

A Review Paper on Seismic Retrofitting of Pure Masonry Structure

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Abstract— By viewing the latest earthquake in Nepal (25 April 2015) the seismic analysis play an important role on the construction area. The building demands to build earthquake proof and earthquake resistant. Some building structure which is previously constructed demand to retrofitting. When we hear the term retrofitting we focused on maintain the previously constructed building through different techniques. On the basis of construction the retrofitting can be divided in to two parts masonry retrofitting and RC frame retrofitting. In the following paper we widely discussed about the retrofitting and their techniques. Which is used in the construction site? The retrofitting provided extra strength to the building under seismic load and lateral load. Retrofitting make a building earthquake resist in this paper we discuss retrofitting, types of retrofitting, analysis method of retrofitting.

Keywords: Seismic Retrofitting, Masonry Structure, RC Frame Structure, Seismic Analysis Method

I. INTRODUCTION

To prevent the disaster in future earthquake, the retrofitting play an important role in the structural fundamentals. When we concentrated on the world retrofitting first question plugged in our mind. What is the retrofitting? In general way if we can explain the retrofitting can be define as a techniques which is use to maintain a structure to resist any lateral force such as seismic forces. Due to seismic activity the seismic force worked in to wave form. The seismic waves effect on the building structure in the form of lateral loading. To prevent the structure from these lateral loading there are following methods, which is use for retrofitting. For different types of building structure such as masonry structure, RC frame structure, we use different type of techniques which is point out as below. Concrete jacketing is considered as an important method for strengthening and repairing RC beam. Jacketing of RC beam is done by enlarging the existing cross-section with a new layer of concrete that is reinforced with both longitude and transverse reinforcement. Use of steel plates retrofitting has been used as a method of enhance the shear strength and ductility of square reinforcement (RC) column. Wrapping with fibre reinforced polymer sheets to improve the seismic capability of structure. Retrofitting is the process of additional of new features. The older buildings, heritage structure, bridge etc. Retrofitting reduces the vulnerability of damage of an existing structure during a near future seismic activity.

A. Concept of Seismic Retrofitting

Seismic retrofitting is a way to improve building structure to make the structure more resistant under seismic activity, ground motion or soil failure due to earthquake. In the present time various structures made without any adequate detailing and reinforcement for seismic protection. In many part of developing countries such as India, Pakistan, Nepal, Iran and

china the structure made without detailing and reinforced structure mostly in rural areas. Retrofitting is provided to improve the construction quality and bearing capacity for external load capability.

B. Requirement of Retrofitting-

Seismic retrofitting are required to improve basic error in the structure, which is arrive at any time of construction in beginning of the construction phase till end of the construction such as

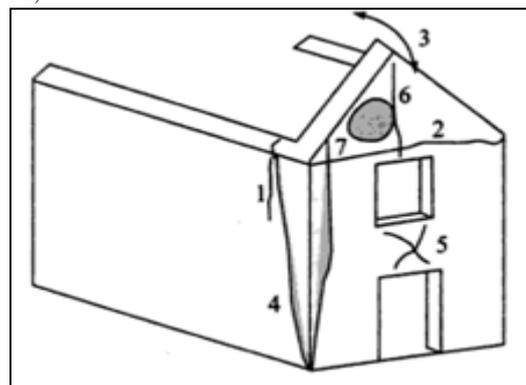
- Design errors before or after construction,
- Insufficient concrete production in the construction,
- Bad execution processes,
- Due to earthquake effects,
- Due to accidental causes such as fire, explosion and collision,
- Due to lack of detailing.

C. Failure condition in masonry structure under seismic forces

There are following failure condition which is develop through the seismic condition. The seismic condition effects on the structural fundamental of the section. The seismic forces give then various failure conditions which is shown as below.

1) Out-of-Plane failure

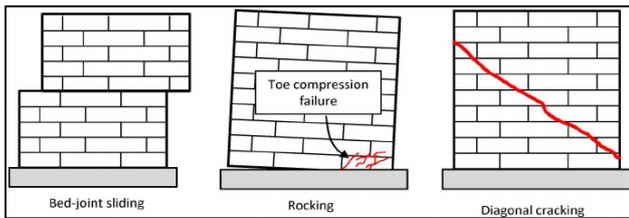
out-of-plane failure developed due to perpendicular loads acting on the wall section. The out of plane failure can be express by the following fundamental figure as given below. Here the,



- 1) Vertical crack in the corner and T walls.
- 2) Horizontal cracks along the facade
- 3) Partial collapse of an exterior wall
- 4) wythe separation
- 5) Cracks at lintel and top of slender pier
- 6) Cracks at the level of roof
- 7) Masonry ejection

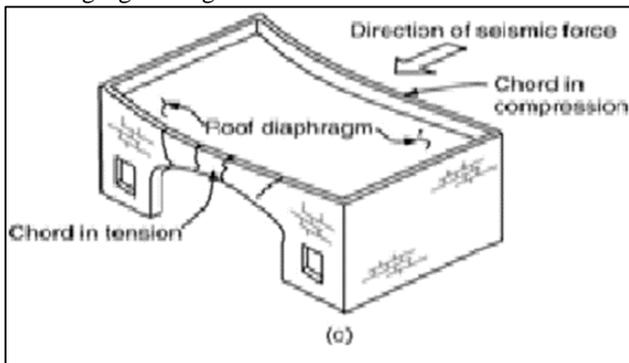
2) In plane failure

In plane failure is caused by in plane seismic loads acting along in the plane of wall characterized by distributed diagonal cracking in the wall section as shown in the following figures.



3) Diaphragm Failure

Diaphragm failure is caused by the low shear resisting capacity of the structure when the earth seismic motion developed then the plasticity of the structure forces the structure to revised its own position cause of these fundamental force disturbance the diaphragm failure is developed. Which is shown on the following figure as given below.



D. Efficiency and Effect of Retrofitting

Retrofitting improve the strength of the building under lateral loading and increasing the resistant to lateral loads, improving the ductility and an association of both. Retrofitting improve the building structure through improving the fundamental aspects of the section structure with their different retrofitting techniques. In the retrofitting we mostly done two basic concept

- Addition new structural elements
- Strengthening of the existing structural elements.

E. Basic Retrofitting Techniques

There are following techniques are present in the local and global market which is use for retrofitting of structure these strategies is

1) Global Techniques and Strategies

Surface treatment (shotcrete), stitching and grout/ epoxy injection, re-pointing, bamboo reinforcement, post tensioning (rubber tyres), PP strip reinforcement, steel mesh cage, plastic carries bag net are the basic global techniques.

2) Local Techniques

Steel jacketing, concrete jacketing, use of steel plate, wrapping with fibre reinforcement polymer sheets.

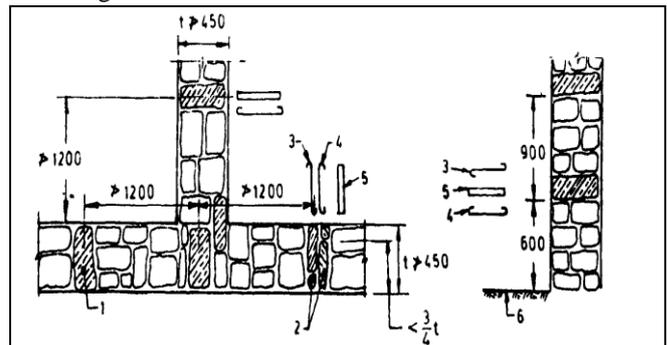
F. Techniques for Masonry Retrofitting

There are following techniques which is explain in the IS code 13935 And IS code 13828 which is mostly used for the masonry structure. These techniques play an important role in the retrofitting techniques. The fundamental techniques are explain as below

1) Through Stone and Bond Element

In the following fundamental techniques we use a stone member as a combiner for the wall structure, after adding the stone member in the section the section work like a single

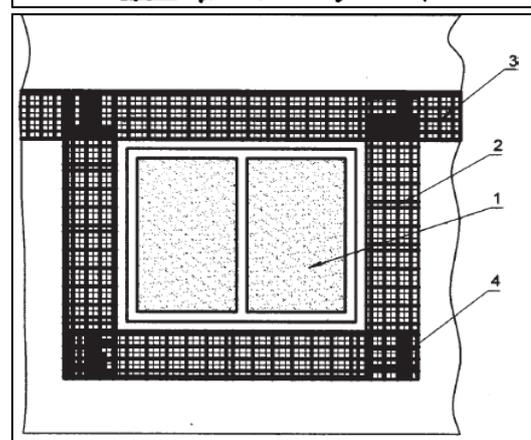
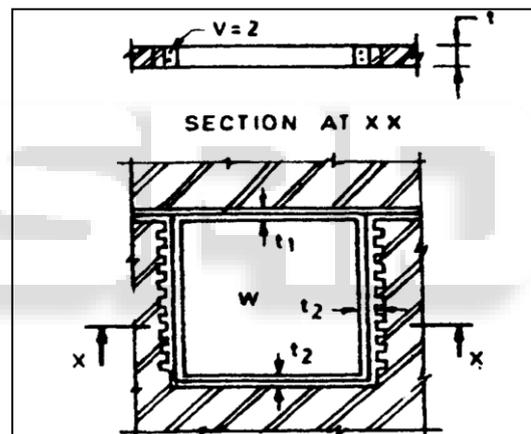
member. With the help of reinforcement, wooden block and other system we make it as a single member, which increase the strength of the section.



{A} Section plan of wall {B} Cross-section of the wall
1- Through stone 2-pair of over lapping stone 3-S-shape tie 4-hooked tie 5- wood plank 6- floor level

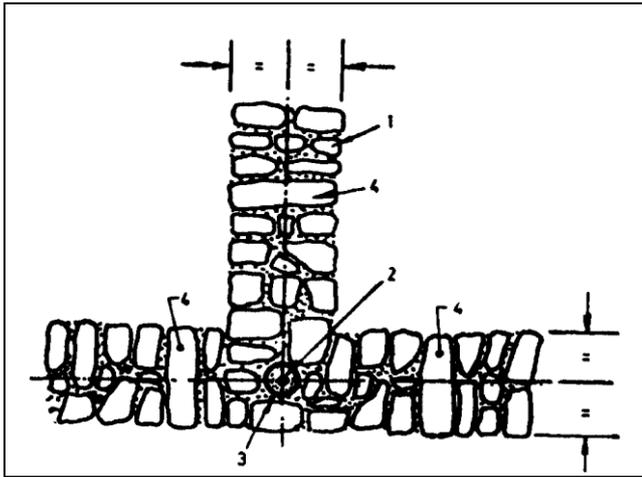
2) Strengthening through Reinforcement around Opening

In the following fundamental techniques we use the wire to provide the covering area of the window opening and that mesh of gauge 10 with 8 wire in the vertical direction at spacing 25mm in a belt of 200mm or a mesh of gauge 13 with wire @25mm in a belt width of 250mm which may be used.



3) By Installing Vertical Steel bar in the Stone Masonry

When we providing vertical bar in the stone masonry, first note that use a casing pipe is recommended around which masonry build to height of 600mm. The pipe will be remove after filling the cavity through M15 grade of concrete, we can use self-compacting concrete in the cavity filling for the structure fundamental the self-compacting concrete give the better result to the stone masonry section.

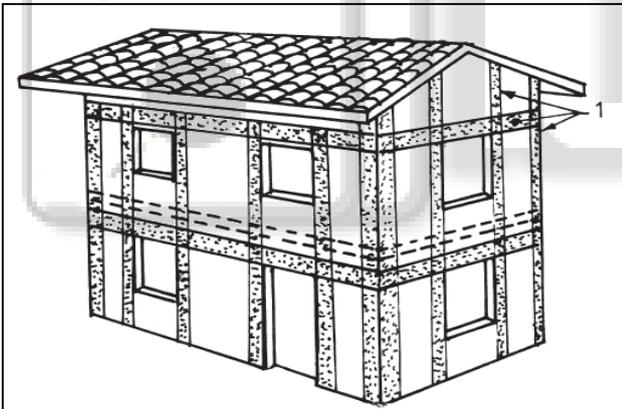


1-Stone wall 2-Vertical steel wall 3-casing pipe 4- through stone or bonding element

Typical construction detail for installing vertical steel bar in the random rubble stone masonry

4) Through Providing Seismic Belt

One of the most common and effective method of retrofitting is providing the seismic belt to the section to providing the extra strength to building. That seismic belt is provided just above the lintel or window or door opening, below the roof level. That seismic belt provided all around the surface wall. Seismic belt is not required at the plinth level, unless the plinth height is more than 900mm. These seismic belt provide extra strength to the section.



G. Equipment and Software for Analysis the Retrofitted Structure

In the present time there are various software are present in the market for seismic analysis of structure and a basic equipment which is use for seismic analysis are point out as below.

1) Equipment for Seismic Analysis

Shaking table test (1D and 3D present in local market)

2) Software for Seismic Analysis

ETAAB, SAP2000, ANSYS for better result. Staad pro also good software for seismic analysis but retrofitted structure cannot be analysis by this software.

II. LITERATURE SURVEY

1) Luca martellato et al reviewed on, "Review of seismic retrofitting strategies for residential building in an international context". In the following review paper he

focused on seismic retrofitting, seismic evaluation, upgrading strategies, seismic vulnerability, international code, URM building. In the following study is belonging to improve the durability of existing housing in the Groningen area. He focused on weak aspect target of retrofitting such as overall strength, overall stiffness, mortar joint, and irregularity in plan and evaluation, wall dia for connection, deterioration of wall, diameter for deficiencies and foundation deficiency. He takes different countries seismic retrofitting guideline such as Europe, Italy, U.S.A. and New Zeland. He discussed processes for improvement of seismic building performance by reduction of element mass, local modification of component increasing building strength ductility and reduction of irregularity in plan and evaluation. He discussed various retrofitting techniques and at least he concluded that a series of parameter with lead to most technically reliable approach structural efficiency, aesthetically, scalability, repeatability, economically suitable for technical reliable.

2) Ratnesh kumar et al reviewed on, "Review of retrofitting technique for masonry in filled RC frame building". In the following paper he focused on retrofitting strategies, retrofitting techniques and their use. He discussed various strategies of retrofitting and retrofitting techniques such as additional of shear wall additional of bracing, FRP wrapping to strengthen exiting beam and column, steel jacketing of exiting column, RC jacketing of exiting beam and column and bonding FRP to URM infill. At least he concluded that the combination of some retrofitting technique we can improve the performance of building structure.

3) Subhashini S. Ramteke et al worked on, "pushover analysis and seismic retrofitting using shear wall and bracing system of frame structure". In the following paper he focused on a nonlinear static push over analysis, a shear wall, bracing system, RC building, and seismic retrofitting. He performed push over analysis using the displacement coefficient method. In the following analysis he worked on the basis of IS Code 1893:2002 and zone 5th for analysis. He performs pushover analysis with the help of SAP 2000. He used various bracing system and shear wall at different location. At least he concluded that the floor displacement is maximum for without retrofitting building frame as compare to retrofitted building frame and we can provide X bracing system to structure to resist the seismic force without compromising with strength and stiffness of the structure.

4) M.A. El Gawady et al worked o, "retrofitting of masonry wall using shotcrete". In the paper he retrofitted on a single side using a 40mm thick layer of shotcrete and the last one retrofitted on the double side using 20mm thick layer. In the following paper he takes two sample single side and double side sample. Provide shotcrete and concluded that retrofitting on double side had more ductile failure and energy dissipation.

5) Krirtika Gupta et al reviewed on, "review paper on seismic retrofitting of structure". In the following review paper he focused on shear wall, reinforced concrete, seismic retrofitting, retrofitting bonding and beam

column, Staddpro 8i. After various literature review paper he concluded that the following method are carried out by most of researchers which are concrete jacketing of column of ground floor, brick masonry fill in the ground floor, x and v bracing, shear wall, FRP of beams and column.

- 6) M. El Gawady et al reviewed on, "A review of conventional seismic retrofitting techniques for URM". In the following paper he focused on the retrofitting, rehabilitation, repair and seismic fundamentals. This paper reviews of retrofitting procedures, advantage, disadvantage, limitation, effect of each retrofitting techniques. he discuss various method such as Ferro cements, reinforced plaster, shotcrete, grout and epoxy injection, external reinforcement, post tensioning and centre care technique. Which is used in the retrofitting? At least he summarised all fundamental knowledge in to a table and explain all advantage and disadvantage of techniques.
- 7) S.I. Khan et al worked on, "Seismic retrofitting of RC building by using different bracing system". In the following paper he focused on a nonlinear static push over analysis using the displacement coefficient method as described in FEMA 365. He took a hostel building which is four story rectangular structures. He used SAP2000 for analysis he concluded that X and V bracing are good for retrofitting for better result.
- 8) Edvardo N.B.S. Juilo et al worked on "reinforced concrete jacketing interface influence on cyclic loading response". In the following paper he focused on cyclic loading, interface, jacketing, seismic response, strengthening and surface preparation. He took total seven models for analysis with different structural aspect. After providing the jacket to all the structure he declared all type of model in to a table form. After technical analysis and result he concluded that for a bending moment/ shear force ratio lower than 1.0m (3.281ft), debonding of jacketing may occur without treatment of the interface surface.
- 9) G.E. Thermou et al worked on, "Seismic retrofit schemes for RC structure and local global consequences". In the following paper he concentrated on retrofit, repair/strengthening, rehabilitation, structural intervention, seismic upgrading he discuss various method of retrofitting such as injection of cracks, shotcrete, steel plant adhesion, steel jacketing, external bonded FRPs, RC jacketing, addition of walls, steel bracing, base isolation. He also discusses the effect of retrofit on global response.
- 10) E.S. Juilio et al worked on, "structural rehabilitation of columns with reinforced concrete jacketing". In the following paper he focused on RC jacketing, strengthening method structural rehabilitation, structural repair, retrofitting techniques. He discuss why, when and how to rehabilitate a structure and also discuss repairing techniques of RC elements. He discusses RC jacketing for the failure structure which is damage through earthquakes and other causes. In the conclusion he focused on repair method of original column, interface surface preparation, use of bonding agent, application of steel connection, temporary shoring, anchoring of the

added longitudinal reinforcement, continuity between floor of the added longitudinal reinforcement, position of the steel bars of the longitudinal reinforcement, added stirrups and added concrete.

- 11) Sagar R. Padol et al reviewed on, "Review paper on seismic response on multi-storeyed RCC building with mass irregularity". In the following paper he focused on seismic analysis, time history analysis, base shear, story shear and story displacement. He used IS code 1893 in the following review paper, he focused on effect of mass irregularity on the different floor in RCC building with time history and analysis is done by using ETAB software. In the following paper he focused on following methodology. Extensive literature survey referring books, selection of types of structure modelling of selecting structure, analytical work to carried out, interpretation of result and conclusion. He worked on RCC building using time history method with the help of ETAB software. At least he concluded that effect of earth quake can be minimising by shear wall, base isolation.

III. FUTURE SCOPE

After studying various technical papers on retrofitting techniques we can say the retrofitting is a wider area for researchers for their research. Mostly topics for research are Bracing system, steel jacketing, RC jacketing, shear wall, shotcrete, epoxy injection, pure masonry structural analysis through shaking table test, RC frame analysis through SAP2000, ETAB, seismic analysis through ANSYS are various research area for upcoming researchers. If u wants better result in the term of analysis you can use shaking table test for a scale model. This method provides you a better result.

IV. CONCLUSION

In the following review paper we can concluded after studying all fundamentals about the seismic retrofitting we can say that retrofitting play an important role in the construction area. Retrofitting provide extra strength to the failure building structure and make the structure earthquake resist and more capable for lateral loading.

Retrofitting in pure masonry structure give adequate strength under seismic loading.

- Retrofitting in pure masonry structure increase life of the structure.
- It's provided the stiffness to the structure under seismic loading.
- Retrofitting is the cheapest way to improve the building structural quality
- It is a less time taken process compare to other fundamental techniques.

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