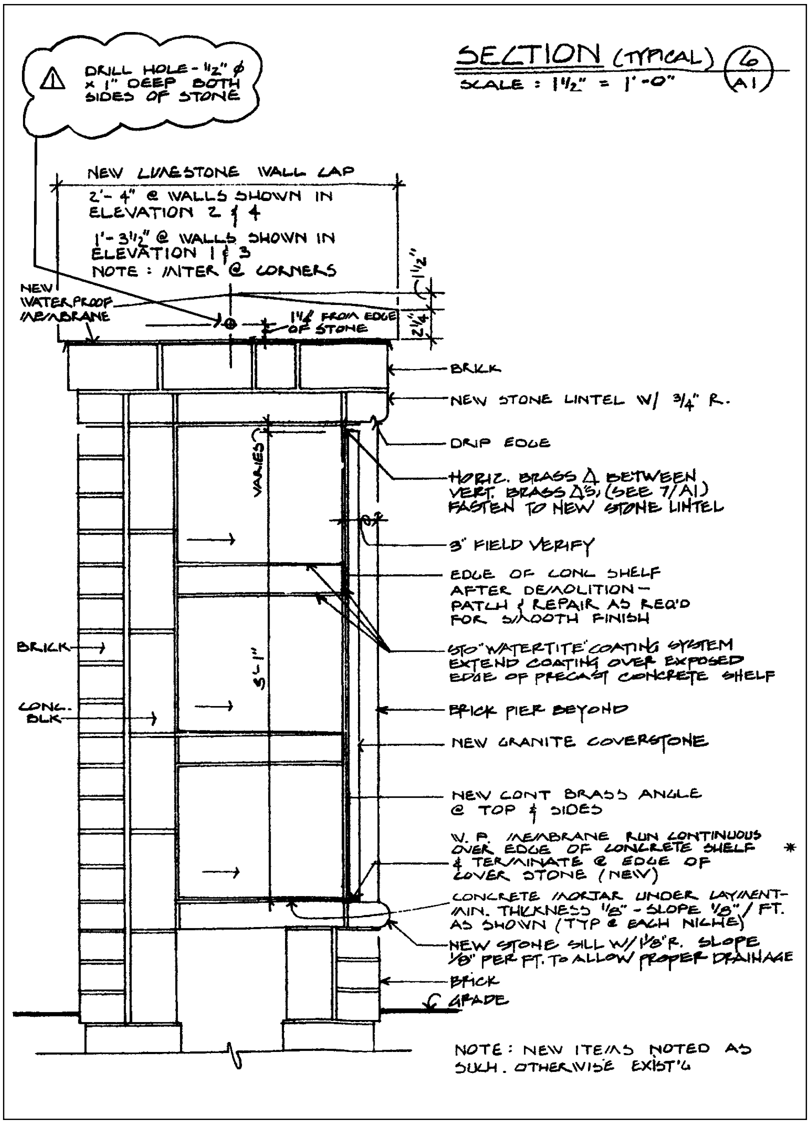
Towson United Methodist Church Columbarium Restoration

Cause and Effect

By Stephen A. Johanson

In 1994, the Towson United Methodist Church engaged an architectural /engineering group to prepare plans and specifications to restore their deteriorating columbarium. A field study was engaged to map the type and extent of deteriorated stone, distressed metal trim finishes, and structural damage to the urn niches and masonry core. The Breckstone Group, Inc., of Wilmington, Delaware, developed plans and specifications for the restoration of this structure. Specific detailing was outlined to assure waterproofing practices and repair material selection met with the current requirements of the National Brick Institute and ASTM Standards.

Culbertson Restoration Limited of Maryland was enlisted in the spring of 1995 to perform these repairs. The specified scope of work included the removal of existing brick wall cap; removal and replacement of the masonry facade; removal of the existing concrete lintels and marble cover-stones; waterproofing of wall and niche interiors; and installation of new cover-stones, metal accent plates, and stone wall cap. Detail 6/A1 identifies, in general, the proposed scope (see Figures 1 and 2).



Detail 6/A1

Fig. 1

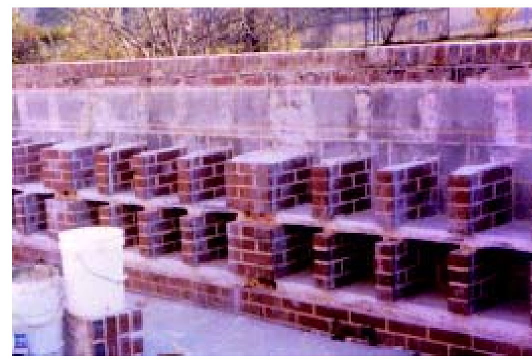


Fig. 2

Fig. 3

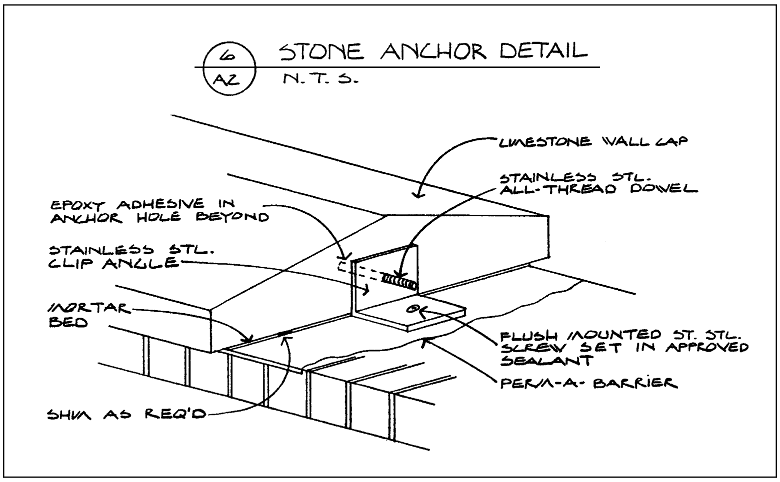
Problems

Within one year after the completion of this project, the columbarium began experiencing efflorescence on the interior and exterior walls (see Figure 3). Efforts by the contractor to clean the staining from the wall only slightly improved the appearance. Restoration chemicals were used with similar results. In 1997, the mortared joints between the dolomite capstones were replaced with a flexible urethane joint. These remedies helped improve the appearance of the columbarium. None of these attempts, however, fully resolved the recurring problem.

Culbertson Restoration and The Breckstone Group employed the John Greenwalt Lee Company and Dr. James Edwin Adams, PhD, to review photographs of the masonry walls of the columbarium, which were taken before, during, and after construction. A preliminary investigation was performed of the wall to test multiple samples of the brick and mortar. Plans and specifications for the project were provided for their review. A complete history of remedial work, which was performed to eliminate the efflorescence problem, was also provided.

The laboratory analysis examined the masonry surfaces for the presence of soluble salts and/or insoluble precipitates. The analysis identified the white surface deposit as precipitated calcite. Precipitates are the products of concentrations of ions of a substance in a saturated solution of the substance. This precipitate formed as a solid, white, or translucent substance deposited on the surface of the brick and adjacent masonry surfaces. The following is an explanation of the dissolution of calcium in water and its precipitation as calcite.

There are several reactions involved in the leaching of calcium bicarbonate from calcareous materials. These reactions involve water, carbon dioxide, and a calcium compound. Calcium bicarbonate is the most soluble form of calcium and is produced in the following reactions:



Detail 6/A2

REACTION A:

$$H_2O\ (l) + CO_2\ (G) = H_2CO_3\ (aq),$$
$$H_2CO_3(aq) + CaCO_3\ (s) = Ca(HCO_3)_2(aq)$$

The reaction described above will result from carbonic acid (acid rain) in contact with calcareous materials. Lime (CaO) and portlandite $Ca(OH)_2$ can also form calcium bicarbonate and then dissolve:

REACTION B:

$$CaO(s) + H_2O\ (l) = Ca(OH)_2\ (s),$$
$$H_2O\ (l) + CO_2\ (g) = H_2CO_3\ (aq)$$

then,

$$Ca(OH)_2\ (s) + 2H_2CO_3\ (aq) =$$
$$Ca(HCO_3)_2\ (aq) + 2H_2O\ (l)$$

In the above cases, the production of calcium bicarbonate is dependent on carbonic acid, common in rainwater. The mortar used in the Towson Columbarium contained hydrated lime $Ca(OH)_2$ that allowed the second set of reactions to occur. If there is limestone in the aggregate fraction of the mortar, then the first set of reactions will also occur and contribute to the formation of calcium bicarbonate.

After calcium bicarbonate has formed and dissolved, it is free to move in solution. During transport, periods will occur when the calcium bicarbonate is no longer in equilibrium with the other calcium compounds, or the carbon dioxide is no longer at equilibrium with the water. Temperature and pH are also important in forming the precipitate. If either temperature or pH is raised, calcite will become less soluble and precipitate out of the solution as follows:

$$Ca(HCO_3)_2 = CaCO_3(ppt) + H_2O + CO_2$$

Solution

The above description of the mechanism of calcite formation is helpful in understanding the nature of the problem of "staining" on the columbarium. The placement of the waterproof layer (see Detail 6/A2) between the top of the brick wall and the mortar above meant water that entered the vertical joints in the stone cap was trapped. Over time, this high water content in the fresh bedding mortar enabled the lime (as calcium hydroxide) to go into the solution. It was carried to the surface where it dipped and ran down the face of the bricks and also collected on the stone nosing below. Culbertson's reports of the appearance of the initial deposits, and results from the cleaning, support this conclusion.

Once the vertical joints were raked out and caulked, the amount of new deposition decreased as less water entered above the waterproof membrane. In addition, the remaining calcium hydroxide was largely converted to calcium carbonate. The amount

Fig. 4

Fig. 5

Fig. 6

of lime in the mortar limits the amount of calcite that can be deposited over time. With the water movement restricted, new deposits are not likely.

Recommendation

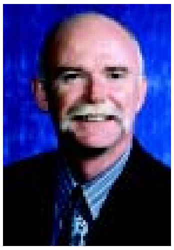
Design considerations on future projects should include extending the capstone to extend a minimum of two (2) inches beyond the face of the wall. The overhang should be provided with a three-eighths (3/8) inch drip lip, located approximately three-quarter (3/4) inch back from the edge of the capstone.

Resolution

The small amount of calcite that remains on the surface of the stone and concrete can be removed or greatly reduced by gentle mechanical cleaning. We started with some tests in small, out-of-the-way areas using a medium grade of Scotchbrite. The deposits on the brick were individually removed with very dilute hydrochloric acid. Reduce standard muriatic acid to a concentration of 2% with water. Wetting the wall down before you begin is important. Continue to wet ahead of the immediate working area. Apply the 2% solution with a bristle brush directly to the calcite deposits. They should come off immediately. Try not to flood the wall or the mortar joints with the dilute acid. Rinse the surface, allow surface to dry, and rinse again. Repeat several times. After each rinse, it is prudent to check the pH of the wall. Allow the wall to dry overnight or over several days and then re-examine it. Repeat the cleaning process on any remaining deposits, then rinse again, checking the pH in the remaining isolated areas. Even though this type of cleaning process is labor intensive, satisfactory results can be achieved once the cause is defined. The end effect, after all, resolved each party's concern.

Repair

The duration of work was approximately three (3) months. All deteriorated pre-cast and masonry were removed from the structure. Each niche received new pre-cast planks and additional masonry units. Repair mortars lined each urn niche. Curing of the structure (see Figure 4) provided for proper hydration of the masonry mortar and copolymer repair mortars. A new waterproofing through-wall flashing was installed on top of the columbarium's wall (see Figure 5). Architectural metal ornamental finishes and marble niche cover stones were added (see Figure 6). Dolomite capstones were set in a mortar bed. Head joints were grouted with the same material consisting of portland cement, ASTM C 150, Type 1; hydrated lime, ASTM C 207, Type 5; and mortar aggregate, ASTM C 144, standard masonry type (see Figure 6).



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