THE EARTHQUAKE RESPONSE OF A CANTILEVER TIMOSHENKO BEAM

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ABSTRACT

In this paper an attempt is made to solve the equation of motion of a cantilever beam where the combined effects of shear forces, bending and rotatory inertia are taken into consideration, when subjected to an earthquake type disturbance at the clamped end. A numerical sample is worked out where the results of the analysis are applied to a 12 storey reinforced concrete building which is subjected to the strong motion records of E1, Centro, 1940, N-S component, Taft, 1952, E-W and N-S components.

Introduction

For some kind of structures it is deemed necessary to take into consideration the effect of rotatory inertia and shear in analysing the response due to earthquake type disturbances. Certain "box type" reinforced concrete buildings that solely consist of seismic shear-walls and reinforced slabs without any structural frames, may have large effective cross sectional moment of inertia such that the effect of rotatory inertia is no longer negligible. The best mathematical model for such structures appears to be the Timoshenko beam where the combined effects of shear, rotatory inertia and bending are considered, however as the theory involved is rather complicated it has not as yet found much use in structural vibration.

In the following the theory is presented along the lines set in a paper by T.C. Huang (1), where the free vibration of single span beams is analysed and the frequency equation and characteristic functions for various end conditions are presented.

Conclusion

A last few concluding remarks may be added. The main purpose of this paper has been to investigate the possibilities of using the Timoshenko beam as a model for certain structural vibration problems. It is difficult to draw any general conclusions from the numerical results, the material not being sufficient. It may however be pointed out as an interesting feature that the maximum shear distribution is approximately parabolic in shape which indicates that an appropriate horizontal design load would be that of an inverted triangle.

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1. Huang, T.C., "The Effect of Shear Deformation and Rotatory Inertia on the Frequencies and Normal Mode Equations of Uniform Beams with Simple End Conditions", Journal of Appl. Mech. 28 (4) 1961, Trans. ASME.