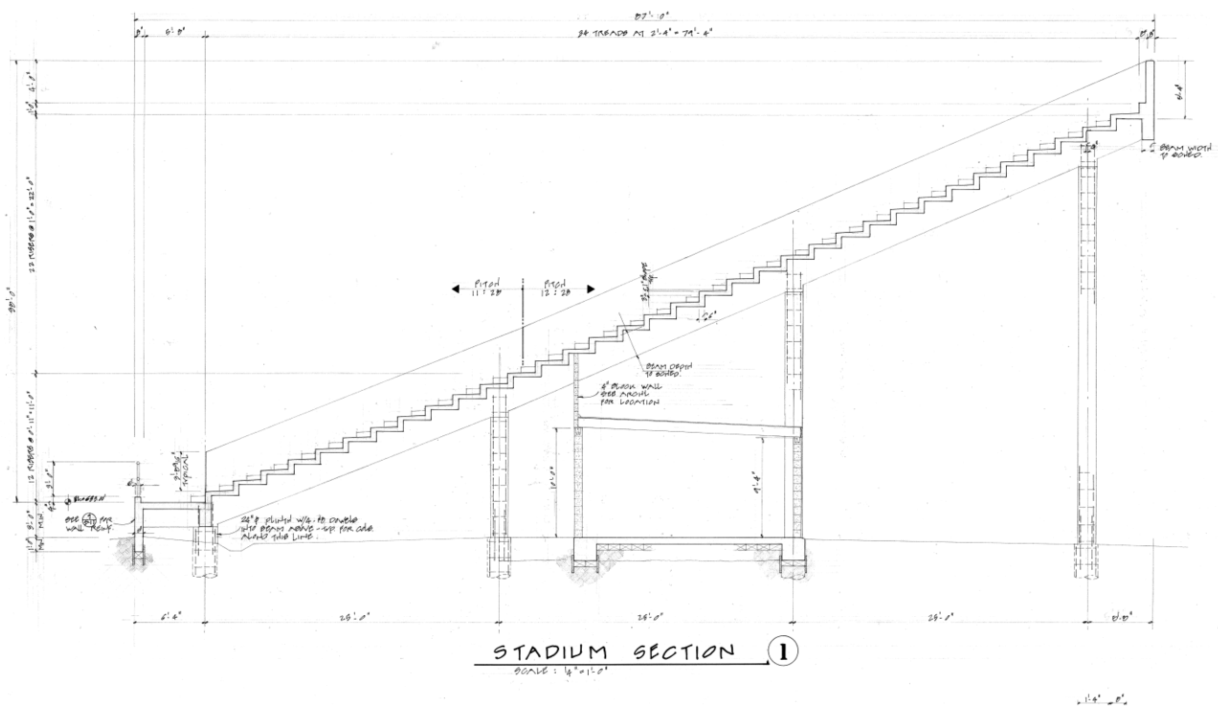
STRUCTURAL ASSESSMENT – Burger Athletic Complex Stadiums (BLDG-951M&N)

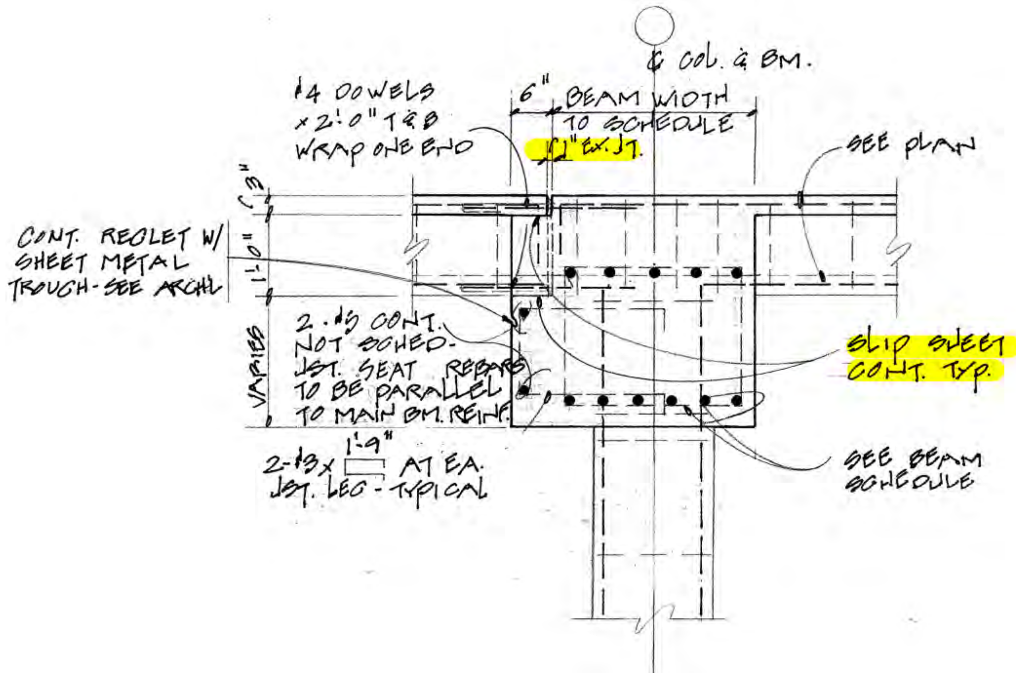
Building Purpose	Stadium Seating
Inspection Date	September 23, 2016 and November 14, 2016
Inspection Conditions	94° - Overcast (9/23/16) 70° - Overcast (11/14/16)

Building Description / Reported Structural Concern

Brief Description of Existing Stadium Seating Structure: The east and west stadium structures consist of cast-in-place, suspended concrete framing. At ground-level, the concession area and other enclosed spaces are supported on a suspended flat slab and suspended edge beams. The low side of the stadium seats is supported on suspended foundation beams running north-south and span between piers. The low side beams are not connected to or braced by any ground-level framing in the east-west direction. Void spaces below beams and slabs are maintained by precast concrete soil retainers. The high side of the stadium seats is supported by tall 18" square cast-in-place concrete columns bearing directly on isolated drilled piers; no ground-level beams or slabs brace the top of piers/bottom of columns or connect them together. The stadium seats are framed with sloping beams that span between columns in the east-west direction (perpendicular to the seats). Cast-in-place concrete, stepped deck and vertical joists form the stadium seats and span north-south between beams. See typical section below from the original plans dated 5-26-1975:



Beams and stepped deck/joists are cast monolithically, with the exception of the deck and joists at intermediate expansion joints. According to the existing plans, intermediate expansion joints run east-west and are located roughly at 1/3 points along the length of the stands. The concrete deck/joists on one side of the expansion joint (the north and south sections of the stadium) are cast monolithically with the supporting beam below and the concrete deck/joists on the other side of the joint (the center section of the stadium) bear on top of the same beam but are isolated from the beam with slip sheeting to allow lateral movement. The detail below depicts the concrete framing at intermediate expansion joints:



During our review of the drawing records as part of our investigation, we discovered repair documents from 2006 that address many of the distressed/damaged areas observed while at the site. The 2006 repair documents state that the stadium structure damage is a result of building movement/settlement. They also state that the repair measures are meant to control crack expansion due to water infiltration and to relieve the unintended stresses being applied to the existing CMU walls, but that the repair work is not intended to stabilize the structures' movements.

Reported Stadium Seating Structural Concern: An Owner's representative reported that daylight was visible through the concrete stands near a beam in the East Stadium. Cracking was reported in a nearby concrete column supporting the beam. Cracking was also noted in the CMU wall abutting the cracked column.

During our site visit we realized that the concrete distress and damage was not limited to the small area reported but instead was prevalent and significant throughout both the east and west stadium structures.

Structural Assessment Site Observations

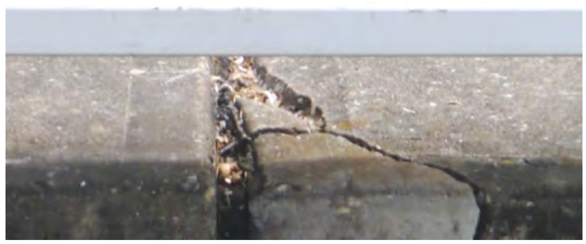
While at the site we found several signs of significant structural distress, some of which are potentially a safety concern. We made the following observations of the east and west grandstands from above and below the bleacher seating:

- **East Stadium Intermediate Expansion Joints:** Both the reported daylight visible through the east stadium structure and the cracking noted in the concrete framing and CMU walls are located near the south intermediate expansion joint. At this location, the deck/joists to the south of the expansion joint are cast integrally with the beam while the deck/joists on the north side are isolated from the supporting beam. At the north expansion joint, the deck/joists to the north of the expansion joint are cast integrally with the beam while the deck/joists on the south side are isolated from the supporting beam. At the north intermediate joint, a horizontal separation of the deck/joists on either side of the joint ranged from 1" to 3" and a vertical upward displacement of approximately 1" was visible from where the isolated north deck was originally cast against the beam. At the south intermediate joint, a horizontal separation of approximately 1" and a vertical displacement of approximately 2" were measured from where the south deck was originally cast against the beam. For both intermediate joints in the east stadium structure, vertical separation was primarily found along the beam near where it intersected with the CMU wall; everywhere else along the beams had little to no vertical separation between the beam and the stand framing bearing on it. Where it could be measured, the bearing width of the isolated stand framing was measured as approximately 4" (measured near CMU walls). The beam was starting to spall on the top corners where the isolated stand above was bearing on the beam. The spalls appeared to be a mix of old and recent activity and spalled concrete was caught in the gutter. Severely cracked and spalled concrete was observed at the top of the deck near the horizontal expansion joint dowels that connect the deck on each side of the joint. The concrete in this area appeared to have been repaired in the past (presumably in 2006) but new damage has since developed. Water staining is prevalent on the vertical faces of the beams below the intermediate joints.

A brief observation of the west stadium expansion joints was conducted and horizontal, but not vertical, separation was observed; the amount of separation observed was less in magnitude than at the east stadium.

Horizontal & vertical separation at south expansion joint; New damage at previously repaired concrete

(East Stadium, View from Top of Deck)



New concrete damage at expansion joint (since 2006 repair work)

(East Stadium, View from Top of Deck)

Vertical and horizontal separation of isolated deck and supporting beam at south intermediate expansion joint

(East Stadium, View from Below Deck)

Vertical and horizontal separation of isolated deck and supporting beam at north intermediate expansion joint

(East Stadium, View from Below Deck)

Horizontal seperation of the supporting beam and isolated deck

Horizontal seperation of supporting beam and isolated deck

Vertical gap betweem supporting beam and isolated deck

Daylight visible betweem supporting beam and isolated deck

Concrete at the top corner of the supporting beam is spalling (below isolated deck)

Spalled beam concrete caught in the gutter

- **Columns:** Flexural cracks were observed near the base of several tall columns along the back side of both stadium structures. Similar flexural cracking was also observed at the tops of several tall columns; some of these cracks had been previously repaired and some of the repaired cracks have re-opened. Severity of the cracking at the top of the column roughly matches that of the cracking at the bottom of the column but the top cracks were typically on the opposite face from the bottom cracks. Additionally, several of the tall columns visually appeared to deflect laterally (i.e. appeared to be leaning). Generally, columns north of the north expansion joint deflect towards the north while columns south of the south expansion joint deflect towards the south.

Measurements to determine deflection were taken at tops and bottoms of select columns on the eastern stadium. The measurements were performed by running a plumb-bob from the top center of a column face and measuring the difference to the bottom center of the column. This method only captures deflections between top and bottom of the column and does not capture any deflection along the length of the columns. Column deflections ranged from no discernible top-to-bottom deflection to approximately 1-1/4" of deflection. Locations of the columns which were measured and the measurements taken can be found in the attached plan with measurements, photo log, and notes. It should be noted that it was very windy on the day the measurements were taken; affects of the wind were minimalized by shielding the plumb-bob from the wind as much as possible and only taking measurements between gusts, but the wind may still have affected the measurements taken.

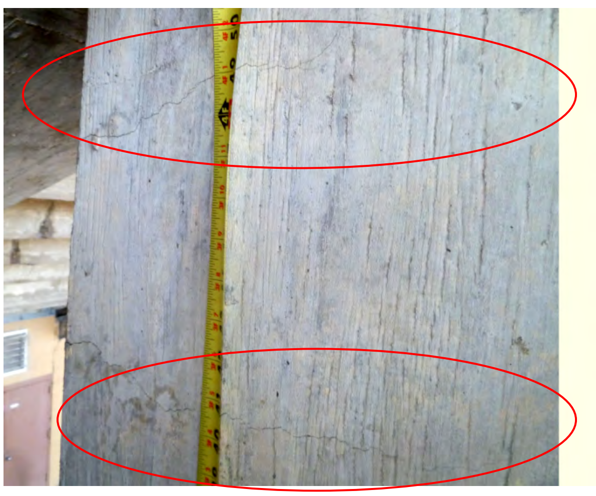
Note that the 2006 repair effort did not address any cracks or other distress in the columns, so we can only conclude that overall the structural distress of both grandstand structures has advanced since 2006 and will likely continue to worsen over time.

Flexural Cracking Near Bottom of Column

Flexural Cracking Near Bottom of Column

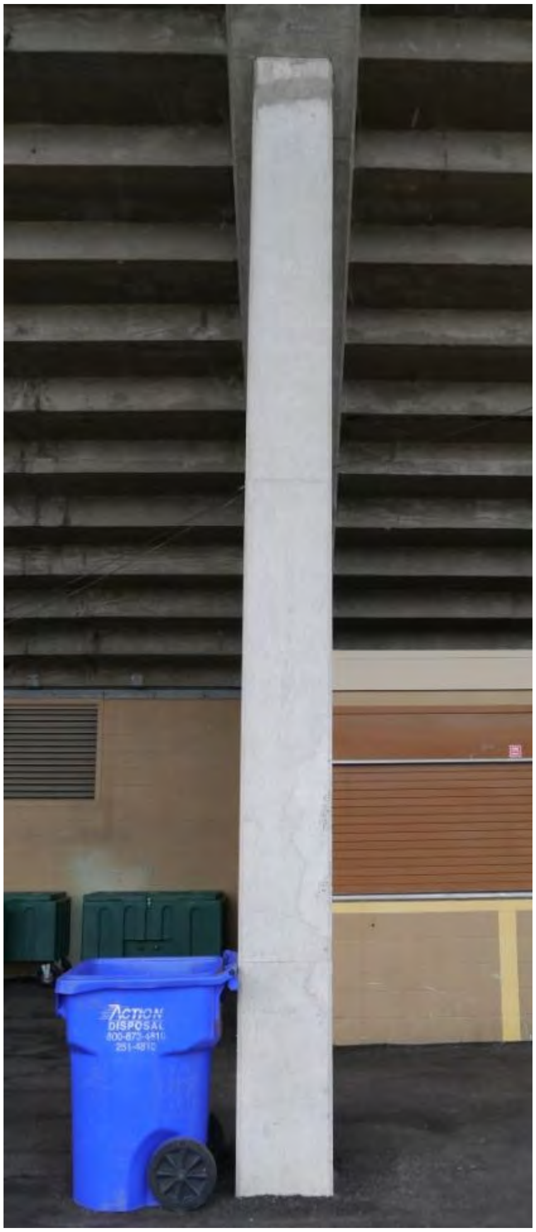
Previously repaired cracks at top of column have re-opened

Previously repaired cracks at top of column have re-opened and new cracks have developed



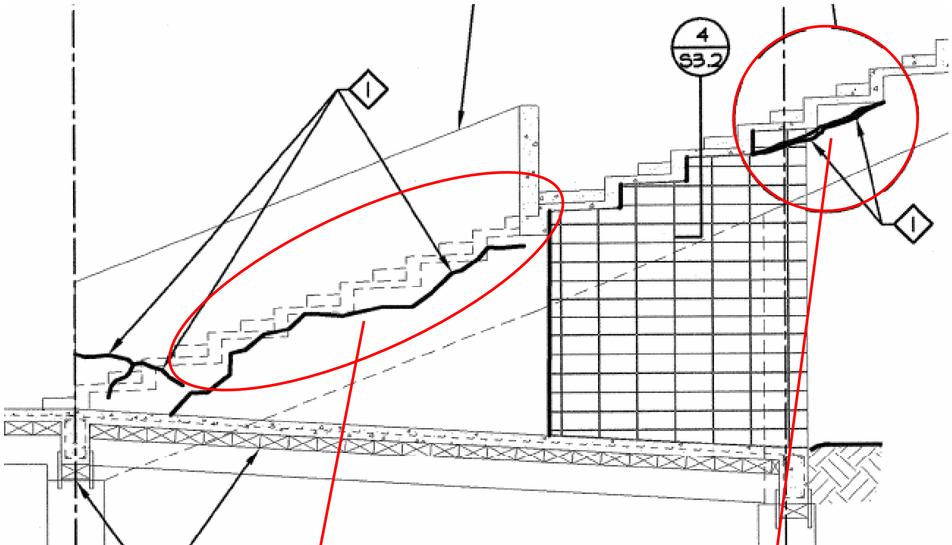
Cracks in the top of column extended as far as 4'-8"" from the top of column

Edge column has seperated from CMU wall

 Lateral deflection at top of column	 Lateral deflection at top of column – top portion of column has separated from CMU wall

- **Stadium Seating Beams and Deck/Joists:** Cracks in the beams, joists and deck are prevalent throughout both the east and west stadium structures. Numerous spalls are present with exposed and corroded reinforcement. In general, damage to concrete framing appeared more common in the vicinity of the intermediate expansion joints. Some damaged areas that had been previously repaired have since re-cracked, and some previous concrete repairs are failing. Also, some of the cracks that were supposed to have been repaired in 2006 with epoxy-injection do not appear to have been repaired.

Water staining is visible on the underside of the beams, deck and joists in many areas indicating water has infiltrated through the concrete deck/joists via full-depth cracks and open expansion joints. While not the base source of the structural distress, water infiltration facilitates rebar corrosion which contributes to and exasperates any existing concrete damage.



2006 Repair Details Cracks to be Repaired via Epoxy Injection

Cracks at south ramp wall do not appear to have been repaired via epoxy injection

Cracks at nearby beam do not appear to have been repaired via epoxy injection

Significant cracking in deck and joists; Water strains due to water infiltration thru deck cracks


Spalling with exposed/corroded reinforcing at underside of deck; Water strains due to water infiltration thru deck cracks


Exposed/corroded beam reinforcing


Cracked beam soffit

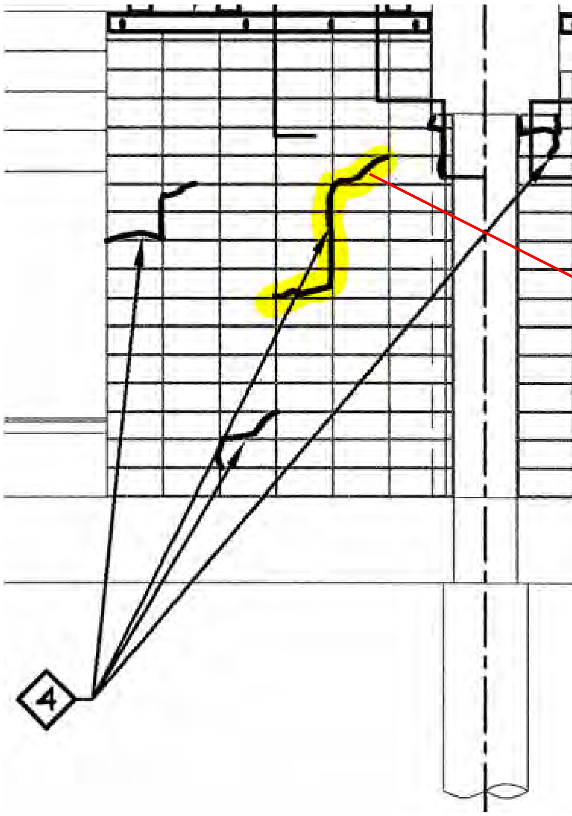

Failing concrete repair patch on beam soffit; Exposed/corroded beam reinforcement


Prevalent cracks on top of deck allow water to infiltrate the concrete & exasperate progression of damage

- **CMU Walls:** Old and new cracks were prevalent in the CMU walls below the stadium seating.

  In the 2006 repair work, the top of the CMU walls were retrofitted at their connection to the concrete stadium framing because, according to the 2006 repair documents, the concrete framing had settled vertically and was inadvertently loading the non-load bearing CMU walls and causing wall distress.

  Several cracks that were supposed to be epoxy injected in 2006 did not appear to have been repaired, and some of those cracks appear to have worsened.

	
From 2006 repair plans: extent of crack in CMU adjacent to intermediate expansion joint	Same crack in CMU shown to the left – Note that wall crack has propogated since detailed in 2006

- **Apparent Structural Deficiencies in Original Design:** Per the original construction documents, the columns supporting the high end of the stadium framing are 18” square and are reinforced with four #8 vertical bars and #3 horizontal ties at 16” on center. The columns sit on 24” diameter straight-shaft piers. The bottoms of columns/tops of piers are not laterally braced by any perpendicular floor framing. As a result, the tallest columns – the ones that appeared to be deflecting laterally – are 35 feet tall but actually have unbraced lengths anywhere from 40ft to 50ft, depending on the stiffness of the soil material above the limestone (soil profile unknown).

Original plans require piers to extend to solid limestone. Estimated pier depths per the original plans for the east stadium vary from 8ft at the north end to 63ft at the south end, and vary for the west stadium structure from 7ft at north end to 25ft at the south end. It is unusual to see such different depths of piers from one end of a structure to the other, especially considering these piers are not braced at their tops by any floor framing. The difference in depth to fixity results in very different structural stiffnesses from one end of the structure to the other, which causes the structure to perform more rigidly on one end and more flexibly on the other. The east stadium has the largest difference between short and long pier lengths, which could explain why the east stadium shows more signs of structural distress than the west stadium. Additionally, the short piers at the north ends of the stadiums may not penetrate into competent limestone material sufficiently enough to resist rotation, which may also be contributing to the outward settlement/deflection of the structures.

By today's standards the column sizes for such slender unbraced columns seem small, the vertical reinforcement seems light, and the horizontal confinement does not meet minimum code standards. We would expect to see larger columns and a closer horizontal tie spacing to provide some confinement to the section for the columns with longer unbraced lengths.

A structural analysis model, using RISA3D software, was developed to assess the structural adequacy of the stadium's columns. The model was first used to check service deflection due to dead load only, in order to compare expected deflections of the stadium to the measured ones. The maximum top of column deflection predicted in the analytical model due to dead loads only was 0.14" which is far less than the maximum measured deflection of 1-1/4" and average deflection of 1/2" measured in the field. The model was also used to check the structural capacity of the stadium columns for service and factored load combinations. Under unfactored service loads the columns were found to be structurally adequate with an available capacity of 13.4% over the required capacity (i.e. 13.4% over-capacity). **However, under current code-mandated factored loads, the columns were found to be structurally inadequate, having an available capacity of 70% of the needed capacity (i.e. column are 30% under-capacity).** The load combination that leads to the failure is (1.2 x Dead Load) + (1.0 x Live Load) + (1.6 x Sway parallel to seats). Sway loading is an additional load required for stadiums per the "2012 ICC Standard on Bleachers, Folding and Telescopic Seating, and Grandstands" that accounts for the crowd swaying back and forth. We researched whether this code requirement existed in 1975 when the stadium was designed, but could find no record of it being a design requirement in 1975.

Conclusions

The column strength deficiency is concerning and should be addressed immediately. Unfortunately, the more the columns deflect the less flexural capacity they have, which in turn causes them to deflect even more, which causes their flexural capacity to reduce even further. This cycle of increased bending and reduced capacity is referred to as "p-delta effect" and will continue to worsen over time. The two back rows of taller columns need to be strengthened or braced immediately. The structural capacity of the stadium is acceptable when all code conservatism is removed and a service check is performed. However, at full capacity the stadium does not meet code-required, factored load combination checks.

In addition to column strength deficiencies, the concrete framing in general is in very poor condition. We believe the movement at the intermediate expansion joints is responsible for much of the damage and is likely due to outward displacement and/or settlement of the stadium foundations. New damage at previously repaired areas indicates the movement/settlement and resulting structural distress are progressing and will likely continue to worsen over time. Water infiltration will worsen the existing damage and deterioration over time (i.e. will propagate cracks, expand spalling, advance reinforcement corrosion).

Structural repair work required includes repairing spalled/cracked/honeycombed columns, beams, slabs and joists throughout both stadium structures. Exposed/corroded reinforcement needs to be cleaned and protected from further water exposure. Top of stadium decks require a waterproofing membrane to prevent further water infiltration.

In order to better understand the cause(s) of the structural distress, additional investigation is needed to obtain detailed measurements and soil information. Once investigation work is complete, both structures will need significant remedial work. Alternatively, the extensive cost of investigation and repair work may prove that complete replacement of the stadium structures is the best option.

Burger Athletic Complex Stadiums – Summary of Structural Repair Recommendations

This document is based on current conditions observed during fieldwork and provides recommendations for corrective actions.

Burger Athletic Complex Stadium Seating Structural Repair Recommendations

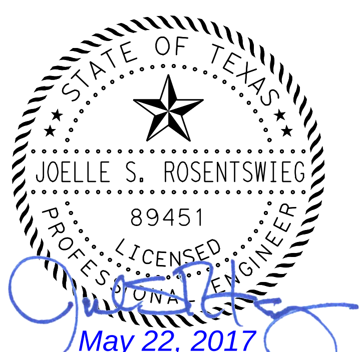
Option A

1. **Detailed Investigation:**
   a. Geotechnical investigation with new borings to understand the area's soil profile and to assess the detailed piers for adequate embedment and rotational restraint. (Up to $15,000 for 6 new borings, soil analysis & detailed report with foundation recommendations)
   b. Detailed Survey of structures to measure: 1) the vertical and horizontal movements at the intermediate expansion joints, 2) the lateral displacements of the tall columns (both in-plane and out-of-plane of the beam-column frames), and 3) the vertical deflections of the bleacher joists and deck as they span between beams. This survey work will determine the locations and magnitudes of movements/displacements (both lateral and vertical) and will help explain the structural behavior of the concrete framing. ($6,000 for survey work & report)
   c. Structural analysis based on the above to confirm causes of distress and original design deficiencies and determine required retrofit. (Up to $10,000 for detailed analyses & report)

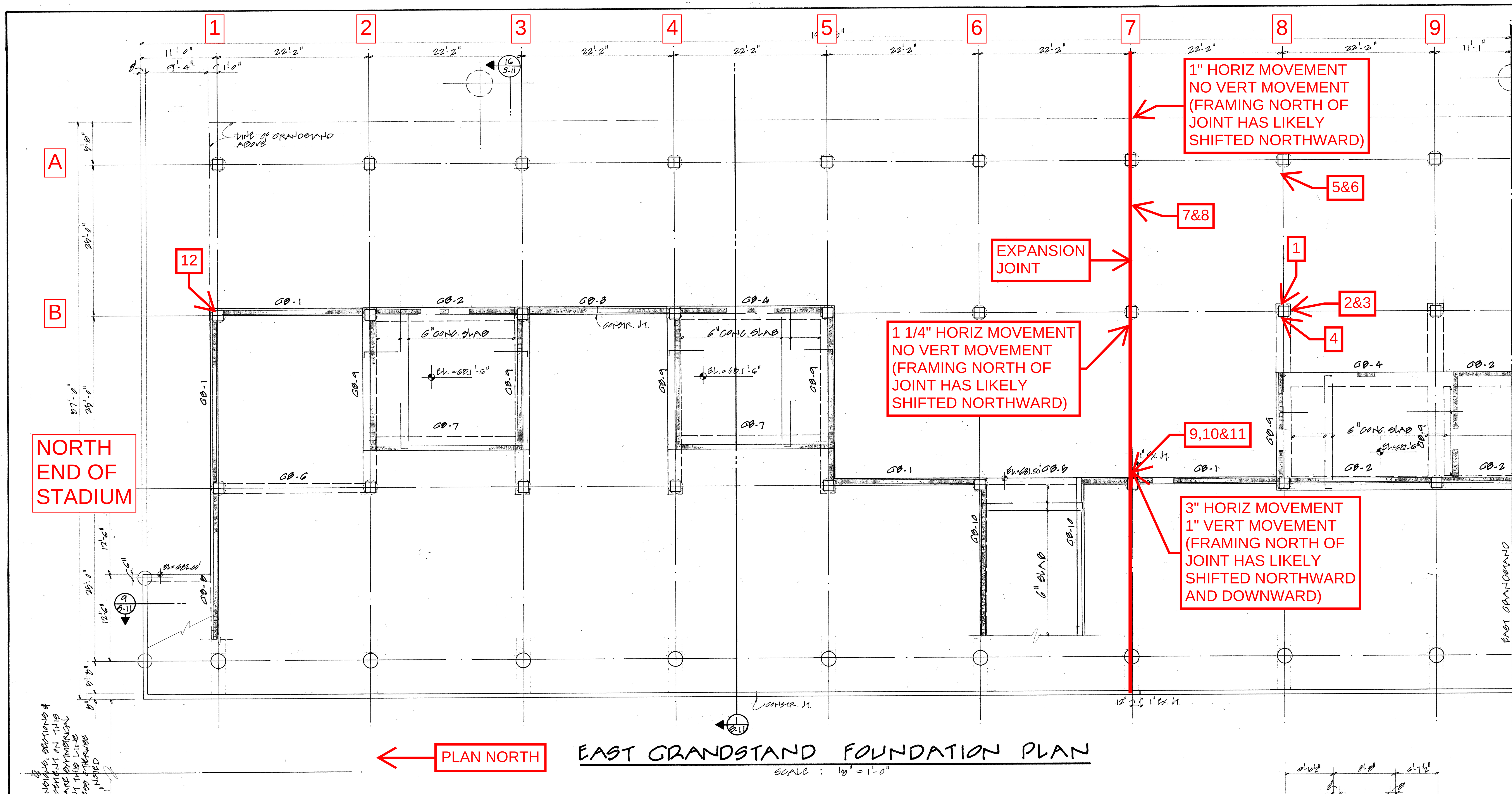
2. **Retrofit Design:**
   a. Structural design and production of construction documents for repairing and strengthening the existing structures. Repair will consist of crack and spall repairs and adding a waterproofing membrane to the top surface of deck/joists to prevent water infiltration. Retrofit work may consist of column strengthening and/or additional bracing at tops of piers and at mid-height of columns. New piers and columns may also be added. Cost of retrofit work will be extensive.

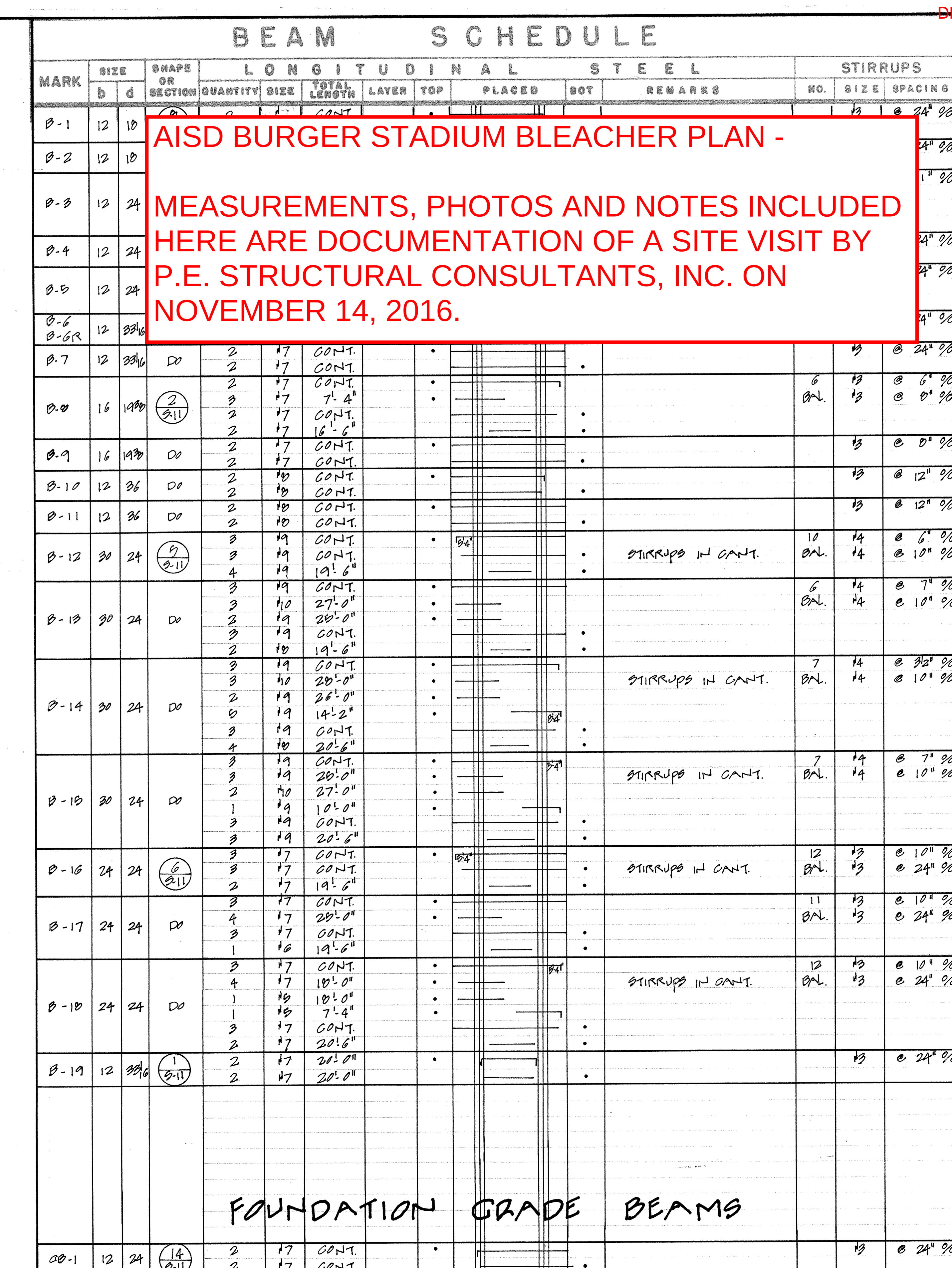
Option B

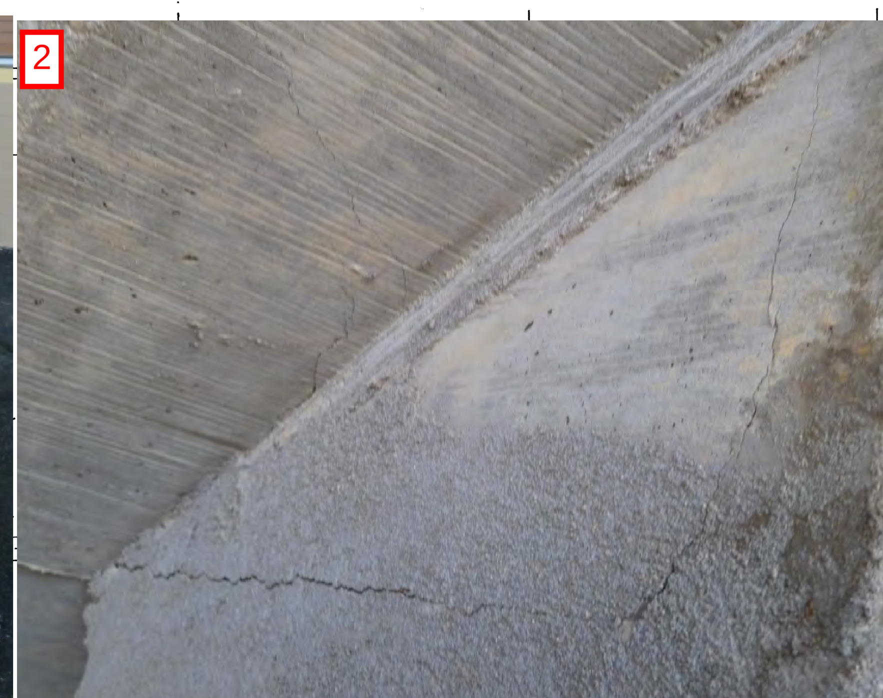
1. **Complete Replacement:**
   We estimate cost of remediation effort outlined in Option A will be substantial. A complete replacement of the structures is likely a better option considering the age of the stadium structures and their advanced level of distress – some of which may not be detectable and may remain after retrofit.

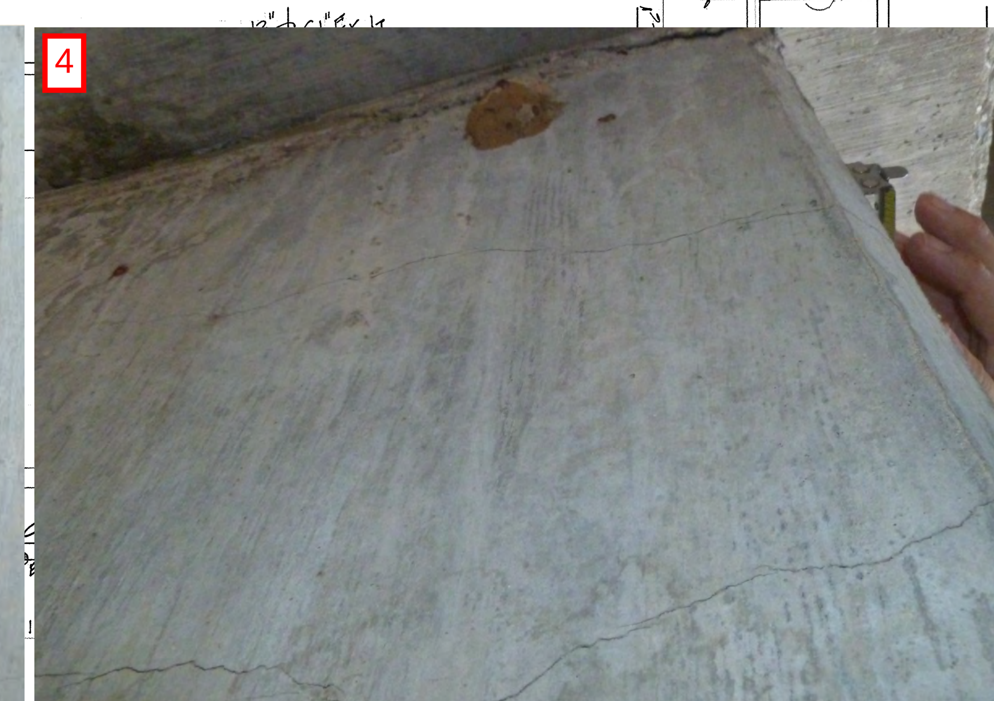


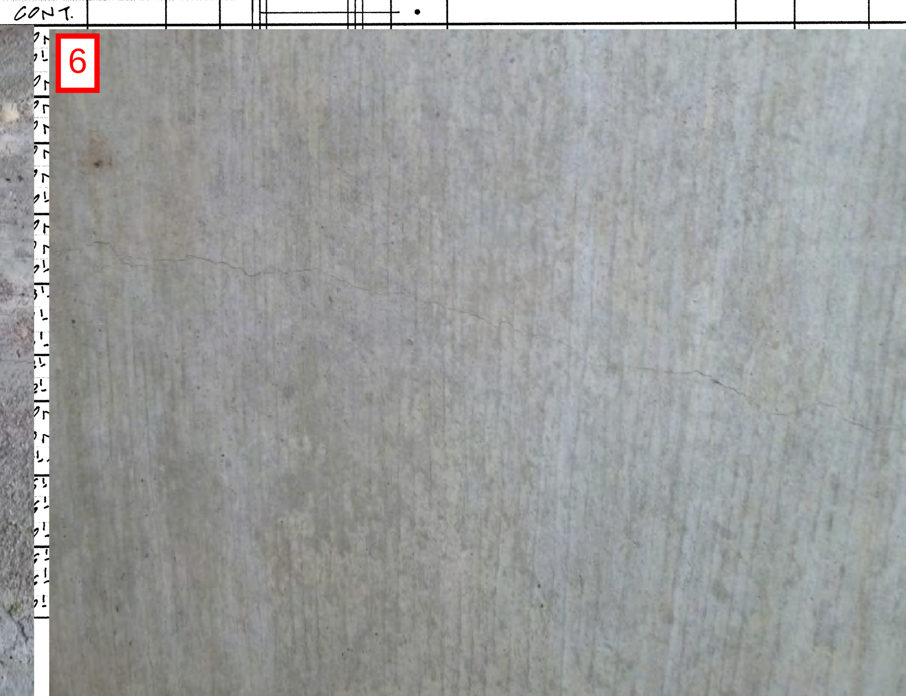
Note: This report is based on and limited to the observations and information noted above. This is not a guarantee. Additional deficiencies may exist which were not observed and which may require additional remedial work which is not listed here.

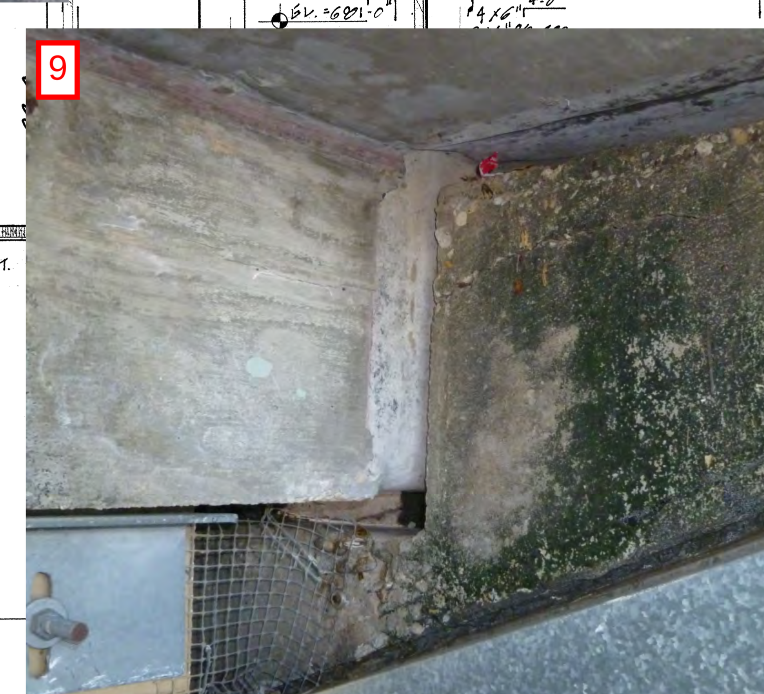


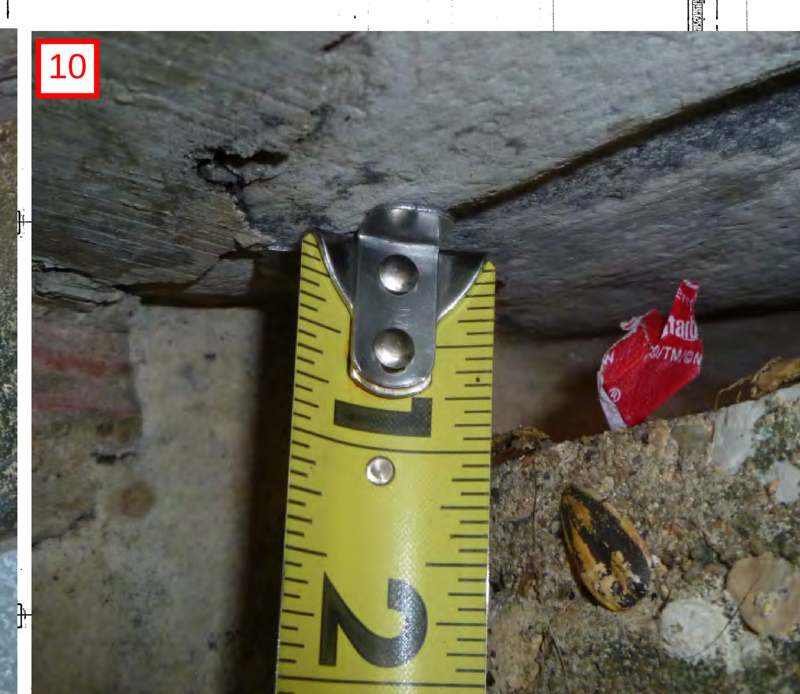


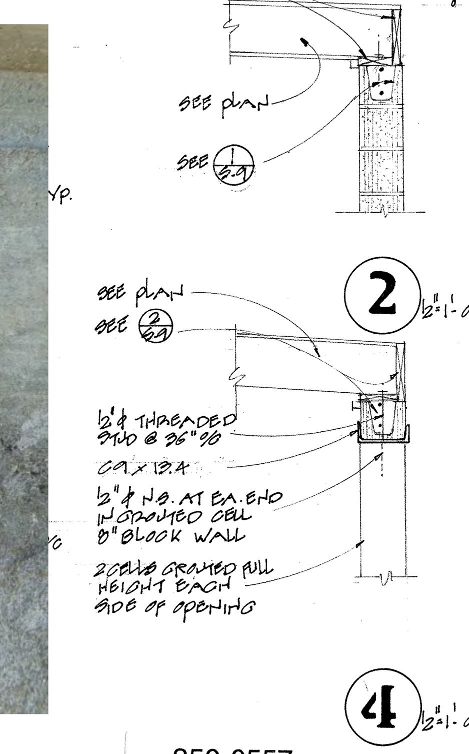












TYPICAL ROOF PLAN @ REST ROOMS SCALE : 1/8" = 1'-0"

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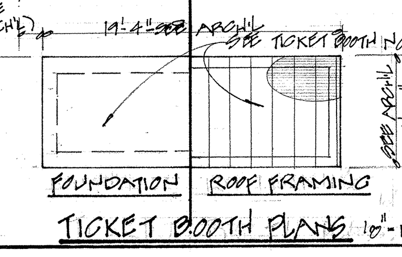
GRANDSTAND & FOUNDATION NOTES:

1. ALL PIERS 24"Ø STRAIGHT SHAFTS REINFORCED W/6-#8 VERT. & #3 TIES @ 10"o/c.
2. ALL CONCRETE COLUMNS 10"x10" REINFORCED W/4-#8 VERT. & #3 TIES @ 16"o/c.
3. LINTELS OVER OPENINGS IN MASONRY PARTITIONS NOT OTHERWISE COVERED ARE TO BE OF 8" PRECAST CONCRETE. DIMENSIONS SHALL BE 8"x8" FOR OPENINGS UP TO 6'-0" REINFORCED W/2-#4 TOP AND BOTTOM.
4. SEE ARCH'L FOR VERIFICATION OF ALL OPENINGS IN MASONRY WALLS.

TICKET BOOTH NOTES:

1. SEE ARCH'L DRAWINGS FOR DIMENSIONS.
2. SLAB DEPTH & REINF. = 5" W/#4 @ 12"o/c EA. WAY.
3. GRADE BEAMS = 12"x24" W/2-#7 CONT. TOP & BOT. & #3 TIES @ 24"o/c - SIMILIAR TO BEAM IN (B/S-11)
4. ROOFING TO BE B/U ROOF ON 3/4" SOLID SHEATHING ON 2x10 JOISTS @ 16"o/c.



GRANDSTAND FOUNDATION PLANS & DETAILS, BEAM SCHEDULE		
DATE: 5-26-75	TONEY BURGER ATHLETIC FACILITY AUSTIN INDEPENDENT SCHOOL DISTRICT	
REVISION	DIVISION OF SCHOOL PLANT 6100 GUADALUPE AUSTIN, TEXAS	SHEET S-9 OF 14

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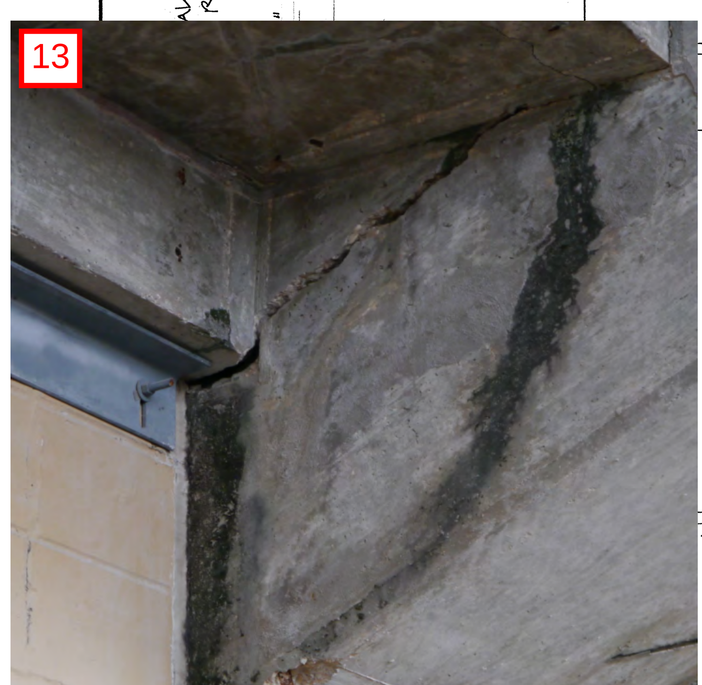

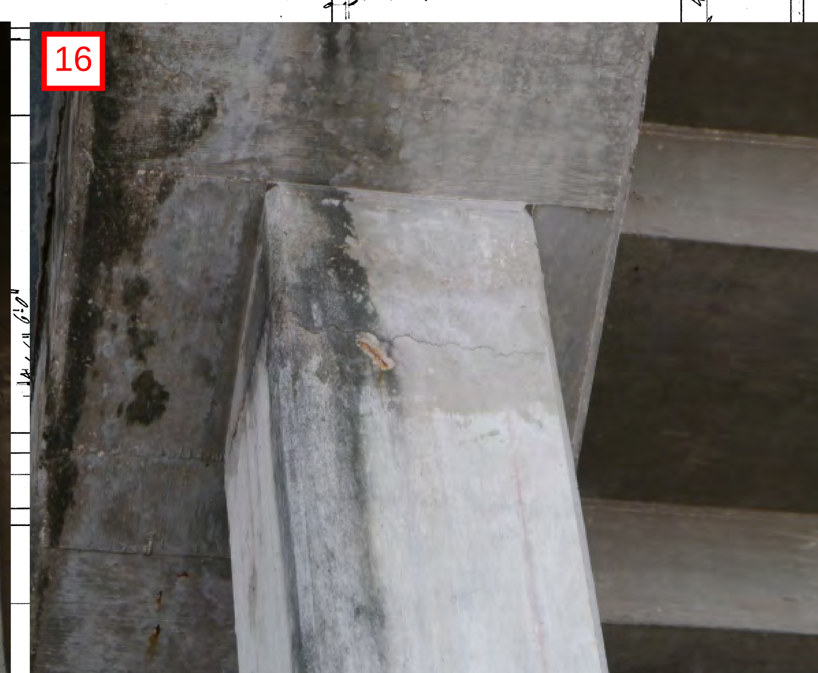

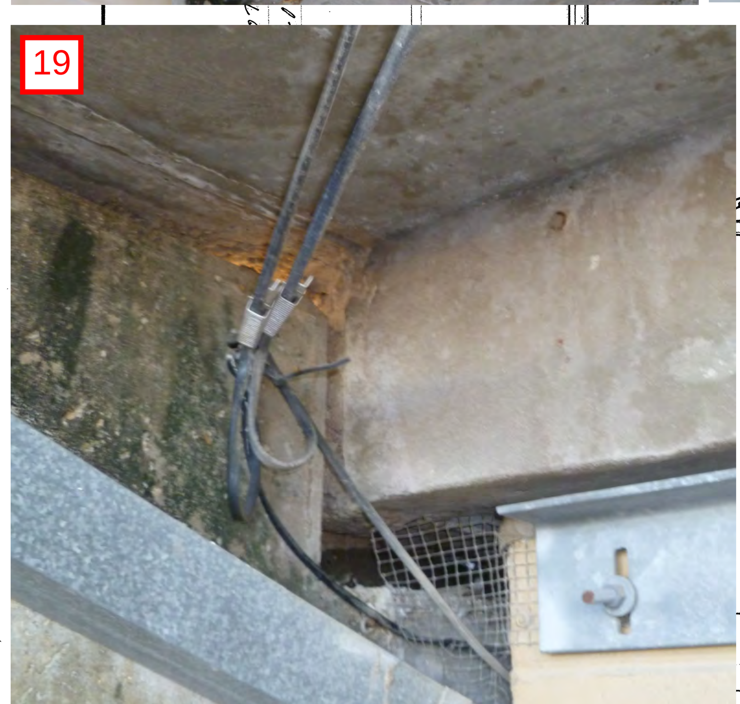

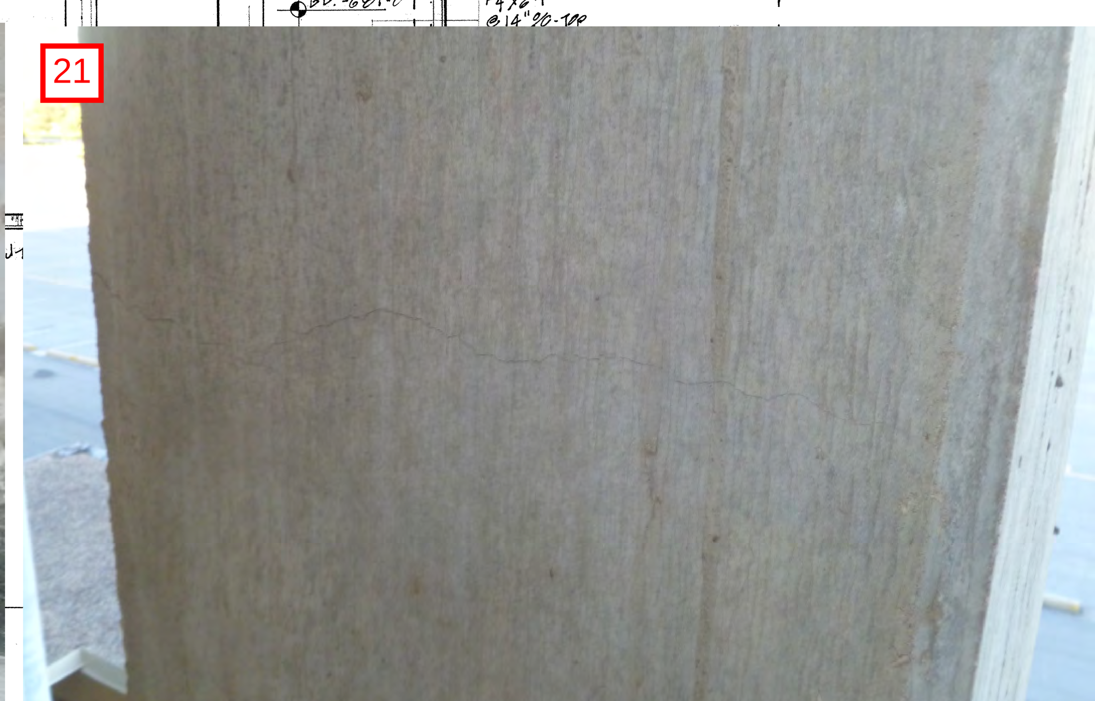

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TYPICAL ROOF PLAN OF REG

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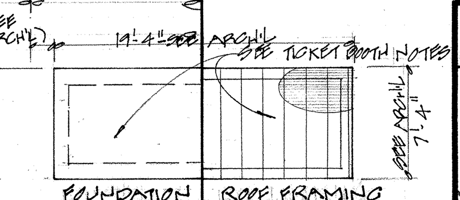
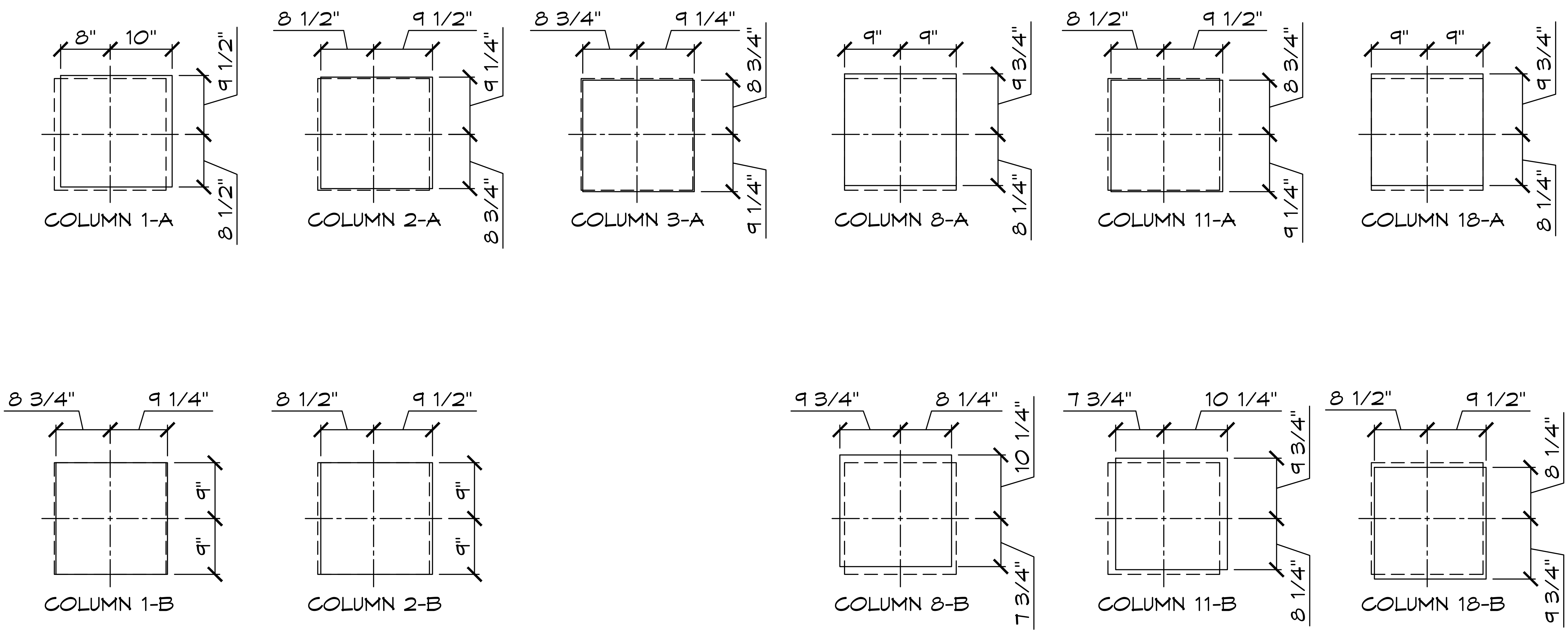


TICKET BOOTH PLANS 1/8" = 1'-0"

W. CLARK CRAIG CONSULTING ENGINEERS 403 EAST FIFTEENTH AUSTIN, TEXAS

GRANDSTAND FOUNDATION PLANS & DETAILS, BEAM SCHEDULE

DATE: 5-26-75	TONEY BURGER ATHLETIC FACILITY AUSTIN INDEPENDENT SCHOOL DISTRICT	
REVISION	DIVISION OF SCHOOL PLANT 6100 GUADALUPE AUSTIN, TEXAS	SHEET S-9 OF 14



1) THE DASHED COLUMN REPRESENTS THE POSITION OF THE COLUMN AT THE TOP OF THE COLUMN.
2) THE SOLID COLUMN REPRESENTS THE POSITION OF THE COLUMN AT THE BOTTOM OF THE COLUMN.
3) THE DASHED CENTERLINES ARE FOR THE TOP OF COLUMN.
4) MEASUREMENTS ARE FROM THE EDGES OF THE BOTTOM COLUMN TO THE CENTERLINE OF THE TOP COLUMN.