from experience

Urethane Foam as a Structural Material

By: Craig E. Barnes, P.E., S.E.

The use of urethane foam as infill in wall masonry repairs, and as a base for EIFS wall systems, is relatively straight forward and a well know use. Here are some general considerations. The most effective foam to use is a two part central mixed product with a free rise density of 1.5 to 2.5 pcf. The foam should meet the requirement of Class I per ASTM E84 Standard and NFPA Class A requirements for Smoke Development and Flame Spread. (The use of insulation foam in any situation warrants the review of the application, as it relates to fire assembly/flame spread.)

The substrate on which the foam is to be sprayed needs to be relatively clean and dry. The foam will stick to essentially everything, but moisture will retard the foam formation and will create uneven foam surfaces and voids. Protection of workmen and adjacent property is required because of overspray. Setup time varies with temperature. Additives can be used to allow applications in cold weather.

Once the foam has set, the surface can be trimmed with a hand saw or a reciprocating saw to form a plane satisfactory for coating and followed by covering with a waterproofing membrane, or concealment by an architectural finish. The use of a milling machine has been used to form flat planes when used with EIFS finishes.

Alternate Uses

The use of spray foam has been found to be effective in filling the space between steel columns and new brick veneer, which is created following the removal of the solid brick masonry, characteristic of transitional brick and steel construction. The removal of the brick is frequently necessary to expose the steel to clean rust scale and repair the columns.

In one interesting application, small bathroom windows no longer of use were coated with foam. The foam was then treated with a waterproofing coating and covered with masonry, rather than having to remove the windows and then infill with a structural stud wall. The foam encased and secured cold form channels set loosely in place to be used as positive attachment for masonry.

The recent renovation of the 100 year old Lenox Hotel in Boston MA (see May 2003 *STRUCTURE magazine*) made use of urethane foam for both insulation and structural purposes. At the outset, the urethane foam was to serve as an insulator, as well as a surface leveling material for rough profile masonry substrate and as a mounting surface for drainage mat. *Figure 1* illustrates the original construction shown on a plan wall section where the wall is penetrated by a window. The 12-inch thick masonry wall had worked well resisting wind loads for 100 years; however the reconstruction would result in an 8-inch wall for wind resistance. In most areas, the strength of the wall was maintained by the use of cold form stud construction let in to the masonry substrate, particularly where terra cotta surrounds were removed. According to Massachusetts Building Code, 780 CMR, Chapter 34, as a historical structure, as well as a structure where the cost of repairs are less than half the value of the building, seismic consideration is not necessary. There were, however, areas with wind load concentration such that the capacity of the masonry was exceeded. This occurred in the masonry adjacent to window openings. The pure structural solution to this problem is shown in *Figure 2*. Note how the solid terra cotta surround has been removed and replaced with a thin glass fiber reinforced enclosure, which conceals the load collecting cold form metal stud structure. Where loads concentrated to such an extent, the five stud cluster seen in *Figure 2* became necessary; the only easy part was showing the detail on paper. To engage the cold form metal structure installed as reinforcement turned out to be impractical, given the depth constraints of the wall construction. The use of HSS sections was possible although this would involve a change order and mixing of trades, not always desirable in the predominant Boston union market. As a result, other solutions were explored.

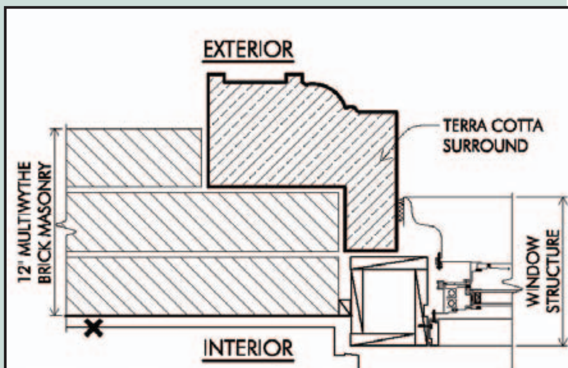

FIGURE 1 - EXISTING WALL SECTION
✕ = VAPOR CONDENSATION POINT

For years, the construction industry has relied on the adhesion capacity of sprayed urethane foam to provide a connecting limit between building materials. Structural insulated panel systems (SIPS) have been using this concept for a long while. SIPS are a combination of plywood, dimensional lumber, and foam insulation. Our office has just completed a large single family home utilizing the panels. The SIPS was revealed to be more cost effective and lighter weight than the traditional stick built design. Further research revealed INSULATOR® insulation has been tested and demonstrated to yield improved racking characteristics when used as foamed insulation between cold form metal studs. Test results are reported in "Testing and Adoption of Spray Polyurethane Foam for Wood Frame Building Construction", May 25, 1992, prepared by NAHA Research

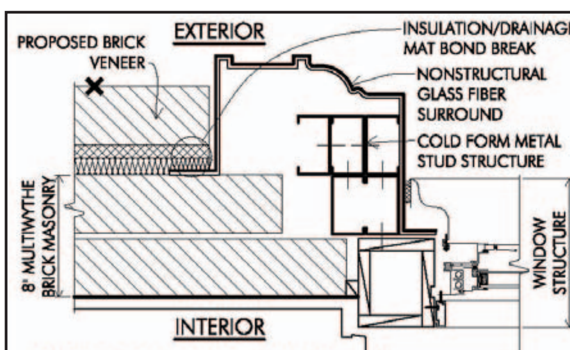

FIGURE 2 - PROPOSED WALL SECTION
UTILIZING COLD FORM STUDS AS SOLE STRUCTURAL ELEMENTS
✕ = VAPOR CONDENSATION POINT

Center for the Society of the Plastics Industry/Polyurethane Foam Contractors Division. While neither of these uses are directly transferable to our situation, they are referenced to illustrate the increasing use of spray foam insulation as a structural material.

In the case of the Lenox Hotel, as an upper bound strength, the use of the cold form studs, urethane foam, and brick as a composite structural element would be the ideal solution. As a lower bound, using the insulation simply as a compression/tension link between the cold form metal and masonry was, in our opinion, not fully recognizing the contribution of the insulation. As a compromise solution, the insulation was treated as a viscous material transferring interface shear, but having no strength to resist tension and compression. In this way, tension in the brick was limited to a maximum of 5 psi. There is also reason to believe the system will work compositely for a number of years before unknown environmental factors, which may or may not occur, such as condensation, moisture, or bond degradation between the materials, begin to effect composite action. In any case, mechanical interface load transfer between the materials will be maintained indefinitely.

We are very comfortable with the function of the resulting product. A good portion of that comfort has resulted from our experience with foam insulation. However, not all engineers will have the advantage we have. Therefore, test results for bond, and for structural and material properties for foam when the material is new, and the same results when the product has been exposed to a variety of environmental conditions over a long period of time will be beneficial for designer use.

The Solution

Figure 3 shows the resulting detail. The steel studs are set in an envelope created by the first interior brick wythe and the foam insulation. This arrangement worked well to meet the constraints imposed by the original construction. Additionally, the insulation value of the wall was improved remarkably. One caution; the foam needs to be applied with care as the expansion of the product can cause the studs to "walk" along the wall line and to bow outward. Expanding foam creates substantial force when confined. For those with interest in the location of the potential vapor condensation point, please refer to the Figures.■

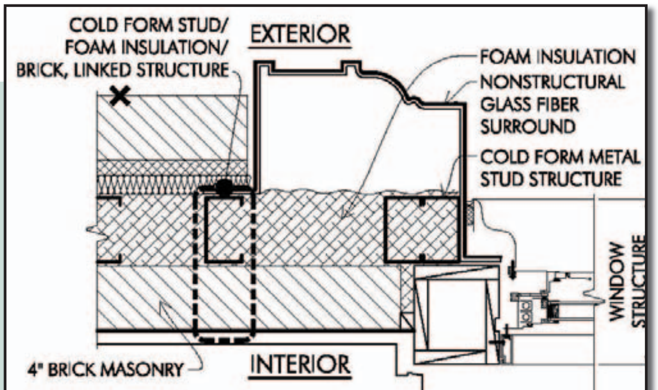

FIGURE 3 - PROPOSED WALL SECTION
UTILIZING LINK STRUCTURE
✖ = VAPOR CONDENSATION POINT

Craig E. Barnes, PE, of CBI Consulting Inc., has over 38 years experience designing, coordinating, and managing structural and civil engineering projects throughout New England. Mr. Barnes has designed governmental, educational, industrial, and residential projects utilizing all types of construction and materials.