

Chapter 4

Multi-Degrees of Freedom Structural Damping

ABSTRACT

Damping is the most difficult structure characteristic to evaluate because it depends on several parameters, who are in the structure itself, like support type, internal friction materials of a studied structure. In addition, parameters surrounding the structure like soil type have a direct effect on damping. These things make it difficult to evaluate properly. This chapter allows us to evaluate different types of damping, as damping proportional to stiffness matrix: Rayleigh damping, Cauchy damping, and viscous equivalent damping.

INTRODUCTION

The core of this chapter is the evaluation of all damping types namely Viscous equivalent, Rayleigh, Cauchy damping. Damping is a means of reducing speed through resistance to motion, particularly by forcing an object through a liquid or a gas, or along another body. The damping unit is often proposed as Force * length / time (N.m /s).

In practice, all structures, meets resistance during their movements. Consequently, the amplitude of the movement does not remain unchanged; but it will diminish gradually with time, in the case of free vibrations; until the motion stops. The damping forces must depend on the vibratory system itself, as well as external factors surrounding the system. In a system, damping occurs due to the internal friction forces of the materials of the structure and the external effects in which the structure is immersed.

DAMPING TYPES

An exact representation of damping phenomenon involves difficulties; however, as for each of its nature, the damping can be presented into four following types:

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1. Structural damping.
2. Viscous damping.
3. Coulomb damping.
4. Negative damping.

The structural damping is due to the internal molecular friction force of the material of the structure, or it is due to the own connections of the system.

The viscous damping appears in the case of a vibrating system in a fluid; the damping force in this case is proportional to the speed:

$$F_0 = C\dot{U}$$

Where \dot{u} the velocity and C is the damping constant.

The Coulomb damping, it is also known as a dry friction; it appears when the movement of the body is in a sealed surface, the damping force in this case is given as follows:

$$F_0 = \mu N$$

Where μ is the kinematic coefficient of friction and N is the normal force of body motion on the surface.

Negative damping is a very special case, where damping adds energy to the system rather than dissipating it, resulting in amplification of the amplitude, it is the case of poor soil.

In this chapter, we will focus only on damping proportional to stiffness matrix Rayleigh damping, Cauchy damping, and Viscous equivalent damping

Just like a one-degree of freedom system, there is no analytic way of assessing damping the best way it is experimental.

As long as there is no firm form of the damping matrix $[C]$; we can safely assume that the matrix $[C]$ so that the orthogonality is ensured.

$$[\varphi]^T [C] [\varphi] = \underbrace{[C^*]}_{\text{diagonal matrix}}$$

There are five ways to choose the damping matrix $[C]$ which are enumerated as follows (Chopra 2001) & (Clough 1995).

Proportional Mass Damping

In this case we assume that there is a proportional relationship between damping matrix and mass matrix by coefficient.

$$[C] = \alpha[M]$$

We assume

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