Structural Condition Assessment
Key West Diesel Plant
Key West, Florida

Prepared For

AMEC Foster Wheeler Environmental & Infrastructure, Inc.
5845 NW 158th Street
Miami Lakes, Florida 33014

Prepared By

Atlantic Engineering Services of Jacksonville
6501 Arlington Expressway, Building B, Suite 201
Jacksonville, FL 32211

AES Project No. 316-048
August 3, 2016

ATLANTIC ENGINEERING SERVICES

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August 3, 2016

Mr. Greg W. Corning, P.E.
AMEC Foster Wheeler Environmental & Infrastructure, Inc.
5845 NW 158th Street
Miami Lakes, Florida 33014-6721

Re: Structural Condition Assessment
Key West Diesel Plant
Key West, Florida

AES Project: #316-048

Dear Greg:

Atlantic Engineering Services of Jacksonville (AES) has completed its structural condition assessment of the Key West Diesel Plant also known as the Angela Street Diesel Plant, which is located at the corner of Fort Street and Geraldine Street, along the extension of Fort Street to Angela Street in Key West, Florida. Our assessment consisted of a visual review of the abandoned Diesel Plant structure on June 21, 22 and 23, 2016, along with carbonation and chloride testing. Concrete chloride testing was performed by AMEC Foster Wheeler Environmental Infrastructure, Inc. and carbonation testing was performed by AES. Present at the site was Mr. Mark J. Keister, P.E.

BACKGROUND

The Key West Diesel Plant also known as the Angela Street Diesel Plant was the original site of a manufactured gas plant operated by the former Key West Gas Light Company dating back to the late 1880's. By 1887, the name of the Key West Gas Light Company had changed to the Key West Gas and Electric Light Company, and in 1889 discontinued the manufacturing of gas on the property and erected an electrical lighting power house. In 1898, Key West Electric Company was incorporated and carried on electric generation at the site. In 1943, the city of Key West acquired the Key West Electric Company and the electric company was subsequently referred to as the City Electrical System. Diesel Plant operations ceased in the late 1960's and in 2002 the name of the company was changed to Keys Energy Services. Keys Energy Services is the current owner of the property with the Diesel Plant abandoned and an electrical substation occupying the remainder of the site.

The abandoned Diesel Plant consists of four (4) connected one-story, buildings with the three (3) eastern buildings housing four (4) electric dynamos and the southwestern building having a lower roof that probably housed a shop and support spaces. The northernmost eastern building (Building I) houses one (1) dynamo and consists of a high new pre-engineered wood truss framed roof with plywood sheathing and metal roofing supported by perimeter multi-wythe brick walls and interior steel beams and columns (see Photographs 1 and 2). The easternmost center building (Building II) houses two (2) dynamos and consists of metal roofing on plywood sheathing, on wood joists and beams supported by heavy timber trusses and steel beams and columns that support crane beams (see Photographs 3 and 4). The heavy timber roof trusses are supported by perimeter multi-wythe brick walls. The southernmost eastern building (Building IV) houses one (1) dynamo and consists of metal roofing on wood sheathing on wood joists and beams supported by heavy timber trusses, and perimeter low multi-wythe brick walls and upper concrete walls (see Photographs 5 and 6).

Below the roof structure is a gantry crane supported by a steel crane beam and steel columns independent of the perimeter brick walls. To the east of this building is an exterior concrete exhaust structure (Building V), which consists of a concrete roof slab with concrete parapets supported by concrete walls (see Photographs 7 and 8). The southwestern building (Building III) consists of metal roofing on wood sheathing on wood joists, and beams supported by interior steel beams and columns and perimeter multi-wythe brick walls, CMU walls and concrete walls (see Photographs 9 and 10).

All of the dynamos are in pits filled with water and there is extensive trenching with fuel and coolant supply lines around the dynamos, which is also filled with water. In the eastern center building (Building II), there is an interior concrete platform with perimeter steel framed concrete platforms, which appears to have been a central control area (see Photograph 11). In the southwestern building (Building III), there are shallow trenches and numerous equipment foundations. It is unknown what the foundations are, but they are either piles bearing on shallow rock or shallow foundations bearing on the shallow rock.

OBSERVATIONS

Our structural condition assessment consisted of a visual review of the structure. The survey plans (see Appendix A), approximately locates the deteriorated areas pinpointed during our survey. Concrete carbonation testing was determined at four (4) locations and concrete chloride testing was also determined at four (4) locations. The testing locations are noted on the survey plans (see Appendix A). The results for the concrete carbonation testing are shown in Appendix B and the results for chloride testing results are also shown in Appendix B.

Fresh concrete has a PH of approximately 12 to 13, which creates a layer of passivity on embedded reinforcing that protects the reinforcing from corrosion. With exposure to atmospheric carbon dioxide, concrete PH slowly decreases over time as carbon dioxide penetrates the concrete. When the concrete PH reduces to a value of about 9 to 10, the passivating layer protecting the reinforcing is destroyed and the reinforcing can corrode due to exposure to oxygen and water. The PH at all four (4) locations is 9.5 or lower at the face of reinforcing and the concrete is no longer protecting the reinforcing from corrosion near the surface of the concrete.

Chlorides in concrete greatly accelerate corrosion and the lower the concrete PH, the greater the impact of chloride induced corrosion. Chloride content in concrete exposed to moisture should be less than .15% of Cl to weight of cement and the chloride corrosion threshold is 1.2 lbs. of chloride per cubic yard of concrete, which works out to .0317% Cl for concrete weighing 140 lbs. /cubic yard. Of the four (4) samples tested for chlorides, all exceeded the chloride corrosion threshold with three (3) being very high in chloride content.

I. The northernmost, eastern building (Building I) has been recently re-roofed and the original wood structure supported by the steel beams and trusses have been replaced with plywood sheathing and wood trusses. The new roofing and roof structure is in excellent condition except that the roofing screws are not stainless steel and are corroding (see Photograph 12). The original steel beams, trusses and columns are in good condition with surficial corrosion except for one (1) column, which has a badly corroded base with more than 20% material loss (see Photograph 13). The slab on grade is cracked and uneven and there is a large crack at the interior door to the adjacent building, and several of the western window sills are spalled with corroded reinforcing and the remainder are cracked (see Photographs 14, 15 and 16).

The exterior masonry walls are in good condition but there are numerous cracks, corroded embedments, deteriorated mortar, corroded lintels, deteriorated face brick, brick cracks with vegetation and random cracks in the concrete water table (see Photographs 17, 18, 19, 20, 21, 22 and 23). At the western return metal panel wall, there is a badly corroded angle purlin and a large column spall with corroded reinforcing and an area of missing metal wall panel (see Photographs 24, 25 and 26). The remaining metal panels are corroded and in poor condition (see Photograph 27).

II. The eastern center building (Building II) is in much worse condition than the Building I with metal roofing in extremely poor condition with large areas of missing metal roofing and large areas of deteriorated roof decking (see Photograph 28). The roof wood structure is in good condition as well as the steel structure with surficial corrosion except for several badly corroded columns and post bases with more than 20% material loss (see Photographs 29 and 30).

The stair to the concrete platform has badly corroded stair stringer bases with more than 20% material loss and the concrete platform has extensive large concrete spalls with exposed corroding reinforcing (see Photographs 31, 32 and 33). The exterior masonry walls are in good condition, but there are numerous cracks, corroded embedments, deteriorated mortar, deteriorated face brick, infilled arch brick with no lintel, large areas of missing brick, corroding lintels and brick cracks with vegetation (see Photographs 34, 35, 36, 37, 38 and 39).

III. The southwestern building (Building III) is in worse condition than Building I, but in better condition than the Building II and Building IV. The western metal roof is in good condition with several areas of corroded metal roofing and corroded roofing screws. The eastern metal roof is in poor condition with areas of missing roofing, extensive metal roofing deterioration and areas of deteriorated wood decking (see Photograph 46). The roof wood joists, beams, steel beams and columns are in good condition with surficial steel corrosion on the steel members and a deteriorated wood beam kicker (see Photograph 47). The slab on grade is cracked and uneven and the exterior high concrete has large areas of spalling concrete and a spalling concrete lintel (see Photographs 48 and 49). The exterior CMU and brick has several cracks, corroded embedments and delaminating stucco.

IV. The southernmost eastern building (Building IV) is in worse condition than Building II with a large area of missing metal roofing and wood sheathing, a deteriorated bottom roof truss chord and a wall opening with numerous loose and missing bricks with bricks falling (see Photographs 40, 41 and 42). The wood roof joists are in poor condition but the wood trusses appear in good condition. The steel structure is in good condition with surficial corrosion but many of the steel column bases are severely corroded with more than 20% material loss (see Photograph 43). The exterior masonry walls are in good condition but there are numerous cracks, corroded embedments, deteriorated mortar and loose and missing face brick. The upper concrete walls have large areas of honey combed concrete and an area of spalled concrete with corroded reinforcing (see Photographs 44 and 45).

V. The concrete exhaust building (Building V) is in good condition with corroded steel ladders; a badly corroded pipe support, a cracked housekeeping pad and a hairline crack in the roof parapet (see Photographs 50, 51, 52 and 53). The exterior pit and chute walls are in poor condition with cracked and spalling concrete with corroding reinforcing (see Photograph 54). All of the interior pits are full of water and breeding mosquitos. The interior trench and pit edge angles are in poor condition and badly corroded (see Photograph 55). All of the dynamos are in poor condition and badly corroded (see Photograph 56).

EVALUATION AND RECOMMENDATIONS

Building I is in good condition with the exterior masonry requiring repair and several window lintels requiring replacement. The steel structure is in good condition with surficial corrosion except for one (1) column that needs reinforcement due to excessive corrosion at its base. All of the steel needs to be cleaned of corrosion and coated with a corrosion inhibiting coating. The slab on grade is cracked and uneven and is due for replacement. The exterior masonry requires repointing and all of the corroded embedments and steel lintels need to be cleaned of corrosion and coated with a corrosion inhibiting coating. The deteriorated face brick needs to be removed and replaced and the vegetation in the wall cracks needs to be removed and the cracks repointed. At the western return metal panel wall, the badly corroded angle purlin needs replacement as well as the wall metal panels. The concrete spall in this wall also requires repair.

The remainder of the buildings are in worse condition than Building I with Building IV being in the worst condition with a portion of missing roof. These buildings are stable but require new roofs with extensive roof sheathing replacement and some wood structure reinforcement and replacement. At the areas of missing and badly deteriorated roofing, these roofs could sustain significant damage in a severe wind event losing the remainder of their roofing and sheathing. In general, the steel structure is in good condition with surficial corrosion but several columns will need reinforcement due to excessive corrosion at their bases. All of the steel needs to be cleaned of corrosion and coated with a corrosion inhibiting coating. At Building IV, the wall opening with numerous loose and missing bricks and falling bricks needs to be shored or repaired immediately to prevent further deterioration of the wall. The exterior masonry walls are in good condition except for the northwest corner of Building II where there is a large area of missing brick that needs to be rebuilt. The remaining walls need to be repointed, deteriorated face brick removed and replaced and the vegetation in the wall cracks removed and the cracks repointed. Like Building I, all of the corroded embedments and steel lintels need to be cleaned of corrosion and coated with a corrosion inhibiting coating. In many of the arched brick openings, brick has been infilled with no lintel installed. This infill brick is being held in place by the mortar alone and in areas is cracking. This infill brick needs to be removed or steel lintels installed to support it. At Building II, the concrete platform is in poor condition with large spalls and the concrete carbonated to the reinforcing with the concrete containing high levels of chlorides. If it is the owner's desire to rehabilitate this platform when the concrete is repaired, it should be treated with a penetrating corrosion inhibitor or an active cathodic protection system installed. Due to the thickness of the platform walls, both will be expensive, therefore strong consideration should be taken for demolishing this platform. The exterior concrete walls and pits, except for Building V, are in poor condition requiring extensive repair. Like the Building II concrete platform, the concrete contains high levels of chlorides and once repaired, the walls should be treated with a penetrating corrosion inhibitor or an active cathodic protection system installed, and the exterior concrete coated with a penetrating sealer. The exterior pits and chutes are abandoned and should be cleaned of debris, the top of the deteriorated walls demolished to 8" below grade and filled with clean fill or stone. All of the interior trench and pit edge angles are in poor condition and badly corroded. All of the dynamo pits are full of water and breeding mosquitos. When the deteriorated dynamos are removed, the pits need to be pumped empty of water. The pits and trenches need to be dewatered, cleared of debris with the edge angles removed, and the pits and trenches filled with clean fill or stone with a concrete slab on grade placed, drilled and adhesived into the pit and trench walls level with the surrounding concrete slabs on grade. If any of the dynamos are kept for display, their pits should be pumped empty of water and filled and capped as described above.

CONCLUSIONS

Building I is in good condition having been re-roofed but does require repair as outlined above. The remainder of the buildings are in worse condition, with Building IV being in the worst condition with a large portion of roof missing and a wall opening with numerous loose, missing and falling bricks. This opening needs to be shored or repaired immediately. These buildings are stable but they need to be re-roofed and damaged sheathing and roofing members replaced. At the areas of missing and badly deteriorated roofing, these roofs could sustain significant damage in a severe wind event losing the remainder of their roofing and sheathing. The exterior masonry requires extensive repointing and isolated areas of rebuilding. All of the concrete has a high chloride content and the walls and center building platform requires extensive concrete repair. Strong consideration should be taken for removing this platform in lieu of repair. All of the structural steel requires cleaning of corrosion and coating with a corrosion inhibiting coating. Many of the column bases require reinforcement due to excessive corrosion. The exterior walls have a great deal of corroding embedments, which require cleaning of corrosion and coating with a rust inhibitive coating. All of the dynamo pits are full of water and their pits should be filled and capped. All of the remaining pits and trenches should also be dewatered, filled and capped as well as the exterior chutes and pits.

It has been a pleasure serving you as a consulting structural engineer. Please contact our office if there are any questions regarding this correspondence, or if you need any additional information.

Very truly yours,
ATLANTIC ENGINEERING SERVICES OF JACKSONVILLE
FLORIDA CERTIFICATE OF AUTHORIZATION #791

Mark J. Keister, P.E.
Principal

MJK/drg

MARK J. KEISTER
LICENSE
NO. 37435
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

08/08/16

PHOTOGRAPH 1 (BUILDING I)

PHOTOGRAPH 2 (BUILDING I)

PHOTOGRAPH 3 (BUILDING II)

PHOTOGRAPH 4 (BUILDING II)

PHOTOGRAPH 5 (BUILDING IV AND V)

PHOTOGRAPH 6 (BUILDING IV)

PHOTOGRAPH 7 (BUILDING V)

PHOTOGRAPH 8 (BUILDING V)

PHOTOGRAPH 9 (BUILDING III)

PHOTOGRAPH 10 (BUILDING III)

PHOTOGRAPH 11 (BUILDING II)

PHOTOGRAPH 12 (BUILDING I)

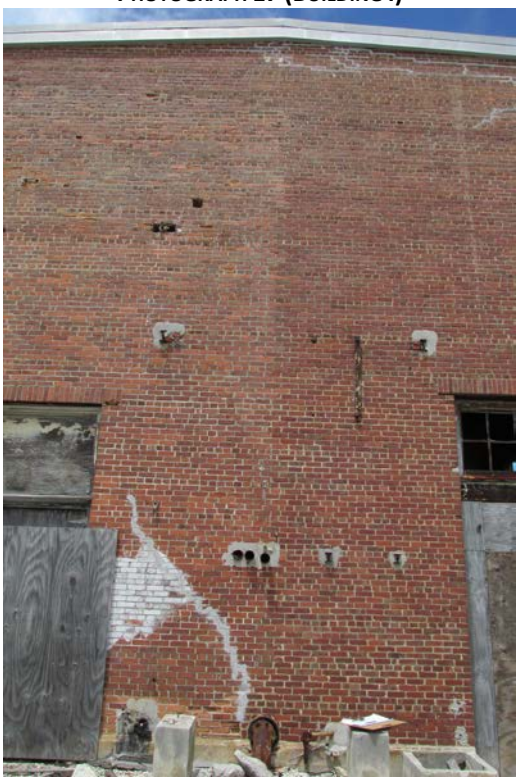
PHOTOGRAPH 13 (BUILDING I)

PHOTOGRAPH 14 (BUILDING I)

PHOTOGRAPH 15 (BUILDING I)

PHOTOGRAPH 16 (BUILDING I)

PHOTOGRAPH 17 (BUILDING I)



PHOTOGRAPH 18 (BUILDING I)

PHOTOGRAPH 19 (BUILDING I)

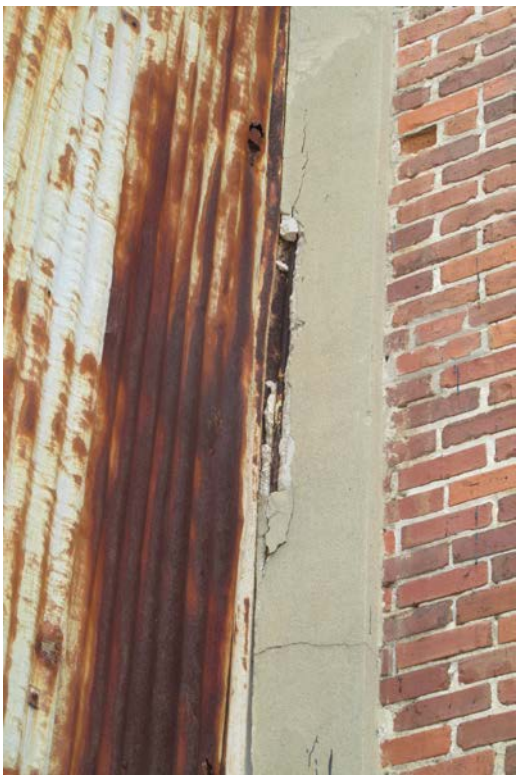
PHOTOGRAPH 20 (BUILDING I)

PHOTOGRAPH 21 (BUILDING I)

PHOTOGRAPH 22 (BUILDING I)

PHOTOGRAPH 23 (BUILDING I)

PHOTOGRAPH 24 (BUILDING I)



PHOTOGRAPH 25 (BUILDING I)

PHOTOGRAPH 26 (BUILDING I)

PHOTOGRAPH 27 (BUILDING I)

PHOTOGRAPH 28 (BUILDING II)

PHOTOGRAPH 29 (BUILDING II)

PHOTOGRAPH 30 (BUILDING II)

PHOTOGRAPH 31 (BUILDING II)

PHOTOGRAPH 32 (BUILDING II)

PHOTOGRAPH 33 (BUILDING II)

PHOTOGRAPH 34 (BUILDING II)

PHOTOGRAPH 35 (BUILDING II)

PHOTOGRAPH 36 (BUILDING II)

PHOTOGRAPH 37 (BUILDING II)

PHOTOGRAPH 38 (BUILDING II)

PHOTOGRAPH 39 (BUILDING II)

PHOTOGRAPH 40 (BUILDING IV)

PHOTOGRAPH 41 (BUILDING IV)

PHOTOGRAPH 42 (BUILDING IV)

PHOTOGRAPH 43 (BUILDING IV)

PHOTOGRAPH 44 (BUILDING IV)

PHOTOGRAPH 45 (BUILDING IV)

PHOTOGRAPH 46 (BUILDING III)

PHOTOGRAPH 47 (BUILDING III)

PHOTOGRAPH 48 (BUILDING III)

PHOTOGRAPH 49 (BUILDING III)

PHOTOGRAPH 50 (BUILDING V)

PHOTOGRAPH 51 (BUILDING V)

PHOTOGRAPH 52 (BUILDING V)

PHOTOGRAPH 53 (BUILDING V)

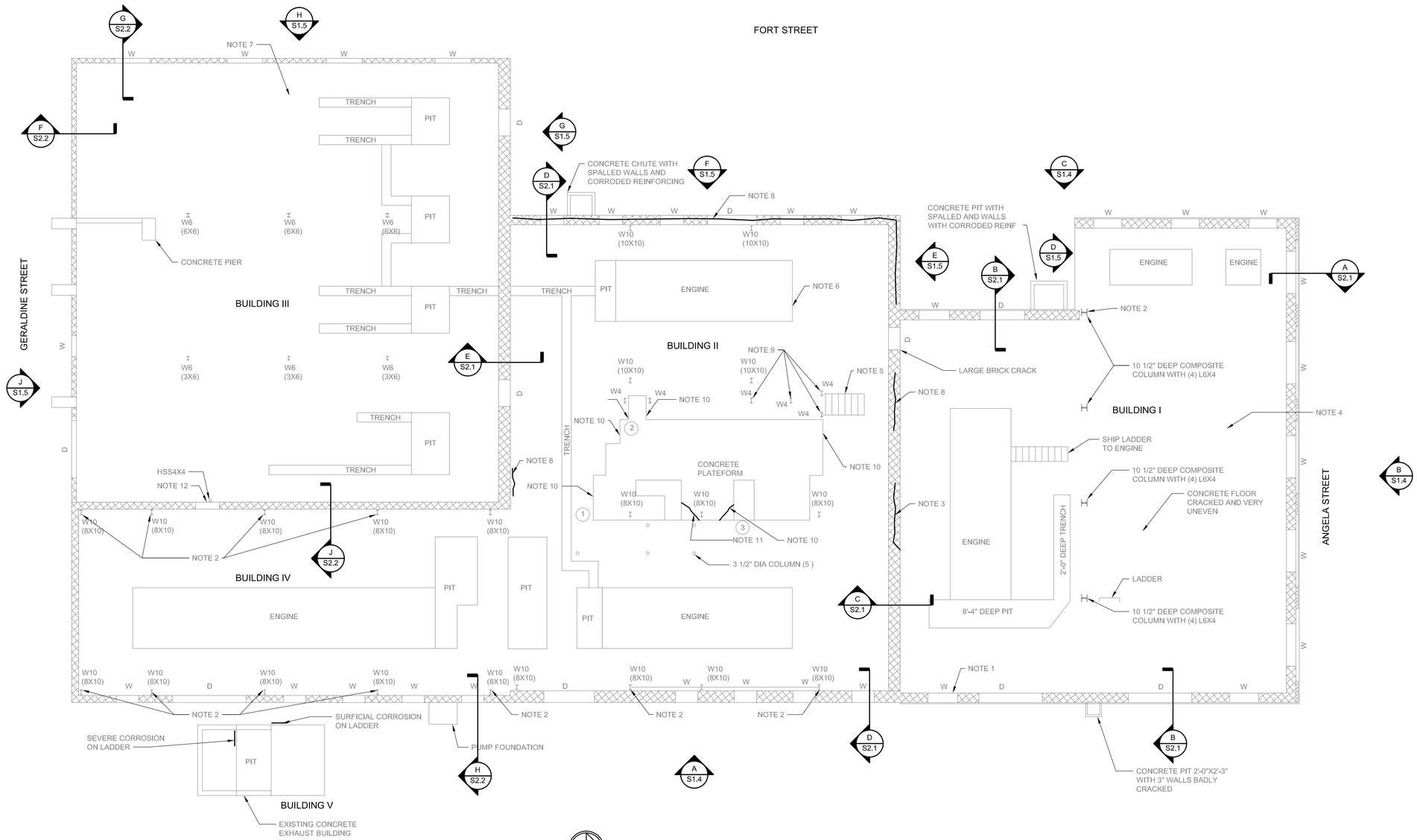
PHOTOGRAPH 54

PHOTOGRAPH 55 (BUILDING III)

PHOTOGRAPH 56 (BUILDING I)

APPENDIX A

SURVEY DRAWINGS



EXISTING FLOOR PLAN

SCALE: 1/8"=1'-0"

SURVEY NOTES:

1. DETERIORATED FACE OF BRICK
2. BADLY CORRODED COLUMN BASE AND OR COLUMN
3. CRACKS IN BRICK AT WALL PENETRATIONS AND ELEVATED OPENINGS
4. CONCRETE FLOOR CRACKED AND UNEVEN
5. BADLY CORRODED STAIR STRINGERS AT BASE OF STAIR
6. TRENCH AND PIT EDGE ANGLE BADLY CORRODED
7. CONCRETE FLOOR CRACKED AND UNEVEN - TRENCH AND PIT EDGE ANGLES ARE BADLY CORRODED
8. DETERIORATED MORTAR JOINTS
9. BADLY CORRODED POST BASE
10. LARGE SPALL WITH EXPOSED CORRODING REINFORCING
11. SEVERE CRACK AT CONCRETE BASE
12. BADLY DETERIORATED BRICK AT WALL OPENING
13. SURFICIAL CORROSION ON ALL STRUCTURAL STEEL.

(#) CARBONATION AND CHLORIDE TEST

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DIESEL PLANT STRUCTURAL SURVEY

KEY WEST, FLORIDA

Project Status

SEAL: MARK J KEISTER PE 37435

REVISED / ISSUED FOR:

REV	DATE	DESCRIPTION

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DATE:	08.03.2016
DRAWN BY:	JEM
CHECKED BY:	MJK

SHEET TITLE:

EXISTING FLOOR PLAN

SHEET NO.

S1.1

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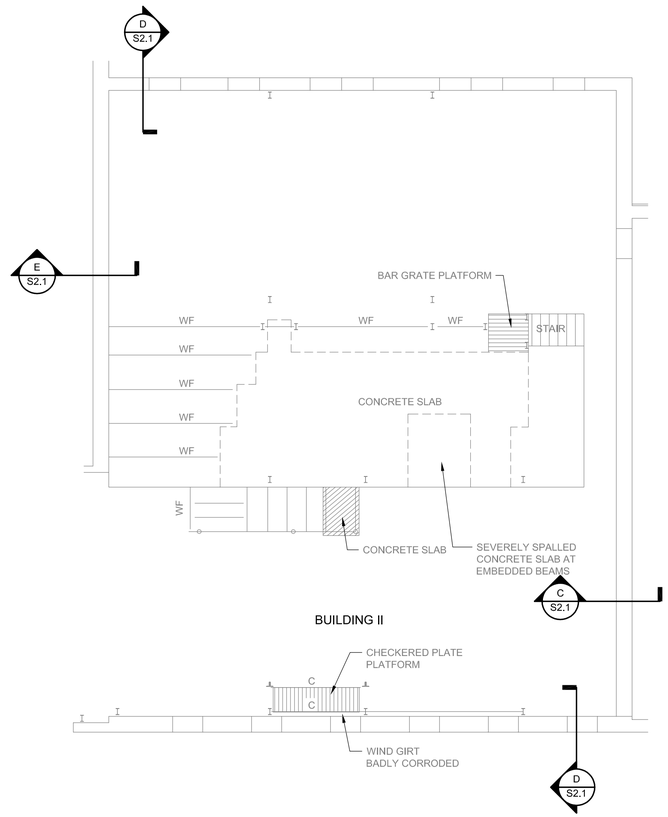
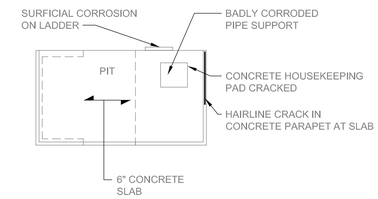


EXISTING MEZZANINE FLOOR PLAN BUILDING II

SCALE: 1/8"=1'-0"

SURVEY NOTES:

1. SURFICIAL CORROSION ON ALL STRUCTURAL STEEL.



EXISTING CONCRETE EXHAUST ROOF PLAN BUILDING V

SCALE: 1/8"=1'-0"

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SHEET TITLE:

EXISTING MEZZANINE FLOOR PLAN

SHEET NO.

S1.2

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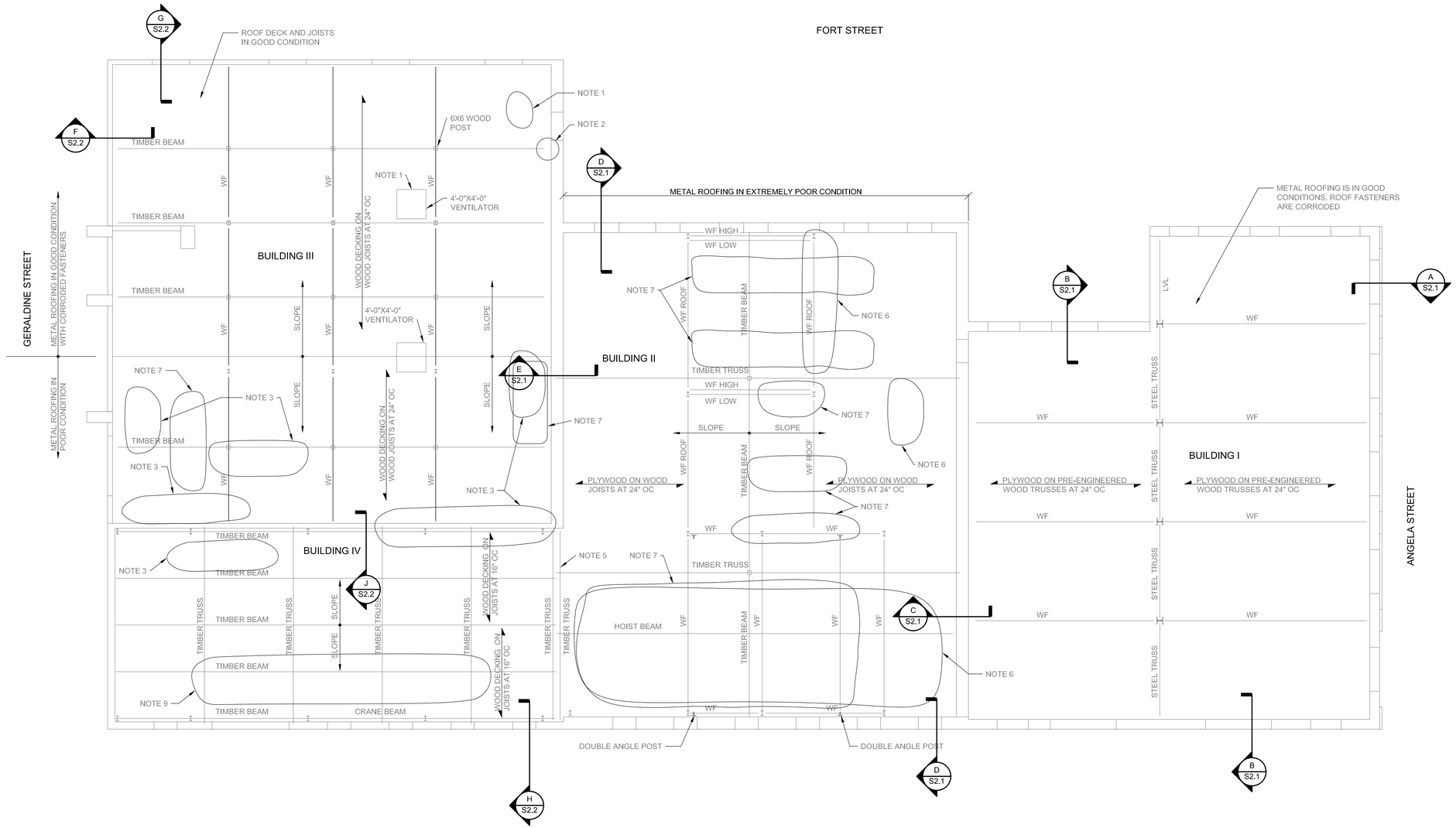
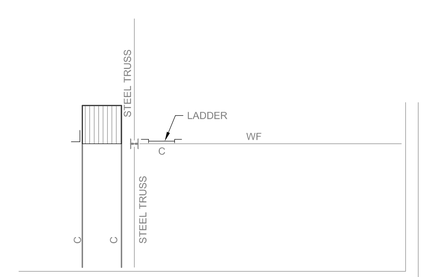


EXISTING ROOF FRAMING PLAN

SCALE: 1/8"=1'-0"

SURVEY NOTES:

1. CORRODED AREA ON METAL ROOFING
2. DETERIORATED BEAM KICKER
3. BADLY DETERIORATED OR MISSING ROOF DECK
4. DETERIORATED ROOF SHEATHING
5. BADLY DETERIORATED BOTTOM TRUSS CHORD
6. DETERIORATED ROOF SHEATHING
7. AREA OF MISSING METAL ROOFING
8. SURFICIAL CORROSION ON ALL STRUCTURAL STEEL
9. BADLY DETERIORATED AND MISSING ROOF DECK, JOINTS AND METAL DECK



ELEVATED PLATFORM BUILDING I

SCALE: 1/8"=1'-0"

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EXISTING ROOF FRAMING PLAN

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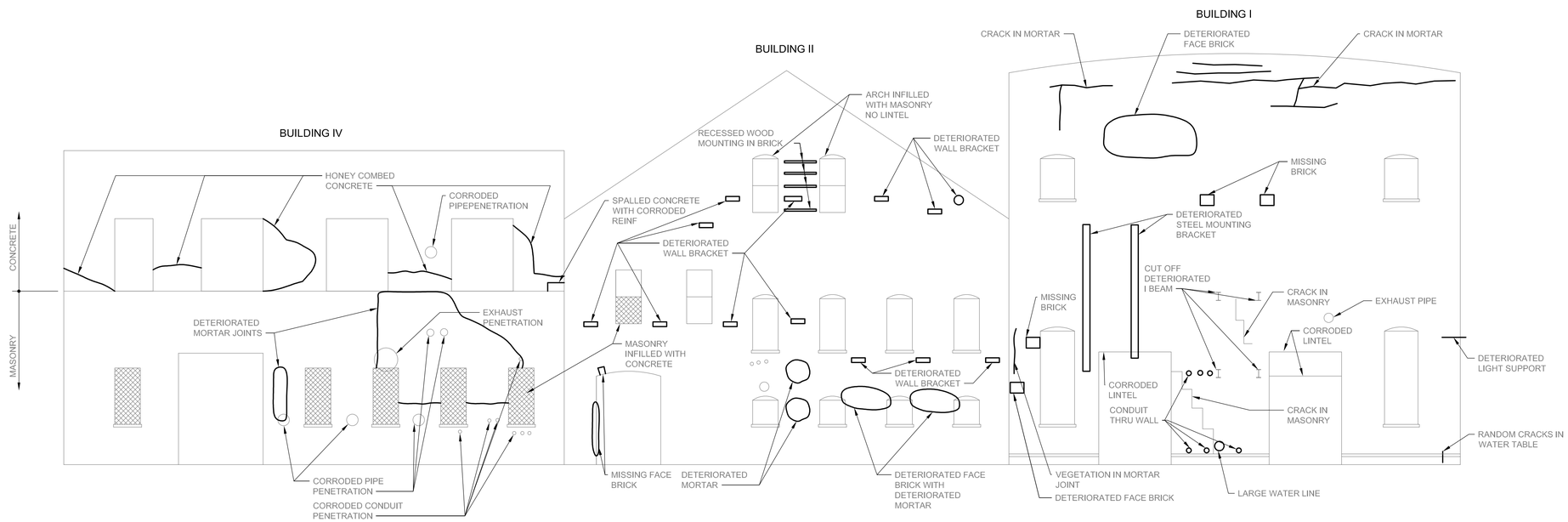

ELEVATION (A / S1.4)
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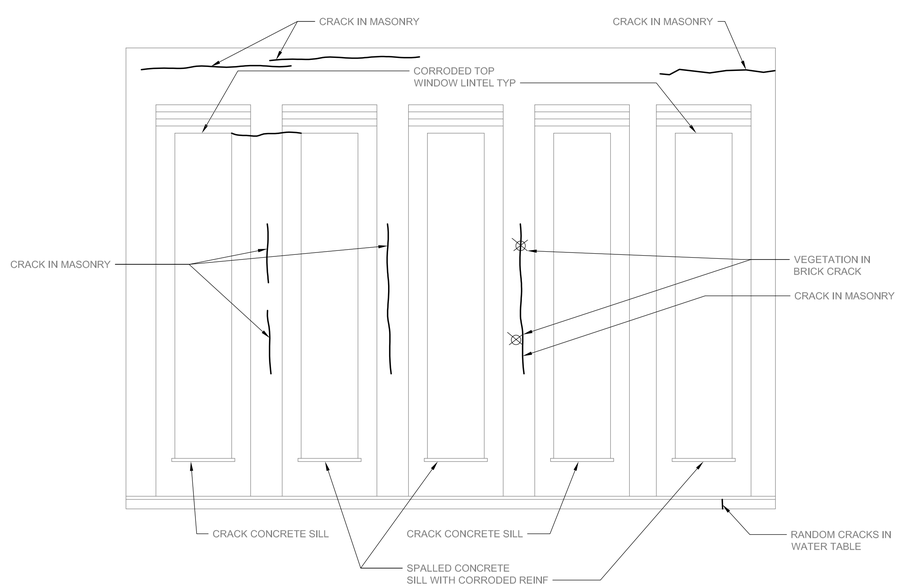

ELEVATION BUILDING III (B / S1.4)
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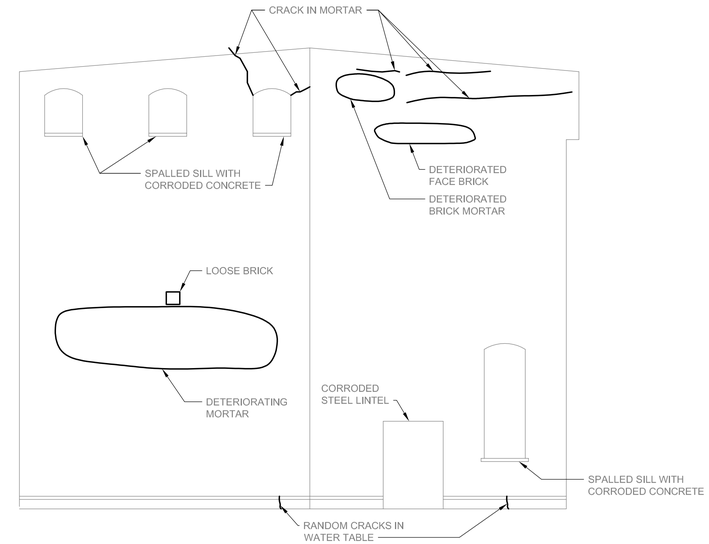

ELEVATION BUILDING I (C / S1.4)
SCALE: 1/8"=1'-0"

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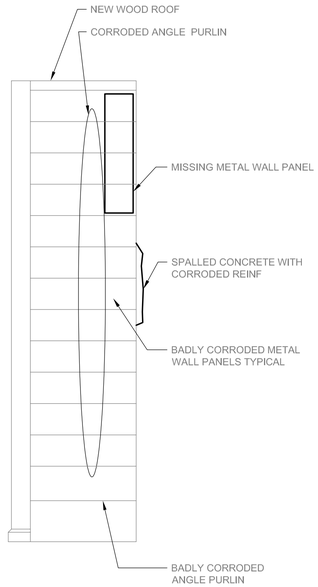
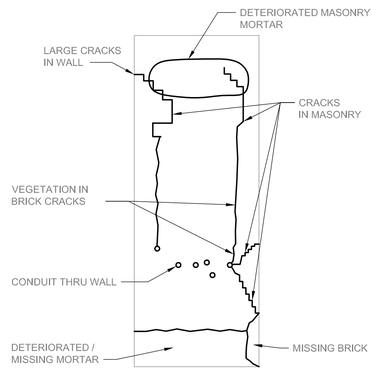


ELEVATION BUILDING I (D / S1.5)
SCALE: 1/8"=1'-0"



ELEVATION BUILDING II (E / S1.5)
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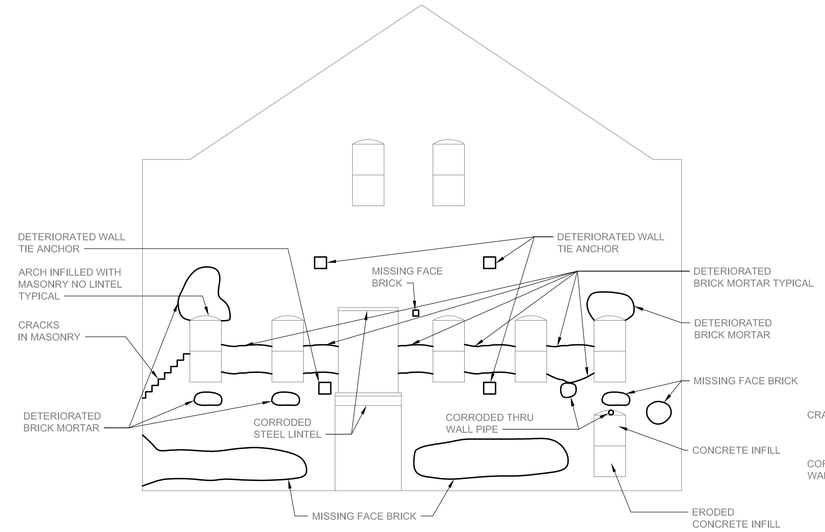

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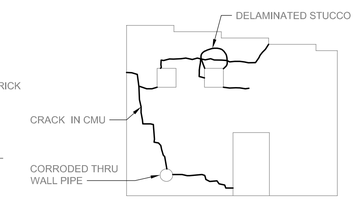

ELEVATION BUILDING III (G / S1.5)
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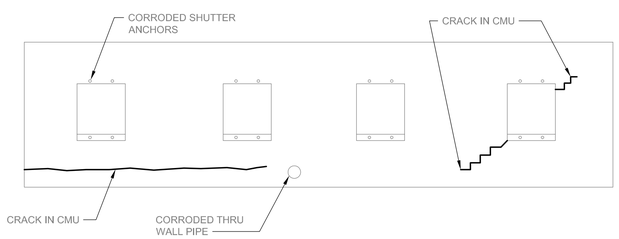

ELEVATION BUILDING III (H / S1.5)
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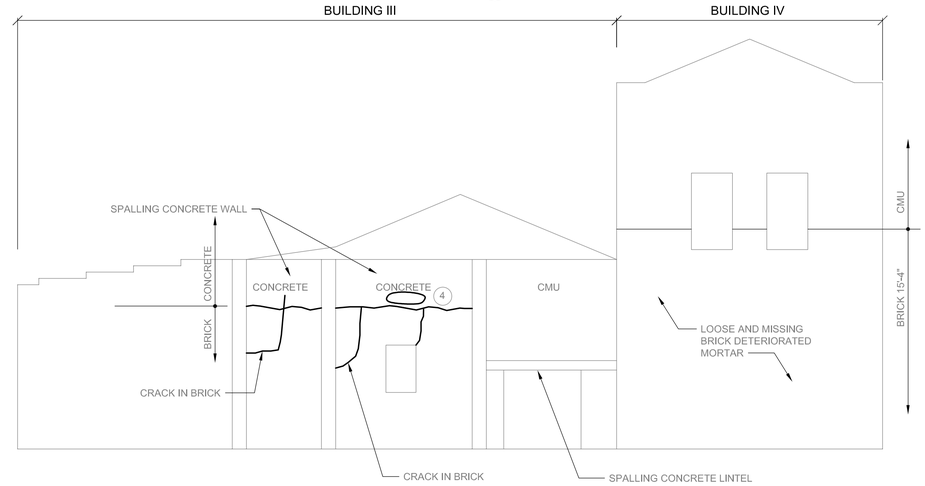

ELEVATION (J / S1.5)
SCALE: 1/8"=1'-0"

(#) CARBONATION AND CHLORIDE TEST

AES ATLANTIC ENGINEERING SERVICES
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DIESEL PLANT STRUCTURAL SURVEY
KEY WEST, FLORIDA

Project Status

SEAL: MARK J KEISTER PE 37435

REVISED / ISSUED FOR:

REV	DATE	DESCRIPTION

PROJECT NO.	316-048
DATE:	08.03.2016
DRAWN BY:	JEM
CHECKED BY:	MJK

SHEET TITLE:
EXISTING ELEVATIONS

SHEET NO.
S1.5

8/03/2016 11:46:43 AM

SECTION A S2.1
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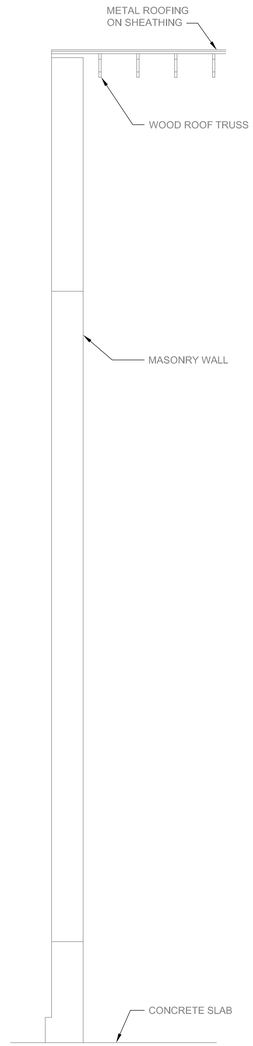

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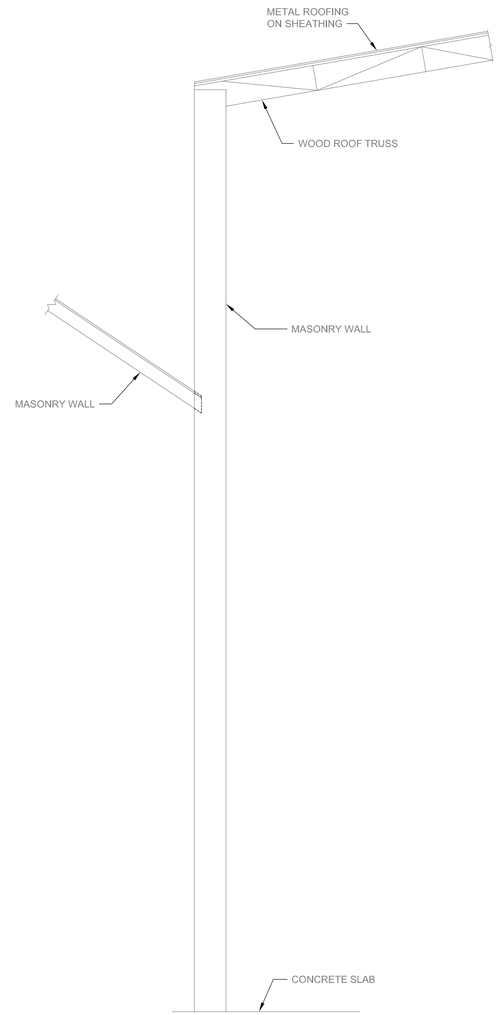

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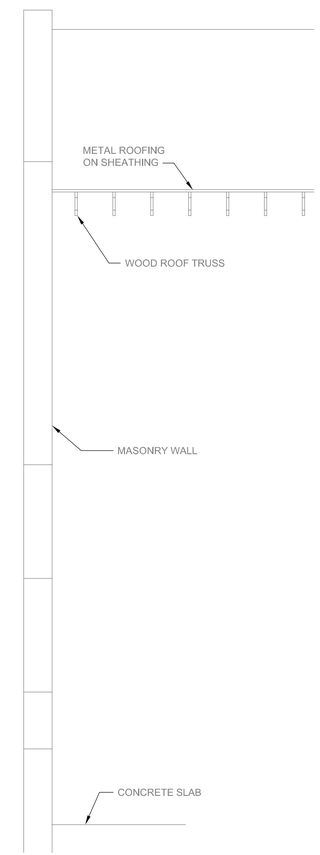

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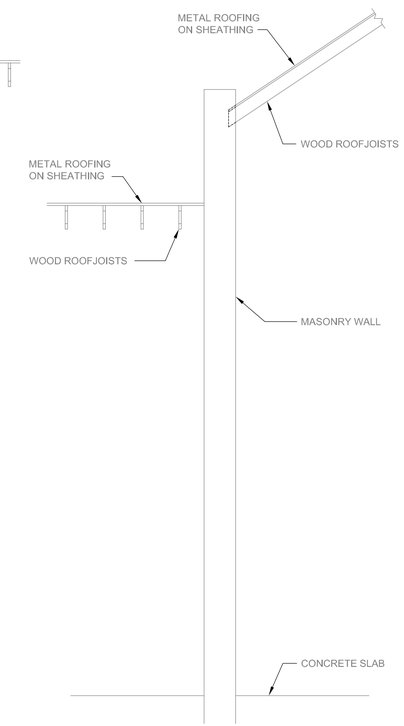

SECTION E S2.1
SCALE: 1/4" = 1'-0"

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SHEET TITLE:

SECTIONS

SHEET NO.

S2.1

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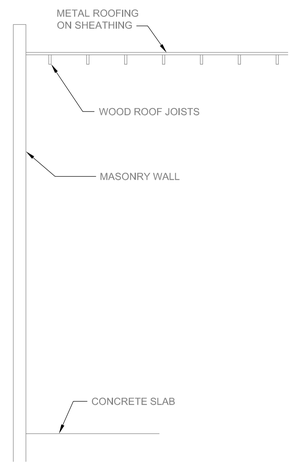

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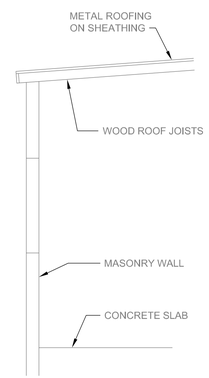

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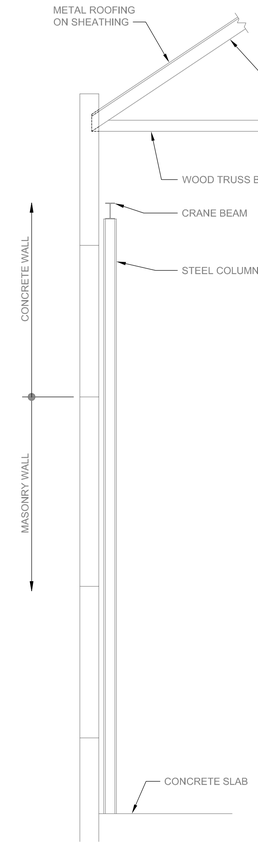

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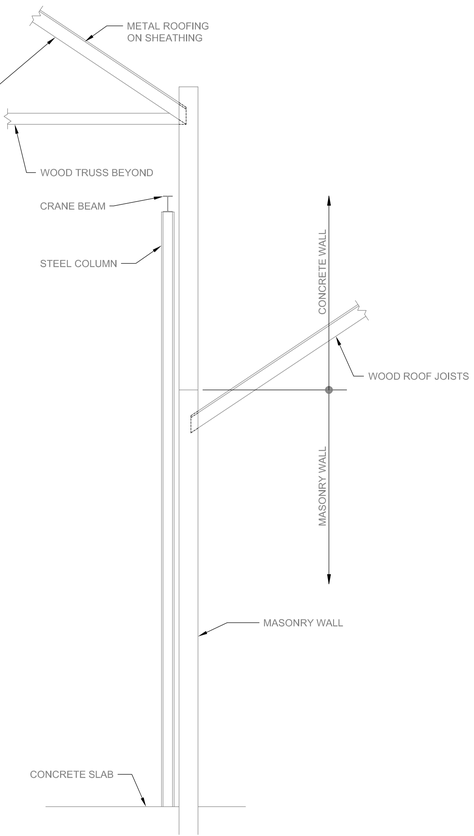

SECTION J S2.2
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SHEET TITLE:
SECTIONS

SHEET NO.
S2.2

8/03/2016 11:44:07 AM

ATLANTIC ENGINEERING SERVICES

APPENDIX B

CHLORIDE AND CARBONATION TESTING

REPORT OF ACID SOLUBLE CHLORIDE TESTING

amec foster wheeler

PROJECT: Laboratory Testing

PROJECT NO.: 6738-13-5286

CLIENT: Atlantic Engineering Services

DATE TESTED: July 8, 2016

As requested, AMEC Foster Wheeler has completed testing of 4 concrete fragments received from Atlantic Engineering Services on June 30, 2016 . The samples were crushed and tested in general accordance with Florida Test Method FM 5-516. Results are outlined below.

Choride Content

Sample ID	% Cl	ppm
1 - Ph. 9.5 @ 1.5" below concrete surface at reinforcing	12.98	129814.0
2 - Ph. 6.5 @ 5" below concrete surface at reinforcing	3.601	36007.4
3 - Ph. 8.5 @ 12" below concrete surface at reinforcing	11.10	111003.0
4 - Ph. 7.5 @ 3" below concrete surface at reinforcing	10.46	104594.1

Respectfully submitted

Mike J. Holm, P.E.

ATLANTIC ENGINEERING SERVICES

APPENDIX C

DEFINITION OF TERMS ASSOCIATED WITH THE DURABILITY OF CONCRETE

DEFINITION OF TERMS ASSOCIATED WITH THE DURABILITY OF CONCRETE
(From ACI 201.1R-08)

1 CRACKING

Crack- A complete or incomplete separation, of either concrete or masonry, into two or more parts produced by breaking or fracturing.

1.1 *Checking*- Development of shallow cracks at closely spaced but irregular intervals on the surface of plaster, cement paste, mortar, or concrete (See also *cracks* and *crazing*).

1.2 *Craze cracks*- Fine random cracks or fissures in a surface of plaster, cement paste, mortar or concrete.
Crazing- The development of craze cracks; the pattern of craze cracks existing in a surface (See also *checking* and *cracks*).

1.3 *D-cracks*- A series of cracks in concrete near and roughly parallel to joints and edges.

1.4 *Diagonal crack*- In a flexural member, an inclined crack, caused by shear stress, usually at approximately 45 degrees to the axis; or a crack in a slab, not parallel to either the lateral or longitudinal directions.

1.5 *Hairline cracks*- Cracks in an exposed-to-view concrete surface having widths so small as to be barely perceptible.

1.6 *Longitudinal cracks*- A crack that develops parallel to the length of the member.

1.7 *Map cracking*- 1) Intersecting cracks that extend below the surface of hardened concrete; caused by shrinkage of the drying surface concrete that is restrained by concrete at greater depths where either little or no shrinkage occurs; vary in width from fine and barely visible to open and well defined; or 2) the chief symptom of a chemical reaction between alkalis in cement and mineral constituents in aggregate within hardened concrete; due to differential rate of volume change in different members of the concrete; cracking is usually random and on a fairly large scale and, in severe instances, the cracks may reach a width of 12.7 mm (0.50 in.) (See also *checking* and *crazing*; also known as *pattern cracking*).

1.8 *Pattern cracking*- Cracking on concrete surfaces in the form of a repeated sequence; resulting from a decrease in volume of the material near the surface, or an increase in volume of the material below the surface, or both (see *map cracking*).

1.9 *Plastic shrinkage cracking*- Cracking that occurs in the surface of fresh concrete soon after it is placed and while it is still plastic.

1.10 *Random cracks*- Uncontrolled cracks that develop at various directions away from the control joints.

1.11 *Shrinkage cracking*- Cracking of a structure or member due to failure in tension caused by external or internal restraints as reduction in moisture content develops, carbonation occurs, or both.

1.12 *Temperature cracking*- Cracking due to tensile failure, caused by temperature drop in members subjected to external restraints or by a temperature differential in members subjected to internal restraints.

1.13 *Transverse cracks*- Cracks that occur across the longer dimension of the member.

2 DISTRESS

Deterioration- 1) Physical manifestation of failure of a material (for example, cracking, delamination, flaking, pitting, scaling, spalling, and staining) caused by environmental or internal autogenous influences on rock and hardened concrete as well as other materials; or 2) Decomposition of material during either testing or exposure to service (See also *disintegration*).

2.1 *Chalking*- Formation of a loose powder resulting from the disintegration of the surface of concrete or an applied coating, such as cementitious coating.

2.2 *Curling*- The distortion of concrete member from its original shape such as the warping of a slab due to differences in temperature or moisture content in the zones adjacent to its opposite faces (See also *warping*).

2.3 *Deflection*- Movement of a point on a structure or structural element, usually measured as a linear displacement or as succession displacements transverse to a reference line or axis.

2.4 *Deformation*- A change in dimension or shape.

2.5 *Delamination*- A separation along a plane parallel to a surface, as in the case of a concrete slab, a horizontal splitting, cracking, or separation within a slab in a plane roughly parallel to, and generally near, the upper surface; found most frequently in bridge decks and caused by the corrosion of reinforcing steel or freezing or thawing; similar to spalling, scaling, or peeling except that delamination affects large areas and can often only be detected by non-destructive tests, such as tapping or chain dragging.

2.6 *Disintegration*- Reduction into small fragments and subsequently into particles (See also *deterioration*).

2.7 *Distortion*- See *Deformation.*

2.8 *Drummy area*- area where there is a hollow sound beneath a layer of concrete due to a delamination, poor consolidation, or void (See also *delamination*).

2.9 *Dusting*- The development of a powdered material at the surface of hardened concrete (See also *chalking*).

2.10 *Efflorescence*- A deposit of salts, usually white, formed on a surface, the substance having emerged in solution from within either concrete or masonry and subsequently been precipitated by a reaction, such as carbonation or evaporation.

2.11 *Exfoliation*- Disintegration occurring by peeling off in successive layers; swelling up, and opening into leaves or plates like a partly opened book.

2.12 *Exudation*- A liquid or viscous gel-like material discharged through a pore, crack, or opening in the surface of concrete.

2.13 *Joint deficiencies*- Expansion, contraction, and construction joints not functioning in intended service conditions.

- **2.13.1** *Joint spall*- A spall adjacent to a joint.
- **2.13.2** *Joint sealant failure*- Joints opened due to a cracked and/or debonded sealant.
- **2.13.3** *Joint leakage*- Liquid migrating through the joint.
- **2.13.4** *Joint fault*- Differential displacement of a portion of a structure along a joint.

2.14 *Leakage*- Contained material is migrating through the concrete member.

- **2.14.1** Leakage, liquid- Liquid is migrating through the concrete.
- **2.14.2** Leakage, gas- Gas is migrating through the concrete.

2.15 *Mortar flaking*- A form of scaling over course aggregate.

2.16 *Peeling*- A process in which thin flakes of mortar are broken away from a concrete surface, such as by deterioration or by adherence of surface mortar to forms as forms are removed.

2.17 *Pitting*- Development of relatively small cavities in a surface; in concrete, localized disintegration, such as a popout; localized corrosion evident as minute cavities on the surface.

2.18 *Popout*- The breaking away of small portions of a concrete surface due to localized internal pressure that leaves a shallow, typical conical, depression with a broken course aggregate at the bottom.

- **2.18.1** *Popouts, small*- Popouts leaving depressions up to 10 mm (0.4 in.) in diameter, or the equivalent.
- **2.18.2** *Popouts, medium*- Popouts leaving depressions between 10 and 50 mm (0.4 and 2 in.) in diameter.
- **2.18.3** *Popouts, large*- Popouts leaving depressions greater than 50 mm (2 in.) in diameter.

2.19 *Scaling*- Local flaking or peeling away of the near-surface portion of hardened concrete or mortar (See also *peeling* and *spalls*).

- **2.19.1** *Scaling, light*- Loss of surface mortar without exposure of coarse aggregate.
- **2.19.2** *Scaling, medium*- Loss of surface mortar 5 to 10 mm (0.2 to 0.4 in.) in depth and exposure of coarse aggregate.
- **2.19.3** *Scaling, severe*- Loss of surface mortar 5 to 10 mm (0.2 to 0.4 in.) in depth with some loss of mortar surrounding aggregate particles 10 to 20 mm (0.4 to 0.8 in.) in depth.
- **2.19.4** *Scaling, very severe*- Loss of coarse aggregate particles as well as surface mortar, generally to a depth greater than 20 mm (0.8 in.).

2.20 *Spall*- A fragment, usually in the shape of a flake, detached from a concrete member by a blow, by the action of weather, by pressure, by fire, or by expansion within the larger mass.

- **2.20.1** *Small spall*- A roughly circular depression not greater than 20 mm (0.8 in.) in depth and 150 mm (6 in.) in any dimension.
- **2.20.2** *Large spall*- May be roughly circular or oval or, in some cases, elongated, and is more than 20 mm (0.8 in.) in depth and 150 mm (6 in.) in greatest dimension.

2.21 *Warping*- Out-of-plane deformation of the corners, edges, and surface of a pavement, slab, or wall panel from its original shape (See also *curling*).

3 TEXTURAL FEATURES AND PHENOMENA RELATIVE TO THEIR DEVELOPMENT.

3.1 *Air void*- A space in cement paste, mortar, or concrete filled with air; an entrapped air void is characteristically 1 mm (0.04 in.) or greater in size and irregular in shape; entrained air void is typically between 10 µm and 1 mm (0.04 mil and 0.04 in.) in diameter and spherical or nearly so.

3.2 *Blistering*- the irregular raising of a thin layer at the surface of placed mortar or concrete during or soon after the completion of the finishing operation; also, bulging of the finish plaster coat as it separates and draws away from the base coat.

3.3 *Bugholes*- Small regular or irregular cavities, usually not exceeding 15 mm (0.6 in.) in diameter, resulting from entrapment of air bubbles at the surface of formed concrete during placement and consolidation (Also known as surface air voids).

3.4 *Cold joint*- A joint or discontinuity resulting from a delay in placement of sufficient duration to preclude intermingling and bonding of the material in two successive lifts of concrete, mortar, or the like.

3.5 *Cold-joint lines*- Visible lines on the surfaces of formed concrete indicating the presence of a cold joint where one layer of concrete had hardened before subsequent concrete was placed.

3.6 *Discoloration*- Departure of color from that which is normal or desired (See also *staining*).

3.7 *Honeycomb*- Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

3.8 *Incrustation*- A crust or coating, generally hard, formed on the surface of concrete or masonry construction or on aggregate particles.

3.9 *Laitance*- A layer of weak material known as residue derived from cementitious material and aggregate fines either: 1) carried by bleeding to the surface or to the internal cavities of freshly placed concrete; or 2) separated from the concrete and deposited on the concrete surface or internal cavities during placement of concrete underwater.

3.10 *Sand pocket*- A zone in concrete or mortar containing fine aggregate with little or no cement material.

3.11 *Sand streak*- A streak of exposed fine aggregate in the surface of formed concrete, caused by bleeding.

3.12 *Segregation*- The differential concentration of the components of mixed concrete, aggregate, or the like, resulting in nonuniform proportions in the mass.

3.13 *Staining*- Discoloration by foreign matter.

3.14 *Stalactite*- A downward-pointing deposit formed as an accretion of mineral matter produced by evaporation of dripping liquid from the surface of concrete, commonly shaped like an icicle (See also *stalagmite*).

3.15 *Stalagmite*- An upward-pointing deposit formed as an accretion of mineral matter produced by evaporation of dripping liquid, projecting from the surface of rock or of concrete, commonly roughly conical in shape (See also *stalactite*).

3.16 *Stratification*- The separation of overwet or overvibrated concrete into horizontal layers with increasingly lighter material toward the top; water, laitance, mortar, and coarse aggregate tend to occupy successively lower positions in that order; a layered structure in concrete resulting from placing of successive batches that differ in appearance; occurrence in aggregate stockpiles of layers of differing grading or composition; a layered structure in a rock foundation.

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APPENDIX D

EXISTING STRUCTURAL CONDITIONS EVALUATION CRITERIA

ATLANTIC ENGINEERING SERVICES

EXISTING STRUCTURAL CONDITIONS
EVALUATION CRITERIA

EXCELLENT	**Meets or exceeds current structural code requirements.** Capable of safely carrying proposed occupancies. No significant vibrations, cracking or deflections. No structural reinforcement or repairs required. Very minor, if any, maintenance required.
GOOD	**Meets current structural code requirements.** Capable of safely carrying proposed occupancies. Deflections, cracking, vibrations may be observable. No structural reinforcement required. Minor structural repairs required. Some significant maintenance repairs required.
FAIR	**Majority of structure meets structural code requirements.** Portions of structure are not capable of carrying proposed occupancies. Deflections, cracking, vibrations, structural distress is observable. Structural reinforcement required in limited portions of the structure. Structural repairs required generally. Many significant maintenance repairs required.
POOR	**Majority of structure does not meet structural code requirements.** Much of the building is not capable of carrying proposed occupancies. Deflections, cracking, vibrations, structural distress commonly observable throughout the structure. Major reinforcement or reconstruction of the structure is required. Major maintenance repairs are required.
EXTREMELY POOR	**Collapse of structure is imminent.** Structure exhibits significant deflections, cracking, vibrations, structural distress. Structure requires extensive reinforcement or reconstruction of impractical scope.

NOTE: Some parts of each definition may not apply.