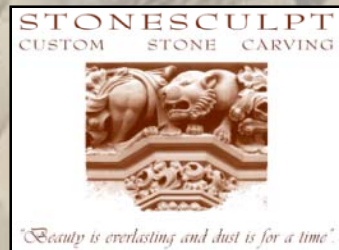


# Stanford Balustrade Restoration

2006-2007



# Background

- Sandstone balustrade built circa 1906
- Consists of three elements:
  - Balustrade
  - Walls
  - Light posts
- Divided into sections with 5 to 15 balusters
  - 68 Sections
  - 495 Balusters
  - 6 Light posts

# Project Goals

- Restore the structural and aesthetic integrity of the balustrade
- Preserve as much of the original masonry as possible
- Take preventative measures to delay future degradation

# Symptoms of Deterioration

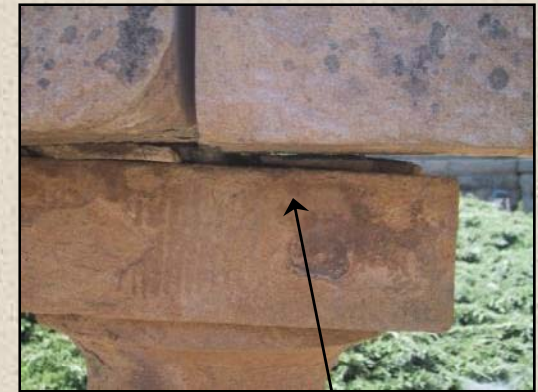
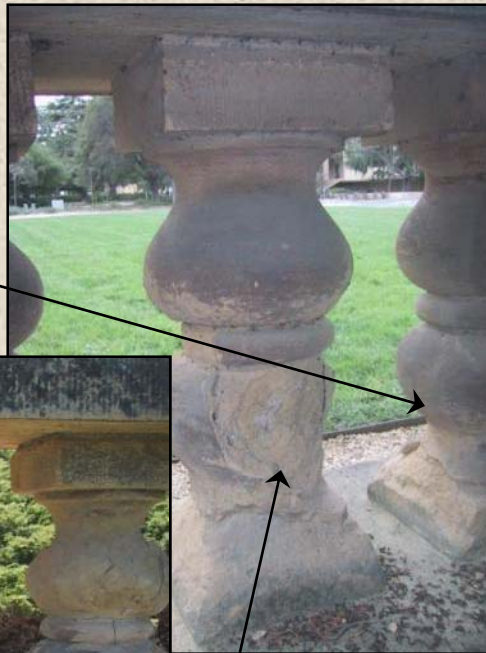
- Hardening
- Fissuring
- Spalling
- Surface Flaking
- Surface Discoloration
- Fracturing and Displacement



# Symptoms of Deterioration

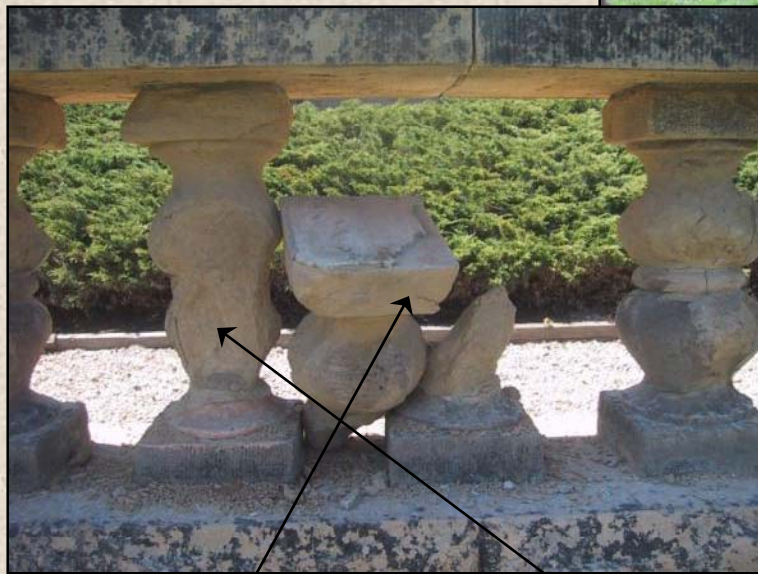
- Balusters

Hardening



Fissuring

Displacement



Collapse

Spalling



# Symptoms of Deterioration

- Top stones

Fissuring



Surface Flaking

Hardening

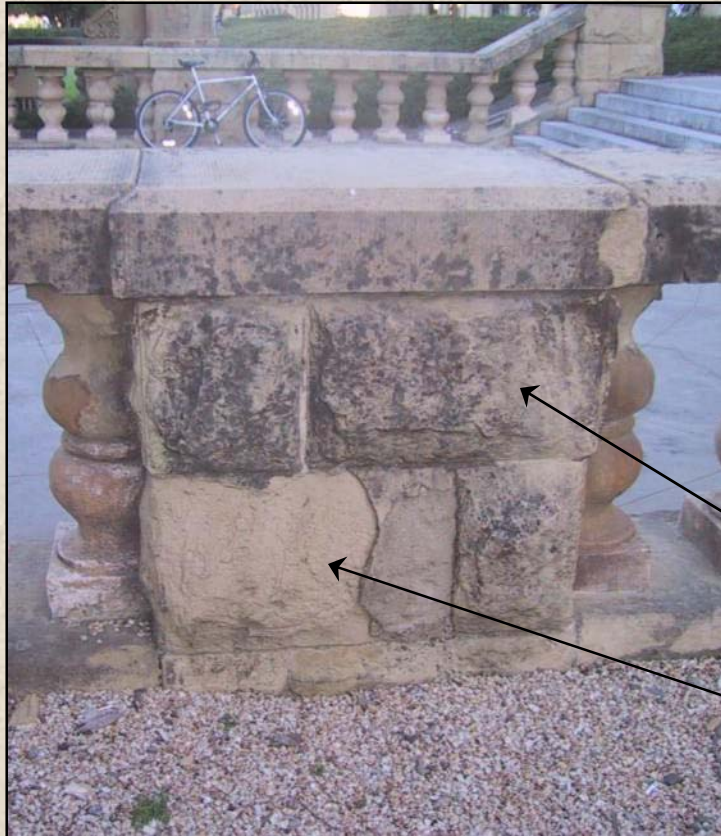


Spalling



# Symptoms of Deterioration

- Walls



Fracturing

Hardening

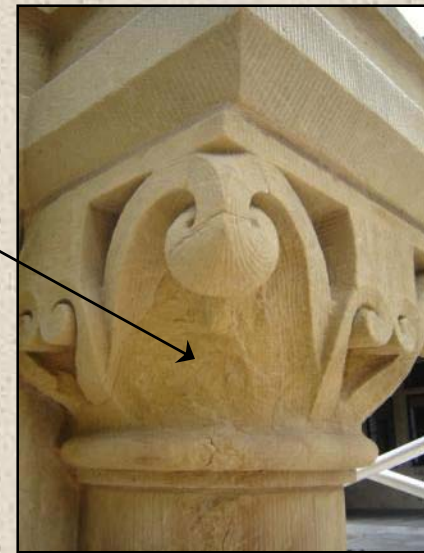
Spalling

Displacement

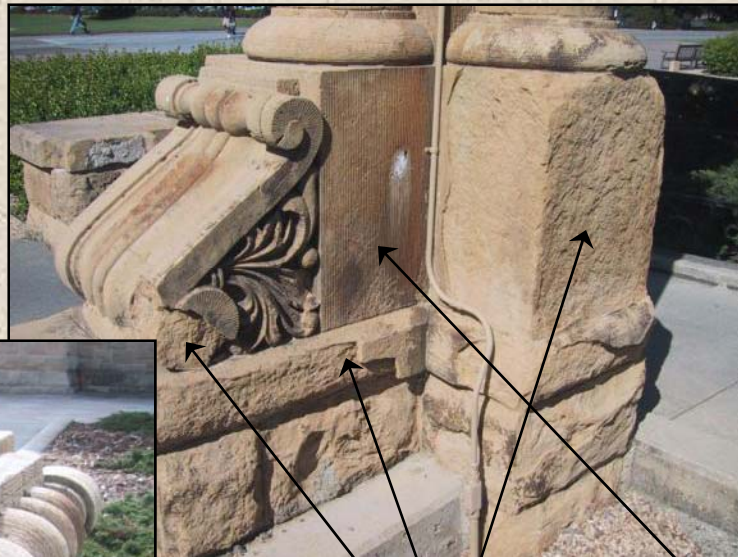
# Symptoms of Deterioration

- Light posts

Surface Flaking



Fissuring



Spalling

Ferrous Stains





# Previous Work

- Concrete patches
- Precast replacement balusters
- Redesigned irrigation and drainage



# Restoration Techniques

- Cleaning
- Replacement Balusters and Top Stones
- Structural Reinforcement
- Realignment of Displaced Stones
- Repointing
- Composite Patching
- Fissure Repair
- Waterproofing

# Restoration Techniques

- Cleaning



Power washing removed layers of dirt and biological growth.



Redish brown stains on light posts were removed with Ferrous Stain Remover by Prosoco (above). Tests were first preformed to determine the workability of the product (right).



# Restoration Techniques

- Replacement Balusters



1. Joints between top stones were opened.



2. Top stones were removed. Mechanical keys existed between some top stones, making removal difficult in some cases.



3. Balusters were first loosened (top) and then removed. Upon removal, the extent of decay became apparent, as the bottoms of nearly all the balusters fell off (bottom).

# Restoration Techniques

- Replacement Balusters



4. New, pre-cast balusters were installed in the original positions.

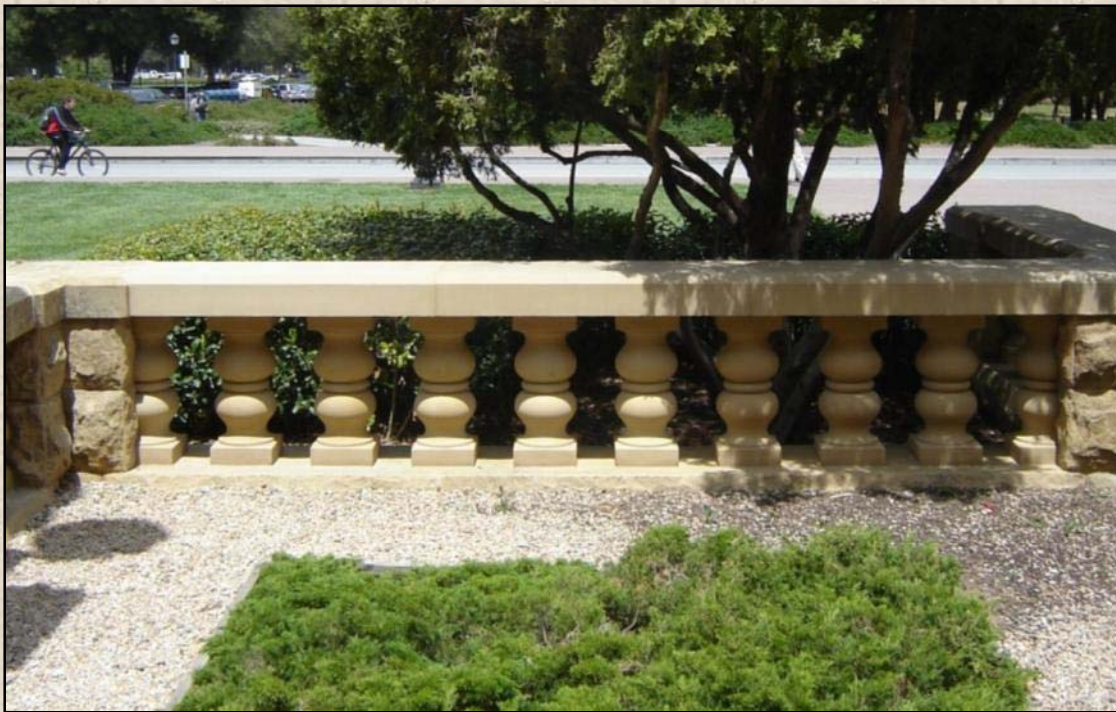


5. Top stones were replaced (above). Many top stones were curved slightly upwards on either end. Mortar thickness on top of the balusters (left) had to be adjusted to take this into account.



# Restoration Techniques

- Replacement Top Stones

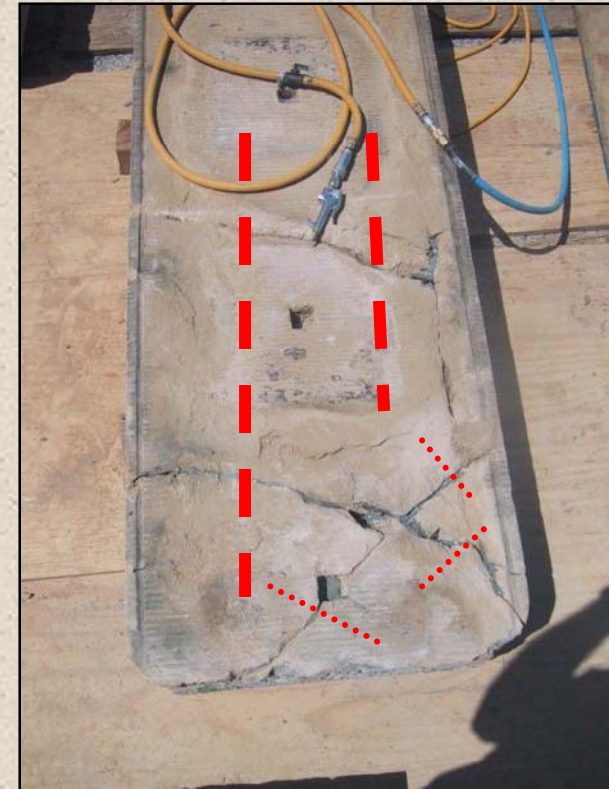
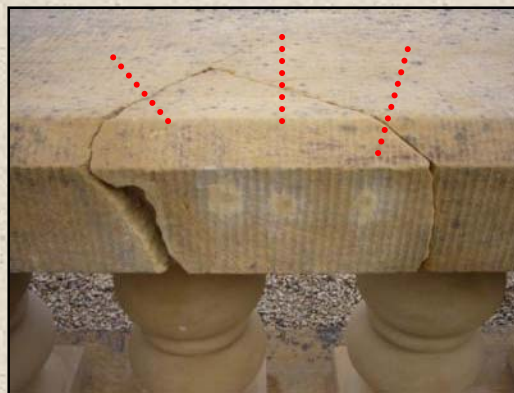


In cases where top stones were completely missing, they were replaced with pre-cast stones (above). In one case, the last original top stone from Stanford's storage site, "the Boneyard" was used as a replacement (top right). This stone, required the creation of tooling marks on the side faces; this was accomplished by hand with flat chisels (bottom right).

# Restoration Techniques

- Structural Reinforcement

Top stones with large breaks were removed using angled steel braces, then the pieces were separated and cleaned (right). In some cases, channels were made across the break on the underside (below), and two layers of 1" stainless steel support rods with epoxy were inserted. Later, the channels were covered by composite patching, along with other prepared areas of the underside.



In other cases, holes were drilled horizontally into each piece. A stainless steel rod with epoxy was inserted, and the pieces were pushed together. In the photographs above and to the left, large dashed lines represent where 1" rods have been inserted, and small dashed lines represent 1/2" rods.

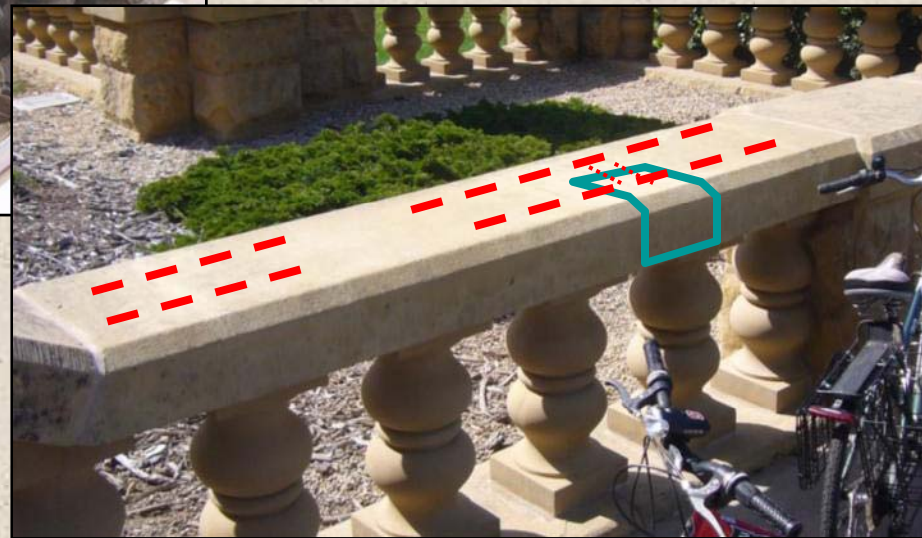
# Restoration Techniques

- Structural Reinforcement (Dutchmen)



In the diagram below, the blue outlines the area where the dutchmen was installed. The large red dashed lines represent 1" diameter rods, and the small red lines represent 1/2" diameter rods.

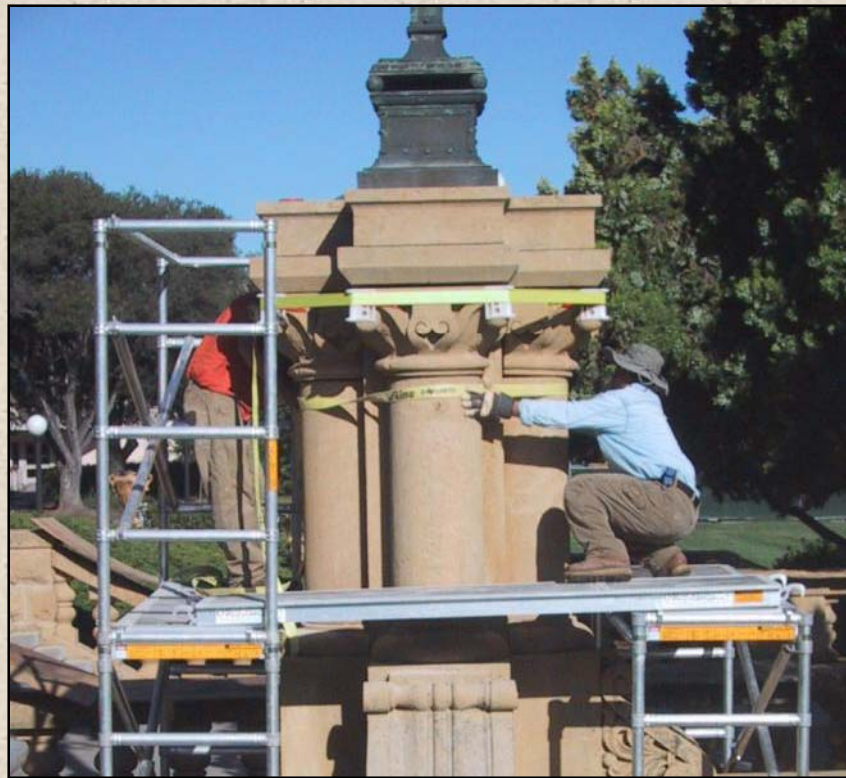
In one case, a large dutchmen was necessary to repair a severely damaged top stone (above). The missing area was first cut to a rectangular shape. A piece of original sandstone from "the Boneyard" was cut to match and installed with stainless steel rods. Other fractured pieces were also reinforced so the final product looks like one solid stone (right).





# Restoration Techniques

- Realignment of Displaced Stones



# Restoration Techniques

- Repointing

Many joints in the walls and light posts were in need of repointing. These joints were first opened with a grinder (below) and cleaned.



Before repointing, various mortar mixes and pigments were tested to find a color and texture that matched the old mortar (above).

After installation, the joints around the new balusters were repointed (above). The joints between top stones were first filled with grout (right) to 1" below the surface, and then repointed.



# Restoration Techniques

- Composite Patching
  - Cathedral Stone Products, Inc.
    - Jahn M70 Repair Mortar
      - Water based,  $>1/4$ " depth, self-curing, color matched
      - Edges, corners, and undersides of top stones
      - Edges and topsides of bottom stones
      - Bottoms of balusters not replaced
      - Columns and capitals of light posts
      - Faces of rough cut wall stones
    - Jahn M125 Thin-set Repair Mortar
      - Water based,  $<1/4$ " depth, color matched
      - Fissures and small voids on all masonry elements

# Restoration Techniques

- Composite Patching
  - Edison Coatings, Inc.
    - Custom SYSTEM 45
      - Polymer based,  $>1/4$ " depth, not color matched
      - Bottom sides of some top stones
      - Not used as extensively as Jahn M70
    - Thinfill 55
      - Polymer based,  $<1/4$ " depth, not color matched
      - Fissures and small voids
      - Not used as extensively as Jahn M125

# Restoration Techniques

- Composite Patching

- Jahn M70 Repair Mortar

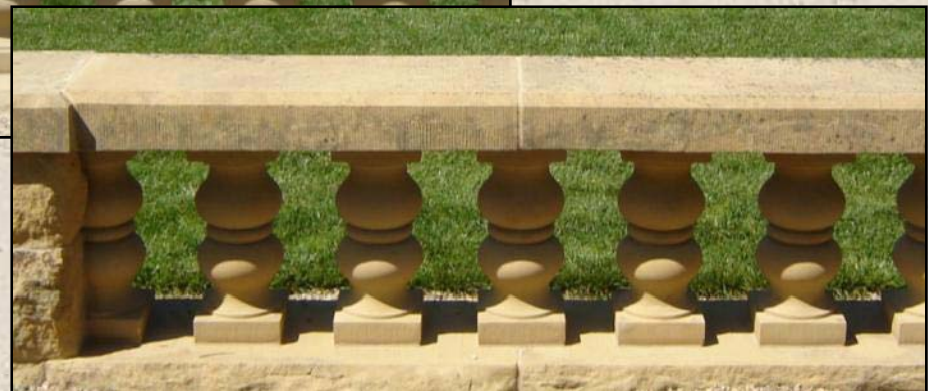
- (similar process for Custom SYSTEM 45)



Loose and deteriorated stone is first removed from the surface. In some cases, large pieces of loose stone can be reattached with pins and epoxy. A grinder is then used to create a mechanical key over area to be patched. The weathered edges are cut to at least ¼" and a crosshatched pattern is created along the surface.

# Restoration Techniques

- Composite Patching



Note areas where pieces have been pinned back in their original location, as well as areas which have been patched.

# Restoration Techniques

- Composite Patching



Extensive patching on the undersides of top stones. This was the only area where Custom SYSTEM 45 was used, because the color did not match the sandstone.



# Restoration Techniques

- Composite Patching

Balusters not in need of replacement were patched in three layers: the square base, the circular disc, and the remaining curved area.





# Restoration Techniques

- Composite Patching

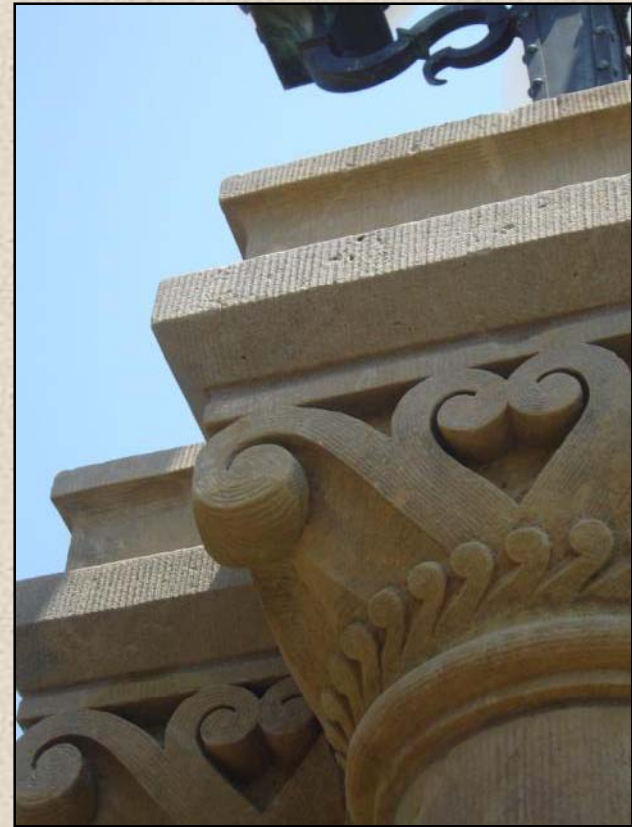


Old concrete based patches were first removed before patching with Jahn M70.



# Restoration Techniques

- Composite Patching



In severely deteriorated areas, small stainless steel pins were added as structural reinforcement for the patch.

# Restoration Techniques

- Composite Patching



Patches that required complex shaping were accomplished with the help of stencils made from areas which had not deteriorated.

# Restoration Techniques

- Composite Patching
  - Jahn M125 or Thinfill 55



Patching with Jahn M125 or Thinfill 55 was similar to patching with Jahn M70, but on a smaller scale.



# Restoration Techniques

- Fissure Repair
  - Jahn M125 or Thinfill 55



Large cracks were first injected with Jahn M125 or Thinfill 55 (left). At the surface, cracks were filled with a trowel (above). After partial drying the mortar was scraped and tooled to match the profile of the surrounding stone. Later, pigments were applied to match the surrounding color.

# Restoration Techniques

- Waterproofing
  - R97 by Cathedral Stone Products, Inc.

Two coats of R97 water repellent were applied to all masonry units after patching and repointing were complete. In the photograph on the right, R97 has been applied to the top stone on the left, note the effect of the water repellent.



# Summary

- 435 New balusters installed
- 60 Older balusters restored
- 5 Missing top stones replaced
- 33 Top stones reinforced with 1" steel

The Stonesculpt team, from top left: Jason Black, Alfonso Orozco, Orion Lakota, Gyurme Tethong, Starford TauTua'a, Shawn, Oleg Lobykin.

