THE UNIVERSITY of TENNESSEE
Department of Civil and Environmental Engineering
223 Perkins Hall
Knoxville, Tennessee 37996-2010
Phone: (865) 974-2503
Fax: (865) 974-2669
E-mail: cee@utk.edu
web: www.engr.utk.edu/civil/

December 9, 2005

Mr. Danny Buchanan
P.O. Box 421
Trussville, AL 35173.

Dear Mr. Buchanan:

Enclosed please find a report on Speed Arch. Speed Arch is an innovative, economical means of providing formwork for constructing masonry arches. The attached report analyzes Speed Arch in the worst case – a horizontal jack arch. Speed Arch has sufficient strength even in this configuration. For the more typical curved arch, Speed Arch will have additional strength over that calculated. Speed Arch provides an acceptable alternative formwork for the construction of masonry arches.

Sincerely,

Richard M. Bennett, PhD, PE

Evaluation of Speed Arch

Richard Bennett, Ph.D., P.E.
Department of Civil and Environmental Engineering
The University of Tennessee
Knoxville, TN 37996-2010

Description of Speed Arch: Speed Arch is designed to be a form for constructing masonry arches. It is a time-saving and economical alternative to the traditional wood form construction for masonry arches. Speed Arch is not designed to be a structural element and carry load after completion of the arch. After the masonry arch is completed, the Speed Arch is no longer necessary to carry the imposed loads; the masonry arch carries the loads. The sole purpose of speed arch is to enable construction of the arch. It is a formwork – a formwork that stays in place after completion of construction. Speed Arch is to be distinguished from a lintel, which is a structural element designed to carry loads. Speed Arch should not be used as a lintel, but it is a cost-effective and very satisfactory formwork for constructing masonry arches.

Analysis of Speed Arch as Formwork: The worst case for the use of Speed Arch would be a jack arch, in which the masonry is horizontal. The critical failure mode of Speed Arch in this case would be bending of the outstanding leg. The analysis of the bending stress is as follows:

Use a 1.00 inch width and a 0.070 inch thickness.

Section modulus: $S = \frac{bt^2}{6} = \frac{1.00(0.070)^2}{6} = 0.000817 in^3$

Use an allowable bending stress of 20 ksi. This is below the yield point for any type of steel in ASTM A 653. For temporary construction loads, close to yield is acceptable.

Allowable moment: $M = \sigma S = 20000 psi\left(0.000817 in^3\right) = 16.33 lb - in$

Assume centroid of reaction is at eccentricity of 2.00 inches from critical section.

Allowable load: $P = M / e = 16.33 lb - in / 2.0 in = 8.17 lb$

Divide allowable load by 2, since tabs are only over half of support. P = 4.08lb/in

Brick weight of 40 psf, or 3.33 lb/(inch width)/(ft height)

Determine brick height, h: $h = 4.08 / 3.33 = 1.22 \, ft \; height = 14.7 inches \; height$

Height corresponds to an 8 inch soldier course and 2-3 courses of brick

Comments on analysis: The analysis assumes the worst case – a jack arch. With any curvature, the Speed Arch will have additional capacity. A finite element analysis was performed of the 6 inch segment at the top of a 6 ft semicircular arch. Shell elements were used along with a nonlinear material model to account for yielding. This portion was 40% stronger than the flat arch. The analysis also assumes a conservative value for allowable stress. Thus, Speed Arch has the strength to act as a formwork, even in the worst case.

Check fastener strength of Speed Arch:

Assume an 8d common nail fastener. For softwoods with a specific gravity of 0.36, the single shear allowable shear load is 72 pounds. The nail spacing is 2 inches on center, so the allowable shear load is 36 pounds/inch. This corresponds to approximately 10 ft of veneer before the nail fails in shear. Fastening with an 8d common nail is adequate, even if a few nails are missed. An alternate attachment would be screws, which could be used either with wood or metal studs.

Comments on brick strength gain, and the ability of the arch to support itself and additional load: Brick gains compressive strength quite quickly, so an arch is able to support itself, and some additional load, shortly after construction. A study by McGinley et al (2003) measured lintel deflections when reshores were removed 1.5 hours after the brick was laid. From the deflections, it was clear the brick was carrying most of the load itself, indicating the ability of brick to carry compressive loads shortly after being laid. An arch will therefore quickly gain strength, so that additional masonry can be laid without imposing additional stress on the formwork – Speed Arch.

Reference: McGinley, W. M., Johnson, E.N., and Bennett, R.M. (2003). "Considerations in the design of lintels for masonry veneers." Ninth North American Masonry Conference, The Masonry Society, 346-357.