IMPACT-FEM FOR CABLE TRANSPORT PROBLEMS

calculix09 (http://www.youtube.com/user/calculix09/videos)

There is an old and well known type of transport called cable transport.

http://en.wikipedia.org/wiki/Cable_transport
http://en.wikipedia.org/wiki/Aerial_lift

The important engineering problem is in increasing the speed and capacity of these systems.
The dynamics of such systems is described by the wave equation.

http://en.wikipedia.org/wiki/Wave_equation

It can be solved with open-source or commercial math code (GetDP , SciLab, etc)
but most simple way to solve it without programming is in using finite element programs with explicit solver.

Let's start with static part of this problem (it is a simple special case of the dynamic problems).

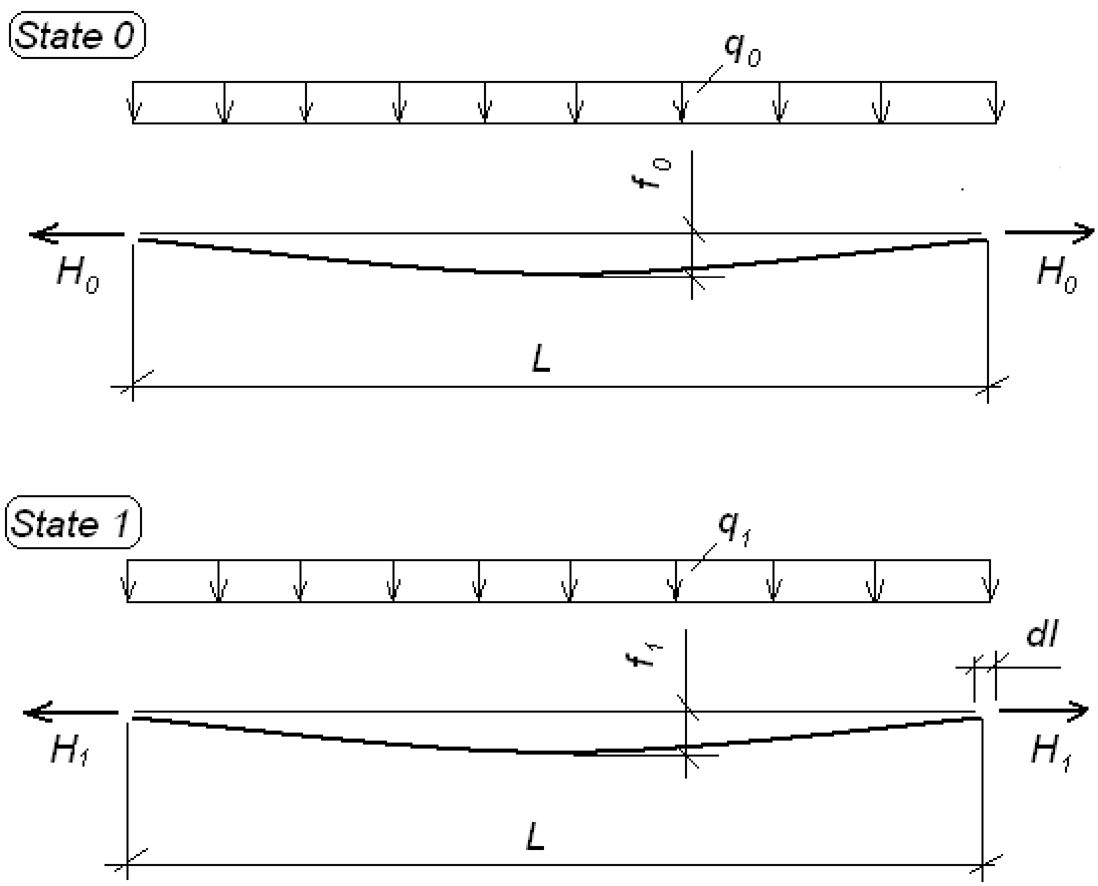


Fig. 1

There are tree main sets of equations are available for this system.

1. Static equations: $\frac{q_0 \cdot L^2}{8} = H_0 \cdot f_0$; $\frac{q_1 \cdot L^2}{8} = H_1 \cdot f_1$
2. Geometric Equations : $S_0 = L \cdot \left[1 + \frac{8}{3}\left(\frac{f_0}{L}\right)^2\right]$; $S_1 = L \cdot \left[1 + \frac{8}{3}\left(\frac{f_1}{L}\right)^2\right]$ (where S_i is length of curve)
3. Hooke's law equation: $S_1 + dl - S_0 = \frac{(H_1 - H_0) \cdot L}{E \cdot A}$.

Geometric Equations are obtained by approximate formula:

$$S = \int_0^L \sqrt{1 + y'^2}\, dx \approx \int_0^L \left(1 + \frac{1}{2} y'^2\right) dx$$

, where $y = \left(\frac{4f}{L^2}\right) \cdot x \cdot (L - x)$;

The common solution is given by:

$$\sigma_1 - \frac{p_1^2 L^2 E}{24 \sigma_1^2} = \sigma_0 - \frac{p_0^2 L^2 E}{24 \sigma_0^2} + E \frac{dl}{L}$$;

where $\sigma_1 = H_1 / A$; $\sigma_0 = H_0 / A$; $p_1 = q_1 / A$; $p_0 = q_0 / A$.

Thus two states are always considered. First state is "zero" (after installation) state, and second state when the load was changed.
Basically $p_0 = p_1 = g / A$ where g – is weight per length.

Let's assume that $q_0 = dl = 0$ and f_0 is determined. In this case.

$$L + \frac{8f^2}{3L} - S = \frac{pSL^2}{8\, fE}$$.

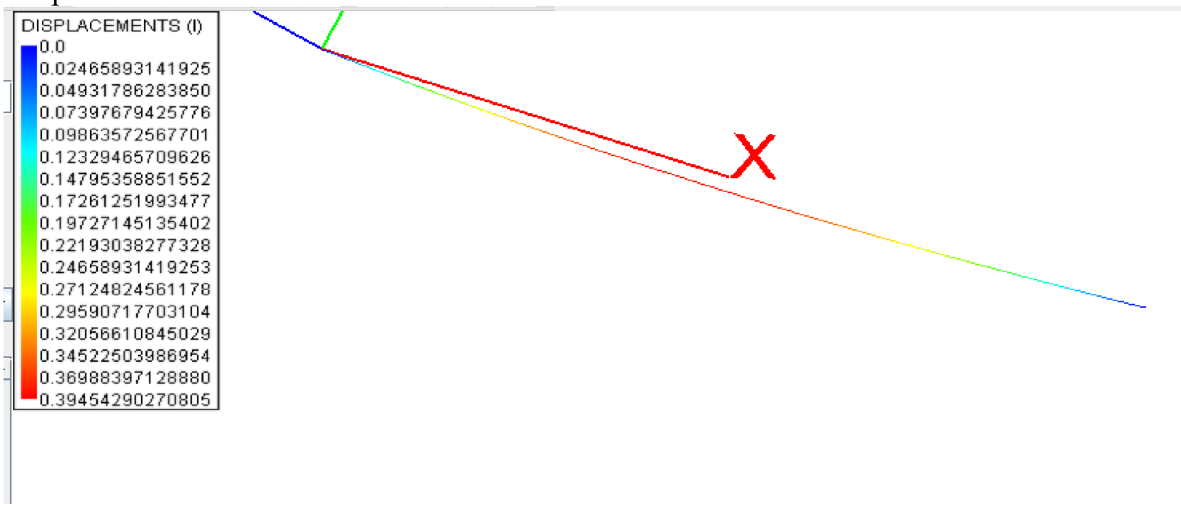
Where: $S = L + \frac{8f_0^2}{3L}$ Solution is:

$$f = \left(\frac{L\sqrt{-L\left(32E^2S^3 + \left(-9p^2L^3 - 96E^2L\right)S^2 + 96E^2L^2S - 32E^2L^3\right)}}{128E} + \frac{3pL^3S}{128E}\right)^{1/3} - \frac{L^2 - LS}{8\left(\frac{L\sqrt{-L\left(32E^2S^3 + \left(-9p^2L^3 - 96E^2L\right)S^2 + 96E^2L^2S - 32E^2L^3\right)}}{128E} + \frac{3pL^3S}{128E}\right)^{1/3}}$$

(were obtained in wxMaxima http://www.ma.utexas.edu/users/wfs/)

You can generate .in files for Impact-FEM with spreadsheet for three cases:
1) static loading, 2) dynamic loading under the moving force (with constant speed), applied to the cable
3) dynamic loading with carrier in contact with two cables.

Max. Displacement for static case is similar with theoretical results:



OUTPUT DATA					
S0=	91.47	m	300.11	ft	
Area =	1.25E-03	m²			
p=q/A=	6.90E+04	N/m³			
Final Sag Value f=	1.44	m	**4.74**	**Ft = L/**	63.34
disp=f-f0=	**0.38**	**m**	1.24	ft	
Stress =	4.99E+07	Pa	7.24	ksi	
Tension Force = Stress*Area =	**6.24E+04**	**N**	14018	lbf	

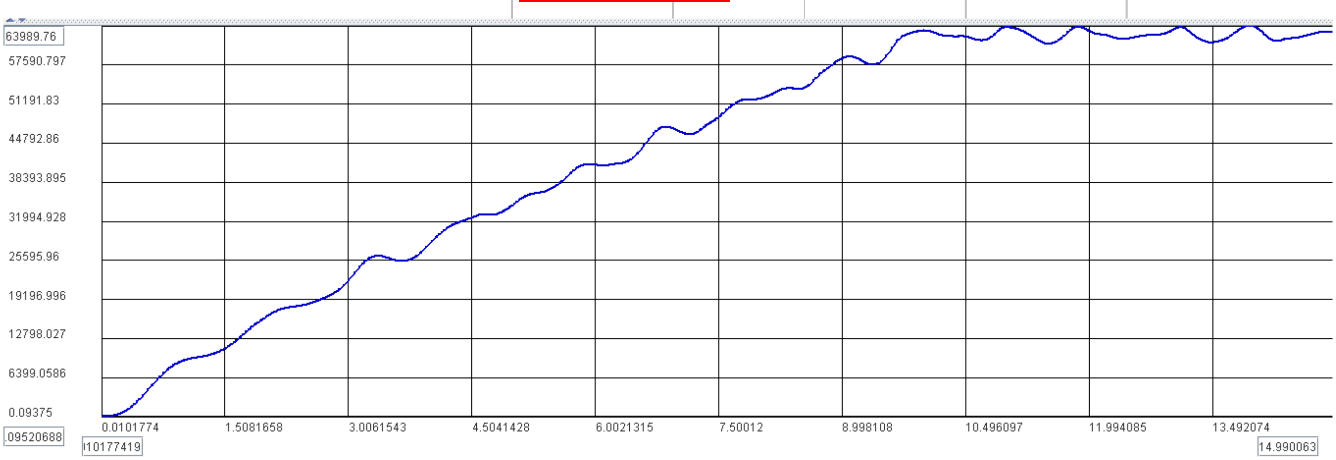


Fig. 2

The results obtained for dynamic loading can be used for fatigue calculation of the cable.