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Failure Control Of A Skyscraper Using Different Methods Of Retrofitting

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ABSTRACT

A skyscraper is a tall, continuously habitable building having multiple floors. The term was originally used to describe one of at least 35-50 floors, mostly designed for office, commercial and residential uses. A skyscraper can also be called a high-rise, but the term skyscraper is often used for buildings higher than 50 m (164 ft). One common feature of skyscrapers is having a steel framework that supports curtain walls. These curtain walls either bear on the framework below or are suspended from the framework above, rather than load-bearing walls of conventional construction.

The load a skyscraper experiences is largely from the force of the building material itself. In most building designs, the weight of the structure is much larger than the weight of the material that it will support beyond its own weight. In technical terms, the dead load, the load of the structure, is larger than the live load.

The basic principles of design for vertical and lateral loads (wind & seismic) are the same for low, medium or high rise building. But a building gets high, both vertical & lateral loads become controlling factors. The vertical loads increase in direct proportion to the floor area and number of floors. In contrast to this, the effect of lateral loads on a building is not linear and increase rapidly with increase in height. Due to these lateral loads, deflection & moments on steel components will be very high. By retrofitting the structure, these types of failures can be controlled

In the present analysis, a Skyscraper with 40 floors will be analyzed. It will be tested by different methods of retrofitting like shear walls, bracings and fixed dampers at different locations. The building will be considered on medium soil and analyzed in all the four zones. Moments, Drift, Torsion and storey shear will be compared for all the cases.

A commercial package, ETABS will be used for analyzing Skyscraper of 120m height and for different zones. The results will be compared using tables & graphs to find out the most optimized solution.

1. INTRODUCTION

The term "skyscraper" was first applied to buildings of steel framed construction of at least 10 stories in the late 19th century, a result of public amazement at the tall buildings being built in major cities like Chicago, New York City, Tokyo, Beijing, etc….The structural definition of the word skyscraper was refined later by architectural historians, based on engineering developments of the 1880s that had enabled construction of tall multi-Storey buildings. This definition was based on the steel skeleton as opposed to constructions of load-bearing masonry, which passed their practical limit in 1891 with Chicago's Monad Nock Building.The design and construction of skyscrapers involves creating safe, habitable spaces in very tall buildings. The buildings must support their weight, resist wind and earthquakes, and protect occupants from fire. Yet they must also be conveniently accessible, even on the upper floors, and provide utilities and a comfortable climate for the occupants. The problems posed in skyscraper design are considered among the most complex encountered given the balances required between economics, engineering, and construction management.

2. RETROFITTING

Retrofitting refers to the addition of new technology or features to older systems in order to enhance the stability of the structure.

3. SEISMIC RETROFITTING

Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. With better understanding of seismic demand on structures and with our recent experiences with large earthquakes near urban centers, the need of seismic retrofitting is well acknowledged. Prior to the introduction of modern seismic codes in the late 1960s for developed countries (US, Japan etc.) and late 1970s for many other parts of the world (Turkey, China etc.), many structures were designed without adequate detailing and reinforcement for seismic protection. In view of the imminent problem, various research works have been carried out. State-of-the-art technical guidelines for seismic assessment, retrofit and rehabilitation have been published around the world – such as the ASCE-SEI 41and the New Zealand Society for Earthquake Engineering (NZSEE)'s guidelines.

The retrofit techniques outlined here are also applicable for other natural hazards such as tropical cyclones, tornadoes, and severe winds from thunderstorms. Whilst current practice of seismic retrofitting is predominantly concerned with structural improvements to reduce the seismic hazard of using the structures, it is similarly essential to reduce the hazards and losses from non-structural elements. It is also important to keep in mind that there is no such thing as an earthquake-proof structure, although seismic performance can be greatly enhanced through proper initial design or subsequent modifications.

INFILLS

EXTERNAL BRACINGS

OBJECTIVES OF THE STUDY:

The primary objectives of the present study are:

To analyse the skyscraper by retrofitting it with shear walls, steel bracings and with friction dampers. For this

Four models are developed

Model – 1(Normal Model)

Model – 2(Shear Walls)

Model – 3(Steel Bracings)

Model – 4(Friction Dampers)

These models are analyzed for all the four earthquake zones by considering soil as medium type(II).

SCOPE OF THE INVESTIGATION

In the present study a typical 40 storied skyscrapper is analyzed using commercial ETABS v 9.4.7 by DynamicMethod of Analysis by retrofitting the structure with steel bracings, shear walls and friction dampers at different locations, the results are compared to the normal model and conclusions are made regarding behaviour.

4. LITERATURE REVIEW

Rosinblueth and Holtz et al.,

They considered completely uniform structure suggested a solution of a differential equation and presented tables which are useful for symmetric buildings. The method requires assumption of first approximation which is improved in successive iterations which describes shear wall with entire load if it is much more rigid than the rest of structure and if it is not then the initial distribution of horizontal shear among walls and frames may differ widely.

Mo and Jost (1993) et al.,

Form this study it was concluded that the effect of concrete strength on the framed shear walls is due to increasing the concrete strength from 25 MPa to 35.0 MPa which results to maximum deflection to decrease by 30% for the El Centro record. It also help in maximizing shear force increase by 56% for the ten-Storey shear wall and for the five-Storey shear wall, the maximum deflection is increased by 27% and the maximum shear force increased by 30%. The effect of steel yielding stress from 413 MPa to 482 MPa is negligible. Hence shear reinforcement provided at the critical section proved to be insufficient to avoid an early shear failure.

Satish Annigiri and Ashok K. Jain (1994) et al.,

They carried out a research on the eccentricity distribution for floor and Storey eccentricity for different types of lateral load distributions along the height of the building. The static methods as per code is torsional analysis are evaluated which are dynamic methods specified as per IS: 1893 (1984) and UBC (1991) codes. The main thrust due to accidental eccentricity. A 6 storied framed building with setbacks and 2 storied framed-shear wall building were considered. In an asymmetric building it is suitable for 3-D dynamic analysis carried out including the effect of accidental eccentricity. There is a need for upgrading torsional provisions in IS: 1893 explanatorily to define how to compute design eccentricity and account for accidental torsion, both in static as well as dynamic analysis.

5. RETROFITTING

Retrofitting is making changes to an existing building to protect it from flooding or other hazards such as high winds and earthquakes. Retrofitting is advancement in the construction technology, including both methods and materials, to cope up with the increasing frequency and intensity of the natural hazards and their effects on buildings. Many houses existing today were built when little was known about where and how often floods and other hazardous events would occur or how buildings should be protected, and houses being built today may benefit from improvements based on what we learn in the future. As a result, retrofitting has become a necessary and important tool in hazard mitigation

Retrofitting specifically for earthquake hazards is often referred to as "**rehabilitation**".

In earthquake engineering terminology, Repair, Restoration and Retrofitting have acquired the following meanings:

Repair: Actions taken for patching up of superficial defects and doing the finishes.

Restoration: Action taken for restoring the lost strength of Structural elements.

Retrofitting: Actions for upgrading the seismic restoring of an existing building. So that it becomes safer under the recurrence of likely future earthquakes.

6. NEED FOR SEISMIC RETROFITTING

To ensure the safety and security of a building, employees, structure functionality, machinery and inventory

Essential to reduce hazard and losses from non-structural elements.

Predominantly concerned with structural improvement to reduce seismic hazard.

Important buildings must be strengthened, whose services are assumed to be essential just after an earthquake like hospitals.

SEISMIC STRENGTHENING (RETROFITTING)

It will involve actions for upgrading the seismic resistance of an existing building so that it becomes safer under the occurrence of probable future earthquakes.

The seismic behavior of existing g buildings is affected by their original structural inadequacies, material degradation due to gain and alterations carried out during use over time. The complete replacement of such buildings in a given area is just not possible due to a number of social, cultural and financial problems. Therefore, seismic strengthening of existing undamaged or damaged buildings is a definite requirement. Seismic strengthening structural restoration and cosmetic repairs may sometimes cost up to 25 to 30 percent of the cost of rebuilding although usually it may not exceed 12 to 15 percent. Hence justification of strengthening work must be fully considered from cost point of view.

EARTHQUAKE RESISTANT RETROFITTING OF BUILDINGS:

For achieving safety of buildings against collapse in a future severe earthquake, the following retrofitting actions are recommended. The amount and placing of the retrofitting element depends upon the seismic zone, the importance of the building and the stiffness of the base soil.

Seismic Retrofitting Techniques are required for concrete constructions which are vulnerable to damage and failures by seismic forces. In the past thirty years, moderate to severe earthquakes occurs around the world every year. Such events lead to damage to the concrete structures as well as failures.

Thus the aim is to focus on a few specific procedures which may improve the practice for the evaluation of seismic vulnerability of existing reinforced concrete buildings of more importance and for their seismic retrofitting by means of various innovative techniques such as base isolation and mass reduction.

So Seismic Retrofitting is a collection of mitigation technique for Earthquake engineering. It is of utmost importance for historic monuments, areas prone to severe earthquakes and tall or expensive structures.

7. BASIC CONCEPT OF RETROFITTING

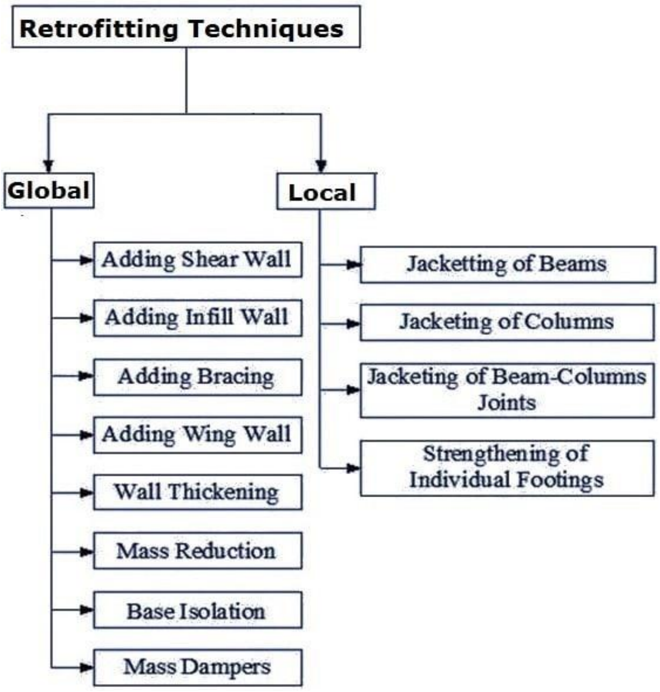
This aims at:

Up-gradation of lateral strength of the structure.

Increase in the ductility of the structure.

Increase in strength and ductility.

8. CLASSIFICATION OF RETROFITTING TECHNIQUES



9. MODELLING

GEOMETRICAL PROPERTIES:

Height of typical Storey = 3 m

Height of ground Storey = 3 m

Length of the building = 21 m

Width of the building = 21 m

Span in both the direction = 21 m

Height of the building = 120 m

Number of stores = 40

Wall thickness = 230 mm

Slab Thickness = 150 mm

Grade of the concrete = M 30

Grade of the steel = Fe 500

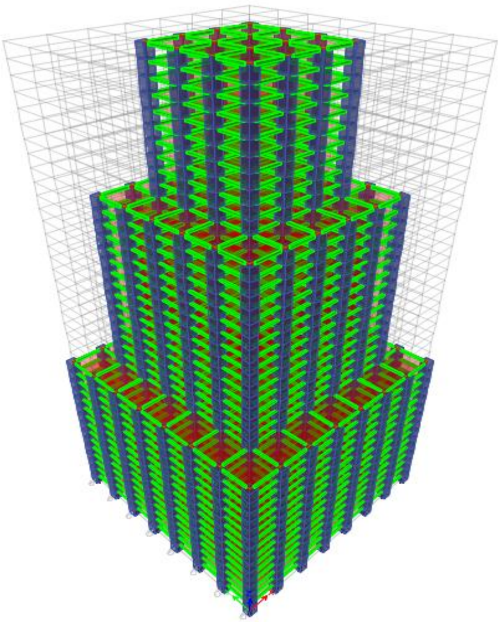
Thickness of shear wall = 230 mm

Support = Fixed

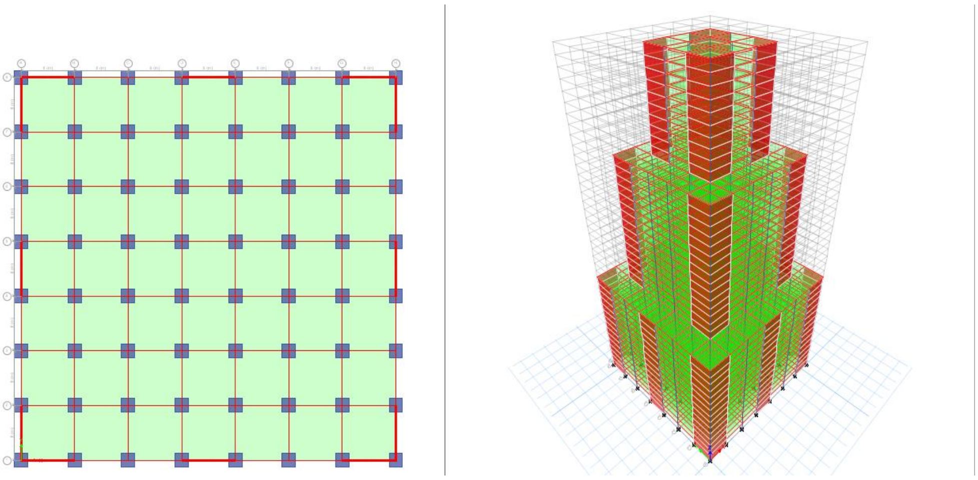
Column sizes = 0.6m X 0.6m up to 40 Storey

15. Beam size = 0.4 m X 0.4 m

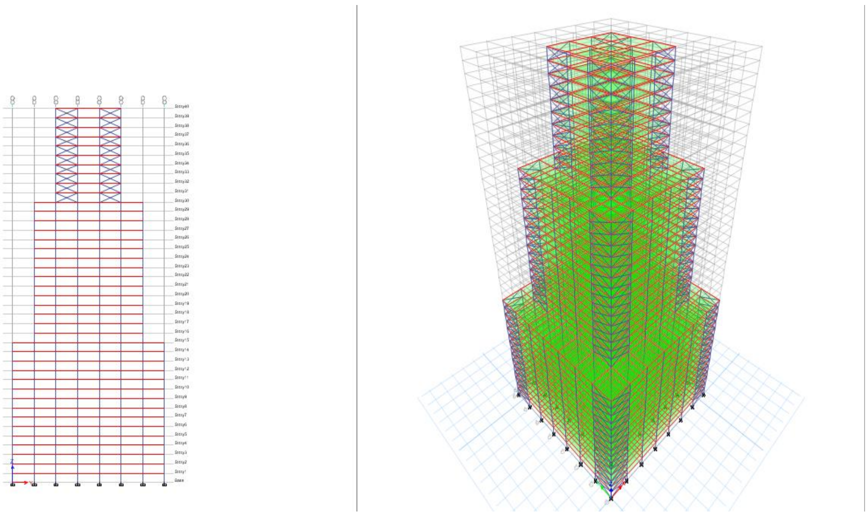
16. Location of Building = Vijayawada



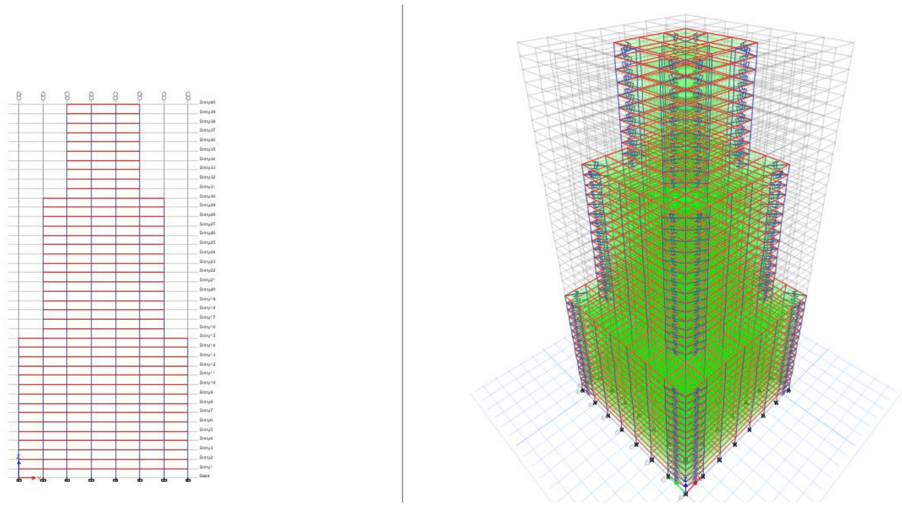
General model



Model retrofitted with shear walls



Model retrofitted with steel bracings

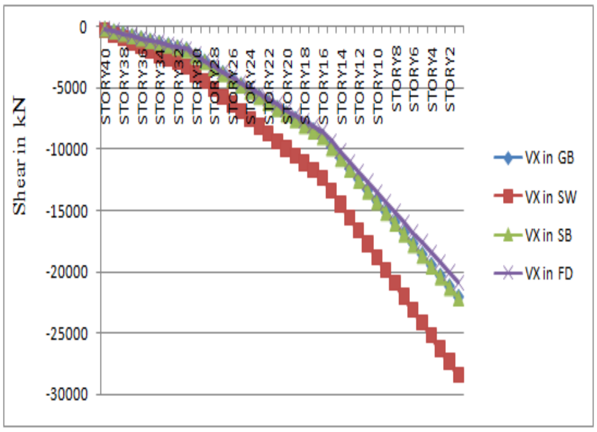


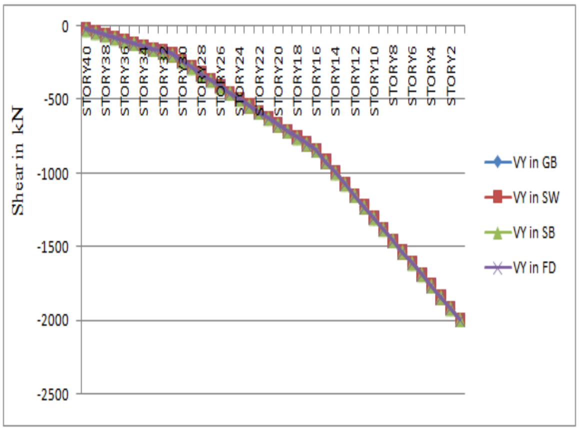
Model retrofitted with friction dampers

10. RESULTS

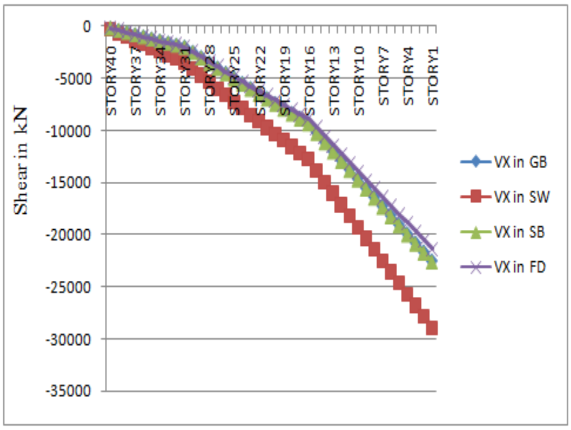
STORY SHEAR

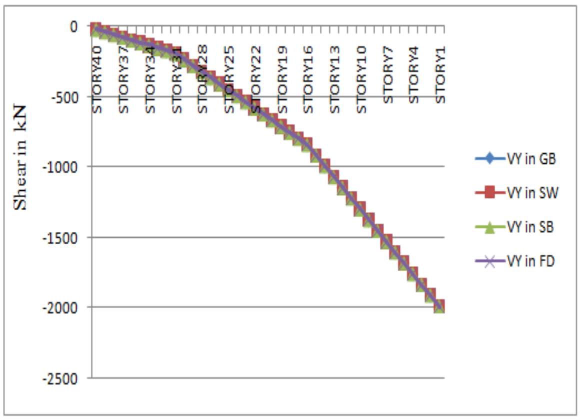
Storey Shear in X-Direction for Zone II **Storey Shear in Y-Direction for Zone II**



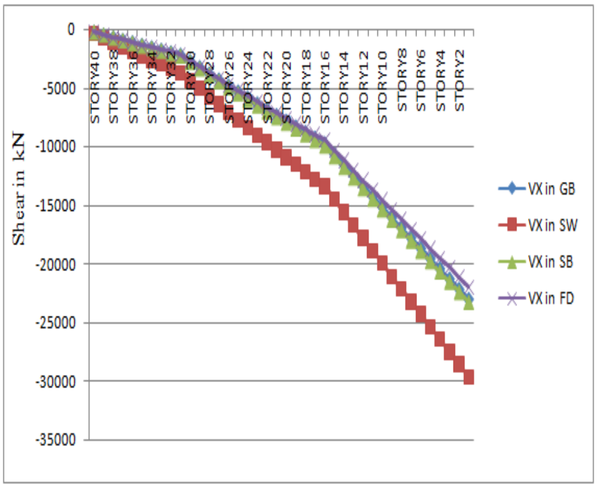


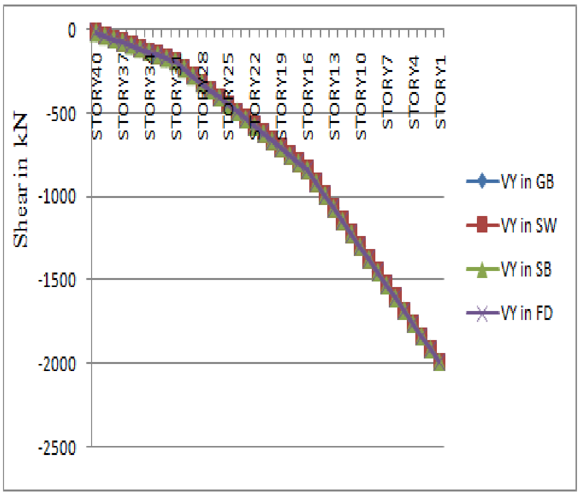
Storey Shear in X-Direction for Zone III **Storey Shear in Y-Direction for Zone III**



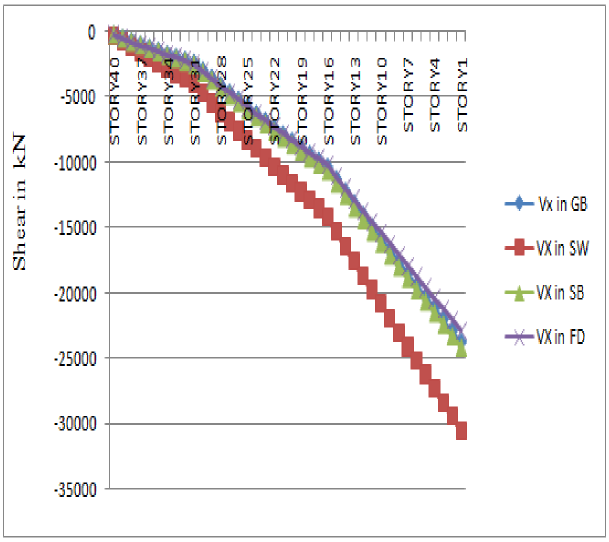


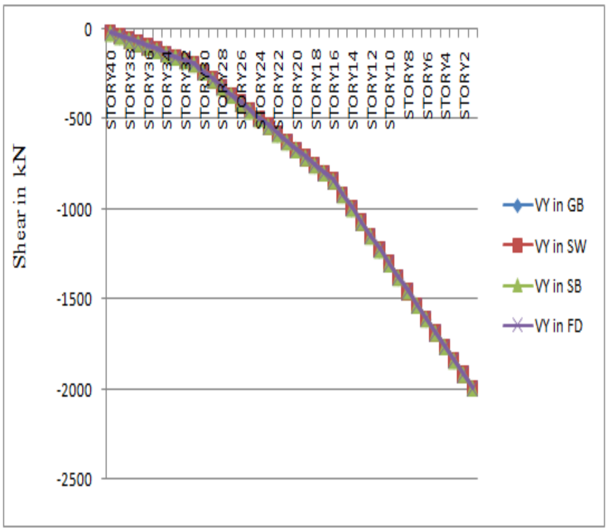
Storey Shear in X-Direction for Zone IV **Storey Shear in Y-Direction for Zone IV**





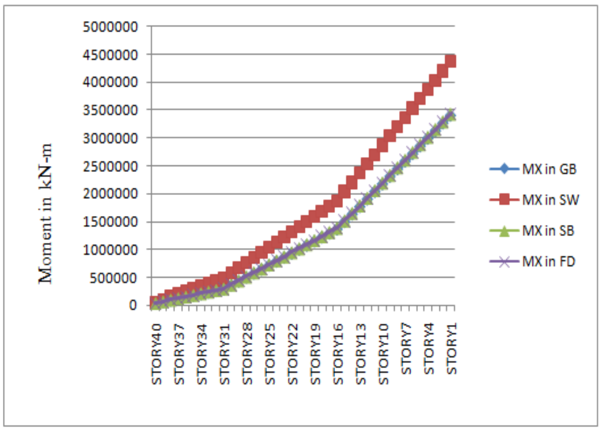
Storey Shear in X-Direction for Zone V Storey Shear in Y-Direction for Zone V

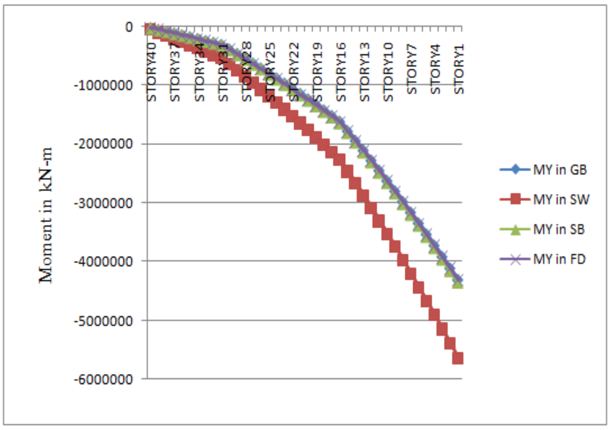




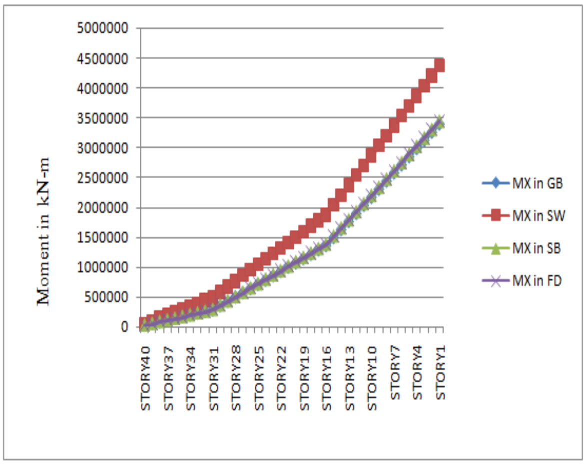
STOREY MOMENT

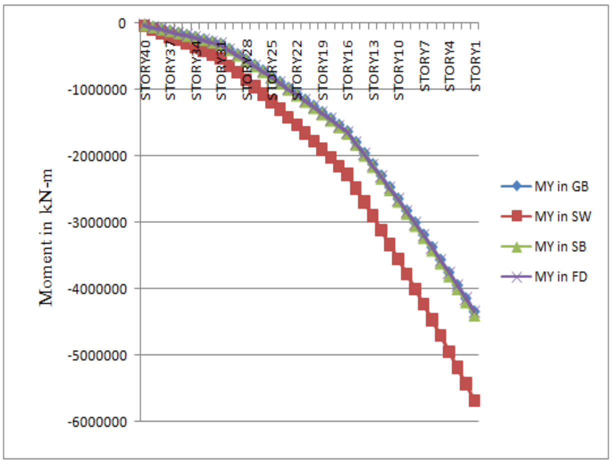
Storey Moment in X-Direction for Zone II Storey Moment in Y-Direction for Zone II



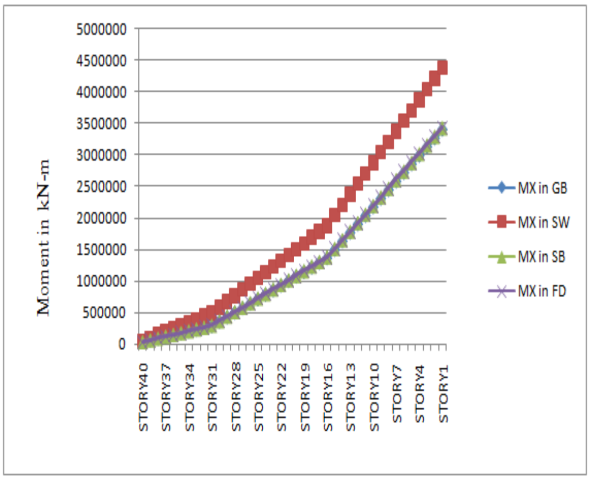


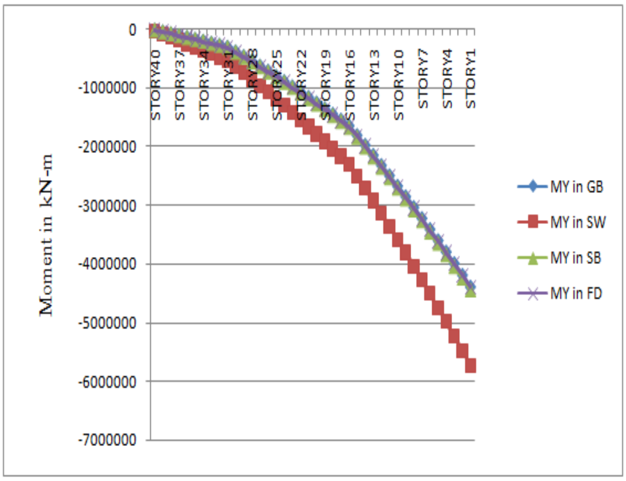
Storey Moment in X-Direction for Zone III Storey Moment in Y-Direction for Zone III



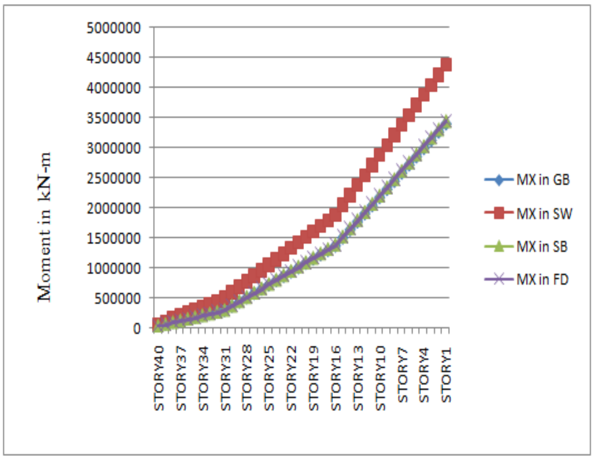


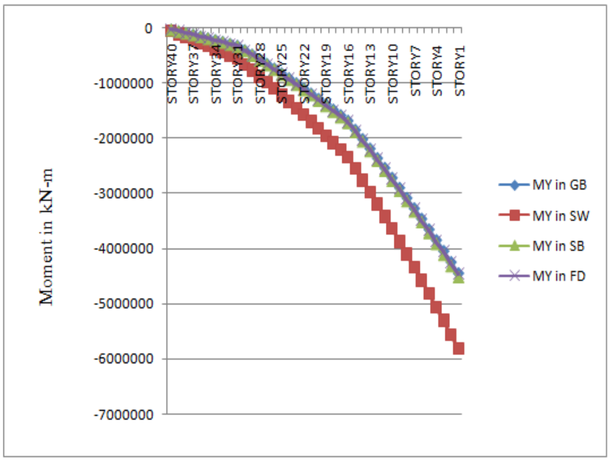
Storey Moment in X-Direction for Zone IV Storey Moment in Y-Direction for Zone IV





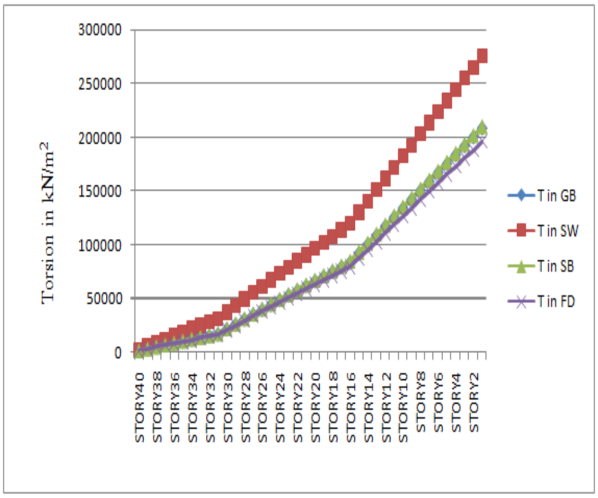
Storey Moment in X-Direction for Zone V   Storey Moment in Y-Direction for Zone V

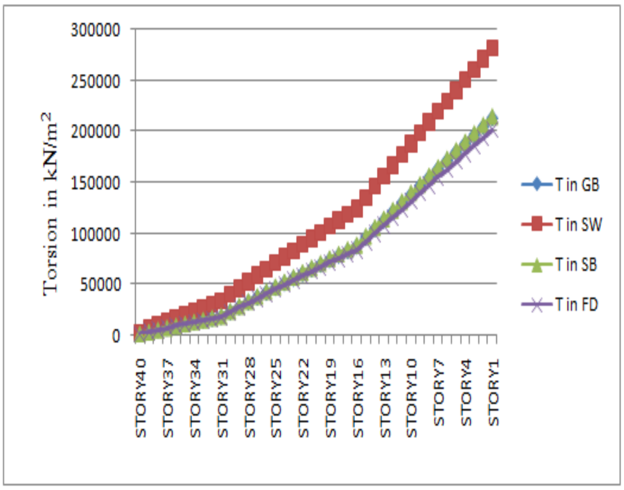




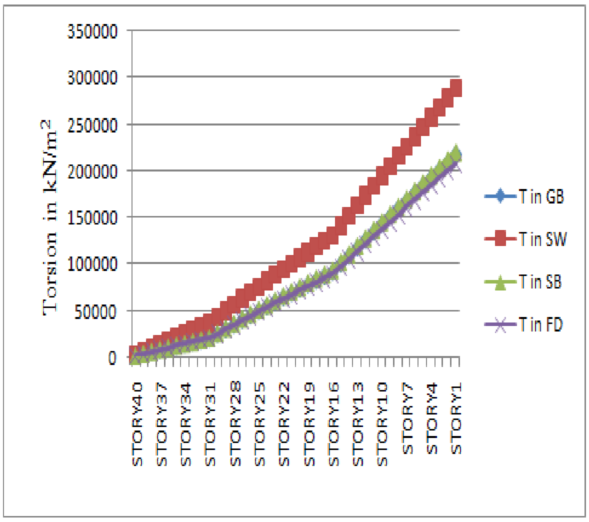
TORSION

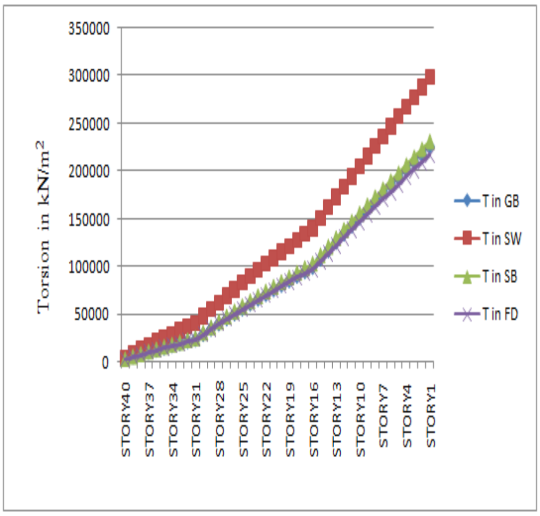
Torsion for Zone II   Torsion for Zone III





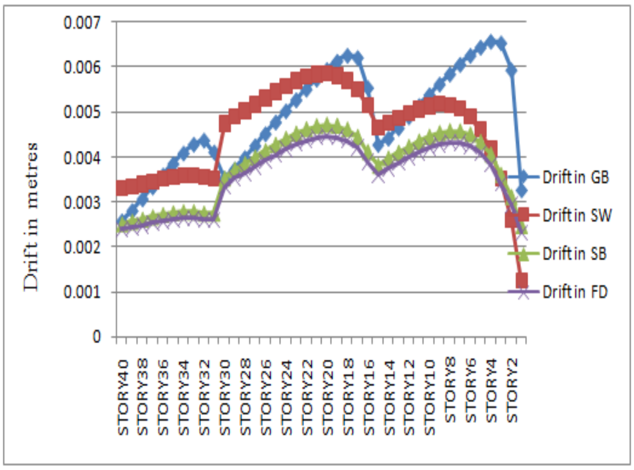
Torsion for Zone IV Torsion for Zone V

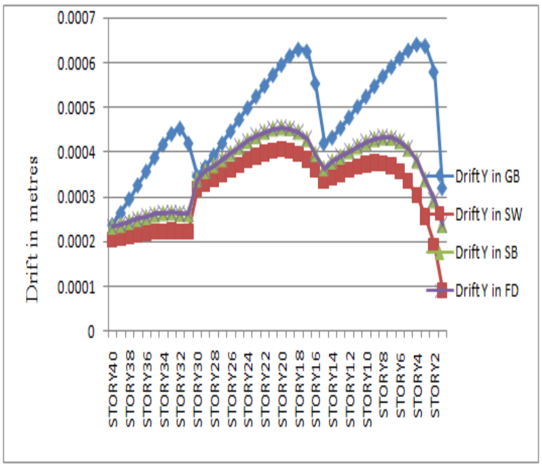




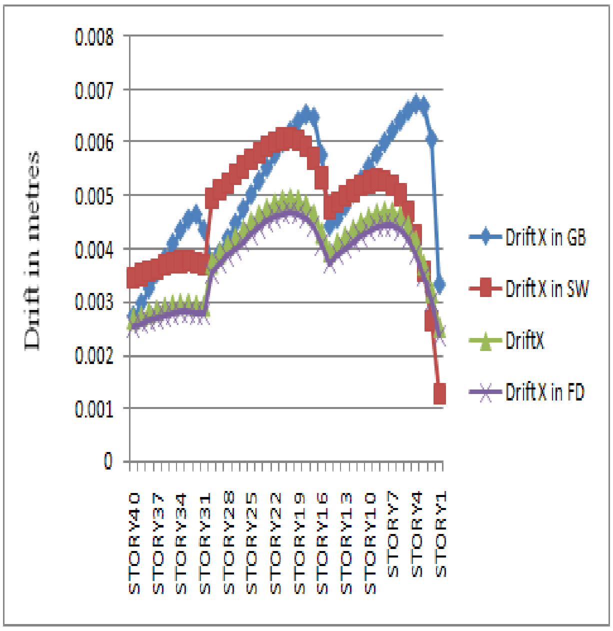
STOREY DRIFT

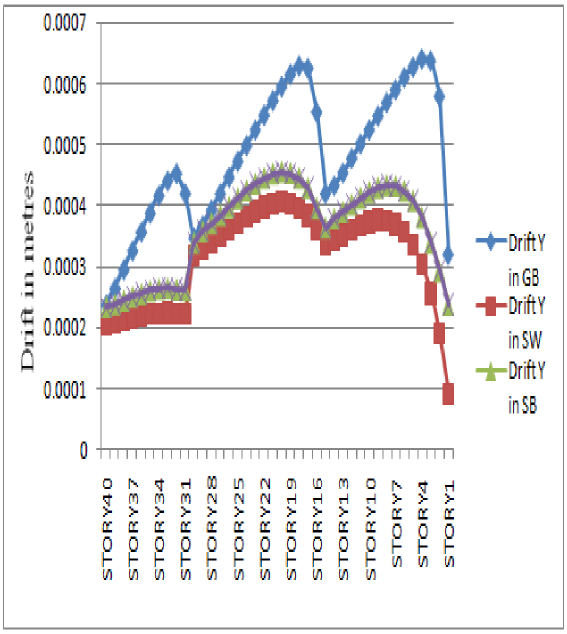
Storey Drift in X- Direction for Zone II Storey Drift in Y-Direction for Zone II



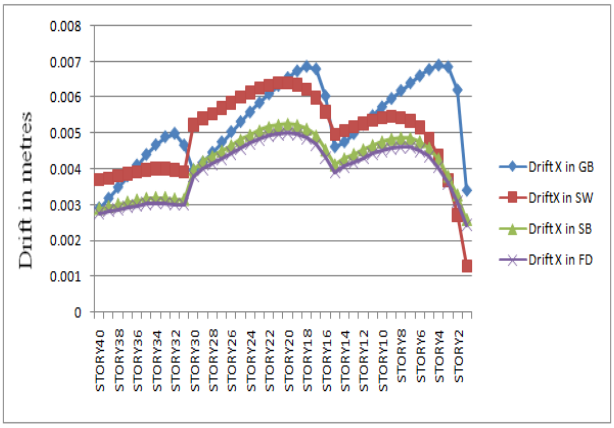


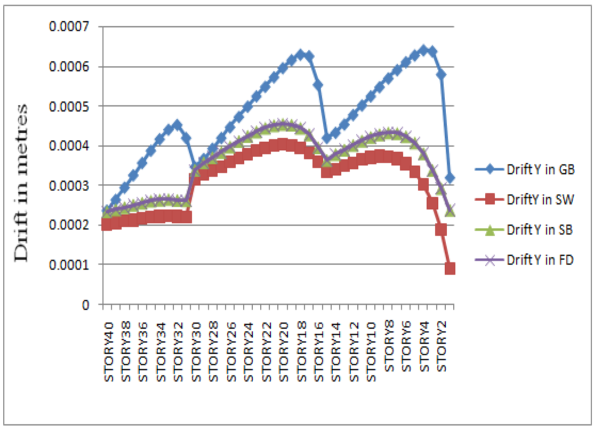
Storey Drift in X-Direction for Zone III Storey Drift in Y-Direction for Zone III



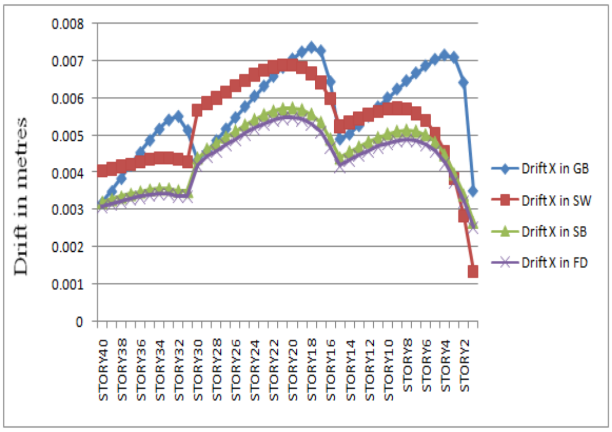


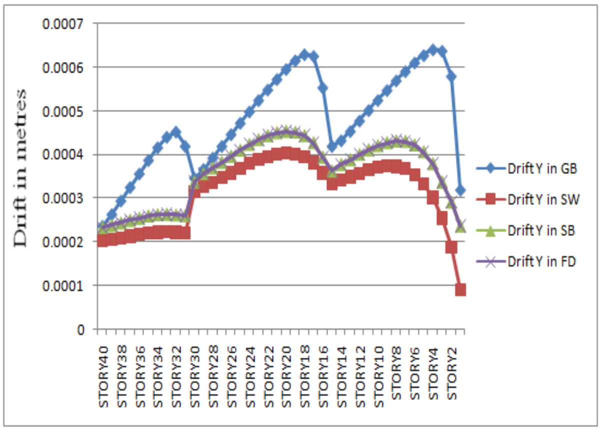
Storey Drift in X-Direction for Zone IV **Storey Drift in Y-Direction for Zone IV**





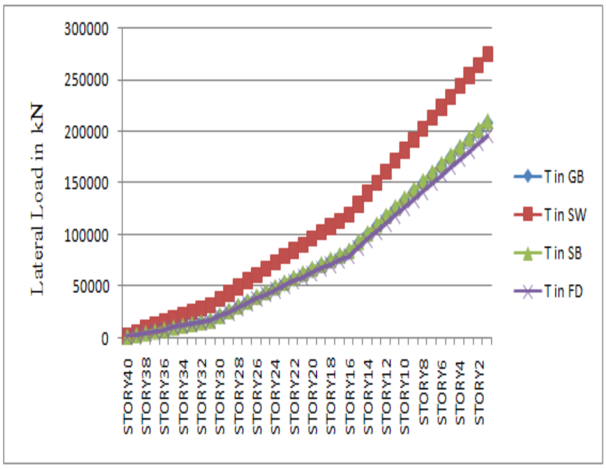
Storey Drift in X-Direction for Zone V **Storey Drift in Y-Direction for Zone V**

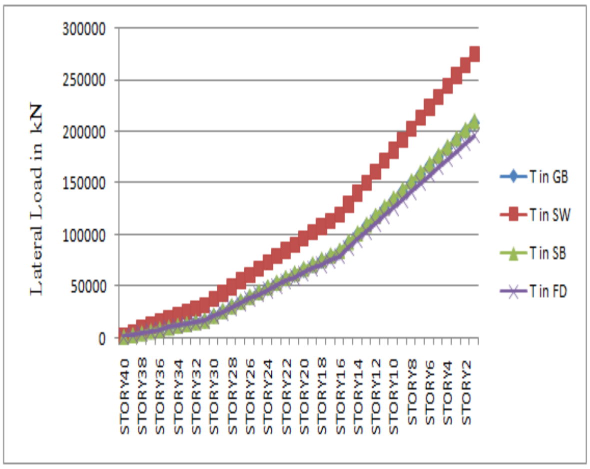




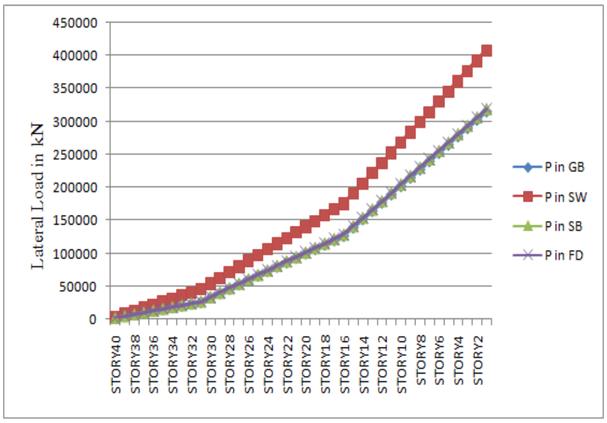
LATERAL LOAD

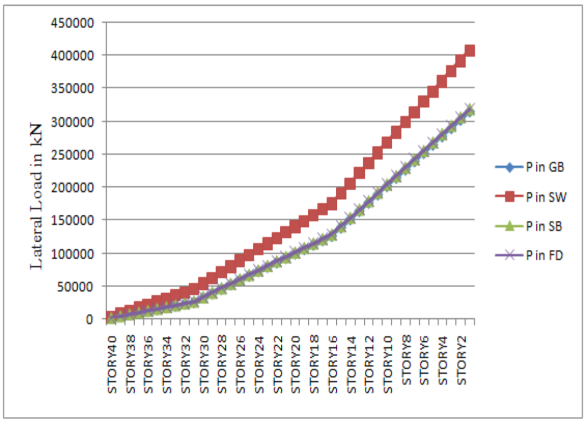
Lateral Load in Zone II **Lateral Load in Zone III**





Lateral Load in Zone IV   Lateral Load in Zone V





11. CONCLUSIONS

From the above results following conclusions have been made regarding,

Amongst all the three retrofits used, friction dampers are yielding the best results and hence it can be concluded that friction dampers are the best retrofits.

Optimum control of drift in X-direction is observed when the structure is retrofitted with friction dampers followed by steel bracings and shear walls.

Regarding the drift in Y-direction, optimum control is achieved in the case of shear walls and both steel bracings and shear walls are yielding same results.

The decrements observed when the structure is retrofitted with shear walls and steel bracings are closely following each other when compared to friction dampers in the case of drift in X-direction.

Best control of drift is observed in the case of all models in Y-direction when the structure is retrofitted with friction dampers.

Except drift there is an increment in all parameters particularly in the case of shear walls because of the addition of loads of the retrofits to the structural members.

When the structure is retrofitted with friction dampers a decrement is observed in all parameters in almost every zone.

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