PERFORATING THE MASONRY WALLS IN REHABILITATION OF MASONRY BUILDINGS USING CENTER CORE METHOD

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ABSTRACT

Center core method is advanced method for rehabilitation of masonry buildings. First, vertical holes with given intervals are perforated on the walls to the footing and then reinforcing steel bars are embedded in the holes and cement grout will be injected finally to create bond strength between wall and bars. This is a nondestructive method which could be achieved without evacuation of the buildings. In Iran there are many unreinforced masonry and historical buildings which need to be retrofitted against seismic hazard, therefore this method could be utilized widely. Since the beginning of building rehabilitation in Iran, consulting engineers have sometimes offered this method but in spite of economical benefits it has never been used because of feasibility uncertainties and the difference between masonry walls in Iran and other countries. The main contribution of this study is to investigate drilling techniques and equipments and design of drilling bit used in this method without deterioration and cracking of the wall. To achieve this aim four holes (7m high) were perforated in an unreinforced masonry building by 10 different drilling bits and 2 different drilling, then the method effective and nondestructive technique and equipment were adopted by observing and controlling the cracks and drilling bit penetration along the wall. It was found that the combination of coring and non-coring drilling bit caused no cracks on the finishing and the least deviation along the boreholes and the most effective drilling was obtained by minimizing the bit pressure, balancing its rotation velocity and minimizing air pressure for removing cuttings. The hydraulic drilling machine was selected due to its lightness compared to other machines.

Keywords: Center Core, Masonry Building, Historical Building, Rehabilitation

1. INTRODUCTION

Earthquake is the most sever threat to Iranian historical monuments and buildings. Most of such buildings are located on the seismic belt such as Bam fort which was completely destroyed in 2003 Bam earthquake. Expert’s investigations have shown that at least it would take 12 years and 120 million dollars to remove it. However since the typical methods of rehabilitation lead to
considerable changes in architectural and general shape of buildings, they are not recommended for ancient and historical buildings. Consequently a rehabilitation plan which doesn’t affect the general shape of the buildings would be of most application. One of the disadvantages of typical rehabilitation methods is the necessity to evacuate the residents during rehabilitation process. This would slow down this process especially in urban buildings. Therefore a new approach through which rehabilitation may be achieved without evacuating the residents is necessary. According to domestic statistics, most of the existing buildings in Iran are masonry. Similarly, more than 90% of school buildings have masonry structures (24411 ones). So, rehabilitation methods which are consistent with masonry buildings are inevitable.

Center core method is a method of masonry unreinforced buildings rehabilitation through which a borehole is perforated from the finishing to the base and after embedding steel bars, is filled with cement grout. Grout penetration through the wall creates a homogenous and uniform system. Being non-destructive is the most important advantage of this method which makes it possible for the users to go on during rehabilitation process. [1,2,3] It is also useful for historical buildings because of being non-destructive. In recent years, some methods of rehabilitation based on perforating and embedding bars or pretensioning have been proposed, although difficulties and uncertainties of perforating operation have made them infeasible. The aim of this method is to find special techniques of perforating holes without destroying or cracking the masonry walls. To achieve this, four holes (7 meters high) were perforated in an unreinforced masonry building by 10 different drilling bits and 2 different drilling machines. Selecting the new bits will be based on the destruction type and its rotation.

In general, drilling system includes drilling machine, rod, stabilizer and bit. Drilling machine produces the energy for rotation of the bit. Rod transmits the rotating force to the stabilizer and bit. Stabilizer reduces the lateral movements and bit shaking along the drilling path. Bit is the most important member in this system. It penetrates through the depth and determines the drilling path. Figure 1 shows the components of the drilling system.

![Figure 1. Components of drilling system](image)

2. THE BUILDING UNDER STUDY

Since the proposed drilling system should be generalized for most of masonry buildings, the building must be studied under the most critical conditions. These conditions are as follows:

- Very weak mortar: the mortar used for sticking the bricks is composed of lime mud. It has the lowest shear strength among other mortars. So many problems during the drilling operation will appear as damages and cracks on the wall.
- Strong bricks: the bricks used for this building have a good quality so that their combination with the weak mortar produces a non uniform system which is not strong enough to resist dispersion.
- Loose finishing of the wall: finishing is performed on a thick layer of lime mud which has the least cohesion with the finishing.
- Wall thickness is at most 30 centimetres: typical brickling for structural walls are usually about 30 cm thick.
- The building has at least 2 stories: since the number of stories in masonry buildings is
limited to 2 in Iran, the drilling method should feasible at highest elevation.
- As the height of drilling increases, the bit deviation increases. The maximum allowable deviation in center core method in technical documents is 1.6 cm per 10 m drilling.
- The selected school is located in 11th Tehran call “Do Shahid” (Fig 2). It is a 3 story building aged about 50 years. The second story has a light ceiling with wood trusses. The floors are archaic diaphragms. Finishing composed of straw mud and the mortar between bricks is lime mud. The walls which surround the stairs are 30 cm thick (Fig3). As the roof is not strong enough to resist the equipment loads, it was decided to perform the plan on the second story floor (Fig 2, 3).

Figure 2. View of “Do Shahid” school

Figure 3. Mortar, brick and finishing of masonry walls

3. PERFORATING BOREHOLES

It was decided to perforate 4 boreholes (7 m high) in each borehole, drilling technique, equipments and bits were changed according to the damage and bit rotation to obtain the most suitable ones. The results are as following:
### Table-I. Results of boreholes

<table>
<thead>
<tr>
<th>Bore</th>
<th>Stage</th>
<th>Bit Kind</th>
<th>Diameter</th>
<th>Stabilizer</th>
<th>Drilling machine</th>
<th>The reason of changing the drilling bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>I</td>
<td>Diamond Non-coring</td>
<td>60</td>
<td>-</td>
<td>SGZ</td>
<td>Bit deviation due to large contact surface with cement</td>
</tr>
<tr>
<td>A</td>
<td>II</td>
<td>Diamond coring</td>
<td>76</td>
<td>✓</td>
<td>SGZ</td>
<td>This bit was used first for initial orientation and then bits with larger diameters were used.</td>
</tr>
<tr>
<td>A</td>
<td>III</td>
<td>TC Coring</td>
<td>93</td>
<td>✓</td>
<td>SGZ</td>
<td>Cracks 50 cm over the bit were observed. In the weakest part of the wall due to high air pressure and lack of mortar in the gap between two bricks, the air flow pushes the finishing and damages it such that cuttings were dispersed.</td>
</tr>
<tr>
<td>A</td>
<td>IV</td>
<td>TC Non-coring</td>
<td>93</td>
<td>✓</td>
<td>SGZ</td>
<td>Cracks appear due to weak bricking</td>
</tr>
<tr>
<td>A</td>
<td>V</td>
<td>TC Non-coring</td>
<td>66</td>
<td>-</td>
<td>SGZ</td>
<td>Finishing remains unhurt</td>
</tr>
<tr>
<td>B</td>
<td>I</td>
<td>TC Non-coring</td>
<td>76</td>
<td>-</td>
<td>SGZ</td>
<td>At -1.6 m elevation, finishing collapses due to small number of bricking, incorrect bricking and existence of voids that causes to exist of air and deterioration of finishing.</td>
</tr>
<tr>
<td>B</td>
<td>II</td>
<td>TC Non-coring</td>
<td>76</td>
<td>-</td>
<td>SGZ</td>
<td>At 2.05m elevation from the ground, finishing cracks due to low quality of bricks. (placement of the fragment of gypsum instead of brick)</td>
</tr>
<tr>
<td>C</td>
<td>I</td>
<td>TC Non-coring</td>
<td>76</td>
<td>✓</td>
<td>SGZ</td>
<td>At elevation -1m outcrop of brick due to contact of bit with half melt brick</td>
</tr>
<tr>
<td>C</td>
<td>II</td>
<td>TC Non-coring</td>
<td>76</td>
<td>✓</td>
<td>SGZ</td>
<td>At elevation -1.6 m outcrop of brick while the bit locates at -1.8 m. At elevation -1.8 m outcrop of brick while the bit locates at -2 m. In both of cases huge aggregation of aggregates observed that indicates, escape of aggregates is impossible.</td>
</tr>
<tr>
<td>C</td>
<td>III</td>
<td>TC Non-coring</td>
<td>76</td>
<td>✓</td>
<td>SGZ</td>
<td>At elevation -5 m cracks in finishing which causes the dust to go out of finishing</td>
</tr>
<tr>
<td>D</td>
<td>I</td>
<td>TC Coring &amp; Non-Coring</td>
<td>76</td>
<td>✓</td>
<td>hydraulic</td>
<td>Cracks in finishing – the edges of stabilizer get involved with the structure and large pieces of cuttings are produced.</td>
</tr>
<tr>
<td>D</td>
<td>I</td>
<td>TC Coring &amp; Non-Coring</td>
<td>76</td>
<td>-</td>
<td>hydraulic</td>
<td>As the bit penetrated through the wall, the system was opened to observe the performance. The cuttings were of dust size. Some cuttings were larger due to rotation the bit at the bottom part of the brick. No cracks happen in this stage.</td>
</tr>
</tbody>
</table>

Different parts of the drilling system and equipments are shown in the following figures.
Figure 4. Hydraulic drilling machine

Figure 5. SGZ-ID drilling machine

Figure 6. Air Compressor

Figure 7. Equipment of drilling

Figure 8. Bit used in bore C

Figure 9. Bit used in bore A stage V

Figure 10. View of bit and stabilizer (bore D stage I)
4. CONCLUSION

The main purpose of this study is to investigate the feasibility of perforating boreholes masonry walls according to Iranian construction type without damaging the finishing. To do this, 4 boreholes (7 m high) were perforated in a masonry 3 story building aged 50. The school had the most critical conditions regarding the mortar, height, finishing. Ten bits, two drilling machines and different drilling techniques were tested. At each stage of drilling, new bits were used according to the damages and cracks. The results were:

1- Rate of penetration with non-coring bits is high. However, these bits are not as precise as coring bits. In spite of high precision coring bits are not so fast due to several pull out of the bits for emptying the cores. Also equal diameter of the bit and the hole increases the temperature of the holes and cracks the finishing.

2- If non-coring bits are used, as the size of TCs increases, the deviation of the hole will increase. Larger cuttings lead to asymmetric engagement of TC and cuttings and make a permanent change in the axis of rotation.

3- Stabilizers are used to increase the accuracy and decrease the deviation in drilling path. Although, it must be noted that they increase air pressure on the surface of the holes and crack the finishing.

4- The most important result of this study is the combination of coring and non-coring bits. To stabilize the drilling path and decrease the deviation, a guide is installed on the TC-Non-Coring bit instead of stabilizers. On the whole, this drilling bit contains a TC Coring bit which cores from the masonry walls. This bit penetrates through the wall as a guide and prevents the bit from deviation and out of axis rotation. In a short distance from the TC-Coring bit, TC Non-Coring bit is installed. This bit crushes the cores and makes the cuttings ready for being removed from the hole as dust. The smaller the cuttings are, the lower air pressure is needed to remove them.
This newly invented bit could use for mining, oil and other excavations as well.

TC bits minimize the costs of the project.

The height of the coring past of the bit was considered to be one centimetre, so the cuttings crush by Non-Coring bit. Passes it by easily during the drilling operation. When the drilling area is not uniform (the ground for instance), the coring part must be higher. In such cases, we can reach the desired height by making small holes on the face of the bit.

If the drilling area is tough and rigid, drilling should be more careful. So it is recommended to use diamond coring instead.

Hydraulic drilling machines have a better performance compared to SGZ Rotary machine because they are larger.

The drilling technique must be such that. The bit pressure would be minimum.

The brick type, mortar and the quality of bricking are determining factors for setting the drilling speed and air pressure. It seems that we can’t have exact qualities of such factors now; however, an expert drilling operator may achieve this.

During drilling operation, the speed and air pressure could be set by observing the size of cuttings. An expert can minimize the size of cuttings by paying attention to it. Also the cuttings could determine the brick, mortar characteristics.

5. REFERENCES

