

The Evaluation of Historic Structures

Structural Engineers Association of Wisconsin

Timothy Crowe, RA, SE, PE
April 21, 2017



Presentation Objectives

- Review principals and philosophies related to the building preservation work.
- Describe building preservation and restoration challenges related to building codes.
- Examine assessment approaches for existing structures and materials, and outline nondestructive testing options that are available
- Present brief example(s) of preservation approaches carried out.



Preservation Principals and Philosophies

- Preserve the historic fabric.
- Retain integrity of the building structure.
- Avoid unnecessary alterations.
- Avoid remediation that is not reversible.

WJE



St. Lawrence Basilica, Asheville, NC

WJE



WJE

St. Lawrence Basilica, Ashville, NC (1905)



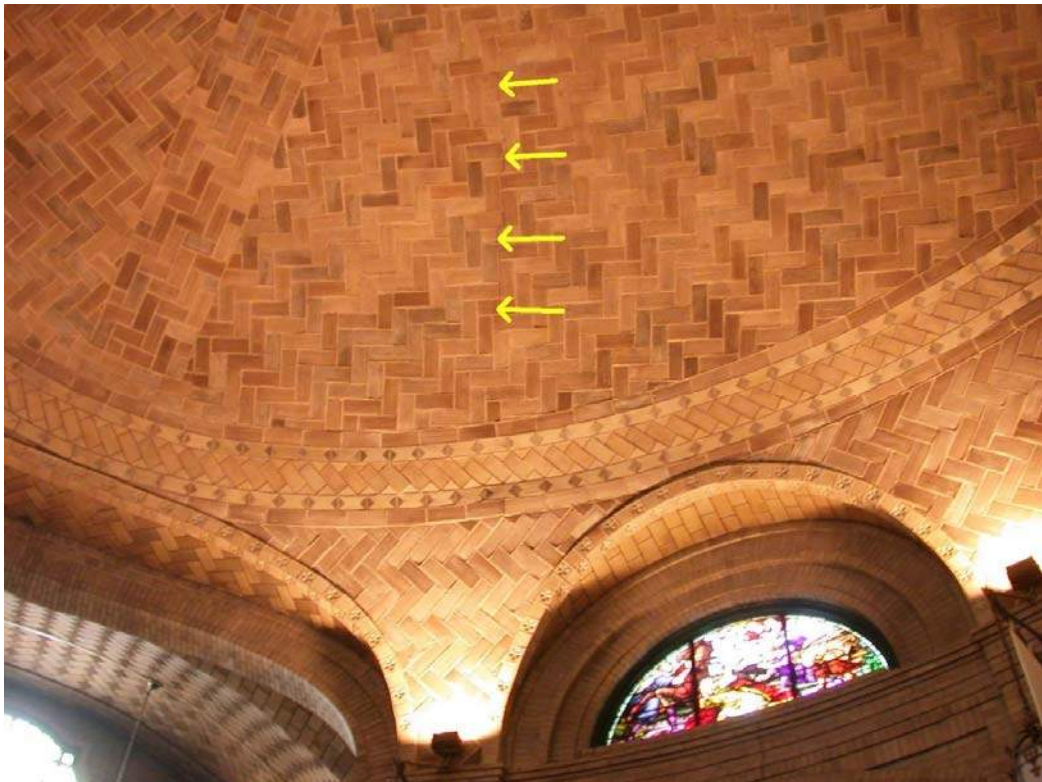
WJE

St. Lawrence Basilica, Ashville, NC (1905)



WJE

St. Lawrence Basilica, Asheville, NC (1905)



WJE

St. Lawrence Basilica, Asheville, NC (1905)

Basis of Procedure

- Listen to the structure.
- Research available data, libraries and other sources are available.
- Inspection is a snapshot in time. Scrutinize the data

WJE

Medical Analogy

- Building past history
- Prior therapies and interventions.
- Review current symptoms.
- Implementation of a therapy or intervention.
- Monitoring of that intervention.

WJE

Challenges with Building Codes

What is the objective of the “preservation” task at hand.

- Building maintenance, (preservation or even restoration).
- Building alterations and or expansions.
- Adaptive reuse and/or change in occupancy.

WJE

Challenges with Building Codes

- 2012 IBC included chapter 34.
- 2015 IBC eliminated Chapter 34
- Now the trend is solely toward the IEBC

SECTION 3409 HISTORIC BUILDINGS

3409.1 Historic buildings. The provisions of this code relating to the construction, *repair, alteration, addition*, restoration and movement of structures, and change of occupancy shall not be mandatory for *historic buildings* where such buildings are judged by the *building official* to not constitute a distinct life safety hazard.

3409.2 Flood hazard areas. Within *flood hazard areas* established in accordance with Section 1612.3, where the work proposed constitutes *substantial improvement* as defined in Section 1612.2, the building shall be brought into compliance with Section 1612.

Exception: *Historic buildings* that are:

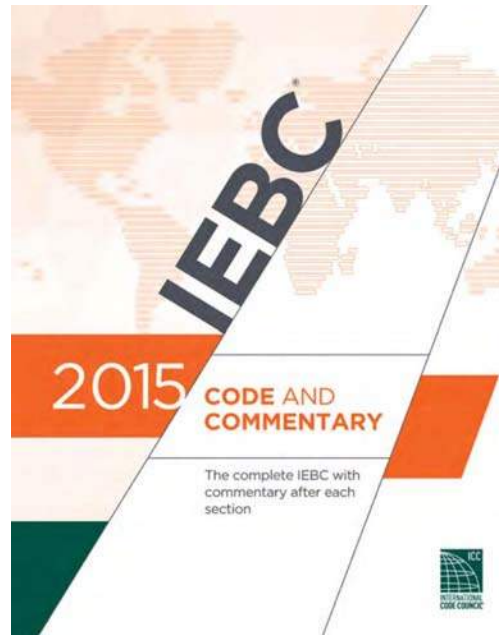
1. *Listed* or preliminarily determined to be eligible for listing in the National Register of Historic Places;
2. Determined by the Secretary of the U.S. Department of Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined to qualify as an historic district; or
3. Designated as historic under a state or local historic preservation program that is *approved* by the Department of Interior.

WJE

Challenges with Building Codes

Now the trend is solely toward the IEBC

WJE



Challenges with Building Codes

IEBC Triggers:
Dangerous is defined
(IEBC2006)

DANGEROUS. Any building or structure or any individual member with any of the structural conditions or defects described below shall be deemed dangerous:

WJE

1. The stress in a member or portion thereof due to all factored dead and live loads is more than one and one third the nominal strength allowed in the *International Building Code* for new buildings of similar structure, purpose, or location.
2. Any portion, member, or appurtenance thereof likely to fail, or to become detached or dislodged, or to collapse and thereby injure persons.
3. Any portion of a building, or any member, appurtenance, or ornamentation on the exterior thereof is not of sufficient strength or stability, or is not anchored, attached, or fastened in place so as to be capable of resisting a wind pressure of two thirds of that specified in the *International Building Code* for new buildings of similar structure, purpose, or location without exceeding the nominal strength permitted in the *International Building Code* for such buildings.
4. The building, or any portion thereof, is likely to collapse partially or completely because of dilapidation, deterioration or decay; construction in violation of the *International Building Code*; the removal, movement or instability of any portion of the ground necessary for the purpose of supporting such building; the deterioration, decay or inadequacy of its foundation; damage due to fire, earthquake, wind or flood; or any other similar cause.
5. The exterior walls or other vertical structural members list, lean, or buckle to such an extent that a plumb line passing through the center of gravity does not fall inside the middle one third of the base.

Challenges with Building Codes



1883 Wood framed church, Code officials – administrative relief.

WJE



Challenges with Building Codes

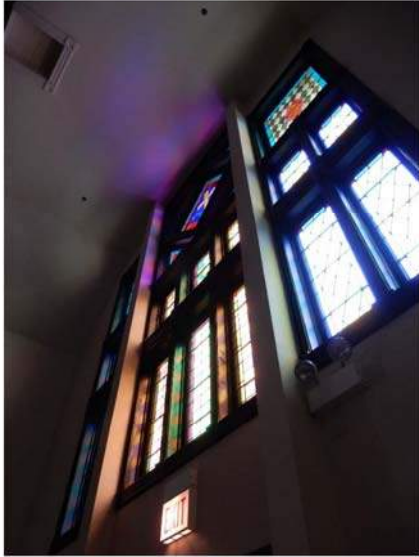


Bowed wall, with discontinuous studs.

WJE



Challenges with Building Codes

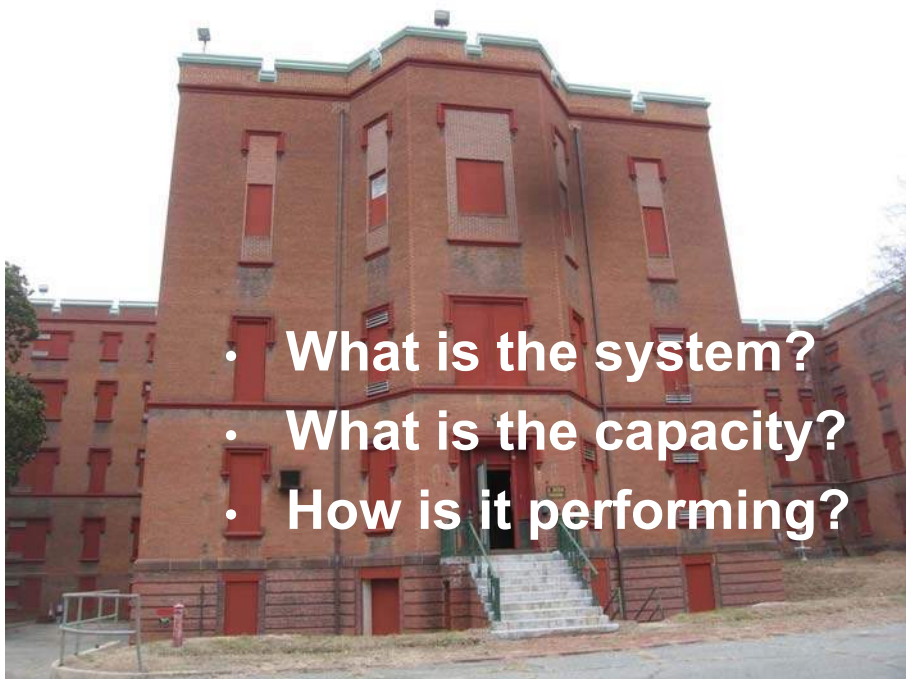


1884 Wood framed church, Code officials – administrative relief.

WJE



Structural Assessments



- What is the system?
- What is the capacity?
- How is it performing?

WJE

Structural Assessments

Depending upon the material at hand, approaches that will be taken will vary significantly

- Wood
- Steel
- Masonry (brick/stone/other)
- Concrete

WJE

Structural Assessments

Aspects that will always be part of the process will include.

- Document reviews,
- Building history
- Visual examinations.

WJE

Visual Examination



WJE

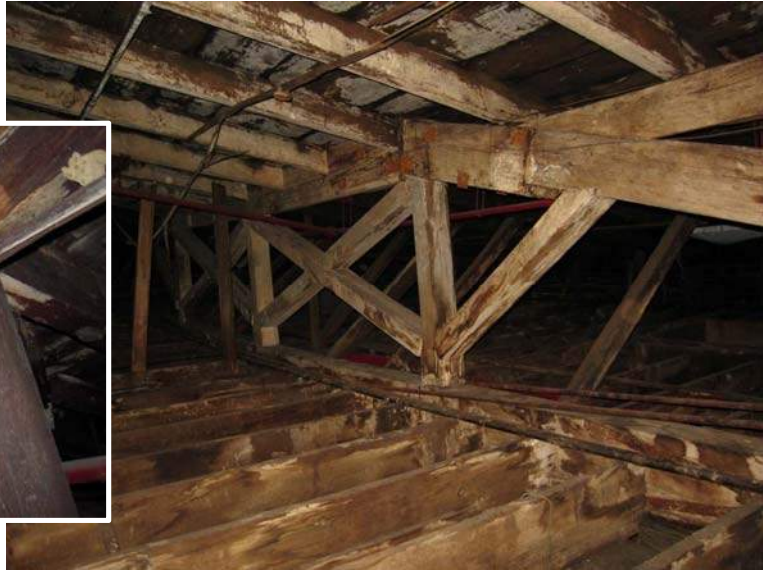
Visual Examination

- Water moisture shedding / control
- Cracks / displacements
- Decay / deterioration
- Deflections / deformations
- Past interventions

WJE

Visual Examination

18 50s roof framing in Washington DC, Moisture effects, Longer term moisture infiltration, roof



WJE

1980s Residential Building

Moisture effects, Poor vapor barrier and air barrier into attic. Condensation and frost.



WJE

1870s Commercial Building

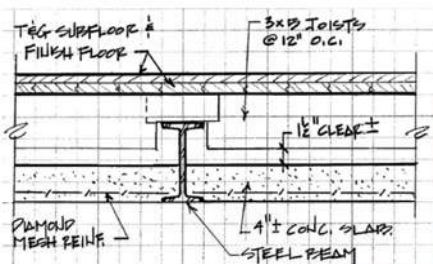
Moisture effects, rising damp, deterioration to foundations.



WJE

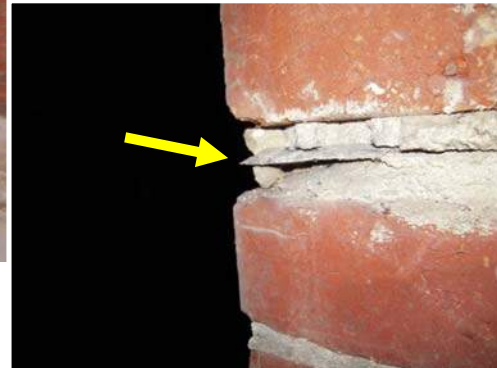
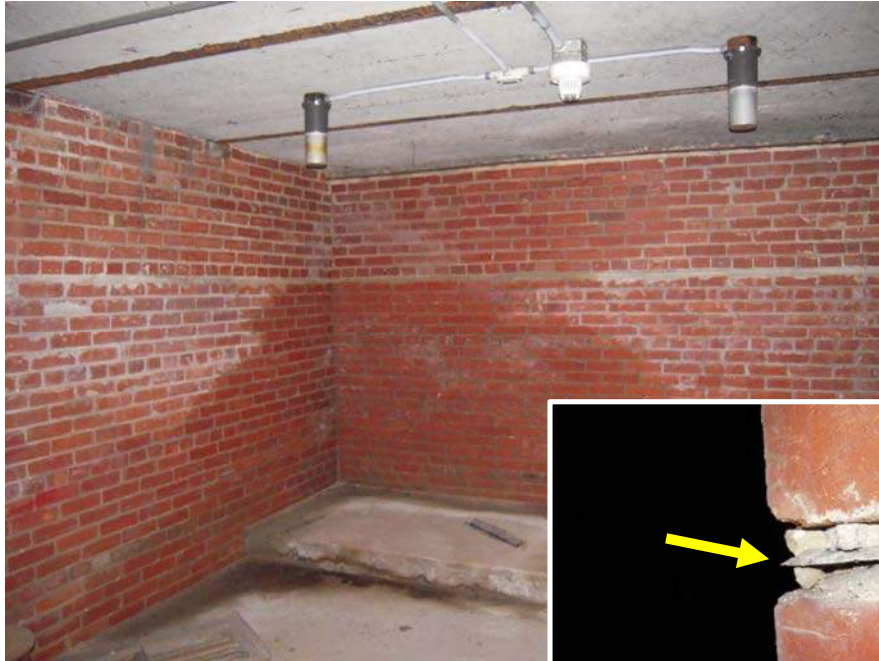
Building circa 1902

Moisture effects, Exposed steel in poorly vented crawlspace



WJE

Building circa 1902



WJE

Visual Examination

Cracks and displacement



WJE

Visual Examination



WJE

Visual Examination

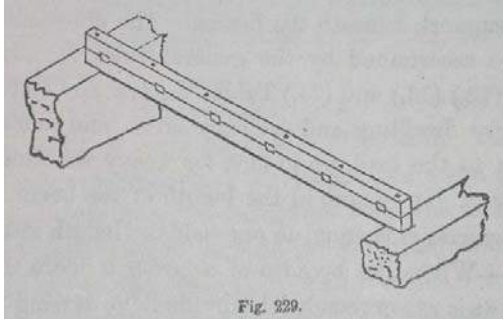
Decay and displacement of framing members in 1870s Bbell tower.



WJE

Visual Examination

1860s church in Chicago, with keyed beam construction



WJE

Visual Examination

Past interventions: 1908 university building in Lincoln Nebraska



WJE

Visual Examination

Past interventions: 1908 university building in Lincoln Nebraska



WJE

Visual Examination

Past interventions: 1915 Church building



WJE

Visual Examination

Past interventions: 1915 Church building

WJE



Visual Examination

Use of Drones is now an option in certain situations.



WJE



Visual Examination to NDT

Infrared photography:



WJE



Non destructive testing concrete

Simple hand tools,
keep things low-tech.



WJE

Non destructive testing concrete

Ultrasonic testing devices such as GPR.

WJE



Non destructive testing concrete

Ultrasonic testing devices such as metal detector .

Actually is useful for concrete, masonry, wood

WJE



Non destructive testing concrete

Coring of material
for compressive
strength testing
and chemical
analysis



WJE

Non destructive testing Wood



Hand tools,
scratch awls.

WJE



Non-destructive testing Wood



Levels and
measuring devices.

WJE



Non-destructive testing Wood



Moisture meters
and hygrometers

WJE



Non-destructive testing Wood



WJE

Non-destructive testing Wood



Wood plugs to
assess glued joints
and hygrometers with
wands for cavities.

WJE



Non-destructive testing Steel

Steel coupons for yield and tensile strength tests and chemical analysis for determining weldability.



WJE

Non-destructive testing Steel



Ultrasonic thickness measuring device (Krautkramer) for blind measurements of steel members.

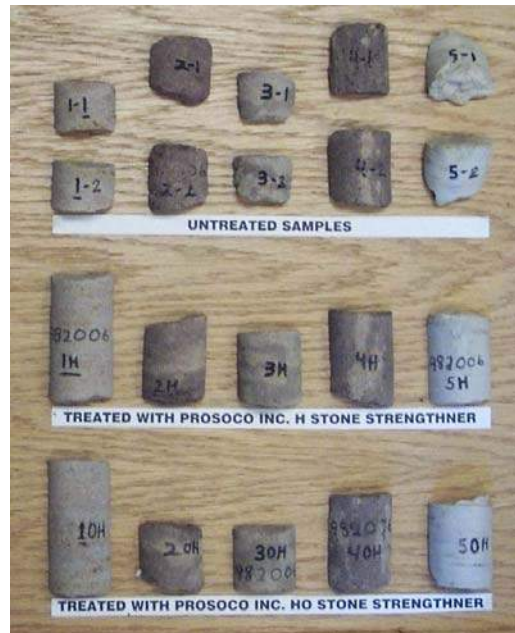


WJE

Material Analysis



Stone coring for material analysis, petrographic examination and freeze-thaw testing of treatments



WJE

Material Analysis

ASTM C67 - Compressive strength testing and freeze-thaw testing of proposed replacement material

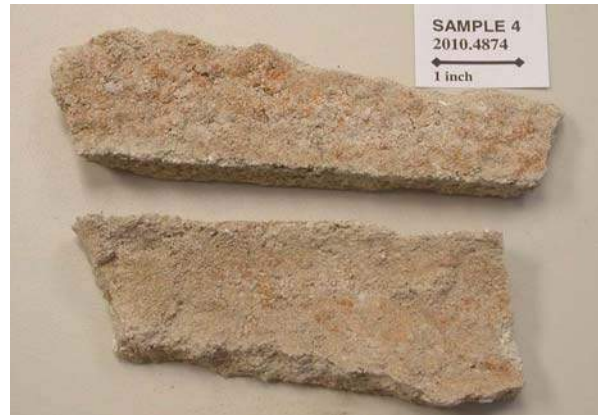


WJE

Material Analysis

ASTM C856, *Standard Practice for Petrographic Examination of Hardened Concrete*, which also applies to mortar.

ASTM C1324, *Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*.



WJE



**Case Study
Building 31
St. Elizabeths
Washington, DC**



WJE

Constructed Circa 1878 / 1900

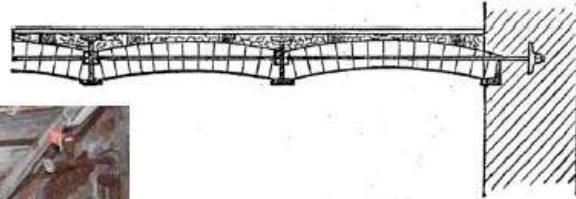


Fig. 38. Brick Floor-arch

WJE



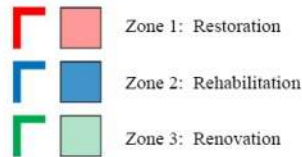
Building 31



WJE



Figure 107. First floor plan showing preservation zoning. The building exterior is designated as Zone 1, including exterior stairs. The non-original stairs from the south porch are designated as Zone 3. The fire escape on the east elevation is designated as Zone 2. Most of the interior is designated as Zone 2, except for bathrooms, which are designated as Zone 3. Non-original partition walls are also designated as Zone 3.



WJE

Short Term Recommendations

- Restrict access and enhance ventilation
- Perform isolated masonry repairs to stabilize weakened elements.
- More detailed inspection of walls and floors upon removal of interior finishes.
- Monitor moisture seepage at lower level.
Confirm water table and monitor site drainage.

WJE

Long Term Recommendations

- The installation of a continuous drain tile and waterproofing system.
- Perform masonry repairs and tuckpointing.
- Perform an analysis of main floor structure to evaluate proposed building occupancy loads.
- Framing repairs (address corroded elements).
- Coordinate wall and roof repairs, with window restoration and building finish repair.



Building Modifications:

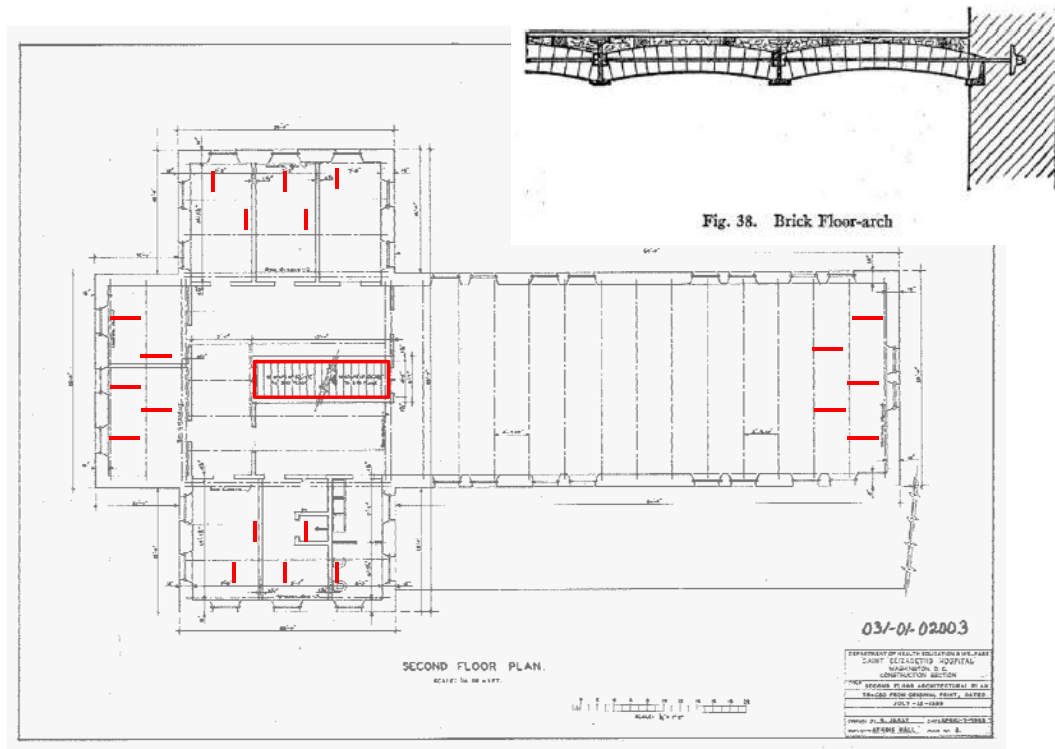
- Space Program Requirements from DHS / Perkins+Will.
 - Vertically expand lower level required underpinning
 - High-density storage
- Increased floor loads
- Increased thermal performance of Buildings per DHS and GSA.
 - Blast design
 - IBC / IECC compliance
 - Seismic assessment



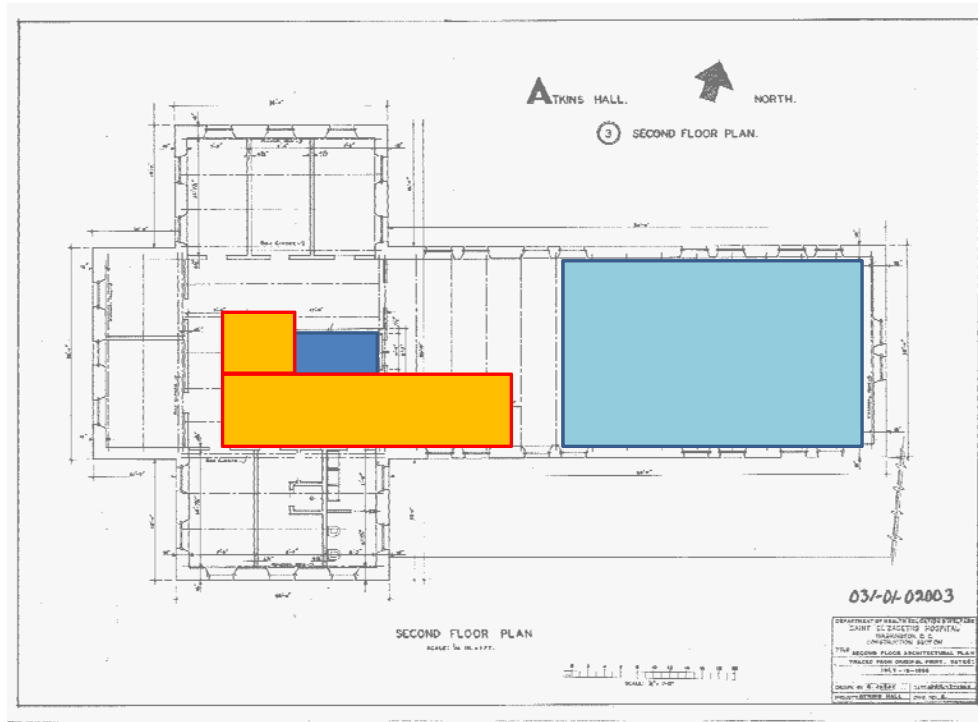
Building 31 Adaptive Reuse



WJE



WJE



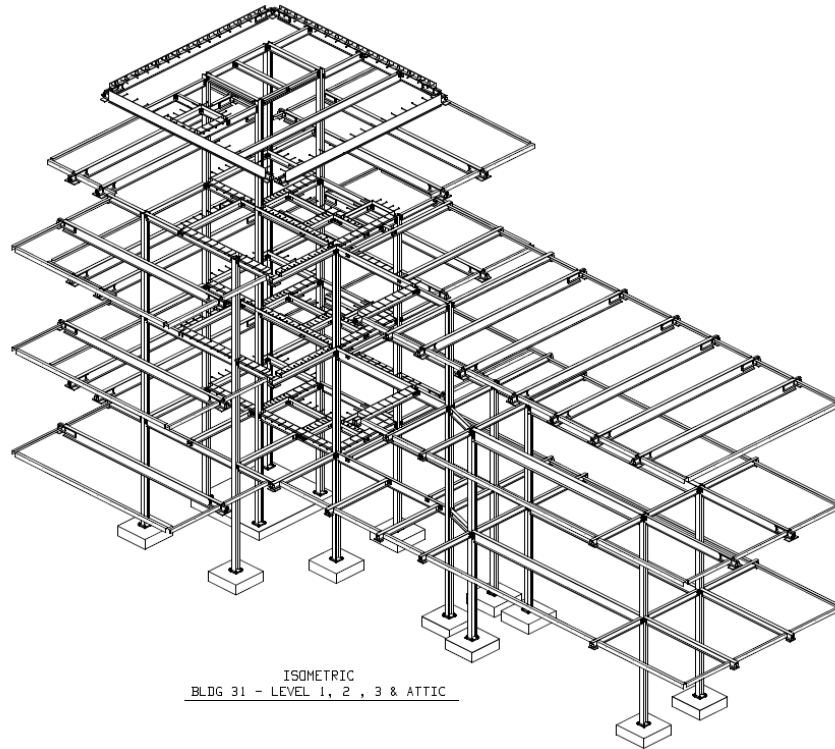
WJE

Inspection pits / steel assessment



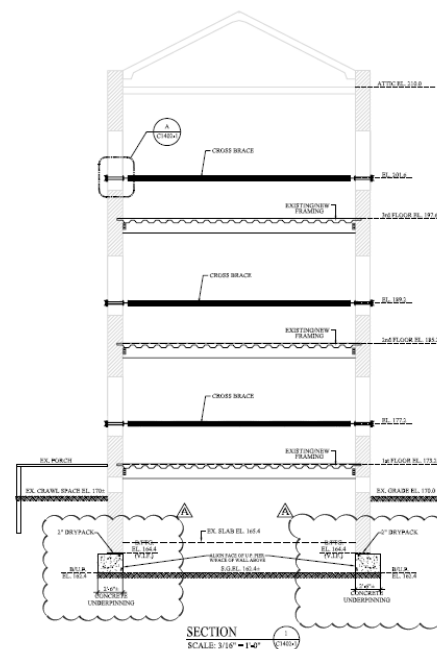
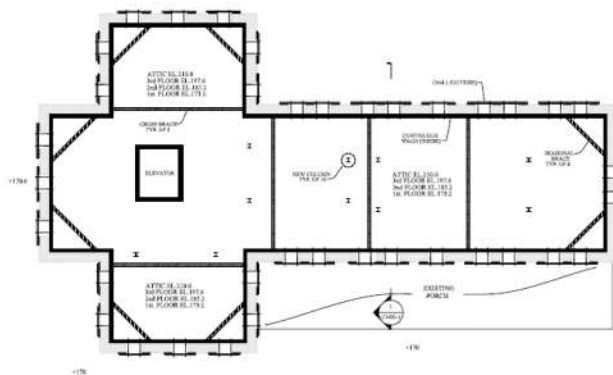
WJE

New steel to be installed



WJE

Temporary Bracing methodology



WJE

Wall bracing



WJE

March 22, 2011

Wall bracing / monitoring



WJE

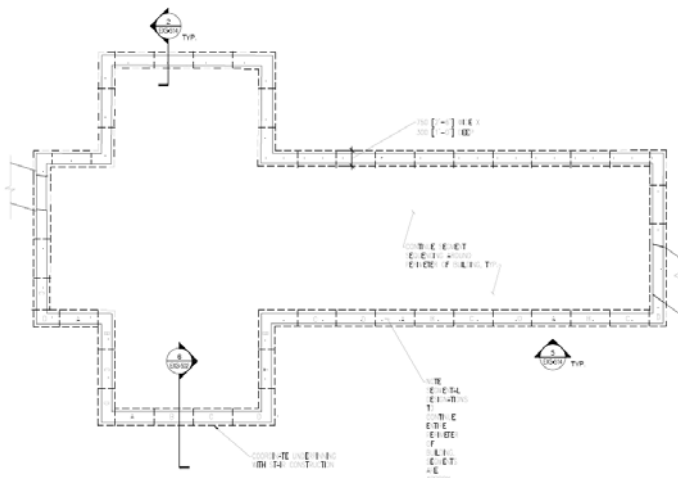
March 22, 2011

Wall bracing

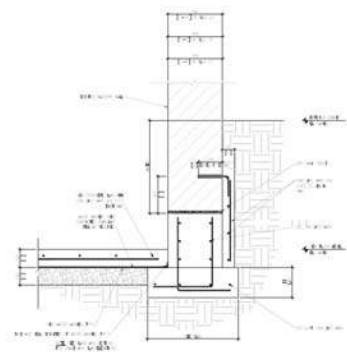


WJE

Underpinning approach



1 FOUNDATION PLAN FOR UNDERPINNING-BUILDING 31
05014 1:100



NEW UNDERPINNING DETAIL

WJE



WJE

Underpinning work commenced



WJE

May 18, 2011

Underpinning work in progress



WJE

May 25, 2011

Roof framing reinforced



WJE

May 25, 2011



WJE

June 07, 2011



WJE

June 29, 2011



WJE

June 29, 2011



WJE

July 20, 2011



WJE

July 20, 2011



WJE

July 20, 2011

Concrete Jacket



WJE

August 30, 2011

The last steel beams were removed



WJE

September 7, 2011

Waterproofing and drain tile



WJE

September 20, 2011

Steel framing installation



WJE

October 25, 2011

Concrete Placement



WJE

October 25, 2011

Concrete Placement



WJE

October 25, 2011

Steel framing installation



WJE

October 26, 2011

Lateral Bracing Removal



WJE

November 16, 2011



WJE

Window installation in progress



WJE

March 22, 2011 to
September 19, 2012



WJE

July 17, 2013

Building 31 to date



February 2, 2009



March 22, 2011 to
August 27, 2013

WJE

Questions?

WJE