

REINFORCEMENT OF MASONRY WALLS

FIELD

[0001] The present disclosure generally relates to a method of reinforcing a masonry wall.

BACKGROUND

[0002] Stones, bricks and cementitious blocks are some of the most used construction materials. They are commonly used to create structural, boundary and partition walls (or "masonry walls") in residential, commercial, and industrial buildings. The service life of these structures varies from 50 to 120 years depending on the local regulations and requirements. During their designed life, these structures are expected to undergo changes of usage, be subjected to increased loadings, experience possible damage from impact loads or may need to be modified to fit into the changes in the building codes. As a result, the need to enhance these walls' structural integrity and ability to withstand loadings which the wall was not originally intended for becomes crucial (e.g., out-of-plane moment and in-plane shear). The key challenges are to be able to carry out the enhancement of the masonry walls seamlessly, with minimum disruption to the occupant's daily routine, preserving their appearance to the extent practicable, while providing increased design structural soundness when completed.

SUMMARY

[0003] In one aspect, a method of reinforcing a masonry wall generally comprises removing existing cement mortar in the masonry wall at a plurality of discrete locations to a depth from an exposed surface of the wall to form first receptacles. First reinforcing elements configured to carry a curable polymer are inserted into the first receptacles. Existing cement mortar in the masonry wall is removed to a depth to form a second receptacle that extends at least from one of the first receptacles to another of the first receptacles and intersects both the one first receptacle and the other first receptacle. A second reinforcing element configured to carry a curable polymer is placed into the second receptacle, and the first reinforcing element is bonded to the second reinforcing element.

[0004] Other objects and features of the present disclosure will be in part apparent and in part pointed out herein.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0005] FIG. 1 is a front view of a masonry wall with reinforcement members installed;
- [0006] FIG. 2 is a front view of a first reinforcing element;
- [0007] FIG. 3 is a perspective view of a first reinforcing element;
- [0008] FIG. 4 is a front view of a masonry wall formed with first receptacles for receiving the first reinforcing element;
- [0009] FIG. 5 is an enlarged, schematic and fragmentary perspective of a first reinforcing element in a portion of a masonry wall;
- [0010] FIG. 6 is a schematic perspective view of a portion of a masonry wall with the first reinforcing elements installed and one of the second reinforcing elements exploded above its installed position;
- [0011] FIG. 7 is a front view of a masonry wall similar to Fig. 4, but showing installation of fiber anchors;
- [0012] FIG. 8 is a fragmentary, exploded perspective of a fiber anchor, reinforcing panel and a masonry wall on which the fiber anchor and reinforcing panel are to be installed;
- [0013] FIG. 9 is the perspective of Fig. 8, but showing the fiber anchor and reinforcing sheet installed on the masonry wall;
- [0014] FIG. 10 is a highly schematic side view of the arrangement shown in Fig. 8; and
- [0015] FIG. 11 is a schematic vertical section of the installed fiber anchor and reinforcing panel on the masonry wall.
- [0016] Corresponding reference characters indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION

[0017] Referring to Fig. 1, a masonry wall (illustrated as brick wall 100) has been reinforced according to the method described below. The brick wall 100 includes bricks 105 separated from one another by mortar, including horizontally extending mortar beds above and below the bricks and vertically extending mortar perpends between adjacent bricks. The illustrated brick wall 100 is reinforced using a first reinforcing member and a second reinforcing member, as will be described. Preferably, the first and second reinforcing members are a fiber reinforced polymer. However, reinforcement members which are not fiber reinforced polymer, or which are some mixture of fiber reinforced polymer and some other kind of reinforcement are also contemplated.

[0018] As seen in Figs. 2 and 3, the first reinforcing element is generally shown as an I-shaped insert 110. A plurality of I-shaped inserts 110 are placed into discrete locations 112 in the brick wall 100. As seen in Fig. 4, first receptacles 115 are formed at the discrete locations 112. The first receptacles 115 are formed by removing the cement mortar from when the brick wall 100 was initially built. The first receptacles 115 may, as illustrated, be formed by removing the cement mortar at a plurality of perpends 114 of the cement mortar and removing adjacent portions of a bed 116 of the cement mortar at the top of the perpend and at the bottom of the perpend. Moreover, parts of the bricks adjacent the top and bottom of the perpend are also removed. The first receptacle 115, by removing the cement mortar, is generally I-shaped, but may have other shapes within the scope of the present invention. Similarly, the insert 110 may be other than I-shaped. Preferably, the I-shaped insert 110 is smaller than, but generally conforms to the first receptacle 115 when inserted into the first receptacle. More specifically, the first receptacle 115 is formed to generally conform to the shape of the pre-made insert 110. In the illustrated embodiment the portions of the bricks 105 that are removed receive the upper and lower flanges of the I-shaped insert 110 so that the top and bottom surfaces of the flanges are flush with or project only slightly beyond the respective upper and lower surfaces of the bricks. In one non-limiting embodiment, the insert 110 is about 40 mm in depth, 76 mm in height and 76 mm in width. The thickness of the flanges and web of the I-shaped insert 110 are each about 6.4 mm. It will be understood that the size and shape of the insert 110, is determined by the geometry of the masonry in which the insert will be used.

[0019] Referring to Fig. 5, the I-shaped insert 110 fits into the first receptacle 115. The I-shaped insert 110 may comprise a fibrous material that may be impregnated with a curable polymer (e.g., resin, epoxy). The curable polymer secures the I-shaped insert 110 in the first receptacle 115 and, along with the I-shaped insert 110, strengthens and stabilizes the bricks 105 with respect to each other.

[0020] The second reinforcing element, as seen in Fig. 6, is generally shown as a thin, flat strip 120 of fibrous material capable of retaining liquid polymer in the material. The strip 120 can be formed as one piece or formed as a laminate. A plurality of second receptacles 125 (see, Fig. 5) are formed by removing the existing cement mortar from the plurality of mortar beds 116 extending between two first receptacles 115. The strip 120 placed into the second receptacles 125 is sized smaller than the second receptacle, but preferably conforms to the second receptacle. More specifically, the second receptacle 125 is formed so that it is similar in size and shape to the pre-made strip 120. The strip spans between the I-shaped inserts 110 in the second receptacle 125. The strip 120 can be impregnated with a curable polymer. The curable polymer in the strip 120 bonds the strip to the adjacent bricks, as well as to the I-shaped insert 110. The curing of the curable polymer and bonding between the I-shaped insert 110, the strip 120, and the bricks 105 facilitates the reinforcement of the brick wall 100.

[0021] Referring to Fig. 7, the brick wall 100 may be further reinforced using fiber anchors 130. The fiber anchors 130 are formed by a collection of fibers that are bundled together in a bottom portion of the anchor and loose in a top portion of the anchor. As seen in Figs. 8-11, the fiber anchor 130 is installed into a brick 105 of the brick wall 100. The bundled bottom portion of the fiber anchor 130 is inserted into the brick wall 100 and the protruding fibers are spread over the face of the brick wall and secured to the face of the brick wall using the curable polymer. The bundled bottom portion of the fiber anchor 130 may extend through one of the strips 120 and be bonded to the strip. As shown in Fig. 7, each bundled bottom portion of the fiber anchor is inserted in the bed 116 of the mortar at the top or bottom of one of the perpend that does not receive one of the I-shaped inserts 110. The locations of the fiber anchors 130 is alternated from the bottom of the perpendicular to the top of the perpendicular as you go up on the wall. Of course, other arrangements and locations of the fiber anchors 130 can be used without departing from the scope of the present invention. The top portion of the fiber anchor 130 can have its loose fibers spread over the faces of the bricks 105 and attached by application of a suitable

curable polymer such as epoxy. However as better illustrated in Figs. 8-11, a panel 132 of fibrous material carrying a curable polymer can be placed over the face of the brick wall 100. Often multiple panels (not shown) would be used over the full length of the brick wall being repaired. The panel 132 can carry a curable polymer that can harden to provide strength for the brick wall 100, but which also adheres the panel to the wall. The fiber anchors 130 can be received through the panel 132 into the brick wall 100, and the loose fibers of the top portion of the fiber anchor spread over an exterior face of the panel. It will be understood that in this way the fiber anchor 130 can structurally connect the panel 132 to the first and second reinforcing members 110, 112 so that these fiber reinforced polymer components can cooperate to strengthen the brick wall 100. In one non-limiting embodiment, the bundled bottom portion of the fiber anchor 130 is received to a depth of about 50 mm into the brick wall. The loose fibers at the top end of the fiber anchor 130 can be spread in a circle having a radius of about 50 mm. Other dimensions are possible and will usually be determined based on the size and shape of the wall as well as the loads encountered by the wall.

[0022] Having described the structure of one embodiment of a reinforced brick wall 130, a method for reinforcing the brick wall will now be described. A first step of the method of reinforcing a brick wall 100 comprises removing the existing cement mortar at the plurality of discrete locations to form the first receptacles 115 (Fig. 4). In addition, portions of the bricks 105 at the tops and bottoms of the perpend are also removed. The excavation of the mortar and brick portions is to a depth less than the full depth of the bricks 105 and as shown is less than about one half the depth of the bricks. As shown in Figs. 4 and 6, the locations of the first receptacles 115 (and inserts 110 received in the receptacles) are spaced apart in regular intervals. The first receptacles 115 are formed in all of a group of vertically aligned perpend. To either side of this vertical column of first receptacles 115 and inserts 110, two perpend are skipped and another column of vertically aligned perpend are dug out to form additional receptacles 115 to receive I-shaped inserts 110. Other arrangements and patterns of placement of the receptacles, inserts and strips may be used within the scope of the present invention.

[0023] Having formed the first receptacles 115, the fibrous I-shaped inserts 110 are inserted into the first receptacles 115. The I-shaped insert 110 is configured to carry a curable polymer into the first receptacle 115. In one embodiment, the I-shaped insert 110 is impregnated with the curable polymer prior to the I-shaped insert being inserted into the first receptacle 115.

In another embodiment of the method, the I-shaped insert 110 is impregnated with the curable polymer after the I-shaped insert is inserted in the first receptacle 115. It is also possible to impregnate the I-shaped insert 110 prior to insertion into the first receptacle 115 and subsequently apply additional curable polymer to the insert.

[0024] The existing cement mortar in the brick wall 100 is then removed to form the second receptacles 125. Each second receptacle extends at least from one of the I-shaped inserts 110 to another of the I-shaped inserts and intersecting one of the first receptacles 115 and the other of the first receptacles. As shown in Figs. 1 and 6, the second receptacles 125 extend substantially the full width of the brick wall 100 and intersect numerous locations where the I-shaped inserts 110 would be or are placed. The depth of the excavation to form the second receptacle 125 is less than the full depth of the brick 105, and in the illustrated embodiment is less than half the depth of the brick. As shown, the depth of the second receptacle 125 is about the same as the first receptacle.

[0025] The strip 120 configured to carry a curable polymer is placed into the second receptacle 125. In one embodiment, the strip 120 is impregnated with the curable polymer prior to the strip being inserted into the second receptacle 125. In another embodiment of the method, the strip 120 is impregnated with the curable polymer after the strip is inserted into the second receptacle 125. It is also possible to impregnate the strip 120 prior to insertion into the second receptacle 125 and subsequently to apply additional curable polymer to the strip. In that event, curable polymer may be applied to both the I-shaped inserts 110 and the strips 120 essentially at the same time. The curable polymer cures and bonds the I-shaped insert 110 to the strip 120.

[0026] After the I-shaped inserts 110 and strips 120 have been inserted into the receptacles 115 and 125, the technician inspects the installation to locate any voids in the first and second receptacles. The voids are filled with curable polymer. In one embodiment, the curable polymer is an epoxy which cures to a high compression strength.

[0027] Optionally, the brick wall 100 may be further reinforced by installing fiber anchors 130 into the brick wall and applying a panel 132 of fiber reinforced polymer to the face of the wall. Locations for the fiber anchors 130 can be selected, such as describe previously herein, and holes formed in the brick wall to receive the individual anchors. Corresponding holes can be formed in the panel(s) 132 so that the fiber anchors 130 can be received through the panel and into the brick wall 100. It is also possible that the fiber anchors could be inserted prior

to application of the panel, but this requires control of the loose fibers at the top end of the fiber anchor. The fiber anchors 130 can be further secured into place by the curing of the curable polymer applied to the anchors before and/or after insertion of the anchors into the brick wall. Application of the panel(s) 132 can be carried out by impregnating the panel with curable polymer and applying the panel to the brick wall 100. The curable polymer may provide sufficient adhesion to retain the panel 132 on the brick wall 100 prior to curing. However, if necessary a tack coat could be applied to the brick wall 100 prior to application of the panel 132 to assure proper adherence of the panel to the wall. Additional curable polymer can be applied to the panel 132 after it is adhered to the brick wall 100. If a tack coat is used, then potentially no curable polymer could be applied to the panel 132 until after application of the panel to the brick wall 100.

[0028] Once the fiber anchors 130 and panel(s) 132 are applied to the brick wall 100 a more intimate and more-efficient force transferring connection of the panels to the fiber anchors can be achieved. The loose fibers of the fiber anchors 130 are spread generally in a circle from the fiber anchor over the face of the panel 132. The splayed fibers of the fiber anchor 130 can be secured to the panel simply by the curable polymer present in the panel. However, additional curable polymer (e.g., an epoxy) can be applied over the splayed fibers to further secure the fiber anchors 130 to the panels.

[0029] It will be apparent that modifications and variations are possible without departing from the scope of the invention defined in the appended claims. As various changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

WHAT IS CLAIMED IS:

1. A method of reinforcing a masonry wall, the method comprising:

removing existing cement mortar in the masonry wall at a plurality of discrete locations to a depth from an exposed surface of the wall to form first receptacles;

inserting first reinforcing elements configured to carry a curable polymer into the first receptacles;

removing existing cement mortar in the masonry wall to a depth to form a second receptacle, the second receptacle extending at least from one of the first receptacles to another of the first receptacles and intersecting both the one first receptacle and the other first receptacle;

placing a second reinforcing element configured to carry a curable polymer into the second receptacle; and

bonding the first reinforcing element to the second reinforcing element.

2. The method of reinforcing a masonry wall as set forth in claim 1 wherein the first reinforcing elements each comprise an insert having an I-shaped cross section.

3. The method of reinforcing a masonry wall as set forth in claim 2 wherein the insert is made of a fibrous material.

4. The method of reinforcing a masonry wall as set forth in claim 1 further comprising impregnating the first reinforcing element with the curable polymer prior to said step of placing the first reinforcing element in the first receptacle.

5. The method of reinforcing a masonry wall as set forth in claim 1 further comprising impregnating the first reinforcing element with the curable polymer after said step of placing the first reinforcing element in the first receptacle.

6. The method of reinforcing a masonry wall as set forth in claim 1 further comprising impregnating the second reinforcing element with the curable polymer prior to said step of placing the second reinforcing element in the second receptacle.

7. The method of reinforcing a masonry wall as set forth in claim 1 further comprising impregnating the second reinforcing element with the curable polymer after said step of placing the second reinforcing element in the second receptacle.

8. The method of reinforcing a masonry wall as set forth in claim 1 wherein the second reinforcing element comprises a strip of material.

9. The method of reinforcing a masonry wall as set forth in claim 8 wherein the strip of material forming the second reinforcing element is a fibrous material.

10. The method of reinforcing a masonry wall as set forth in claim 1 wherein the step of removing the existing cement mortar in the masonry wall at a plurality of discrete locations comprises at least at some of the discrete locations removing all of the mortar of perpend to a predetermined depth of the cement mortar and removing adjacent portions of a bed of the cement mortar at a top of the perpend and at a bottom of the perpend to form the first receptacle.

11. The method of reinforcing a masonry wall as set forth in claim 10 wherein the first receptacle is I-shaped and at least some of the first reinforcing members are I-shaped.

12. The method of reinforcing a masonry wall as set forth in claim 10 wherein the step of removing the existing cement mortar in the masonry wall to form the second receptacle comprises removing cement mortar from the bed of cement mortar.

13. The method of reinforcing a masonry wall as set forth in claim 1 wherein the step of bonding the first reinforcing element to the second reinforcing element comprises applying a curable polymer to the first and second reinforcing elements as they reside in the first and second receptacles.

14. The method of reinforcing a masonry wall as set forth in claim 1 further comprising identifying any voids in the first and second receptacles after placement of the first and second reinforcing members in the first and second receptacles, and filling the identified voids with a curable polymer.

15. The method of reinforcing a masonry wall as set forth in claim 1 further comprising installing fiber anchors into the masonry wall.

16. The method of reinforcing a masonry wall as set forth in claim 15 wherein installing fiber anchors comprises for each fiber anchor, inserting a bundle of fibers into the masonry wall, spreading fibers from the fiber anchor over a face of the masonry wall and securing the spread fibers to the face of the masonry wall using a curable polymer.

17. The method of reinforcing a masonry wall as set forth in claim 16 wherein the bundle of each fiber anchor is bonded to the second reinforcing member.

18. The method of reinforcing a masonry wall as set forth in claim 15 wherein installing fiber anchors comprises installing fiber anchors into the cement mortar at intersections of perpend of cement board with beds of cement mortar.

19. The method of reinforcing a masonry wall as set forth in claim 15 further comprising applying a panel of fibrous material over the masonry wall.

20. The method of reinforcing a masonry wall as set forth in claim 19 wherein the step of installing fiber anchors into the masonry wall includes receiving the anchors through the panel.

21. The method of reinforcing a masonry wall as set forth in claim 20 further comprising spreading fibers from the fiber anchor over a face of the masonry wall and securing the spread fibers to an exterior face of the panel using a curable polymer.