Load bearing masonry of CMU and brick veneer for a dormitory.

Co$t-Competitiveness of Masonry Construction

By Richard E. Klingner, Ph.D., P.E.

Regardless of its performance as building envelope, as architecture, or as structure, the viability of masonry construction depends on its cost-competitiveness in the construction marketplace. The cost of masonry can be described in terms of its design cost; its manufacturing cost; its cost at the job site; its cost in the structure; its initial cost to the owner; its life-cycle cost; and its cost to the environment.

Design and Specification Cost of Masonry

At first glance, it might seem inappropriate to relate cost-competitiveness to design cost. Closer examination, however, reveals otherwise. In the traditional process of design and construction, design fees are a percentage of the structural cost of the building. The percentage of jobs built according to that process continues to decrease, and to be supplanted by a system in which a designer and the specifier negotiate fees for services. From the owner's viewpoint, a building is an investment tool, and other things being equal, the cost of design and specification should be about the same regardless of the building material used.

A designer's viewpoint, then, must consider design cost. Construction materials that require lower design effort per square foot of usable space are more attractive. Masonry must compete, by this criterion, with other construction materials, including structural steel (in which final design of connections is usually carried out by the steel fabricator); reinforced concrete (in which details of reinforcement are usually prepared by the reinforcement detailer); tilt-up (in which design of reinforcement can be based on standard details disseminated by the tilt-up industry); glass curtain walls; metal panels; exterior insulation and finish systems (EIFS); and metal, vinyl or wood siding. By this criterion, masonry is relatively unattractive. It is perceived as having relatively few design aids available; its design is viewed as complex, old-fashioned, or difficult in other ways; and, it is viewed by some designers as difficult to interface with other materials. In recent years, this challenge has been answered by The Masonry Society's *Masonry Designers' Guide*, the latest edition of which has just been published (MDG 2007).

Brick veneer over CMU infill walls for a hospital.

A specifier's viewpoint must also consider cost. Construction materials that require lower specification effort per square foot of usable space are more attractive. By this criterion, attractive construction materials include structural steel; reinforced concrete and tilt-up (specification is simple, and standard reference specifications are available), glass curtain walls; metal panels; exterior insulation and finish systems (EIFS); and metal, vinyl or wood siding. By this criterion, masonry is again relatively unattractive. Its specification requires the separate and coordinated specification of units, mortar, grout and accessory materials. Three excellent guide specifications (MasterSpec, SpecText, and the *TMS Annotated Guide*) are available, and the *MSJC Specification* (MSJC 2005b) is an excellent reference specification linked to the MSJC *Code* (MSJC 2005a). The problem is that many specifiers do not know masonry well enough to use these specification tools effectively.

There is a tremendous need for the development and promulgation of standard specifications for typical masonry construction (veneer on houses, veneer on frame buildings, or low-rise commercial construction).

Manufacturing Cost of Masonry Units

Masonry units themselves are not expensive. Concrete masonry units (8x8x16 inches) cost about $1.00. Modular clay units cost about $0.25. Raw materials for masonry units are available within a reasonable distance of most major construction markets in the US.

Challenges to increasing masonry production lie in the time and investment needed to bring new plants on line, and in the increasing complexity of environmental regulations governing production. For example, a modern concrete masonry plant, capable of producing 16 million 8-x8-x16-inch. equivalents yearly, requires an investment of about 10 million dollars and a lead time of about 3 years. A modern clay masonry plant, capable of producing 60 million modular equivalents yearly, requires an investment of about 25 million dollars and a lead time of about 5 years. There is a need for focused research to decrease the capital investment and time required to bring new concrete and clay masonry plants on line. Modern environmental regulations governing control of emissions and dust are an expensive reality.

Once operational, modern masonry plants can be very efficient. Concrete masonry plants commonly cure units less than 24 hours. Modern clay masonry plants can use computer-controlled firing cycles lasting 12 hours, rather the 30 hours that used to be typical. Increasingly, plants use robotic handling equipment to increase productivity. Manufacturers should work to decrease the production cost of masonry units even more.

Cost of Masonry at the Job Site

Given the cost of masonry units as produced, the cost of masonry at the job site is controlled by the cost of transportation, which depends in turn on the weight of units required for each square foot of wall area. Under current economic conditions, it is ordinarily cost-competitive to ship concrete masonry units within a 150-mile radius of their point of production. This radius increases for concrete and clay units with distinctive appearance or characteristics. Clearly, this radius can be increased by units with decreased density.

Brick veneer over CMU infill for a university building.

Brick veneer over light gauge metal framing for a technology building.

Manufacturers should continue to work to decrease the weight of masonry units, or to decrease the thickness of masonry units, so that a wall of the same surface area can weigh less. In addition to decreasing transportation costs, this also offers the potential benefit of reduced seismic forces.

Cost of Masonry in the Structure

Given the cost of masonry units at the job site, the cost of installed masonry is controlled by the costs of masonry mortar, grout and accessory materials, and by the costs of installing the units plus those other materials to form masonry elements.

The cost of installed units increases whenever units must be cut, or whenever units are broken or chipped in transportation or handling. The cost of installed masonry mortar and grout depends somewhat on the cost of the materials themselves, but more on the costs of preparing and placing them. It increases whenever materials must be handled in bag form, whenever batching is incorrect, whenever mortar is difficult to use, or whenever mortar is mixed but not used. The cost of installed accessory materials depends to a limited extent on the cost of the materials themselves, but primarily on their ease of installation.

There are needs to:

- encourage specifiers to use modular design;
- develop cost-effective ways to decrease breakage and chippage of masonry units;
- develop masonry mortars with improved performance;
- encourage the use of compatible combinations of mortar and units;
- develop better techniques for hot- and cold-weather construction;
- use more cost-effective ways (such as silo systems) to batch, mix and deliver mortar;
- use more cost-effective scaffolding systems, such as self-elevating scaffolds;
- develop more cost-effective flashing, insulation and vapor barriers;
- develop more cost-effective ways of protecting masonry during construction;
- develop more cost-effective ways of keeping masonry clean during construction; and
- develop more cost-effective ways of cleaning masonry after construction.

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One factor often identified as important in the installation cost of masonry is the cost of mason labor. The scarcity of masons, widely discussed at the beginning of the 90s, is still with us in many areas. The masonry industry must continue its efforts to recruit and train new masons.

Brick veneer over CMU infill walls for a school.

One challenge is the development of standard wall types with uniform specifications and construction details. For example, we could have a standard residential veneer wall; a rain-screen wall; a standard drainage wall with CMU backup; a standard drainage wall with metal stud backup; a standard fully grouted barrier wall; and a standard partially grouted barrier wall. These six basic wall types would represent practically all modern masonry construction. Other types could easily be added.

Development of standard wall types would involve the re-packaging of existing knowledge, rather than the development of new knowledge. Design provisions, specifications, and technical notes should be synthesized to give masonry users simple recipes for how to use masonry correctly. A designer should be able to go to a web site and download design procedures, examples, complete specifications, and drawings for each wall type. Finally, constructors should be able to download step-by-step instructions, in words and pictures, and in different languages, showing the proper assembly of each wall type.

Life-Cycle Cost of a Masonry Building

The life-cycle cost of a building is the present value of its initial cost, plus the present value of the costs incurred over its lifetime, minus the present value of its sale price at the end of its lifetime. Costs incurred over the lifetime of a building include utilities, maintenance, and repairs. If masonry is properly designed, specified and constructed, its maintenance cost is very low compared to that of other envelope materials. For example, it does not need painting.

There is a need to work on better ways to document and reduce the maintenance and repair costs of masonry buildings. For example, the development of better ways to reduce efflorescence would enhance the appeal of masonry, and also reduce the probability of damage due to improper cleaning.

Insurance cost is another significant part of the life-cycle cost of masonry buildings. Insurance costs (for example, for fire) are driven in part by the actuarial risk of loss in masonry buildings, and in part by the by the potential costs of changing current methods for classifying buildings. For example, fire-insurance premiums are the same, or almost the same, for masonry bearing-wall houses as for wood-frame houses, even though masonry is far less flammable. Reasons for this are that much of the loss in residential fires is to the contents of the house rather than to the house itself, and that to charge lower premiums for masonry than for wood-frame houses could reduce the revenue of insurance companies, and would require them to distinguish between types of construction on insurance applications.

The masonry technical community should develop better strategies for reducing the cost of insurance premiums for masonry buildings, and should implement those strategies.

The industry should also update criteria for compiling life-cycle costs for buildings of different materials, and should update the corresponding values for masonry buildings. Updates should reflect historical trends in energy and construction costs. Updates should be used to project the life-cycle cost-competitiveness of masonry buildings, to identify areas in which life-cycle costs could be improved, and to effect improvements in those areas.

Brick veneer for a town hall.

Stone veneer for the entry of a ski lodge.

Cost of Masonry to the Environment

Another approach to life-cycle cost is the cost of a masonry building to the environment. This is the sum of the energy required to manufacture the raw materials from which the building is made; to construct the building; to operate the building; and to dispose of the building when its useful life is over. This type of life-cycle cost, however, may also include the day-to-day details of the cost of operating the building. For example, buildings with high thermal mass may have lower peak power demands, and therefore lower energy costs.

The masonry technical community should work to update the criteria of organizations such as the Green Building Council and Green Globe for assessing life-cycle environmental costs for buildings of different materials, and should update the corresponding values for masonry buildings. Updates should reflect historical trends in energy costs and metering policies. Updates should be used to project the environmental friendliness of masonry buildings, to identify areas in which environmental friendliness could be improved, and to develop research focused on those areas.

Brick veneer over light gauge metal framing for a technology building.

Cost-Effectiveness of Masonry in Niche Markets

Niche markets for masonry include fireplaces, pavers, segmental retaining walls, and landscaping applications. Focused research should continue on potential challenges to those markets (such as the poor seismic performance of unreinforced masonry chimneys), and on ways of meeting those challenges.

Cost-Effectiveness of Masonry in New Markets

The masonry industry has sometimes been criticized as opposing innovation. In my opinion, this criticism is simplistic and somewhat unfair. The industry includes producers, users and general interest groups; each benefits to some degree from the status quo. While they might benefit collectively from changes, they are not accustomed to working together to identify potentially useful changes, to explore their possible repercussions, and to work together to bring them about.

There is a need to regularly examine the potential of new markets, and to prepare to be competitive in those markets.

- One example of this is post-tensioned masonry. This innovation has only recently arrived in the US, and could benefit from more demonstration projects to validate its use.
- Another example is segmental retaining walls, which consist of face units tied to a soil mass to produce an integral self-sustaining system. These are increasingly popular in landscaping applications.
  There is a need to optimize the attachment of the face units, to assess their performance under extreme loadings, and to develop new units for this application.
- A final example is the use of innovative materials such as autoclaved aerated concrete masonry, or innovative construction systems such as mortarless systems. More projects involving such systems should be encouraged.▪

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