MASONRY INSIGHTS

Reinforcing Existing Masonry For New Lateral Loads - Part II

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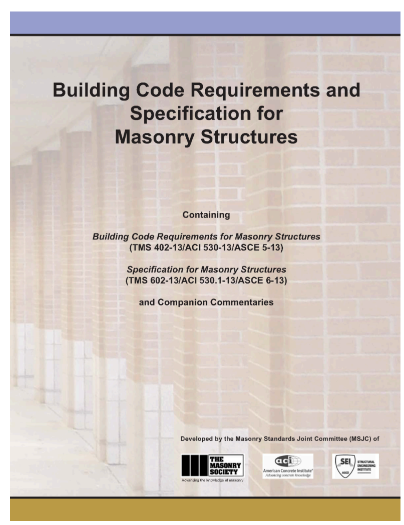
This Masonry Insights series explores reinforcing existing masonry shear walls for new lateral loads from an engineering design perspective. Part I of this series released previously focused on technical approaches to increasing in-plane shear capacity and flexural strength capacity in existing masonry walls. This article, Part 2 of the series, will focus on code requirements, foundation design considerations of sliding and overturning resistance, and external reinforcement options when increasing shear load demand onto existing walls.

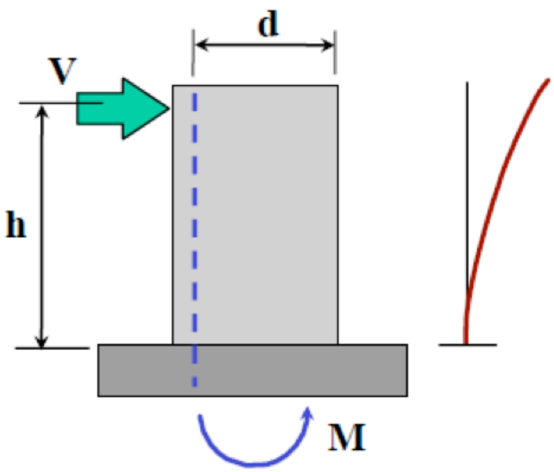
Masonry Shear Walls

Code Requirements



Masonry shear walls must resist lateral loads due to wind or seismic events based on geographic building location per the applicable building code. Depending on the magnitude of the load, shear walls may or may not require reinforcing to provide adequate lateral resistance. However, building codes may have minimum reinforcing requirements. For example, when the building is located in an area of low seismicity, minimum vertical and horizontal wall reinforcement may still be required even if the shear wall is classified and designed as unreinforced. Areas of higher seismicity will require even more minimum reinforcement depending on the shear wall classification as laid out in TMS 402-13 Chapter 7. For the case of typical running bond masonry, the minimum horizontal reinforcement in some cases can be met with two W1.7 joint reinforcement bars at 16" on center. Other cases require horizontal reinforcing bars of at least 0.2 in^2 at a spacing between 120" and 48" on center. Additionally, per TMS 402-13 Chapter 7, a minimum amount of vertical reinforcement may also be required for specific seismic categories that consist of at least 0.2 in^2 at a spacing between 120" and 48" on center. Field installation of reinforcement for existing masonry retrofit situations will be discussed below.

Overturning and Sliding Resistance



Once there is adequate shear and flexural resistance for the internal shear wall forces, soil bearing capacity and global stability must be reviewed based on standard engineering principles. In an existing shear wall scenario with additional lateral loading applied, the overturning moment (OTM) also increases with three implications. First, sufficient dead load must be present to resist overturning moment and to prevent the shear wall from turning over. When calculating the resisting dead load, building components that can be counted to resist OTM include the weight of the wall itself, tributary roof weight, tributary weight of floors above, the weight of the foundation and the weight of the soil that is above the foundation. Any superimposed dead load (such as due to floor finishes, MEP, etc) is not typically considered as part of the resisting dead load. Second, the maximum bearing pressure under the foundation needs to be compared with the allowable bearing capacity of the soil (typically provided in the geotechnical report). Third, the footing must be checked for potential uplift at any corners. If the soil bearing pressure is exceeded or the footing may see potential uplift, the supporting footing size will need to increase. This requires partial excavation of the footing for access to underpin or enlarge the existing foundation.

If additional overturning resistance is required, dead load can be increased in a variety of ways. Options include attaching to adjacent structural elements, increasing the foundation size to increase the footing weight and capture more soil dead load, or increasing the dead weight of the masonry wall by fully grouting all cores within the shear wall. Unfortunately, all of these options have drawbacks so it is beneficial to review all options. Adjacent masonry walls or columns could provide the necessary dead load as long as a connection between elements can properly transfer the forces. However, the further the elements are apart, the more difficult it can be to transfer the dead load force through the connection. Adding to the foundations will add dead load from both the extra concrete and extra soil. Unfortunately, this will likely require significant excavation work, compaction of the soil, shoring, and replacement of the existing slab and other building elements removed during the work. Fully grouting the wall will provide some extra dead load but in turn may exceed the allowable soil bearing capacity under the foundation. It is possible that a combination of these or other retrofit options may be required to minimize construction cost while fulfilling all structural design requirements.

Finally, a sliding resistance check must also be made. The first check would be to confirm that shear is adequately transferred from the wall to the foundation. If the wall is unreinforced, then confirm that the masonry wall to foundation is adequate in shear friction capacity. If the wall is reinforced, then check that adequate shear reinforcement area is provided and developed into wall and foundation.

Once the shear is transferred to the foundation, confirm that the shear can adequately transfer from the bottom of foundation to the supporting soil. Based on the friction coefficient between the foundation and the soil, adequate weight from all building dead load tributary to the shear wall must be present to prevent sliding. The imposed lateral shear force must be less than the frictional resistance at the base of the footing. If greater sliding resistance is needed, the wall footing size can be increased as discussed above. In addition, a shear key can be provided at the base of the wall footing. However, a shear key can be difficult to install.

Alternative Reinforcement Options

Traditionally, shear wall reinforcement is located inside of the masonry cores, however, there are some external reinforcement options available that could produce more capacity or be more cost effective for building retrofits. Research has been conducted on using fiber reinforcing polymers (FRP) and through-bolted steel plates for strengthening masonry shear walls. Figure 1 shows examples of various exterior reinforcing patterns that have been tested. Care must be taken to fully review the research for each of these options to understand all design implications of these methods. Keep in mind that these options only replace the internal rebar and that all other engineering mechanics, such as overturning, soil bearing pressure, and sliding friction, must still be reviewed.

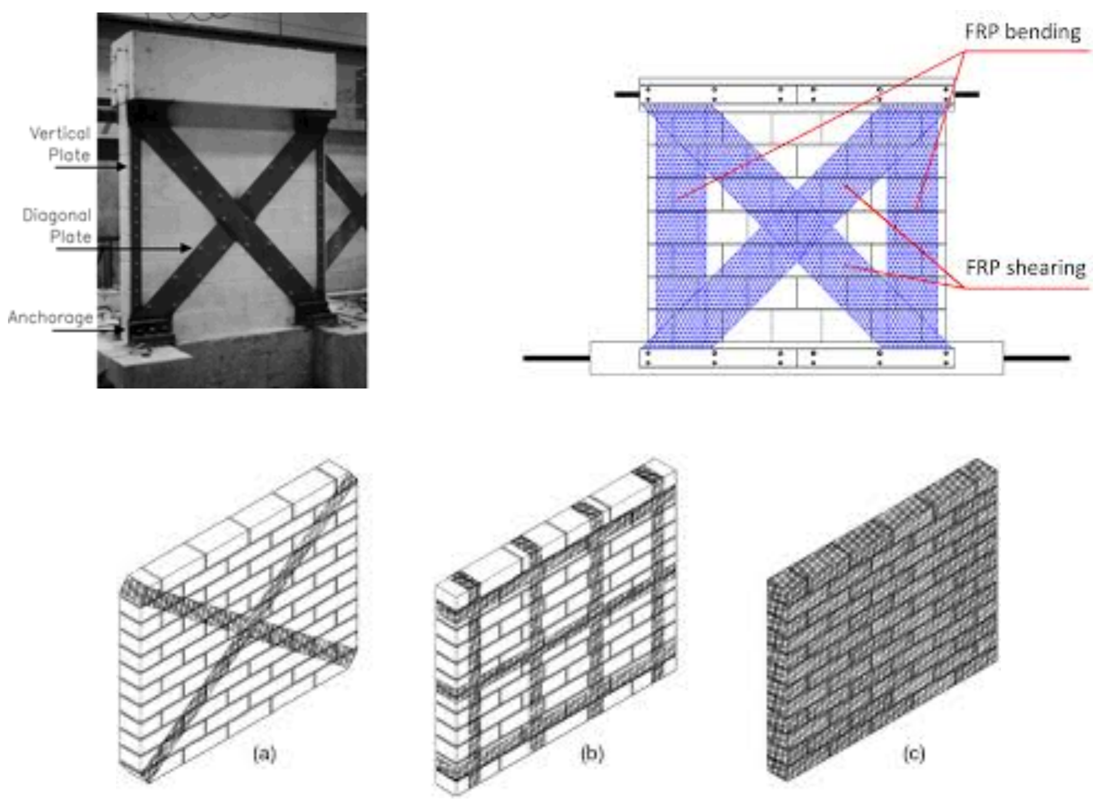


Figure 1: External CMU reinforcement

Concluding Thoughts

Increasing shear wall capacity in existing masonry walls requires several technical considerations - shear capacity, flexural capacity, foundation design, load path, code provisions, etc. However, it is also critical to weigh practical considerations of constructability, retrofit, and cost. It is best to carefully review all options available when determining the most efficient path for increased shear wall capacity of existing structures, as typically the simplest option tends to be the most economical.