Seismic Evaluating the Steel Building Designed by ASD and LRFD (Nonlinear Dynamical and Statical Analysis)

Hamid Samadi
Department of Civil Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
h.samadi@gmail.com
Maryam Tanoorsaz
Department of Civil Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
Maryamtanoorsaz@yahoo.com

Abstract

LRFD method was discussed through tenth chapter of Iranian National Building Rules for the first one; so it was displaced instead of ASD. Seismic operation of designed structures will be evaluated by the two methods discussed in this paper as a result of a research project. Therefore 3 plans of a 5 floors building are selected and designing would be done using ETABS, navigation of seismic aspects would be done using PERFORM 3D. The results will show that designed building by LRFD method have more weight and better seismic operation.

Keywords: Steel Buildings, ASD, LRFD, Nonlinear Dynamical Analysis.

Introduction

While buildings are usually designed for seismic resistance using elastic analysis, most will experience significant inelastic deformations under large earthquakes. Modern performance-based design methods require ways to determine the realistic behavior of structures under such conditions. Enabled by advancements in computing technologies and available test data, nonlinear analyses provide the means for calculating structural response beyond the elastic range, including strength and stiffness deterioration associated with inelastic material behavior and large displacements. As such, nonlinear analysis can play an important role in the design of new and existing buildings.

For the nonlinear dynamic analysis the records were selected to represent wide ranges of duration and frequency content. Considering the change in the stiffness and the energy dissipation capacities, the performance of the existing and retrofitted buildings were evaluated in terms of story drifts and damage states. It was found that each earthquake record exhibited its own peculiarities, dictated by frequency content, duration, sequence of peaks and their amplitude. The seismic performance of retrofitted buildings resulted in lower displacements and higher energy dissipation capacity depending mainly on the properties of the ground motions and the retrofitting strategies. Moreover, severe structural damage (irreparable or collapse) was observed for the existing building. However, buildings with retrofit alternatives exhibited lower damage levels changing from no damage to irreparable damage states.

Nonlinear analyses involve significantly more effort to perform and should be approached with specific objectives in mind. Typical instances where nonlinear analysis is applied in structural earthquake engineering practice are to: (1) assess and design seismic retrofit solutions for existing buildings; (2) design new buildings that employ structural materials,

Issue 5, Vol. 1 January 2016
ISSN 2319 – 7277

systems, or other features that do not conform to current building code requirements; (3) assess the performance of buildings for specific owner/stakeholder requirements. If the intent of using a nonlinear analysis is to justify a design that would not satisfy the prescriptive building code requirements, it is essential to develop the basis for acceptance with the building code authority at the outset of a project.

Dynamic Properties

Before any analysis can be carried out, it is necessary to determine the dynamic properties of the structure. These properties include stiffness, mass and damping. The terms in this matrix are a function of several modeling choices that are made. These aspects of the analysis are described later in the example. The computer can also determine the mass properties automatically, but for this analysis they are developed by hand and are explicitly included in the computer model.

Seismic Weight

In the past it was often advantageous to model floor plates as rigid diaphragms because this allowed for a reduction in the total number of degrees of freedom used in the analysis and a significant reduction in analysis time. The use of such elements provides an added benefit of improved accuracy because the true “semi-rigid” behavior of the diaphragms is modeled directly. Where it is not necessary to recover diaphragm stresses, a very coarse element mesh may be used for modeling the diaphragm.

Where the diaphragm is modeled using finite elements, the diaphragm mass, including contributions from structural dead weight and superimposed dead weight, is automatically represented by entering the proper density and thickness of the diaphragm elements. The density may be adjusted to represent superimposed dead loads (but the thickness and modulus are “true” values). Center of mass locations are required for the purpose of applying lateral forces in the ELF method and for determining story drift. Due to the various sizes and shapes of the floor plates and to the different dead weights associated with areas within the same floor plate, the computation of mass properties is not easily carried out by hand. For this reason, a special purpose computer program was used. The basic input for the program consists of the shape of the floor plate, its mass density and definitions of auxiliary masses such as line, rectangular and concentrated mass. Seismic analysis is a subset of structural analysis and is the calculation of the response of a building (or nonbuilding) structure toearthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit (see structural engineering) in regions where earthquakes are prevalent. The earliest provisions for seismic resistance were the requirement to design for a lateral force equal to a proportion of the building weight (applied at each floor level). This approach was adopted in the appendix of the 1927 Uniform Building Code (UBC), which was used on the west coast of the USA. It later became clear that the dynamic properties of the structure affected the loads generated during an earthquake.

Equivalent Static Analysis

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher

 Issue 5, Vol. 1 January 2016
ISSN 2319 – 7277

modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g. force reduction factors).

Linear Dynamic Procedure

The linear dynamic procedure (LDP) employs a modal spectral analysis that uses linear elastic response spectra that are not modified to account for the anticipated nonlinear response of the real structure. The computer modeling for the LDP is the same as with the LSP. As was the case with the LSP, it is expected that the resulting model displacements will approximate the maximum displacements on the structure from the design earthquake. Once again, the consequence of matching the expected displacements is that it results in member forces that exceed the forces that would be obtained from a building that experiences strength and stiffness loss at yield, so modification factors are used to account for the expected inelastic behavior.

Nonlinear Static Procedure

The nonlinear static procedure (NSP) requires a computational model that incorporates the nonlinear load-deformation characteristics of the individual components. This model is subjected to monotonically increasing lateral loads representing inertial earthquake forces until a target displacement is exceeded or a failure mechanism develops. The target displacement is intended to be the maximum displacement likely to be experienced by the building during the design earthquake. If an appropriate lateral load pattern is used, the structural member forces predicted by the model should be a reasonable approximation of the actual earthquake forces.

Structure Formation through the modeling study

The regulations and mathematical formulas, also relations used in this considerations, further factors and coefficients which are got through the research are as the following.
Q is the load building carries and R is resistance. γ_i and $\emptyset$ are the coefficient as the qualified factors for buildings and structures which studying.

$$Q=R \tag{1}$$

$$\sum \gamma_i Q_i = \emptyset R_n \tag{2}$$

$$\sum Q_i \leq \left(\frac{\emptyset}{\gamma}\right) R_n = \frac{R_n}{\Omega} \tag{3}$$

Studied Models and Results

Navigated models in this paper doing an applied research are as the below.

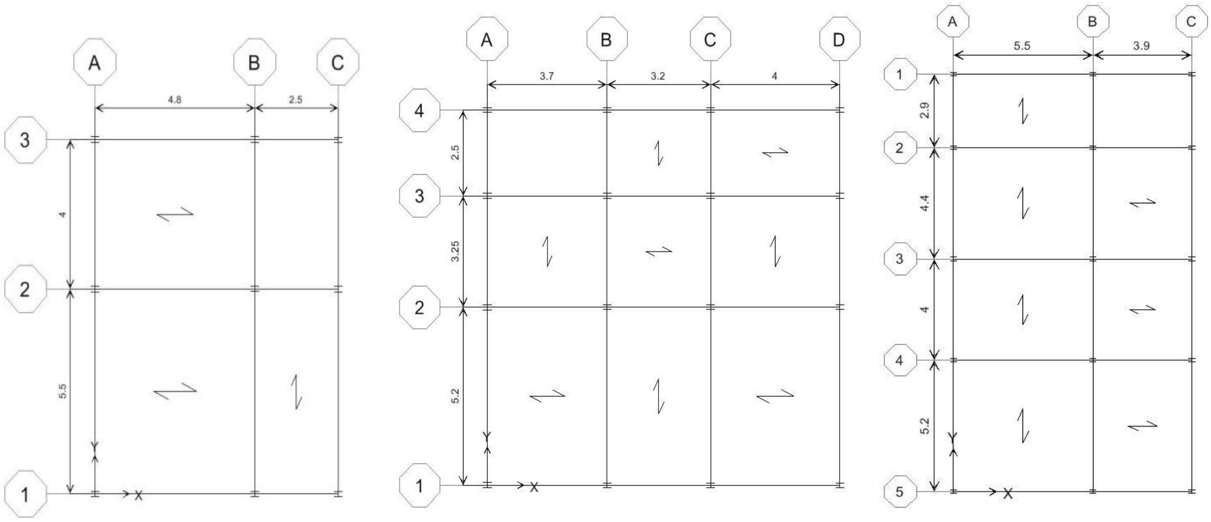
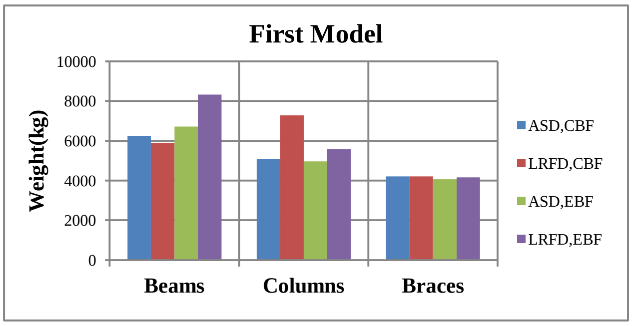
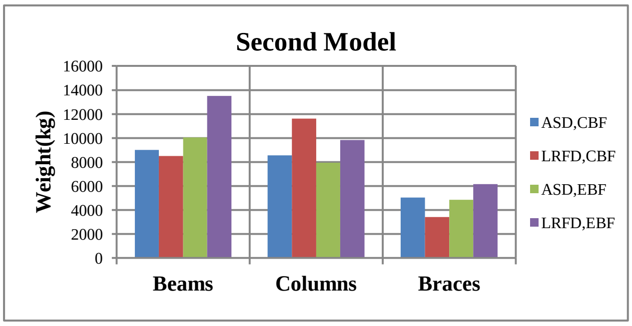


Fig.1 1st, 2nd and 3d models studied through the research

Weight changes of members in the above models are got as:





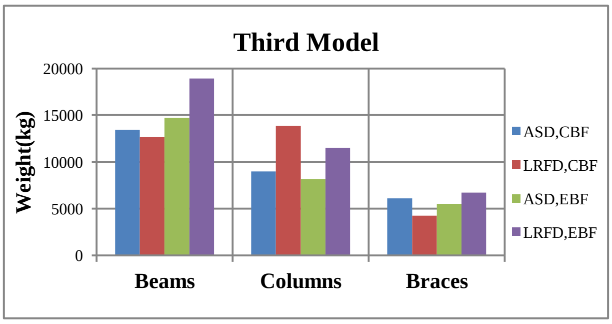


Fig.2 Weight changes of members in the models

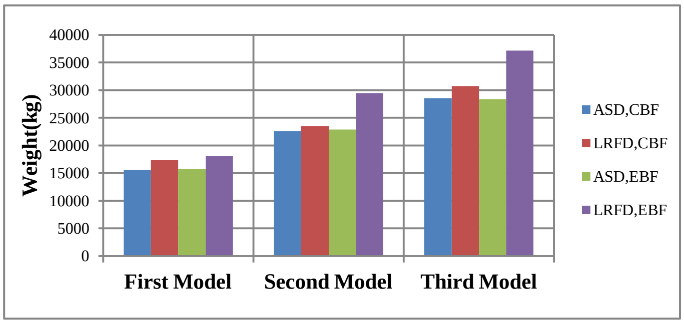
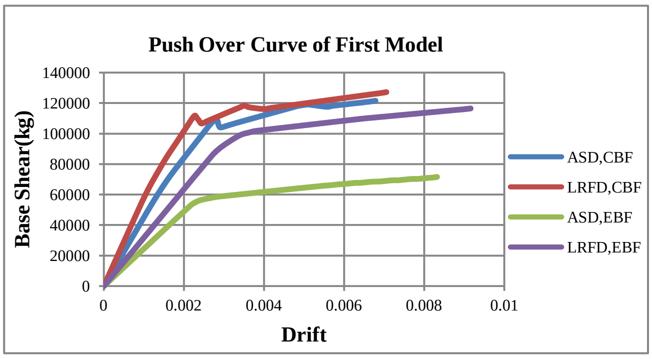
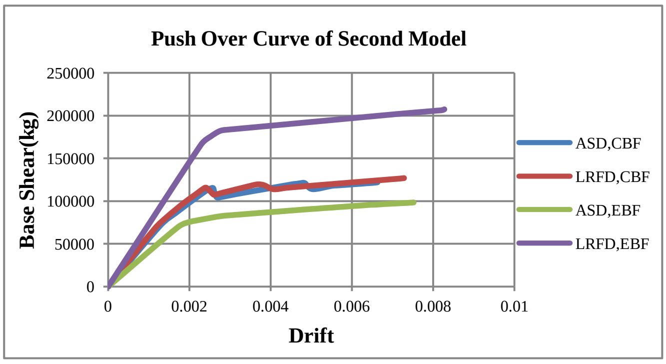


Fig.3 Building weight changes in the models





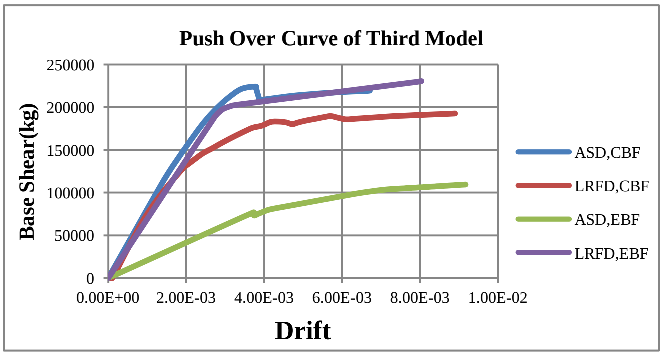
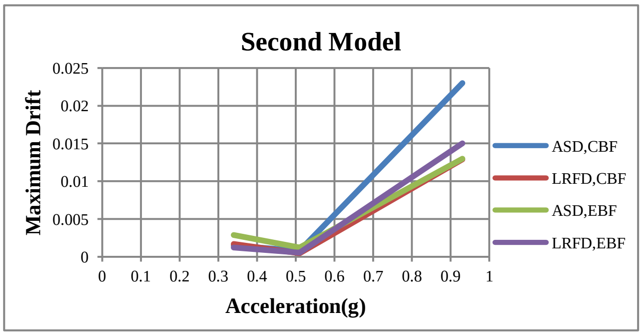


Fig. 4 Push Over curves of the models studied

Issue 5, Vol. 1 January 2016
ISSN 2319 – 7277



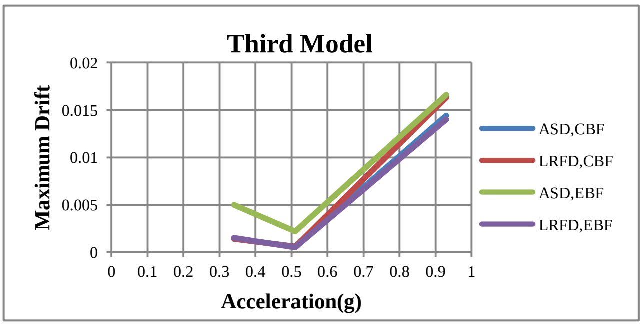


Fig.5 max place change of the models affected by earthquake

Conclusions

1- Considerations show that in buildings with convergent supporters for marginal carrier system, weight of supporters designed by lrfd rather than asd method is decreased.
2- Columns weight in buildings having convergent and divergent supporters designed by lrfd rather than asd is increased.
3- As a result of analyzing the finding through designs by the two used methods, weight of building in lrfd rather than asd is increased.
4- All the models designed by lrfd under the considered accelerations through the research, the maximum marginal placement have decreased.

References

Mentzer, Michelle. (2001). Should Structural Engineers Adopt A New Design Method? LRFD vs. ASD. English 202C.24.

American Institute of steel construction (AISC-360), Specification for structural steel buildings.

American Society of Civil Engineers (ASCE 7), Minimum Design Loads for Buildings and Other Structures.

Elms, D.G. and Richards, R. (1990). “Seismic design of retaining walls.” *ASCE Specialty Conference: Design and Performance of Earth Retaining Structures*, Cornell University, Ithaca, New York: 854 -871.

Asghari, A., Shoaibi, Sh., Sadeghi, A., (2013), Histirical View on Steel Structures by Methods LRFD and ASD, 3d National Conference on Structure and Steel & 1st National Conference on Light Steel Structures (LSF).

Frankenberger, P.C., Bloomfield, R.A., Anderson, P.L. “Reinforced earth walls withstand Northridge Earthquake.” (1996), *Proceedings of 1996 International Symposium on Earth Reinforcement / Fukuoka / Kyushu / Japan*, Vol. 1, Balkema, Netherlands: 345 – 350.

Siddharthan, R.V. et al. (2004) “Seismic deformation of bar mat mechanically stabilized earth walls. I: Centrifuge tests.” Journal of Geotechnical and Geoenvironmental Engineering, January 2004, ASCE.

http://Peer.berkeley.edu/nga/search.html