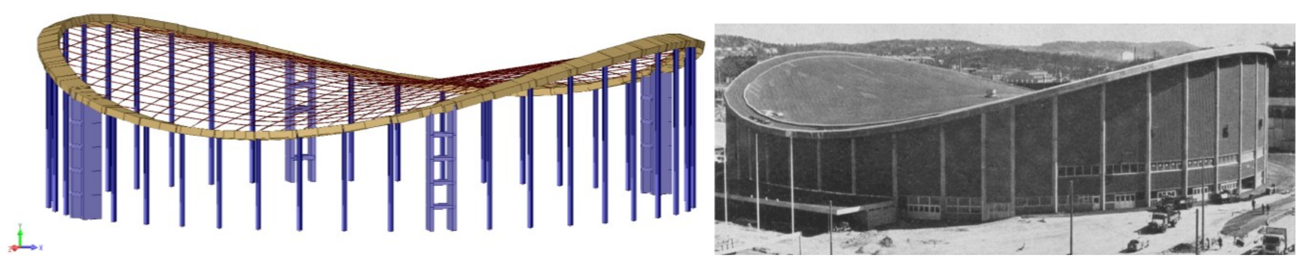
CATENARY CABLE

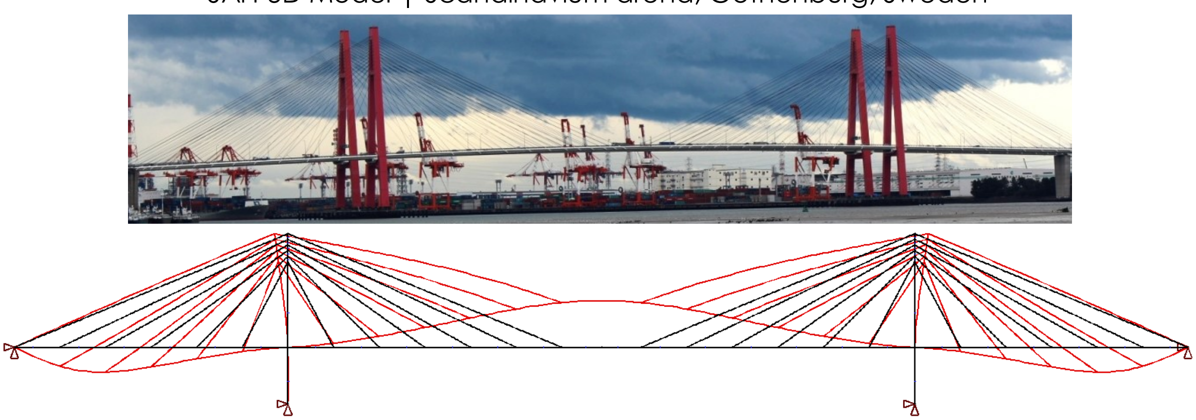
INTRODUCTION

In the past decades, cable structures have been widely used in engineering applications because of their various advantages such as high strength, large degrees of flexibility, elastic behavior, light weight, the ability to preload and profitable buildings.

The increasing of attention on cable structures is not only because of their intrinsic beauty, but also their stubborn natures of not easily disclosing the secret behind their non-linear behavior. Cable structures present a behavior with strong geometrical non-linearity. These cable structures are very flexible and undergo large displacements before reaching their equilibrium configuration. Because of this inherent non-linear behavior, the conventional linear analysis which assumes the small elastic deformations or displacements is often not applicable.



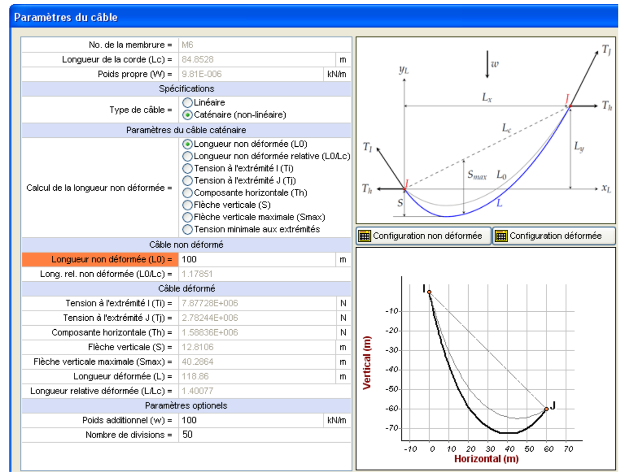
SAFI 3D Model | Scandinavium arena, Gothenburg, Sweden



SAFI 2D Model | Meiko Nishi Bridge, Negoya, Japan (Natural frequencies Analysis)

CATENARY CABLE FEATURE IN SAFI

In the interface of SAFI, the user can create a catenary cable by associating a cable type section to a member. The cable Settings command allows to specify the type of cable; linear or catenary. This command facilitates the automatic determination of the undistorted length of the cable (L_0) using different input datas (pre tension, minimal tension, vertical deflexion, etc).

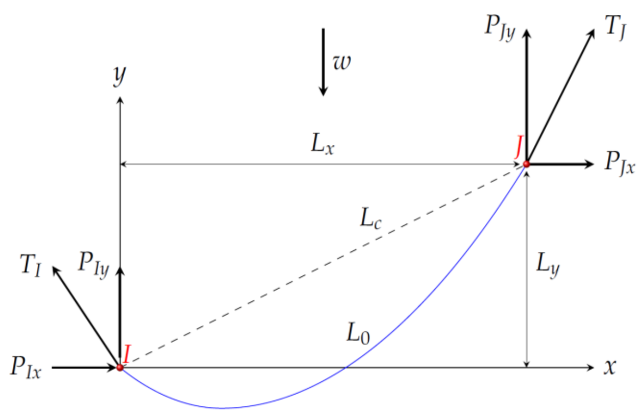


The **catenary** cable element is a highly non-linear element, used to model the behavior of a catenary cable suspended between two points under the effect of its own weight. This formulation reflects the nonlinearity due to large displacements. A cable has no bending, shear, compression or torsion rigidity. Therefore ends fixities are ignored and the cables are always treated as members acting in tension only.

The exact balance equations of an elastic catenary cable under an uniform load (w) are :

$$L_x = -P_{Ix}\left(\frac{L_0}{EA} + \frac{1}{w}\ln\left(\frac{P_{Jy} + T_J}{T_I - P_{Iy}}\right)\right)$$

$$L_y = \frac{1}{2EAw}\left(T_J^2 - T_I^2\right) + \frac{T_J - T_I}{w}$$



where :

L_x : The vector component $\overrightarrow{IJ}$ on x axis

L_y : The vector component $\overrightarrow{IJ}$ on y axis

P_{Ix} : The component on x local axis of the force at joint I

P_{Iy} : Component on y local axis of the force at joint I

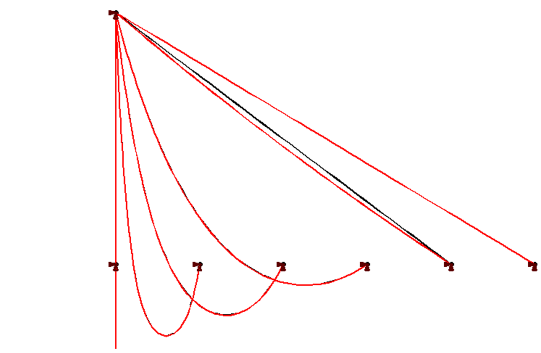
P_{Jx} : Component on x local axis of the force at joint J

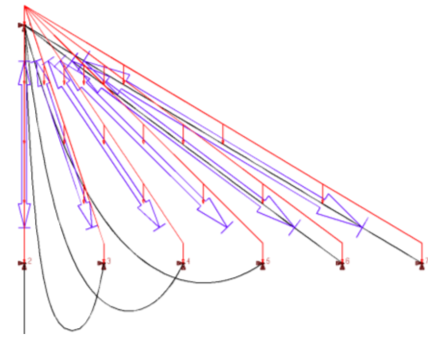
P_{Jy} : Component on y local axis of the force at joint J

The rigidity of the catenary element depends on the area (A), the modulus of elasticity (E), of the initial length (L_0), of the transverse load (w) and of the position of the joints. **The nonlinear analysis is required** to consider all of these factors. Although other types of analysis are permitted in SAFI, the analysis results are approximate. The rigidity of the catenary element is calculated from a joint position corresponding to its initial configuration not deformed for all other types of analysis. In addition, the rigidity of the catenary element is calculated by considering the load (w) equal to its own weight for the following analyzes: linear analysis without iteration (one analysis only for all combinations), buckling analysis, analysis of natural frequencies, seismic analysis and / or dynamic analysis of moving loads.

COMPARISON EXAMPLES

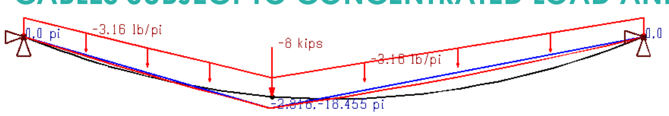
CABLES SUBJECT TO UNIFORM LOADS AND THERMAL LOADS

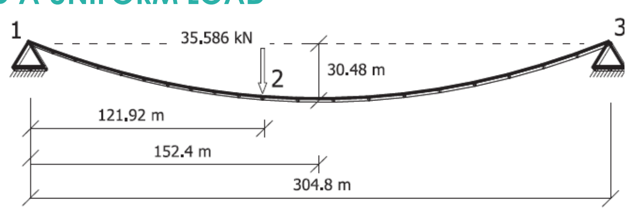




Cable	Reaction [N]	SAFI	(Peyrot et Goulois 1979)	(SAP2000)	Relative error
1-2	R_x	0	0	0	0.0%
	R_y	20.02	20.02	20.02	0.0%
1-3	R_x	3.06	3.06	3.06	0.0%
	R_y	19.93	19.93	19.93	0.0%
1-4	R_x	9.17	9.17	9.17	0.0%
	R_y	19.24	19.24	19.24	0.0%
1-5	R_x	22.15	22.15	22.15	0.0%
	R_y	15.73	15.73	15.73	0.0%
1-6	R_x	504.1	504	504.1	0.0%
	R_y	-328.87	-328.8	-328.9	0.0%
1-7	R_x	4258491	4170000	4258491	2.1%
	R_y	-2555045	-2511000	-2555045	1.8%

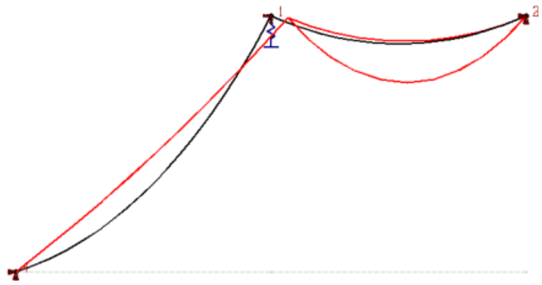
CABLES SUBJECT TO CONCENTRATED LOAD AND A UNIFORM LOAD

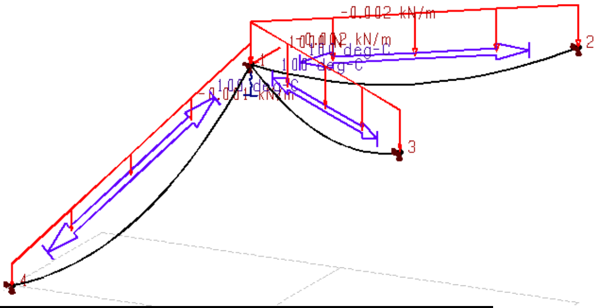




Displacement	SAFI	(Tibert 1999)	(SAP2000)	Relative error
x [pi]	-2.189	-2.189	-2.819	0.0%
y [pi]	-18.458	-18.457	-18.457	0.0%

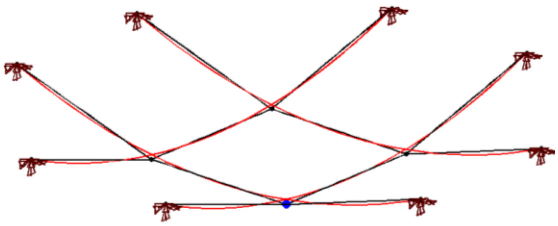
3 DIMENSIONS CABLES SYSTEM WITH SPRING SUBJECTED TO DIFFERENT LOADS

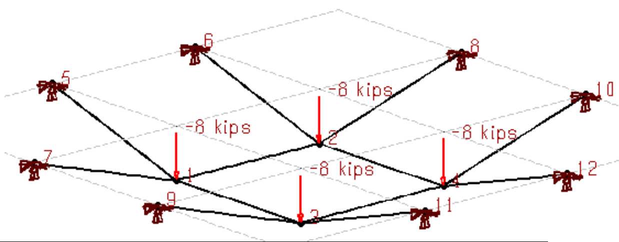




Displacement	SAFI	(Peyrot et Goulois 1979)	Relative error
x [m]	26.471	26.473	0.0%
y [m]	41.138	41.135	0.0%
z [m]	-2.875	-2.874	0.0%

PRE TENSIONED CABLE MESH SUBJECTED TO VERTICAL LOADS





Displacement	SAFI	(Tibert 1999)	(SAP2000)	Relative error
x [pi]	-0.1328	-0.1328	-0.1328	0.0%
y [pi]	-1.4745	-1.4764	-1.4745	-0.1%
z [pi]	-0.1328	-0.1328	-0.1328	0.0%

REFERENCES

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SAFI QUALITY SOFTWARE INC.

3393 Sainte-Foy Road | QC | Canada
G1X1S7 | info@safi.com
T.F.1.800.810.9454 | W.418.654.9454