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VALDESE PUBLIC SAFETY BUILDING INSPECTION

NORTH CAROLINA
PROFESSIONAL
SEAL
034996
ENGINEER
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PREPARED FOR	Chief Watts, Valdese Fire Department

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1 Executive Summary

The Public Safety Building and Town Hall Building were investigated on February 5th 2018. Findings include multiple horizontal and vertical cracks in the interior wythes of the buildings. Cracks range from 1/16” to 3/8” wide. The horizontal cracks appear attributable to either expansive roof forces or contractive internal floor forces. Either cause would induce out of plane loading to create the horizontal cracks. The vertical cracks appear attributable to expansion and contraction forces within the walls. No vertical expansion joints were provided per Record Drawings nor per field observation. Lack of expansion joints or defects associated with horizontal joint reinforcing may have contributed to the cracks. The forces applied are likely on account of temperature, changes in moisture, and shrinkage.

Both the horizontal and vertical cracks may adversely affect the load carrying capacity of the building. Further investigation and analysis is required to determine the full severity of the condition and the appropriate repairs. In interim the cracks should be monitored.

Outside the buildings exhibit mortar joint spalls at approximately 16” on center. The joints were likely reinforced with bare metal joint reinforcing. Contemporary joint reinforcing is galvanized. Corrosion of the joint reinforcing has caused expansive corrosion forces to pop and spall the joints. The condition of the joint reinforcing as it relates to function as wall ties is not known. Mortar joint deterioration is a problem that may allow excessive moisture to enter the internal cavity. A more significant problem may exist if the internal wall ties are in poor condition due to corrosion.

The storm water pipe located under the engine bay has a history of sinkhole development at the manhole to the east. It is unclear what measures were taken to prevent subsequent sinkhole development. In general, storm pipes under critical infrastructure is not good practice if avoidable. The storm pipe under the engine bay poses some risk to the operational readiness of the Fire Department.

Other miscellaneous cracks in the slabs are notable, but do not appear significant in terms of adverse effects. Cracks in the engine bay slab for instance appear attributable to shrinkage and stress concentrations. The cracks should be monitored. One instance of settlement cracking is evident on the exterior southeast corner of the Public Safety Building. The cracks do not appear excessive now, but they should be monitored.

Minimum critical investigations and analysis should be conducted per Section 7. Cracks should be further catalogued, gauged, and monitored for one year. The condition of the internal cavity wall ties should be determined. The existing storm pipe condition should be determined and the pipe should be routinely inspected periodically going forward. Any additional tasks or repairs should be conducted based on the findings of the minimum investigation items noted.

The full cost of repairing the building is not clear at this time since the full scope is heavily contingent on subsequent investigation and analysis efforts. Approximate maximum and minimum costs are provided in Section 7.

Maximum repair design and construction cost could potentially be in excess of $400,000 dollars. A similar footprint Public Safety Building at 7,400 square feet may cost on the order of $1,000,000 to $1,400,000 dollars. If the full extent of potential repairs is required, it is likely the repairs would not be cost effective in terms of long term planning for the City of Valdese.

Typical service life for buildings is 50 years. The Public Safety Building is 41 years old. Spending 20 to 30% of new building cost for repairs is only reasonable if a service life extension of 25 years or more is the result. It is possible that the building may become operationally obsolete in the next 10 to 20 years. It is common for building maintenance to increase with age. Therefore, other major building repairs may be necessary despite wall repairs now.

A minimum effort should be conducted to assure that life and safety requirements are met at the existing building in the short term (see Section 7). However, it appears prudent for the City of Valdese to consider building replacement as the most operationally efficient and cost effective solution.

The report below and attached Appendix detail and catalogue the defects at the site and the recommended actions.

2 Description of Structure

The Valdese Public Facilities Building was built in three distinct sections. The first was the old Firehouse which was built in excess of 60 years ago. The second was the Town Hall Addition which was built circa 1973. Lastly, the Public Safety Addition was built circa 1977 per available record drawings. The two additions flank the original Firehouse building to the North and the South as shown in figures 1 and 2.

The Town Hall is constructed of double wythes with a 2" wide cavity between. The internal wythe is 6" to 8" concrete masonry units, and the external wythe is 4" clay brick. A 6" steel reinforced bond beam is located at the top of the wall at the joist bearing elevation. Wire joint reinforcing spaced at 16" on center vertically ties the two wythes together. Steel bar joists support the roof metal deck and span from east to west. The bar joists bear on the east and west masonry walls and internal masonry walls. The roof slopes to the north wall. No apparent roof expansion joints were installed on the east and west walls, but the drawings indicate a roof expansion at the connection to the existing Firehouse wall.

The Public Safety Addition is similar in construction to the Town Hall with masonry double wythe cavity walls on each of the four exterior walls. However, the double wythes are both 4" brick internal and external. The 2" cavity is filled with rigid insulation and the wythes are tied together with ladder type wire joint reinforcing spaced at 16" on center vertically. Steel reinforced bond beams are located at the tops of the external walls where the joists are anchored. The steel bar joists span from east to west and bear on internal steel beams and the external walls. Weep holes are apparent on south wall per visual inspection. And the interior floor is reinforced concrete slab on infill.

The Engine Bay was added with the Public Safety Addition and is located between the addition offices and the previously existing old Firehouse Building.

3 Inspection and Observed Conditions

The inspection team visited the site on February 5th, 2018 between the hours of 9:00 and 12:00. The inspection began in the Public Safety Building interior where all four external walls were observed along with miscellaneous interior points of interest on the concrete floor slab. Next the team moved outside and toured external wall surfaces around the entire building perimeter. Finally, the interior of the Town Hall and Engine Bay were observed along with the interior of the Old Firehouse.

3.1 Inspection and Investigation Methods

Inspection included photo documentation of the masonry and floor slab defects internally and externally. Crack widths were measured as part of the photo documentation process. Locations of photos were documented and are shown in Figures 1 and 2. Additional Photos may be requested or may be viewed in Report provided by West Consultants, PLLC.

Record drawings were provided for review by the Valdese Fire Department. Engineer reviewed the drawings as it relates to the relevant structural components, building materials, detailing, and layout. Cross correlations between defects noted in the photo documentation and the drawings were identified where possible.

Interviews with Chief Watts and associates were conducted as it relates to the history of the masonry defects and historical sink hole formation at the site. Discussions with contractor's and engineers experienced in masonry construction were conducted to gain additional understanding of construction techniques of the 1970's.

3.2 Town Hall Inspection Findings

Interior Defects

Cracks exist in the Town Hall Building primarily along the building external perimeter wall on the north, east and west sides. Cracks vary in thickness between 1/16" and 3/16" maximum and are both horizontal and vertical in orientation.

The horizontal cracks are typically located at the approximate elevation of the bottom of the steel reinforced Bond Beam, see Photo 3 and 4 and Figure 7. This condition persists along the north exterior wall and east exterior wall. Per Figure 7 from the Town Hall record drawings, the joint at the bottom of the bond beam is located at the crack elevation. In addition, the presumed horizontal joint reinforcing elevation is at the joint at the bottom of the bond beam. Horizontal joint reinforcing and the infilled bond beam appear to create a stress concentration at that elevation with respect out of plane loading.

Horizontal cracks in the west wall appear to be one course lower. It is apparent that the crack on the west wall is also attributable to out of plane loading. It is possible a variance in horizontal joint reinforcing on the front west wall accounts for the variance in elevation of the typical horizontal crack. Since the front wall also includes windows and doors a-typical to the building at large, it is likely the variance is on account of this difference.

Vertical cracks are located at approximately 10 feet on center in the rear room of the building along the east exterior wall and part of the north wall. The cracks generally extend from floor to near the ceiling, but do not appear to extend above the reinforced bond beam at the top of the cmu interior wythe. It is reasonably obvious that the reason this is so is because the grouted and reinforced bond beam is restrained against cracking relative to the hollow unreinforced interior cmu wythe immediately below. Typical vertical cracks are depicted in Photos 2, 3, 4, and 5.

The reason for the horizontal cracks appears to be out of plane loading induced at the roof elevation. Effectively the roof is pushing the top of the walls away from the center of the building which creates a crack on the inside face at the point of least resistance. This point is obviously the joint immediately below or near the bond beam. The exact reason for the out of plane loading in excess of the walls inherent strength is difficult to determine with the limited observation conducted to date. However, it stands to reason that the loading is attributable to differential expansion or contraction of the roof and/or wall footprint respectively. In the roof expansion case, the roof would have expanded under thermal load and pushed the walls outward. In the latter contraction case, the interior fill of the building would have contracted due to drying of the soil underneath or shrinkage of the interior floor slab. This contraction would tend to pull the walls inward creating the outward pressure on the walls from the roof. In either case, the inherent lack of strength in tension for masonry is why the wall the cracked from the induced out of plane bending. Once cracks like these open, it is often the case that they never fully close even if the expansive force is later reversed due to change in season or otherwise.

The roof was equipped with one expansion joint per record drawings and shown in attached Figure 8. The expansion joint is located along the south wall which is shared by the old previously existing Firehouse building. No expansion joints were provided, per record drawings, at either the east or west walls. It is clear that expansive forces should be expected in the east to west direction. It is less clear why expansive forces effected the horizontal crack in the north wall since expansion forces should have been partially alleviated by the joint at the south wall. It is possible the joint was either installed incorrectly or was less effective than the designer's intent.

Similarly, the exact reason for the vertical cracks is difficult to determine with limited observation to date. However, it is obvious that differential expansive and contractive movement is to blame. The cracks may have formed from shrinkage of the masonry immediately after completion of the wall at the time of original construction. The shrinkage effect would be enhanced if the wall was exposed to significant moisture before the roof was installed and the building dried in. If very wet, the wall may have expanded due to moisture expansion and contracted once dry. Again, masonry is good in compression not tension. The wall readily pushes itself longer under expansive load (moisture or hot temperatures), but cannot fully pull itself shorter due to contraction forces (drying, curing, or cold temperature). Joint reinforcing is typically installed to lessen this effect, but correct installation is necessary to achieve desired results of spreading out and minimizing crack width. It is possible that limited or incorrect splicing of joint reinforcing may have accentuated the crack development in this wall.

No vertical expansion joints were noted in the Town Hall record drawings. No vertical expansion joints were found during inspection. Typical expansion joint spacing for similar walls in contemporary construction is on the order of every 25 to 50 feet. Lack of vertical expansion/contraction joints certainly added to the vertical cracking effect observed.

Exterior Defects

Outside, cracking is generally not apparent, but spalling is pervasive along the north exterior wall. The spalling is generally isolated to the masonry joints and is spaced at approximately 16" on center vertically. The spacing matches the joint reinforcing spacing detailed in Figure 7. It appears the steel joint reinforcing has corroded and spalled the joints (popped the mortar) due to expansive corrosion induced forces. Brick has also spalled in a few locations as shown in Photo 7. Buildings built circa the 1970's utilized joint reinforcing and walls ties that were not coated or galvanized. A short time later, galvanizing was introduced but was of a lesser quality when compared to modern hot dip galvanizing. It is reasonable to assume that this building built in 1973 utilized uncoated joint reinforcing and the apparent susceptibility to corrosion is the result. The joint reinforcing may have also been placed too close to the exterior mortar joint surface allowing for water to more quickly reach the susceptible steel.

3.3 Public Safety Building Inspection Findings

Interior Defects

Masonry wall cracking defects in the Public Safety Building are similar in form and apparent cause to the cracks in the Town Hall. Some differences apply and are likely on account of minor differences in construction materials. For instance, the interior wythe of the cavity wall in the Public Safety Building is 4" brick. In general, expansion or contraction forces applied at the roof elevation appear to induce out of plane bending stress on the wall in a similar fashion to the Town Hall Building.

A horizontal crack runs virtually the entire perimeter of the building and is located approximately 4 ½ bricks below the drop ceiling on the east wall the south wall and part of the north wall per Photos 12 and 13. The west wall horizontal crack elevation varies to approximately 10 ½ bricks below the drop ceiling which is consistent with a horizontal joint reinforcing spacing of 16". Similarly, 4 ½ bricks below the drop ceiling is consistent with joint reinforcing detailed in Figure 4 per Record Drawings.

Variance in the crack location on the west wall may be attributable to geometry variances associated with the front entrance. The north, east, and south walls are all very similar geometrically with minimal window or door interruptions. The crack width appears to vary between the north wall and the south wall. It stands to reason that the north wall is more thoroughly braced since it doubles as the engine bay wall. In other words, the south wall is more free to displace and create a larger width crack. Cracks vary from approximately 1/16" to ¼" widths.

Vertical cracks are often isolated above the horizontal crack elevation. It appears that the open horizontal crack allows for slippage above and breaks the plane of the vertical crack. On the east and south walls, vertical cracks travel the full height of the wall from floor to drop ceiling and number approximately 2 per wall. Similar to the Town Hall, these cracks appear attributable to expansion and contraction forces where the wall once was expanded and since contracted to form the cracks. No vertical expansion joints were detailed in the drawings nor were found during inspection. Expansion may have prevented or helped control the cracking. In addition, incorrect or limited horizontal joint reinforcing may have accentuated crack development. For instance, the large crack in Photo 10 may have developed at an interruption in horizontal joint reinforcing. The crack is approximately 3/8” wide.

Some slab cracking is evident through the linoleum tile in interrogation, Photo 11. The cracks appear isolated. Separation is evident between the slab and the wall along the east wall as shown in Photo 27. The separation may be attributable to the same forces acting out of plane on the walls to create the horizontal crack.

Exterior Defects

Exterior wall defects are similar to the Town Hall and generally appear attributable to corrosion of horizontal joint reinforcing. Some previous repairs are evident on the south wall. Another difference is an isolated differential settlement crack located at the southeast corner as shown in Photo 14. The crack is somewhat mirrored internally inside the IT room.

Engine Bay Defects

The slab inside the engine bay exhibits cracking at locations of stress concentration like corners and slab pipe penetrations as shown in Photos 24 and 25. Especially since no control joints are evident, the cracks appear attributable to typical shrinkage and/or temperature cracking in slabs on grade.

According to testimony at the time of the inspection, the east bay door column was once repaired previously. The repaired column has since cracked as shown in Photo 22. The concrete slab at the east bay doors has also cracked, and it appears attributable to typical slab cracking phenomenon.

It is difficult to say why exactly the column has cracked. The proximity of the engine bay door connections may be a potential cause, but it is important to note the historical problematic nature of this location. Per testimony from Chief Watts at the time of inspection, there is a history of sink hole development at a manhole junction box location approximately 20 feet from the engine bay doors to the east, Photo 19 and 20.

Apparently, a city storm sewer pipe is not only located near the engine bay, but runs underneath as depicted in Figures 2 and 3. Building above storm drainage pipes is not considered good practice contemporarily unless no other options are available. According to Chief Watts it is not clear if any special repair measures were undertaken at the time of sinkhole repair. Therefore, it is unclear if the cause of the sinkhole was adequately addressed at the time of previous repair or if partial pipe leakage can be expected to persist or not. Until such time confirmation is made, it is prudent to assume the issue is unresolved.

4 Conclusions

Many of the observed defects are typical of masonry construction, especially for buildings of significant age like the Town Hall and Public Works Buildings which are near their respective service life end. The Town Hall Building is 45 years old and the Public Safety Building is 41 years old. A reasonable service life for buildings like these is on the order of 50 years. In the building industry, service life in years, if noted in design documents, is rarely stated in excess of 50 years. If buildings are designed to exceed a 50 year design life, special details are typically included to achieve this goal. For instance, galvanizing or use of stainless steel for bolts, steel shapes, and/or concrete and masonry reinforcing is appropriate for longer design service life. Expansion joints are also a common tool used to extend service life of masonry construction or at least to maintain a relatively defect free building.

Similarly, it is not uncommon for masonry defects to exist in buildings, but not be visible. For instance, the Town Hall Building has drop ceiling removed and furring strips that were not covered with drywall. As such, the masonry crack defects are visible where they otherwise would not be with drywall and drop ceilings installed. In the case of the Public Safety Building the designers intent was for visible brick interior wythe. As it turned out, masonry defects are highly visible in this case.

The question then becomes, how critical are the visible defects and what is the appropriate course of action?

Horizontal Cracks

The horizontal cracks in the Town Hall are less severe than in the Public works building. This is true both in terms of severity and implications. The Town Hall internal wythe is much thicker at 6 to 8" compared to the Public Safety Building 4" brick. Even with cracking as it is, the Town Hall walls are more stable if for no other reason than because the walls are thicker.

Horizontal crack development appears to be on account of roof expansion and/or internal contraction. These forces are inevitable. Proper detailing such as roof expansion joints and/or vertical steel reinforcing can be used in new construction to minimize or eliminate crack formation like this. These items were not installed in either building. (Exception is the marginally effective roof expansion joint in Town Hall).

For both buildings, the lateral force resisting system has been compromised as it relates to lateral load (Seismic Loading likely controls lateral loads for consideration). The plane where the crack is located is effectively debonded and reduces the effective wall thickness for shear forces. Vertical gravity load capacity has also been compromised, especially for the Public Safety Building. Where the crack is at the widest, it is reasonable assume that the exterior wythe of brick is supporting all the gravity load from the roof.

The proper repair for the cracks is dependent on the findings of additional investigation work. For instance, whether or not the cracks are active needs to be determined to develop the appropriate fix. Crack gauges observed over time can be implemented to achieve this understanding. Once the nature of the crack is determined, a repair method can be analyzed.

If the crack is active, a flexible joint is the most appropriate repair. However, the flexible joint would not serve to reestablish lateral and gravity load connectivity. Instead the flexible joint would permanently alter the load path of the existing structure. An analysis to determine the implications of the altered load path would be necessary to determine if additional alterations are necessary to compensate. The *North Carolina Building Code for Existing Buildings* covers this scenario as shown in the exerts below.

[B] 403.3 Existing structural elements carrying gravity load. Any existing gravity load-carrying structural element for which an *alteration* causes an increase in design gravity load of more than 5 percent shall be strengthened, supplemented, replaced or otherwise altered as needed to carry the increased gravity load required by the *International Building Code* for new structures. Any existing gravity load-carrying structural element whose gravity load-carrying capacity is decreased as part of the *alteration* shall be shown to have the capacity to resist the applicable design gravity loads required by the *International Building Code* for new structures.

[B] 403.3.1 Design live load. Where the *alteration* does not result in increased design live load, existing gravity load-carrying structural elements shall be permitted to be evaluated and designed for live loads approved prior to the *alteration*. If the approved live load is less than that required by Section 1607 of the *International Building Code*, the area designed for the nonconforming live load shall be posted with placards of approved design indicating the approved live load. Where the *alteration* does result in increased design live load, the live load required by Section 1607 of the *International Building Code* shall be used.

[B] 403.4 Existing structural elements carrying lateral load. Except as permitted by Section 403.5, when the *alteration* increases design lateral loads in accordance with Section 1609 or 1613 of the *International Building Code*, or where the *alteration* results in a structural irregularity as defined in ASCE 7, or where the *alteration* decreases the capacity of any existing lateral load-carrying structural element, the structure of the altered building or structure shall be shown to meet the requirements of Sections 1609 and 1613 of the *International Building Code*.

Exception: Any existing lateral load-carrying structural element whose demand-capacity ratio with the *alteration* considered is no more than 10 percent greater than its demand-capacity ratio with the *alteration* ignored shall be permitted to remain unaltered. For purposes of calculating demand-capacity ratios, the demand shall consider applicable load combinations with design lateral loads or forces in accordance with Sections 1609 and 1613 of the *International Building Code*. For purposes of this exception, comparisons of demand-capacity ratios and calculation of design lateral loads, forces and capacities shall account for the cumulative effects of *additions* and *alterations* since original construction.

North Carolina State Building Code: Existing Building Code

If it can be shown that the repairs are merely reestablishment of the original condition, then “alteration” code implications can be avoided. For instance Section 404 covers this scenario.

SECTION 404
REPAIRS

[B] 404.1 General. Buildings and structures, and parts thereof, shall be repaired in compliance with Section 401.2 and Section 404. Work on nondamaged components that is necessary for the required *repair* of damaged components shall be considered part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section 401.2, ordinary repairs exempt from permit by North Carolina statute, and abatement of wear due to normal service conditions shall not be subject to the requirements for repairs in this section.

[B] 404.2.1 Evaluation. The building shall be evaluated by a *registered design professional*, and the evaluation findings shall be submitted to the *building official*. The evaluation shall establish whether the damaged building, if repaired to its predamage state, would comply with the provisions of the *International Building Code* for wind and earthquake loads.

North Carolina State Building Code: Existing Building Code

Even at this early stage, it appears unlikely that effective repairs would qualify as “unaltered”. In either case, more investigation and analysis is required to make the distinction.

Full extents of the Horizontal crack defects also must be determined. For instance, the drop ceiling in the Public Safety Building needs to be selectively removed for a more thorough evaluation. Crack gauges need to be monitored for a minimum of one full year to note changes with respect to all four seasons.

Vertical Cracks

Vertical cracks appear to be attributable to expansion forces with only partial contraction. A rigid repair is not appropriate. For instance, grouting the vertical cracks would likely not only not work, but also add expansive forces to the structure and force to walls to grow even longer. The appropriate repair is a flexible expansion/contraction joint installed at the most severe crack locations. The building has already shown where the forces tend to concentrate, therefore, joints at these locations is empirically appropriate. Aside from joints at these locations, additional joints may be appropriate. It may also be appropriate to install the joints on both sides of the wall interior and exterior. More investigation and analysis is necessary to determine the most effective specific course of action.

In new construction, vertical joints are often armored. That is, brick or block is turned 90 degrees relative to the typical placement to close off the end of the cavity at the joints. Shear keys may also be employed at joints in new construction. Application of joints in this case appears appropriate to control any additional crack formation, but like the horizontal crack repair, the change may need to be considered an “alteration”.

Existing Spalls and Joint Reinforcing

One could potentially argue that the cracks are aesthetic issues. This is partially true. For instance, the crack could be covered with sheet rock to hide them. This would not be uncommon, but it is likely not appropriate in this case. For instance, it is obvious that corrosion has significantly affected the exterior wall joints. Even pristine wythes can be expected to transmit wind driven rain into the cavity of cavity walls. It is likely that significant moisture has penetrated the cavity in this case since the popped joints are much more susceptible to rain intrusion. Also, it is highly likely based on chronology and site corrosion evidence that the joint reinforcing is not galvanized. As such, it is possible the ties between the walls have been compromised. Therefore, the walls should not be covered internally until such time the condition of the wall ties is investigated.

Similarly, the efficacy of the existing flashing and weeps needs to be investigated. No detailing was provided in the record drawings for flashing and weeps in the Public Safety Building. Weep holes are evident on the south wall, but the detailing is not possible to determine at this time. Also, the condition of the flashing needs to be investigated to determine if it is still effective.

As for the joint repairs existing, they are appropriate, but should not be considered long lasting. Also, without replacement of severely compromised corroded reinforcing, the fix is largely cosmetic. Future joint repairs of this kind should be thoroughly applied. That is, the reinforcing needs to be evaluated as part of the joint repair procedure. Where reinforcing is significantly degraded, it should be replaced with new hot dip galvanized reinforcing.

The other troubling aspect of joint and/or reinforcing replacement is the replaced joint reinforcing is not easily connected to the existing wall ties. Where wall ties are not welded to the exterior wire, the embedment pull out capacity is lessened. A thorough structural evaluation is necessary to determine if enough tie embedment remains to achieve an effective double wythe cavity wall.

The existing walls appear to be equipped with rigid insulation inside the cavity. Fiber optic evaluation of the interior cavity does not appear feasible. Therefore, evaluation of the existing wall ties appears to require partial demolition of the existing wall. It is also reasonable to expect differential severity in corrosion from one location to another. Wind direction and other variable environmental factors may affect the severity of corrosion from one location to another. Therefore, multiple locations are required to fully ascertain the condition for all locations by an effectively representative sampling.

Should tie reinforcing prove to be corroded or otherwise ineffective as part of a comprehensive repair, then other methods of adequately joining the wythes are possible. Epoxy dowel anchor partial through bolts could be employed. They could be installed from the inside wythe and be embedded partial depth into the external wythe. Full through bolts could be employed as well, but moisture effects of the penetrated outside wall would need to be evaluated.

Obviously, through bolts would not be the most cosmetically pleasing alternative and the cost would be significant as well. Cosmetic coverings could be installed on the outside or inside like drywall or stucco. Stucco could be employed to create a water-resistant covering over through bolts. But again, this will surely add cost.

Engine Bay and Storm Water Pipe

The efflorescence in the engine bay is minimal and likely is residual early bloom or minor ambient moisture in the cavity escaping. It is possible a roof leak has contributed, but implications appear minor at this time. The condition should be monitored and reevaluated if it worsens.

The cracks in the engine bay slab appear attributable to shrinkage on account of absent control joints and locations consistent with stress concentrations. The condition should be monitored and reevaluated if it worsens. The same conclusion is appropriate for the external concrete slab on the east side outside the bay doors.

The cracked column between bay doors on the east side appears to be a minor condition. However, it is coincidental that the column exhibits cracking and is also in close proximity to the known historical sink hole location. It is possible that the crack is on account of minor original construction or repair construction defect. However, it is also within the realm of possibility it is associated with some other larger instability. The crack should be monitored with crack gauges and reevaluated if it worsens.

The historical sinkhole requires additional evaluation. Placement of critical infrastructure over underground drain pipes is not good practice. The question is generally not if their will ever be a problem, but rather a question of when. All material degrades over time. In the case of storm pipes, corrosion, abrasion, and chloride ion penetration will ultimately lead to failure of the pipe. Corrosion and abrasion affect both steel and concrete pipes. Chloride ion penetration only affects concrete pipes and manhole boxes, but ultimately leads to internal steel reinforcing corrosion and concrete spalling.

It is not known at this time what type or diameter of pipe exists under the engine bay. City records can be reviewed to determine that. This will provide some insight into the possible condition, but further field evaluation is prudent especially since the pipe apparently predates the Public Safety Building and is likely on the order of 50 years plus in age. 50 years is the generally accepted service life for storm sewers as well. Special detailing can lengthen service life to 100 years, but it is highly unlikely this detailing was employed 50 years ago in this case.

Apart from the age, the history of sinkhole development at this site dictates are more thorough evaluation. Many sinkholes develop at joints in sewer systems. The joints are generally the weakest link whether grouted or fitted with elastic gaskets. As the material degrades or shifts from settlement, voids allow fill to enter the pipe. Sinkholes are the result.

It is possible for sinkholes to develop along the pipe length or at joints in the pipe. Again, it is only a matter of time.

The current condition of the pipe should be evaluated with remotely operated vehicle (ROV). Pipe cleaning should also be performed at the time of inspection a required to adequately observe the pipe condition. The limits of pipe evaluation should extend a minimum from the upstream manhole on the east side of the building to the downstream side on the west side at least 50 feet from the building perimeter.

If significant deterioration is found, the pipe should be repaired immediately. All manner of deterioration should be addressed at the time. For instance, it is unclear if leaky joints were the cause of the historical sink hole or if the defect was adequately repaired at the time. Any joint defects should be repaired, and if the pipe is in poor condition it should be equipped with a new liner capable of acting as an in situ pipe replacement. Liners like this are often placed pneumatically.

Settlement Cracks

The only obvious settlement cracks are located on the southeast corner of the Public Safety Building. The cracks should be gauged and monitored.

5 Recommendations

The following List provides instruction for the immediate and long term recommendations. Adhere to chronology of steps where noted.

Install Gauges and Monitor

1. Install and monitor gauges described below for one full year.
2. Install graduated crack gauges on all existing cracks in walls, slabs, and columns.
3. Photograph all gauges at the time of installation. Photo should provide legible baseline reading.
4. Monitor the gauges weekly and record numerical values in journal. Record interior temperature and humidity and exterior temperature and humidity at the time of gauge reading. Record specific to the building compartment. Town Hall, Public Safety, Engine Bay.

5. Set up a rain gauge outside the building. After any rainstorm, record the gauge reading. If multiple days of rain happen consecutively, record the gauge reading daily until the rain ceases.
6. Record snow events. Rulers can work.
7. Engineer can assist with gauge layout and quantity. Gauges are inexpensive, therefore, quantity need not be discriminatory, but should be strategically placed.
8. Apply gauges to any new cracks that develop and/or any new cracks discovered during the other recommended investigative steps.

Additional Near Term Investigative Work for Buildings

9. Selectively remove drop ceiling in the Public Safety Building near the exterior walls and record the condition of the walls above. Record crack locations, widths, termination points, and orientation. Install crack gauges where additional cracks or lengths found.
10. After drop ceiling removal and investigation. Selectively remove a 1 to 2 foot wide section of internal wythe brick wall in the Public Safety Building. The width may vary depending on spacing of wall ties. A minimum of three locations should be removed initially, one on the east wall, one on the west wall, and one on the south wall. Remove wall from the interior to avoid extensive weather proofing exterior wall during process. Removal should be from the floor to the ceiling. Removal should be performed by a licensed building contractor with experience in selective demolition and masonry repair. Contact Engineer to layout removals in best locations regarding building concerns and adaptation for continued Police and Fire Department operations.
11. Depending on results of initial wall removal investigation, add additional locations in Public Safety and/or Town Hall Buildings. Contact Engineer to plan removals.
12. After information is obtained from removals, reinstall brick in like kind. Alterations may be necessary if anomalous findings dictate. However, in general, removals should be replaced quickly. Contact engineer prior to removal repair so that he can view the interior.

Plumb and Level Measurements of Slabs and Walls

13. Accurately measure how plumb and level walls and interior slabs are. Record any slope breaks in walls. For instance, it is reasonable to assume that the plumb reading above and below the larger horizontal cracks in the Public Safety building are different. Contact engineer for assistance.

Additional Near Term Investigative Work for Storm Pipe

14. Obtain town record documents, if possible, that provide record drawing information for the pipe.
15. Determine if any photos or records exist concerning the historical sinkholes and repairs.
16. Transmit drawings and other records to engineer and allow for him to review.
17. Contact Pipe investigation company to conduct pipe condition assessment. Contact engineer if assistance required. Condition assessment should include evaluation of the manhole, manhole to pipe joints, and pipe condition in general and at joints.
18. Transmit pipe condition assessment video and records to engineer for review.

Additional Near Term Analysis and Code Review

19. Engineer can begin evaluation of code and structural implications in the interim while immediate investigation items are underway. Conclusions from analysis could change overtime, but engineer may develop understanding of implications of existing defects and flexible joint installation and if additional structural modifications are required to account for any repairs that may be more aptly referred to as "alterations". Provide notice to proceed to engineer.

The findings of the initial steps may dictate what subsequent steps are required. Initial and subsequent investigation steps will ultimately dictate the appropriate repairs. The relative cost and disruptive nature of the appropriate repairs may dictate decisions for the Town of Valdese as it relates to final solution. Some additional potential steps and/or repairs may include.

Long Run Investigation and Potential Repair Steps

1. In the event the interior slab for any of the buildings appears to slump, contact engineer immediately.
2. Should any of the known cracks significantly worsen, contact engineer immediately. Should any new cracks develop, contact engineer immediately.
3. Should pipe evaluation findings indicate the pipe or manhole is in disrepair, apply repairs per engineer. Possible repairs could potentially include:
    a. Excavate and remove and reinstall manhole.
    b. Apply Joint repairs at pipe to manhole connections if feasible.
    c. Install pneumatic pipe liner.
4. The proper repairs for wall cracks is dependent on the findings of additional investigative and analysis work. However, likely and/or possible repairs may include:
    a. Sawcut existing large vertical crack locations and install flexible joints.
    b. Where code/analysis dictates, install cavity end reinforcement at new flexible joints.
    c. Sawcut existing horizontal cracks and install flexible joint, if deemed appropriate.
    d. Where code/analysis dictates, install wall reinforcement as it relates to horizontal joints.
    e. Where corrosion of existing joint reinforcing is severe or where repairs limit the efficacy of the existing joint reinforcement, install wall reinforcement as required like through bolts, vertical reinforcing bars in the cavity, straps, etc.
    f. Where aesthetics or water-resistance of repair methods dictate, install stucco, drywall, or other wall coverings as required.

6. Service Life and Alternative Recommendations

The building is near the generally accepted service life end at 41 years old. Minimal repairs, if acceptable by Code and/or operations, will most likely only prolong the inevitable. For instance, where the bare metal joint reinforcing is not replaced, it can be expected to further corrode and cause subsequent problems.

It is common for buildings of this age to require increasing levels of periodic maintenance. Cost effective repairs now, may not prove cost effective in the long run as subsequent necessary repair efforts add up over time. For instance, even if the walls are adequately repaired, other building systems like plumbing may reach the point where significant repairs are required in addition to the performed wall repairs.

In the case where extensive repairs are proven necessary, the repairs may not be cost effective in the near term. For instance, if existing wall ties are proven insufficient, replacement is surely a disruptive and costly undertaking.

The engine bay pipe is another complication concerning cost effectiveness of repairs. As mentioned, pipes under critical infrastructure is not good practice if avoidable. If repairs are proven necessary now, the disruption and cost could be significant. Even if no repairs are required per investigation there is still an inherent risk remaining, since no investigation can be perfect and defects may go unnoticed. Routine inspection of the pipe is highly advisable regardless of the findings in the near term or any recommended repairs. The pipe should be inspected by ROV at a minimum of every 5 years given the critical nature of the infrastructure above. Routine inspection will obviously add recurring cost.

Finally, one of the main reasons that specific service life goals are established for buildings is because buildings tend to become obsolete within 50 to 75 years. Spending top dollar on resilient construction details on the front end, preventative maintenance, or in this case pervasive investigation and repairs is not appropriate if the building could be expected to become obsolete for either reasons of size or function in the next 10 to 20 years.

If the City of Valdese expects the building may become obsolete within the next 10 to 20 years, it may be advisable to forgo any non-critical near-term repairs and begin planning for a new replacement building. Additions or renovation of the Town Hall building for added Public Safety space requirements does not appear cost effective relative to a new building given the obvious maintenance inducing defects of the existing building.

7. Opinion of Probable Cost

It is difficult to determine all of the prospective costs associated with building investigation and repairs, since much is contingent on subsequent efforts. Approximate ranges are provided:

1. Near Term Investigative Work
    a. Engineering Fees for Site Visits — $1,500 to $3,000
    b. Engineering Fees for Code Compliance Review and Analysis — $3,000 to $8,000
    c. Engineering Design Services — $3,000 to $10,000
    d. Engineering Services for Coordination and Solicitation of Subs — $1,000 to $3,000
    e. Crack Gauges, Equipment, and Install — $1,000
    f. Drop Ceiling Removal — $0.00 to $1,000
        i. $0.00 if Valdese Fire or engineer can perform
    g. Contractor for Brick Removal and Repair — $3,000 to $10,000
    h. Pipe Cleaning and ROV Pipe Inspection — $5,000 to $15,000
    i. Crack and Rain Gauge Monitoring — $0.00 to $10,000
        i. $0.00 if Valdese Fire can perform
    j. Engineering Review of Data and Inspection Findings — $3,000 to $10,000

    Total Opinion of Probable Cost — $20,500 to $71,000

2. Repair Work (Highly Contingent on Investigations and Analysis Results)
    a. Joint Installation for Public Safety Building — $10,000 to $50,000+
    b. Exterior Mortar Joint Repair — $8,000 to $200,000+
        i. High figures include dowel tie replacement, vertical reinforcing or straps, sheet rock, and stucco
    c. Manhole Repair/Replacement and Pipe Liner Installation — $30,000 to $70,000+

    Total Opinion of Probable Cost — $48,000 to $320,000+

3. Periodic Pipe Inspections (cost per year, frequency to be determined) — $1,000 to $3,000

Critical Minimum Front End Items to Perform include:

Drop Ceiling Removal and investigation

Brick Tie wall opening corrosion investigation

Pipe Inspection and Record Review

Crack Gauge Install and Monitoring

Additional Code Review, Design, and Repairs as dictated by above minimum critical investigations results.

Appendix A

Photographs

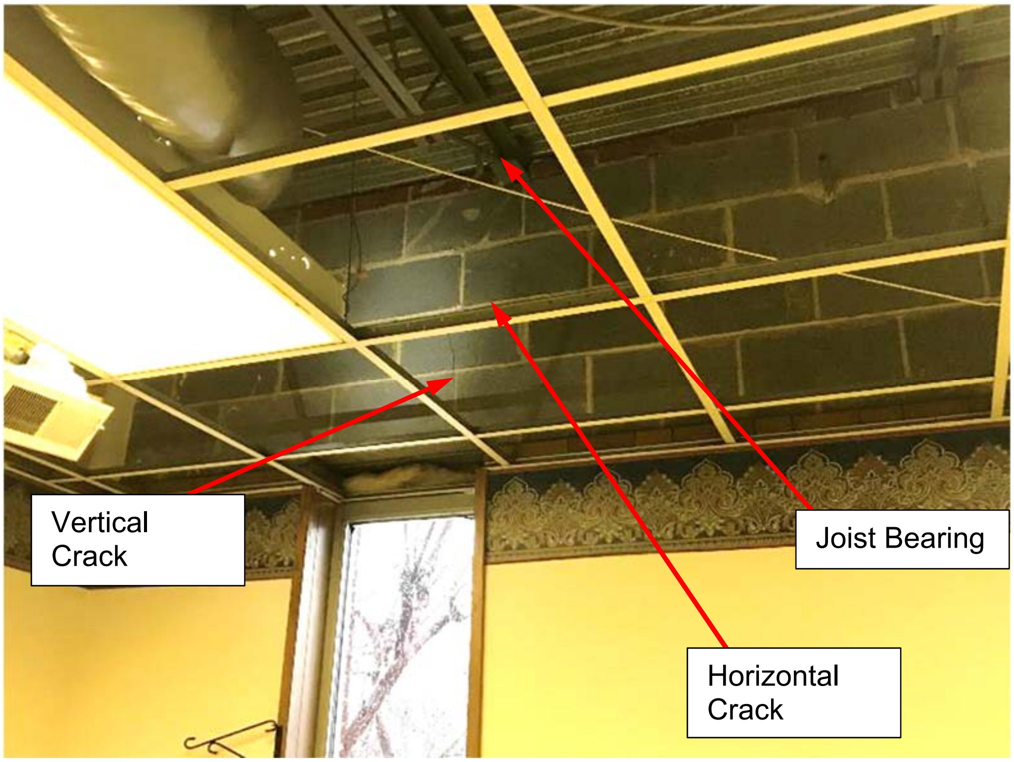


Photo 1 Town Hall – West Wall – Horizontal and Vertical Cracks

Photo 2 Town Hall – West Wall – Horizontal and Vertical Cracks

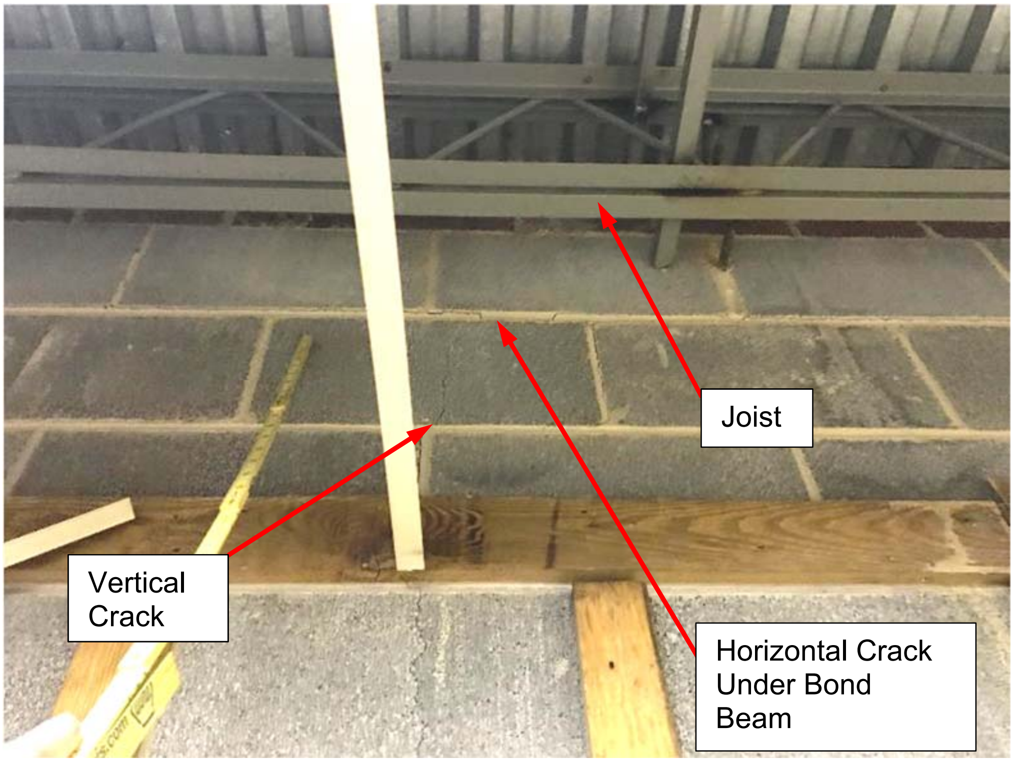


Photo 3 Town Hall – South Wall – Horizontal and Vertical Cracks

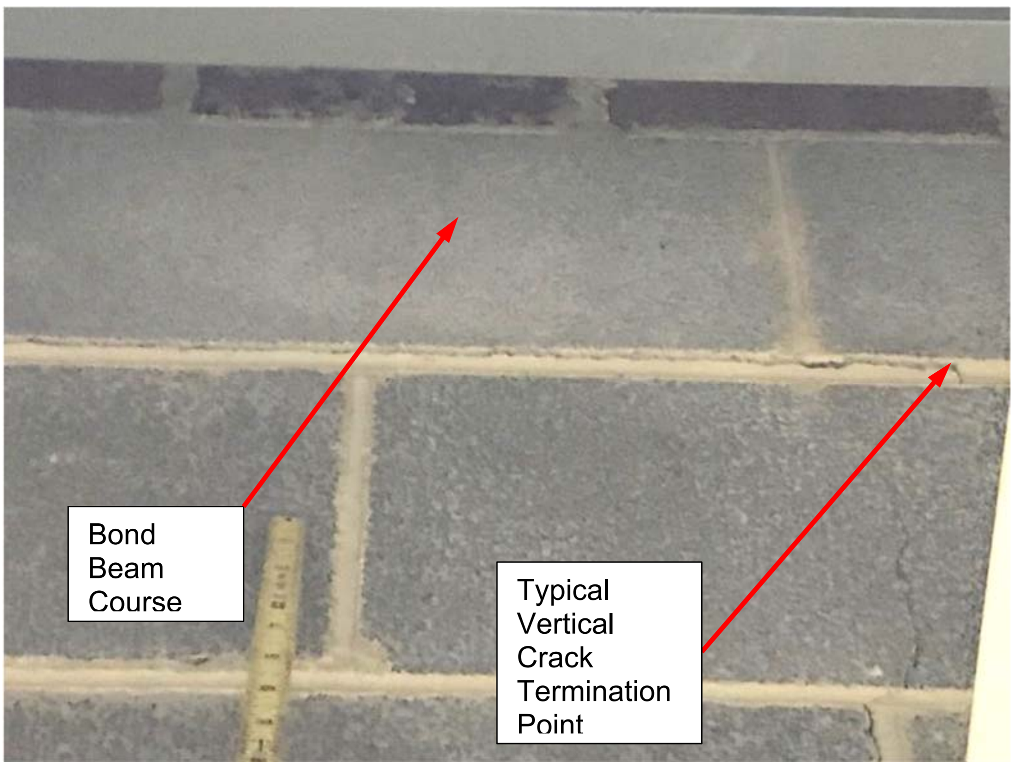


Photo 4 Town Hall – South Wall – Horizontal and Vertical Cracks

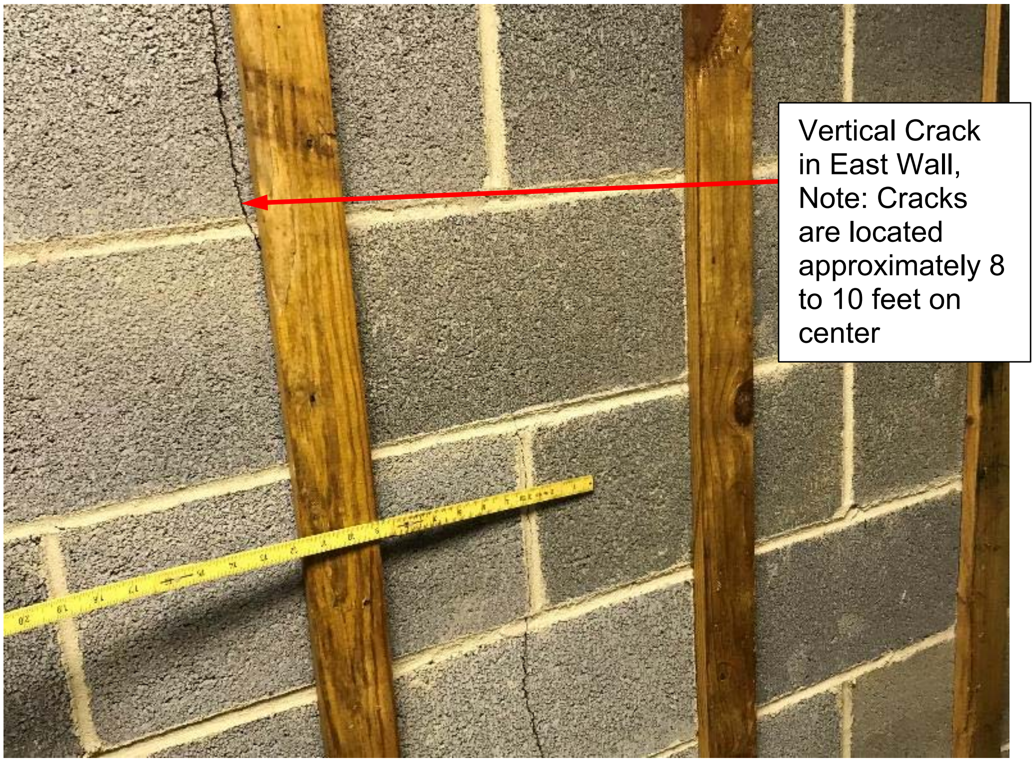


Photo 5 Town Hall – East Wall – Vertical Cracks

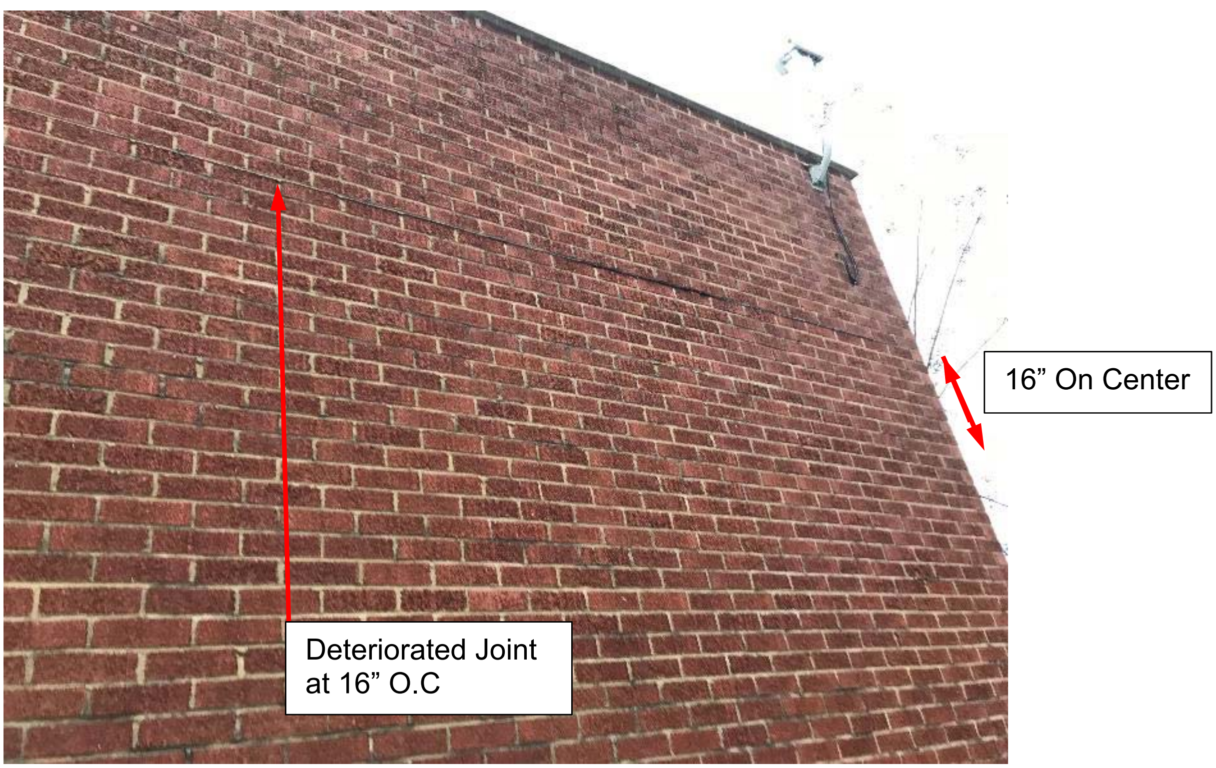


Photo 6 Town Hall – South Wall – Deteriorated Joints

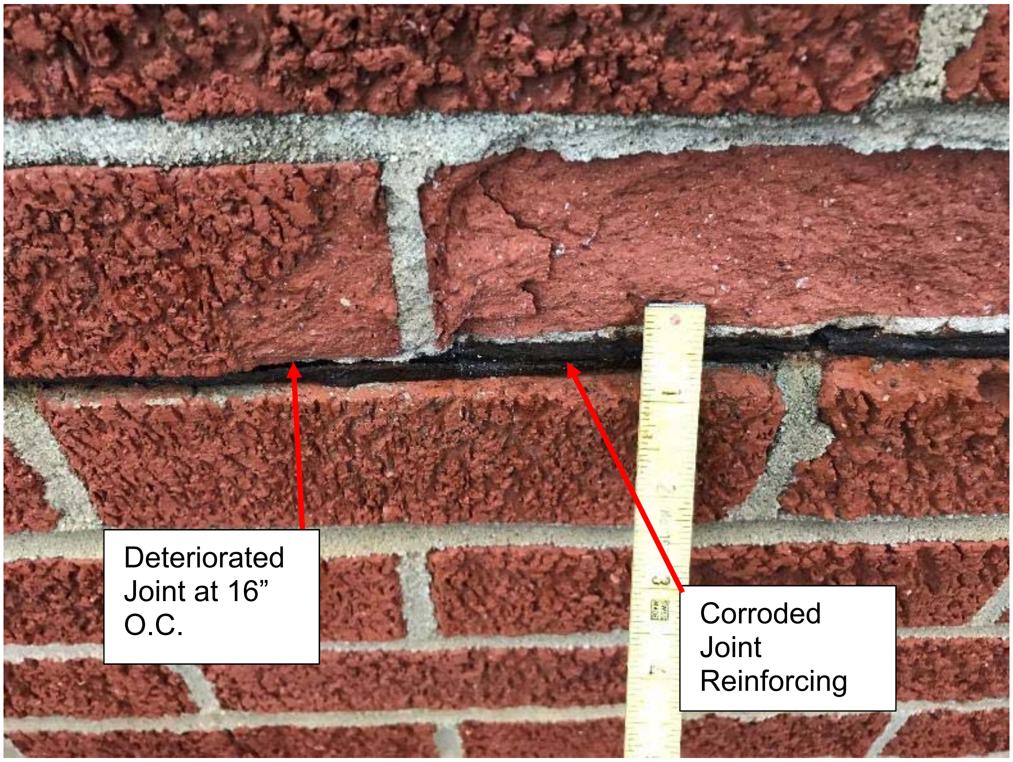


Photo 7 Town Hall – South Wall – Deteriorated Joints

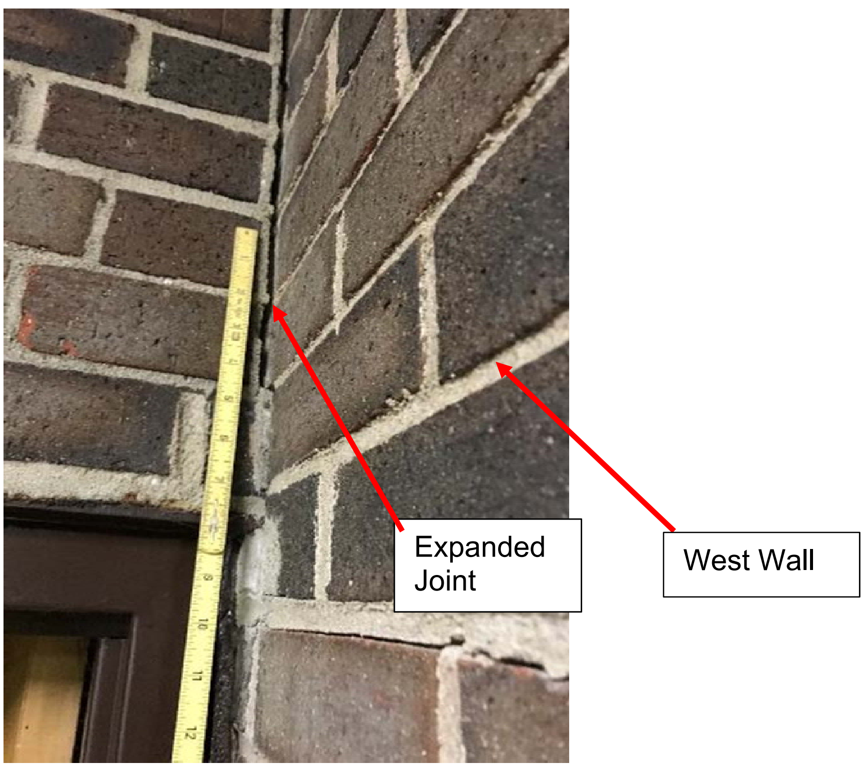


Photo 8 Public Safety Building – West Wall – Expanded Joint/Crack

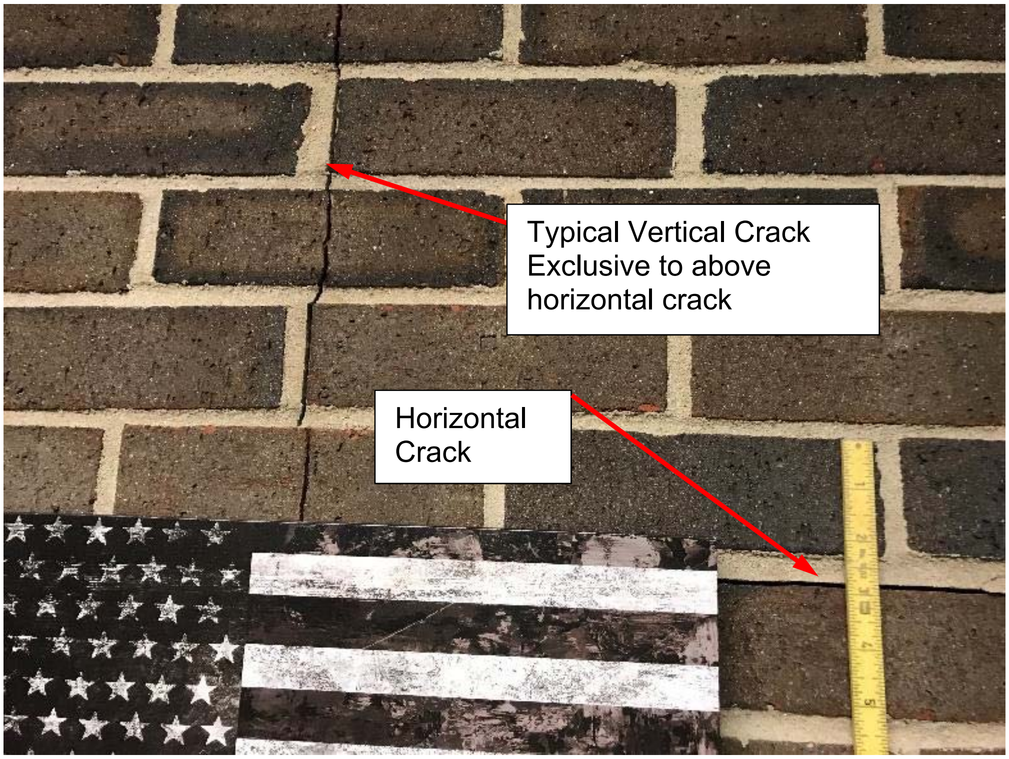


Photo 9 Public Safety Building – West Wall – Horiz./ Vertical Cracks

Photo 10 Public Safety Building – East Wall –Vertical Crack

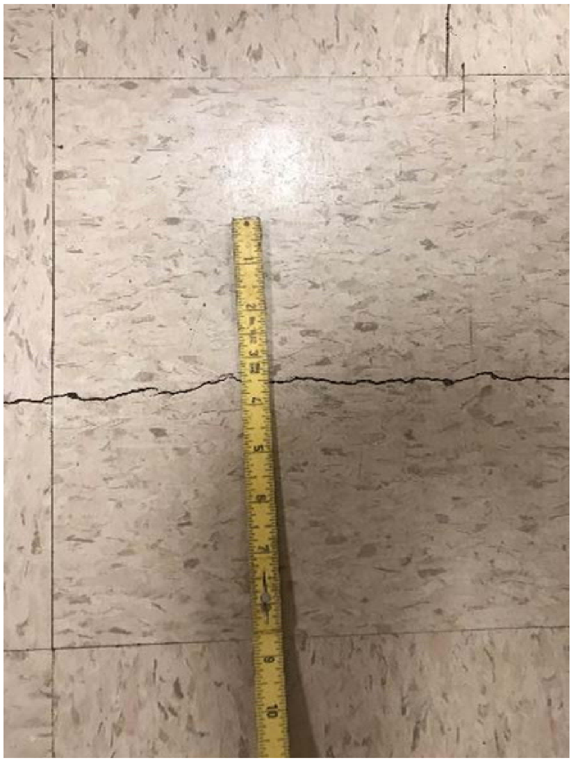


Photo 11 Public Safety Building – Interior Slab – Crack

Photo 12 Public Safety Building – South Wall – Horizontal Crack

Photo 13 Public Safety Building – South Wall – Horizontal Crack

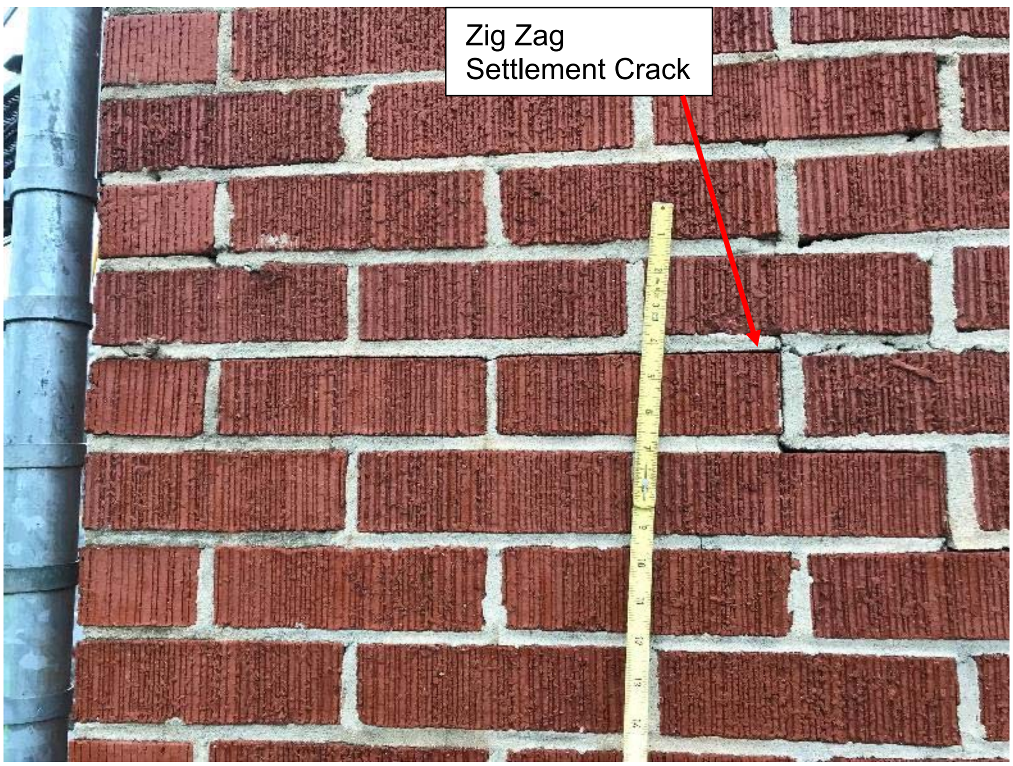


Photo 14 Public Safety Building – Southeast Corner – Zig Zag Crack

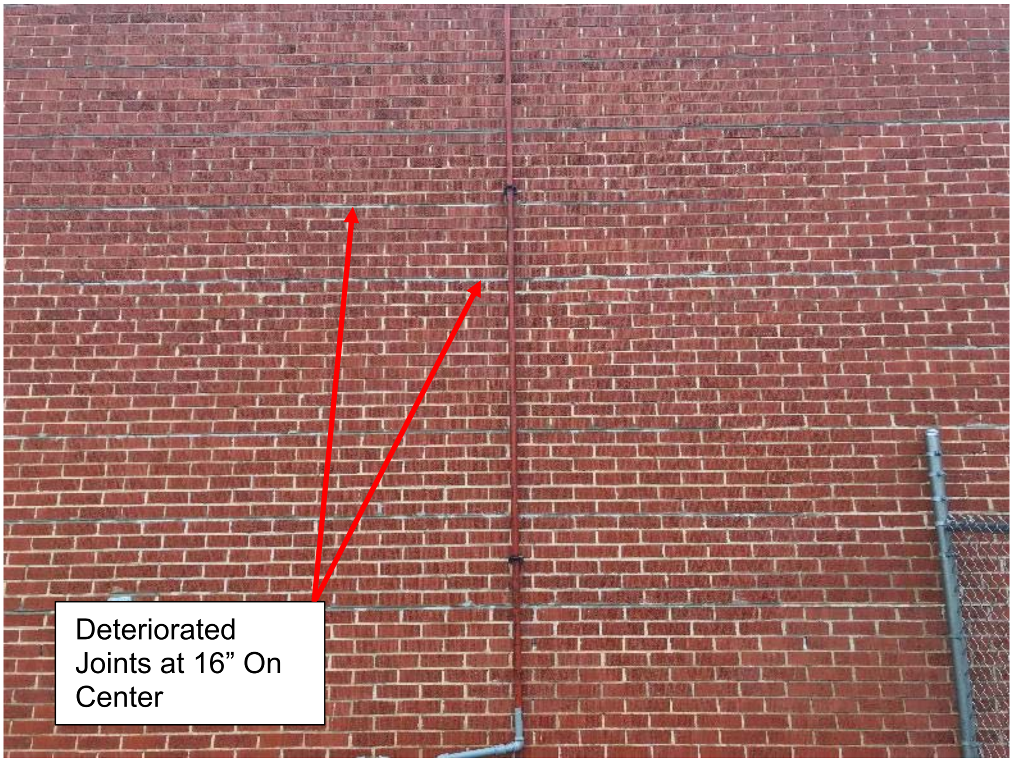


Photo 15 Public Safety Building – South Wall – Deteriorated Joints

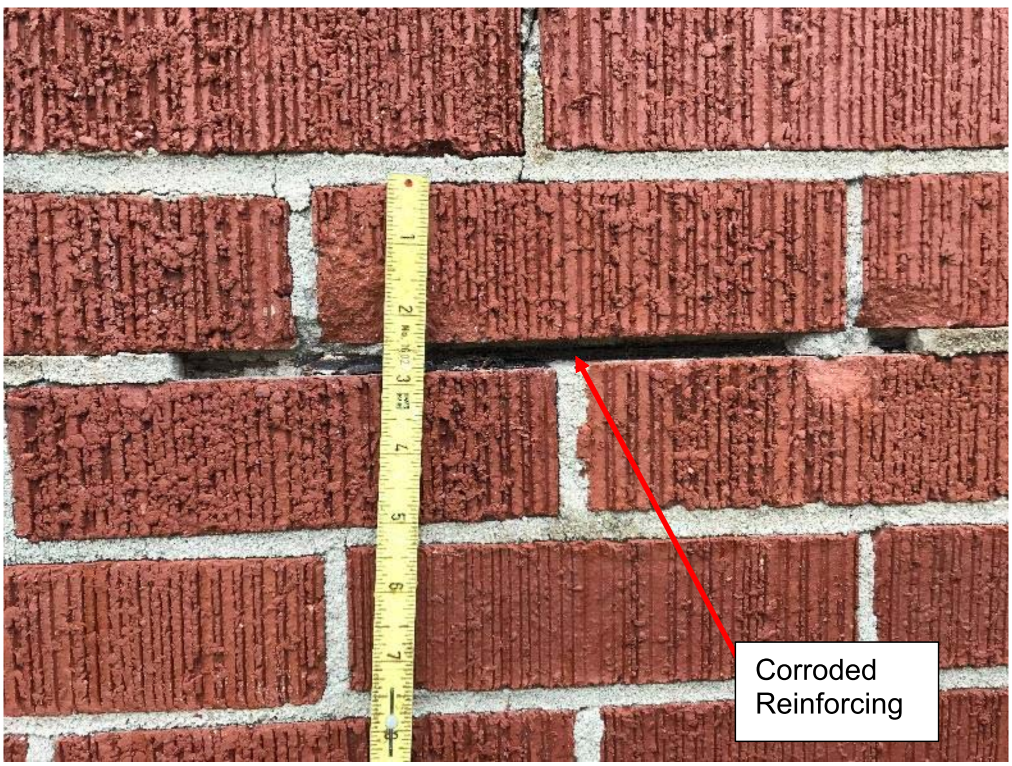


Photo 16 Public Safety Building – South Wall – Deteriorated Joints

Photo 17 Public Safety Building – South Wall – Repaired Joint and Weep

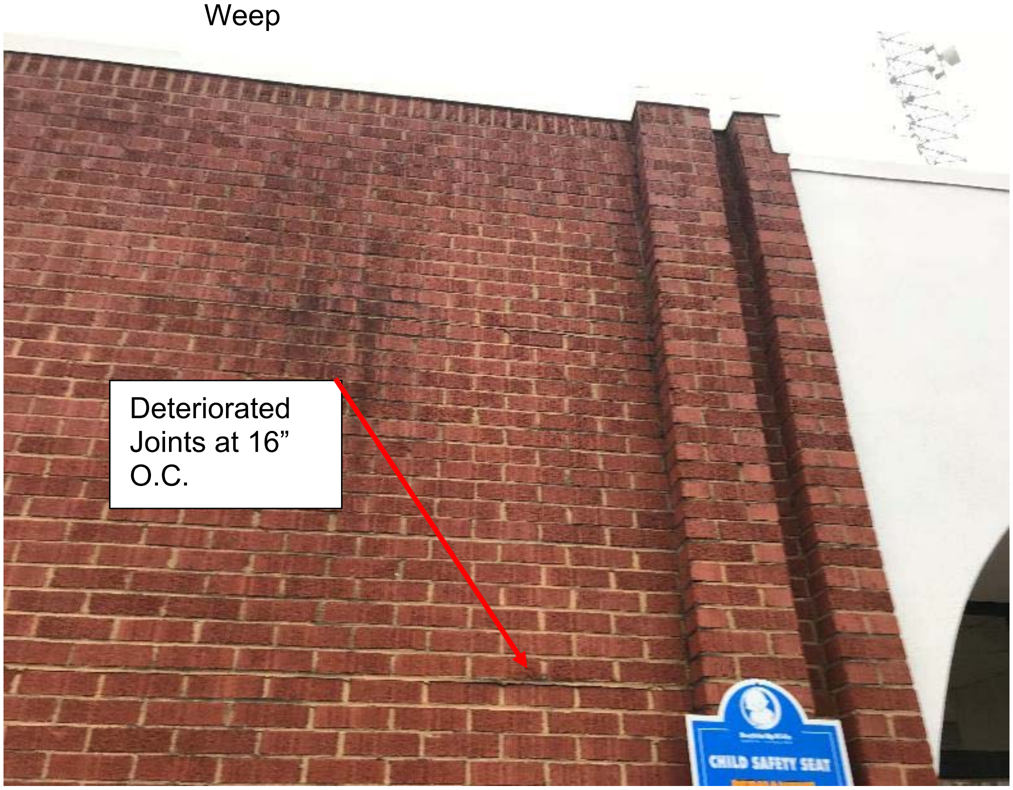


Photo 18 Public Safety Building – West Wall – Deteriorated Joints

Photo 19 Public Safety Building – East Side – Manhole

Photo 20 Public Safety Building – East Side – Historical Sink Hole

Photo 21 Public Safety Building – East Side – Cracked Slab

Photo 22 Public Safety Building – East Side – Cracked Column

Photo 23 Public Safety Building – Engine Bay – Efflorescence

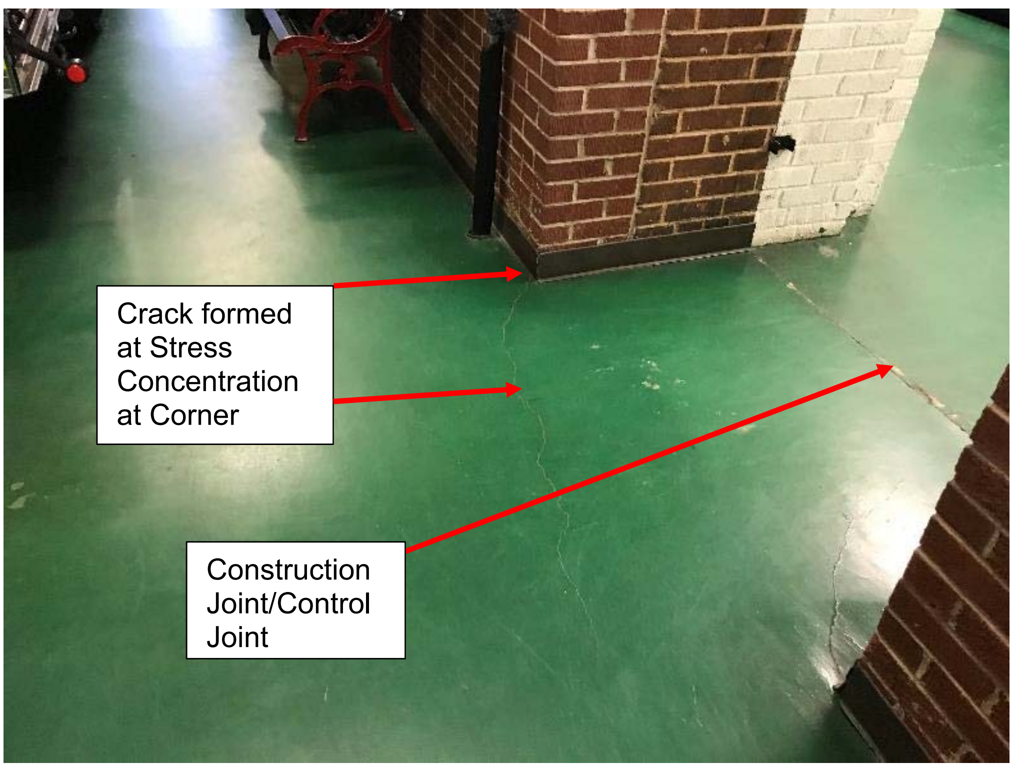


Photo 24 Public Safety Building – Engine Bay – Cracked Slab

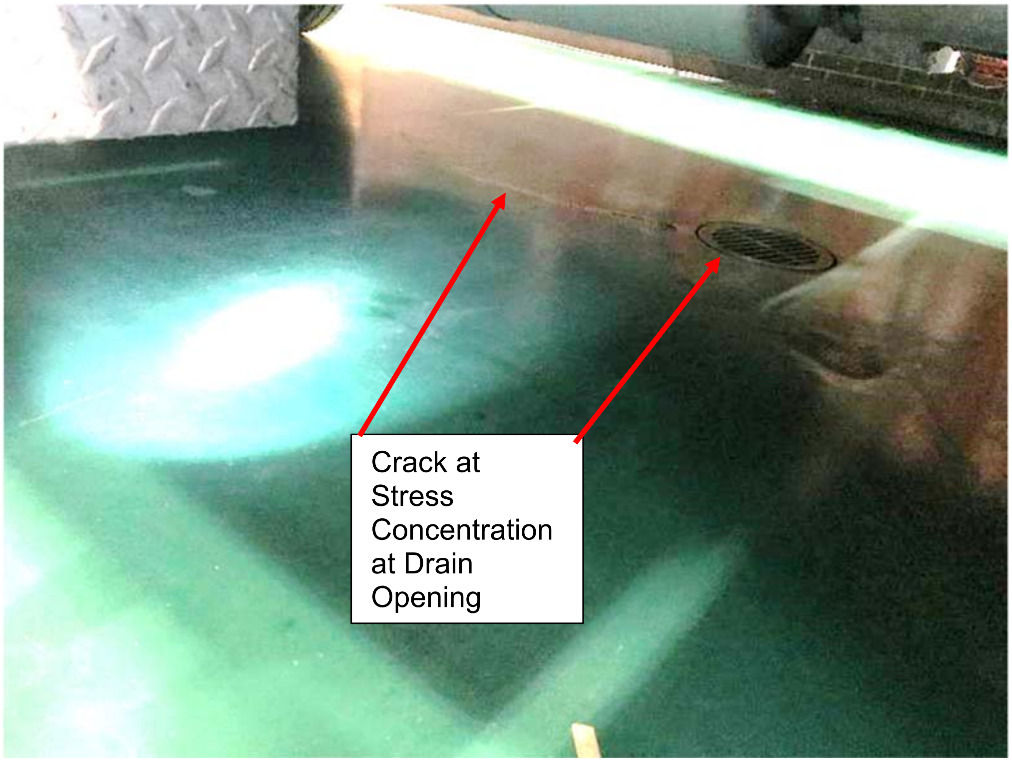


Photo 25 Public Safety Building – Engine Bay – Cracked Slab

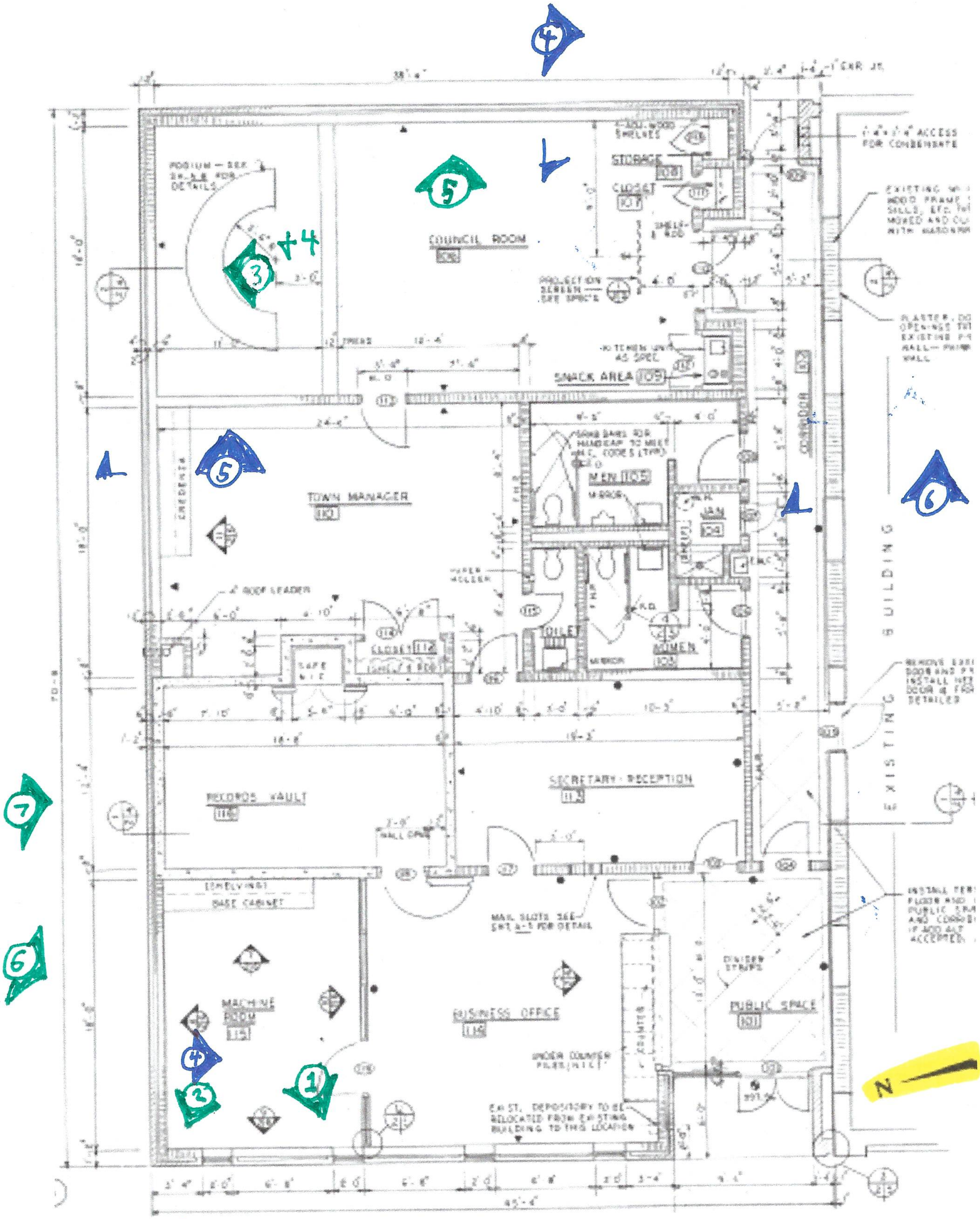
Photo 26 Public Safety Building – East Wall – Separation at Door Frame

Photo 27 Public Safety Building – East Wall IT Room – Wall Separation

Photo 28 Public Safety Building – West Wall – Wall and Slab Crack

Appendix B

Figures

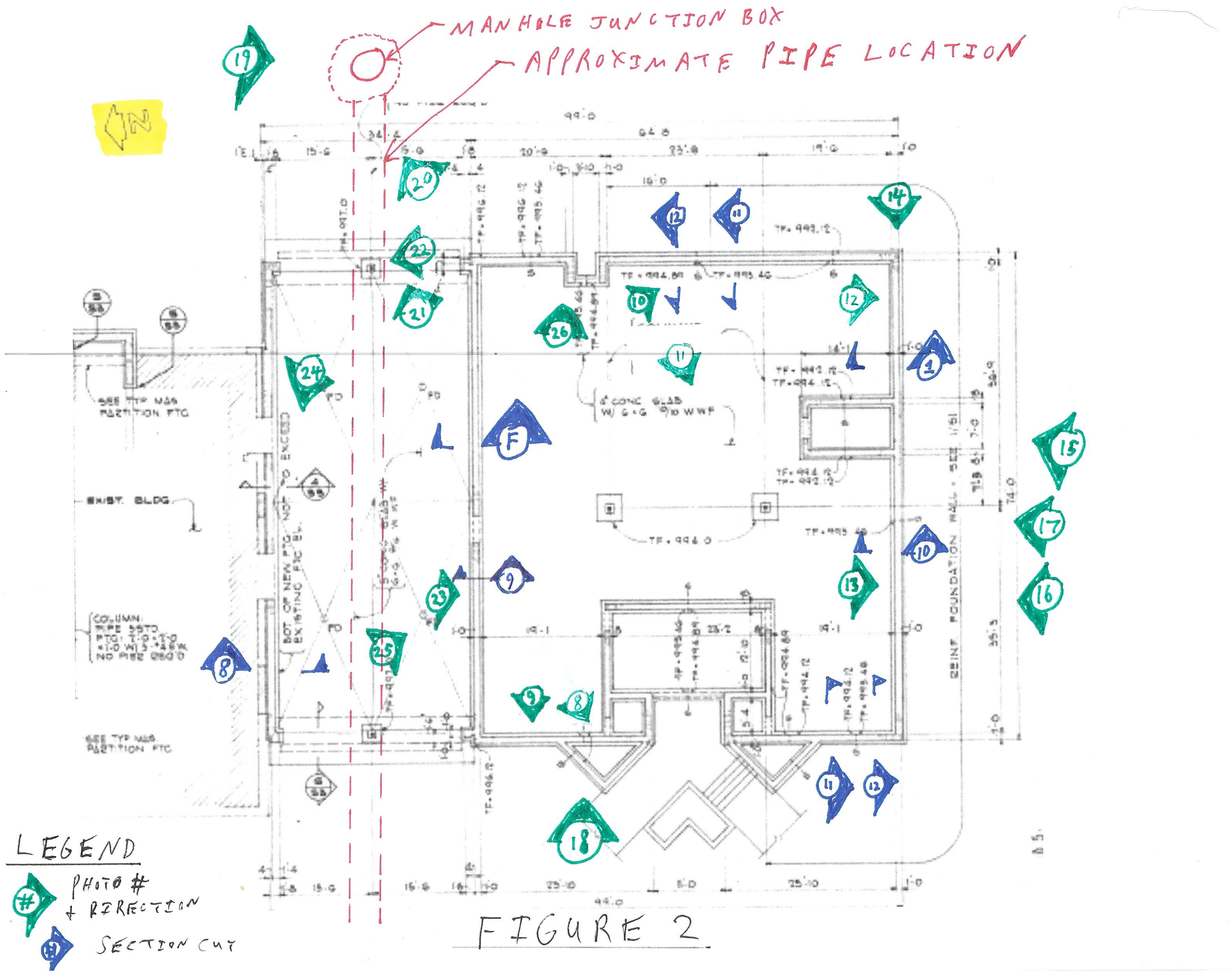


LEGEND

PHOTO # + DIRECTION

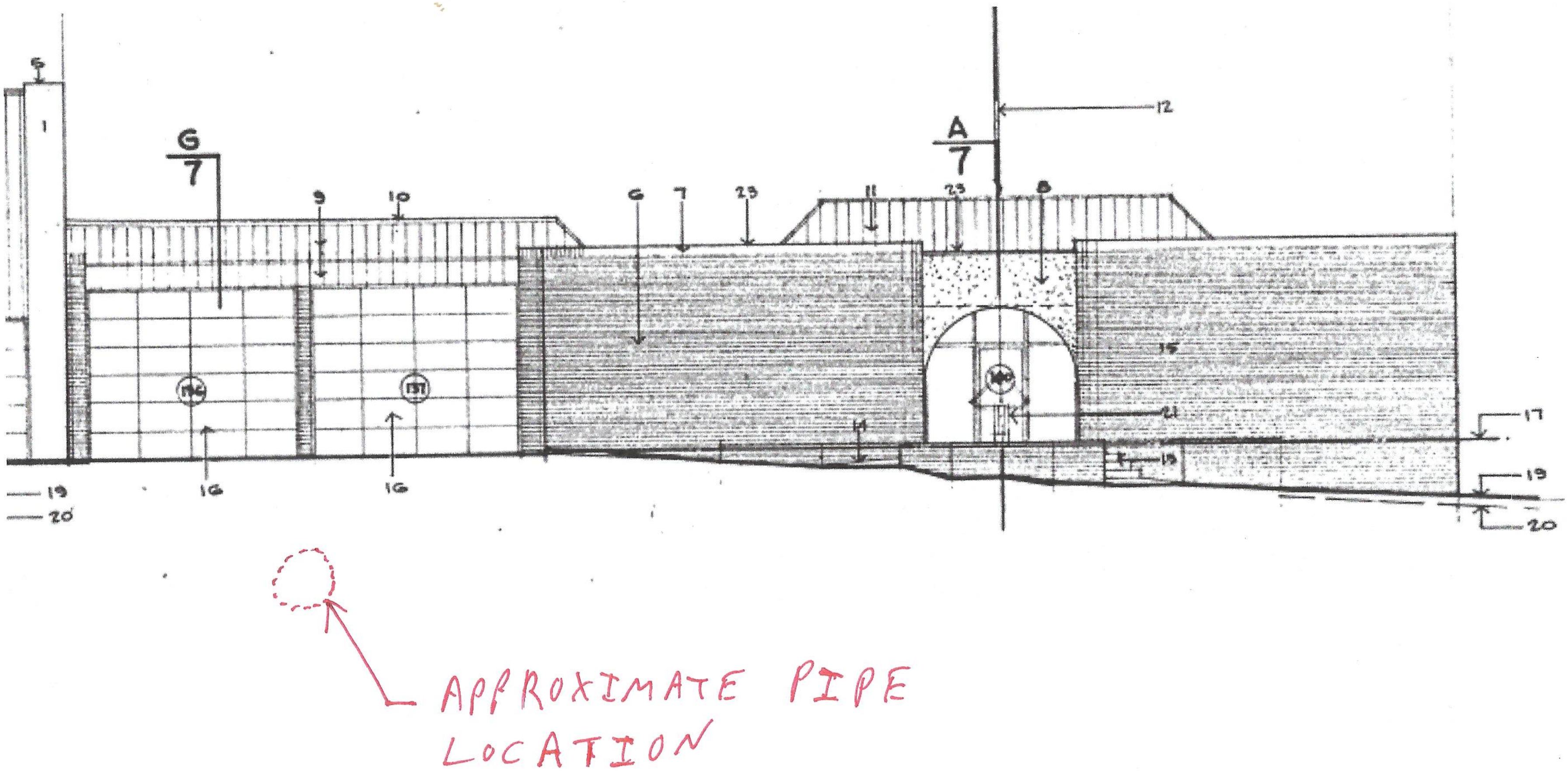
SECTION CUT

FIGURE 1



MANHOLE JUNCTION BOX
APPROXIMATE PIPE LOCATION
N
LEGEND
PHOTO #
+ DIRECTION
SECTION CUT
EXIST. BLDG
SEE TYP MAS PARTITION FTG
BOT OF NEW FTG NOT TO EXCEED EXISTING FTG EL
4" CONC SLAB W/ G+G 6/10 WWF
BRINE FOUNDATION WALL - SEE 1/S1
TF. 994.0

FIGURE 2



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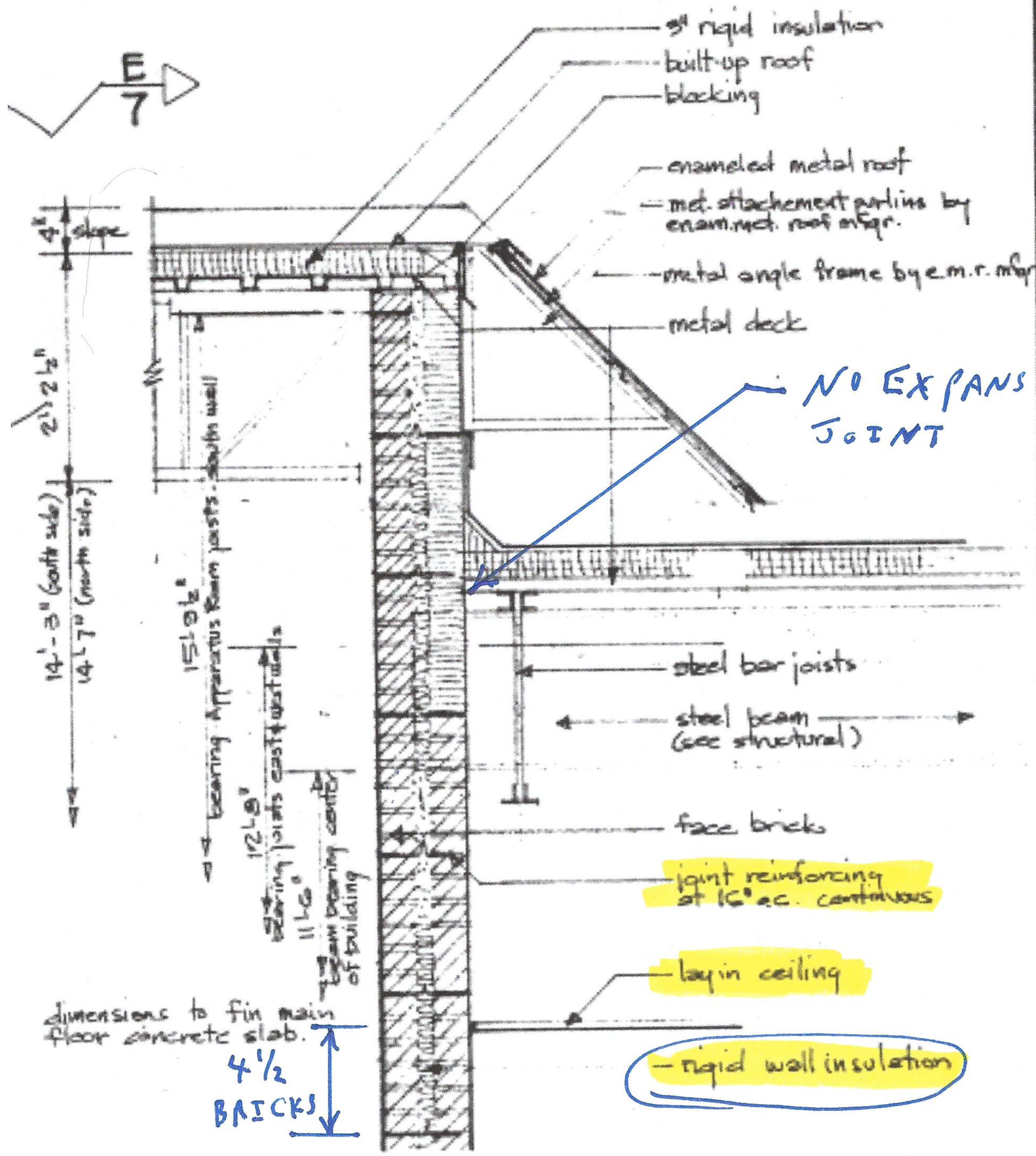
APPROXIMATE PIPE
LOCATION

FIGURE 3



SECTION F
7

scale 3/4" = 1'-0"

FIGURE 4

SECTION F

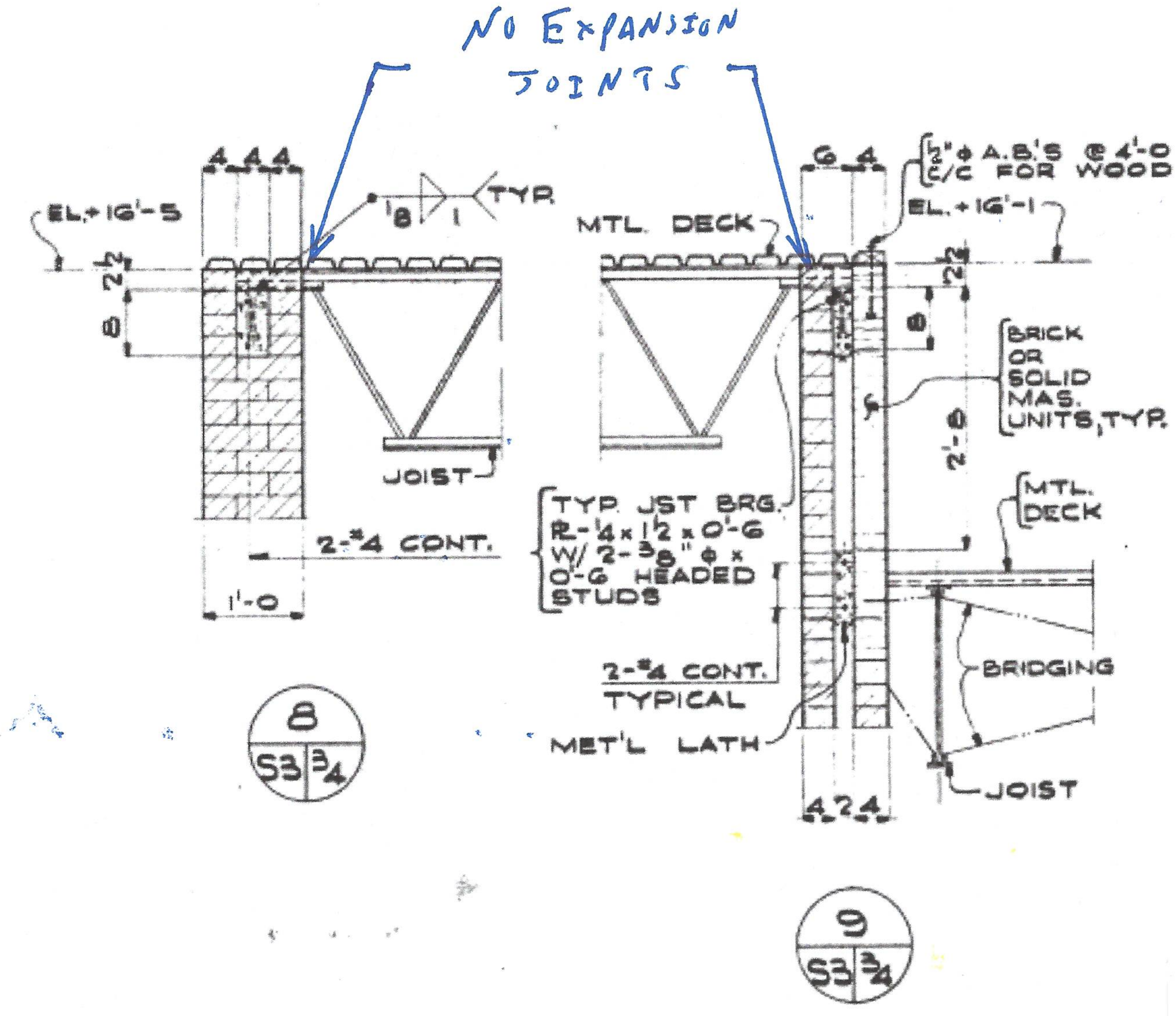


FIGURE 5

SECTION 8 + 9

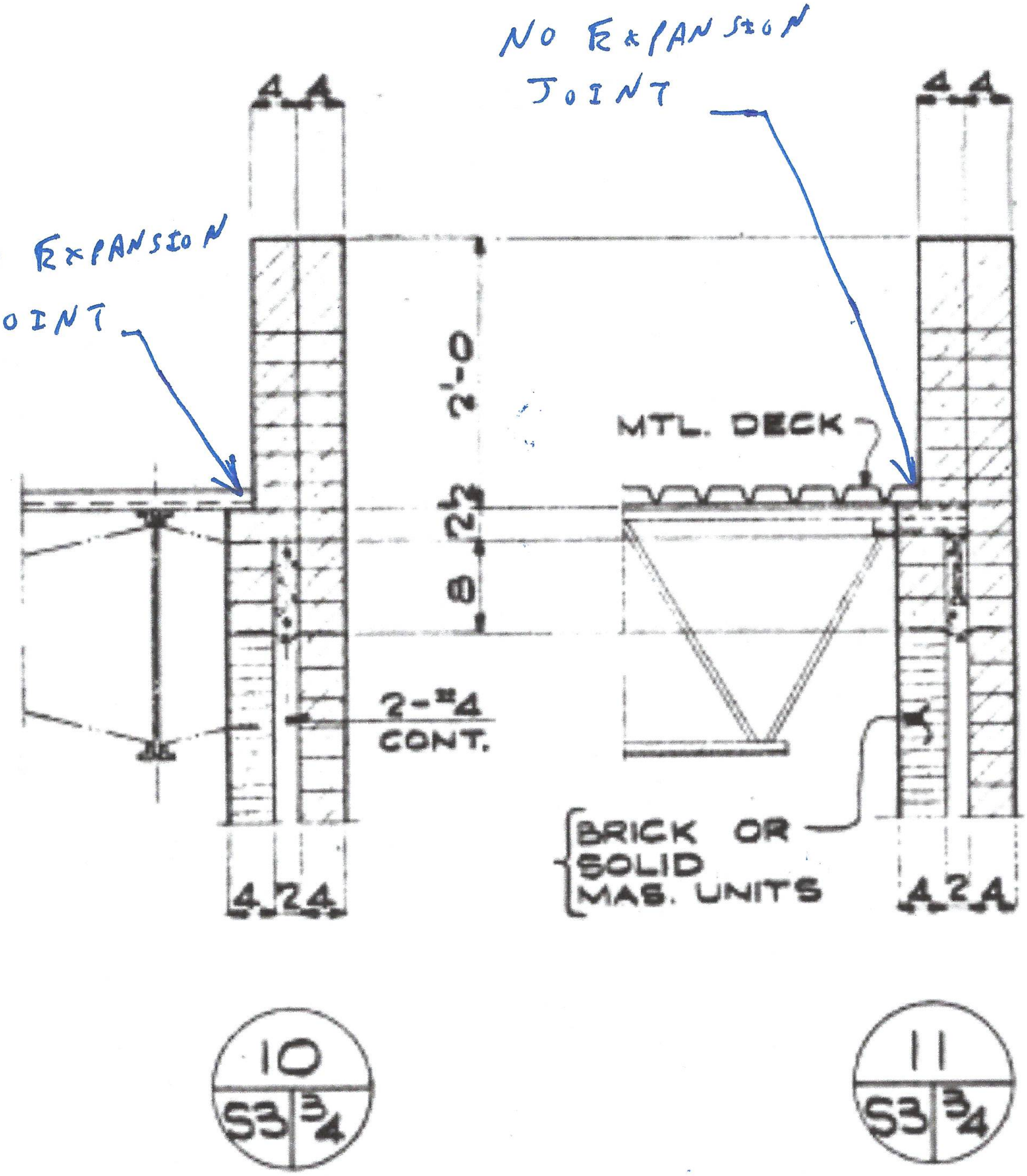
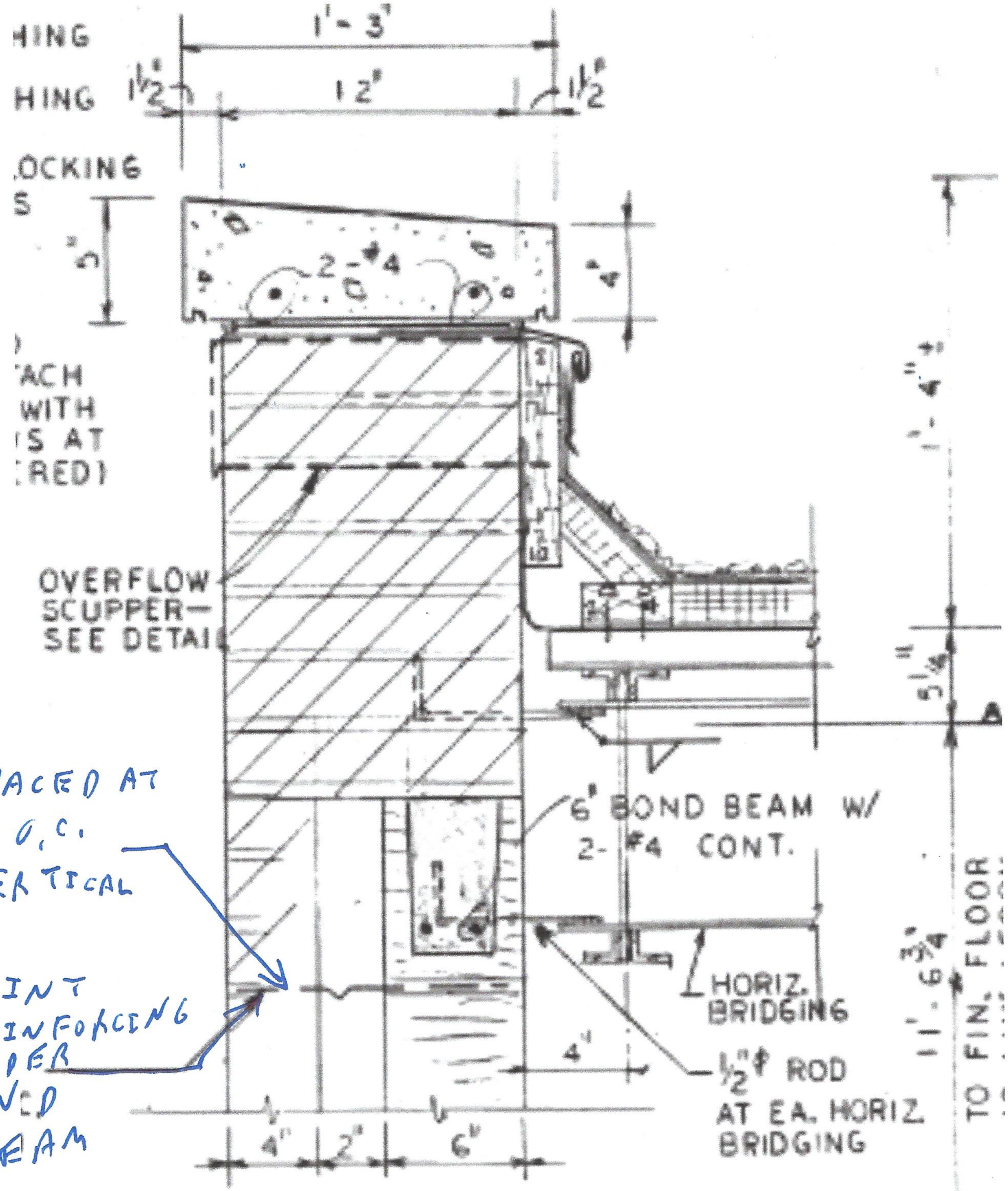


FIGURE 6

SECTION 10 + 11



5
3 | 5

SECTION AT SIDE WALL—
SCALE 1 1/2" = 1'-0"

FIGURE 7
SECTION 5

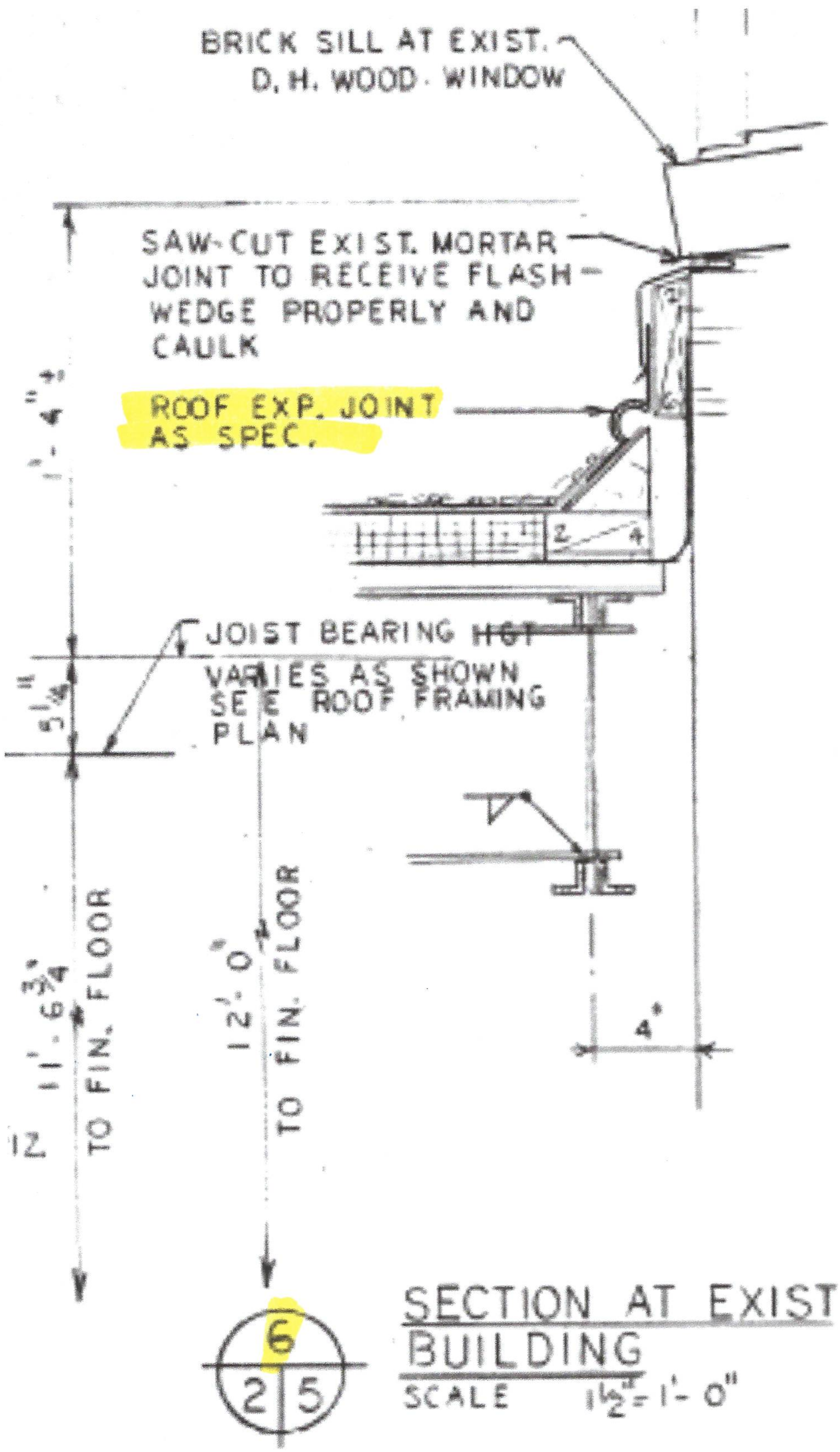
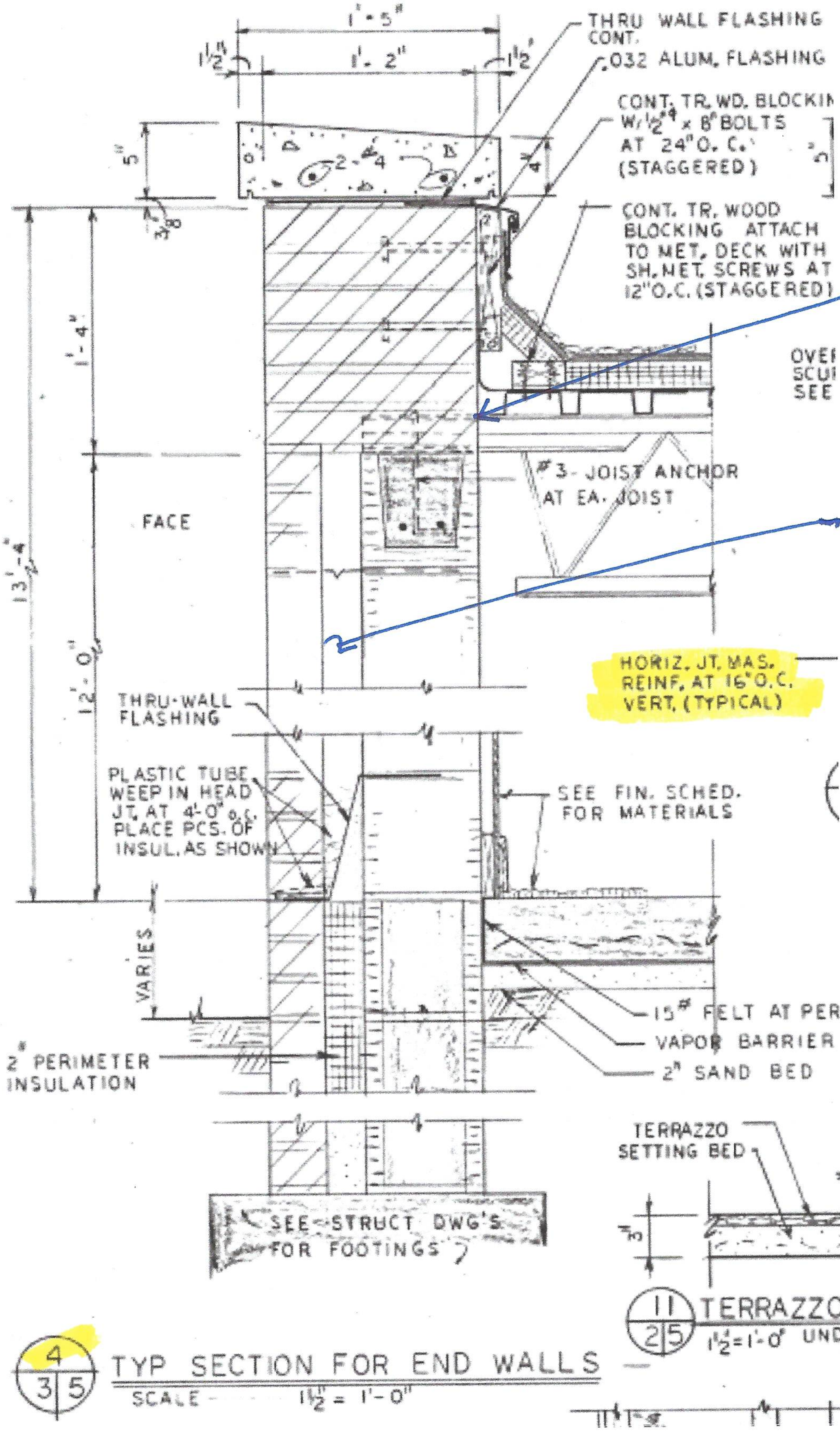


FIGURE 8

SECTION 6

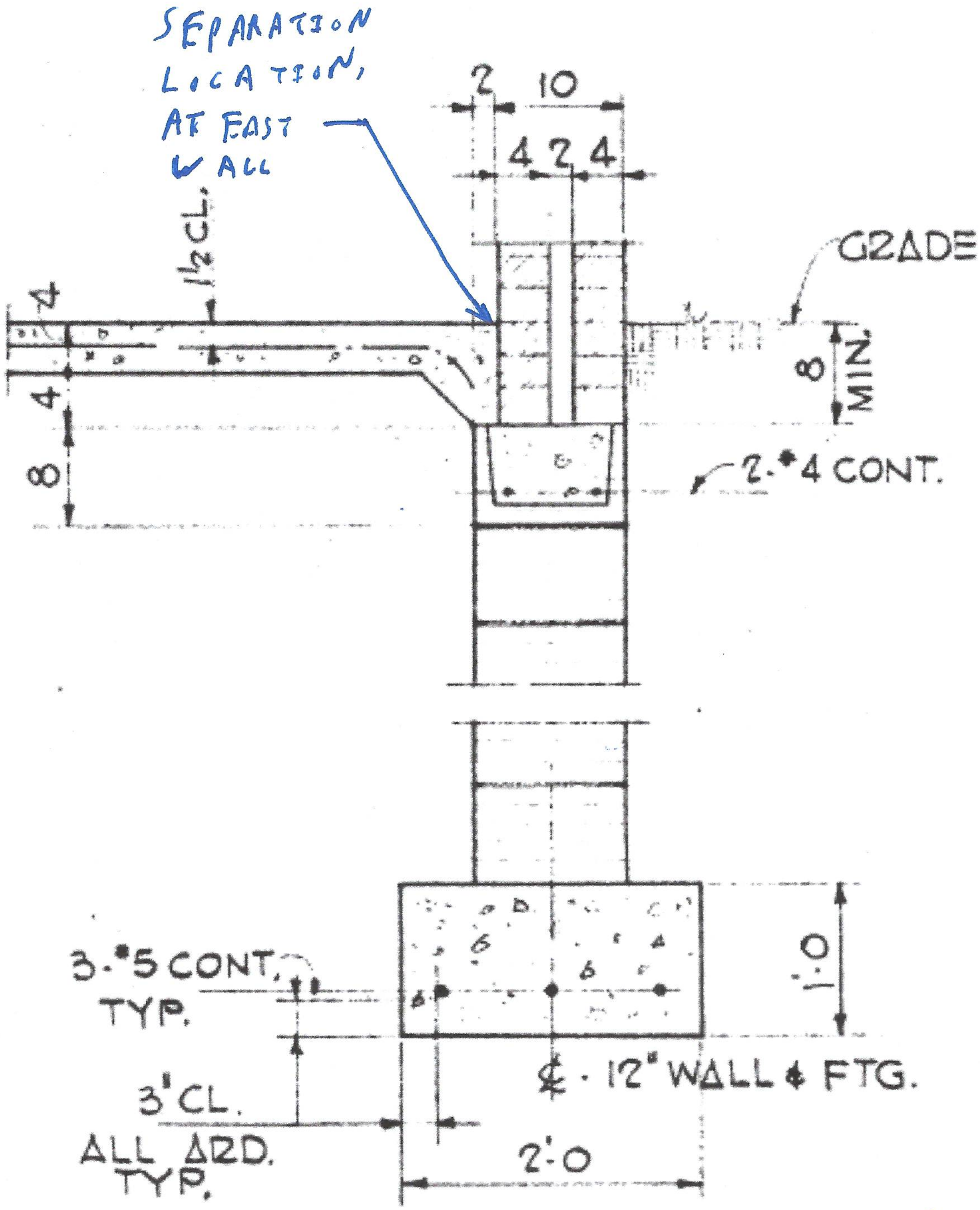


4/35 TYP SECTION FOR END WALLS

SCALE 1 1/2" = 1'-0"

FIGURE 9

SECTION 4



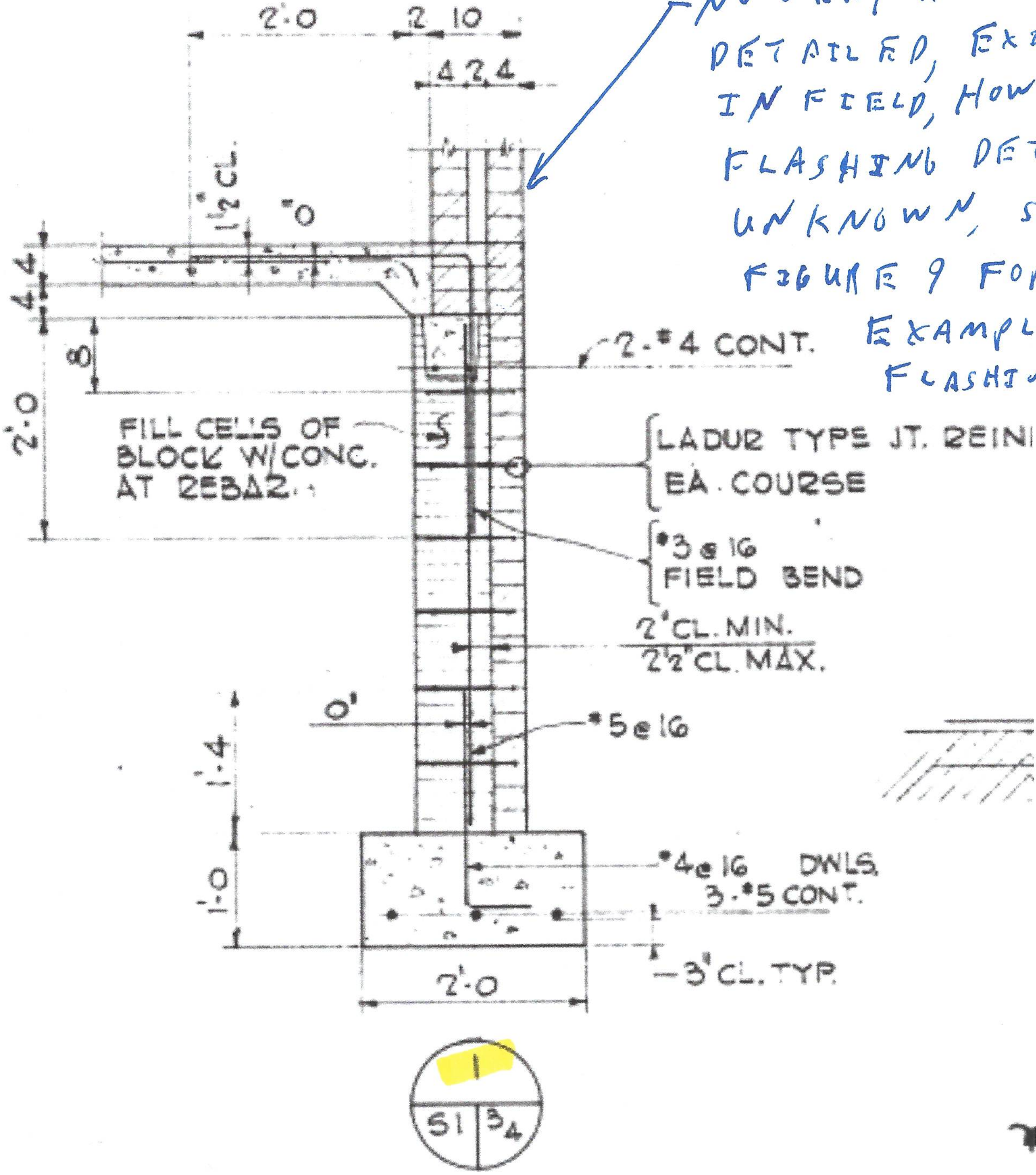
(12) TYP. EXT. WALL FTG.

3/4" = 1'-0

PUBLIC SAFETY BUILDING

FIGURE 10

SECTION 12



NO WEEP HOLES DETAILED, EXIST IN FIELD, HOWEVER FLASHING DETAIL UNKNOWN, SEE FIGURE 9 FOR EXAMPLE FLASHING

FIGURE 11

SECTION 1

C. MICHAEL ALBERTO, III, P. E., PLLC

LICENSE NO. P-1753
580 20TH AVENUE COURT NW
HICKORY N C 28601

CIVIL ENGINEERING
STRUCTURAL ENGINEERING
SITE PLANNING
CONSTRUCTION CONSULTANT

PHONE 919-621-7667
FAX 828-327-3188
cmichael.alberto@gmail.com

3/18/18

INVOICE NO. 18037

MR. CHARLIE WATTS, FIRE CHIEF
TOWN OF VALDESE
P.O. BOX 339
VALDESE, N C 28690

RE: INSPECTION OF CRACKS IN BUILDING FOR
FIRE DEPARTMENT AND POLICE DEPARTMENT

ATTN: MR. WATTS

ENGINEERING SERVICES TO INSPECT AND EVALUATE CRACKS IN BUILDINGS AT THE ABOVE REFERENCED PROJECT.

19.0 HOURS @ $ 130.00 / HOUR--TOTAL = $ 2,470.00

THANK YOU,

C. MICHAEL ALBERTO, P. E.