Historic Building Cast Stone and Masonry Façade Restoration Using Photogrammetry

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WALKER
CONSULTANTS

PROJECT BACKGROUND

Lancaster Hotel

- 12-Story Structure Built in 1926
- Reinforced concrete frame
- Façade: Single wythe brick veneer with ornamental cast stone elements and terracotta copings
- Historic Landmark by Texas Historical Commission (1984)

CONDITION ASSESSMENT

- Binocular Survey and Close-up observation from suspended scaffolding performed (2002-2014)

- Deterioration Observed:
  - Deteriorated mortar joints, failed sealants
  - Cracked and spalled masonry and terracotta
  - Corroded shelf angles
  - Cracked, spalled, or missing ornamental cast stone

- Cast stone reinforcement cover was inadequate

DETERIORATED SPANDREL PANELS

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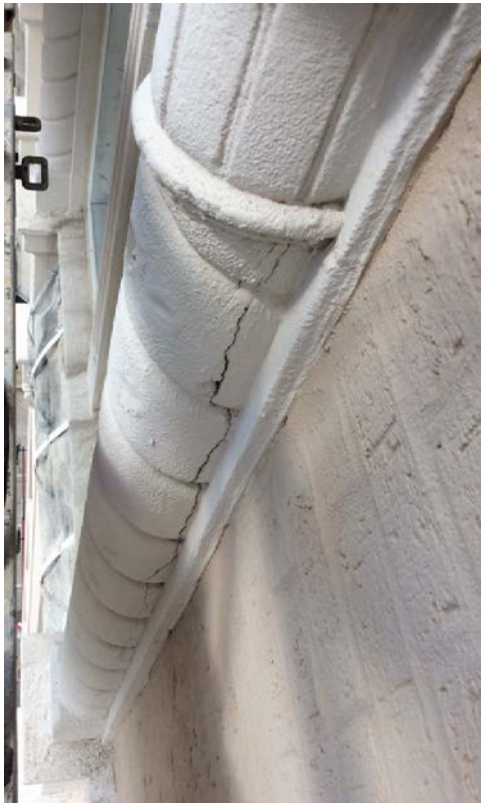
ORNAMENTAL CAST STONE DISTRESS



WATERPROOFING AND STRUCTURAL ELEMENTS

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REPAIR PROGRAM

- Repair façade cracks and localized cast stone, masonry spalls.
- Repair deteriorated shelf angles and lintels
- Repair building terracotta coping
- Replace cast-stone in kind:
  - 28 spiral column and bracket units
  - 14 spandrel panels (30” high x 60” wide)

CHALLENGES

- Accessibility
  - Spandrel panels located near roof level
- Existing Damage
  - Panels severely deteriorated
- Complex Geometry

CHALLENGES

Required a method that was:

- Cost-effective
- Simple to implement in the field
- Accurate in geometry and scale
- Able modify object during post-processing
- Compatible with existing 3D printing and milling technology

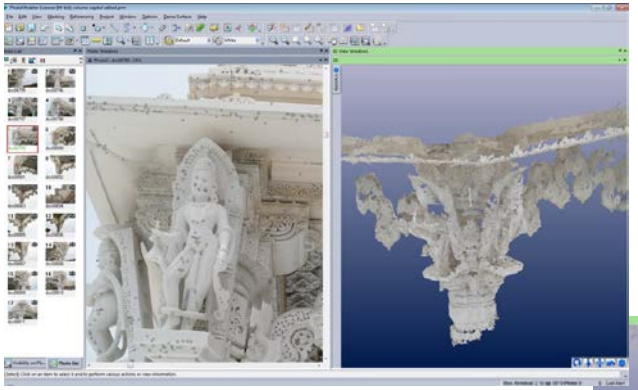
WHAT IS PHOTOGRAMMETRY?

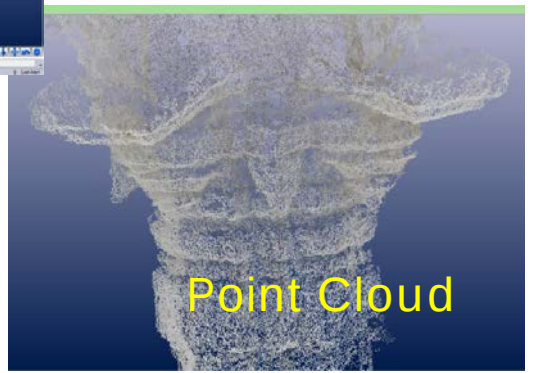
It is the science of making measurements from photographs

1. Mathematical algorithms scan the photographs taken to find matches.

2. Once points are matched, (X,Y,Z) coordinates are developed for each point.

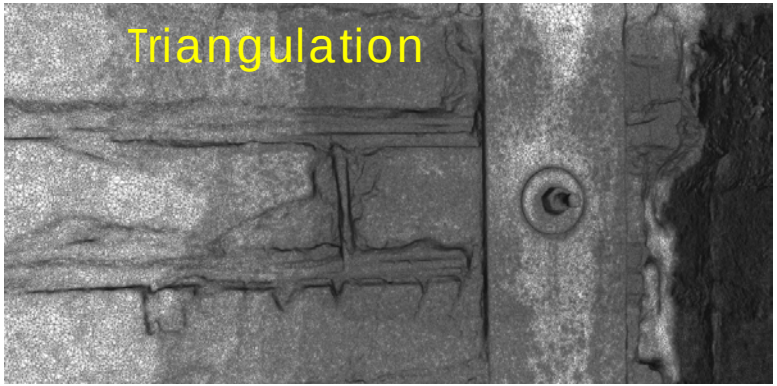
3. Points create a Dense Point Cloud similar to the output of a laser scan (lower number of points).





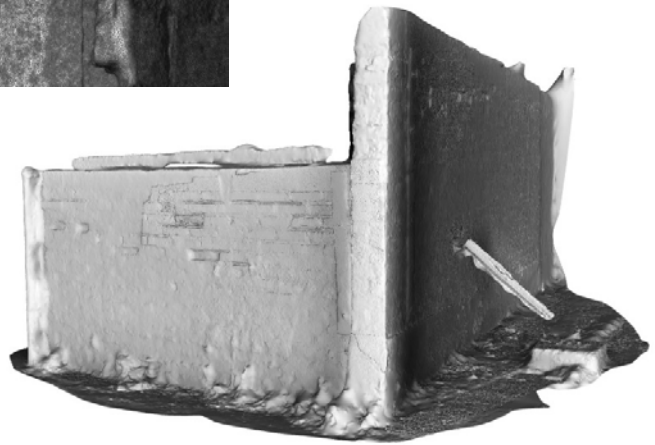
PHOTOGRAMMETRY 101

4. Point cloud is triangulated by creating surfaces between the points



5. Textures are created in the model based on the input photographs

6. Model undergoes post-processing



Mesh without Textures

REPLICATING THE LANCASTER HOTEL SPANDREL PANELS

WORK FLOW

1. Document:

Document object with photographs and overall dimensions

2. Model:

Develop a 3D model using photogrammetry software

3. Post-process:

Adjust scale, dimensions, and repair any deficiencies present in the physical object

4. Fabricate:

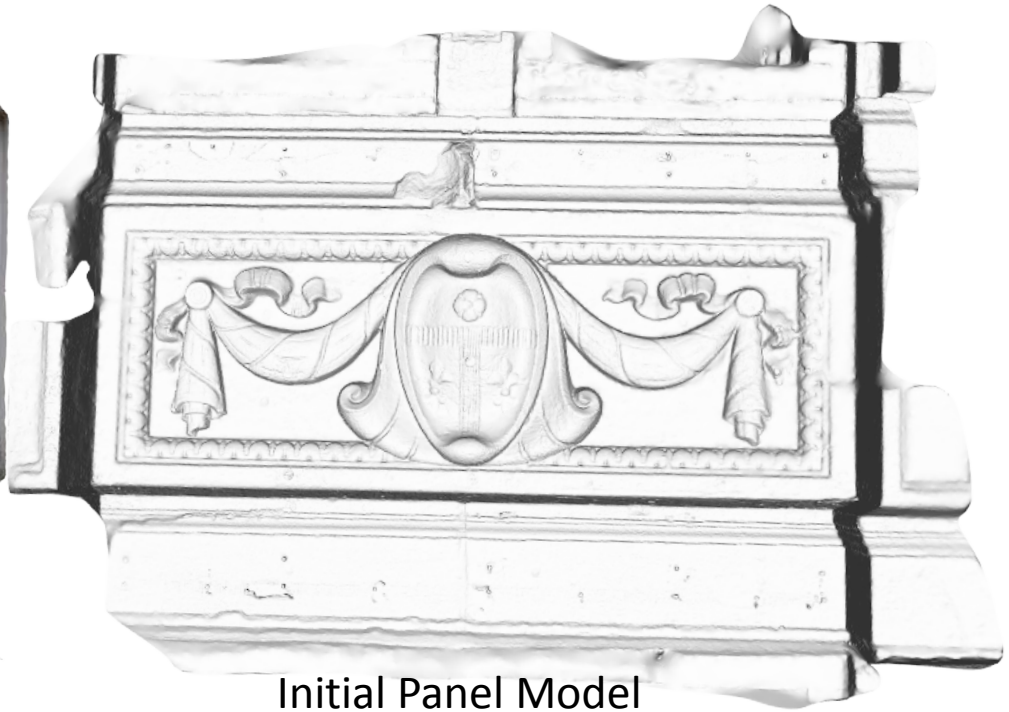
Export completed 3D model and send to print

DOCUMENTATION

- 100’s of photographs taken of a “good” condition panel
- Markers were used to “guide” software in matching photographs

MODELING

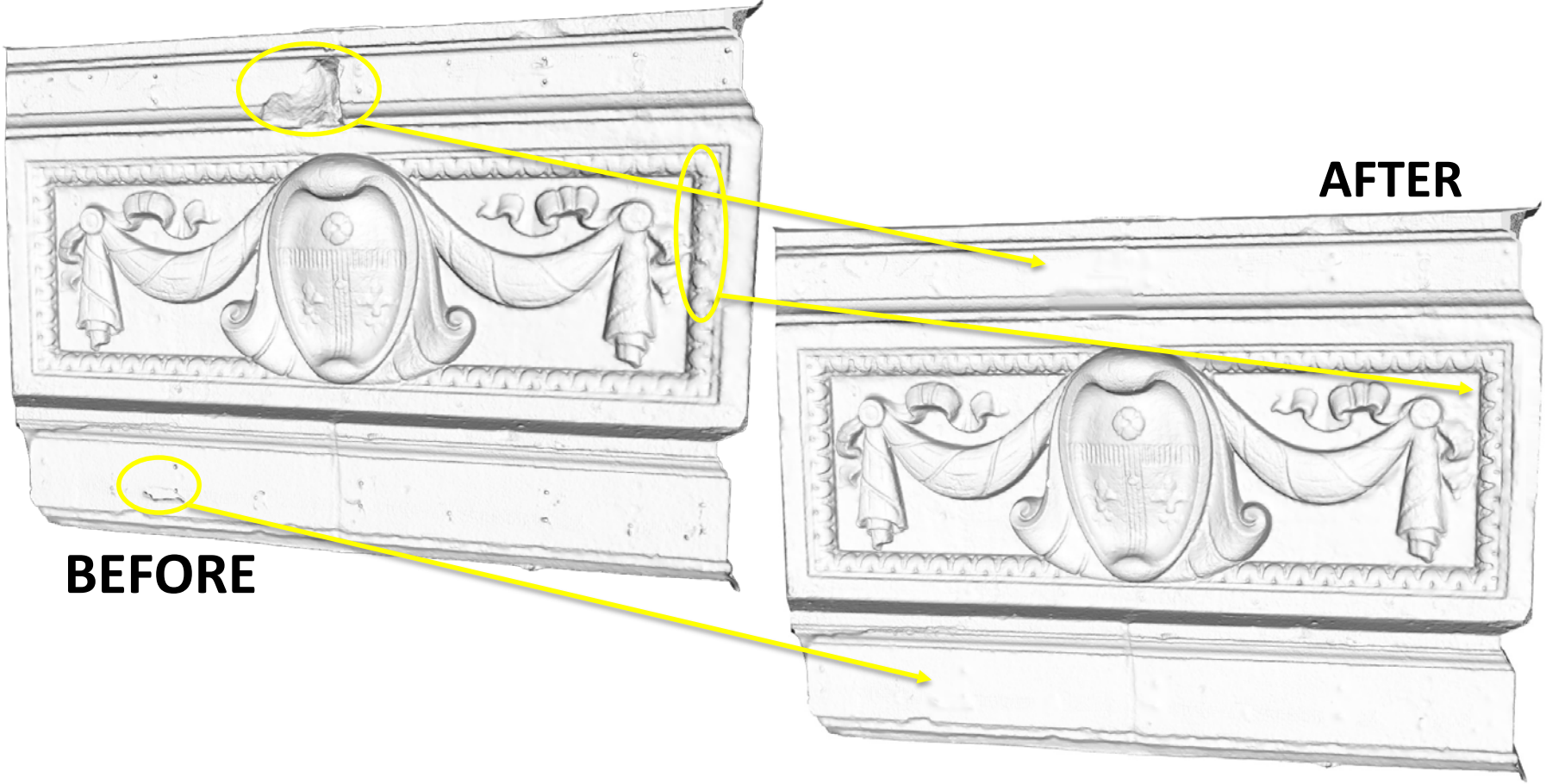
Photograph of Panel



Initial Panel Model

POST-PROCESSING

- Manipulate model to fill in cast-stone spalls and holes
- Smoothen rough areas in model
- Touch-up highly-detailed regions


AFTER
BEFORE

FABRICATING THE SPANDREL PANEL

Method	Advantage	Disadvantage
3D Printing	Fast	Limited to small scale objects and plastic materials
Rapid Prototyping	Fast	Costly and limited to small scale objects and limited materials
CNC Milling	Slower	Cost-effective, not limited to small scale objects, can be used with different materials (wood, stone, metal, foam, etc.)

CNC Milling options:

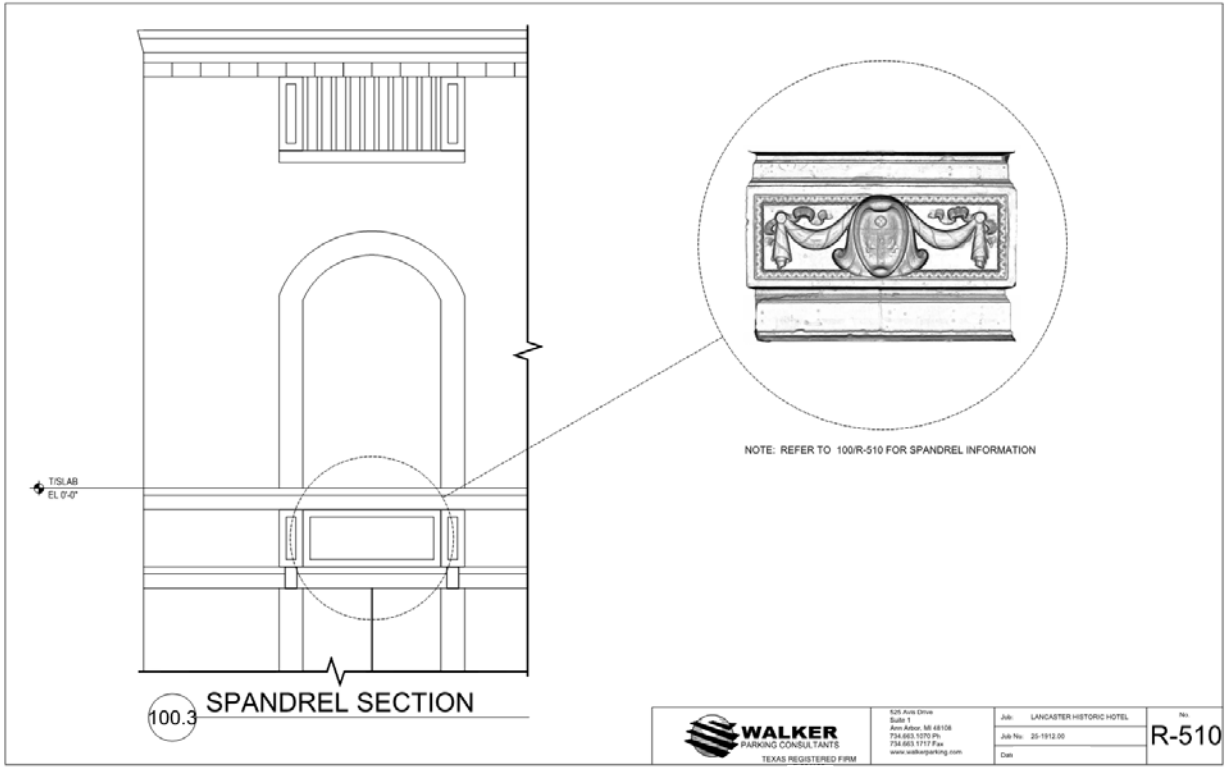
- Mill spandrel panel using a 3-axis CNC mill out of high-density foam and coat it with polyurethane
- Mill spandrel panel out of low-density foam, use master copy to create a rubber mold.

CAST STONE MIX DESIGN

- 6500 psi strength at 28 days
- 6-8% absorption rate
- Limit shrinkage to 0.065%
- Fine grained aggregate required to match texture
- Non-corrosive reinforcement

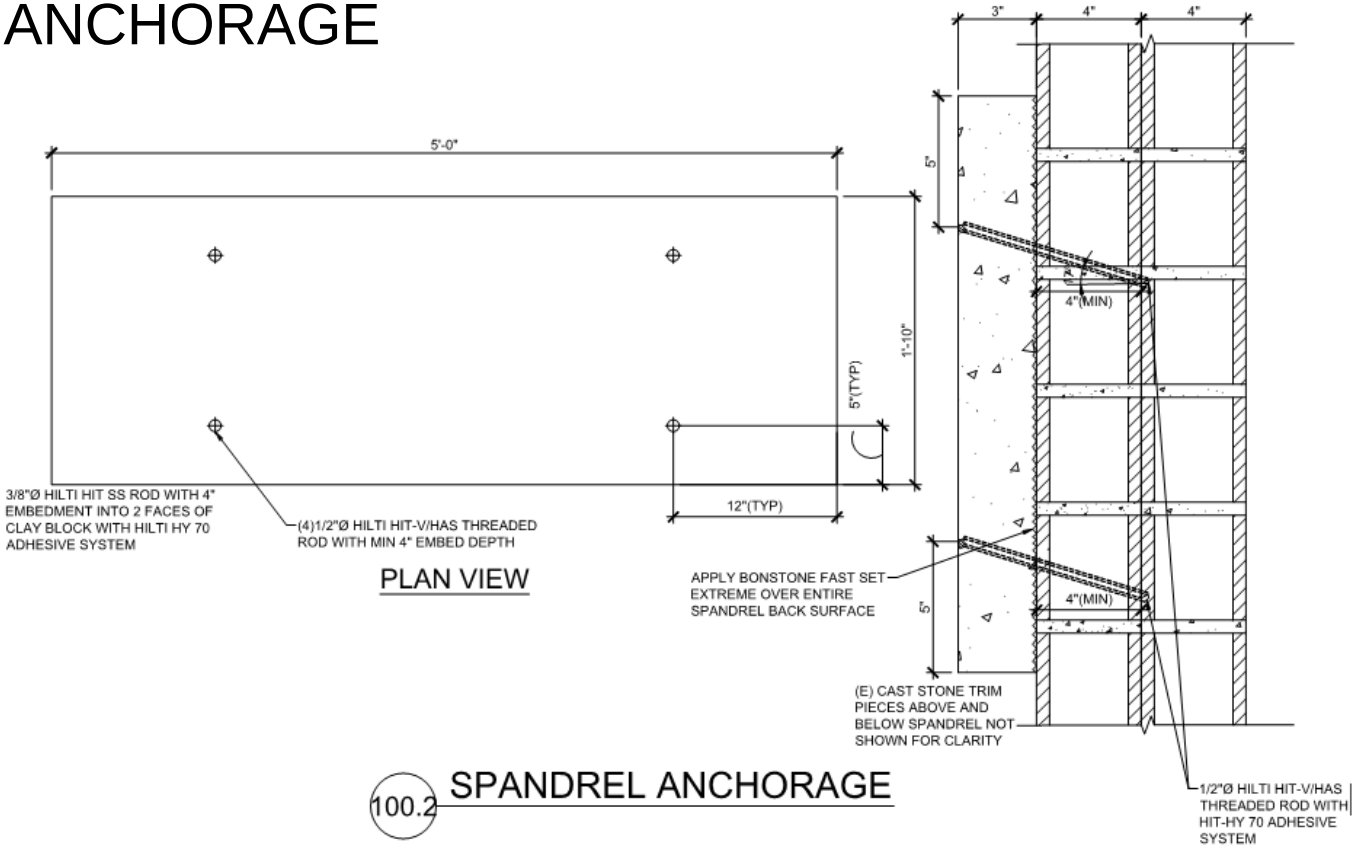
Added Protection:

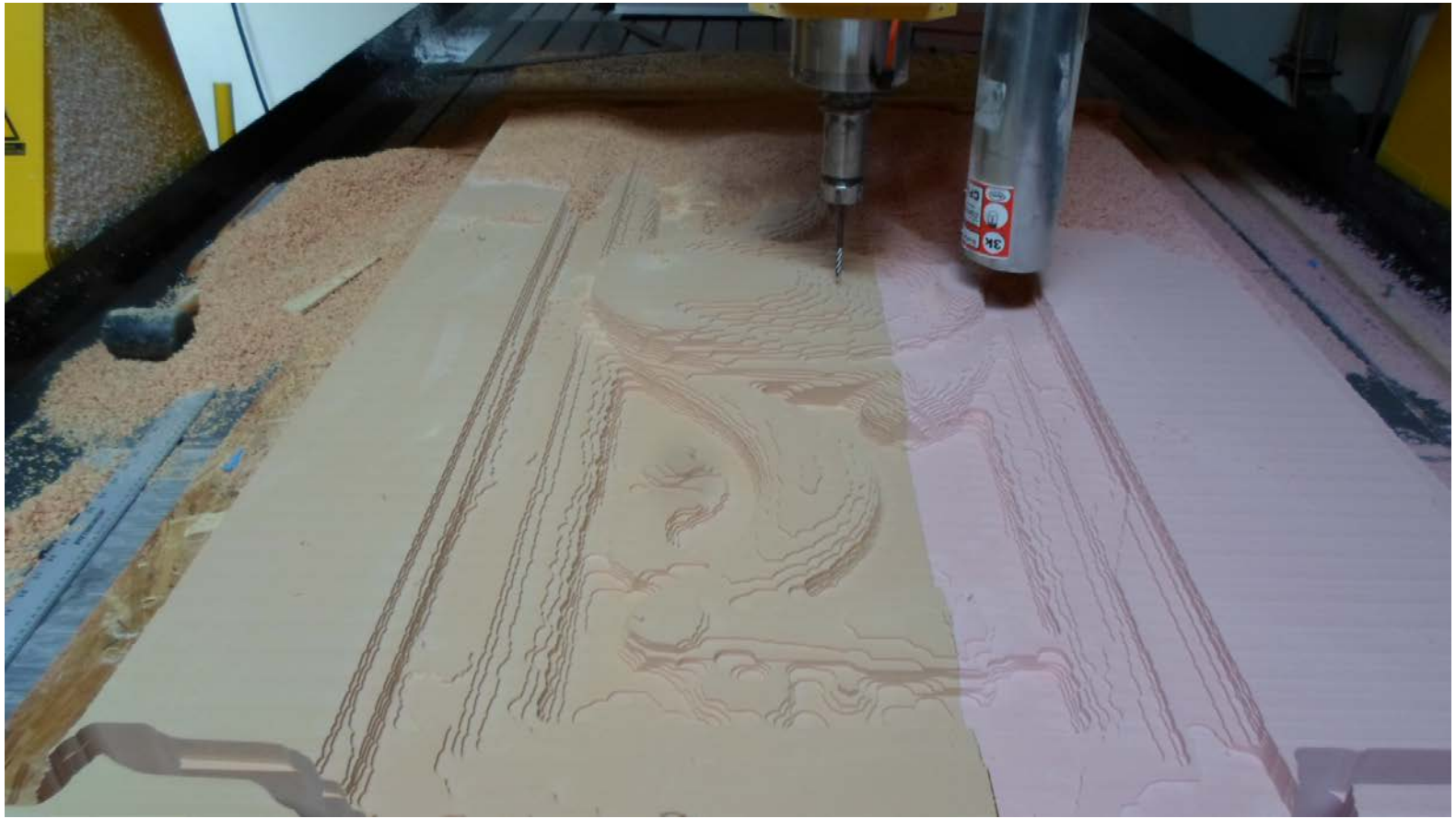
- Silane Sealer



DESIGNING THE ANCHORAGE

- Existing shelf angles used for gravity support
- Stainless steel post-installed chemical anchors for wind loads






WALKER
Crack
Meter


M.DEGEORGE

ADVANTAGES TO USING PHOTOGRAMMETRY

- Cost-Effective
  - No special equipment required, just a photogrammetry software
  - Lower cost to model, mold, and fabricate
- Accessible
  - Can be performed by any properly trained personnel
- Reduces Risk
  - Non-destructive, removal of object is not necessary
- Provides Good Results


QUESTIONS?