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Pushover Analysis of Reinforced Concrete T-Beam Bridge

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ABSTRACT

Structural design and analysis produce the capability of resisting all the applied loads without failure during its intended life. Lateral loads mainly due to earthquake govern the design of high-rise buildings. The interior structural system or exterior structural system provides the resistance to lateral loads in the structure. The present paper describes the analysis and design of high-rise buildings with Steel Plate Shear Wall (SPSW) for (G+20) stories. The properties of Steel plate shear wall system include the stiffness for control of structural displacement, ductile failure mechanism and high-energy absorption. The design and analysis of the composite building with steel plate shear wall is carried out using software ETABS. The present study is to carry out the response spectrum analysis of a high-rise composite building by optimizing the thickness of steel plate shear wall and to compare the results of displacement, story drift, overturning moment and story shear. The models are analyzed by Response Spectrum analysis as per IS 1893:2016. All structural members are designed as per IS 800:2007 considering all load combinations.

INTRODUCTION

General

In the last few decades, shear walls have been used extensively in countries especially where high seismic risk is observed. The major factors for inclusion of shear walls are ability to minimize lateral drifts, inter story displacement and excellent performance in past earthquake record. Shear walls are designed not only to resist gravity loads but also can take care overturning moments as well as shear forces. They have very large in plane stiffness that limits the amount of lateral displacement of the building under lateral loadings. Shear walls are intended to behave elastically during moderate or low seismic loading to prevent non-structural damage in the building. However, it is expected that the walls will be exposed to in elastic deformation during less or frequent earthquakes. Thus, shear walls must be designed to withstand forces that cause inelastic deformations while maintaining their ability to carry load and dissipate energy. Structural and non-structural damage is expected during severe earthquakes however; collapse prevention and life safety is the main concern in the design.

The Investigations of strong ground motions revealed that properly designed and detailed shear wall buildings performed well in past earthquakes. Shear walls built in high seismic regions should be in compliance with special detailing requirements. However, prior observations indicated that even buildings that have high shear walls area to floor area ratios with walls that do not have special seismic detailing survived high magnitude earthquakes. These observations drew attention of both practical engineers and academic researchers to shear wall-frame buildings. To minimize loss after earthquakes, the experimental and analytical studies on seismic design approaches encourage use of shear walls for earthquake-resistant design.

Definition Of Steel Plated Shear Wall

The fundamental capacity of steel plate shear divider is to oppose flat story shear and toppling Minute because of horizontal burdens. As a rule, steel plate shear divider framework comprises of a Steel plate divider, two limit segments and level floor pillars. Together, the steel plate wall and the two limit segments go about as a vertical plate brace. The sections go about as spines of vertical plate brace and the steel plate divider goes about as its web. The flat floor bars act, pretty much, as transverse stiffeners in a plate support.

Shear Wall And Effect Of Shear Wall

The wall in a building which resists lateral loads originating from wind or earthquakes are known as shear walls.

Reinforced concrete walls are strength and portent elements frequently used in constructions in seismic areas because they have a high lateral stiffness and Resistance to external horizontal loads, these shear walls may be added solely to resist horizontal forces or concrete walls enclosing stairways elevated shafts and utility cores may serve as shear walls. Shear walls not only have a very large in plane stiffness and therefore resist lateral load and control deflection very efficiently but they also help in reductions of structural & non-structural damage. The building incorporated with shear wall sufficiently ductile will be much away from seismic vulnerability and building failure in the earthquake sensitive zones thus resulting in increased life safety & low property loss.

Advantages Of Steel-Plate Shear Walls

- For the same shear capacity, a CSW will have a smaller thickness, less weight and most likely larger shear stiffness than a RCSW.
- The smaller footprint of the CSW is attractive architecturally as more floor space is used.
- The lesser the weight of CSW leads to lower seismic forces and smaller foundations
- The RC wall of the CSW can be either cast-in-place or precast.

LITERATURE REVIEW

General

Most of the codes refer to three types of analysis for earthquake forces, namely: (i) Response Spectrum Analysis (RSA), (ii) Response History Analysis (RHA), and (iii) Seismic Coefficient.

Method of Analysis Seismic Analysis of Structures, Prof. T K Datta the response spectrum method of analysis allows the designer to use a set of equivalent lateral forces for each mode of vibration and carry out a static analysis to obtain a good estimate of the mean peak response of the structure. The response history method of analysis provides the maximum response of the structure under any time history of loading. The term equivalent lateral load analysis of tall structures, such as buildings, chimneys, towers, and so on, is not only used for the response spectrum method of analysis of structures, but also for another very popular method of analysis called the seismic coefficient method prescribed in different codes. Out of these three methods the first two methods require rigorous analysis and is calculation intensive, thereby making the Seismic Coefficient Method a popular choice.

S.M.R. Mortazavi (2013): Research on the Behavior of the Steel Plated Shear Wall by Finite Element Method In this paper, using the uniaxial diagonal tension model and/or shell elements model of the system, behavior of such system has been acquired. Through the nonlinear dynamic analysis, the behavior of the steel plated shear wall system has shown to have a good ductility especially when it is subjected to cyclic or earthquake excitations. It was revealed that for analyzing such system and in order to lower the time-consuming computations and to be more effective, the uniaxial model can replace the shell element model. To understand the behavior of the steel plated shear wall in detail, the significant parameters affecting the overall behavior of the system are recognized.

Pundkar R.S: (2013) Influence of Steel Plate Shear Wallon Multi storey Steel Building

From preliminary investigation reveals that the significant effects on deflection in orthogonal direction by the shifting the shear wall location. Placing Shear wall away from center of gravity resulted in increase in lateral deflection. It may be observed fromFig.III.1.1,III. 1.2, III.1.3, and III.1.4 that displacement of the building have been reduced due to presence of shear wall placed at center. Placing of shear wall in y direction the displacement reduces but displacement not reduces in X direction. Results indicate that steel plate shear walls have a large effect on the behavior of frames under earthquake excitation. In general, infill steel plate increases stiffness of the structure.

Anshuman, Dipendu Bhunia, Bhavin Ramjiyani (2011)

Concluded that one of the most commonly used lateral-load resisting systems in high- rise buildings are Shear wall systems. Shear walls have very high in-plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads.

Vaseem Khan (2018): a review on design and layout of shear walls in tall building located in different seismic zones The review of earlier studies related to Study design and layout of shear walls in tall building located in different seismic zones reveals, high-performing shear wall layout designs for tall buildings that can respond to both structural and architectural design goals. The method is compatible with a large variety of buildings, from low-rise to high-rise, from wide to tall (aspect ratio), from to residential and commercial.

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Design Philosophy

Limit State Method of design has been used throughout unless specified. In any method of design, the following are the common steps to be followed:

1. To assess the dead loads and other external loads and forces likely to be applied on the structure,
2. To determine the design loads from different combinations of loads.
3. To estimate structural responses (bending moment, shear force, axial thrust etc.)due to the design loads,
4. To determine the cross-sectional areas of concrete sections and amounts of reinforcement needed.

Many of the above steps have lot of uncertainties. Estimation of loads and evaluation of material properties are to name a few. Hence, some suitable factors of safety should be taken into consideration depending on the degrees of such uncertainties.

Computation Of The Fundamental Time Period

Most of the codes provide an empirical formula for finding the fundamental time period of the buildings based on experimental and practical observations. However, some of the codes, such as the International Building Code, USA, and the National Building Code, Canada, allow calculation of the fundamental time period of buildings using a formula which is almost the same as that used for calculating the approximate fundamental time period of a building frame using Rayleigh's method.

Dynamic Analysis

Dynamic analysis shall be performed to obtain the design seismic forces and its distribution to different levels along the height of building and to the various lateral load resisting elements in following cases:

a.Regular Building – Greater than 40 m height in zone IV and V and those greater than 90 m in height in zone II and III.

b.Irregular building – All framed buildings higher than 12 m in zone IV and V, and those greater than 40 m height in zone II and III.

c.For irregular building lesser than 40min height in zone II and III, dynamic analysis even though not mandatory, is recommended.

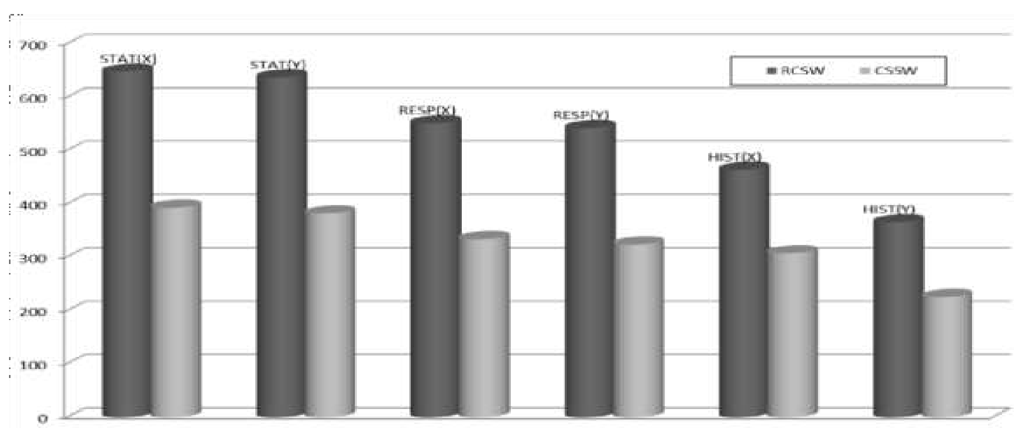
ANALYSIS RESULTS AND DISCUSSION

The analysis of different models of varying heights produced a large set of data. Microsoft excel was used for tabulation plotting and analysis of results obtained by ETABS analysis. The first objective was to figure out the key parameters that affected the building. Tabulation was done for different key parameters for all the models. Sample tabulation has been shown below for Type A structures having 20story's.

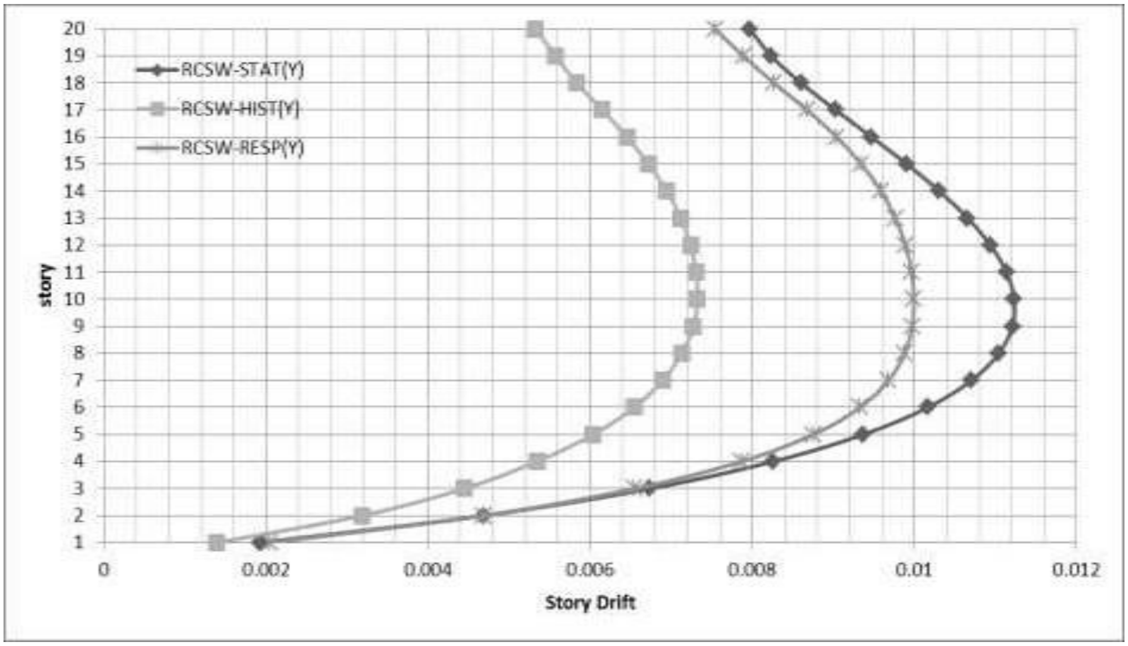
Analysis

Diaphragm Acceleration

The beam slab diaphragm was assumed to be rigid as per the guidelines of the Shear Building Model. On giving rigid diaphragm command to the program, the following output was obtained. **The same above parameters have been tabulated for all other types,Type A-reinforced concrete shear walls (RCSW) and Type B-steel-plate shear walls (SPSW) for 20 storey's. The results were tabulated and plotted as below.**



Comparison of Base Shear for 20-Story Buildings.



A. RCSW

CONCLUSIONS

Providing RC buildings with composite shear walls (Steel Plated) instead of RC shear walls is a very efficient and attractive structural decision to be implemented in regions vulnerable to earthquakes, due to the following advantages:

A significant reduction in the total dead load of the building due to less thickness of the steel wall compared to the RC shear wall. Consequently, the story-shear forces and base shear are reduced by 46% in the eight-story buildings, and 38% in the twenty-story buildings.

The inelastic drifts in the buildings with composite shear walls are higher than those in the buildings with RC shear walls by 26% in the twenty-story buildings.

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