Axial load determination by means of modal analysis

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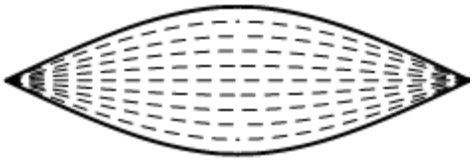
The aim of the thesis is to determine compressive loads in columns by measuring how it vibrates. Experiments show that the applied method is promising but is in need of further development.

In structural engineering the measurement of loads is of interest in order to verify design assumptions/theories. However the measurement of loads in real structures such as columns in a building can be difficult to perform practically.

Therefore the possibility to estimate the load by measuring vibrations is investigated.

Vibration & Load

When a structure is impacted and then allowed to vibrate freely, it vibrates in a speed (frequency) and shape specific for the structure in question; i.e. its natural frequency.



Shape of a vibrating string

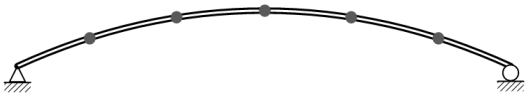
For instance when a guitar wire is plucked, it will then vibrate at its natural frequency, which we recognize as a specific musical note. The exact frequency (or note) of the wire depends on the magnitude of tension that is exerted upon it; an increase in tension yields an increase in vibration frequency and vice versa. This phenomenon is used when tuning string instruments such as guitars by adjusting the tension to produce a specific note.

This effect can also be observed in columns that are compressed, which decreases the frequency as the compressive load is increased.

Given this relation between frequency and load, the frequency could be used to determine the load.

Experimental testing

In order to use this relationship the exact condition of columns connections (at the ends) must be known. This is very hard to determine precisely in practice and therefore these are treated as unknown variables. Thus both the frequency and at least five points of the vibration shape must be measured for calculations to be possible.



Vibrating beam and measured shape points

Previous to this study some experimental testing had been done, however this was mainly performed slender test specimens in tension. Since building structures often are non-slender and in compression, four different columns were tested in compression.

The results of the study show that the method is very sensitive to the measured vibration shape. The use of an extra point (six instead of five) greatly increased the accuracy of the load estimation.

The main conclusion of the thesis is that the method could be of practical use in the future, but it requires further development.