CALCULATION OF LATERAL LOAD ON BUILDING BASED ON ENERGY METHOD

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Since all natural forces act dynamically into the structures, structural analysis and optimizations under such loads seem difficult due to various variables, non-linear time dependent constrains and objective functions. The static loads are an appropriate substitution for the dynamic or earthquake loads because of their facilities in practical applications. Due to such facilities, most of the constructional codes are intended to use equivalent static loads (ESLs) rather than dynamic loads. They use dynamic factors and structural optimization seems to succeed for static loads with those factors (Haftka and Gurdal, 1991). However, the dynamic factors are not legitimately made based on sound mathematics. They are determined by specifications or experiences. Many researches have been carried out about the different methods figuring such loads out. Based on previous researches, two different ways had been proposed to achieve ESLs. Exact ESLs and approximated ESLs. Exact ways usually need some presumptions, such as the shape or location of the load, so the presumption tends to determine the quality of the solution. Approximated methods are divided into displacement-based approach and stress-based approach according to the constraints of the problem (Akbari and Sadoughi, 2012)

In this paper, a method is proposed for transformation of seismic loads (in the form of standard response spectra) into equivalent dynamic loads based on the finite-element method. By using the implemented code in the MATLAB environment and then solving an optimization sub-problem (sequential quadratic programming), transformation of seismic loads into equivalent static loads would be done.

In this research, a new approximated method is discussed. It is an energy-based approach to find ESLs in order to create the same amount of input energy as the dynamic loads do. The seismic input energy imparted to a structure (E_I) is equal to the sum of the kinetic energy (E_K), the elastic strain energy (E_S), the energy dissipated by hysteretic action of the structural elements (E_D), and the energy dissipated by viscous damping (E_P) (Pengyyun et al., 2011). It is expressed as below:

$$E_K + E_D + E_S + E_P = E_I \quad (1)$$

In that:

$$E_K = \frac{1}{2}\dot{x}^T M\dot{x} \quad (2)$$

$$E_D = \int \dot{x}^T C\dot{x}\,dt \quad (3)$$

$$E_S = \int x^T K\,dx \quad (4)$$

$$E_P = -\int u^T H^T dx \quad (5)$$

$$E_I = -\int \ddot{x}_g MI dx \quad (6)$$

In this study, we assumed that there is no viscous damping, thus, the E_P is zero here. And the static energy of the structure is:

$$E_{st} = \frac{1}{2} x^T Kx \xrightarrow{Kx=P} E_{st} = \frac{1}{2} x_{Dy}^T P \quad (7)$$

In the code implemented in MATLAB, these energies, are calculated by the results of response spectrum analysis of structure. Then, the optimization sub problem should be run. Optimization is done by calling the optimization toolbox of MATLAB. The optimization problem should be solved as coming equation:

Finding P_j

to minimize the square sum of P_j

$$E_K + E_D + E_E \leq \frac{1}{2} \sum_{i=1}^{n} x_j P_j \quad (8)$$

The objective function for optimization problem is the square sum of elements of static load vector. Then the ESLs are achieved.

As a simple numerical example, a six story, 3 bay, moment resistant frame is studied in this extended abstract. Results are written down in the table 1 and the frame is illustrated in Figure 1. More cases, with different conditions, including other moment resisting systems and different heights, will be discussed in full paper.

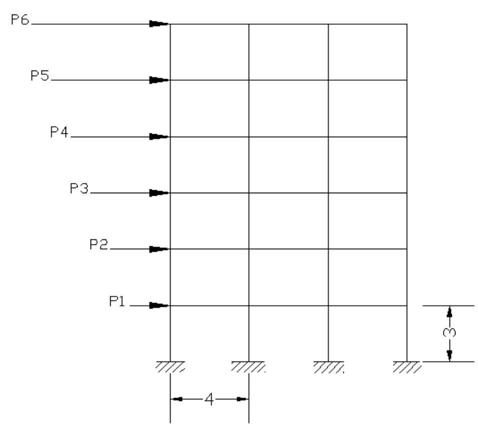

Figure 1. Equal lateral forces applied to the moment resisting frame

Table 1. Lateral loads on each story by energy optimization, quasi static and response spectrum analysis

	P_1	P_2	P_3	P_4	P_5	P_6
Energy	26.7	76.73	128.8	183.17	238.48	298.37
Quasi static	27.53	55.47	80.54	105.61	129.44	151.22
Response spectrum	16.73	39.13	56.75	73.75	96.45	144

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