ACCURACY EVALUATION OF FEMA440 MODIFIED COEFFICIENT EQUIVALENT NONLINEAR PROCEDURE FOR IRREGULAR STEEL MOMENT RESISTING FRAMES

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Abstract

One of well-established procedures for the equivalent nonlinear static procedure is FEMA440 Modified Coefficient Method (MCM) utilizing a displacement modification procedure in which several empirically derived factors are used to modify the response of a single-degree-of freedom model of the structure assuming that it remains elastic. This paper presents a detailed investigation on performance of FEMA440 MCM for estimating frame maximum roof displacement, base shear, and median story drifts of steel moment resisting frames with irregularities in elevation. Results of nonlinear dynamic analyses of 44 irregular frames subjected to a family of 14 ground motions and nonlinear equivalent static analyses of all frames up to the target roof displacement computed by MCM are compared to evaluate the accuracy and conservatism of FEMA440 MCM.

Keywords: FEMA440 Modified Coefficient Method, Equivalent Nonlinear Static Analysis, Irregular Moment Resisting Steel Frames, Target Displacement

1. INTRODUCTION

Reduction of seismic irreparable structural damages has been the main goal of structural engineering. It is well known that structural members commonly behave in the inelastic range during intermediate and sever earthquakes. Therefore nonlinear analyses methods are needed to assess the actual structural behavior in order to retrofit existing structures or design new ones. Nonlinear time history analysis (NL-THA) provides the most accurate modeling for prediction of seismic demands. However its high computational cost and its complexity and sensitivity to nonlinear member models lead to development of simpler method such as equivalent nonlinear static procedures (NSP) for estimating seismic demands. Previous researches [1] have shown that nonlinear static procedures give reasonable estimation for displacement demands for regular frames and frames with base weak story. Currently these NSP methods are restricted to regular buildings with low or medium rise height. Hence evaluation of NSP methods for irregular buildings seems to be necessary.

One of the well-established nonlinear static procedures is the equivalent nonlinear static procedure summarized in FEMA356 [2] based on nonlinear static pushover analysis using the target displacement predicted by the Coefficient Method (CM). CM utilizes a displacement modification procedure in which several empirically derived factors are used to modify the response of a single-degree-of freedom model of the structure assuming that it remains elastic. FEMA440 [3] has suggested some recommendations for improving the performance of CM leading to a Modified Coefficient Method (MCM).

FEMA440 MCM suggests that the maximum demands (displacements and forces) for a nonlinear time history analysis can be estimated from a nonlinear static analysis where roof displacement is the same as maximum roof displacement estimated by the nonlinear time history analysis. The structure layout, boundary conditions, and nonlinearities are the same in both analyses. The lateral loading pattern for the nonlinear