File No. 18-453.1
April 13, 2018

Samir Khanna
Sr. Landscape Project Manager
O'Dell Engineering
6200 Stoneridge Mall Road, Suite 330
Pleasanton, CA 94588

Subject: **GEOTECHNICAL MEMORANDUM**
Robertson Park Rodeo Stadium Seating
Livermore, California

Dear Mr. Khanna,

Crawford & Associates, Inc is pleased to submit this Geotechnical Memorandum for the Robertson Park Rodeo Stadium Seating Project located in Livermore, California. This Memorandum is intended to support the design team during design and construction of the proposed stadium walkway improvement project and includes: scope of services, project description, subsurface conditions, laboratory testing, discussions and conclusions, recommendations.

SCOPE OF GEOTECHNICAL SERVICES

To prepare this Geotechnical Memorandum, CAInc:

- Discussed the proposed improvements with Samir Khanna with O'Dell Engineering;
- Reviewed the project plan provide by Blackwater;
- Reviewed 1996 plan set of the Rodeo Stadium provided by O'Dell Engineering;
- Completed five cores (C1 to C5) and hand auger borings within the existing concrete stadium seating to a maximum depth of 30 inches on March 28, 2018;
- Performed laboratory tests on soil samples collected from the test borings;
- Performed engineering analysis to develop our conclusions and recommendations.

PROJECT DESCRIPTION

The existing concrete stadium was constructed in 1966 and a metal roof added in the 1990s. We understand the City of Livermore is planning to improve the walkway conditions as there are currently large cracking throughout the slabs and small cracking propagating into the seating steps. The project will include concrete reconstruction improvements to help increase safety and aesthetics in the stadium walkway area. Shade structure foundations are unknown.

This memorandum presents the results of our coring, explorations and testing, and provides our recommendations for the concrete walkway construction.

The project is located in at 3000 Robertson Park Road in Livermore California. The Rodeo Grounds are located in the southern area of Livermore just west of Robertson Park Sports Facilities. Figure 1 shows the project location and vicinity.

SUBSURFACE CONDITIONS

EXPLORATION

To characterize the subsurface conditions and obtain samples for laboratory testing, CAInc retained Cal West Concrete Cutting to drill five cores at the site on March 28, 2018. The concrete subcontractor used a portable concrete drill to drill the borings with a 6-inch outside diameter core bit.

We obtained drive samples from two of the five hand borings of the soil underlying the concrete slab using hand sampling tools. CAInc's Project Engineer, Ms. Hailey Wagenman and Project Manager David Castro, logged the borings consistent with the Unified Soil Classification System (USCS). We retained soil samples in containers for laboratory testing and reference. At the completion of drilling the borings were backfilled with clean sand and quick setting concrete.

We planned the general core locations based on the proposed improvements and discussions with O'Dell Engineering. We show the core locations on the Figure 1.

SOIL DESCRIPTION

We show the core and hand sampling results in Table 1.

Table 1: Subsurface Materials

Core	Concrete Thickness (in)	Max Depth (in)	Soil Descriptions
1	5 (walkway)	8 (root and gravel refusal)	Poorly graded gravel with sand and clay, moist, dark brown, fine to coarse gravel, fine to coarse sand.
2	9 (step)	11 (gravel refusal)	Poorly graded gravel with sand and clay, moist, dark brown, fine to coarse gravel, fine to coarse sand.
3	9 (step)	28	Silty sand, dry, dark brown, 20% fines, fine to medium sand.
4	5 (walkway)	7.5 (gravel refusal)	Lean clay with sand, moist, dark brown, 10% fine sand.
5	3.5 (walkway)	7.5	Silty sand, dry, dark brown, 20% fines, fine to coarse sand

LABORATORY TESTING

To classify the subsurface soil and obtain parameters for analysis, CAInc completed the following laboratory testing on samples obtained from the hand auger borings. Tests include:

- Moisture content and dry density for strength estimates; and
- Compaction curve for maximum density estimates.

DISCUSSIONS AND CONCLUSIONS

We discussed the planned project with O'Dell Engineering and reviewed the 1966 plans. We understand the concrete stadium was constructed in the 1960s and the shade structure added in the 1990s. City of Livermore personnel report the shade structure moves significantly during windy events. During our field work we observed severe cracking along the walkway at the top of the concrete stadium seating. Severe crack locations were identified by O'Dell Engineering and are shown on Figure 1. We observed vertical displacement at most of the shade structure columns adjacent to the walkway of up to two inches. We completed moisture density tests on selected soil samples we obtained from below the concrete and compared them to maximum dry density curves completed for the subgrade soil at C3 and C5. We estimate the existing subgrade density is at about 80% relative compaction which is well below the minimum of 90% that is typically specified.

The 1966 plan set shows 4-inch thick concrete at the walkway over Class II aggregate and about 8-inches for the step thickness. The soils logged below the existing walkway and steps are not consistent and vary from gravel with sand near the north end to silty sand and lean clay with sand near the south end. Existing shade structure foundation information was not provided or readily available.

Based on the data obtained from our field exploration and our review of the 1966 plan set we conclude the following;

- Shade structure column settlement was/is likely caused by poor compaction in the underlying bearing material.
- Settlement of the structure columns caused stress to the walkway concrete and induced the cracking.
- Shade structure movement during wind events likely propagated cracks throughout the walkway and into the steps.

RECOMMENDATIONS

Based on the foregoing, we recommend the following:

- Remove the existing concrete walkway and underlying aggregate base section to expose the soil subgrade. Demolish and clear the walkway to remove existing concrete, aggregate base, vegetation, tree roots, debris, abandoned utilities, soft or unstable areas, or other deleterious materials. Precautions are required to protect existing support column foundations for the shade structure.

- The surface(s) exposed by stripping/excavation per above should be favorably field-reviewed by personnel from this office with respect to suitability as fill foundation. The approved surface should be scarified to 8-inches depth, moisture conditioned as necessary to over-optimum moisture content and compacted to at least 90% relative compaction per ASTM D1557. Inability to achieve the required compaction may be used as a field criterion to identify areas requiring additional removal or (re)compaction.

- Place a minimum of 4-inches of Aggregate Base (Caltrans Class II AB) compacted to 95% relative compaction based on ASTM D1557.

- Pour a minimum of 4-inches of concrete flatwork on the compacted Aggregate Base. The concrete should have a minimum 28-day compressive strength of 4,000 psi. The structural engineer should provide reinforcement recommendations, if necessary, to resist anticipated loads and shrinkage/temperature stresses

- Construct control and construction joints in accordance with Portland Cement Association guidelines to help control shrinkage cracking. The Portland Cement Association recommends panels should be square when possible, not to exceed length to width ratio of 1.5:1 and joints should be spaced at 24 times slab thickness (4" slab should have 8 ft joints max).

- Construct expansion joints between the new flatwork and existing columns to help decrease cracking from column footing movement/settlement.

RISK MANAGEMENT

Our experience, and that of our profession, clearly indicates that the risks of costly design, construction, and maintenance problems can be significantly lowered by retaining the Geotechnical Engineer of Record to provide additional services during design and construction. For this project, CAInc should be retained as the Geotechnical Engineer of Record to:

- Review and provide comments on the civil plans and specifications prior to construction;
- Monitor construction to check and document our report assumptions. At a minimum, CAInc should monitor scarification and compaction of subgrade and aggregate base;
- Update this report if design changes occur, 2 years or more lapse between this report and construction, and/or site conditions have changed.

If we are not retained to perform the above applicable services, we are not responsible for any other party's interpretation of our report, and subsequent addendums, letters, and discussions.

LIMITATIONS

CAInc performed services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. Where referenced, we used ASTM or Caltrans standards as a general (not strict) *guideline* only. We do not warranty our services.

CAInc based this report on the current site conditions. We assumed the soil conditions encountered during our fieldwork are representative of the subsurface conditions at the site. Actual conditions between coring locations can be different.

Our scope did not include evaluation of on-site hazardous materials, site geology, site seismicity and flooding potential.

The boring locations shown on Figure 1 are based on visual comparisons made in the field between site features and features shown on aerial mapping, therefore they are approximate.

Modern design and construction are complex, with many regulatory restrictions, involved parties, and construction alternatives. It is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

Sincerely,

Crawford & Associates, Inc.,

David P. Castro, PE
Project Manager

Reviewed by;

W. Eric Nichols, CEG, PE
Senior Project Manager

Attachments:
Figure 1-Exploration Map
Laboratory Test Results

North

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ROBERTSON PARK
RODEO SEATING

LIVERMORE, CA

Figure 1
Exploration Map

Proj. No:	18-453.1
Scale:	1"=40'
Date:	

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: Robertson Park - Rodeo Seating
CAInc File No: 18-453.1
Date: 3/29/18
Technician: HFW

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	C3-1	C5-1			
USCS Symbol	SM	CL/SM			
Depth (ft.)	-	-			
Sample Length (in.)	3.403	5.201			
Diameter (in.)	1.919	1.926			
Sample Volume (ft^3)	0.00570	0.00877			
Total Mass Soil+Tube (g)	410.2	708.4			
Mass of Tube (g)	182.0	180.4			
Tare No.	D6	B16			
Tare (g)	13.7	21.0			
Wet Soil + Tare (g)	41.5	50.8			
Dry Soil + Tare (g)	39.1	47.3			
Dry Soil (g)	25.4	26.3			
Water (g)	2.5	3.5			
Moisture (%)	**9.6**	**13.3**			
Dry Density (pcf)	**80.6**	**117.2**			

Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: Robertson Park - Rodeo Seating
CAInc File No: 18-453.1
Date: 3/29/18 Sample ID: C3-subgrade
Technician: HFW/MEA Depth (ft): -
USCS Classification: SM

Modified Compaction - ASTM D1557

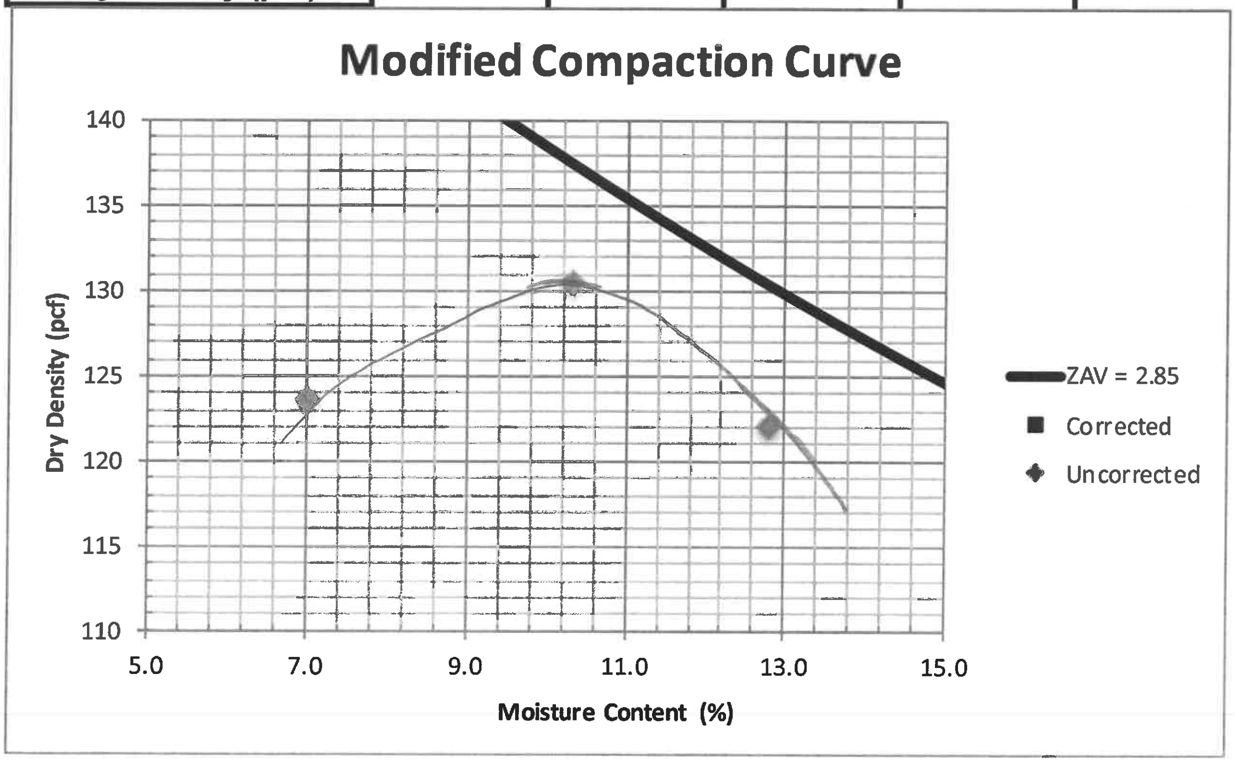
Method B

Oversize Fraction: 4.80 %

Moisture (%)	**7.0**	**10.3**	**12.8**	**#DIV/0!**
Dry Density (pcf)	**123.7**	**130.6**	**122.1**	**#DIV/0!**

ROCK CORRECTED

Moisture (%)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**NA**
Dry Density (pcf)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**NA**



	UNCORRECTED	CORRECTED
Optimum Moisture (%)	10.3	NA
Maximum Dry Denstiy (pcf)	130.6	NA

Project Name: Robertson Park -Rodeo Seating
CAInc File No: 18-453.1
Date: 29-Mar Sample ID: C5 subgrade
Technician: HFW/MEA Depth (ft): 0
USCS Classification: CL/SM

Modified Compaction - ASTM D1557

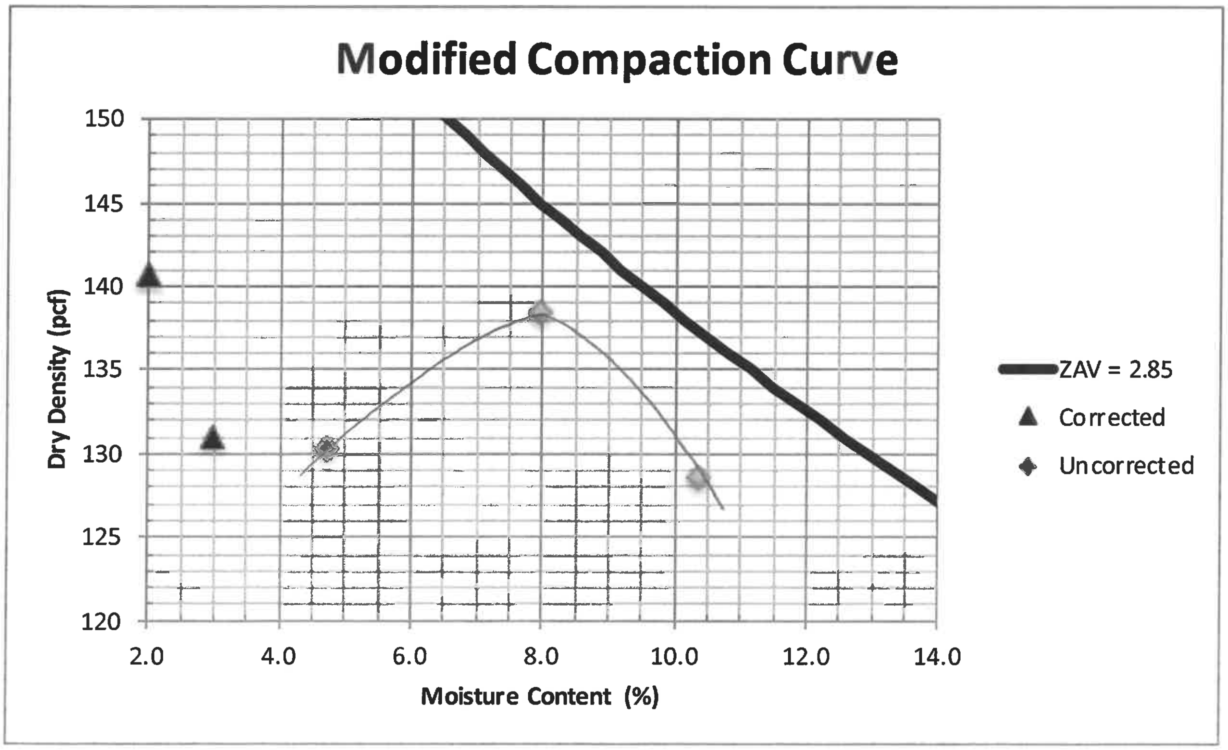
Method C

Oversize Fraction: 7.20 %

Moisture (%)	**4.7**	**8.0**	**10.4**	**#DIV/0!**
Dry Density (pcf)	**130.4**	**138.5**	**128.6**	**#DIV/0!**

ROCK CORRECTED

Moisture (%)	**5.0**	**8.0**	**10.2**	**NA**
Dry Density (pcf)	**132.8**	**140.7**	**131.1**	**NA**



	UNCORRECTED	CORRECTED
Optimum Moisture (%)	8	8
Maximum Dry Denstiy (pcf)	138.5	140.7