team™ TECHNOLOGY BRIEF
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RESOURCE INFORMATION FROM THE INTERNATIONAL MASONRY INSTITUTE

Section 7.3

Stone Veneer Walls Laid in Mortar

Scope

This guide provides general information on the construction of anchored veneer walls built using stone set in mortar. Current masonry standards allow the use of stone but provide no specific guidance to designers and contractors on their design, specifications, or installation of cavity walls. This guide is intended to provide general guidance and options for designers and contractors who want to use stone veneer with a specific emphasis on rubble stone. The recommendations have added application for ashlar stone.

Background

Stone walls, and particularly rubble walls, have been a building system for a millennia. They are composed of irregularly-shaped and sized pieces of stone. Material costs were low if the stone was gathered from a field or stream. Examples still exist world-wide. The walls were built dry-laid or with mud mortar depending on local practice and availability of materials. These walls vary in thickness but are rarely thinner than 16 inches *(Figure 1)*.

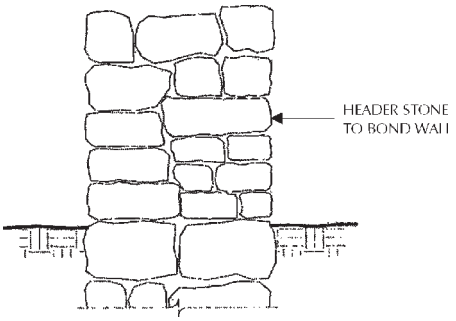

Figure 1 - Stone Wall

Starting around 50 B.C., the Romans chose to add marble veneers to the rubble walls to give them a more lavish appearance. While many of these early examples of veneered rubble walls have been stripped of their marble, the rubble cores remain.

Through the ages, European practice has been to use rubble walls as fortifications, retaining walls, buildings, and as the backing for a more decorative and durable stone exterior. In recent centuries, these walls were constructed with lime mortars; many were also covered in a stucco for improved durability and appearance. Even today, rubble walls represent a significant portion of the residential masonry walls in the world, particularly in southern Asia and eastern Europe.

When the Europeans came to the United States, they brought their masonry building technology. Thus, there are numerous examples of rubble wall construction including houses, forts, churches, universities, retaining walls, fences, and more. While there are many structures with exposed rubble walls, an even greater use of rubble wall construction was for the backing for brick, stone, and stucco.

With the introduction and availability of unit masonry such as clay tile, brick, and concrete masonry, rubble masonry generally declined in use. Often, unit masonry became the backing for a stone exterior. For the past 50 years in the United States, rubble wall construction has been relegated to the homeowner wishing to build a landscape wall and the preservationist restoring a historic structure. However, in recent years there has been a renewed interest in rubble stone along with other stone systems.

There are generally two options for constructing rubble veneer walls. The first is a barrier wall and the second is the cavity system. The *International Building Code* (*IBC*) allows stone veneer to be constructed as a barrier wall (*see IBC 1405.6*). When this veneer is anchored to a masonry back-up, the code requires a 1 inch grouted collar joint. Barrier walls rely on the mass of the masonry to absorb moisture which penetrates the veneer. Cracks create a pathway for water to enter the building.

The second option uses cavity wall technology. This system uses brick, thin stone veneers, and concrete masonry, and has nearly replaced the barrier-type stone walls of past centuries. Cavity walls were developed as a means to minimize water penetration. However, there are no specific standards for using rubble veneer in this application. This guide is intended to provide general guidance and options for designers and contractors who want to use stone veneer in cavity wall construction.

Definitions for Use as a Veneer

Cavity wall - Wall construction with a continuous air space.

Anchored veneer - A non-structural masonry facing anchored to a backing support.

Rubble stone - Rough stone from a quarry or field or stream. The stones are irregular in size and shape. They may be shaped or unshaped and can be laid randomly or in coursing.

Random rubble - Rubble stone constructed without regard to coursing.

Coursed rubble - Rubble stone constructed with approximately level coursing at regular vertical intervals. The courses may be discontinuous.

Ashlar stone - Cut rectangular stone ashlar masonry which can be installed random or coursed.

Masonry Standards

The current standards for anchored veneers in the U.S. are in Chapter 6 of *Building Code Requirements for Masonry Structures (ACI 530/ASCE 5/TMS 402)* by the Masonry Standards Joint Committee (MSJC).

Specifications are in *Specifications for Masonry Structures (ACI 530.1/ASCE 6/TMS 602)*.

The majority of the veneer information provided in the MSJC is directed toward clay brick and concrete masonry veneers.

In concept, cavity walls constructed with anchored veneers include four primary features:

- a drainage path for water that penetrates the veneer, including weep holes
- anchors to laterally support the veneer
- minimum veneer thickness of 2 5/8 inches
- veneer laid in other than a running bond is to have joint reinforcement of at least one wire spaced a maximum of 18 inches vertically

For typical veneers, the drainage path is provided by an opening cavity between the veneer and the backing. In recent years, cavity drainage systems have been developed and are becoming more popular as a means to keep the bottoms of cavities free draining. These systems are commonly composed of synthetic material and are inserted into the base of the cavity to allow free drainage even if mortar droppings spill into the cavity. *(See Figure 2.)*

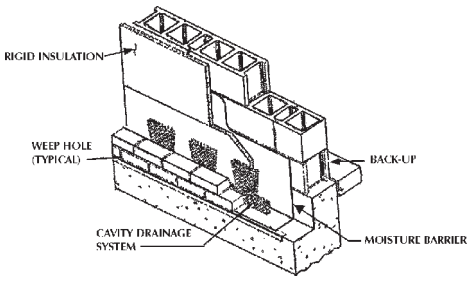

Figure 2 - Cavity Drainage System

The use of stone veneer will generally not result in running bond. Therefore, joint reinforcement is required. However this requirement was developed for unit masonry and is not considered applicable to stone masonry except where required for seismic concerns.

Construction

Drainage Path

To meet the drainage intent of the masonry standards for anchored veneers, the masonry contractor has several options. The stones can be individually cut and shaped to provide an open cavity, or a reliable drainage system can be installed. Cutting stone should be minimized for cost reasons.

The open cavity is primarily suited to masonry units that have a consistent dimension. Even with this control on the thickness, keeping the cavity clear can be a challenge. Thus, there have been cavity drainage systems developed for unit masonry.

There are synthetic drainage systems now available that can be used in conjunction with masonry to provide a drainage path. They are generally a cellular material covered in filter fabric developed for use in geotechnical applications. While these materials were developed to filter out soil particles, they perform also as drainage systems for cavities. Instead of constructing a cavity, a collar joint is created with the drainage material. To avoid clogging the filter, the collar joint should not be grouted. The mortar alone should not clog the filter unless it is overly fluid. (*See Figure 3.*)

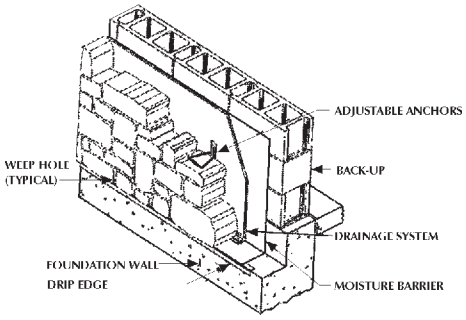

Figure 3 - Stone Veneer

Since the drainage system is in contact with the back-up, a water-proof membrane is recommended to avoid leaks through the back-up. Otherwise, there is a chance of directing cavity moisture into the back-up.

Anchorage

Not all veneer ties and anchors are suited to rubble walls. An acceptable anchorage system must accommodate the irregular sized stones. Various suppliers are marketing systems that are intended to be used with concrete masonry back-up. However, some do not meet the criteria for anchorage in accordance with MSJC in that the ties do not have two legs and the elements allow too much lateral movement. The MSJC restricts movement of the anchor elements

to 1/16 inch. *Figure 4* shows one system which must be modified to meet the MSJC.

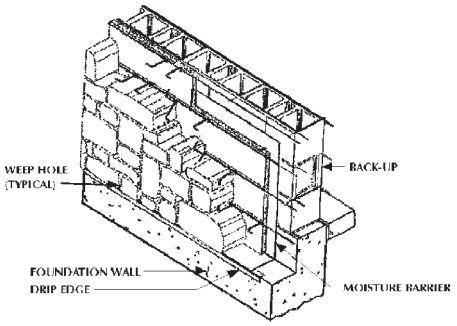

Figure 4 - Stone Veneer

Figure 5 shows two systems that meet the MSJC criteria and provide the necessary flexibility. While the layout of the ties and anchors is irregular to meet the joints of the stones, they must still be installed approximately 16 inches on center horizontally and vertically. The actual limits in accordance with MSJC are 32 inches horizontally and 18 inches vertically, with an upper limit of 2.67 square feet per tie.

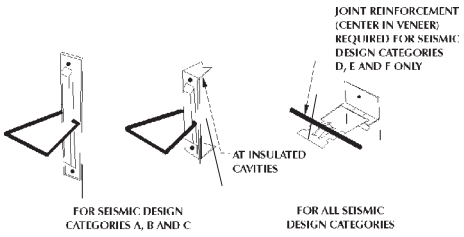

Figure 5 - Stone Veneer Ties and Anchors

Meeting the seismic anchorage provisions requires added modifications. The seismic requirements sometimes require the joint reinforcement to be attached to the veneer ties.

Mortar

Type N mortar is the preferred mortar for stone veneers on modern buildings. ASTM C 270 allows Type S also. For historic structures, masons often use high lime mortars. If portland cement is used in the mix, it should be non-staining cement.

The mortar mix should be placed drier than is normal for clay brick or concrete masonry to avoid settlement of the stone. If needed, wood wedges can be used to hold the stone alignment while the mortar sets. Remove the wedges and repoint the void before the mortar fully cures.

The thickness of the mortar joints is an important factor. Besides being a costly item, the mortar will experience more shrinkage and possible cracking the thicker it is. Also, thicker joints take longer to strengthen during curing. Therefore, mortar joints should be kept to less than 3/4 inch wherever possible. Initial shrinkage of the joints can be minimized by pre-hydrating the mortar.

Stone

Anchored veneer must be at least 2 5/8 inches thick in accordance with MSJC. However, for rubble and ashlar stone, this is too small. Preferably, stone veneer should be 4- to 6- inches thick. This allows for variations in the stone and provides a suitable bedding plane for the anchors. The bedding plane is most important for rubble walls. While ashlar stone tends to be flat, rubble stone can be rounded.

It is preferable to use full thickness stones at anchor locations to ensure full engagement of the anchor. Small stones are common in thick walls as fillers but they are not recommended for use in veneer walls because the thickness of the veneer is decreased locally. This reduces both the wall strength and the surface area for the tie to bond.

In all cases, the stone selected should be clean, hard, durable, and not highly porous. Some pre-wetting the stone is preferable to avoid absorbing the mortar moisture too quickly.

Seismic Provisions

Seismic provisions are continually being revised in the United States as new research and testing are completed. The prescriptive requirements for anchorage and reinforcement of anchored veneer in accordance with the MSJC vary based upon the Seismic Design Category (SDC). SDC is a function of the site soil conditions, the seismic properties of the site represented by ground accelerations, and the use of the specific structure being designed.

For SDC A and B, there are no special requirements.

For SDC C, the veneer is to be isolated so that vertical and lateral seismic forces resisted by the structures are not imparted to the veneer.

For SDC D, the requirements of SDC C apply, plus:

a) Support each story independently
b) reduce the maximum wall area of each anchor by 25 percent, and
c) provide joint reinforcement (single wire) at 18 inches on center vertically.

For SDC E and F, the requirements of SDC D apply, plus:

a) provide vertical expansion joints at all returns and corners, and
b) mechanically attach joint reinforcement with clips or hooks.

The lack of regular coursing in stone veneer walls makes the anchoring particularly challenging to achieve.

Reinforcement

For Seismic Design Categories A, B, and C, no joint reinforcement is needed. Therefore, only veneer anchors are required.

Joint reinforcement is required for SDC D, E, and F. Where it is necessary to install joint reinforcement, it is easier to use a tie which attaches the joint reinforcement to the back-up. This attachment of the anchor to the

reinforcement is required for SDC E and F.

The selection of the individual veneer stones in SDC D, E, and F becomes a factor due to the requirement for joint reinforcement. While the joint reinforcement is more suited to level courses, it can be bent to follow the irregular layout of the joints. *Figures 6 and 7* show examples to achieve the intent of the standards. Where the reinforcement is kinked, it is necessary to add extra anchors. At discontinuous ends, there should be an anchor within 4 inches of the end of the reinforcement.

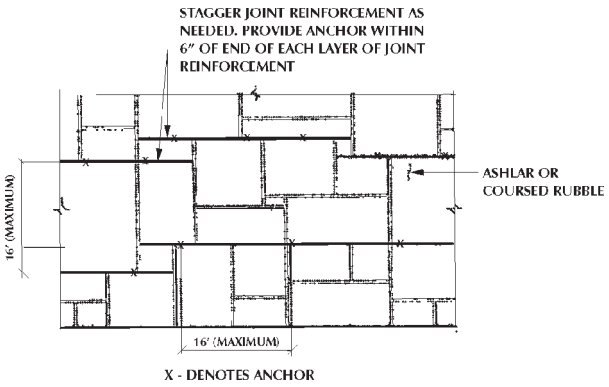

Figure 6 - Joint Reinforcement (Seismic Design Categories D, E, and F)

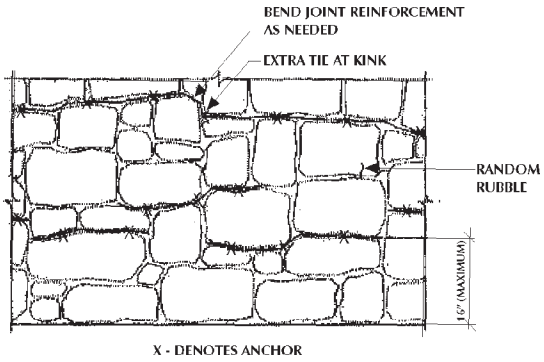

Figure 7 - Joint Reinforcement (Seismic Design Categories D, E, and F)

Details

Figures 8 and 9 show possible cross-sections. The actual back-up and the use of insulation are design choices. Refer back to Figures 6 and 7 for the reinforcement placement, if needed.

Specifications

A sample specification is available from IMI that can be modified and incorporated into a project.

Limitations

All veneers have limitations as noted in the MSJC. One that is significant involves wood backing. Since stone veneer usually has a weight greater than 40 psf of wall area, it can not be supported vertically by wood framing.

Conclusion

Cavity walls with stone veneers of rubble stone and ashlar stone can be constructed using methods familiar to most masons. Open cavities are not necessary because drainage paths can be created without cutting and shaping every stone through the use of modern synthetic drainage materials. Seismic reinforcement can be installed in the veneers but extra ties and anchors are needed.

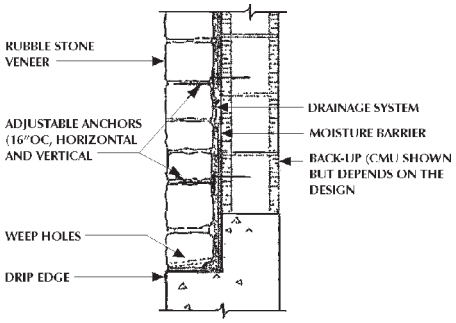

Figure 8 - Uninsulated Section

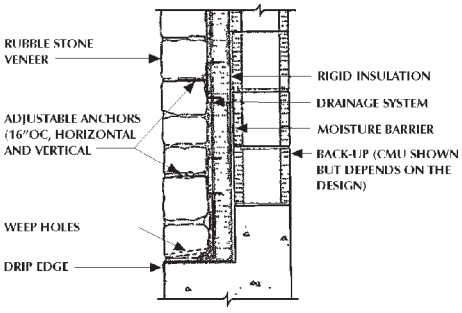

Figure 9 - Insulated Section