CDM

Memorandum

To: *Phil Parkins, PE*

From: *James Forehand, PE*

Date: *November 23, 2009*

Subject: *City of Asheville Town Mountain Water Distribution, Pump Station, and Water Storage Improvements*
COA No. WC-07-08-006
Peach Knob Pump Station Structural Inspection

On November 11, 2009, a CDM structural engineer visited the Peach Knob Pump Station as part of a structural investigation requested by The City of Asheville Water Resources Department (City). The purpose of this site visit was to assess the structural integrity of the pump station and identify issues that may have contributed to the cracking of the pump station walls.

Condition Assessment

Based upon conversation with City staff, it is our understanding that neither Contract Documents nor Record Drawings are available for the Peach Knob Pump Station structure. An analytical assessment of the existing Peach Knob Pump Station structure cannot be performed with the information that is available. Therefore, the condition assessment is based on a visual field inspection of the existing structure, relevant identifiable surface anomalies, field measurements, and tests performed on the structure.

Photo 1 is an overall exterior view of the existing pump station. **Figure 1** shows the general building plan along with the corresponding wall elevation labels for reference throughout the following sections. The building was measured as 18′-0″ square interior dimensions (19′-4″ square exterior dimensions). The walls were constructed of 8-inch thick Concrete Masonry Unit (CMU) bearing walls on the two sides supporting the roof and non-bearing CMU walls on the remaining two sides. The height of the walls was measured as 20 block courses (approximately 13′-4″ high) from the slab-on-grade to the ceiling/underside of the roof structure.

The walls appear to bear on a concrete slab-on-grade. No information is available regarding the concrete slab design or construction. The concrete slab is assumed to be either of uniform

thickness throughout, or a thickened concrete turndown. Overall, the base slab appears to be in good condition.

Roof Framing

The roof framing assembly was completely boxed-in, preventing inspection of the framing members and their corresponding connections to the bearing walls. At the top of the block walls/eave height of roof, the ceiling finish consists of what appears to be plywood attached to the underside of roof joists. Along the interior perimeter of the building, there appears to be a wood nailer between the transition of the ceiling soffit and the block wall with no visible connection to the soffit or wall. Viewing from the exterior, based on the observable geometry, the roof framing consists of a gabled framed roof with the ridge line at the center of the building spanning north-south. No structural deficiencies were noted regarding the buildings ceiling or roof framing. However, the continuity of the load path is questionable at the wall roof intersection.

Exterior Walls

The focus of the field inspection/investigation was mainly on the condition of the two CMU bearing walls and the two CMU end walls. Conditions for each wall will be described in the sections that follow, separated for the north, east, south, and west walls. Sounding of the CMU walls was employed to determine if the cells were grouted or ungrouted. The presence of grout could indicate that the cell was grouted or reinforced. Sounding was performed horizontally along the same coursing of block, vertically along the same cells of block, and horizontally at the top course of wall at the wall-to-roof transition. Sounding horizontally would indicate whether or not vertical cells were grouted, while sounding vertically would indicate horizontally grouted elements such as bond beams. Sounding horizontally along the top course would indicate if there was a bond beam present. Typically, a bond beam along the top course is required for anchorage of the roofing elements. Based on the sounding results, it is apparent that all CMU blocks are hollow. From this, the conclusion may be drawn that the cells of the CMU walls are ungrouted. Furthermore, based on visual inspection, the CMU cells appear to have been insulated with Styrofoam.

The most visible deficiency of the four CMU walls is the cracking present in the mortar joints. The cracking appears to be following the head and bed joints of the CMU and is present on both the interior and exterior wall elevations, indicating that the wall is fully cracked through both of the face shells. The following subsections are descriptions of the conditions found at each wall of the pump station.

North Wall

The condition of the north interior wall is shown in **Figure 1A** and **Photos 2** through **4**. In these photos, the most prominent surface cracking occurs at the top of wall at the northwest corner, and extends downward and inward along the wall, following the CMU head and bed joints for approximately 5 courses. There are other less severe cracks in the region of the northwest corner, also following the path of the mortar joints. At the opposite end of the

north interior wall (northeast corner), a full thickness crack starts 6 courses up from the concrete floor and extends downward and inward along the wall, following the mortar joints, terminating 1 course above the base slab.

The condition of the north exterior wall is shown in **Figure 1B** and **Photos 5** through **7**. In these photos, cracking that was observed on the north interior wall is reflected through the full wall thickness and is visible on the north exterior wall elevation. The northwest corner cracking starts at the top of wall and extends downward and inward along the wall mortar joints for approximately 5 courses. The northeast corner cracking starts 5 courses up from grade and extends downward and inward along the wall, following the mortar joints, terminating at grade. It should be noted that the northeast building corner is the closest corner of the building adjacent to the soil-nailed excavation for the new CROM storage tank.

East Wall

The east wall is the side of the building closest to the existing tank and soil-nailed wall. The condition of the east interior wall is shown in **Figure 2A** and **Photos 8** and **9**. These photos show that cracking occurs approximately 7 courses up from the slab-on-grade at the northeast corner, and extends downward and inward along the wall, following the mortar joints to the concrete slab-on-grade. There are also other less severe cracks in the region of the northeast corner, at mid-height and top of wall, also following the path of the mortar joints. At the opposite end of the east interior wall (southeast corner), severe cracking occurs at the corner where the south and east walls intersect. This crack starts at the slab-on-grade and extends vertically for about 8 courses. It appears that there has been an attempt to either patch or caulk this vertical crack as evidenced by the presence of caulking material. There is less severe cracking at the southeast corner which extends upward and inward toward the building for about 7 courses, following the mortar joints. There is also mortar joint cracking at the top of the wall at the southeast corner, extending inward along the mortar joint for 3 courses or so, as well as another minor vertical crack at the south and east wall intersection, extending from top of wall, to mid-height elevation.

The condition of the east exterior wall is shown in **Figure 2B** and **Photos 10** through **12**. The cracks that were noted on the interior elevation of this building appear to propagate the full thickness of the wall to the exterior elevation. The northeast corner cracking occurs about 7 courses up from finished floor and extends downward and inward along the wall mortar joints to grade. The southeast corner cracking starts at grade, one cell inward from the exterior corner, and extends vertically for 7 courses. There is also a visible vertical crack two cells in from the exterior corner at the fifth and sixth course above grade.

South Wall

The south wall is the side of the building abutting Patton Mountain Road, which is the street access to the pump building. The condition of the south interior wall is shown in **Figure 3A** and **Photos 13** and **14**. Cracking occurs at the corner where the south and east walls intersect. At the southeast corner, a crack starts at the slab-on-grade and extends vertically for about 8

courses. It appears that there was an attempt to either patch or caulk this vertical crack as evidenced by the presence of caulking. There are other less severe cracks in the region of the southeast corner from mid-height to top of wall, continuing vertically at the corner or one cell inward at the mortar joints. There is also a continuous horizontal crack two courses below the top of wall extending from the southeast corner, about 10 cells interior to the building. For the remaining span of the south interior wall, other than a couple of small vertical cracks in mortar joints near the southwest corner, the wall does not appear to have visible signs of cracking.

The condition of the south exterior wall is shown in **Figure 3B** and **Photo 15**. From this photo, the only visible exterior crack is at the base of the building. This crack, located just above grade, starts at the southeast exterior corner and propagates horizontally along 3 CMU block, or approximately 4 feet. Based on our field observations, no other exterior cracks at the south wall were observed.

West Wall

The west wall is the entry access side of the building, with the full height transom door along the face of this wall. Between the top of the transom door and underside of roof bearing/ceiling, exists a steel beam (header) which spans the width of the doorway and bears on the CMU wall below with approximately 8-inches of bearing each end of beam. Based on measurements taken in the field, this header appears to be a W8 wide flange steel beam. The condition of the west interior wall is shown in **Figure 4A** and **Photos 16** and **17**. The condition of the west exterior wall is shown in **Figure 4B** and **Photo 18**. The only visible cracking in the west wall is at the wall interior just to the north of the steel header bearing. The crack location is 1 course below roof bearing, and extends horizontally for 1 CMU block (two cells) along the mortar joint. The severity of the crack is considered to be minor. Other than this location, no other cracks were observed in the west wall of the building.

Recommendations

Based on the field soundings it appears that the CMU cells are hollow with no reinforcement horizontally or vertically. The full wall thickness cracking at the northwest, northeast, and southeast region of the structure further indicate a lack of grouted cells with reinforcement. Typically, only the face shells of the CMU blocks are grouted. With the cracking penetrating the face shells, there is no structural load path for out-of-plane wind or seismic loads to be resisted or transferred. Therefore, the continuity of the load path has been disrupted and has placed the structure at risk for failure under combined wind and snow loading conditions that are considered normal for this geographical area.

Building modifications that would restore a continuous load path from the roof framing to the unknown slab-on-grade foundation could be implemented. One repair approach would be to remove the roofing, place grout and reinforce the top course of block. The face shells would then have to be saw-cut and removed. Then reinforcing would be placed within the

cells, formed, and grout filled. This approach is very inefficient and could cost upwards of $50,000 based on similar construction done recently.

An approach that is a compromise between rehabilitation and a new structure is to build a new strip footing outbound of the existing slab-on-grade. Then place grouted bond beams and vertically grouted reinforced cells as required by the current building codes. A new roof would then be built after removal of the existing roof. The new roof could be wood or precast concrete construction with proper anchoring to the walls to produce a continuous load path for lateral and uplift loads produced by wind effects of the 90-mph typical design wind speed. The existing walls could then be removed by hand demolition and the wall supported equipment could be relocated to the new walls or located on fabricated supports.

Summary

There are several factors that could have contributed to the cracking noted during the visual inspection. First, the demolition of the existing tank could have induced vibrations that caused cracking in the unreinforced masonry structure. The effects of the settlement, due to the excavation, may have been reduced by underpinning of the pump station prior to demolition activities. However, underpinning may not have completely eliminated the effects of the vibration resulting from the demolition work and soil-nailing.

It is possible that if left unaddressed, the current cracks in the CMU walls could continue to propagate, further compromising the structural integrity of the building. A failure of this structure may present a health and safety hazard to City staff and a loss of functionality of the pump station. Whether or not rehabilitation or reconstruction is implemented, the solution should only be employed after the CROM storage tank is constructed and the area is backfilled.

Photo 1: Peach Knob Pump Station Exterior View

Photo 2: North Interior Wall – Cracking at Northwest Corner

Photo 3: North Interior Wall – Cracking at Northwest Corner

Photo 4: North Interior Wall – Cracking at Northwest Corner

Photo 5: North Exterior Wall – Cracking at Northwest Corner

Photo 6: North Exterior Wall – Cracking at Northeast Corner

Photo 7: North Exterior Wall – Cracking at Northeast Corner

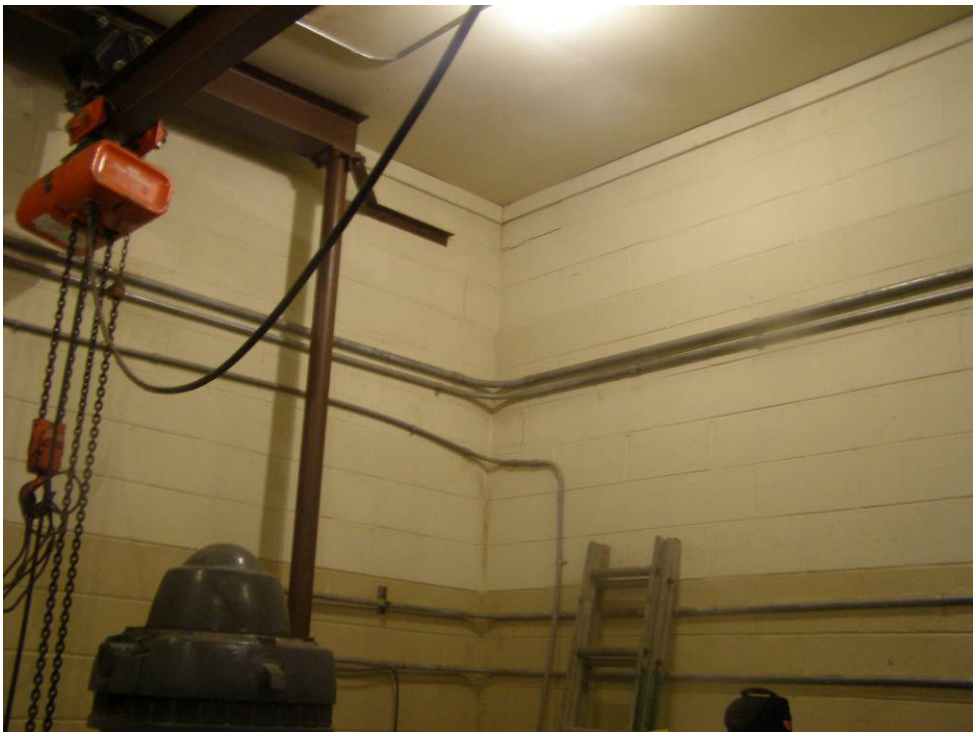

Photo 8: East Interior Wall – Cracking at Southeast Corner

Photo 9: East Interior Wall – Cracking at Southeast Corner

Photo 10: East Exterior Wall – Cracking at Southeast Corner

Photo 11: East Exterior Wall – Cracking at Southeast Corner

Photo 12: East Exterior Wall – Cracking at Northeast Corner

Photo 13: South Interior Wall – Cracking at Southeast Corner

Photo 14: South Interior Wall – Southwest Corner

Photo 15: South Exterior Wall – Cracking at Southeast Corner

Photo 16: West Interior Wall – Southwest Corner

Photo 17: West Interior Wall – Transom Door

Photo 18: West Exterior Wall

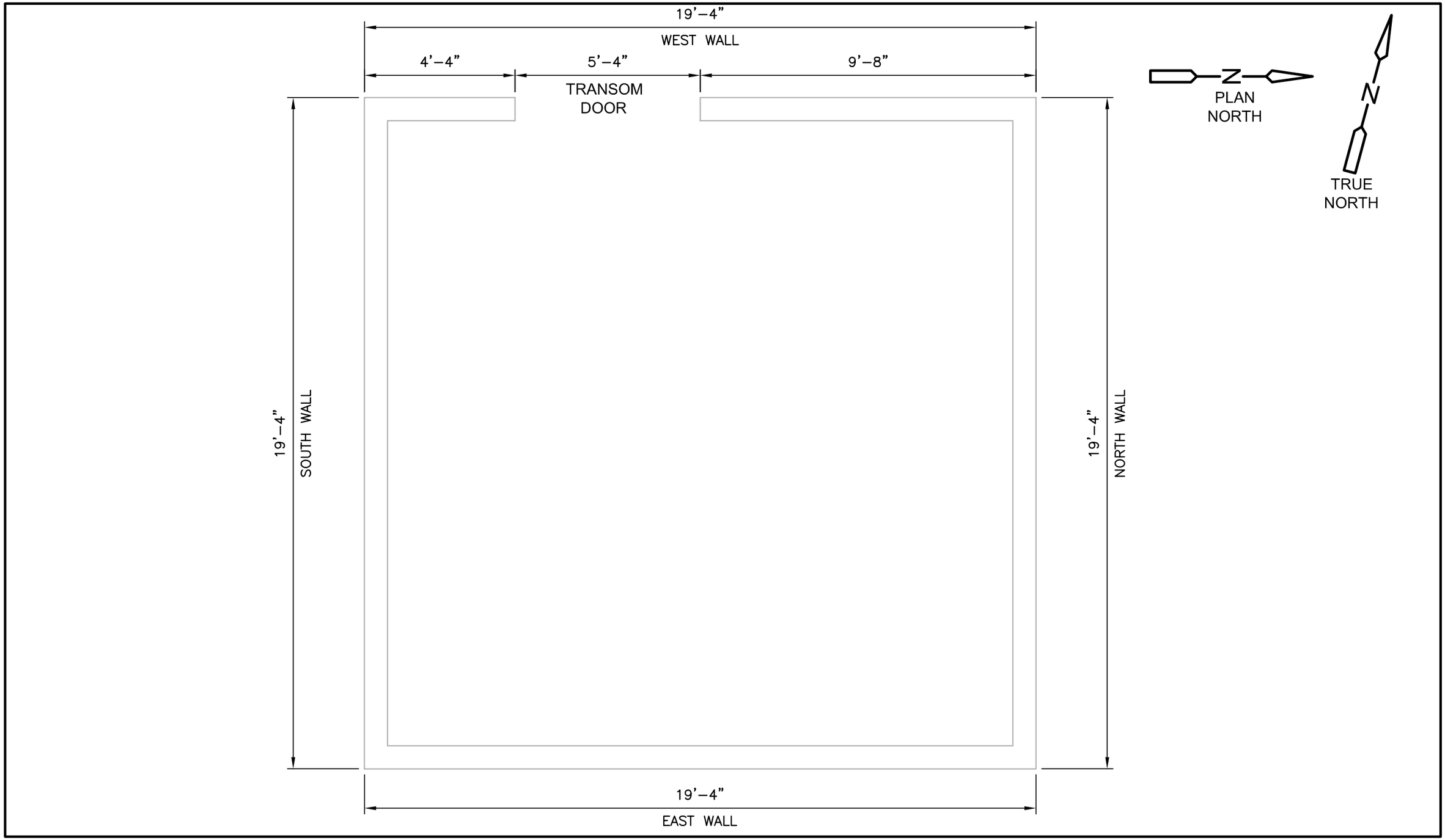

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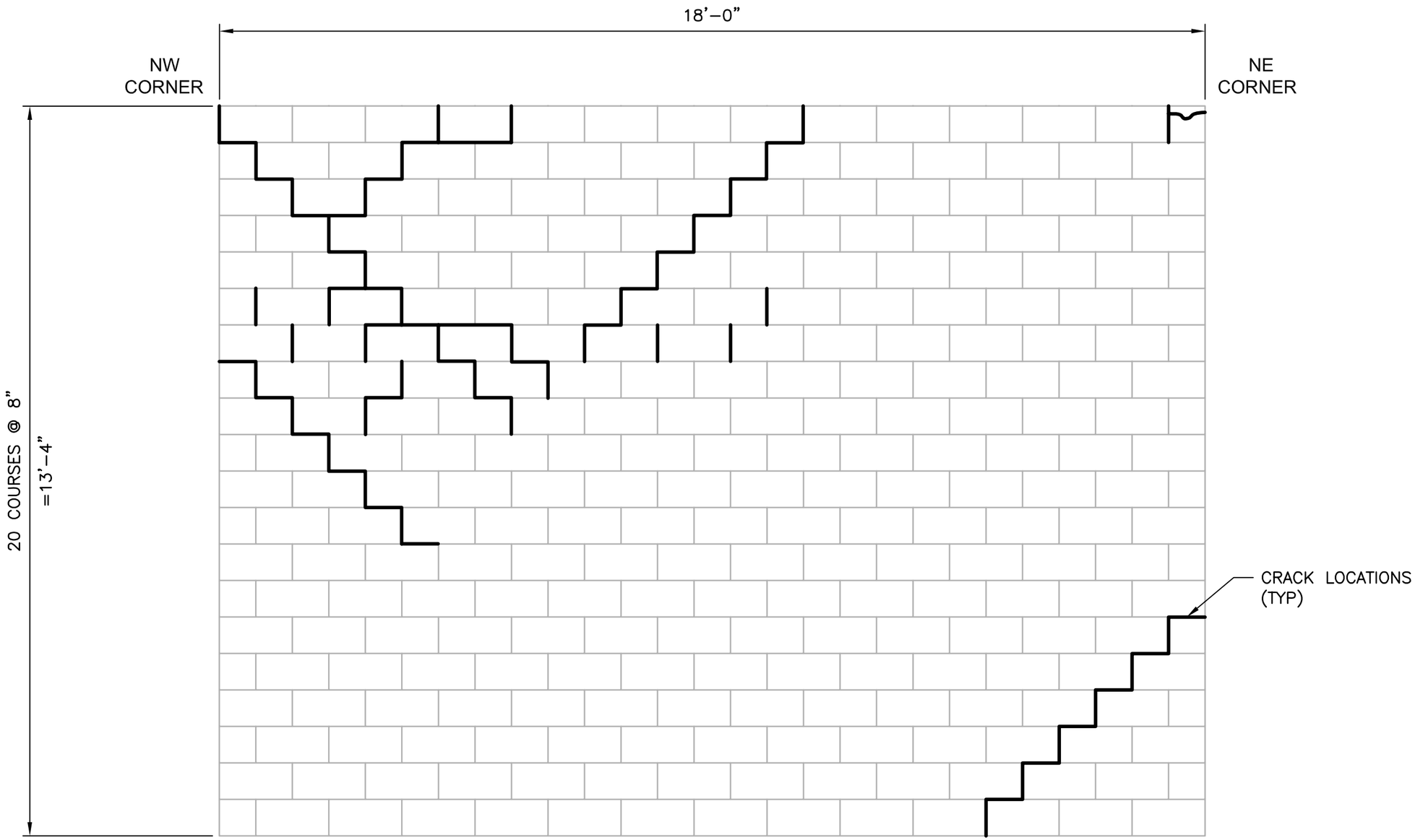
Figure No. 1
PEACH KNOB PUMP STATION BUILDING PLAN



1/2" = 1'– 0"

1 0 1 2

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Figure No. 1A
INSIDE WALL - NORTH

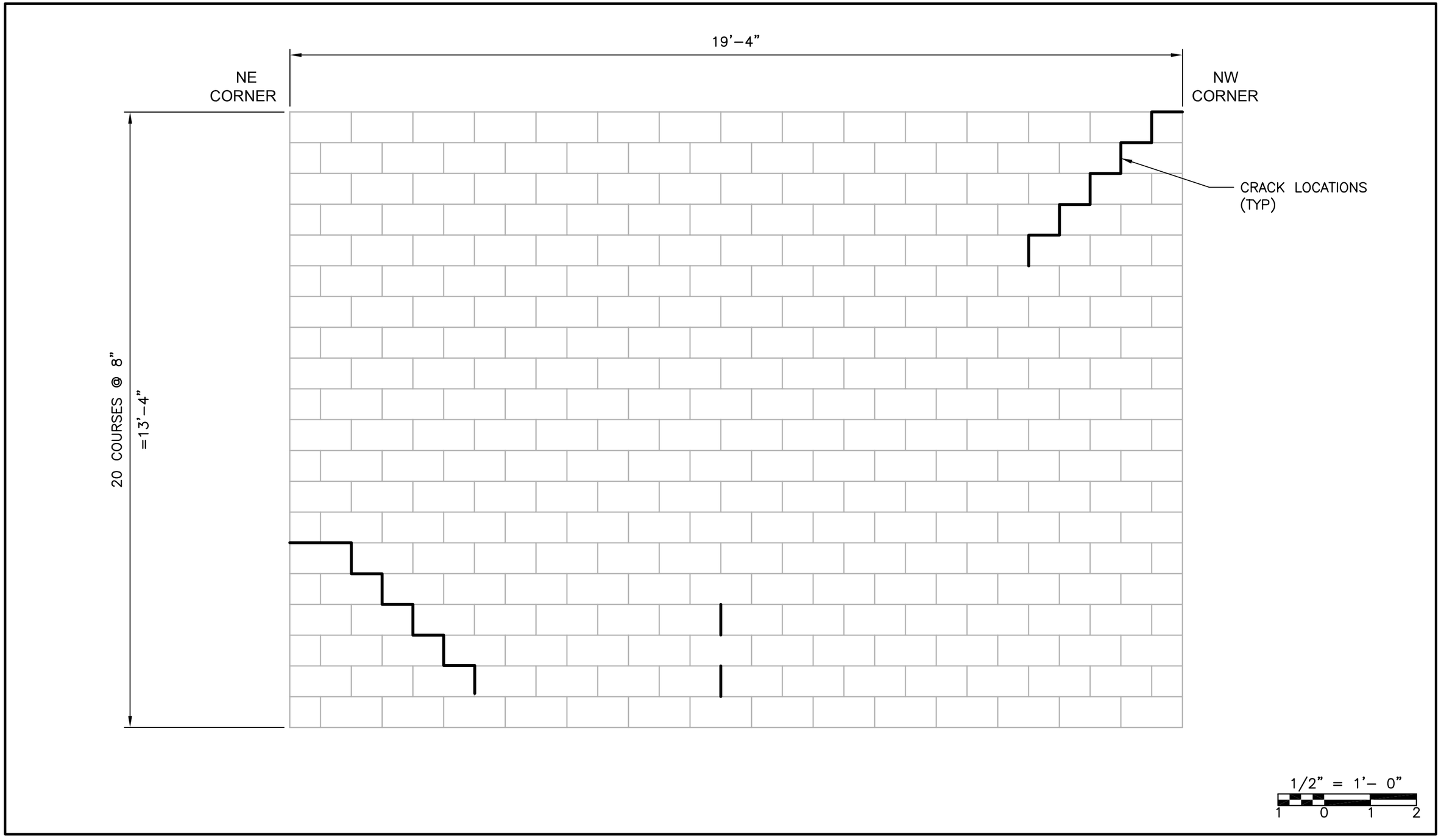

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Figure No. 1B
OUTSIDE WALL - NORTH

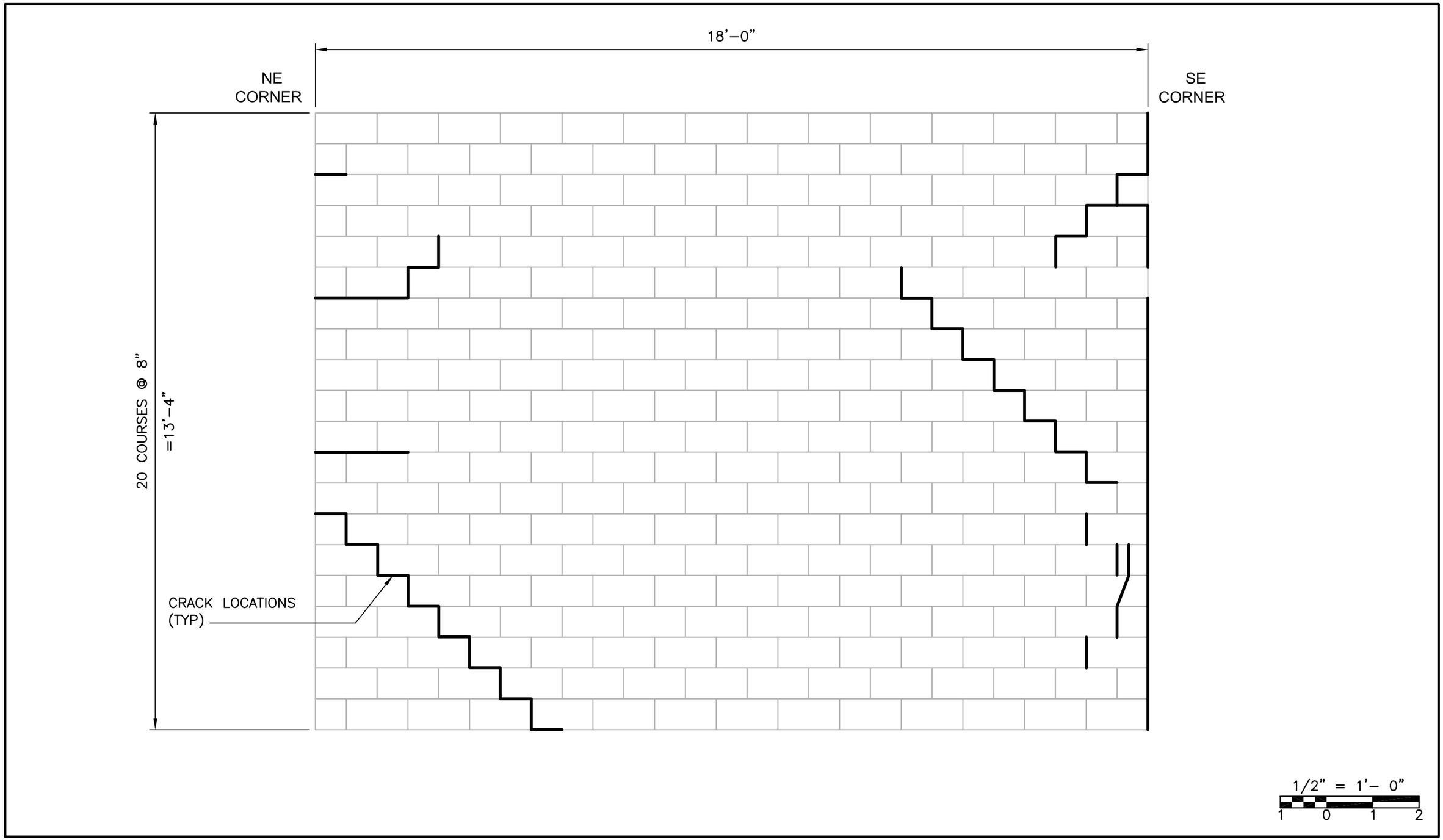

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Figure No. 2A
INSIDE WALL - EAST

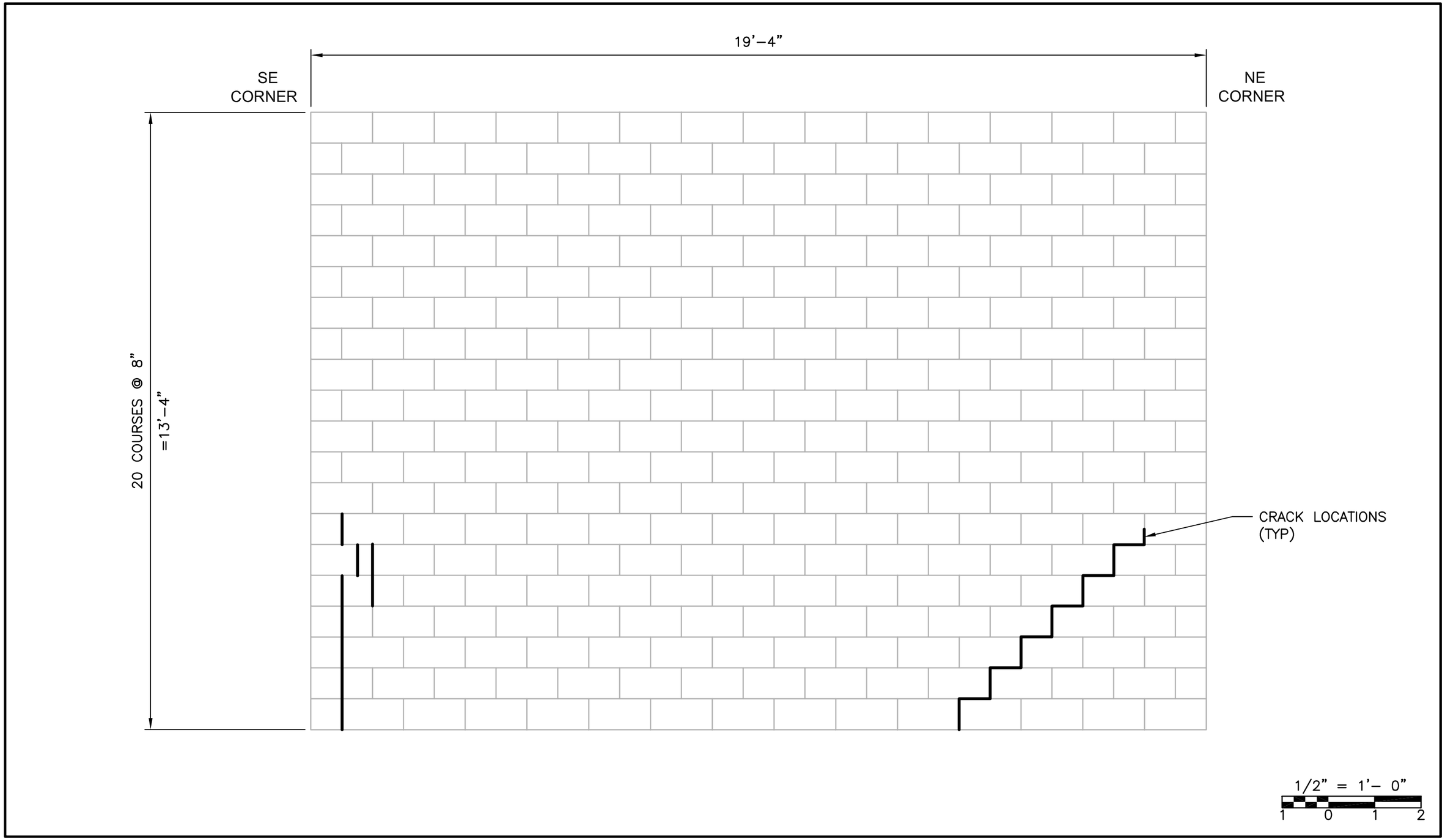

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Figure No. 2B
OUTSIDE WALL - EAST

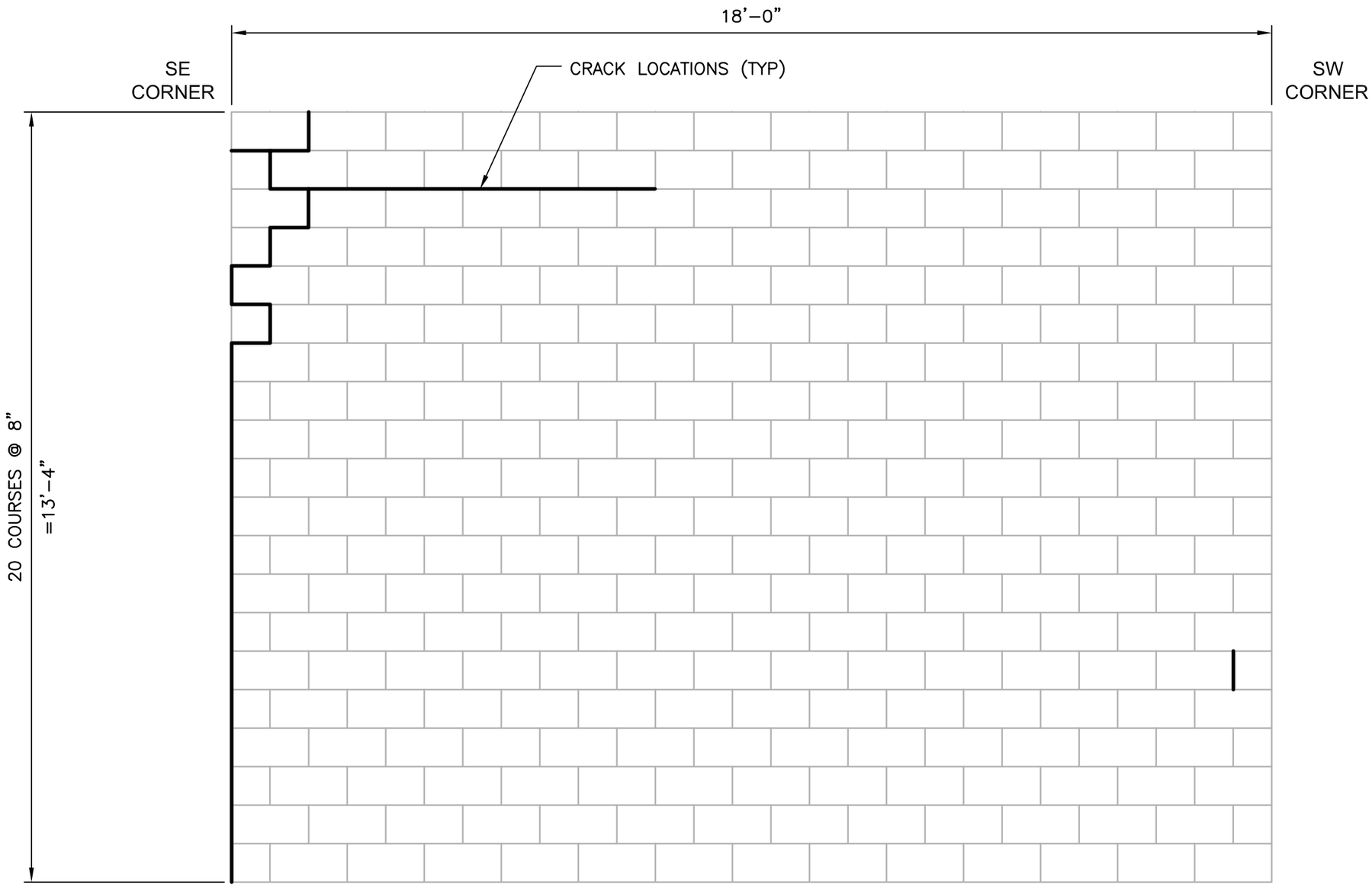

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Figure No. 3A
INSIDE WALL - SOUTH

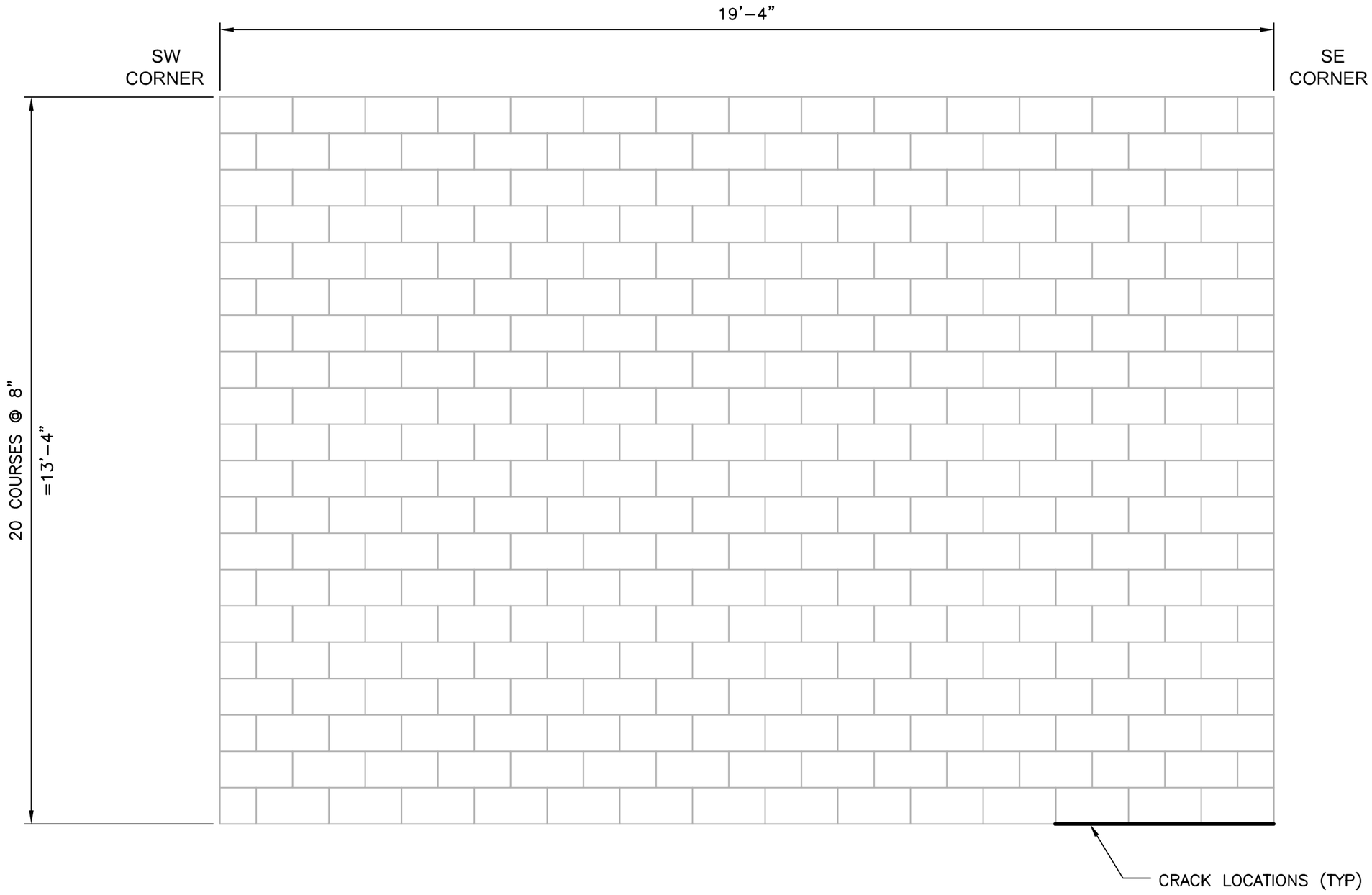

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Figure No. 3B
OUTSIDE WALL - SOUTH

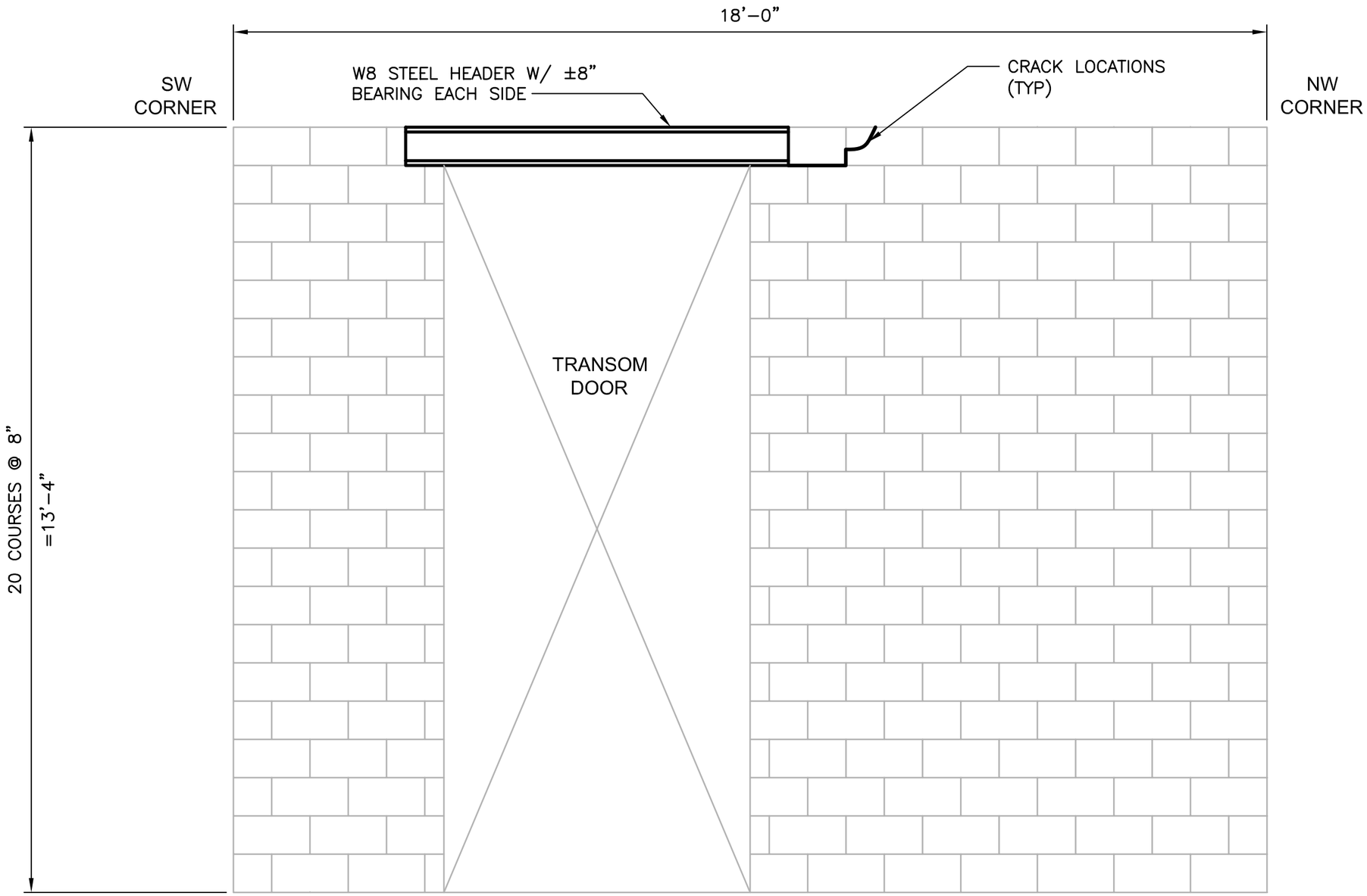

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Figure No. 4A
INSIDE WALL - WEST

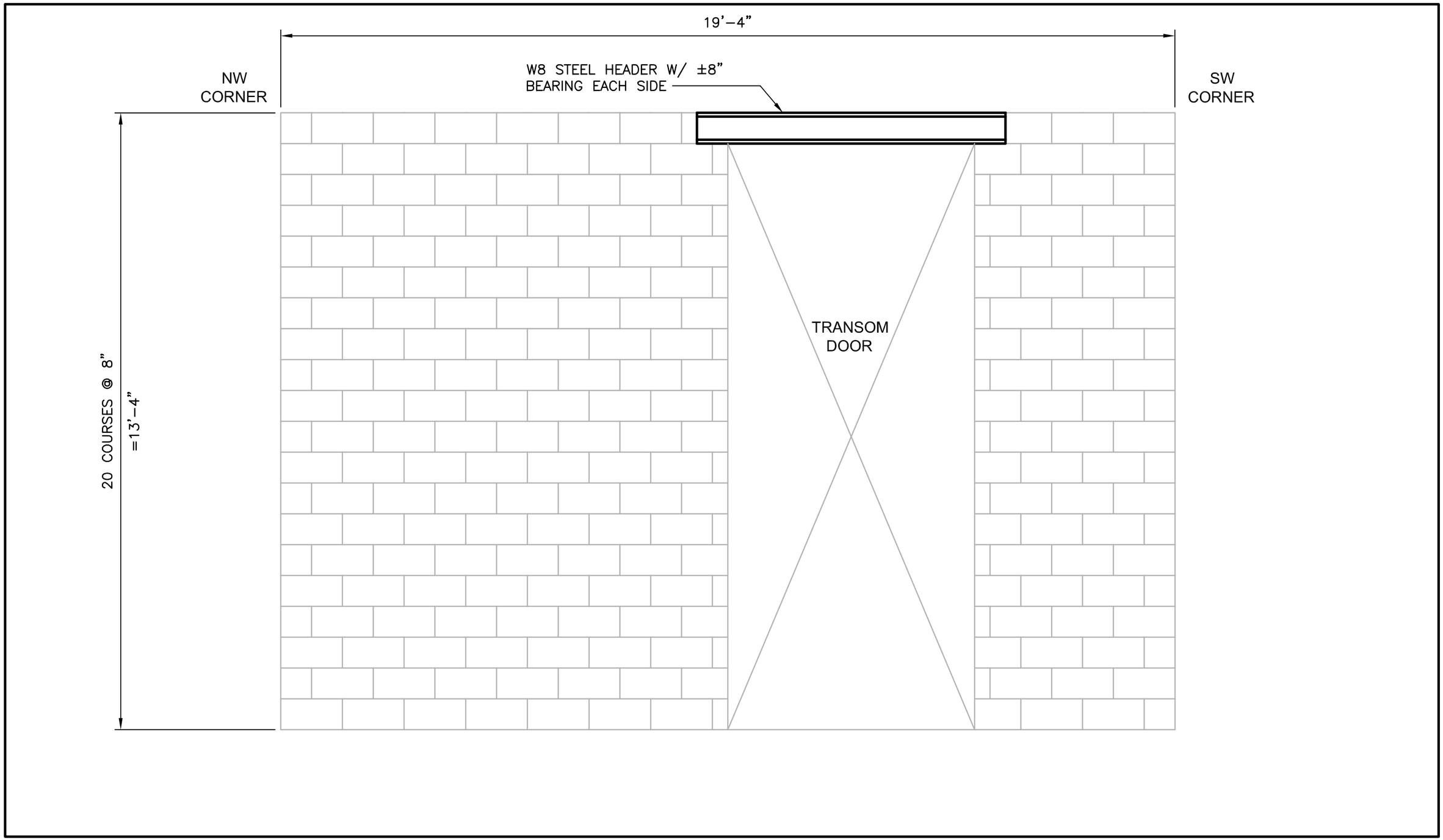

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Figure No. 4B
OUTSIDE WALL - WEST