Conservators Assessment: Masonry and Exterior Paint

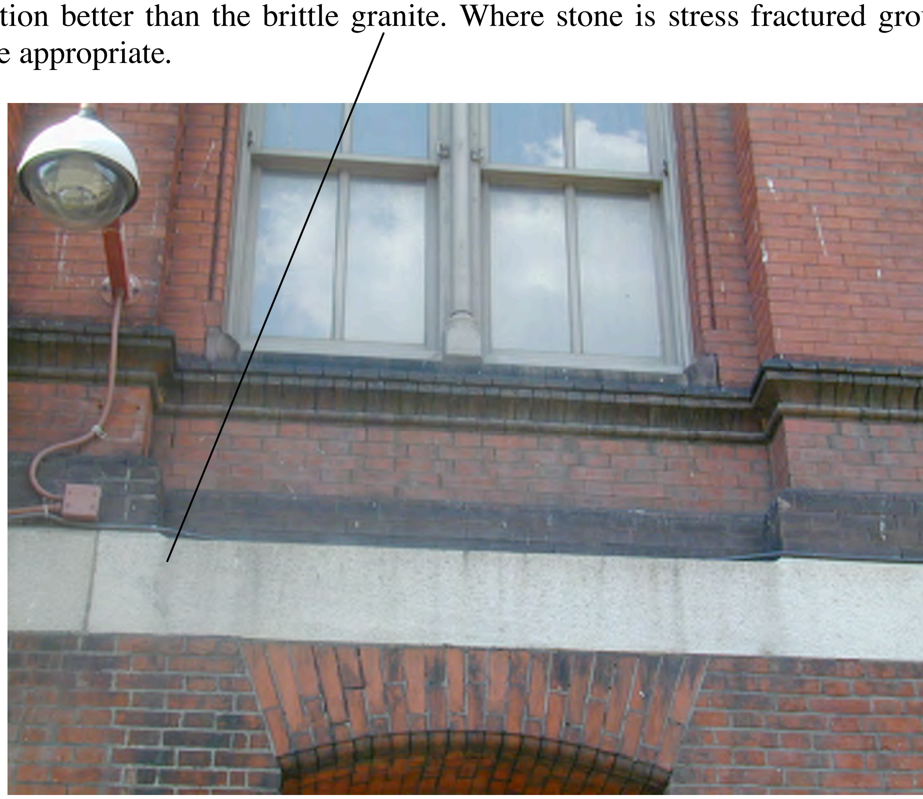
The masonry conditions are quite consistent across the building and most of the same failure mechanisms repeat from elevation to elevation across construction periods.

Stone

Stone copings under the gutters have been subjected to significant water intrusion that during cold weather has assisted frost-jacking damage. These stones need to be relaid in proper alignment. To add to the longevity of the solution and create a better maintenance solution, we recommend a gutter liner that covers the entire upper face of the stone and creates a drip edge to keep water off of the stone surface.

Beyond the immediate delaminations at the surface or areas where the stone has been placed under extreme stress, the sandstone in general appears to be quite sound – with the exception of that form under the granite at the "moat" level. It would be useful to locate any correspondence regarding the later building additions where the sandstone began to be replaced. Was this replacement due to early deterioration or was it only a simplification of the construction palette? Considering the amounts of coal being burned during the decades after construction, rapid deterioration early would have been more likely and the rate may now have simply slowed due to decreases in pollution levels.

Stone failure due to stress fracture is most often seen in the granite elements that are very long compared to their thickness. This is particularly seen at window sills where the jambs are under a considerable load and the window area has almost none. The other stones seen as window sills show less breakage, likely because they will accommodate deformation better than the brittle granite. Where stone is stress fractured grout repairs would be appropriate.



Remediation at Outcroppings and Projecting Belt Courses

At each projecting belt course the mortar formulation is weak already as on the rest of the building. But these areas are also subject to far more weathering as water is continually washing down and wearing away the vertical joints. Skyward-facing mortar joints should be a regular maintenance issue that is addressed at least every couple of decades.

All stone and terracotta outcroppings or projections would do well to be capped in metal. Copper would profoundly stain. Lead-coated copper would not conform to the irregular masonry tops. Lead however is able both to fully conform to all irregularities in the surface below and has enough integral weight that additional attachment methods apart from letting the top edge into a mortar joint and setting with lead wedges would be unnecessary.

Terra Cotta or Shaped Brick Details

The terra cotta – shaped brick and decorative ceramic units are not manufactured to the same quality standards that we would expect today. The existence of large numbers of warped pieces create the appearance of their being way out of position once the surrounding mortar fails. There appear to be many areas of misalignment at first glance which are in fact due to irregularity of the masonry units and not deflections. Therefore expecting a total uniformity of appearance after repair is inappropriate.

This is not to say that there are not a few bricks that have slipped in these arches, but most of the irregularity is due to the misshapen units themselves that created unsolvable condition for the masons.

On the small terra cotta pilaster band that returns into window, the corners are mitered. This creates very thin and therefore very weak corners. These corners occur at the windows and not at the building corners where the pieces have full thickness edges.


Mortar Composition and Weathering

During the construction era of these buildings, carbon black was commonly used as a pigment. These pigments tend to be much less stable than the iron oxide pigments we use today. However, black mortars tend to be weaker because of the amount of pigment loading required to achieve the strong color. In this case, the ratio of binder to cement (lime only) is inherently weak.

Earlier reports on this building suggested the lime-aggregate ratio was 1:1 volume ratio. This would have made an extremely weak mortar. Structural integrity in mortar comes from the aggregate (sand) with greater strength being attributed to angular as opposed to rounded sands since they lock together better. Additionally, the strength accrues to a good particle size ratio meaning that the sand particle is not of a consistent size, but rather occurs over a wide range of sizes with the majority of the aggregate in the mid-range. In this way, the structure of the sand would allow smaller particles to fill in voids that might be created between larger particles.

The cementing portion or binder of any mortar then ideally only thinly coats the aggregate and binds everything together. There must be just enough lime in this mortar to barely cover all aggregate surfaces and no more, no less. A 10% calcium carbonate and 90% aggregate mortar reading then might be misinterpreted as a 1:10 mix when in reality it is much closer actually to a 1:3 mix. This is because one reading relates to mass, the other with volume. Even if assessed solely by mass, with a 30% solids lime putty, then only 3/10 of the binder is putty and the rest is water.

Weathering of the mortar, and specifically dissolution of the binder from heavy acid rain in past eras of heavier sulfur pollution, have lead to white calcite deposition on the front of some joints. Scratching the surface quickly uncovers the original black mortar used to construct the building.

Infill areas

From the outlines of earlier structures on the building façade and the location of infill masonry, it appears that this structure once had a maze of fire escapes that were later removed. The infill areas are unattractively executed and often contribute to deterioration on the building whether through vertical alignment from window sill down through multiple courses of the same joint or from material interactions with the concrete sills at windows (once doors) that are leaching unreacted lime into the surrounding materials below. It would be wise to correct the materials and methods of construction at these locations as part of this project.

Alterations

Alterations related to removal of earlier fire escapes *(outlined).*

Changing Ambient Conditions:
Why Atmospheric Changes Have Accelerated Mortar Decay

Although our increased awareness of the detrimental effects of sulfur emissions often leads to a sense that our environment is generally more polluted today, in fact sulfur compound levels in our atmosphere are actually lower today than they have been during most of the life of the Auditors Building. During periods of high-sulfur coal combustion for heating and lower expectations for clean-burning automobile fuels, the levels of sulfur in the environment were very high and contributed significantly both to the visual soiling of building facades and the development of detrimental chemical compounds on the surface of building materials.

The Windows

The lower windows are new – this includes all of the sash and nearly all of the wooden trim below the transom.

Earlier window locations found in the form of paint ghosts highlight the changes at these windows, i.e. window replacement.

The transom areas appear to be sound in nearly all instances, aside from nearly wholesale paint failure from lack of maintenance. Removal of this lead paint should be carried out using one of the new n-Methyl-2-pyrrolidinone paint strippers with a lead chelator. These strippers remove all traces of the lead while being comparatively safe for the application crew and they do not add any chemicals that would be detrimental to the masonry, unlike methylene chloride or alkaline strippers that are rarely neutralized adequately. Significant failure of window glazing in the transom areas will also require careful replacement.

Originally the window paint was probably not monochromatic. It is our contention that the original visual intent at the windows was for them to "read" as brownstone trimmed, blending in with the surrounding stone, with aged copper sash. This appearance would have imitated a large structure of gothic stone construction. The paint evidence supports this theory as the original was a reddish-brown textured paint on all of the trim area. The sash paint suggest a verdigris color, as with aged copper under highly polluted conditions (it is hard to get copper to change to this green phase under today's cleaner environmental conditions).

Surface Staining

In general the arches have vertical joints that have washed out. It appears that the discolorations in the window recesses are from carbon black dark stains and a lime haze is visible on the undersides due to deterioration of the mortar as water has been washing through. In thinking about how to clean these areas, it should be noted that surface soiling is normally washed away by the rain. It is only in these areas below building projections that are heavily protected from this rainwater washing that the staining is particularly heavy.

Thermal Expansion and Contraction on Large Masonry Structures

This building – as with any large masonry building – is in constant motion due to thermal changes both daily and more extremely seasonally. And expansion and contraction rates are differential from elevation to elevation.

With interior concrete slab floors and the building heated, the slabs are in their warm condition while the skin of the building is trying to contract during the winter. Building corners therefore tend to exhibit the most stresses due to this competing expansion and contraction. Corners can not move in against the slab while the rest of the skin is trying to pull in. The damage is cumulative so the greatest force is at the corners, but the break area is generally focused into the nearest weak point – in this case that means that moving in from the building corners to the nearest weak point the brick window edges show cracking that is more severe moving toward the exterior building corners and to a lesser degree at interior corners. Queen closers at the window edges do allow the cracks to generally follow the mortar joints without pushing on through the bricks themselves.

Around the turn of the century new building materials were being mixed with traditional ones into buildings that were also growing in size. The period of construction for much of this building is relatively early in the use of concrete slabs in buildings, therefore the understanding of these interactions – especially as these buildings are growing much larger and higher – was limited. The addition of expansion joints was a later response to the resulting problems of dissimilar expansion and contraction rates and mass.

First floor brickwork

The appearance of most of the ground floor brickwork is considerably different from the rest of the building because of inappropriate repairs and cleaning methods used in the past. Attempts to remove paint from the surface with unnecessarily high water pressure has significantly increased the surface area and texture of the brick faces in some areas. Removal of fire escapes and gate hinges have left areas with damage due to differential stress and differential weathering of areas that were once protected. Much of the ground floor has also been repointed after brutal grinder cleaning of the joints that has both enlarged the width of the joints and made the coursing appear more irregular, even sloppy, especially with the use of concave jointing tools. And these lower areas of repair were generally repointed with a white mortar, as opposed to using the black mortar of the original construction. This may be due to a perfunctory assessment of the original, but deteriorated mortar where many of the lower joints have a white surface coating from redeposition of calcite where the mortar had been dissolved under acid rainwater.

Gutters

Gutter failure has contributed significantly to deterioration of the uppermost masonry elements. Some of this is due to insufficient drain locations, overly long runs without expansion joints leading to seam failure. An extended life solution associated with this would involve a wider margin to the gutter liners that would completely cover the skyward-facing of the adjacent stones and create a drip edge. The tide lines indicate water is standing in long sections of the gutter for extended periods.

Light well masonry realignment

The retaining walls of the light well "moats" are experiencing a differential horizontal displacement, apparently from the fill load behind. This would imply that the walls are too light. This could be remedied by excavating behind the wall and installing an engineered cast in place concrete retaining wall to which the existing brick walls can be attached as "veneer." The existing walls can be re-aligned before attachment to the structural retaining wall behind and the cracks ad voids grouted. We have re-aligned walls in several projects, one relatively local was for the International Masonry Institute. This is not difficult or on the scale of moving the Cape Hatteras Lighthouse and is very cost effective when compared with replacement.

Buttressing concrete insets worsened misalignment stresses on moat retaining walls - both stone and brick

Summary Comments

Although the current contract recommends complete mortar replacement, a more refined approach that addresses only the most deteriorated joints and a repair schedule that prioritizes grouting and pointing at the belt courses would be a sound approach.