Nonlinear seismic response analysis of reinforced concrete high-rise structures

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Abstract

With the continuous improvement of the building level in the world, high-rise buildings follow the trend of the times and play a very important role in modern urban construction, becoming an important symbol of a modern metropolis. It is very necessary to study the seismic performance of high-rise buildings because of the complexity of high-rise structures. In this paper, the development of aseismic theory, high-rise structure system and its characteristics are introduced, and the analysis and study of structural nonlinearity are described.

Keywords

Nonlinearity; seismic response analysis.

1. Introduction

In recent years, with the emergence of high-rise structures, long-span bridges and large stadiums with long natural vibration period, the seismic performance of such high-rise structures has increasingly become one of the difficult problems to be solved in the engineering field.

2. Development of structural seismic theory

Over the past century, experts and scholars in various countries have been devoted to the study of structural seismic theory, and the study of seismic theory has also made considerable progress. The development of structural seismic theory can be divided into three stages: static theory, response spectrum theory and dynamic theory.

3. Static theory

It was first put forward by Professor Mori of Japan through the limited observation and theoretical knowledge of seismic damage at that time, the seismic design theory is only applicable to rigid structure. It does not take into account the dynamic characteristics of the structure and site differences on the impact of the building structure, indiscriminately on all the structures are used a unified horizontal seismic force to consider the effect of seismic action. Its size is equal to the structural gravity load G multiplied by the seismic coefficient K, that is:

$$F = \alpha G / g = kG$$

Static method does not consider the influence of superstructure deformation on seismic action, and does not consider the change of seismic action with time and its relationship with structural dynamic characteristics, which makes the results of static method have great approximation.

4. Response spectrum theory

Response spectrum theory is based on strong earthquake observation. In the 1940s, M.A.Biot, an American scholar, first proposed the concept of calculating response spectrum from measured records. In the early 1950s, it was implemented by Housner, an American scholar. Several measured ground vibration waves were substituted into single-degree-of-freedom dynamic response equations to calculate their respective responses. The maximum elastic seismic response (acceleration, velocity, displacement) is obtained, and the relationship between the maximum seismic response and the natural period of the structure is obtained. The maximum earthquake action can be calculated from the response spectrum, and then the seismic response can be calculated by the static analysis method, so it still belongs to the equivalent static method. However, the response spectrum theory considers the vibration characteristics of the structure truthfully, and the calculation is simple and practical, so it is still a main seismic analysis method given in seismic codes of various countries.

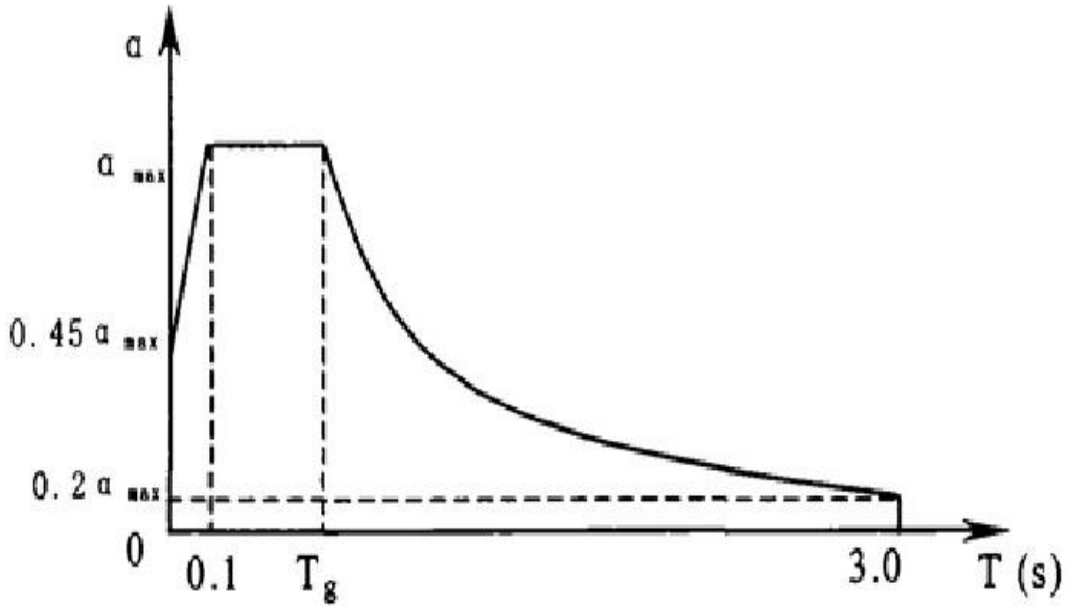

Fig.1 Seismic influence coefficient curve

5. Dynamic theory

Dynamics theory is to solve seismic response directly by dynamic equation, which originated from the popularization and application of computer technology in the 1960s. Because the seismic wave is a complex random vibration, it is impossible to get the analytic solution directly for the vibration of multi-degree-of-freedom system, and only the step-by-step integration method can be used. This method has a large amount of calculation work, and can be realized only on the premise of the development of computer application.

The seismic response equation of multi degree of freedom system is:

$$[M]\left\{\ddot{x}(t)\right\}+[N]\left\{\dot{x}(t)\right\}+[C]\left\{x(t)\right\}=-[M]\left\{\ddot{x}_g(t)\right\}$$

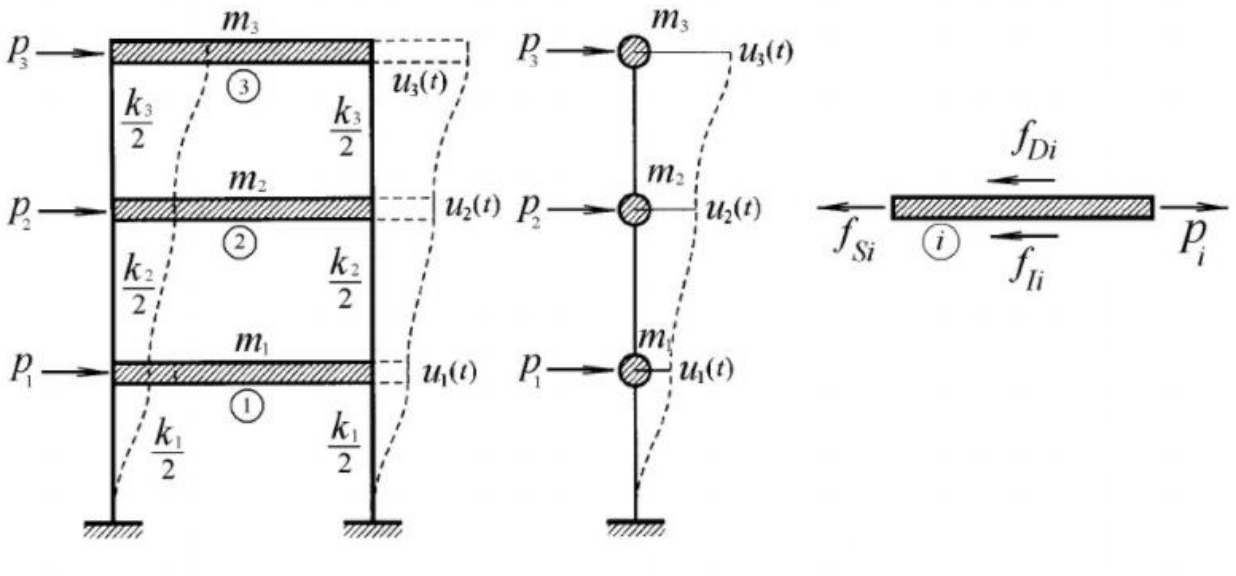

Fig.2 Structural analysis model

6. Summary

In order to reduce the casualties and economic losses caused by earthquakes, it is very important to control the degree of seismic damage of structures and components in the design stage, and it is also the fundamental to control the loss of earthquake disasters. However, in order to truly embody the idea of performance seismic design in practical engineering, a large number of further studies are needed. For the super high-rise building structure, through dynamic elastic-plastic time-history analysis and static elastic-plastic analysis, we can accurately grasp the structural safety of the structure system under frequent earthquakes and rare earthquakes, which is a necessary means for future structural seismic performance design.

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