

**IMPACT-FEM
FOR CABLE TRANSPORTATION PROBLEMS
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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).

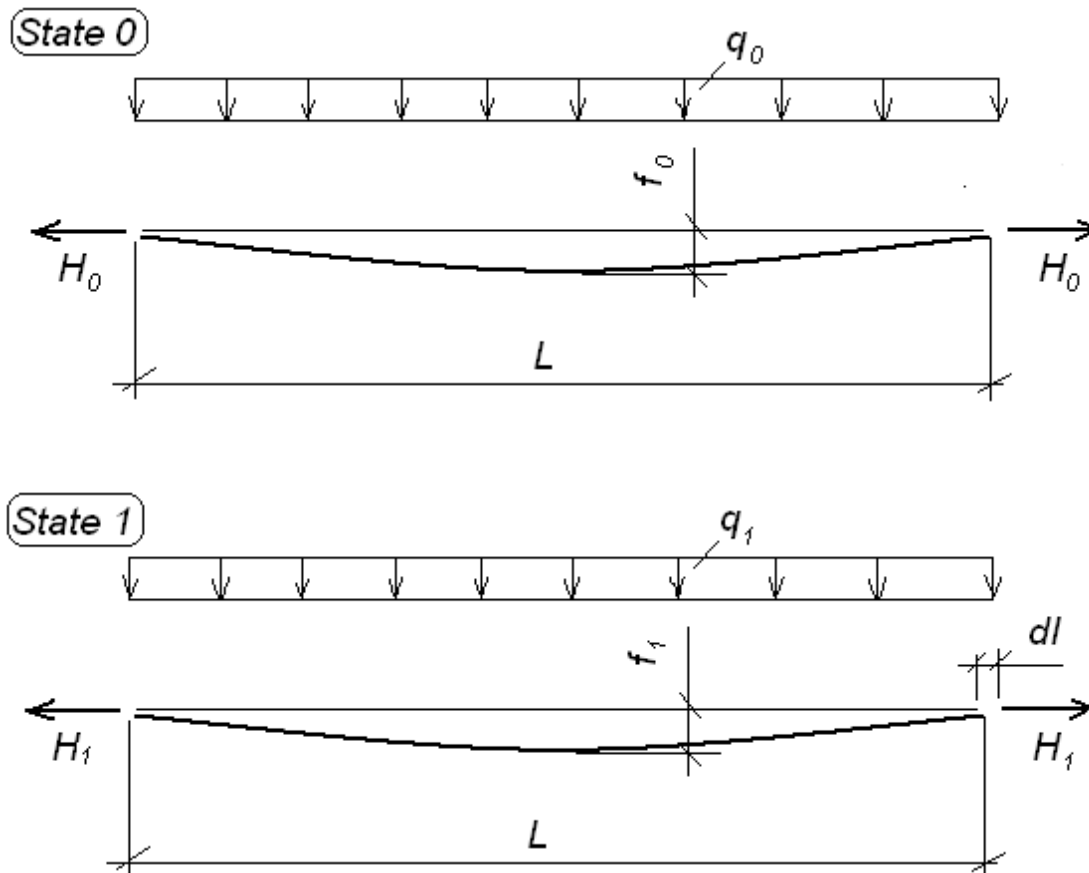


Fig. 1

There are three main sets of equations 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:

$$S = \int_0^L \sqrt{1 + y'^2} dx \approx \int_0^L \left(1 + \frac{1}{2} y'^2 \right) dx, \text{ where } y = \left(\frac{4f}{L^2} \right) \cdot x \cdot (L - x) ;$$

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.

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

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

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

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

The Impact-FEM web site: <http://www.impact-fem.org/>

The Impact input file can be generated by OpenOffice spreadsheet [impactgen.ods](#)
(you should allow macros first)

See the animation here:

<http://youtu.be/BpSK8GRnH5A>

<http://youtu.be/brsBV-Uejxw>

<http://youtu.be/B6PSS2rQjx8>