ACME BRICK

#222

TECHNICAL SERVICES DIGEST January 2015

## SUBJECT: Storm Debris Resistance of Face Brick

Testing at Texas Tech University has shown that 4” modular face brick veneer can absorb the impact and prevent penetration of the large windborne debris missile specified by FEMA and in the Florida Building Code for Broward and Dade counties. The intent of the code is to prevent wind-borne debris from hurricane force winds from penetrating the building enclosure. There are two debris types: Large objects and Small. Large objects are represented by a 9 lb 2x4 timber impacting the wall end-on at 34 mph. Small objects include gravel and other hard objects, which cause glass breakage and damage to light weight cladding materials. The hardness and mass of brick is such that small storm debris does not penetrate it, so only large object debris testing is needed to demonstrate complete storm debris resistance of facing brick cladding.

## Testing:

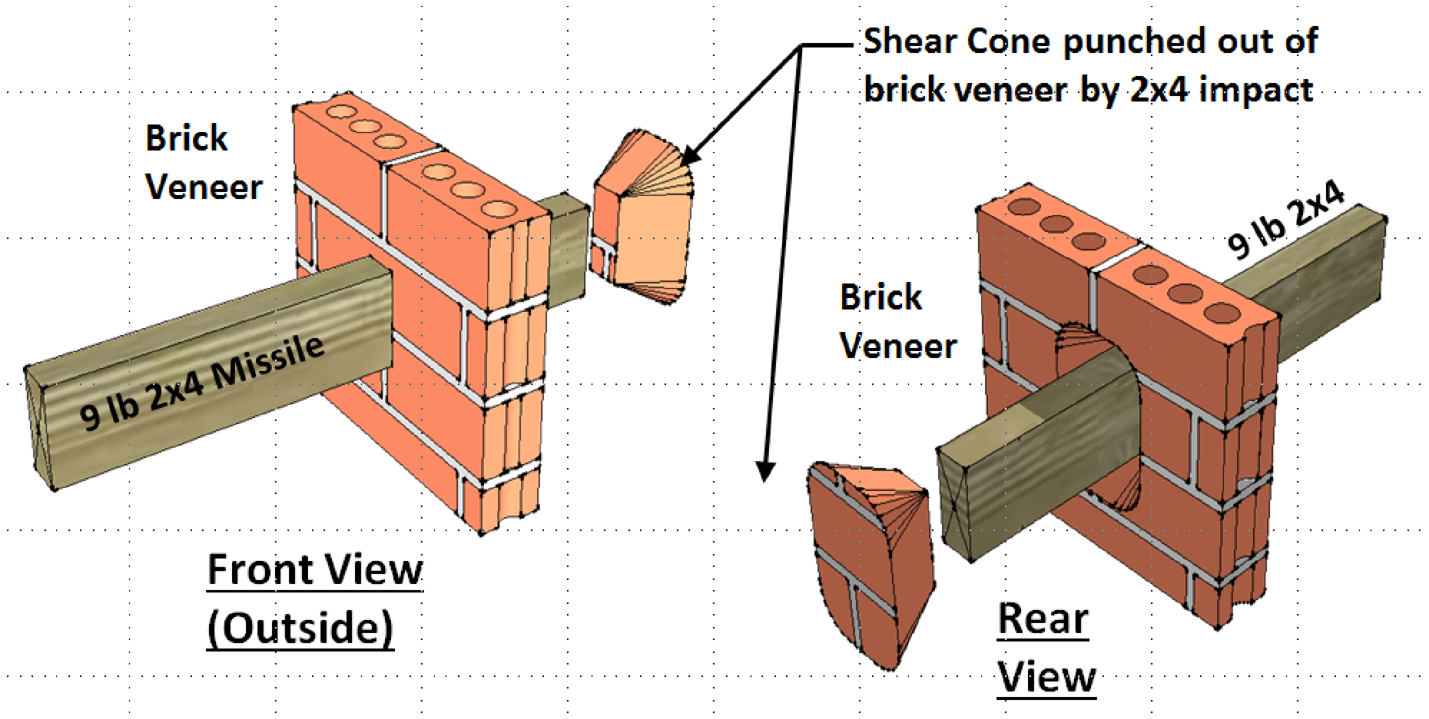
A number of tests have been done at Texas Tech University using a calibrated air canon. The results of many of those tests have been summarized in a report by Bennett, *et al*[i] presented in the Journal of the Masonry Society. In those tests, 2x4 timbers were fired into walls clad with fired clay brick with at increasing velocities until penetration of the wall system occurred. All claddings were installed on 2x4 framed walls with 7/16” OSB sheathing, batt insulation, and ½” gypsum board interior finishes. In the table below we have summarized the two 9-lbm missiles and their velocities from that report, that just penetrated the brick veneer, but did not penetrate the interior sheathing:

| Timber missile | Cladding | Penetration Velocity | Momentum | Kinetic energy |
|---|---|---|---|---|
| 9.0 lbm (4.09 kg) 2x4 | 4” modular (3.625”) face brick | 76 mph (36 m/s) | 31.2 lb-s 140 N-s | 1740 ft-lb (2350 J) |
| 9.0 lbm (4.09 kg) 2x4 | 4” modular (3.625”) face brick | 79 mph (36 m/s) | 32.4 lb-s 145 N-s | 1880 ft-lb (2540 J) |

These two missile impacts appear to represent the missile velocity required to shatter the brick and impact the sheathing behind it. We will use the lower velocity of 76 mph to represent the maximum impact velocity the 4” brick can withstand.

We also note in the report that when the timber missiles penetrated brick veneer, the impact punched out a cone of approximately a 30 degree angle perpendicular to the wall face. Using that angle for other brick thicknesses, we can calculate the kinetic energy and the velocity needed to punch out a similar shear cone for other thicknesses of brickwork by comparing the surface area of the shear cones.

Calculations of the area of those shear cones give 69.4 in$^2$ for the 3.65” brick and 44.7 in$^2$ for a 2.625” brick, as shown below. 2.625” is the thinnest brick allowed by the masonry code.




**30 degree Shear Cone**

| Thickness, T | Cone Area |
|---|---|
| 3.625 in | 69.4 $in^2$ |
| 2.625 in | 44.7 $in^2$ |

The 2.625" brick has 64% of the shear cone area of the 3.625" brick as tested. So we can expect it to absorb 64% of the impact energy or 1531 Joules. That gives a velocity for the 9 lbm 2x4 of 60.8 mph.

| Timber missile | Cladding | Penetration Velocity | Momentum[ii] | Kinetic energy |
|---|---|---|---|---|
| 9.0 lbm (4.09 kg) 2x4 | 4" modular (3.625") face brick | 76 mph (36 m/s) | 31.2 lb-s 140 N-s | 1740 ft-lb (2350 J) |
| 9.0 lbm (4.09 kg) 2x4 | 3" (2.625") face brick | 60.8 mph (27.4 m/s) | 24.9 lb-s 112 N-s | 1129 ft-lb (1531 J) |
| 9.0 lbm (4.09 kg) 2x4 | Florida Bldg Code large wind debris | 34 mph (15.3 m/s) | 13.9 lb-s 63 N-s | 353 ft-lb (479 J) |

## Allowing for brick with reduced compressive strength

Finally we can adjust for brick of less compressive strength than those used in the tests, even though such brick are very rarely used. Unit compressive strength of brick in the test = 5870 psi, which is typical of grade SW face brick. Minimum strength for grade MW face brick in ASTM C216 is 2500 psi.
Shear strength factor for the lower strength brick = $\sqrt{(2500/5870)}$ = 65%.
Reduced kinetic energy for 2500 psi 3” brick = 65%x1531 J = 999 Joules = 9 lb 2x4@49 mph.
This is still 2 times the energy of the design large debris missile at 34 mph.

## Conclusions:

Based on the above calculations, even the thinnest and lowest strength brickwork allowed in the masonry code will resist the impact of a 9 lb 2x4 timber at 49 mph. This has more than twice the impact energy of the 34 mph large hurricane missile specified in the Florida code. Smaller missiles do not penetrate brick, even if they cause surface damage, so we can conclude that any anchored brick veneer that meets ASTM standards for minimum compressive strength and building code requirements for minimum thickness will resist penetration by the specified large or small hurricane missiles.

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[i] Impact Resistance of Residential Wall Systems to Wind-Borne Debris, Bennett, Borchelt, Bryja, Kjorlien, Masonry Society Journal, Nov. 2006.

[ii] The momentum of the missiles were also recorded in the study, and there seems to be good correlation between impact momentum and missile penetration. However, we have chosen to use impact energy, rather than momentum, because it is more conservative, and the sample size is too small to draw generalized conclusions.