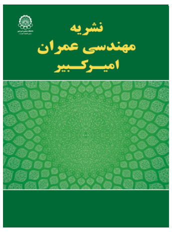

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Effects of higher modes and degrees of freedom on energy requirement in reinforced concrete structures with steel shear wall

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ABSTRACT: It is necessary to provide seismic design criteria for structural systems in order to optimally design bending reinforced concrete frames with steel shear wall. Researchers have used energy requirements as one of the most important and efficient tools to measure and minimize cumulative damage to structures, which depend strongly on the time and duration of the earthquake. Therefore, this study attempts to investigate the energy response properties of an equivalent single degree of freedom versus near pulse species acceleration accelerometers to estimate the maximum energy types and its relation to a multi-degree of freedom for three reinforced concrete structures with steel shear walls, low-rise, mid-rise and high-rise under ductile coefficients of 1, 2, 3, 4 and 5. The results of the study of the changes in the ratio of cyclic energy to total energy wasted in the structures show that in the multi-degree system, the period is independent of the periodicity to the extent that the effect of higher modes is negligible. Also, by increasing the ductility coefficient, this ratio for the multi-degree system is closer to the results of the one-degree system and, in a sense, increasing the ductility coefficient results in a decrease in the effects of higher modes.

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1. INTRODUCTION

In the energy-based design method, the purpose is to provide energy dissipation capacity in the structure against the need for the amount of input seismic energy. In the early years of energy-based design philosophy, input energy was assumed to be largely independent of structural properties, including stiffness distribution at the height [1-6].

It was also assumed that over a wide range of periods, the input energy was even independent of the period and its spectral value was constant. With the further development of the philosophy of energy-based design, this assumption was criticized and became a challenging topic [7-9].

Seismic resistance of structures in conventional seismic design methods is considered appropriate when the deformation capacity or resistance limit of the structure is considered more than the demand for large earthquakes. This is despite the fact that most of the damage caused by earthquakes is due to inelastic cycles and the energy input to the structure as one of the parameters depends on the cyclical behavior of structures.

Therefore, the concept of energy has been considered by scientists in research communities and many researchers have used the concept of energy in the analysis of structures and models of damage. Hausner [1] first used the limit design method using the concept of energy to study the seismicity of structures in 1956. Despite the primitiveness of Hausner's proposed relationships, the parameters he cited were the cornerstone for the future development of the energy method in the seismic design of structures.

The main purpose of this study is to investigate the input energy to reinforced concrete structures with steel shear wall according to the latest findings related to earthquakes near faults. Due to the appropriate access to a significant number of earthquakes near the fault, an attempt has been made to specifically address the effect of progressive orientation on the energy input to the structure.

In this research, the input energy to the structure and its constituent components, including damping energy, cyclic energy and energy lost in structures with SDOF and MDOF are calculated. At the end of this study, in order to explain the effects of degrees of freedom on energy needs, the ratio of energy needs obtained from a structure of several degrees of freedom is divided by the values corresponding to the structure of one degree of freedom and suitable application ratios for estimating energy in structures of several degrees of freedom achieved.

2. METHODOLOGY

In this study, an attempt is made to estimate the maximum types of energy and its relationship with the multi-degree of freedom system by examining the energy response characteristics of the analysis of systems with one degree of freedom equivalent to accelerometers near pulse-type faults.

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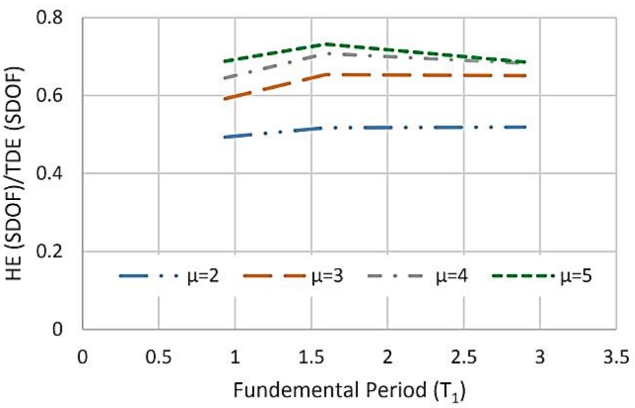

Fig. 1. Changes in the ratio of cyclic energy to total wasted energy in a system with SDOF equivalent to the periodicity

In the models of this study, the elastic rotation period is from 0.98 to 2.89 seconds. On the other hand, ductility coefficient values of 1, 2, 3, 4 and 5 are considered. Obviously, the formability of the unit is to ensure the survival of the structure in the elastic domain. On the other hand, all models are modeled as a structure of one degree of freedom.

Energy needs as one of the important and efficient tools in measuring and minimizing the cumulative damage are considered by researchers and depend on the intensity and duration of the earthquake and with a change in the ductility coefficient, a change in the intensity of the earthquake will occur. Therefore, in order not to affect the energy needs of the two mentioned factors, dimensionless application diagrams are defined as applied energy ratios.

3. RESULTS AND DISCUSSION

Seismic input energy to structures with low lateral strength is related to the dissipated energy of balanced cycles and often to the degree of structural damage. As shown, it is not very sensitive to the degree of nonlinearity (except for medium-period structures); it seems logical that part of the energy wasted by cyclic performance is to be evaluated.

Fig. 1 shows the changes in the ratio of cyclic energy to total energy dissipated in the SDOF under the close record of the species pulse fault. According to Fig. 1 for the studied structures, the ratio increases with increasing and with increasing the main period of the structure, this ratio decreases due to growth and decreases linearly. The rate of change obtained in the long period range is highly dependent on the seismic energy content, which of course can be seen by referring to the elastic response spectrum. For example, if the rate of degradation of the average response spectrum is severe over a long period, the ratio decreases more rapidly [10, 11].

4. CONCLUSIONS

In order to improve the seismic design of structures, the relative input energy from the earthquake to the structure is considered as seismic loading in the structure design. In this research, by proposing practical and useful ratios, the relationship between energy in structures of one degree of freedom and several degrees of freedom has been investigated. For this purpose, ratios such as the ratio of inelastic to elastic energy dissipated, the ratio of hysteresis energy dissipated to the total energy dissipated for systems with several degrees of freedom and one degree of freedom equivalent, and to account for the effects of degrees of freedom, the energy requirement for systems In structures of one degree of freedom is equivalent to all. The results of this study are presented below:

• Except in structures with the medium period, it does not depend much on the degree of nonlinearity of the structure (coefficient). This means that there is a balance between the wasted energy and the viscous damping energy, which makes the sum of these two energy loss mechanisms less sensitive to the degree of nonlinearity of the structure. Also, for periods longer than 2.5 seconds, the ratio decreases with increasing ductility coefficient, and in this period range, the calculated need ratio is less dependent on the period change.

• The study of the ratio of cyclic energy requirements to the total energy wasted in a system of one degree of freedom indicates that for short-term structures, the ratio increases with increasing ductility coefficient. But in medium and high-rise structures, this ratio decreases with increasing ductility.

One of the practical ratios that can be used to evaluate the relationship between a multi-degree-of-freedom system and a one-degree-of-freedom system is the ratio of the energy requirements of a non-elastic multi-degree-of-freedom system to the elastic needs of a one-degree-of-freedom structure. Examination of this ratio shows that increasing the periodicity and increasing the importance of the effects of degrees of freedom increases the need for a system of several degrees of freedom. The value of the ratio also increases with increasing the ductility coefficient. Therefore, the changes in the TDE ratio correspond almost to the ductility coefficient of the degree of nonlinearity.

The cyclic energy requirement in a multi-degree-of-freedom system is part of the input energy that is wasted by the surrender of structural elements. The ratio of need for multi-degree models of freedom can be a useful functional ratio. Examination of the ratio shows that in the system, several degrees of freedom are independent of the periodicity to the extent that the effect of higher modes is not so noticeable. Also, by increasing the ductility coefficient, this ratio for the multi-degree of freedom system is closer to the results of the one-degree-of-freedom system, and in other words, increasing the ductility coefficient leads to reducing the effects of higher modes.

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