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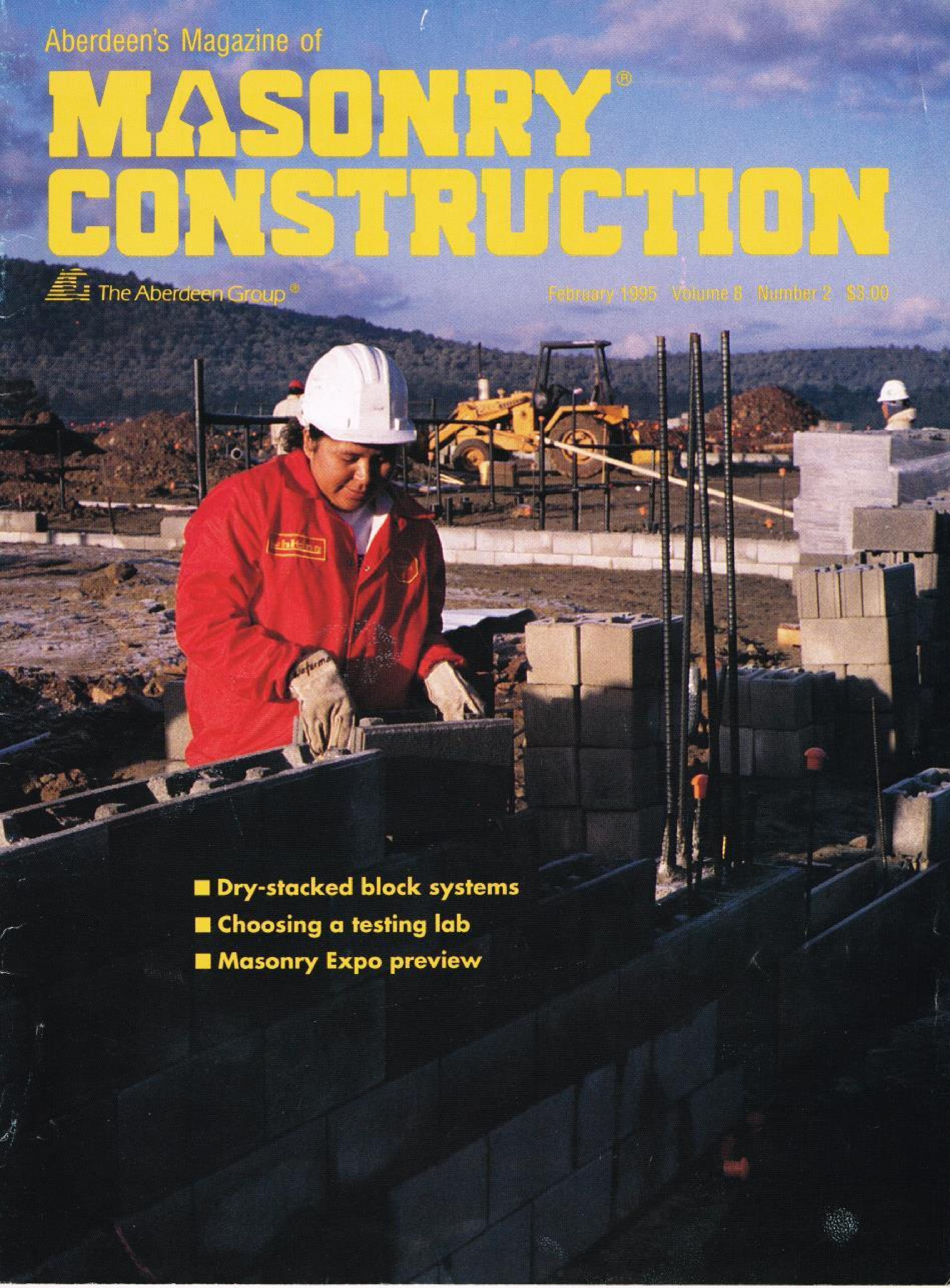


■ Dry-stacked block systems

■ Choosing a testing lab

■ Masonry Expo preview

Using dry-stacked concrete masonry for affordable construction

Interlocking mortarless systems have the potential to reduce costs without sacrificing performance

By Tom Hines

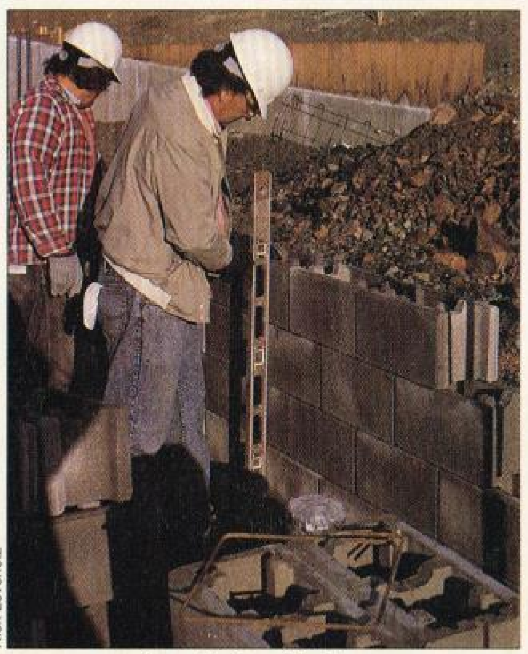
Masonry has inherent properties that contribute to reducing construction costs. Compared with structural steel, masonry materials require less energy to produce. Masons require less technical training than workers who build with structural steel or reinforced concrete. And masonry is multifunctional, in that placing the units provides for closure, structure, and finish in one. However, masonry's cost-effectiveness could be enhanced further by eliminating one of its traditional components, mortar.

Watching a mason lay concrete block walls, one would assume that mortar acts as an adhesive to "glue" the block together. But mortar as normally mixed and used has little, if any, strength in tension and relatively poor adhesion. Except in direct compression, the mortar joint's structural strength is negligible. Rather, the mortar serves mainly as a bed to aid in leveling the block.

Over the past 20 years, researchers have developed a number of mortarless masonry systems using block that interlock to provide leveling and alignment. Though still uncommon, these systems could be used to construct strong, durable, and cost-effective buildings.

Mortared system drawbacks

Building mortared masonry is time-consuming. A good crew (one mason and two helpers), working on straight walls with minimal reinforcing, can lay 150 to 200 blocks per day on average. Some crews have been known to place 300 units a day. More extensive horizontal and vertical reinforcement and grouting complicates the installation and reduces output. A major factor in these productivity rates is the time it takes to apply mortar and maintain the proper horizontal and vertical alignment.


Nick Levenetz

Using special interlocking block, masons can build plumb, level walls without mortar.

Many common workmanship problems also relate to mortar: e.g., moving a unit after its initial set; improper tooling; incompletely filling head and bed joints; omitting horizontal wire reinforcing; and leaving mortar droppings in cores to be grouted. All these practices compromise a masonry assembly's performance, often increasing maintenance and repair costs after the project is completed. Minimizing such problems would greatly increase masonry's attractiveness to building owners and designers.

Benefits of interlocking dry-stacked systems

Self-aligning concrete masonry systems that use minimal amounts of mortar offer several potential benefits that could improve masonry's overall effectiveness.

- Problems associated with mortared joints, such as inadequate bond and mortar cracking, that provide an obvious path for water penetration would no longer be factors in an assembly's performance.
- Quality control of the assembly would lie with the manufacturer of the interlocking block, substantially reducing responsibility at the job-site.
- Using interlocking units without mortar, the mason could put more units in the wall in a given period of time. Output has been as much as 900 to 1,200 units a day per crew (Ref. 1).
- Units could be placed by semi-skilled and unskilled labor with proper guidance. The combined effect of less skilled labor and increased output has been estimated to reduce labor cost by as much as 80% (Ref. 2).
- Because interlocking block provide stability during construction, floor and roof loads could be placed on wall assemblies without waiting for mortar to cure, thus further speeding construction.

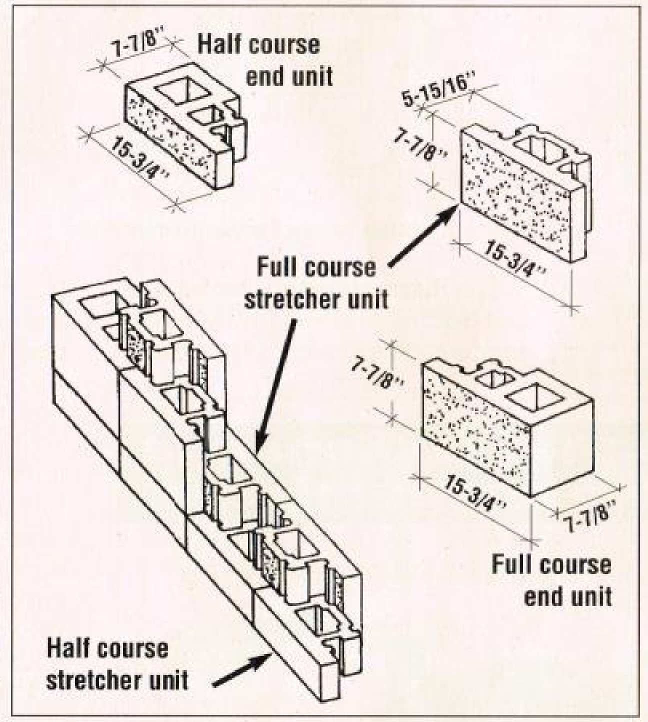


Figure 1. Alternating face shell system components.

Principles of practical interlocking systems

Any practical block system has to follow some basic principles.

Ease of design. The interlocking mechanism must be clearly thought out and explained so that architects can understand how it works and design with it easily. The blocks themselves should meet requirements contained in existing material standards and building codes. The geometric relations of the system also should be expressed as equations that allow design in accordance with established structural principles and building codes.

Ease of production. The blocks must be capable of being produced economically on conventional block machines. Most mortarless block systems have relied on tongue-and-groove or dovetail patterns to achieve interlocking. But experience has shown that manufacturing block with tongue-and-groove face shell bedding surfaces is impractical, given the configuration of standard block machines and the difficulty of meeting close tolerances.

Ease of construction. The system should be designed from the outset for ungrouted, partially grouted, or fully grouted applications. Systems that may be reinforced and grouted need to provide for the placement of steel and grout. Construction methods should accommodate the use of unskilled or semiskilled labor. The number of shapes or components included in the system should be kept low, to simplify estimating quantities and minimize confusion on the jobsite.

Current products

Among the many mortarless block systems that have been developed around the world, two that are commercially available now seem the most promising. A third system, not yet in production but under study at Drexel University, also seems to have commercial potential.

Alternating face shell system. This dry-stacked system, developed and marketed in Canada, consists of stretcher, corner, and jamb units in both full and half heights (Figure 1). It provides positive interlock horizontally, through shear keys, and vertically, through a stepped arrangement of alternating courses produced through a half-height base course. A $3^{13}/_{16}$-inch overlap creates continuity past the weak areas of the bed joints.

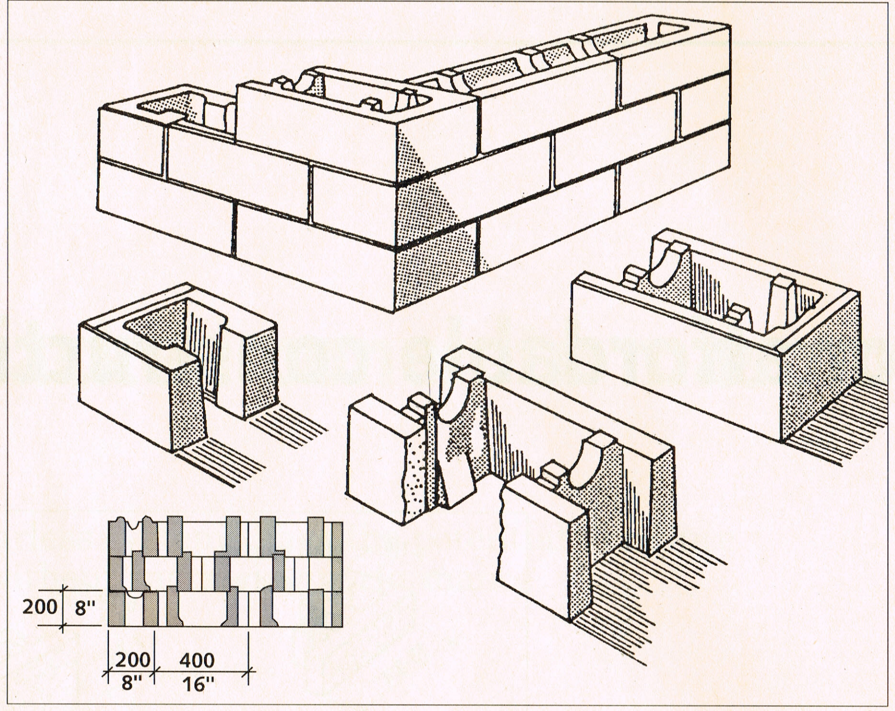


Figure 2. Projecting lug system components.

The discontinuity of both head and bed joints through the wall enhances the system's fire resistance, reduces accidental sound transmission, and improves resistance to air flow.

As with conventional construction, workers with some technical skill are needed to ensure straight lines and verticality, but beyond this, semiskilled labor is sufficient to install the block. The interlocking features provide stability during construction, assist with alignment and leveling, and limit the construction tolerances.

Projecting lug system. Another commercially available system combines lugs molded into the webs with tongues and grooves molded into the end faces to permit the blocks to stack and lock together without mortar as shown in Figure 2. It has three standard units—a stretcher, a half block, and a corner also used as an end block.

Recesses between the lugs provide for reinforcing to be placed horizontally and vertically without tying. The initial course must be laid flat and plumb to allow for positive dry-stacking of the remaining units. Technical skill is required for this phase, but once it is completed, semiskilled and unskilled labor can be used to stack the remaining courses. It is possible for a crew to dry-stack more than 1,200 units in one day.

Dovetail block system. This system, still under development, takes an interesting alternative approach (Figure 3). It features interlocking dovetail slots and lugs at opposite ends of the blocks. Notched-web units can be used to hold horizontal reinforcing steel and large cells accommodate vertical rebar and grout.

As the system was originally designed, horizontal alignment was to be accomplished by grooves formed in the face shells. Because of the difficulty of producing grooved face shells with current technology, researchers are now working on an alternative interlocking method. For surface bonded or grouted walls, however, the system could compete with other commercially available systems.

Completion options

Depending on the building's final occupancy, the assembly can be completed in one of three ways (Ref. 3): plain, surface-bonded, or grouted.

Plain dry-stacked units can be used for retaining walls, foundation walls, partitions, and loadbearing walls up to about 9 feet tall in structures not intended for human occupancy.

For surface-bonded walls, dry-stacked units can be finished on both sides with a cementitious or acrylic bonding matrix reinforced with fiberglass mesh or plastic fibers. This material serves as a rain and air barrier, as well as providing the final surface finish and color. Height limits can be as high as 21 feet 8 inches for two-story loadbearing walls.

In grouted construction, dry-stacked interlocking units have their cores partially or fully filled with grout, and can include both horizontal and vertical reinforcement. Unreinforced grouted walls provide for greater load capacities and heights than simply surface-bonded assemblies. Reinforced,

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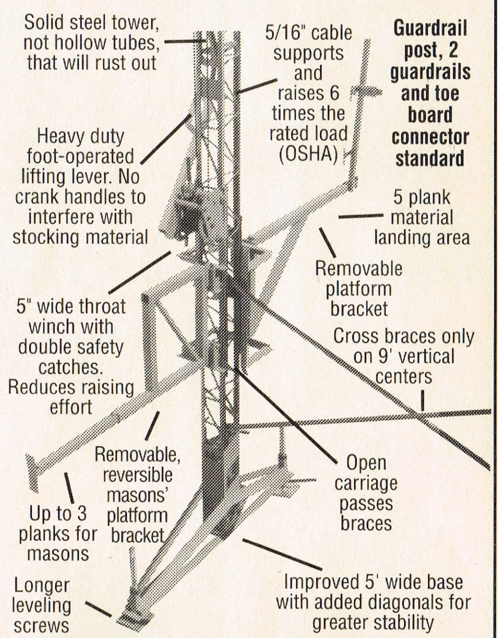

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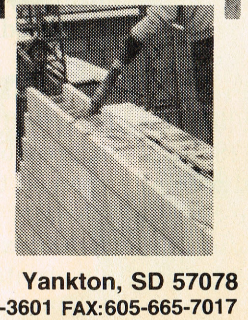

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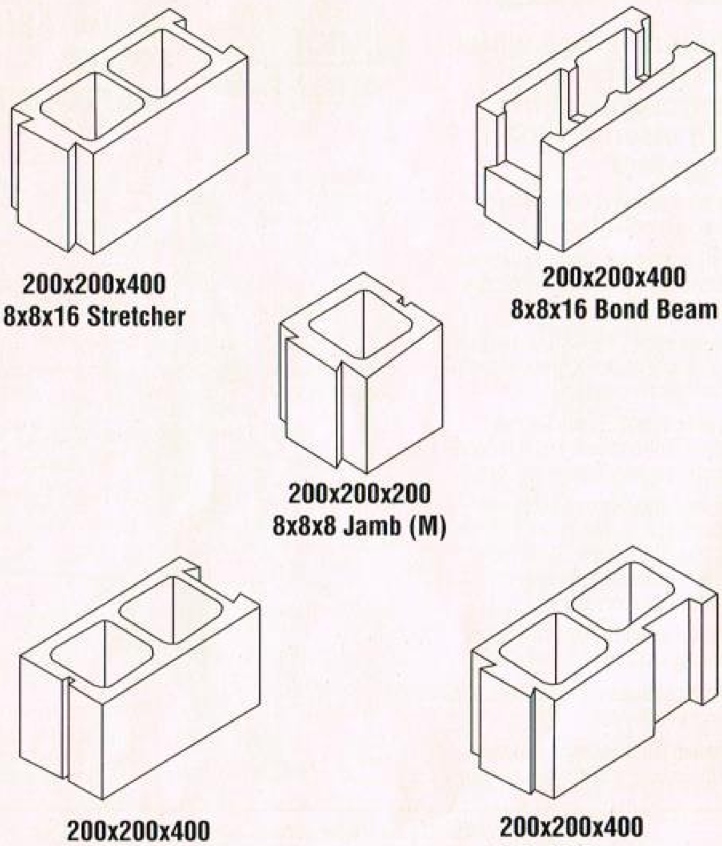

Figure 3. Dovetail block system components.

grouted walls provide masonry assemblies with properties and load capacities similar to conventional reinforced masonry systems. Height limits can approach 36 feet for three-story loadbearing walls.

Sample projects suggest substantial savings

Two small-scale projects at a Texas university have been designed by the author for construction using dry-stacked interlocking concrete masonry. In each case, the potential savings over conventional mortared masonry was substantial.

Project One is a small equine facility measuring 160 feet long by 28 feet wide, open on the front and partially open on the ends. The concrete masonry walls, including about 2,100 8x8x16-inch units, were fully grouted for protection against the horses' kicking. The interlocking units were specified in the base bid and the mortared system was specified as an alternate for comparison.

The low bidder for the project gave a base bid of $138,000. The alternate substituting the mortared system for the interlocking system was $19,000 higher, almost a 14% increase. The alternate timetable to complete the project was 10 additional days.

Project Two was a research facility of 12,356 square feet. The building included two parts: a maintenance/storage facility and an area used for classrooms and offices. Here again, interlocking units were part of the base bid with a mortared system as an alternative.

For this project, the low bidder gave a base bid of $338,000. To substitute the mortared system for the interlocking system was $34,000 higher, over a 10% increase, and would have required 25 additional days of construction.

Summary

The above projects benefitted in similar ways by using dry-stacked interlocking concrete masonry units as an integral design element of the project. Conventional mortared concrete masonry assemblages are shown to be more costly.

Conclusion

Interlocking dry-stacked concrete masonry systems have been competing successfully against reinforced concrete in Canada for years. Their structural strength and quick installation merit consideration for any construction project. Their applications are limited only by the designer's imagination. ◭

Tom Hines is an architect based in Bryan, Texas. This article is adapted from two papers he has previously published on this subject: The Use of Mortarless, Drystack Concrete Masonry as a Contributor to Affordable Construction, *which was presented at the 4th International Seminar on Structural Masonry for Third World Countries, Madras, India, in December 1992; and* Benefits of Drystack Interlocking Concrete Masonry as a Component of Cost-Effective Construction, Proceedings of the Sixth North American Masonry Conference, *The Masonry Society, 1993.*

For more information about these and other mortarless interlocking block systems, circle **101** on the reader service card.

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2. H.G. Harris, K. Oh, and A. A. Hamid, "Development of New Interlocking and Mortarless Block Masonry Units for Efficient Building Systems," Volume 2, pp. 723-734, *Proceedings of the 6th Canadian Masonry Symposium,* Saskatoon, Saskatchewan, Canada, 1992.

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