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Retrofitting Methods for Unreinforced Masonry Structure

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Abstract—*More than 70% of residential unreinforced masonry structures (URM) are included to estimate the masonry structures. Even in the moderate earthquakes, the structures are highly prone to earthquake shaking which leads to undesirable many losses. Due to the failure of masonry structures many losses are given rise. Because of low resistance to seismic action the unreinforced masonry walls have very stiff and brittle elements. To overcome this problem, we need to do retrofitting of the unreinforced masonry structures (URM). In this paper, we are going to study about the different method of retrofitting and its advantages and disadvantages. Most seismic retrofitting for unreinforced masonry structures (URM) makes efficiency and economy problems. These methods are preferred for retrofitting due to its low cost and not required for high working capacity. In this paper, we also present an overview of project of the ongoing comprehensive test program at Drexel University whose aim is to investigate on the use of Fibre-glass Reinforced Plastic (FRP) laminates for the strengthening and repair of solid unreinforced masonry walls.*

Keywords*: Unreinforced masonry structure, Retrofitting, Earthquake, Behaviour, Safety, fibre glass reinforced plastic, strength.*

1. INTRODUCTION

Stone masonry is a traditional form of the structure which has been used for the hundreds of years in the regions where the stone is easily available. Due to the external effects, there are formed losses in masonry structures. Many losses are caused due to the failure of the unreinforced masonry buildings. The main aim of the retrofitting is to provide the resistance to the damaged construction instatedof repairing thus it becomes reliable under coming earthquake occurrences.

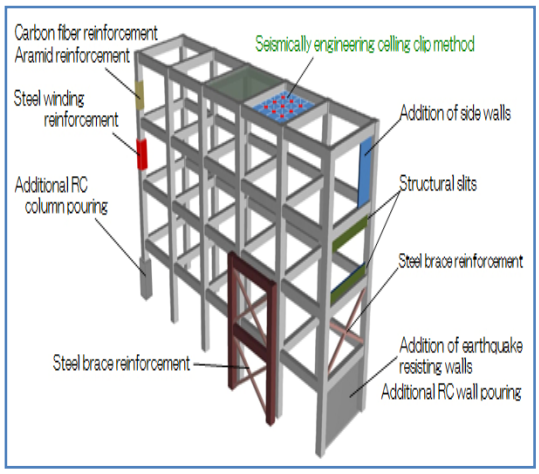

Figure 1. Seismic Retrofitting

Figure 2. Retrofitting Work

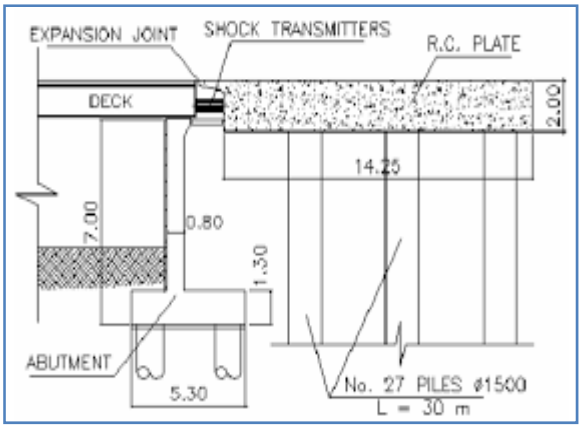

Figure 3. Seismic Retrofitting of Bridges

In the world, a large portion of the residential masonry buildings comes under the masonry structures. The retrofitting techniques are very important for the masonry structures.

2. RETROFITTING METHODS FOR UNREINFORCED MASONRY STRUCTURES

2.1. Surface Treatment

Surface treatment technique is a most common technique which is developed significantly through the experience. This method is used to strengthen the unreinforced masonry wall which is old with architectural worth. The strengthening is done by using shotcrete, bamboo and fiber reinforced polymer. The surface treatment technique improves the seismic capacity of the unreinforced masonry building significantly. It has high strength and there is no need for the special workers.

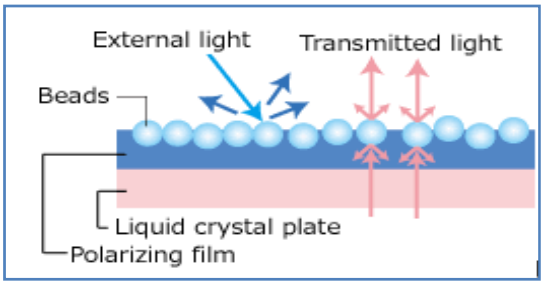

Figure 4. Surface Treatment Technique

2.2. Grouting

For the strengthening of the masonry structures Grout injection technique is one of the most widely used in the unreinforced masonry buildings. Mostly, it is used for the re-establishing the bond in the cracks of the wall. The advantage of this method is that it does not change the architectural aspect of the building and the main disadvantage is that it has high shrinkage and segregation.

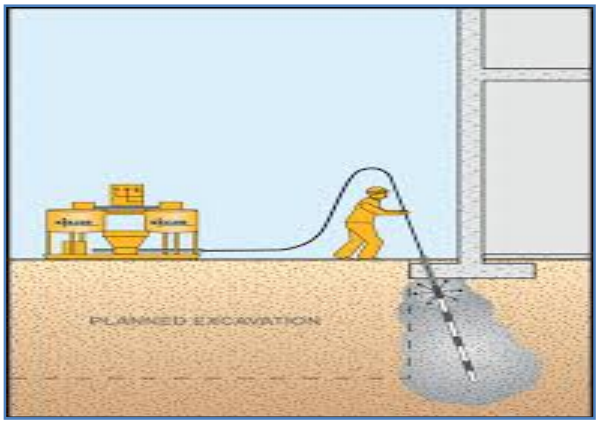

Figure 5. Grouting

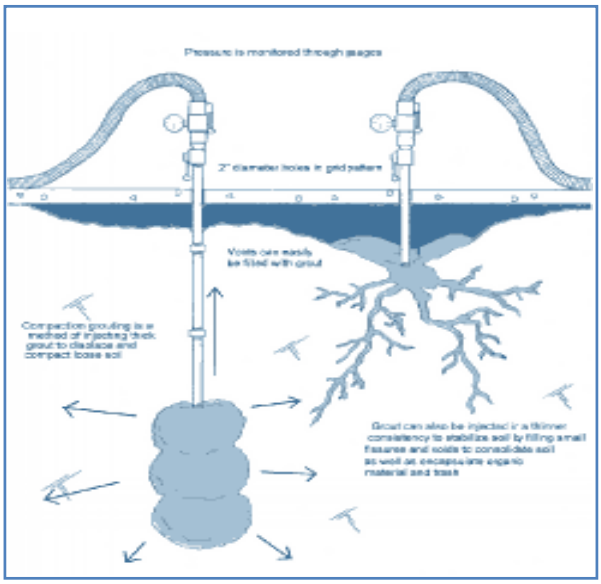

Figure 6. Pressure Grouting

2.3. Post-Tensioning

By introducing prestressed reinforcement along the vertical member, the post tensioning technique is used to improve the strength and ductility of the vertical members of the lateral load resisting frame of the structure. This technique reduces the cracking deflection caused under the service loads. It does not change the appearance of the historical structures. The method is costly and causes shrinkage of masonry. Disadvantage of this method is that the external straps and connections may affect the architectural aspect of the structures and being a external element it is exposed to corrosion.

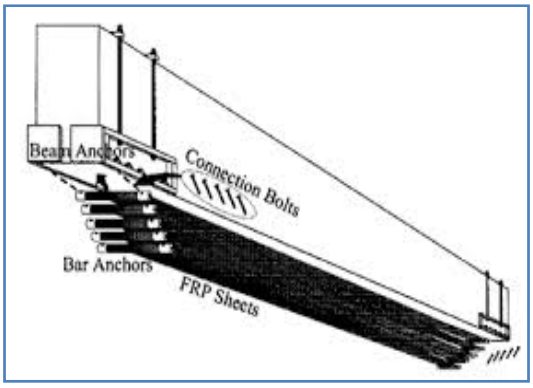

Figure7. Post Tensioning Technique

Figure 8. Unbonded Post Tensioned Slab

2.4. Jacketing

Various attempts are made to tie the masonry walls together by using reinforced concrete elements built within and adjoining the existing structure. In China, the brick walls are strengthened by casting the reinforced concrete columns which are firmly connected to the walls.

3. ADVANTAGES

Following are the advantages of the strengthening method for unreinforced masonry structure:

1. High deformation.
2. High strength.
3. Low cost.
4. Increase ductility.
5. Improve resistance.
6. Reduces cracking.
7. Easy application.
8. Increase flexural strength.
9. Does not change the architectural aspect.
10. High stability.
11. High ultimate load.
12. No corrosion.

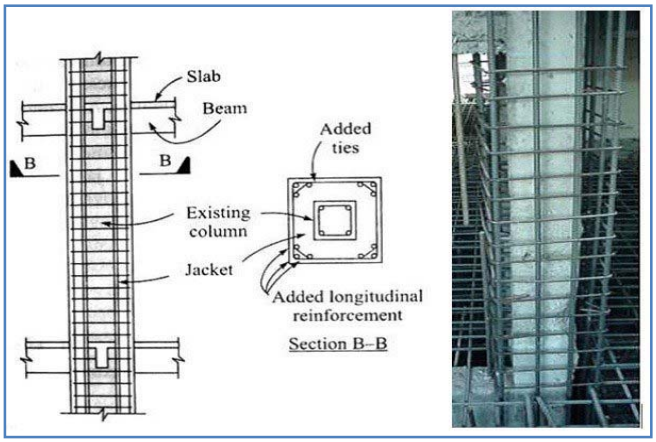

Figure 9.Column Jacketing

4. DISADVANTAGES

Following are the disadvantages of the strengthening method for unreinforced masonry structure:

1. Expensive.
2. High mass.
3. High disturbance.
4. High electric conductivity.
5. High segredation.
6. High shrinkage.
7. Irreversible action.
8. Labour requirement.
9. Anchorage problem.
10. High technology required.

5. EFFECT OF SEISMIC RETROFITTING TECHNIQUE

Following figure shows the effect of retrofitting in different seismic environment.

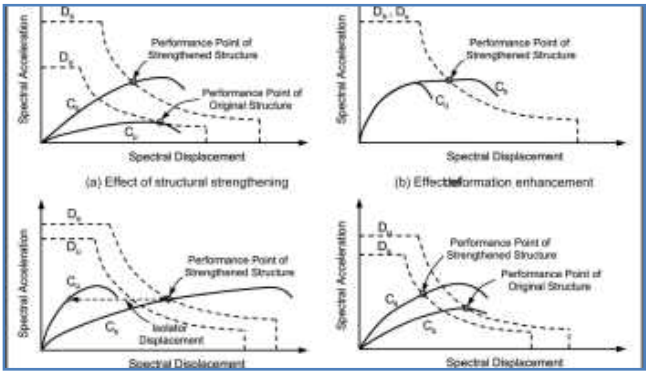

Fig 10: Effect of Seismic Retrofitting Technique

6. TEST PROGRAM AT DREXEL UNIVERSITY

The main aim of the ongoing comprehensive test program at Drexel University is to investigate on the use of Fiber-Glass Reinforced Plastic (FRP) composite laminates for the strengthening and repair of the small-scale solid unreinforced concrete masonry shear walls.

The test program is divided into the three phases:

1. Aimed to study the effect of strengthening in improving the strength of small scale masonry shear walls, it is completed in 1993.
2. It involves the testing of the small 1/3 scale for shear walls which is subjected to the lateral horizontal monotonic and cyclic static load as well as the vertical compressive axial load.
3. It covers the strengthening of shear walls.

The complex matrix of the test shear walls for the phase two and phase three is shown in Table No.1.

Table No. 1: Test Matrix for Drexel Test Program

Wall Specimen	Block Strength MPa (psi)	Masonry Strength MPa (psi)	Aspect Ratio	Axial Stress MPa (psi)	Type of Lateral Load	Remarks
SWA1 SWA2 SWA3 SWA4 SWA5	28 (4000) 28 (4000) 10.5 (1500) 28 (4000) 28 (4000)	20 (2800) 20 (2800) 9.5 (1350) 20 (2800) 20 (2800)	0.5 1 1 1 0.5	1.4 (200) 0.7 (100) 0.7 (100) 0.7 (100) 1.4 (200)	M M M C C	These walls will be repaired after their failure
SWB1 SWB2 SWB3 SWB4 SWB5	28 (4000) 28 (4000) 10.5 (1500) 28 (4000) 28 (4000)	20 (2800) 20 (2800) 9.5 (1350) 20 (2800) 20 (2800)	0.5 1 1 1 0.5	1.4 (200) 0.7 (100) 0.7 (100) 0.7 (100) 1.4 (200)	M M M C C	These walls will be strengthened before testing

7. CONCLUSION

From the above discussion, we concluded that the seismic resistant of the damaged building is increase by using seismic retrofitting instead of repairing building. So, the building is safe for seismic shocks.

1.Surface treatment method are using the strength of unreinforced masonry walls.

2. Advantages of this method no need for special workers.

3. Epoxy injection method, advantage of this method not changing the architectural aspects of the building and disadvantage of the method has been high shrinkage and segregation.

4. Post tensioning technique is used to improve the strength and ductility of the vertical members of the lateral load resisting frame of the structure. This method is costly and causes shrinkage of masonry.

5. Jacketing the brick walls are strengthened by casting the reinforced concrete columns which are firmly connected to wall.

6. Test program at Drexel university improving the strength of small scale masonry shear wall.

8. ACKNOWLEDGMENT

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