One-story Shear Building Displacement Evaluation

Introduction

Single-degree-of-freedom system (SDOF) is very common in the structural engineering such as one-story buildings. These structures are usually subjected to the dynamic loads such as wind loads, live loads, seismic, and impact. It is very important to evaluate the maximum deformation of structures under these dynamic loads to determine if they are still in the safe mode or not. SDOF structures can be idealized as a system with a lumped mass and one massless supporting structure. The viscous damper is widely used in the shear building to decrease the displacement for the structures subjected to external loads. There are two commonly used idealizations to evaluate these structures: the one-story frame (Fig.1a) and mass-spring-damper system (Fig.1b).

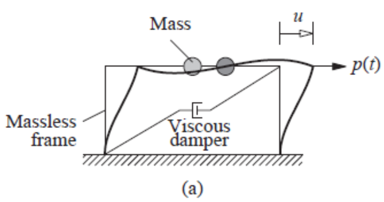


Fig1. (a)

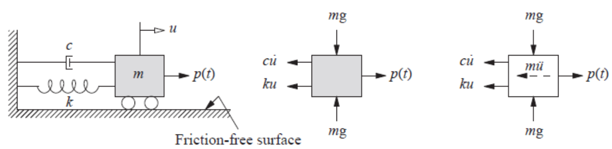


Fig1. (b)

The one-story frame is usually used in the structural engnieering for the shear building. However, the classic SDOF system, shown in Fig.1b, is the mass-spring-damper system connected by the linear springs and viscous dampers. This project will evaluate the maximum deformation (u) of a single degree-of-freedom structure subjected to external loads external forces p(t) for one-story shear building as shown in Fig1.a. The centered differential method, finding the roots process, and the procedure to solve ordinary differential equations will be considered in this project.

Scope of this project

For this project, a single degrees of freedom system subjected to external loads p(t) will be considered. The considered single degree-of-freedom system is in the linear range and the inelastic range is out of the scope. The hooke's law will be used to calculate the displacement for the structures in the linear behavior.

Methodology

The first step to evaluate the structures response is to determine the number of DOFs and in this project the degree of freedom is one. Then, the Newton's second law will be used to establish the equation of motion. The forces acting on the shear building at a time are shown in Fig. 2. These include the external force $p(t)$, the elastic resisting force f_s , and the damping resisting force f_D

The external force $p(t)$ equals to the sum of resisting force f_s and the damping resisting force f_D According to D'Alembert's principle, it means that the mass develops the inertia force f_I proportional to its acceleration in an opposing direction. The f_s is the stiffness k times the displacement and the f_D is proportional to the mass velocity.

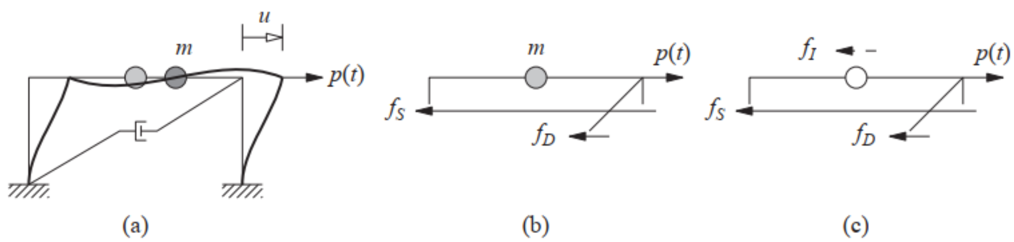


Fig.2 Establish the Equation of Motion for One-story Frame

Using the Newton's second law based on the Fig.2, the equation is given below:

$$m\ddot{u} + c\dot{u} + ku = p(t)$$

where the u is the displacement, m is the mass, c is the damping stiffness and the k is the structure stiffness. The mass, external force, and damping and structure stiffness are known and then estimate the displacement for the structure. Now we can utilize centered difference method to approximate the velocity and acceleration shown in the above equation and to predict the displacement of the structure at the i+1 time. Find the roots and solve the ordinary differential equations based on the initial boundary conditions and the equation of motion.

Notes: (These will be changed after getting feedback)

1. SDOF System parameters:

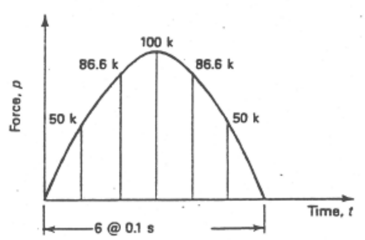
   Mass = 0.3 kip-s^2/in.

   Stiffness = $24EI/h^3$

   Height = 39ft

   where I is the moment inertia of W14×342 used for beam and column.

   Initial conditions$u = 0$; $\dot{u} = 0$; $p(t) = 0$
2. Force information:



References

Chopra, Anil K. *Dynamics of Structures: Theory and Applications to Earthquake Engineering*. Pearson, 2017.