IJIRSET
International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

e-ISSN: 2319-8753 | p-ISSN: 2320-6710

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 2, February 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.512

9940 572 462 | 6381 907 438 | ijirset@gmail.com | www.ijirset.com

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)

| e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.512|

|| Volume 10, Issue 2, February 2021 ||

DOI:10.15680/IJIRSET.2021.1002085

Review on Seismic Retrofitting of RC Structures with Exterior Shear Walls and Bracing

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ABSTRACT: Recent earthquakes that occurred during last ten years have suggested that significant damage happened wasn't specifically on account of methods of earthquakes but on account of bad performance of construction during earthquake. The current building system, that were design and constructed according to first codal provisions, don't satisfy needs of present seismic design and code methods. It's realized that the best technique of lowering the danger of harmful structure is seismic retrofitting. In the recent past, there's a tremendous enhancement of retrofitting techniques. This analysis highlights the concepts of evaluating and also retrofitting of structure against seismic events. A 3 dimensional R.C. frame fashioned with linear elastic compelling analysis. The computer software program ETab is utilized for dynamics analysis strategy is applied to look at the functionality of a reinforced concrete building. The various retrofitting techniques including steel and concrete application and jacketing of fibre reinforced polymer (FRP) composites that happened to be utilized to enhance the load bearing capacity of specific structure elements are highlighted and techniques including shear wall space plus shear cores that enables you to improve general balance of buildings. Most retrofitting techniques are going to result a rise in stiffness as well as somewhat enhance in mass that causes in return a shorter period. Shortening in period of vibration quite often results an increased ductility and strength of retrofitted structure. Consequently, a proposed retrofit program could be believed to achieve success in case it results an increased strength and also ductility capability of the structure that is higher compared to the requirements required by earthquakes.

KEYWORDS: Retrofitting, Seismic Events, FRP, Jacketing, Stiffness

I. INTRODUCTION

1.1 GENERAL

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 asfailures.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 fortheirseismicretrofittingbymeansofvariousinnovativetechniquessuchasbaseisolationandmass 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.

The existing building stock poses a much more serious and complex seismic safety problem when compared to safe earthquake design of new construction. The vast majority of structures located in seismic areas exhibit deficiencies in their resistance to earthquake loads due to a number of reasons, highlighted below.
Older construction, designed according to earlier codes, may not comply with current seismic regulations since focus used to be primarily on warranting sufficient capacity for gravity loads alone. Moreover, the past thirty years have witnessed such a significant increase of knowledge in the field of earthquake engineering that even relatively modem structures may no longer meet the prerequisites of constantly-developing regulations. As a result, several shortcomings can be found in existing buildings such as irregular structural configuration, inappropriate member detailing for ductility and insufficient lateral stiffness, amongst others.

All the above considered, it seems clear that repair and strengthening of both old structures designed according to outdated codes and new but defective earthquake-resistant construction, is urgently needed. This requirement also

| e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.512|

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arises where existing structures must comply with more recent code stipulations, or when these structures are to be reassessed for higher loads.

Further, precise structural assessment quite often stumbles on the unavailability of accurate design plans and the uncertainties regarding material properties, particularly in the case of old structures. In the case of earthquake-hit structures, evaluation of the level of damage can be difficult on occasions, and assumptions basedon engineeringjudgment, rather than codified guidelines, are needed.The superior performance characteristics of new materials, such as fiber-reinforced polymers, may also be exploited. However, some of these highly efficient interventions are expensive (due to the production cost associated to such novelty materials) and require skilled workmanship. This often constitutes a big impediment in the majority of poorer earthquake-prone countries, and the use of familiar construction methods making use of traditional materials, such as steel and concrete, is a preferable solution.

In the case of reinforced concrete (RC) structures, the aforementioned difficulties constitute a particularly serious problem. This type of construction is widely used for critical public buildings, such as schools, hospitals, fire stations and public administration offices, amongst others. Also, this class of structures is commonly associated to large occupancy buildings such as multi-storey residential blocks, offices and hotels. However, despite the importance in safeguarding the seismic behaviour of such sensitive structures, there is very little codified criteria and guidelines for assessment and structural upgrading of RC buildings

The problem, however, becomes more intricate when other factors, beyond the reach of regulations, are taken into account. In fact, it is frequent for existing buildings to have suffered structural modifications applied by their owners without due engineering consideration, thus further hindering what may already be a low seismic resistance. Also, quality of construction may be poor, resulting in a defective design-implementation. The latter may lead to disastrous consequences, as recently highlighted by the devastation and human casualties resulting from the Kocaeli (Turkey) of 17 August 1999 and, to a lesser extent, the North Athens (Greece) earthquake of 7 September 1999.
There are three key concepts in seismic design that were fully developed by researchers and engineers. First, earthquake ground motions generate inertial loads that rapidly change with time. Thus, it is common that calculations include a term labeled with a unit of time (usually seconds) and these terms include periods of vibration or their inverse, frequencies; accelerations and velocities. In many other structural engineering problems such as calculations of gravity loads, no unit of time is used.

II. CHOICES FOR THE LATERAL FORCE-RESISTING ELEMENTS OF STRUCTURAL SYSTEMS

The choices of lateral-force-resisting systems in buildings are limited to the following, with very few exceptions: braced frames (vertically-oriented truss elements), moment-resistant frames, shear walls, diaphragms and response modification techniques that change the seismic demand on the lateral-force-resisting elements. Such techniques focus on changing the forces in the structure due to ground motion (e.g. seismic isolation) or changing the displacement within the structure due to the ground motion (e.g. damping devices). The materials, of which these elements can be made, with very few exceptions, are limited to: steel (including aluminum or other metals), reinforced masonry, reinforced concrete and wood.

2.1 EARTHQUAKE DESIGN PHILOSOPHY

The engineering intention behind earthquake resistant design is not to make earthquake-proof buildings that will not get damaged even during the rare but strong earthquake; such buildings will be too robust and also too expensive. Instead, the engineers make buildings to resist the effects of ground shaking, although they may get damaged severely but would not collapse during the strong earthquake. Thus, safety of human life and contents inside of the building are assured in earthquake resistant buildings. This is a major objective of seismic design codes throughout the world. The earthquake design philosophy may be summarized as follows;
(i)Under minor but frequent shaking, the main members of the building resist earthquake impact without being damaged (staying at elastic range); however building parts that do not carry load may sustain repairable damage.
(ii)Under moderate but occasional shaking, the main members may sustain some repairable damage, while the other parts of the building may be damaged even may need replacement.
(iii)Under strong but rare shaking, the main members may sustain severe (even irreparable) damage, but the building should not collapse.

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2.2 SEISMIC RETROFITTINGTECHNIQUES

- Earthquake creates great devastation in terms of life, money and failures ofstructures.
- Upgrading of certain building systems (existing structures) to make them more resistant to seismic activity (earthquake resistance) is really of moreimportance.
- Structures can be (a) Earthquake damaged, (b) Earthquakevulnerable
- Retrofittingprovestobeabettereconomicconsiderationandimmediatesheltertoproblemsrather than replacement ofbuilding.

2.3 SEISMIC RETROFITTING OF CONCRETE STRUCTURES:

Definition:

It is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes.

The retrofit techniques are also applicable for other natural hazards such as tropical cyclones, tornadoes, and severe winds from thunderstorms.

2.4 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.

2.5 PROBLEMS FACED BY STRUCTURAL ENGINEERS ARE:

Lack of standards for retrofitting methods – Effectiveness of each methods varies a lot depending upon parameters like type of structures, material condition, amount of damage etc.,

2.6 BASIC CONCEPT OF RETROFITTING

- Up gradation of lateral strength of structure
- Increase in ductility of structure
- Increase in strength and ductility

2.6.1Classification of Retrofitting Techniques

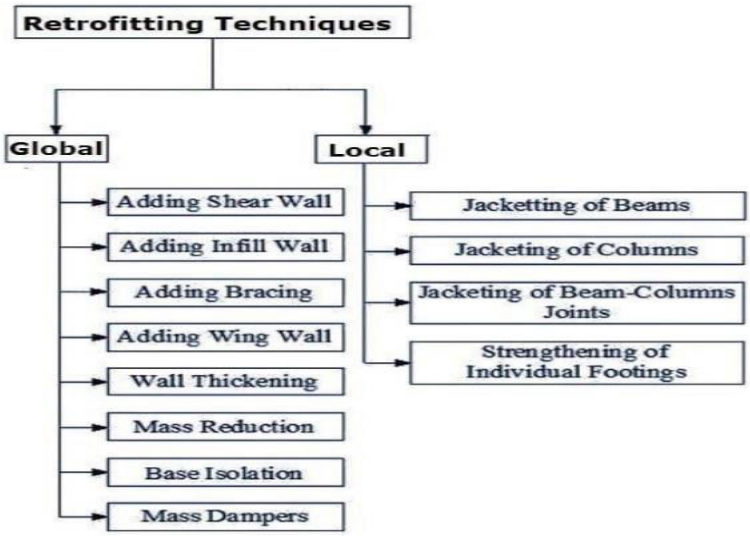

Fig 1.1 Retrofitting Techniques

| e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.512|

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2.7 PROBLEM STATEMENT

The main reason for this particular study is increasing proficiency and knowledge in earthquake resistant design plus seismic rehabilitation of existing buildings and also in order to increase familiarity with modeling & analyzing buildings against seismic loads by utilizing computer software

2.8 SCOPE OF PROJECT

To ensure the safety and security of a building, employees, structure functionality, machinery and inventory. Essential to reduce hazard and losses from 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.

2.9 OBJECTIVE

The objectives of this particular analysis are:

(i) To explore the consequences of earthquake forces on structures and literature search on earthquake resistant design

(ii) To assess the feasibility of seismic evaluation of advantages and buildings of using the retrofit measures designed for strengthening

(iii) To evaluate performance based design and compare various seismic analysis method

(iv) To model a real structure with a structural analysis software program and check out the earthquake results with various analysis methods given in standards and codes & propose most appropriate rehabilitation techniques in terminology of the overall performance

III. LITERATURE REVIEW

Chandurkar, Pajgade et.al (2013)(1) evaluated the result of a 10 storey developing with seismic shear wall structure using ETAB v 9.5. Main focus was comparing the modification of response by modifying the location of shear wall structure in the multi storey structure. 4 models were studied- one to be a bare frame structural program as well as rest three were of dual style structural system. The results were good for shear wall in span that is short at corners. Larger dimension of shear wall was discovered to be inadequate in 10 or even under ten stories.

Viswanath K.G et.al (2010)(7) investigated the seismic performance of reinforced concrete structures utilizing concentric steel bracing. Evaluation of a 4, 8, 12 as well as 16 storied building in seismic zone IV was completed using Staad Pro software, as per Is actually 1893: 2002 (Part I). The bracing was supplied for peripheral columns, as well as the usefulness of steel bracing distribution across the level of the structure, on the seismic functionality of the structure was studied.

Chavan, Jadhav et.al (2014)(2) studied seismic evaluation of reinforced concrete with various bracing plans by equivalent fixed technique through the Staad Pro. software. The plans considered were diagonal, V type, inverted X-type and V-type. It was noticed that lateral displacement reduced by fifty % to sixty % and maximum displacement reduced by utilizing X type bracing. Base shear of the structure was also found to boost from the bare frame, by using of X type bracing, indicating increased stiffness.

Esmaili et al. (2008) (3) analyzed the structural element of a fifty six stories high tower, located in an impressive seismic zone in Tehran. Seismic evaluation of the structure was done by nonlinear dynamic analysis. The current building had primary wall space and the side walls of its as shear walls, attached to the primary wall structure by coupling of beams.

Akbari et al. (2015)(4) assessed seismic vulnerability of steel X braced as well as chevron braced Reinforced Concrete by developing analytical fragility curve. Study of different parameters as level of the frame, the p delta impact as well as the portion of bottom shear just for the bracing technique was completed. For a certain created base shear, steel braced RC dual methods have very low injury probability as well as bigger capacity than unbraced phone system.

Kappos, Manafpour et.al (2000)(5) presented brand new methodology for seismic design of RC developing based upon achievable partial inelastic type of the framework as well as performance requirements for 2 unique limit states. The procedure is developed to a format which may be incorporated with design codes as Eurocode eight. Time-History (Nonlinear dynamic) analysis as well as Pushover analysis (Nonlinear Static analysis) has been investigated.

| e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.512|

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Yamada et al.(2015) (6) studied, experimentally and also analytically, deformation & fracture qualities of lateral load resisting systems shear wall structure for RC frame and steel bracing for metal multi storey frame below earthquake, since versions having three various spans along with three, six as well as nine storeys. Deformations as well as facture outcomes for all of the 3 cases are compared and differences are clarified by normalization of suggested horizontal resisting proportions.

S.S. Patilet al.2013 (7) presented seismic evaluation of excessive rise building by using various lateral load resisting system which are one) bare frame, 2)brace frame, three) shear wall structure frame. This analysis is completed with Response Spectrum Method, and utilizing STAAD Pro application. Test outcome is based on parameters as base shear, story deflection and story drift. They realized that shear wall design provides a lesser amount of story deflection as well as story drift compared to bare frame and braced frame.

Hassaballa A.E. et al.(2013)(8) eight studied the seismic evaluation of a RC developing, and investigate the functionality of existing construction in case subjected to seismic loads. This particular building frame was examined by Response Spectrum Method as well as frame is computed via STAAD Pro application. For seismic evaluation of multistory structure they used static load as well as seismic load and get outcome which design based on reaction spectrum technique necessary large dimension of to resist huge displacement. And realized that drift resulting from nodal displacement as a result of mix of seismic loads and static load had been approximately two to three times the allowable drifts.

Mindaye et al, (2016)(9) nine analyzed the seismic effect of noncommercial G ten RC frame development is examined by the linear evaluation methods of equivalent fixed lateral forces as well as Response spectrum technique using ETAB primary 2015 software as per Is actually 1893:2002 part1. Various result like lateral force, displacement, story drift, overturning moment, base shear are plotted to evaluate the outcome of the dynamic and static analysis. They concluded that powerful story shear is under story shear for those instances. Equivalent static lateral force technique provides higher worth of force as well as moments that make creating uneconomical hence consideration of reaction spectrum strategy is necessary.

Padol S. et al(2015)(10) studied the seismic evaluation of multistoried RCC construction with mass irregularity at various floor amount are performed. This paper highlights the impact of mass irregularity on various floors in RCC construction with Time History Method as well as analysis is accomplished by ETABS software. They realized that anytime system has various irregularity the impact of earthquake on structure could be reduce through shear wall, base isolation etc.

Patil A. S, et.al (2013) (11) studied nonlinear powerful evaluation of ten storied RCC developing considering various seismic intensities as well as analyzed seismic result of that structure. The structure under consideration is modeled with the aid of Sap 2000 15 software and five distinct time histories are used. The outcome of the research shows comparable variations design in seismic effect like base shear as well as storey displacements and realized that time past is practical technique employed for seismic analysis. It offers a much better check on the safety of system analyzed as well as created.

Bhagwat et al.(2014)(12) studied powerful evaluation of G twelve multistoried practiced RCC developing considering for Bhuj and Koyna earthquake is taken out. The time History Analysis and Response Spectrum Analysis along with seismic reactions of the structure are comparatively studied.The modeled with the aid of ETABS9.7.2 application.2 time histories (i.e. Koyna and Bhuj) are already utilized to cultivate various criteria (base shear, storey displacement, storey shear), and also realized that, the valuation of base shear for Bhuj earthquake is 49.11 % much more than the Koyna earthquake, and Response Spectrum technique provides fifty % more outcome compared to Time History Analysis.

Dubey et al. (2015) (13)presented design of multistoried irregular construction with twenty accounts and modeled it with software STAAD PRO for seismic zone IV in India, powerful effect of creating under real earthquake, DELINA (ALASKA)2000 are deemed. This particular paper highlights the comparison of Time History Method and Response Spectrum Method. The story displacement effect continues to be acquired with each technique of powerful analysis, and also Concluded that Time History Analysis is discovered to be two to eight % above that of Response Spectrum Analysis in all kind of building i.e. irregular and regular, For excessive rise building it's essential to offer powerful evaluation due to nonlinear distribution of force. Storey displacement is found increased in THM as compared to RSM,

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DOI:10.15680/IJIRSET.2021.1002085

and found the starting shear is increased in RSM as opposed THM. Thus it could be realized that time history examination is economically better for designing.

Rampure et al. (2016) (14) studied the powerful time history analysis as well as reaction spectrum evaluation associated with a concrete gravity dam by utilizing STAAD PRO. Finite component strategy is utilized to evaluate the dam along with a concrete gravity dam design is ready in STAAD PRO to do time history analysis and response spectrum evaluation as well as comparison is completed between both these techniques. They concluded that STAAD-PRO is very practical & less challenging for powerful analyses and it offers a computing setting to investigate modeling assumption as well as computational tasks associated with the fixed as well as seismic structural balance of gravity dam. It's essential to evaluate the framework by powerful evaluation of both these technique for below the level of dam 100m and above the height of dam 100m.

Hawaldar et al. (2015) (15)presented G+12 storey developing type with as well as without infill the time history analysis utilized for Koynaearthquake and Bhuj feature it's carried through in ETABS 2013 application. The seismic responses of story displacements, storey drifts are found. Time history plots of base force v/s time as well as roof displacement v/s period for each time history capabilities are compared and also analyzed. They realized the displacement values for bhuj functionality are bigger compared to the displacement value for Konya performance and also those for infill building are under that with no in filled building as well as drift importance of bhuj functionality had been far more in comparison with drifts for Konya function as well as infill drift values are comparatively much less than for without infill drift values for equally time history feature.

IV. CONCLUSION

This project work was a small effort towards perceiving the how introducing bracing or a shear wall in a building can make in difference in protecting the building in earthquakes. Almost all the buildings in India are RC frame, and earthquake tremors are felt every now a then in some or the other part of the country. Hence through this project it was tried to appreciate the effectiveness and role of this small extra structural elements that can save both life and property, at least for most of the earthquakes.

The following conclusions were drawn at the end of the study :

1. Base Shear produced in the Bare Frame is maximum for Shear wall at C.
2. In case of bracing system, Bracing System C (with braces at the corners) are the most effective one than other bracing systems, effectively reducing top-storey drift and inter storey drifts in both X- and Z- directions.
3. There is hardly any reduction in drift along Z- direction due to Bracing B, for all the ground motions.
4. Shear Wall A is effective in reducing drifts along X- direction only, and Shear Wall B is effective in reducing drifts along Z- direction only, for all the ground motions.
5. Above all Shear Wall C is the best in all the stiffening cases considered.
6. Shear wall elements are very much efficient in reducing lateral displacement of frame as drift and horizontal deflection induced in shear wall frame are much less than that induced in braced frame and plane frame
7. The location of shear-wall and brace member has significant effect on the seismic response than the plane frame
8. Shear wall construction will provide large stiffness to the building by reducing the damage to the structure.
9. The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures
10. Steel bracings can be used as an alternative to the other strengthening or retrofitting techniques available as the total weight on the existing building will not change significantly
11. Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral loads through axial load mechanism.

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| e-ISSN: 2319-8753, p-ISSN: 2320-6710| www.ijirset.com | Impact Factor: 7.512|

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