Research Article *ISSN: 2319-507X*
Mohammad Javed, IJPRET, 2012; Volume 1(3): 36-47 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

DISASTER MITIGATION THROUGH CONSERVATION OF HERITAGE BUILDINGS IN PESHAWAR CITY

HAFIZ ASFANDYAR AHMED[1], KHAN SHAHZADA[2], BASHIR ALAM[2], MOHAMMAD JAVED[2], SYED MOHAMMAD ALI[2], SYED MUSTAFA ALI SHAH[1]

1. Graduate student, Department of Civil Engineering, University of Engineering and Technology Peshawar, Pakistan.
2. Faculty member, Department of Civil Engineering, University of Engineering and Technology Peshawar, Pakistan.

Accepted Date:

23/10/2012

Publish Date:

01/11/2012

Keywords

Sethi House,

Conservation

Building Code of Pakistan

Corresponding Author

Mr. Mohammad Javed

Faculty member, Department of Civil Engineering, University of Engineering & Technology, Pakistan.

Abstract

This paper presents the disaster mitigation through conservation of historical building of Sethi House Peshawar. The house is approximately two centuries old brick masonry structure with internal woodwork of great heritage importance. Historical (Monumental) buildings are unique as their evaluation or analysis cannot be done by any standard structural scheme: this makes it difficult to evaluate their reliability and performance. Because in addition to many uncertainties that are common in all existing buildings and particular to old buildings, no statistical data is available on the behavior of similar buildings. The rehabilitation of these structures requires that the repairing material and method of construction should be similar to the original material and method of construction, in order to conserve the aesthetic value of the structure. The scope of work included, repair and rehabilitation of cracked arches of basement hall and Level 1 & 2 rooms, roof treatment and perforated bricks masonry parapet walls using hydrated lime, brick surkhi and jute as mortar.

The application of the above mentioned materials improved both the strengthening capacity of the building as well as the aesthetic appearance and has ultimately decreased the associated seismic risk. Because there was no observed damages due to bed-joint sliding, rocking and/or toe crushing. There was no in-plane and out of plane cracking observed in the Structure. Also the wall density ratio for all the floors was found to be greater than the minimum requirements of Building Codes of Pakistan SP 2007.

INTRODUCTION

The historic city of Peshawar was once surrounded by high walls. Today, very few remains of walls are left, but the houses and beautiful Havelis (made by merchants) have an essence of days gone by. Most of the houses are made of bricks with wooden structures for protection against earthquakes (i.e. confined masonry was made by using wood as confinement material). Many of them have beautifully carved wooden doors and latticed wooden balconies. Areas such as Sethi Mohallah still contain many fine examples of the old structure of Peshawar. Sethi Mohallah is an area in the heart of old Peshawar City. The Mohallah contains seven houses (including Sethi house a cultural heritage) built by the Sethis. These houses are a mixture of architecture and the art of Gandhara and in central Asia, are rare heads- piece of architecture located in the old city. The Sethis were basically traders with their large businesses in China, India, Afghanistan, Iran and Central Asia, with the centers of commerce in Mazar sharif, in Tashkent, Bukhara, Samarqand and other cities in the Asia region.

The Sethi house mainly consists of two potions i.e. Male and Female Portion. After their decline in business they sold the female portion of the house. With the passage of time different people used to live in that part and using it by their own choice. Thus the aesthetic and decoration of the house was getting deteriorated day by day. The male portion is still with the Sethi family. However the female portion is purchased by the government of KPK to make the necessary rehabilitations and secures the precious building of Peshawar. The portion is consisting of four levels i.e. a basement and three levels above the ground.

The historical buildings are of great importance. Many international organizations are working on their disaster mitigation with the objective of ensuring life safety, reducing economic disruption, decreasing vulnerability/increasing capacity and decreasing level of conflict. The World Bank uses a broad definition of physical cultural resources: "Movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance." The World Bank also recognizes that "physical cultural resources are important as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices."[3] At the international level, the 2005 Kyoto Declaration on the Protection of Cultural Properties, Historic Areas, and Their Settings from Loss in Disasters established a framework for work on the preservation of cultural properties and historic areas. The United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), and the International Council of Monuments and Sites (ICOMOS) are very much involved for implementation of the Kyoto Declaration. These agencies are often active in post-disaster situations and may provide technical assistance to public officials and owners of heritage assets.[3]

In May 2012, Italy was being hit by an earthquake which caused the collapse of many old buildings that has completed their design life safely. The main reason of this damage could be the cracking and/or failure of those structures before earthquake. As a result the capacity of the structures might have decreased against the loads generated by seismic forces. The collapse of any structure may be due to peak horizontal ground acceleration, duration and time period earthquake, and distance of the area from epicenter, resistance of the structure to gravity and seismic loads or combination of the above mentioned reasons. Generally a building has been subjected to pre cracking before subjected to the seismic load. This pre cracking of the structure causes the structure to become weak and less resistant to seismic loading. This can cause damage to any type of structure. Thus to mitigate the disaster risk, it will be a good practice to conserve/retrofit the old buildings that have been subjected to cracking and/or other types of failures. Several techniques has been proposed by researchers for retrofitting/conservation of buildings throughout the world.[4,5] In order to investigate the seismic capacity of existing buildings in Pakistan several experimental studies has been carried out in the Department of Civil Engineering University of Engineering and Technology Peshawar Pakistan.[6,7,8]

For this reason, the concerned building i.e. Sethi house which survived many earthquakes, was checked for all types of failures with a great deal of accuracy and the building was completely evaluated. The type of failure was categorized on the degree and type of damage. All the failures were studied separately and thus addressed accordingly. The types of failures that were observed in sethi house are described below.

CONDITION SURVEY OF THE BUILDING

Cracks in Arches

Different types of cracks were noticed in arches.

1. ***Shearl Craks***

These Cracks start from the corner of wall and continues through the arches diagonally. These cracks were due to the shear failure of the arches. As shown in figure 1.

2. ***Cracks due to Differential Settlement***

These cracks were observed mainly in the arches of basement and Level I. These cracks were perpendicular to the arch axis. These were straight, erected and passed throughout the arch width as shown in Figure 2. These cracks were formed due to the differential settlement of the foundation beneath.

Cracks in Walls

Walls were also cracked at many places. The main reason of cracks in walls was that the control joints were not provided at desired location. e.g. at the side of window and door opening, at change in wall thicknesses etc. Three main types of cracks were observed in the walls.

1. *Shear Cracks*

These cracks were observed in some walls but they were not so deep and wide. These cracks were diagonal and were observed in some partition walls of the building. (Figure 3)

2. *Cracks due to Openings*

These cracks were found between the openings (i.e. part of wall between door and window). One part of the wall expanded more than the other, thus causing cracks in walls. If joints are not provided at openings, cracking may occur there, as shown in Figure 4.

Figure 1 Shear Cracks in Arches

3. Cracks at Corners

Corners are the points where two or more walls meet. These cracks were commonly found in exterior corners of the building. Cracks at corners form due to excessive brick expansion. These cracks were continuing through full height of wall as shown in Figure 5.

Figure 2 Cracks due to Differential Settlement of Arches

Figure 3 Shear Cracks in Walls

Separation of North Eastern part of House

The North Eastern part of the house was getting separated from the main building and the orthogonal walls of both the blocks got a part of approximately 5-7 inches. That might be due to the excessive settlement of foundation at the North Eastern side of the house. The part was totally isolated from the main building as shown in figure 6.

Deterioration of Roof Slab

The top floor slab was used in very rough manner by the residents in different time intervals. Two major damages that were made are:

i) Too much mud was laid on the slab. Approximately 24-28 inches of mud layer was laid in different times. Due to this, dead load on slab increased very much, thus causing the serviceability problems i.e. Deflection, Cracking etc.

ii) Different users tried to use the roof slab for different purposes according to their requirements. Thus they converted the open area into a kitchen or Toilet, and making its drainage accordingly. As the original drainage system was got hidden under that mud layers it caused the leakage of water into the slab and wood works, which made lot of damage to the nominal strength of the affected materials.

Deterioration of DecorationWork

The outclass decoration work was also deteriorated with the passage of time. The beautiful decoration work was made on Slabs, walls, doors, windows etc. An outclass piece of wooden work was done but it was also under the process of deterioration. The glass work made on slabs was also broken at some corners of the slabs. The walls were totally out of order. The glass work in windows was also broken at many places. Doors due to very rough use gave a bad effect. Approximately all the wood work lost its shine and gloss. However, it remained safe from termite attack in many places except very few. So the beautiful and historical decoration work which is seen very less now a days was losing its original meaning and getting deteriorated day by day. (Figure 7)

Deterioration of Parapet Wall

The parapet wall was also damaged and large numbers of cracks were found to appear in it. It has started losing its stability.

Figure 4 Cracks due to Openings in Walls

Figure 5. Cracks at Corners

Figure 6 Separation of North Eastern part of House

Figure 7 Deterioration of Decoration Work

REHABILITATION SCHEME

The rehabilitation of the building was done by categorizing the problems and then finding the core reasons of the these problems. Because without knowing the reason of a problem it can not be addressed properly. So all the types of failure mentioned from A to F were studied separately and addressed accordingly. Brief description is given below.

The repair of all types of cracks in masonry was done by: sealing of cracked area in the walls, arches etc., pressure grouting of the cracked parts of walls, arches etc. through injection tubes.

Rehabilitation of Arches

The arches were cracked mainly due to differential settlement of the footing beneath them. The cracks were filled out by the mortar made by mixing lime and Surkhi and/or jute where necessary. The grout injection method was used for filling the cracks because of its good efficiency in filling up the joints. (Figure 8)

Rehabilitation of walls

The rehabilitation of walls was also done in a manner that all the cracks were first filled by grout made of Lime and surkhi. The injection method of grout was used as the cracks were very narrow. So to fill all the cracks properly, the grout injection method was suited. After that the plaster was made by using gifto gym fine plaster. (Figure 9)

Rehabilitation of North eastern Part of House:

The North Eastern part of the house was totally isolated from the main building. Following steps were taken for the rehabilitation, re strengthening and rejoining of that part with the main building. (Figure 10)

i. First of all the portion was supported by bracing it laterally with the steel beams in arrangement shown in figure below. Because the portion was getting tilted continuously with the passage of time. So the purpose was to stop that separation.

ii. The upper part of this portion was grabbed by the steel cables, wound on all sides of the portion and supported with the main structure.

iii. The separation which was up to 5-6 inches between both the parts was filled by the mortar made of lime, jute, cement and sand. Attention was given to make the grout stronger.

Figure 8. Rehabilitation of Arches

Figure 9. Rehabilitation Of Walls

Figure 10 Rehabilitation of North Eastern Part of House

Roof Slab treatment

The extra layer of mud which was laid after many years was first removed so that the extra dead load can be removed from the slab. The natural drainage of the slab was restored because it was causing damage to the structure. Polyethylene sheet was laid to resist water penetration, then jumbolon was placed for the proper heat insulation over which 2 to 3 inch layer of mud was placed and the original bricks were placed over it in the same old fashion and joined with the material similar to that originally used before. The roof slab of North Eastern part was also rehabilitated by first removing of the extra mud layers to reduce the dead load. Then the deflected slab was lifted by means of external prestressing of the slab as shown in figure 11.

Figure 11 Roof Slab

Repair Of Decoration Work:

The repair of decoration work was a difficult task. Because the decoration work was centuries old and was done by different artists coming from central Asian countries. This task includes:

i. Repair of ceiling Decoration Work.

ii. Repair of Windows & Doors Decoration Work.

iii. Repair of Walls Decoration. (Figure 12)

Figure 12 Repair of Decoration Work

Rehabilitation of Parapet Wall

Parapet wall was also rehabilitated in the same manner by filling all the cracks in it and providing it the extra stability where required. (Figure 13)

Figure 13 Rehabilitation of Parapet Wall

TESTING OF MATERIALS USED FOR REHABILITATION

The material used in the rehabilitation work was White Lime, Qasoori Fine Lime Powder, Sun Jute, Qasoori Kankar Lime, Termite Repellent, Crush Burn Brick, Gifto Gym Fine plaster, Polyethylene Sheet, Jumbolon, Bricks and Glass.

i. Mortar Compressive Strength

According to ASTM C1019 Samples of 2in. cube were made by the mortar that was used for the filling of cracks and also used for the brickwork. The specimens were tested in the lab and their compressive strength was found to be 1500 psi.

ii. Brick Compressive Strength

Samples of the old bricks that were originally used in the construction of house were taken and tested for compressive loads. Their strength was 3150 psi.

iii. Masonry Compressive Strength

By knowing the compressive strength of masonry unit, the masonry compressive strength was determined by using table 9.4 of Building Codes of Pakistan. The masonry compressive strength was found to be 1400 psi.

REDUCTION OF SEISMIC RISK

Wall Density Ratio

The wall density ratio of the house was within the range that is specified by the Codes. The seismic zone was determined as per described in Table 2.2 of BCP. Peshawar is under zone 2B. Tests on soil determine that it is soil type S_D as per table 4.1 of BCP. The seismic coefficient for respective soil type was determined from table 5.16 of Building Codes of Pakistan.

Following formula was used to calculate the wall density ratio:

Wall density ratio = Total wall area/Total floor area *100

The Wall density ratio was measured for all the floors and the value for all the levels are given below for both the directions I.e. N-S & E-W.

Basement: 10 and 9.4

Level I: 9.5 and 8.7

Level II: 9.3 and 8.5

Level III: 7.5 and 6.2

Thus the wall density ratio was found to be in the safe limit as per Building Codes of Pakistan.

In Plane Cracks Prevention

The walls were observed very carefully to determine the effects of seismic load on the structure. Surprisingly there were no signs of in plane cracking of walls were observed. As many of the walls were cracked due to different reasons discussed earlier, still the cracked walls were safe against the seismic load, so by filling up these cracks with the conventional material of the building the seismic risk will reduce very much.

Out of Plane Failure Prevention:

This type of failure is very dangerous and causes harm to the life so it must be prevented. It normally includes the overturning of walls. The Sethi house was observed to be safe against out of plane failure of walls.

Apart from the above mentioned 3 main factors described to show the safety against the seismic risk, some other types of failure were also checked. So that any of them may or may not occur in the house due to seismic loading. This includes failure of walls due to Bed joint Sliding, Rocking, Toe Crushing, and Diagonal Tensioning. But there was no sign of any type of above mentioned failures in the structure. And it was found safe to use the conventional material for the rehabilitation purposes.

CONCLUSION

Disaster Mitigation involves the complete evaluation of a structure. Because the quality of rehabilitation and repair work will depend on how accurate the problem is addressed. In the building of Sethi House it was observed that the confined masonry gave very good results. And after hundreds of years there was no crack due to gravity or seismic loading. The house was also safe against seismic loading. Because many large Earth quakes came in last 100 years but there was no damage observed due to seismic loading. So a conclusion was made that in rehabilitation, same material would be used to give the aesthetic look. Also the seismic risk was reduced by filling all the cracks, repairing of the damaged parts i.e. parapet walls and by stabilizing the North eastern part of the house.

ACKNOWLEDGMENT

We are very much thankful to Directorate of Archaeology and Museum, Govt. of KPK Peshawar, for their help and support in our research work.

REFERENCES

1. M. Ayub, Qaiser Ali, Khan Shehzada, Amjad Naseer and M. Shoaib, Conservation of Islamia college building in Pakistan, 2nd International conference on Rehabilitation and Maitenance in Civil Engg, 2012.

2. S. Gunay, Spatial Information system for Conservation of Historical Buildings, poster session 2 – Archaeology & Conservation-GIS.

3. Chapter 11, Planning Reconstruction, A handbook for reconstruction after natural disaster, 2010.

4. Manzouri, T., Shing, P. B., Amadei, B., Schuller, M., and Atkinson, R. 1995. Repair and Retrofit of Unreinforced Masonry Walls: Experimental Evaluation and Finite Element Analysis. Rep. No. CU/SR-95/2, Dept. of Civil, Environmental and Architectural Engineering, Univ. of Colorado, Boulder, Colo.

5. Sheppard P, and Tercelj SP, The Effect of Repair and Strengthening Methods for Masonry Walls, 7 WCEE, Istanbul, WCEE, Istanbul.1980: 255-262

6. Ashraf M., Development of Cost-effective and Efficient Retrofitting Technique for Masonry Buildings in Pakistan, Ongoing PhD Research at Department of Civil Engineering, University of Engineering and Technology Peshawar, Pakistan. 2010.

7. Javed. M, Seismic Risk Assessment of Un-reinforced Brick Masonry Buildings System of Northern Pakistan, Ph.D Thesis, Department of Civil Engineering, UET, Peshawar. 2009.

8. Shahzada K., Seismic Risk Assessment of Buildings in Pakistan (Case Study Abboatabad City), PhD thesis, Department of Civil Engineering, UET, Peshawar. 2011.