

OPTIMUM DESIGN OF EARTHQUAKE RESISTANT STRUCTURES

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The structural design optimization methodology was developed in the 1960 decade. From 1970 the research effort in this area has been directed toward developing efficient methods to design large practical structures. The application of optimization techniques to design earthquake resistant structures is also recent and some references can be found in the 5WCEE Proceedings.

In this work, an efficient automated method for the least weight design of earthquake resistant steel frame structures is developed. Two alternative analysis procedures are used; namely, analysis based on equivalent static loads and spectral modal dynamic analysis. The Chilean Seismic Code for Buildings is used for specifying the seismic design loads in both methods of analysis. The constraints on stresses and displacements entering in the design process are also referred to that code. The resulting nonlinear inequality constrained minimization problem is solved using a sequence of unconstrained minimizations via the extended interior penalty function formulation. The Davidon-Fletcher-Powell algorithm is applied for solving the unconstrained minimizations.

The efficiency of the design procedure set forth stems primarily from (1) approximation concepts including (a) design variable linking, (b) temporary deletion of potentially noncritical constraints, and (c) use of first order Taylor series expansions to approximate the dynamic response functions in explicit form with respect to the design variables; and (2) organization of the analysis so that it matches the iterative nature of the design optimization process (for details, see Refs. 1 and 2).

The optimum design of a 6-story, 1-bay steel frame is presented as an example. The loading consists of dead plus live vertical loads and earthquake loads. Nine independent design variables were taken. The weight of the frame at the starting design point in both static and dynamic approaches was 11098 Kg. The static method required 4 unconstrained minimizations and 48.75 sec CPU run time to reach a final point where the weight was 9232 Kg. The dynamic method needed 6 unconstrained minimizations and 153 sec CPU run time to yield a final point at which the weight was 8560 Kg. Computations were performed on the IBM 370/145 computer at University of Chile. The program was written in Fortran and compiled by a Fortran G compiler.

REFERENCES.

1. Cassis, J., "Optimum Design of Structures Subjected to Dynamic Loads", UCLA-ENG. 7451, June 1974.
2. Music, J. and J. Cassis, "Diseño Optimo de Estructuras Sismo-Resistentes", Departamento de Obras Civiles, Universidad de Chile, (report in preparation).

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