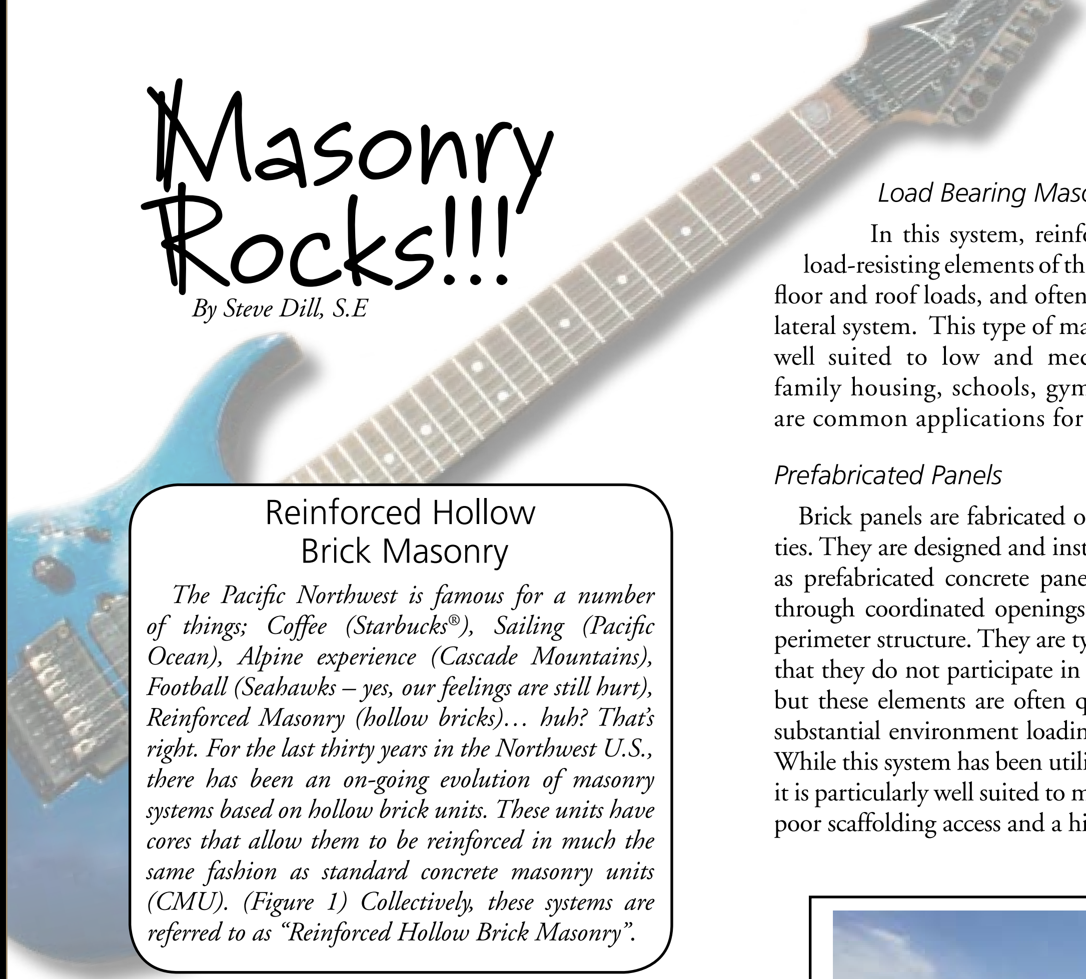

Masonry Rocks!!!

By Steve Dill, S.E

Reinforced Hollow Brick Masonry

The Pacific Northwest is famous for a number of things; Coffee (Starbucks®), Sailing (Pacific Ocean), Alpine experience (Cascade Mountains), Football (Seahawks – yes, our feelings are still hurt), Reinforced Masonry (hollow bricks)… huh? That's right. For the last thirty years in the Northwest U.S., there has been an on-going evolution of masonry systems based on hollow brick units. These units have cores that allow them to be reinforced in much the same fashion as standard concrete masonry units (CMU). (Figure 1) Collectively, these systems are referred to as "Reinforced Hollow Brick Masonry".

Visually, these projects are often indistinguishable from the anchored veneer system that is currently the most popular brick masonry cladding system used in this country. Internally, however, they are quite different. Anchored brick veneer is typically a non-structural component that relies on closely spaced ties to steel (or wood) studs for lateral support. Reinforced masonry, on the other hand, is a reinforced system that has adequate strength to self-span to connections at much larger spacings.

Reinforced brick masonry may be loosely described as being one of three basic types.

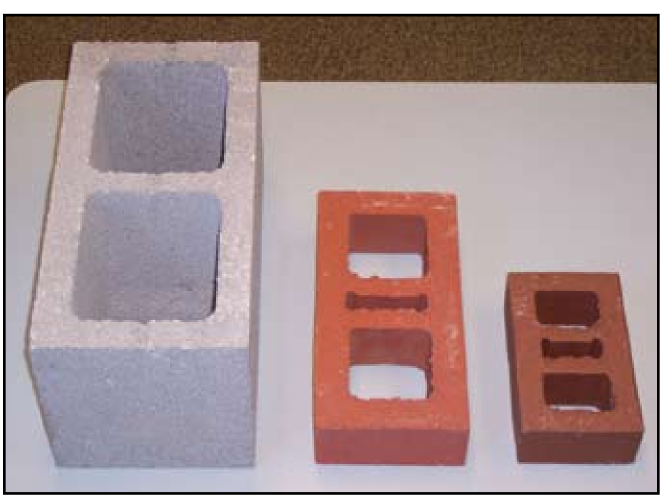

Figure 1: Typical CMU and hollow bricks

Load Bearing Masonry

In this system, reinforced masonry walls are primary load-resisting elements of the structure. They can carry vertical floor and roof loads, and often make up all (or a portion) of the lateral system. This type of masonry construction is particularly well suited to low and medium rise construction. Multi-family housing, schools, gymnasiums, retail, and hospitality are common applications for load-bearing masonry.

Prefabricated Panels

Brick panels are fabricated off-site in simple production facilities. They are designed and installed in much of the same fashion as prefabricated concrete panels by widely spaced connections, through coordinated openings in the exterior sheathing, to the perimeter structure. They are typically non-structural in the sense that they do not participate in the primary load-resisting system, but these elements are often quite long-spanned and subject to substantial environment loading in addition to their self-weight. While this system has been utilized on a wide variety of buildings, it is particularly well suited to medium to high-rise structures with poor scaffolding access and a high degree of repetition.

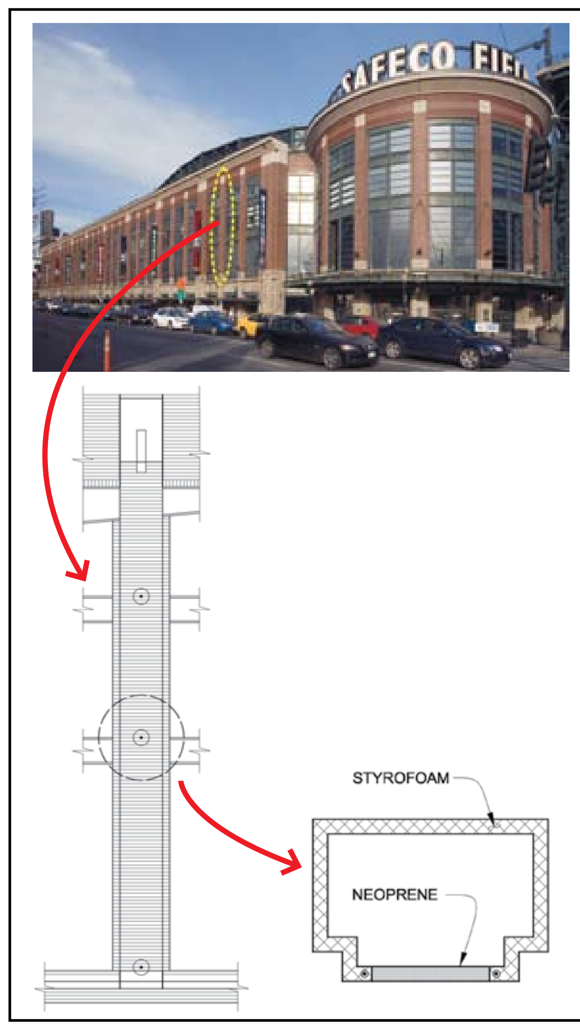

Figure 2: Rocking column covers at Safeco Field

Condition	Anchored Veneer	Reinforced Veneer	Comments
Vertically Self-Supporting	–	+	If the masonry configuration is such that the weight of the masonry can be self-supported, reinforced veneer becomes more economical.
Complex Plan Layout	–	+	When the plan configuration of the masonry is more complex, it is more difficult and expensive to continuously "back" this configuration with studs.
Heavy Integrated Precast	–	+	Because reinforced veneer is a structural component it is better suited to easily support heavy and/or eccentric components.
Complex Masonry Bonding	+	–	Because it is not necessary to align grout cores in anchored veneer, it is easier to accommodate a wide variety of bonding patterns.
High Seismic Performance Standards.	–	+	The flexibility to design the type and pattern of connections better enables reinforced veneer to accommodate seismic drifts.
Contractor and Product Availability	+	–	There are more brick manufactures making standard units than hollow units. There are more contractors familiar with the anchored veneer system than reinforced veneer.

Table 1: Competitive Analysis: Anchored Veneer vs. Reinforced Veneer

Reinforced Veneer

From a structural perspective, reinforced veneer is much the same as prefabricated panels, except that they are hand-laid on site in the same fashion as conventional anchored veneer. The masonry is typically laid after the exterior sheathing and water/air membranes have been installed. The structural connections are designed such that they are pre-sealed into the cavity membrane, or so that the membrane can be easily patched after the mason makes the appropriate final adjustments to the connection hardware. Windows can be installed in advance of the masonry or, most often, they are connected to the masonry after its installation.

Building in a Box

Currently, reinforced veneer is the fastest growing of the three types of reinforced brick systems. It is an economical and flexible cladding system that offers a number of advantages relative to anchored brick veneer. (*Table 1 provides a competitive analysis of reinforced veneer relative to anchored veneer*.) In its most economical form, reinforced veneer is vertically self-supporting with the entire weight of the system bearing on the perimeter foundation. The lateral support of the cladding is accomplished through a variety of widely spaced connections to the perimeter structure. In this configuration, the system has been aptly referred to as a "Building in a Box". Seismic drift is accommodated through establishing an appropriate cavity width, careful consideration of connection layout and panel warping. In this configuration, the loads imparted to the cladding as a result of building drift are a function of the total building displacement, not story drift. For this reason, the "Building in a Box" system is most appropriate for short stiff structures. Recently, this limitation has been exacerbated by the latest building codes, which have tended to increase design drifts.

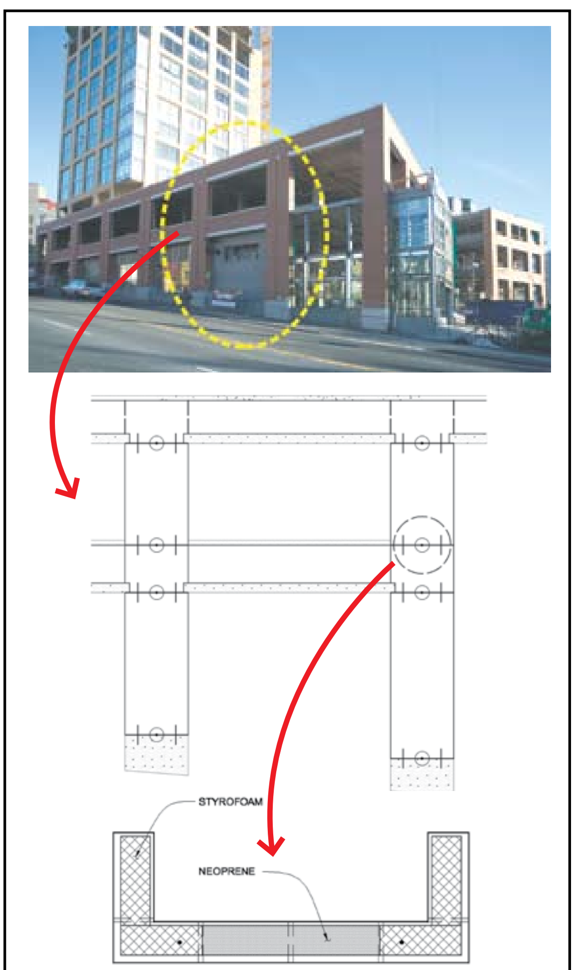

Figure 3: Braced spandrels and rocking column covers

Articulating Systems

In an effort to extend the applicability of reinforced veneer to taller, more flexible structures and to improve the seismic performance of the system for all types of structures, recent designs have begun to explore alternatives to the "Building in a Box" configuration. These alternatives are vertically self-supporting, bearing at the base, thus capturing the economies of that approach, but accommodate building drift in an entirely different way. Rather than isolating from building movements parallel to the cladding, the cladding follows the building more closely and relies on specially detailed hinge locations in the masonry to flex as required to accommodate seismic motions. We have begun to refer to these types of systems as articulating (or "rocking") systems.

The first use of this approach was in the brick column covers used on the Seattle Mariners baseball stadium, Safeco field. The brick cladding for the column covers on this facility were initially designed as prefabricated panels. Reinforced veneer was proposed as a cost saving measure. Neoprene "hinges" replaced the mortar joint at strategic locations in order to accommodate the design drifts associated with the steel superstructure. (*Figure 2*)

Subsequent to that design, several office, health care, and hospitality buildings have used reinforced brick cladding designs that rely on the same articulation concept that was introduced in Safeco Field. Many of these designs have well-stabilized spandrel elements that bear on column covers to transfer the accumulated weight to the base of the structure. In this approach, the hinges necessary to enable an appropriate drift mechanism are commonly located at the horizontal interface between the brick spandrels and the column covers. (*Figure 3*)

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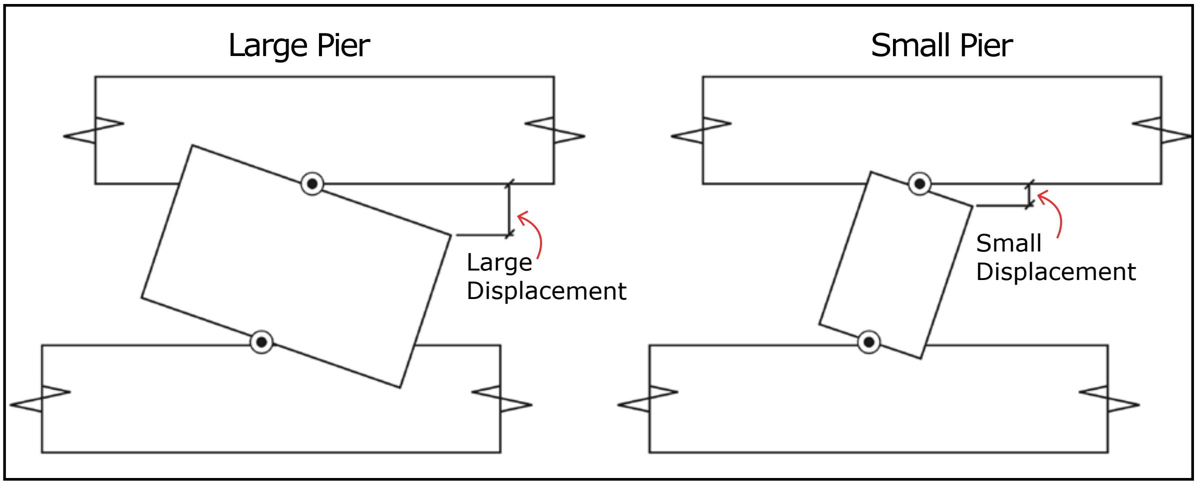

Figure 4: Idealized drift displacement characteristics of small piers vs. large piers

Design Considerations

When contemplating an articulating reinforced veneer for a specific application, there are several important considerations. A few of them include:

Contractor Availability

As with any type of construction, it would be unwise to pursue designing a reinforced veneer solution for a specific building with no assurance that there is at least one local contractor that is willing and able to undertake the project.

Configuration Assessment

To qualify as a good candidate for an articulating solution, the configuration of the cladding must satisfy certain conditions. First, the configuration must be vertically self-supporting over a significant height. Some masonry configurations, like continuous spandrels, must be supported at each floor. Articulation is obviously not an appropriate design choice in this case. More subtly, other configurations, like long runs of solid wall or wide piers between windows, are difficult to articulate and the resulting rigid body motions are problematic to accommodate (*Figure 4*). Again, a conventional floor-supported solution may be a better choice than articulation.

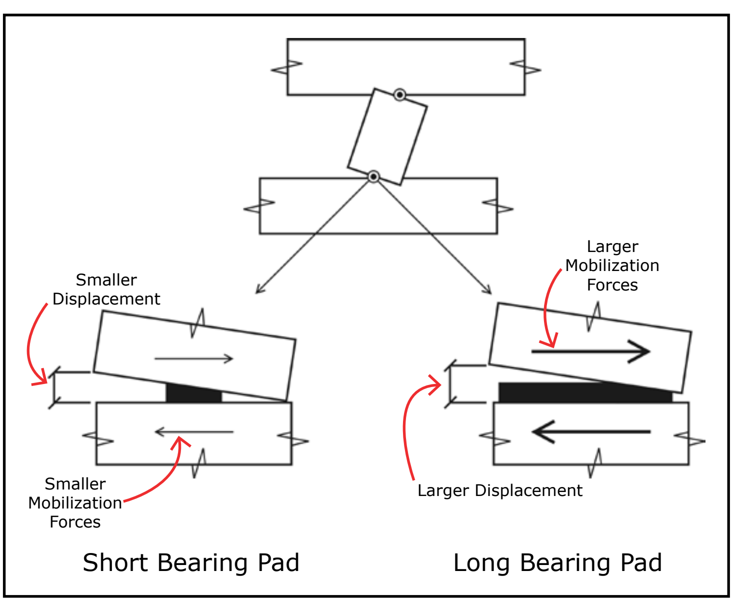

Figure 5: Displacements and Mobilization Forces vs. Extent of Bearing

Mechanism Selection

An early design challenge is to select an appropriate mechanism for the specific combination of cladding configuration and perimeter structure. The chosen mechanism should be stable when subjected to environmental loading, but move freely in both the in-plane and out-of-plane directions in response to expected building drifts. Further, the motions associated with the selected mechanism need to be mobilized with small, manageable connection forces. In general, this criterion is best achieved by putting hinges in the locations at which the configuration would naturally tend to break if it were not jointed.

Hinge Design

The hinge locations represent a compromise between vertical load-carrying capacity and ease of rotation at the joint. The more area of neoprene used in the joint, the higher the compression capacity. However, the longer the extent of the neoprene in the joint the higher the connection forces required to mobilize the mechanism, and the more "climb" the panels undergo as the mechanism works. (*Figure 5*)

Coordinate… Coordinate… Coordinate

As with any cladding, reinforced veneer needs to be carefully coordinated with window systems, air and water barriers, flashing, fire proofing, etc. to ensure satisfactory performance of the overall building envelope. In general, because reinforced veneer has structural capacity and fewer connections to the perimeter structure this coordination activity is somewhat easier, but no less necessary, than with conventional anchored veneer.

Summary

Reinforced brick masonry offers design flexibility that is simply not available in conventional anchored veneer systems. Its structural capacity allows engineers to pursue an expanding variety of design approaches to providing building envelopes, including the time-honored beauty and durability of brick masonry. This flexibility has created an ongoing evolution of brick systems from load bearing brick walls, to prefabricated brick panels and reinforced veneers. The latest variants in this evolution are the articulating systems, through which masonry has finally learned … to rock! ▪

Steve Dill is a principal with KPFF Consulting Engineers. He can be contacted at ***steved@kpff.com****.*