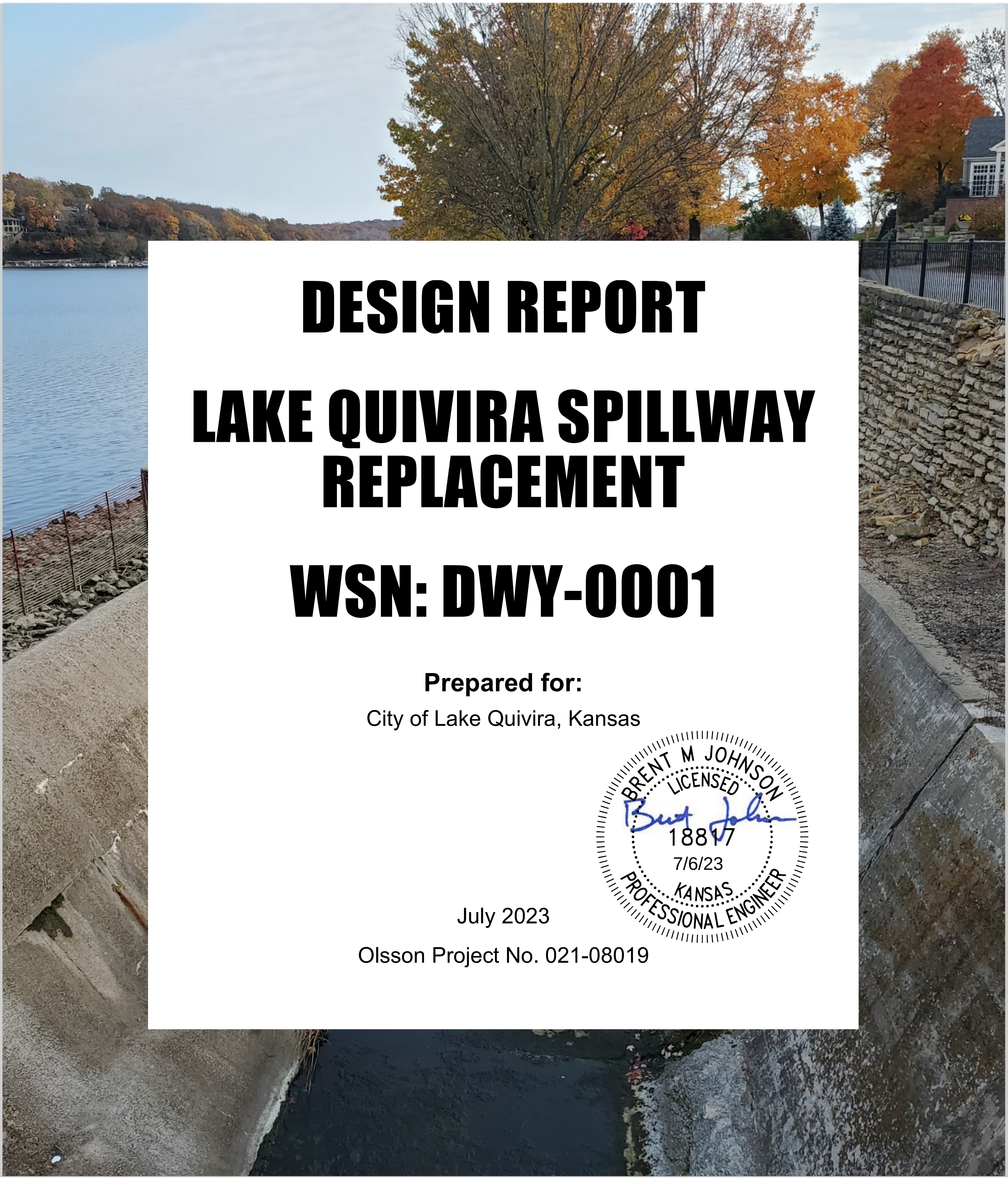


DESIGN REPORT

LAKE QUIVIRA SPILLWAY REPLACEMENT

WSN: DWY-0001

Prepared for:
City of Lake Quivira, Kansas

BRENT M JOHNSON
18817
7/6/23

July 2023
Olsson Project No. 021-08019

olsson

TABLE OF CONTENTS

1. Introduction 1
2. History and Background 3
3. Proposed Construction and Design 4
    Field Data Collection 4
    Channel Geometry 4
    Hydraulic Capacity 5
    Structural Design 6
    Specifications 8
    Construction Considerations 8

APPENDICES

Appendix A Geotechnical Reports

Appendix B Structural Calculations

1. INTRODUCTION

The City of Lake Quivira intends to replace the downstream portion of the principal spillway for the Lake Quivira dam and has engaged Olsson, Inc. to assist in the preparation of design plans, report and specifications for the project. The design report addresses and documents the design process and references used to design the proposed spillway replacement. The design report, related design documents and permit application are being submitted to the chief engineer for review and approval prior to beginning construction of the project.

Lake Quivira is located in the NW ¼ of the SE ¼ of the SW ¼ of Section 23, Township 11 South, and Range 24 East in Wyandotte County, Kansas. The location of the project and Lake Quivira dam is shown in Figure 1.

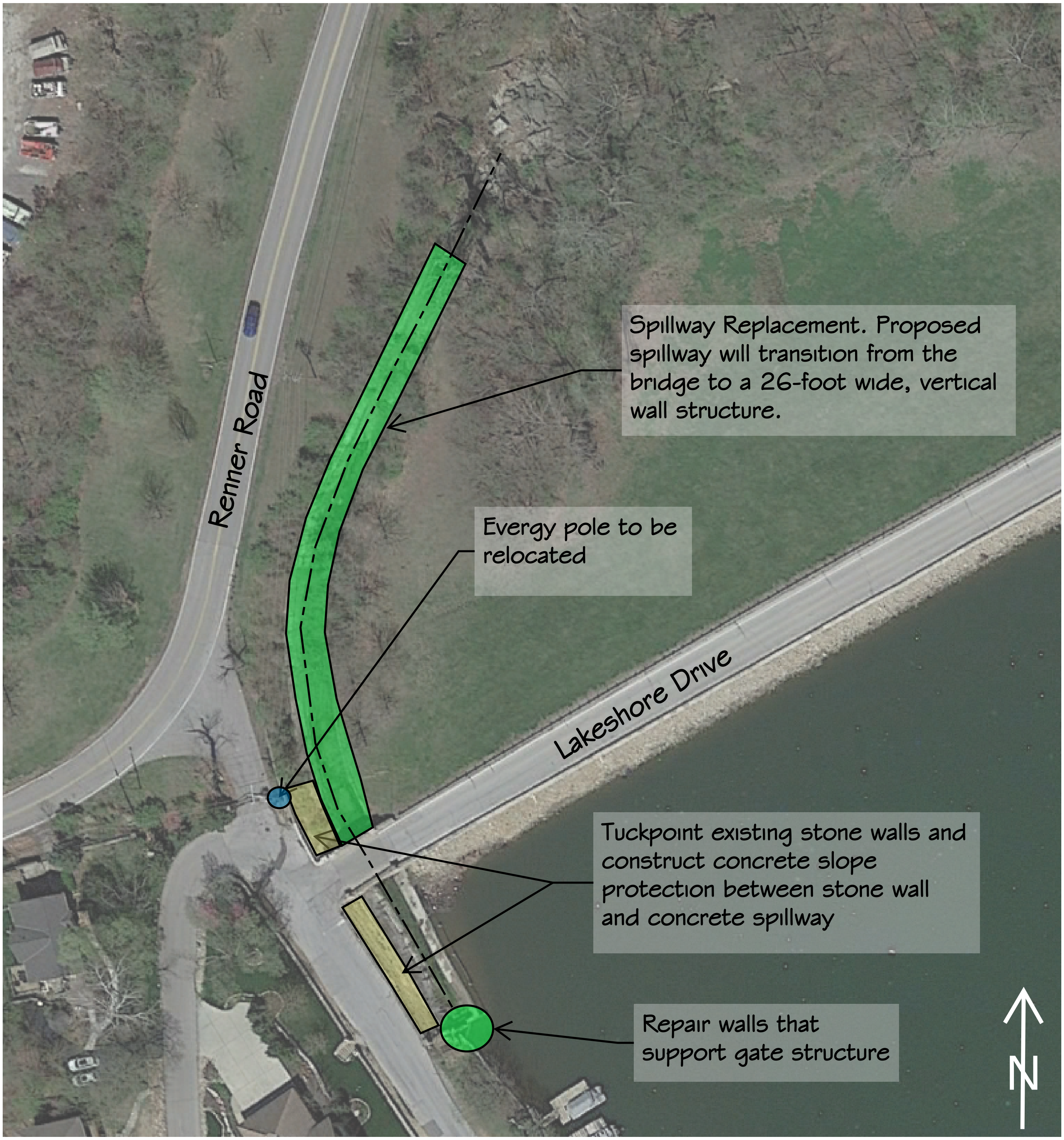


Figure 1. West Spillway Downstream Channel Replacement with Gate Repairs

2. HISTORY AND BACKGROUND

Based on data from prior inspection reports, the Lake Quivira dam was originally constructed in 1935 as an 80-foot high, 1,600-feet long earthen dam. The principal spillway was originally constructed in the left abutment and has a sluice gate that can control the lake levels. The principal spillway is a 93-feet long ogee crest that conveys flow to a concrete channel north to Toolery Creek. The dam has overtopped on three occasions, prior to the construction of the auxiliary spillway in the right abutment in 1973. The auxiliary spillway is 107-feet long, crest weir located in the right abutment.

Previous modifications to the dam include:

- In 1977, the downstream slope was flattened from a 2:1 slope to a 3:1 slope. The original dam crest was also widened from 20-feet to 27-feet. The upstream slope of the dam was also armored with riprap
- The flood of July 1993 created a large scour hole on the downstream end of the auxiliary spillway. The hole was repaired and the auxiliary spillway chute was lengthened to the toe of the dam in 1995. The principal and auxiliary spillways were also lowered at this time.
- In 2014 a new retaining wall was constructed along the top of the dam to replace the existing wall.

A 2015 dam inspection report completed by Shafer, Kline and Warren identified the need to complete repairs on the principal spillway. Design plans, specifications and a report were submitted to the Kansas Division of Water Resources (DWR) and the project was approved for construction in 2017. The repairs to the principal spillway have not been completed as the city was considering alternative designs to re-configure the principal and auxiliary spillway for the dam. Since 2017, the condition of the principal spillway has continued to worsen and in the opinion of Olsson, the previously approved plan to line the existing channel are no longer adequate to provide a long-term solution to the spillway condition.

In the fall of 2021, Olsson worked with Lake Quivira to review the hydrology and hydraulics of the dam’s principal and auxiliary spillways and complete a feasibility report to address the needed repairs on the aging dam. Various solutions were considered in the spillway alternatives analysis, including an evaluation of both spillway structure’s geometry, hydraulic capacity, structural integrity, aesthetics, and opinion of construction costs. The results of Olsson’s analysis were provided to Lake Quivira in March 2022 and the city decided to move forward with the most immediate need for the dam which is the reconstruction of principal spillway chute.

3. PROPOSED CONSTRUCTION AND DESIGN

Field Data Collection

Prior to beginning design work, a full topographic survey of the principal spillway was completed. Survey data and drawings provide all of the physical features within the project vicinity including any utilities that were marked from a one-call utility locate request. Both a gas and water main cross the existing spillway and coordination with these utility owners has been initiated by Olsson. The other major utility conflict is with a power pole and low hanging overhear utilities within the construction limits. Olsson will initiate any relocations required with the utilities during design and will hand over the utility coordination during the construction of the project to the selected contractor.

Three soil borings located to the west of the principal spillway, were collected by a truck-mounted drill rig. The borings were extended to practical auger refusal on limestone bedrock. Laboratory samples were tested for unconfined compressive strength, moisture content, and in-place unit weight test. The results of the borings and laboratory testing are provided in Appendix A.

The results of the initial borings indicate that the downstream portion of the spillway replacement will be founded on competent bedrock. As the spillway channel progresses upstream and the floor elevation rises, the spillway channel foundation will transition from limestone to shale and eventually earthen material. Additional borings were completed within the spillway channel to determine the limits of limestone and shale material so that the design can accommodate these changes.

Channel Geometry

The proposed spillway replacement limits will extend from the northside of Lake Shore Drive and extend north to the terminal point of the principal spillway, approximately 350-feet in length. The existing, trapezoidal channel will be removed and replaced with a 26-foot wide, rectangular channel. A rectangular channel was selected (in lieu of the existing trapezoidal shape) to simplify the construction of the channel by creating a more standard geometric configuration as compared to the existing channel which has a steep 1H:1V channel side slope for the side walls. The top of the proposed rectangular channel width will match the existing top width of the trapezoidal top width of 26-feet. The rectangular channel will also provide some additional flow conveyance with a wider footprint at the bottom of the channel. The proposed rectangular channel will have wall heights that begin at 10-feet near Lakeshore Drive and transition to 6-feet tall near the end of the channel, similar to the existing channel. On the downstream end, the proposed rectangular channel will stop short of the existing channel extents and be keyed into the existing bedrock.

Granular backfill and perforated drainage pipes will be used behind the vertical walls to relieve hydrostatic pressures that may build up following rain events. The walls will also have pedestrian fence located on top portion of the wall to prevent falls into the spillway channel.

Hydraulic Capacity

The Lake Quivira Dam does not currently meet the DWR hydraulic design and freeboard requirements given the size and hazard classification for the dam (Hazard Class C). A waiver by the Chief Engineer has been provided to allow the operation of the dam as previously documented in prior dam inspection reports. A review of the hydrologic modeling for the dam and watershed was completed to verify that the ogee spillway is the controlling factor for the principal spillway discharge and not the downstream spillway channel, which was confirmed through our analysis.

Table 1. 0.4 PMP Hydrologic Analysis.

0.4 PMP Event	Data
Top of Dam (ft)	830.10
Peak Stage (ft)	829.43
Freeboard (ft)	0.67
Principal Spillway Crest Discharge (cfs)	3,310

A hydraulic analysis was completed of the proposed 26-foot-wide concrete spillway with vertical walls. The proposed geometry was entered into HEC-RAS (Version 6.2) and run under the steady flow conditions with a mixed flow regime. A range of flows from 3,000-5,000 cubic feet per second (cfs) was computed to determine the proposed channel capacity. The results of the hydraulic analysis show that the spillway channel has capacity to carry 4,500 cfs before water overtopping the proposed walls. The constrained section of the spillway channel is immediately north of Lake Shore Drive where the spillway channel has a flatter profile slope (roughly 1.1%) as compared to the downstream channel slope (roughly 9.3%). As water continues to flow in the downstream direction, the velocity of the water increases which reduces the overall depth of flow in the spillway channel. Table 2 provides the results of the hydraulic analysis for the 0.4 PMP discharge (3,310 cfs) through the spillway channel.

Table 2. Proposed Channel Capacity at 0.4 PMP

Plan Profile Station	Channel Elev. (ft)	Wall Elev. (ft)	Water Surface Elev. (ft)	Freeboard (ft)	Velocity Channel (fps)
10+75	814.50	822.50	821.08	1.42	18.78
11+25	813.91	822.89	820.36	2.53	19.55
11+75	813.00	820.85	818.67	2.18	21.61
12+25	809.42	816.62	814.27	2.35	26.51
12+75	804.63	811.85	808.86	2.99	31.34
13+50	798.61	804.42	802.41	2.01	35.69
14+00	793.68	799.32	797.81	1.51	38.59

In a hypothetical scenario, if in the future Lake Quivira decided to replace the spillway ogee crest structure within the lake for maintenance reasons or to increase the capacity of spillway crest to increase freeboard, the downstream channel currently being replaced is adequate for a spillway length increase up to 50-percent of the existing 93-foot length. A 50-percent weir length increase is roughly 150-feet of weir length that could be accomplished by lengthening the existing side channel spillway or replacing it with a labyrinth weir or similar structure to stay within the existing footprint. An increase in the weir length to 150-feet will not provide the desired freeboard capacity of the dam and only increases the freeboard by 0.5 feet. To meet the state of Kansas desired freeboard, a combination of increasing the spillway length and raising the crest of the dam would need to be completed.

Structural Design

Structural design of the spillway followed the United States Bureau of Reclamation Design Standard No. 14, Chapter 3: General Spillway Design Considerations and ACI 350-06. The channel was designed to accommodate earth, hydraulic, and live load surcharge pressures. This work included designs for reinforced concrete strength (shear and flexure of the walls and spillway slab), foundation bearing pressure, sliding, and uplift resistances. Structural calculations are provided in Appendix B.

The spillway slab was designed to be founded on a clean and prepared limestone bedrock or flowable fill (1 ksi min strength) that extends down to the clean and prepared limestone bedrock. The spillway slab is keyed into bedrock at control joint and expansion joint locations for each spillway “panel”, which offers a direct mechanical means beyond concrete cohesion that is intended for resisting sliding and intercepting under-drainage. Control joints are placed at 30-foot maximum spacing, and expansion joints are placed at 120-foot maximum spacing.

The channel side walls were designed for a maximum height of 10 feet. The wall thickness is 12 inches where the height is less than 8 feet and 14 inches where the height is greater than 8 feet. The foundation consists of a variable thickness slab. The slab thickness varies with a 4% cross-slope from 15 inches thick at the channel walls to 8¾ inches thick at the centerline.

From Station 10+45 to Station 10+65, the channel width varies from 22 feet at the existing bridge to the typical channel width of 26 feet. Fixed reinforcing dowels and a water stop are placed between the channel and the existing bridge, and an expansion joint is provided at Station 10+65 to allow for movement relative to the bridge.

Structural analysis was performed utilizing a finite element software, LARSA 4D, at three cross-sections along the spillway. The analysis considered dead load from self-weight, horizontal and vertical earth loads, live load surcharge, and horizontal and vertical water loads (inside and outside). A semi-drained loading scenario that considered the drainage pipes located behind the channel to be only partially effective was also included. In the partially drained case, the water level was assumed to be at one third of the wall height. The slab was modeled with compression only spring supports with a modulus of subgrade reaction of 250 psi/in to represent the limestone bedrock or flowable fill. Results of the structural analysis were used for selecting member thicknesses and reinforcement.

Based on the proximity and condition of the stone masonry retaining wall located south of the channel, Olsson advised that the stone retaining wall should be replaced as part of the project. Olsson found that stability of the wall may be compromised during demolition of the spillway due to its position above the channel walls, which impart loading on the spillway. Olsson opined that the extent to which the stone masonry wall imparts loads and it’s stability are dependent on the unknown depth and condition of the wall below grade and subsurface soil conditions during construction. Lake Quivira staff members discussed this aspect of the project and elected to try and salvage the wall, directed Olsson to indicate such assumptions and a requirement for the Contractor to protect the wall during construction, ensure its staff members are aware of the risks and take measures to guard against injury and damages to equipment (including temporary shoring). Lake Quivira will contract a wall rehabilitation/repointing under a separate contract after the spillway work is complete. Should the wall fail during construction, then Lake Quivira will contract a replacement via change order or through the subsequent contract. In an effort to improve upon these considerations, Olsson adjusted the alignment of the channel several feet away from the wall to offer additional clearance to help preserve as much as toe area in front of the wall as possible. It was also discussed with Lake Quivira staff members that the power pole behind the wall could be incidentally de-stabilized if the wall were to fail during construction, and this risk was unreasonable to place on a contractor. A relocation of the power pole is currently being pursued with Evergy and should be completed prior to construction.

In addition to the primary spillway work, Olsson prepared construction documents to direct the dewatering and repair of the upstream headwall around the spillway gate. The concrete headwall has suffered degradation and a large crack opened up in the vertical and horizontal faces, which allows water to bypass the gate when closed. Designs and bid documents indicate that the structure shall be dewatered, inspected, cleaned, and repaired with an injected epoxy resin.

Specifications

Construction specifications for the project have been prepared to align with the project objectives. The City of Lake Quivira does not have their own city specifications and a decision was made by the design team to utilize the nearby City of Overland Park's specifications as a technical reference for the project. Special Conditions for the project have also been prepared to cover unique project requirements such as dewatering during construction.

Construction Considerations

Pending approval from DWR, construction of the project is anticipated to start at the beginning of October 2023. Lake Quivira does an annual drawdown of the lake in the fall for dock maintenance within the lake. The slide gate will be used to lower the lake level to elevation 825.4-feet (NAVD 88) allowing some additional storage within the lake. f

APPENDIX A
GEOTECHNICAL REPORTS

GEOTECHNICAL ENGINEERING REPORT

LAKE QUIVIRA SPILLWAY REHABILITATION

Prepared for:

City of Lake Quivira, Kansas

April 6, 2023

Olsson Project No. A21-08019

April 6, 2023

City of Lake Quivira
Attn: Ms. Kathy Bounds
10 Crescent Drive
City of Lake Quivira, Kansas 66217

Re: Geotechnical Engineering Report
Lake Quivira Spillway Rehabilitation
Lake Quivira, Kansas
Olsson Project No. A21-08019

Dear Ms. Bounds,

Olsson has completed the geotechnical engineering report for the new spillway at Lake Quivira. The enclosed report summarizes our understanding of the project, presents the findings of the borings and laboratory tests, discusses the observed subsurface conditions, and based on those conditions, provides geotechnical engineering recommendations for the new spillway.

We appreciate the opportunity to provide our geotechnical engineering services for this project. If you have any questions or need further assistance, please contact us at your convenience.

Respectfully submitted,
Olsson, Inc.

IAN ANDREW DILLON
22094
4/6/23

JD Putnam, E.I.
Assistant Engineer

Ian A. Dillon, PE
Senior Geotechnical Engineer

TABLE OF CONTENTS

1. Project Introduction 1
1.1 Geotechnical Scope 1
1.2 Site and Project Information.. 1
2. Field Exploraiton and Laboratory Procedures 2
2.1 Field Exploration.. 2
2.2 Laboratory Procedures 2
3. Subsurface Conditions 4
3.1 Subsurface Stratigraphy 4
3.2 Water Level Observations 4
4. Geotechnical Considerations.. 5
5. Site Preparation.. 6
5.1 General Site Preparation Recommendations.. 6
5.2 Structural Fill 6
5.3 Drainage and Groundwater Considerations.. 7
6. Structures 8
6.1 Spillway Foundations.. 8
6.2 Lateral Earth Pressure Parameters.. 8
7. Conclusions and Limitations 11
7.1 Construction Observations and Testing 11
7.2 Limitations 11

LIST OF FIGURES

Figure 1. Project Site and Spillway Location 1

LIST OF TABLES

Table 1. Fill Placement and Compaction Recommendations........ 7
Table 2. Lateral Earth Pressures........ 9

APPENDICES

Appendix A Boring Location Map
Appendix B Borehole Reports, Symbols and Nomenclature
Appendix C Rock Core Photographs

1. PROJECT INTRODUCTION

1.1 Geotechnical Scope

This Geotechnical Engineering Report presents the results of the subsurface exploration performed for the Lake Quivira Spillway Rehabilitation project. We drilled three borings near the existing spillway. The approximate locations of the borings are shown on the Boring Location Map in Appendix A. The associated Borehole Reports are presented in Appendix B. The purpose of this report is to evaluate the existing subsurface conditions encountered at the borings, and based on those conditions, present our opinions and recommendations regarding the following items:

- Generalized geotechnical site preparation concerns addressing fill subgrade preparation, earthwork placement, fill compaction criteria, excavatability of any bedrock, and suitability of on-site materials for use as structural fill.
- Recommended foundation design parameters, including bearing pressures and depths.
- Lateral Earth Pressure for the design of the spillway walls.

1.2 Site and Project Information

We understand the project consists of the reconstruction of the Lake Quivira Spillway (Figure 1). The center line of the existing spillway slopes down from the south to the north with elevations ranging from 814 feet to 794 feet. The existing spillway is planned in the same location and elevation as the existing spillway.

Figure 1. Project Site and Spillway Location

2. FIELD EXPLORAITON AND LABORATORY PROCEDURES

2.1 Field Exploration

The drill crew used a truck mounted Simco-150 drill rig equipped with continuous hollow-stem flight augers to advance the three borings at the site. The locations of the borings were selected by an ***Olsson*** engineer and were located in the field by the drill crew using GPS coordinates via a handheld GPS unit. The boring elevations that are shown on the appended Borehole Reports were obtained by plotting the approximate boring locations on a site topographic map, dated April 3, 2023, and interpolating between the contour lines. These interpolated elevations are reported to the nearest foot on the logs. True surface elevations at these locations could differ due to interpolation, and other differences could occur from superposing approximate boring locations on the topographic plan. The boring locations and elevations should be considered accurate only to the degree implied by the means and methods used to define them.

The drill crew obtained soil samples using thin-walled sampling tubes hydraulically pushed into the soil and split-barreled sampling tubes during the performance of the Standard Penetration Test (SPT) at the depths shown on the appended borehole reports. Rock core samples were obtained using an NQ-2 sized diamond bit core barrel. The drill crew sealed and returned the samples to our laboratory for testing and classification. The sampling depths and SPT blow counts (N-values) are shown on the appended Borehole Reports in Appendix B

The drill crew prepared a field log for each boring. These field logs include visual classifications of the materials encountered during the drilling process as well as the drillers' interpretation of the subsurface conditions between the samples. The drill crew observed water levels in the borings at the times and conditions noted on the Borehole Reports.

2.2 Laboratory Procedures

At our laboratory, we classified the soil samples in accordance with the Unified Soil Classification System (USCS). We measured the moisture content of each sample. Dry density and unconfined compressive strength tests were performed on selected tube samples. One Atterberg limit test was performed on a selected sample to aid in the classification of the soils. We visually examined and photographed the rock core samples recovered from the borings. Photographs of the rock core are provided in Appendix C. We calculated percent recovery (REC) and Rock Quality Designation (RQD) for each core run. RQD is the percent of total length cored consisting only of sound pieces of at-least 4 inches or more in length and is a measure of the integrity of the rock mass in-situ. Based on RQD, rock quality can be described as "Excellent" (90%-100%), "Good" (75%-90%), "Fair" (50%-75%), "Poor" (25%-50%), and "Very Poor" (<25%). Based on the laboratory test results and our observations of the samples, we modified the field logs that were prepared by the drill crew. Results of the laboratory tests are shown on the appended Borehole Reports.

3. SUBSURFACE CONDITIONS

3.1 Subsurface Stratigraphy

The subsurface conditions shown on the borehole reports represent conditions at the specific boring locations at the times they were drilled. Variations may occur between and beyond the borings. The stratification lines shown on the appended Borehole Reports represent the approximate locations of changes in soil and bedrock types. The actual transitions between materials is usually gradual. Based on the borings and laboratory test results, the subsurface conditions at this project site can be generalized as follows.

Below the rootzone, the borings encountered native high plasticity (fat) clay soils. The native soils extended to depths ranging from 6 feet (B-3) to 18.5 feet (B-2). The fat clays were generally firm to stiff with soft areas within the upper 3 feet, brown and gray to reddish brown, silty, and moist.

Bedrock at the site appeared to consist of alternating layers of shale and limestone. The shale was generally weathered brown to gray and olive and had thicknesses ranging from around 2 feet to 4 feet thick. Boring B-2 terminated in gray shale at a depth of 28 feet. The upper 1 to 4 feet of limestone at the site was generally weathered. Boring B-1 encountered practical auger refusal on limestone bedrock at a depth of 16 feet, while boring B-3 terminated in the limestone at a depth of15 feet.

3.2 Water Level Observations

At boring B-1, where rock coring procedures did not occur, we monitored for groundwater during and immediately after the completion of drilling operations. In borings B-2 and B-3, water levels were only measured during drilling operations, prior the commencement of rock coring procedures, as water is injected into the boring to aid in rock coring. Water was not encountered in the borings. The lack of groundwater should not be construed to represent a permanent or stable condition. Variations and uncertainties exist with relatively short-term water level observations in boreholes. Water levels can and should be anticipated to vary between boring locations, as well as time within specific borings. Water typically collects near the interface between different materials, such as soil and bedrock. Groundwater levels can fluctuate with variations in precipitation, site grading, drainage, and adjacent land use. Long term monitoring with piezometers generally provides a more representative reflection of the potential range of groundwater conditions.

4. GEOTECHNICAL CONSIDERATIONS

We anticipate that the new spillway will bear on native clay soils, shale, and limestone bedrock. We anticipate bedrock excavations may be necessary to construct the new spillway. In our experience, materials that can be penetrated with flight augers, such as the weathered limestone and shale bedrock, can typically be excavated using heavy duty construction equipment, such as large backhoes and trackhoes with rock teeth or ripper equipped dozers. Excavations below the depth of auger refusal, within limestone or in confined areas such as utility trenches, may be more difficult and could require hard rock removal techniques.

5. SITE PREPARATION

5.1 General Site Preparation Recommendations

Site preparation should commence with the removal of the existing spillway. Removal operations should include all concrete, aggregate bases, and any previously placed fill soils. Site preparation should follow with the stripping of any organic topsoil, as well as any loose, soft, or otherwise unsuitable materials. These materials should be carefully separated to avoid incorporation of organic materials into new fill sections in the building or pavement areas. Site clearing, grubbing, and stripping should be performed during dry weather conditions. Operation of heavy equipment on the site during wet conditions could result in excessive rutting and mixing of construction debris with the underlying soils.

Based on the provided profile plans of the new spillway, we anticipate shale and limestone bedrock will be encountered during construction. Where bedrock is present within the spillway, we recommend that the bedrock be undercut to at least 4 inches below the base of the spillway. The undercut area should be backfilled with a free draining aggregate such as ASTM No. 57 Stone.

Upon completion of demolition, but prior to any new fill being placed on site, we recommend that the spillway structure subgrade be observed by an ***Olsson*** Geotechnical Engineer. Soft, wet, or unsuitable soils should be removed and replaced per the direction of the Engineer.

5.2 Structural Fill

If necessary, all structural fill and backfill should consist of the flowing approved materials, free of organic matter (organic content less than 5 percent), debris, and particles with sizes larger than 3 inches. Imported fill soils should consist of cohesive soils exhibiting a Liquid Limit (LL) less than 55 and a Plasticity Index (PI) less than 35. If imported soils are planned to be used at the site, samples of the fill should be submitted to ***Olsson*** for laboratory Proctor and classification tests prior to placement on the site. Based on our observations of the materials encountered at the borings, the on-site soils do not appear to be suitable for use as structural fill.

We recommend that all structural fill and backfill be compacted in accordance with the criteria provided in Table 1 below. An ***Olsson*** representative should observe all fill placement operations at the site and perform field compaction tests, as required.

Fill Placement Area	Material	ASTM D-698 Compaction Recommendation	Moisture Content (Percent of Optimum)
Granular Leveling Course 4 inches below base of spillway	ASTM C-33 No.57 Aggregate	65% of Relative Density	As necessary to obtain density
Structural Fill	Imported Clays LL < 55 PI < 35	95%	-1 to +3 percent

Table 1. Fill Placement and Compaction Recommendations

Suitable fill materials should be placed in thin loose lifts of 9 inches or less. Within small excavations, such as in utility trenches, around manholes, or behind retaining walls, the use of vibrating plat compactors, jumping jack compactors or walk behind sheepsfoot compactors may be used to facilitate compaction in these areas. Loose lifts thicknesses of 4 inches or less are recommended where small compaction equipment is used.

The moisture content for suitable borrow soils at the time of compaction should generally be maintained between the ranges specified above. More stringent moisture limits may be necessary with certain soils and some adjustments to moistures contents may be necessary to achieve compaction in accordance with project specifications.

5.3 Drainage and Groundwater Considerations

The area surrounding the site should be sloped to promote surface drainage away from the foundation. Water should not be allowed to collect at the ground surfaces near foundations, floor slabs, or areas of new pavement, either during or after construction. Provisions should be made to quickly remove accumulating seepage water or storm water runoff from excavations. Undercut or excavated areas should be sloped toward one corner to allow rainwater or surface runoff to be quickly collected and gravity drained or pumped from construction areas. Subgrade soils that are exposed to precipitation or runoff should be evaluated by Olsson prior to the placement of new fill, reinforcing steel, or concrete, to determine if corrective action is required.

6. STRUCTURES

6.1 Spillway Wall Foundations

Based on the subsurface conditions encountered at the borings, we anticipate the proposed spillway structure walls will bear on clay soils, shale, and limestone bedrock. For spillway walls bearing on such materials a net allowable bearing pressure of 2,000 pounds per square foot (psf) can be used for design. The net allowable bearing pressure refers to the bearing capacity of the soils at foundation bearing elevations in excess of the surrounding overburden pressure.

In our opinion, the spillway walls could bear on different materials if some differential performance of the spillway can be accepted. Provided that abrupt changes in bearing materials over short distances are avoided, it is our opinion that differential settlement should occur gradually across the spillway footprint as the transition from spillway walls bearing on clay soils and bedrock. Strict moisture and density control of the proposed fill sections will be important to limit potential differential settlement between elements supported on clay soils and bedrock. If no risk of differential settlement can be tolerated, the foundations will need to bear on similar materials. To accomplish this, footings may need to extend downward to bear on bedrock.

All foundations should bear at a minimum depth of 3 feet below the adjacent final ground surface for footings bearing on clay soils or shale bedrock and 2 feet for footings bearing on limestone bedrock.

The base of all foundation excavations should be free of all water and loose material prior to placing concrete. ***Olsson*** should observe the foundation bearing materials at each footing prior to the placement of concrete or reinforcing steel.

After all foundation subgrades have been observed and evaluated by an ***Olsson*** representative, concrete should be placed as soon as possible to avoid subjecting the exposed soils to drying, wetting, or freezing conditions. If the foundation subgrade soils are subjected to such conditions, ***Olsson*** should be contacted to reevaluate the foundation bearing materials.

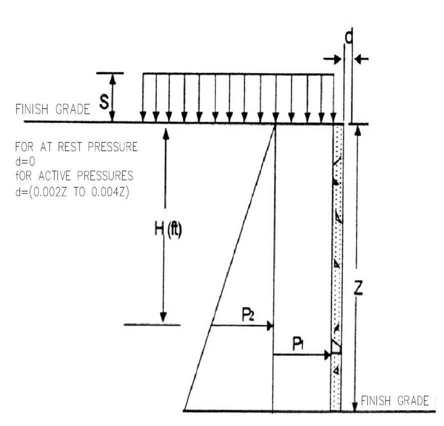
For foundations bearing on cohesive soils and bedrock at this site, in our opinion, up to 1 inch of total settlement and up to ½ inch of differential settlement could be expected.

6.2 Lateral Earth Pressure Parameters for Spillway Walls

The following soil parameters are provided for use in designing below grade cast-in-place concrete spillway walls subject to lateral earth pressures. The parameters are based on the understanding that the retained soils used during construction will be similar in composition to the on-site soils encountered during this exploration. To ensure similarity, we recommend confirmation testing be performed during construction by ***Olsson***.

Walls that are unrestrained at the top and are free to rotate slightly, such as Cast-in-Place concrete cantilever walls, may be designed for “active” earth pressure conditions. The "passive" earth pressure condition should be used to evaluate the resistance of soil to lateral loads. Table 2 presents recommended values of earth pressure coefficients based on our experience with soils in the area. Equivalent fluid densities are frequently used for the calculation of lateral earth pressures for the “at-rest” and “active” conditions and are therefore provided in Table 2.

Legend of Symbols	
Z	Wall Height (ft)
H	Depth Below Surface (ft)
D	Wall Displacement (ft)
S	Surcharge Load (psf)
P_1	Surcharge Pressure (psf)
P_2	Earth Load (psf)
K	Earth Pressure Coefficient
G	Equivalent Fluid Density (pcf)
Pressure Calculations	
Surcharge Pressure	P_1 (psf) = K * S
Earth Load	P_2 (psf) = G (pcf) * H (ft)



Earth Pressure Coefficient (K)			**Equivalent Fluid Density (G)**	
			Drained, pcf	**Undrained, pcf**
Active (K_a)	Cohesive	0.42	51	87
	Granular*	0.31	37	-
Passive (K_p)	Cohesive	2.37	284	199
	Granular*	3.25	390	-

*Granular backfill should be permanently drained

Table 2. Lateral Earth Pressures

The following assumptions were made:

- For active earth pressure, the wall must rotate about its' base, with top lateral movements of 0.002*Z to 0.004*Z, where "Z" is the wall height.
- The equivalent fluid densities in Table 2 do not include the effects of surcharge loading.
- The equivalent fluid densities in Table 2 assume a level backslope. If a backslope is included, ***Olsson*** should be contacted to update the earth pressure coefficient and associated equivalent fluid density.
- The wall must move horizontally to mobilize passive resistance.
- Surcharges are uniform, where "S" is the Surcharge Pressure, in psf.
- In-situ backfill has a maximum weight of 120 pcf.
- Horizontal backfill is compacted to 95% of standard Proctor maximum dry density.
- Heavy equipment and other concentrated load components are not included.
- No hydrostatic pressure acting on wall. Assumes a drained condition.
- No safety factor is included.
- Passive pressure in the frost zone or moisture fluctuation zone should be ignored.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, an ultimate coefficient of friction value of 0.30 should be used where the footing bears on soil and shale bedrock and 0.65 where the footing bears on limestone bedrock.

To intercept infiltrating surface water behind the wall, we recommend a perimeter drain be installed at the foundation level and/or weep holes be placed at regular intervals along the wall. The drain line invert should be below the finished subgrade elevation for the interior floor. The drain line should be sloped to provide positive gravity drainage and should be surrounded by free-draining granular material graded to prevent the intrusion of fines, or an alternative free-draining granular material encapsulated with suitable filter fabric. A minimum 2-foot-wide section of free-draining granular fill should be used for backfilling above the drain line and adjacent to the wall and should extend to within 2 feet of final grade. The granular backfill should be capped with compacted cohesive fill to minimize infiltration of surface water into the drain system.

7. CONCLUSIONS AND LIMITATIONS

7.1 Construction Observations and Testing

We recommend that all earthwork during construction be monitored by a representative of ***Olsson***, including site preparation, placement of all structural fill and trench backfill. The purpose of these services would be to provide ***Olsson*** the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

7.2 Limitations

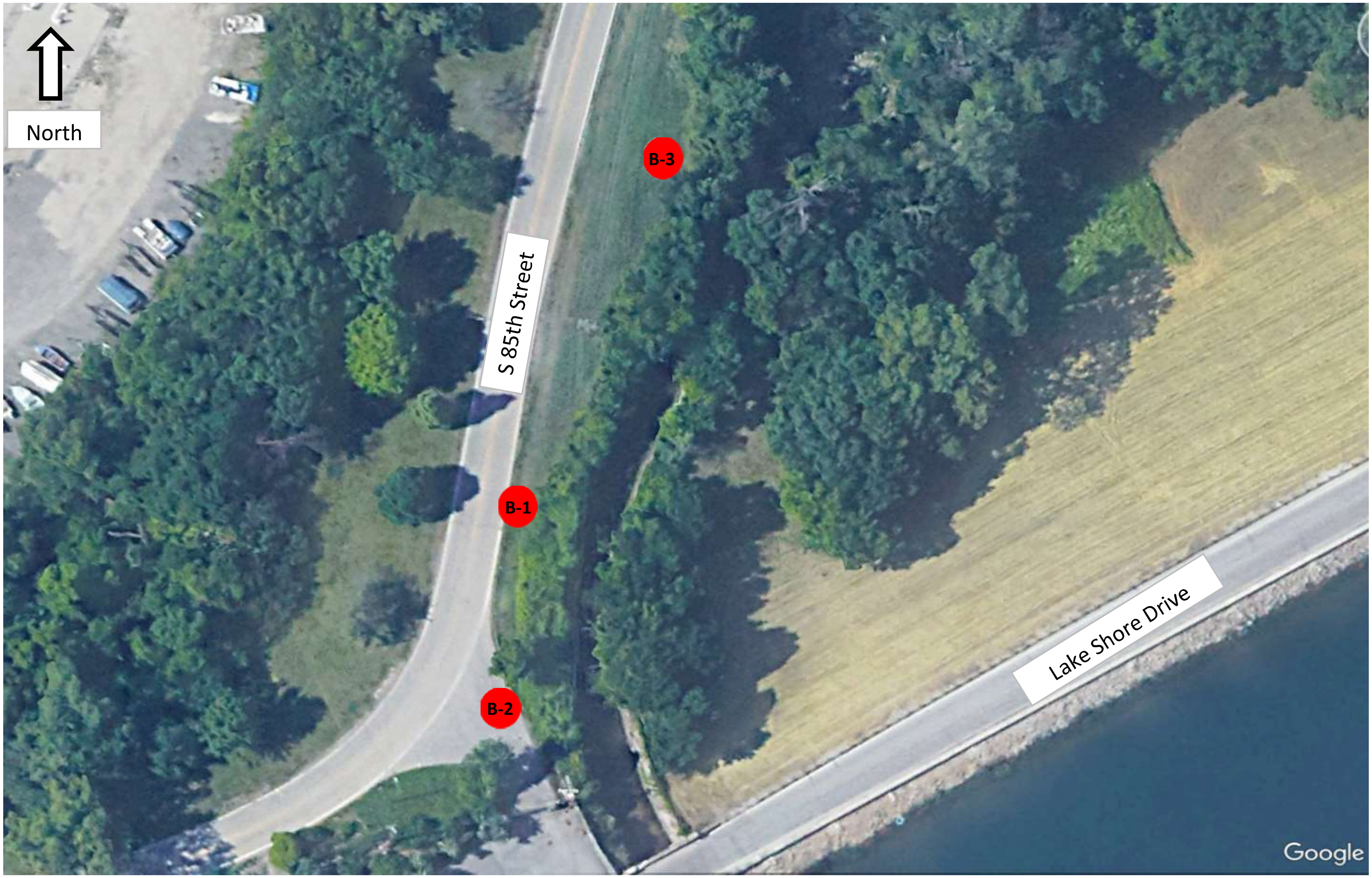
The conclusions and recommendations presented in this report are based on the information available regarding the proposed construction, the results obtained from our borings, laboratory testing program, and our experience with similar projects. The borings represent a very small statistical sampling of subsurface soils and it is possible that conditions may be encountered during construction that are substantially different from those indicated by the borings. In these instances, adjustments to design and construction may be necessary.

This geotechnical report is based on the site plan and our understanding of the project's information as provided to ***Olsson***. Changes in the location or design of new structures could significantly affect the conclusions and recommendations presented in this geotechnical report. ***Olsson*** should be contacted in the event of such changes to determine if the recommendations of this report remain appropriate for the revised site design.

This report was prepared under the direction and supervision of a Professional Engineer registered in the State of Kansas with the firm of **Olsson, Inc**. The conclusions and recommendations contained herein are based on generally accepted, professional, geotechnical engineering practices at the time of this report, within this geographic area. No warranty, express or implied, is intended or made. This report has been prepared for the exclusive use of **City of Lake Quivira, Kansas** and their authorized representatives for the specific application to the proposed project described herein.

APPENDIX A

Boring Location Map



olsson

Scale: n.t.s.	**Boring Location Map**
Project No. A21-08019	**Lake Quivira Dam** **Lake Quivira, Kansas**
Approved by: JDP	
Date: 1/30/2023	

APPENDIX B

Borehole Reports, Symbols and Nomenclature

SYMBOLS AND NOMENCLATURE

DRILLING NOTES

DRILLING AND SAMPLING SYMBOLS

SS: Split-Spoon Sample (1.375” ID, 2.0” OD)
U: Thin-Walled Tube Sample (3.0” OD)
CS: Continuous Sample
BS: Bulk Sample
MC: Modified California Sampler
GB: Grab Sample
SPT: Standard Penetration Test Blows per 6.0”

HSA: Hollow Stem Auger
CFA: Continuous Flight Auger
HA: Hand Auger
CPT: Cone Penetration Test
WB: Wash Bore
FT: Fish Tail Bit
RB: Rock Bit
PP: Pocket Penetrometer

NE: Not Encountered
NP: Not Performed
NA: Not Applicable
% Rec: Percent of Recovery
WD: While Drilling
IAD: Immediately After Drilling
AD: After Drilling
CI: Cave In

DRILLING PROCEDURES

Soil samples designated as “U” samples on the boring logs were obtained in using Thin-Walled Tube Sampling techniques. Soil samples designated as “SS” samples were obtained during Penetration Test using a Split-Spoon Barrel sampler. The standard penetration resistance ‘N’ value is the number of blows of a 140 pound hammer falling 30 inches to drive the Split-Spoon sampler one foot. Soil samples designated as “MC” were obtained in using Thick-Walled, Ring-Lined, Split-Barrel Drive sampling techniques. Recovered samples were sealed in containers, labeled, and protected for transportation to the laboratory for testing.

WATER LEVEL MEASUREMENTS

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In relatively high permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observations.

SOIL PROPERTIES & DESCRIPTIONS

Descriptions of the soils encountered in the soil test borings were prepared using Visual-Manual Procedures for Descriptions and Identification of Soils.

PARTICLE SIZE

Boulders	12 in. +	Coarse Sand	4.75mm-2.0mm	Silt	0.075mm-0.005mm
Cobbles	12 in.-3 in.	Medium Sand	2.0mm-0.425mm	Clay	<0.005mm
Gravel	3 in.-4.75mm	Fine Sand	0.425mm-0.075mm		

COHESIVE SOILS

Consistency	Unconfined Compressive Strength (Qu) (tsf)
Very Soft	<0.25
Soft	0.25 – 0.5
Firm	0.5 – 1.0
Stiff	1.0 – 2.0
Very Stiff	2.0 – 4.0
Hard	> 4.0

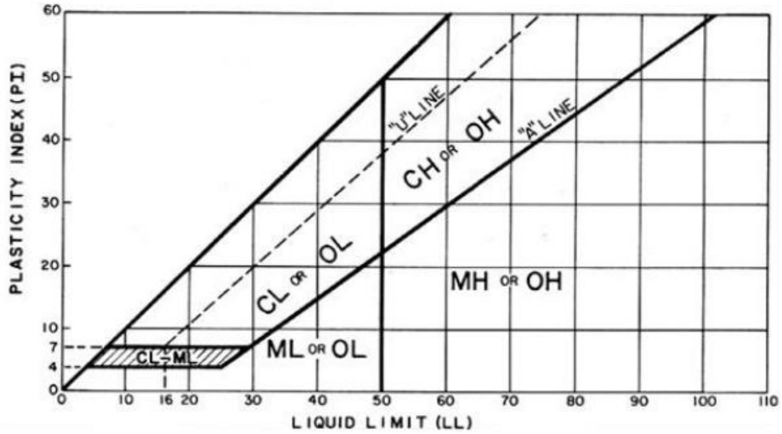
COHESIONLESS SOILS

Relative Density	‘N’ Value
Very Loose	0 – 3
Loose	4 – 9
Medium Dense	10 – 29
Dense	30 – 49
Very Dense	≥ 50

COMPONENT %

Description	Percent (%)
Trace	<5
Few	5 - 10
Little	15 - 25
Some	30 - 45
Mostly	50 - 100

PLASTICITY CHART



ROCK QUALITY DESIGNATION (RQD)

Description	RQD (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

olsson

olsson	BOREHOLE REPORT NO. B-1	Sheet 1 of 1

PROJECT NAME: **Lake Quivira Dam Spillway Rehabilitation 2023**

CLIENT: **City of Lake Quivira, Kansas**

PROJECT NUMBER: **A21-08019**

LOCATION: **Lake Quivira, Kansas**

■ Shelby Tube ☒ Split Spoon

APPROX. SURFACE ELEV. (ft): 822

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	ROOT ZONE **1.0'**		0								
820	***FAT CLAY*** *Stiff, brown with gray, silty, moist* **3.0'**			■ U 1			1.2	24.7	97.3		
815	*Firm, brown with gray, silty, moist* **8.0'**		5	☒ SS 2		3-4-4 N=8		23.3			
	Reddish brown, weathered limestone, moist **9.5'**			■ U 3				24.5	95.4		
810	***WEATHERED LIMESTONE*** **13.5'**		10								
	WEATHERED SHALE *Brown with dark brown, clayey* **15.0'**		15	☒ SS 4		7-8-14 N=22		25.5			
	LIMESTONE *Gray* **15.8'**										

REFUSAL AT 15.8 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Encountered
IAD	▼ Not Encountered
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	1/26/23	FINISHED:	1/26/23
DRILL CO.:	CFS	DRILL RIG:	CME 45B
DRILLER:	JEREMY	LOGGED BY:	NICK

METHOD: CONTINUOUS FLIGHT AUGER

BOREHOLE REPORT NO. B-2

Sheet 1 of 2

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

☒ Split Spoon ■ Shelby Tube ▮ Rock Core

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
830	**APPROX. SURFACE ELEV. (ft):** 830		0								
	ASPHALT ***0.7'***										
	AGGREGATE BASE ***1.0'***										
	FAT CLAY *Firm, brown with gray, silty, moist*			SS 1		4-2-3 N=5		20.0			
	3.0' *Very stiff, brown with gray, silty, moist*			U 2			2.5	24.2	99.9	64/44	
825			5								
	8.5' *Stiff, brown with gray, silty, moist*			SS 3		5-5-6 N=11		24.2			
820			10								
	13.0' *Reddish brown to brown, silty, moist*			U 4				24.2	100.7		
815			15								
	18.5' ***WEATHERED SHALE*** *Gray and reddish brown*			SS 5		15-26-44 N=70		18.7			
810			20								

CONTINUED NEXT PAGE

WATER LEVEL OBSERVATIONS	
WD	▽ Not Encountered
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	1/26/23	FINISHED:	1/26/23
DRILL CO.:	CFS	DRILL RIG:	CME 45B
DRILLER:	JEREMY	LOGGED BY:	NICK
METHOD: HOLLOW STEM AUGER / ROCK CORE			

olsson

BOREHOLE REPORT NO. B-2

Sheet 2 of 2

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

☒ Split Spoon ■ Shelby Tube

▮ Rock Core

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
810			20								
	WEATHERED SHALE *Gray and reddish brown (continued)*										
	22.5'										
	LIMESTONE *Gray*										
	23.0'										
	SHALE *Gray*										
805			25	RC 1							<u>Recovery</u> 83.3% <u>RQD</u> 0.0%
	28.0'										

BASE OF BORING AT 28.0 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Encountered
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	1/26/23	FINISHED:	1/26/23
DRILL CO.:	CFS	DRILL RIG:	CME 45B
DRILLER:	JEREMY	LOGGED BY:	NICK

METHOD: HOLLOW STEM AUGER / ROCK CORE

olsson

BOREHOLE REPORT NO. B-3

Sheet 1 of 1

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

■ Shelby Tube ☒ Split Spoon ◨ Rock Core

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
805	**APPROX. SURFACE ELEV. (ft):** 805		0								
	ROOT ZONE 1.0'										
	FAT CLAY *Soft, brown and gray, silty, mosit* 3.0'			U 1			0.4	24.6	92.4		
	Stiff, light brown, silty, shaley, moist			SS 2		3-5-6 N=11		22.5			
800	6.0'		5								
	WEATHERED SHALE *Olive* 8.5'										
	WEATHERED LIMESTONE 9.8'			SS 3		20-30- 50/4"		16.9			
795	***LIMESTONE*** *Gray*		10	RC 1							Recovery 90.0% RQD 40.0%
790	15.0'		15								

BASE OF BORING AT 15.0 FEET

WATER LEVEL OBSERVATIONS	
WD	∇ Not Encountered
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	1/26/23	FINISHED:	1/26/23
DRILL CO.:	CFS	DRILL RIG:	CME 45B
DRILLER:	JEREMY	LOGGED BY:	NICK
METHOD: HOLLOW STEM AUGER / ROCK CORE			

APPENDIX C

Rock Core Photographs

B-2: Run 1 (23.0'-28.0')

Project Location
S 85th Street, Lake Quivira, Kansas

Olsson Project No:	A21-08019
Client:	City of Lake Quivira, KS
Last Revision Date:	4/5/2023
Engineer:	JDP

olsson

B-3: Run 1 (10.0'-15.0')

Project Location
S 85th Street, Lake Quivira, Kansas

Olsson Project No:	A21-08019
Client:	City of Lake Quivira, KS
Last Revision Date:	4/5/2023
Engineer:	JDP

LAKE QUIVIRA SPILLWAY REHABILIATION

Lake Quivira, Kansas - 2023

April 6, 2023

Olsson Project No. A21-08019

June 1, 2023

City of Lake Quivira, Kansas
Attn: Ms. Kathy Bounds
10 Crescent Drive
Lake Quivira, Kansas 66217

Re: Geotechnical Engineering Drilling Letter
Lake Quivira Spillway Rehabilitation
Lake Quivira, Kansas
Olsson Project No. A21-08019

Dear Ms. Bounds,

Olsson, Inc. (***Olsson***) has completed the authorized additional drilling services for the above reference project. Six exploratory borings were drilled in the spillway at approximate spacing of 75 feet. The approximate locations of the borings are shown on the attached Boring Location Map.

A field crew used a handheld electronic coring machine to advance through the existing concrete spillway. Once through the concrete, the field crew used hand augers to drill to practical hand auger refusal on limestone bedrock. Soil samples were not obtained. After completion of drilling operations, each boring was backfilled with sand and the spillway was patched with non-shrink grout.

The subsurface conditions shown on the attached borehole reports represent conditions at the specific boring locations at the times they were drilled. Variations may occur between and beyond the borings. The stratification lines shown on the attached Borehole Reports represent the approximate locations of changes in soil and bedrock types. The actual transitions between materials is usually gradual. Based on the borings, the subsurface conditions at this project site can be generalized as follows.

At the boring locations, the concrete lined spillway had a thickness between 4 and 6 inches. Around 1 to 14 inches of clay soils were encountered between the base of concrete and the limestone interface. Each boring terminated on the limestone. Depths to refusal range from 5 inches to 24 inches below the surface of the concrete lined spillway.

This letter has been prepared for the exclusive use of our client for specific application to the project discussed. No engineering analysis was performed as part of this letter. No warranties, either express or implied, are intended or made. If you have any question, please contact us.

Sincerely,
Olsson, Inc.

JD Putnam, EI
Assistant Engineer

Ian A. Dillon, PE
Senior Geotechnical Engineer

Attachments:
Boring Location Map
Borehole Reports

olsson

Scale: n.t.s.
Project No.A21-08019
Approved by: JDP
Date: 6/1/2023

Boring Location Map

Lake Quivira Spillway Rehabiliation
Lake Quivira, Kansas

BOREHOLE REPORT NO. B-4

Sheet 1 of 1

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

ELEVATION (ft)	**MATERIAL DESCRIPTION**	**GRAPHIC LOG**	**DEPTH** (ft)	**SAMPLE TYPE NUMBER**	**CLASSIFICATION** (USCS)	**BLOWS/6" N-VALUE**	**UNC. STR.** (tsf)	**MOISTURE** (%)	**DRY DENSITY** (pcf)	**LL/PI** (%)	**ADDITIONAL DATA/ REMARKS**
			0.0								
	CONCRETE ***0.4'***	▒									
	LEAN TO FAT CLAY ***0.8'***	▨									
	LIMESTONE ***0.8'***										

BASE OF BORING AT 0.8 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

olsson

BOREHOLE REPORT NO. B-5

Sheet 1 of 1

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
			0.0								
	CONCRETE *0.5'*	░									
	LEAN TO FAT CLAY *1.5'*	▨									
	LIMESTONE *1.6'*										

BASE OF BORING AT 1.6 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

olsson

BOREHOLE REPORT NO. B-6

Sheet 1 of 1

PROJECT NAME: **Lake Quivira Dam Spillway Rehabilitation 2023**

CLIENT: **City of Lake Quivira, Kansas**

PROJECT NUMBER: **A21-08019**

LOCATION: **Lake Quivira, Kansas**

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
			0.0								
	CONCRETE *0.5'*										
	LEAN TO FAT CLAY *0.7'*										
	LIMESTONE *0.8'*										

BASE OF BORING AT 0.8 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

BOREHOLE REPORT NO. B-7

Sheet 1 of 1

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

ELEVATION (ft)	**MATERIAL DESCRIPTION**	**GRAPHIC LOG**	**DEPTH** (ft)	**SAMPLE TYPE NUMBER**	**CLASSIFICATION** (USCS)	**BLOWS/6" N-VALUE**	**UNC. STR.** (tsf)	**MOISTURE** (%)	**DRY DENSITY** (pcf)	**LL/PI** (%)	**ADDITIONAL DATA/ REMARKS**
			0.0								
	CONCRETE ***0.8'***	⁘									
	LEAN TO FAT CLAY ***1.9'***	▨									
	LIMESTONE ***2.0'***	▦									
	BASE OF BORING AT 2.0 FEET										

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

olsson

BOREHOLE REPORT NO. B-8

Sheet 1 of 1

PROJECT NAME **Lake Quivira Dam Spillway Rehabilitation 2023**	CLIENT **City of Lake Quivira, Kansas**
PROJECT NUMBER **A21-08019**	LOCATION **Lake Quivira, Kansas**

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
			0.0								
	CONCRETE 0.3'	▨									
	LIMESTONE 0.5'	▭									

BASE OF BORING AT 0.5 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

BOREHOLE REPORT NO. B-9

Sheet 1 of 1

PROJECT NAME
Lake Quivira Dam Spillway Rehabilitation 2023

CLIENT
City of Lake Quivira, Kansas

PROJECT NUMBER
A21-08019

LOCATION
Lake Quivira, Kansas

ELEVATION (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft) 0.0	SAMPLE TYPE NUMBER	CLASSIFICATION (USCS)	BLOWS/6" N-VALUE	UNC. STR. (tsf)	MOISTURE (%)	DRY DENSITY (pcf)	LL/PI (%)	ADDITIONAL DATA/ REMARKS
	CONCRETE *0.5'*	▨									

LIMESTONE *0.5'*

BASE OF BORING AT 0.5 FEET

WATER LEVEL OBSERVATIONS	
WD	▽ Not Performed
IAD	▼ Not Performed
AD	▼ Not Performed

OLSSON, INC.
1700 E. 123RD STREET
OLATHE, KANSAS 66061

STARTED:	5/26/23	FINISHED:	5/26/23
DRILL CO.:	OLSSON	DRILL RIG:	HAND AUGER
DRILLER:	B. POINTER	LOGGED BY:	B. POINTER
METHOD: HAND AUGER			

APPENDIX B
STRUCTURAL CALCULATIONS

NEBRASKA MISSOURI KANSAS IOWA COLORADO ARIZONA ARKANSAS OKLAHOMA TEXAS

STRUCTURAL CALCULATIONS

Lake Quivira Spillway Rehabilitation

021-08019

DATE	DESIGNER	CHECKER	TL/SPE REVIEWER
6/29/2023	LAH	ENO	

PROJECT NUMBER	PAGES	REV
021-08019		0

NO	REVISIONS	DATE	DESIGNER	TL/SPE REVIEWER
0				

olsson	CLIENT NAME:	DESIGNER: LAH	DATE: 6/29/2023
	PROJECT NAME: Lake Quivira Spillway Rehab.	PROJECT NO.: 021-08019	REV.: 0

TABLE OF CONTENTS

A – Channel Loads and Analysis Input

B – LARSA Analysis
- B-1: Design Section 1
- B-2: Design Section 2
- B-3: Design Section 3

C – Structural Design
- C-1: Design Section 1
- C-2: Design Section 2
- C-3: Design Section 3

D – Uplift and Sliding Check

A - Channel Loads and Analysis Input

Project: Lake Quivira Spillway **Designed By:** LAH **Date:** 6/28/2023
Subject: Channel Loads **Checked By:** ENO **Sheet** 1 - 3

The channel is analyzed in LARSA 4d using spring supports to model the foundation supported on limestone bedrock or flowable fill. Design loading is according Bureau of Reclamation Design Standards No. 14, Chapter 3. For calculation of lateral earth pressures it is assumed that the drainage system is not fully functioning and 1/3 of the channel height is undrained.

Geometry:

Design Section:	1	2	3
Begin Sta.:	10+45.00	10+65.00	11+85.00
End Sta.:	10+65.00	11+85.00	14+00.00
Wall Height (ft):	10	10.0	8
Undrained Wall Height (ft):	3.33	3.33	2.67
Max. Fill Grade Behind Wall (ft/ft):	0.25	0.25	0.02
Wall Thickness (ft):	1.17	1.17	1.00
Clear Width (ft):	22	26	26
Heel Width (ft):	1.5	1.5	1.5
Total Footing Width (ft):	27.33	31.33	31.00
Max. Footing Thickness (ft):	1.25	1.25	1.25
Min. Footing Thickness (ft):	0.73	0.73	0.73

Unit Weights:

Water:	0.0624	kcf
Soil:	0.12	kcf
Concrete:	0.15	kcf

Soil Properties:

Drained Lateral Earth Pressure:	0.051	kcf	
Undrained Lateral Earth Pressure:	0.087	kcf	
Bedrock/Flow Fill Modulus of Subgrade Reaction:	250	psi/in	(From geotech)
Allowable Bearing Pressure:	3.5	ksf	(From geotech)

Dead Loads (D)

Self weight is applied in LARSA

Earth Loads - Drained Condition (H1):

Design Section:	1	2	3
Additional Fill Height Due to Grade (ft):	0.375	0.375	0.03
Horiz. earth press. @ bottom of drained backfill (ksf):	0.513	0.513	0.409
Vertical Earth Pressure on Heel (ksf):	1.200	1.200	0.960
Vert. comp of horizontal earth press. (ksf):	0.128	0.128	0.008

Earth Loads - Partially Undrained Condition (H2):

Design Section:	1	2	3
Additional Fill Height Due to Grade (ft):	0.375	0.375	0.03
Horiz. earth press. @ bottom of drained backfill (ksf):	0.348	0.348	0.273
Horiz. earth pressure @ bottom of wall (ksf):	0.630	0.630	0.505
Vertical Earth Pressure on Heel (ksf):	1.200	1.200	0.960
Vert. comp of horizontal earth press. (ksf):	0.157	0.157	0.010

Internal Water Pressure (F):

Design Section:	1	2	3
Horizontal water pressure @ bottom of wall (ksf):	0.624	0.624	0.499
Vertical Earth Pressure on Footing (ksf):	0.624	0.624	0.499

Project: Lake Quivira Spillway **Designed By:** LAH **Date:** 6/28/2023
Subject: Channel Loads **Checked By:** ENO **Sheet** 2 - 3

Live Load Surcharge - Drained Condition (L1):

Design Section:	1	2	3
Live Load Surcharge Equivalent Soil Height (ft):	2	2	2
Live Load Surcharge Press. in drained backfill (ksf):	0.102	0.102	0.102

Live Load Surcharge - Partially Undrained Condition (L2):

Design Section:	1	2	3
Live Load Surcharge Equivalent Soil Height (ft):	2	2	2
Live Load Surcharge Press. in drained backfill (ksf):	0.102	0.102	0.102
Live Load Surcharge Press. in undrained backfill (ksf):	0.174	0.174	0.174

Load Combinations and Factors: (ACI-350-06 §9.2.1)

Group 1 Load combinations are for the condition with drained backfill and the spillway channel empty. Group 2 Load combinations are for the condition with drained backfill and the spillway channel full. Group 3 Load combinations are for the condition with partially undrained backfill and the spillway channel full. Group 4 Load combinations are for the condition with partially undrained backfill and the spillway channel empty. The water level for load combinations with the spillway channel full is conservatively assumed to be to the top of the walls. For load combinations with partially undrained backfill, the drained soild elevation is taken as 1/3rd of the wall height. Group 5 load combinations are for the condition with no backfill present and the spillway channel full. Group 5 load combinations apply to design section 3 only, since the channel walls are exposed near the downstream end.

	Combo	D	H1	H2	F	L1	L2
Group 1	1.1	1.4					
	1.2	1.2	1.6				
	1.3	1.2	0.6				
	1.4	1.2	1.6			1.6	
	1.5	0.9	1.6				
	1.6	0.9	0.6				
Group 2	2.1	1.2	1.6		1.2		
	2.2	1.2	0.6		1.2		
	2.3	1.2	1.6		1.2	1.6	
	2.4	0.9	1.6		1.2		
	2.5	0.9	0.6		1.2		
Group 3	3.1	1.2		1.6	1.2		
	3.2	1.2		0.6	1.2		
	3.3	1.2		1.6	1.2		1.6
	3.4	0.9		1.6	1.2		
	3.5	0.9		0.6	1.2		
Group 4	4.1	1.2		1.6			
	4.2	1.2		0.6			
	4.3	1.2		1.6			1.6
	4.4	0.9		1.6			
	4.5	0.9		0.6			
Group 5	5.1	1.4			1.4		
	5.2	1.2			1.2		
	5.3	0.9			1.2		
Service Leve	S.1	1.00	1.00			1.00	
	S.2	1.00	1.00		1.00	1.00	
	S.3	1.00		1.00	1.00		1.00
	S.4	1.00		1.00			1.00
	S.5	1.00			1.00		

Project: Lake Quivira Spillway
Designed By: LAH
Date: 6/28/2023
Subject: Channel Loads
Checked By: ENO
Sheet 3 - 3

Summary of Analysis Results

Bearing Pressure:

Design Section:	1	2	3
Max. Bearing Pressure Result (ksf):	1.74	1.74	1.35
Check:	OK	OK	OK

Design Moment - Walls:

	Design Section:	1	2	3
Stream Face in Tension	Mu (k-ft)	7.29	7.29	7.46
	Ms (k-ft)	0.00	0.00	5.33
Fill Face in Tension	Mu (k-ft)	23.06	23.05	12.80
	Ms (k-ft)	14.41	14.41	8.00

Design Shear- Walls:

	Design Section:	1	2	3
Stream Face in Tension	Vu (k-ft)	2.19	2.19	2.80
	Coincident Mu (k-ft)	7.29	7.29	7.46
Fill Face in Tension	Vu (k-ft)	6.48	6.48	4.44
	Coincident Mu (k-ft)	23.06	23.05	12.80

Design Moment - Footing Near Walls:

	Design Section:	1	2	3
Top Face in Tension	Mu (k-ft)	9.95	9.74	7.42
	Ms (k-ft)	1.54	1.47	5.30
Bottom Face in Tension	Mu (k-ft)	20.58	20.57	11.75
	Ms (k-ft)	12.78	12.79	7.33

Design Shear- Footing Near Walls:

	Design Section:	1	2	3
Top Face in Tension	Vu (k-ft)	0.70	0.73	0.91
	Coincident Mu (k-ft)	0.07	0.09	0.21
Bottom Face in Tension	Vu (k-ft)	5.34	5.35	3.64
	Coincident Mu (k-ft)	19.25	19.24	10.85

Design Moment - Footing Near CL:

	Design Section:	1	2	3
Top Face in Tension	Mu (k-ft)	10.63	11.68	8.76
	Ms (k-ft)	4.96	6.10	4.90

Design Shear- Footing Near CL:

	Design Section:	1	2	3
Top Face in Tension	Vu (k-ft)	1.37	1.12	0.75
	Coincident Mu (k-ft)	1.81	6.24	5.02

B - LARSA Analysis

B-1: Design Section 1

Lake Quivira Spillway - Design Section 1

Thursday, June 29, 2023

Tel:

PROJECT SUMMARY

INPUT PROPERTIES	Count
Universal Restraints	Ty Rxz
Materials	4
Sections	4
User Coordinate System	NONE
Spring Curves	3
Isolater Property	NONE
Creep Definitions	NONE

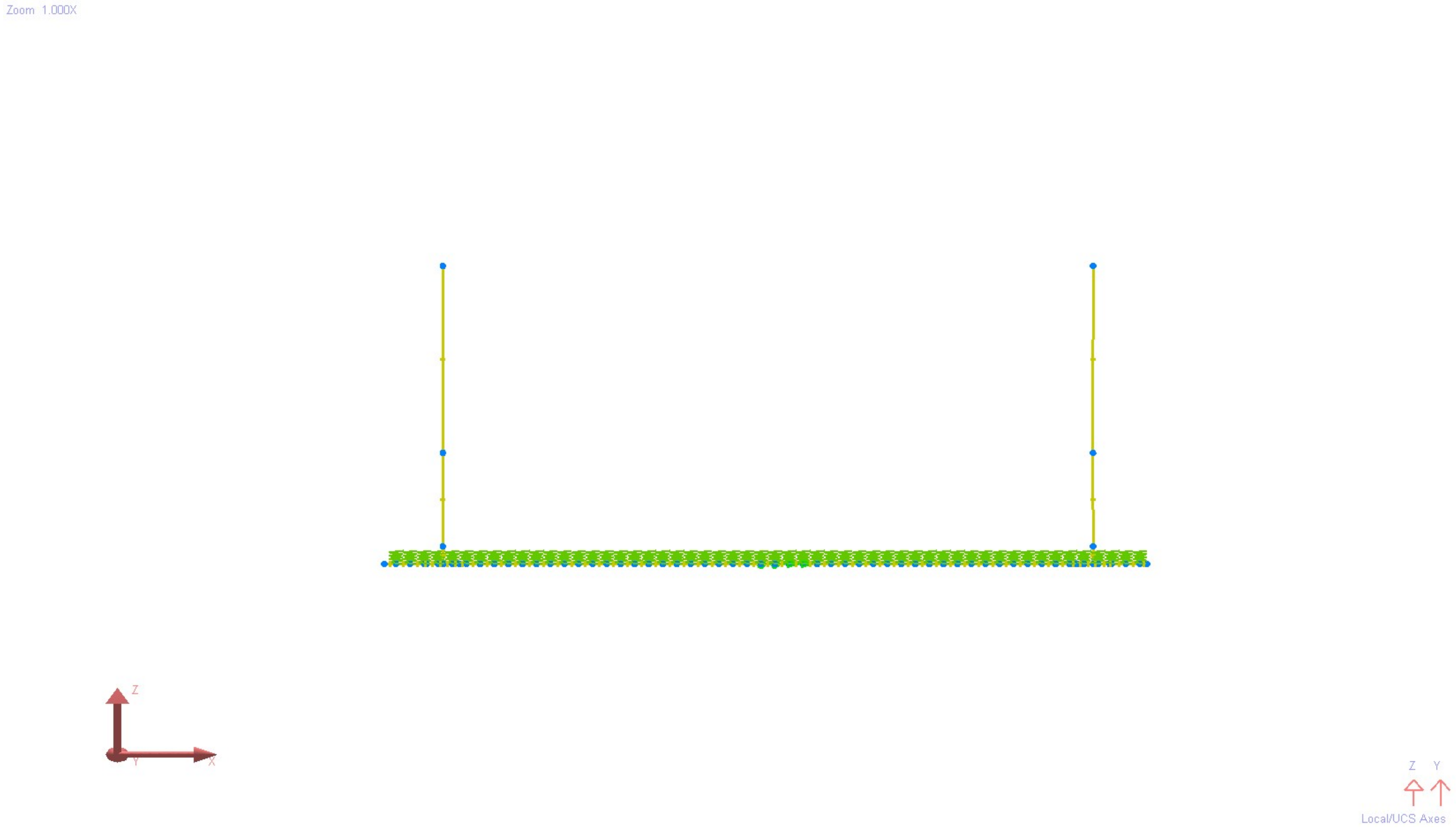
INPUT GEOMETRY	Count
Joints	68
Members	67
Plates	NONE
Springs	54
Isolaters	NONE
Mass Elements	NONE
Slave / Masters	NONE
Tendons	NONE

Load Cases	Count
Load Cases	6
Combination Cases	25
Construction Stages	NONE
Linked Databases	NONE

TABLE OF CONTENTS

INPUTS	Page#	Results	Page#
- INPUT : Material Properties	Page 5		
- INPUT : Spring Properties	Page 5		
- INPUT : Clay Spring Curve	Page 5		
- INPUT : Shale Spring Curve	Page 5		
- INPUT : Limestone Spring Curve	Page 5		
- INPUT : Sections	Page 5		
- INPUT : Joints	Page 6		
- INPUT : Members	Page 7		
- INPUT : Springs	Page 9		

Graphics View 1



INPUT : Material Properties

Name	Modulus of Elasticity (kips/in²)	Poisson Ratio	Shear Modulus (kips/in²)	Unit Weight (kips/in³)	Thermal Expansion (1/ °F *10^-6)	Assigned
Fc_4	3,605.00	0.1697	1,541.00	0.0001	5.500000	No
Fc_4_wtls	3,605.00	0.1697	1,541.00	0.0000	5.500000	No
Fc_5	4,031.00	0.1704	1,722.00	0.0001	5.500000	Yes
Fc_5_wtls	4,031.00	0.1704	1,722.00	0.0000	5.500000	Yes

INPUT : Spring Properties

Name	Type	Backbone	Polygonal Hysteretic Model	Alpha	Beta 1	Beta 2	Gamma	Mu	Assigned	Number of Points
Clay	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Shale	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Limestone	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Yes	3

INPUT : Clay Spring Curve

Displacement (in)	Force (lb)
-1.0000	-8,640.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Shale Spring Curve

Displacement (in)	Force (lb)
-1.0000	-12,960.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Limestone Spring Curve

Displacement (in)	Force (lb)
-1.0000	-1,800.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Sections

Name	Section Area (in²)	Shear Area in yy (in²)	Shear Area in zz (in²)	Torsion Constant (in^4)	Inertia Izz (in^4)	Inertia Iyy (in^4)	Plastic Modulus Zyy (in³)	Plastic Modulus Zzz (in³)	Perimeter (in)	Material Time-Effect	Ductility	Residual Strength (%)	Assigned
Wall	###	###	###	###	###	###	0.0000	0.0000	52.0000	(NONE)	50.	0.	Yes
Slab	###	###	###	###	###	###	0.0000	0.0000	54.0000	(NONE)	50.	0.	Yes
Wall - Stiff	###	###	###	###	###	###	0.0000	0.0000	52.0000	(NONE)	50.	0.	Yes
Slab - Stiff	###	###	###	###	###	###	0.0000	0.0000	54.0000	(NONE)	50.	0.	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
1	-0.1667	0.0000	0.0000	all free	all free	Global	Yes
2	0.2500	0.0000	0.0000	all free	all free	Global	Yes
3	0.7500	0.0000	0.0000	all free	all free	Global	Yes
4	1.2500	0.0000	0.0000	all free	all free	Global	Yes
5	1.3300	0.0000	0.0000	all free	all free	Global	Yes
6	1.7500	0.0000	0.0000	all free	all free	Global	Yes
7	1.9200	0.0000	0.0000	all free	all free	Global	Yes
8	2.2500	0.0000	0.0000	all free	all free	Global	Yes
9	2.5000	0.0000	0.0000	all free	all free	Global	Yes
10	2.7500	0.0000	0.0000	all free	all free	Global	Yes
11	3.2500	0.0000	0.0000	all free	all free	Global	Yes
12	3.7500	0.0000	0.0000	all free	all free	Global	Yes
13	4.2500	0.0000	0.0000	all free	all free	Global	Yes
14	4.7500	0.0000	0.0000	all free	all free	Global	Yes
15	5.2500	0.0000	0.0000	all free	all free	Global	Yes
16	5.7500	0.0000	0.0000	all free	all free	Global	Yes
17	6.2500	0.0000	0.0000	all free	all free	Global	Yes
18	6.7500	0.0000	0.0000	all free	all free	Global	Yes
19	7.2500	0.0000	0.0000	all free	all free	Global	Yes
20	7.7500	0.0000	0.0000	all free	all free	Global	Yes
21	8.2500	0.0000	0.0000	all free	all free	Global	Yes
22	8.7500	0.0000	0.0000	all free	all free	Global	Yes
23	9.2500	0.0000	0.0000	all free	all free	Global	Yes
24	9.7500	0.0000	0.0000	all free	all free	Global	Yes
29	10.2500	0.0000	0.0000	all free	all free	Global	Yes
30	10.7500	0.0000	0.0000	all free	all free	Global	Yes
31	11.2500	0.0000	0.0000	all free	all free	Global	Yes
32	11.7500	0.0000	0.0000	all free	all free	Global	Yes
33	12.2500	0.0000	0.0000	all free	all free	Global	Yes
34	12.7500	0.0000	0.0000	all free	all free	Global	Yes
35	13.2500	0.0000	0.0000	x, y fixed	all free	Global	Yes
36	13.7500	0.0000	0.0000	x, y fixed	all free	Global	Yes
37	14.2500	0.0000	0.0000	all free	all free	Global	Yes
38	14.7500	0.0000	0.0000	all free	all free	Global	Yes
39	15.2500	0.0000	0.0000	all free	all free	Global	Yes
40	15.7500	0.0000	0.0000	all free	all free	Global	Yes
41	16.2500	0.0000	0.0000	all free	all free	Global	Yes
46	16.7500	0.0000	0.0000	all free	all free	Global	Yes
47	17.2500	0.0000	0.0000	all free	all free	Global	Yes
48	17.7500	0.0000	0.0000	all free	all free	Global	Yes
49	18.2500	0.0000	0.0000	all free	all free	Global	Yes
50	18.7500	0.0000	0.0000	all free	all free	Global	Yes
51	19.2500	0.0000	0.0000	all free	all free	Global	Yes
52	19.7500	0.0000	0.0000	all free	all free	Global	Yes
53	20.2500	0.0000	0.0000	all free	all free	Global	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
54	20.7500	0.0000	0.0000	all free	all free	Global	Yes
55	21.2500	0.0000	0.0000	all free	all free	Global	Yes
56	21.7500	0.0000	0.0000	all free	all free	Global	Yes
57	22.2500	0.0000	0.0000	all free	all free	Global	Yes
58	22.7500	0.0000	0.0000	all free	all free	Global	Yes
59	23.2500	0.0000	0.0000	all free	all free	Global	Yes
60	23.7500	0.0000	0.0000	all free	all free	Global	Yes
61	24.2500	0.0000	0.0000	all free	all free	Global	Yes
62	24.5000	0.0000	0.0000	all free	all free	Global	Yes
63	24.7500	0.0000	0.0000	all free	all free	Global	Yes
64	25.0800	0.0000	0.0000	all free	all free	Global	Yes
65	25.2500	0.0000	0.0000	all free	all free	Global	Yes
66	25.6700	0.0000	0.0000	all free	all free	Global	Yes
67	25.7500	0.0000	0.0000	all free	all free	Global	Yes
68	26.2500	0.0000	0.0000	all free	all free	Global	Yes
69	26.7500	0.0000	0.0000	all free	all free	Global	Yes
70	27.0000	0.0000	0.0000	all free	all free	Global	Yes
71	1.9167	0.0000	0.6250	all free	all free	Global	Yes
72	1.9167	0.0000	3.9600	all free	all free	Global	Yes
73	1.9167	0.0000	10.6250	all free	all free	Global	Yes
74	25.0833	0.0000	0.6250	all free	all free	Global	Yes
75	25.0800	0.0000	3.9600	all free	all free	Global	Yes
76	25.0833	0.0000	10.6250	all free	all free	Global	Yes

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
1	1	2	-	Beam	Slab	(same as	Fc_5	0.0000	.4167	0.0000	0.0000	0.0000	0	(none)
2	2	3	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
3	3	4	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
4	4	5	-	Beam	Slab	(same as	Fc_5	0.0000	.08	0.0000	0.0000	0.0000	0	(none)
5	5	6	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.42	0.0000	0.0000	0.0000	0	(none)
6	6	7	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.17	0.0000	0.0000	0.0000	0	(none)
7	7	8	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.33	0.0000	0.0000	0.0000	0	(none)
8	8	9	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
9	9	10	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
10	10	11	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
11	11	12	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
12	12	13	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
13	13	14	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
14	14	15	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
15	15	16	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
16	16	17	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
17	17	18	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
18	18	19	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
19	19	20	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
20	20	21	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
21	21	22	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
22	22	23	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
23	23	24	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
24	24	29	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
29	29	30	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
30	30	31	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
31	31	32	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
32	32	33	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
33	33	34	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
34	34	35	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
35	35	36	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
36	36	37	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
37	37	38	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
38	38	39	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
39	39	40	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
40	40	41	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
41	41	46	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
46	46	47	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
47	47	48	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
48	48	49	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
49	49	50	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
50	50	51	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
51	51	52	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
52	52	53	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
53	53	54	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
54	54	55	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
55	55	56	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
56	56	57	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
57	57	58	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
58	58	59	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
59	59	60	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
60	60	61	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
61	61	62	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
62	62	63	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
63	63	64	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.33	0.0000	0.0000	0.0000	0	(none)
64	64	65	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.17	0.0000	0.0000	0.0000	0	(none)
65	65	66	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.42	0.0000	0.0000	0.0000	0	(none)
66	66	67	-	Beam	Slab	(same as	Fc_5	0.0000	.08	0.0000	0.0000	0.0000	0	(none)
67	67	68	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
68	68	69	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
69	69	70	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
70	7	71	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
71	71	72	-	Beam	Wall	(same as	Fc_5	0.0000	3.335	0.0000	0.0000	0.0000	0	(none)
72	72	73	-	Beam	Wall	(same as	Fc_5	0.0000	6.665	0.0000	0.0000	0.0000	0	(none)
73	64	74	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
74	74	75	-	Beam	Wall	(same as	Fc_5	0.0000	3.335	0.0000	0.0000	0.0000	0	(none)
75	75	76	-	Beam	Wall	(same as	Fc_5	0.0000	6.665	0.0000	0.0000	0.0000	0	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compressi on (lb/in)	Maximum Tension (lb or lb-in)	Maximum Compressi on (lb or lb-	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
1	2	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
2	3	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
3	4	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
4	6	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
5	8	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
6	10	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
7	11	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
8	12	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
9	13	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
10	14	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
11	15	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
12	16	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
13	17	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
14	18	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
15	19	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
16	20	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
17	21	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
18	22	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
19	23	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
20	24	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
21	29	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
22	30	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
23	31	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
24	32	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
29	33	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
30	34	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
31	35	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
32	36	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
33	37	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
34	38	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
35	39	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
36	40	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
37	41	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
38	46	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
39	47	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
40	48	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
41	49	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
46	50	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
47	51	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
48	52	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
49	53	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
50	54	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
51	55	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
52	56	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
53	57	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
54	58	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
55	59	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compression (lb/in)	Maximum Tension (lb)	Maximum Compression (lb)	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
56	60	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
57	61	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
58	63	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
59	65	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
60	67	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
61	68	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
62	69	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

LOAD COMBINATION 1.1

Load Case	Factor
D	1.40

LOAD COMBINATION 1.2

Load Case	Factor
D	1.20
H1	1.60

LOAD COMBINATION 1.3

Load Case	Factor
D	1.20
H1	0.60

LOAD COMBINATION 1.4

Load Case	Factor
D	1.20
H1	1.60
L1	1.60

LOAD COMBINATION 1.5

Load Case	Factor
D	0.90
H1	1.60

LOAD COMBINATION 1.6

Load Case	Factor
D	0.90
H1	0.60

LOAD COMBINATION 2.1

Load Case	Factor
D	1.20
H1	1.60
F	1.20

LOAD COMBINATION 2.2

Load Case	Factor
D	1.20
H1	0.60
F	1.20

LOAD COMBINATION 2.3

Load Case	Factor
D	1.20
H1	1.60
F	1.20
L1	1.60

LOAD COMBINATION 2.4

Load Case	Factor
D	0.90
H1	1.60
F	1.20

LOAD COMBINATION 2.5

Load Case	Factor
D	0.90
H1	0.60
F	1.20

LOAD COMBINATION 3.1

Load Case	Factor
D	1.20
H2	1.60
F	1.20

LOAD COMBINATION 3.2

Load Case	Factor
D	1.20

LOAD COMBINATION 3.2

Load Case	Factor
H2	0.60
F	1.20

LOAD COMBINATION 3.3

Load Case	Factor
D	1.20
H2	1.60
F	1.20
L2	1.60

LOAD COMBINATION 3.4

Load Case	Factor
D	0.90
H2	1.60
F	1.20

LOAD COMBINATION 3.5

Load Case	Factor
D	0.90
H2	0.60
F	1.20

LOAD COMBINATION 4.1

Load Case	Factor
D	1.20
H2	1.60

LOAD COMBINATION 4.2

Load Case	Factor
D	1.20
H2	0.60

LOAD COMBINATION 4.3

Load Case	Factor
D	1.20
H2	1.60
L2	1.60

LOAD COMBINATION 4.4

Load Case	Factor
D	0.90
H2	1.60

LOAD COMBINATION 4.5

Load Case	Factor
D	0.90
H2	0.60

LOAD COMBINATION S.1

Load Case	Factor
D	1.00
H1	1.00
L1	1.00

LOAD COMBINATION S.2

Load Case	Factor
D	1.00
H1	1.00
F	1.00
L1	1.00

LOAD COMBINATION S.3

Load Case	Factor
D	1.00
H2	1.00
F	1.00
L2	1.00

LOAD COMBINATION S.4

Load Case	Factor
D	1.00
H2	1.00
L2	1.00

B-2: Design Section 2

Lake Quivira Spillway - Design Section 2

Thursday, June 29, 2023

Tel:

PROJECT SUMMARY

INPUT PROPERTIES	Count
Universal Restraints	Ty Rxz
Materials	4
Sections	4
User Coordinate System	NONE
Spring Curves	3
Isolater Property	NONE
Creep Definitions	NONE

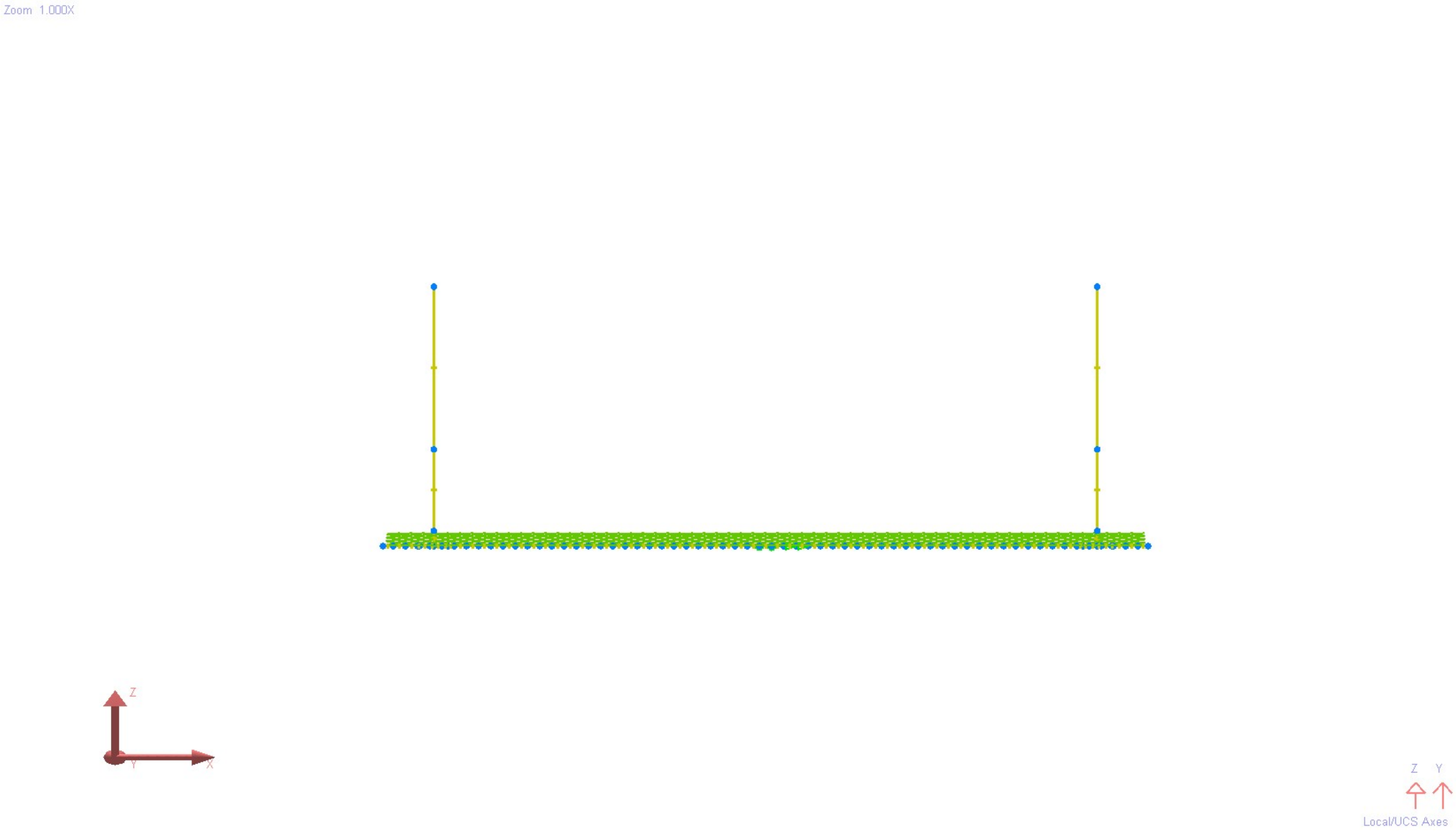
INPUT GEOMETRY	Count
Joints	76
Members	75
Plates	NONE
Springs	62
Isolaters	NONE
Mass Elements	NONE
Slave / Masters	NONE
Tendons	NONE

Load Cases	Count
Load Cases	6
Combination Cases	25
Construction Stages	NONE
Linked Databases	NONE

TABLE OF CONTENTS

INPUTS	Page#	Results	Page#
- INPUT : Material Properties	Page 5		
- INPUT : Spring Properties	Page 5		
- INPUT : Clay Spring Curve	Page 5		
- INPUT : Shale Spring Curve	Page 5		
- INPUT : Limestone Spring Curve	Page 5		
- INPUT : Sections	Page 5		
- INPUT : Joints	Page 6		
- INPUT : Members	Page 7		
- INPUT : Springs	Page 9		

Graphics View 1



INPUT : Material Properties

Name	Modulus of Elasticity (kips/in^2)	Poisson Ratio	Shear Modulus (kips/in^2)	Unit Weight (kips/in^3)	Thermal Expansion (1/ °F *10^-6)	Assigned
Fc_4	3,605.00	0.1697	1,541.00	0.0001	5.500000	No
Fc_4_wtls	3,605.00	0.1697	1,541.00	0.0000	5.500000	No
Fc_5	4,031.00	0.1704	1,722.00	0.0001	5.500000	Yes
Fc_5_wtls	4,031.00	0.1704	1,722.00	0.0000	5.500000	Yes

INPUT : Spring Properties

Name	Type	Backbone	Polygonal Hysteretic Model	Alpha	Beta 1	Beta 2	Gamma	Mu	Assigned	Number of Points
Clay	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Shale	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Limestone	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Yes	3

INPUT : Clay Spring Curve

Displacement (in)	Force (lb)
-1.0000	-8,640.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Shale Spring Curve

Displacement (in)	Force (lb)
-1.0000	-12,960.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Limestone Spring Curve

Displacement (in)	Force (lb)
-1.0000	-1,800.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Sections

Name	Section Area (in^2)	Shear Area in yy (in^2)	Shear Area in zz (in^2)	Torsion Constant (in^4)	Inertia Izz (in^4)	Inertia Iyy (in^4)	Plastic Modulus Zyy (in^3)	Plastic Modulus Zzz (in^3)	Perimeter (in)	Material Time-Effect	Ductility	Residual Strength (%)	Assigned
Wall	###	###	###	###	###	###	0.0000	0.0000	52.0000	(NONE)	50.	0.	Yes
Slab	###	###	###	###	###	###	0.0000	0.0000	54.0000	(NONE)	50.	0.	Yes
Wall - Stiff	###	###	###	###	###	###	0.0000	0.0000	52.0000	(NONE)	50.	0.	Yes
Slab - Stiff	###	###	###	###	###	###	0.0000	0.0000	54.0000	(NONE)	50.	0.	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
1	-0.1667	0.0000	0.0000	all free	all free	Global	Yes
2	0.2500	0.0000	0.0000	all free	all free	Global	Yes
3	0.7500	0.0000	0.0000	all free	all free	Global	Yes
4	1.2500	0.0000	0.0000	all free	all free	Global	Yes
5	1.3300	0.0000	0.0000	all free	all free	Global	Yes
6	1.7500	0.0000	0.0000	all free	all free	Global	Yes
7	1.9167	0.0000	0.0000	all free	all free	Global	Yes
8	2.2500	0.0000	0.0000	all free	all free	Global	Yes
9	2.5000	0.0000	0.0000	all free	all free	Global	Yes
10	2.7500	0.0000	0.0000	all free	all free	Global	Yes
11	3.2500	0.0000	0.0000	all free	all free	Global	Yes
12	3.7500	0.0000	0.0000	all free	all free	Global	Yes
13	4.2500	0.0000	0.0000	all free	all free	Global	Yes
14	4.7500	0.0000	0.0000	all free	all free	Global	Yes
15	5.2500	0.0000	0.0000	all free	all free	Global	Yes
16	5.7500	0.0000	0.0000	all free	all free	Global	Yes
17	6.2500	0.0000	0.0000	all free	all free	Global	Yes
18	6.7500	0.0000	0.0000	all free	all free	Global	Yes
19	7.2500	0.0000	0.0000	all free	all free	Global	Yes
20	7.7500	0.0000	0.0000	all free	all free	Global	Yes
21	8.2500	0.0000	0.0000	all free	all free	Global	Yes
22	8.7500	0.0000	0.0000	all free	all free	Global	Yes
23	9.2500	0.0000	0.0000	all free	all free	Global	Yes
24	9.7500	0.0000	0.0000	all free	all free	Global	Yes
25	10.2500	0.0000	0.0000	all free	all free	Global	Yes
26	10.7500	0.0000	0.0000	all free	all free	Global	Yes
27	11.2500	0.0000	0.0000	all free	all free	Global	Yes
28	11.7500	0.0000	0.0000	all free	all free	Global	Yes
29	12.2500	0.0000	0.0000	all free	all free	Global	Yes
30	12.7500	0.0000	0.0000	all free	all free	Global	Yes
31	13.2500	0.0000	0.0000	all free	all free	Global	Yes
32	13.7500	0.0000	0.0000	all free	all free	Global	Yes
33	14.2500	0.0000	0.0000	all free	all free	Global	Yes
34	14.7500	0.0000	0.0000	all free	all free	Global	Yes
35	15.2500	0.0000	0.0000	x, y fixed	all free	Global	Yes
36	15.7500	0.0000	0.0000	x, y fixed	all free	Global	Yes
37	16.2500	0.0000	0.0000	all free	all free	Global	Yes
38	16.7500	0.0000	0.0000	all free	all free	Global	Yes
39	17.2500	0.0000	0.0000	all free	all free	Global	Yes
40	17.7500	0.0000	0.0000	all free	all free	Global	Yes
41	18.2500	0.0000	0.0000	all free	all free	Global	Yes
42	18.7500	0.0000	0.0000	all free	all free	Global	Yes
43	19.2500	0.0000	0.0000	all free	all free	Global	Yes
44	19.7500	0.0000	0.0000	all free	all free	Global	Yes
45	20.2500	0.0000	0.0000	all free	all free	Global	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
46	20.7500	0.0000	0.0000	all free	all free	Global	Yes
47	21.2500	0.0000	0.0000	all free	all free	Global	Yes
48	21.7500	0.0000	0.0000	all free	all free	Global	Yes
49	22.2500	0.0000	0.0000	all free	all free	Global	Yes
50	22.7500	0.0000	0.0000	all free	all free	Global	Yes
51	23.2500	0.0000	0.0000	all free	all free	Global	Yes
52	23.7500	0.0000	0.0000	all free	all free	Global	Yes
53	24.2500	0.0000	0.0000	all free	all free	Global	Yes
54	24.7500	0.0000	0.0000	all free	all free	Global	Yes
55	25.2500	0.0000	0.0000	all free	all free	Global	Yes
56	25.7500	0.0000	0.0000	all free	all free	Global	Yes
57	26.2500	0.0000	0.0000	all free	all free	Global	Yes
58	26.7500	0.0000	0.0000	all free	all free	Global	Yes
59	27.2500	0.0000	0.0000	all free	all free	Global	Yes
60	27.7500	0.0000	0.0000	all free	all free	Global	Yes
61	28.2500	0.0000	0.0000	all free	all free	Global	Yes
62	28.5000	0.0000	0.0000	all free	all free	Global	Yes
63	28.7500	0.0000	0.0000	all free	all free	Global	Yes
64	29.0800	0.0000	0.0000	all free	all free	Global	Yes
65	29.2500	0.0000	0.0000	all free	all free	Global	Yes
66	29.6700	0.0000	0.0000	all free	all free	Global	Yes
67	29.7500	0.0000	0.0000	all free	all free	Global	Yes
68	30.2500	0.0000	0.0000	all free	all free	Global	Yes
69	30.7500	0.0000	0.0000	all free	all free	Global	Yes
70	31.1667	0.0000	0.0000	all free	all free	Global	Yes
71	1.9167	0.0000	0.6250	all free	all free	Global	Yes
72	1.9167	0.0000	3.9583	all free	all free	Global	Yes
73	1.9167	0.0000	10.6250	all free	all free	Global	Yes
74	29.0833	0.0000	0.6250	all free	all free	Global	Yes
75	29.0833	0.0000	3.9583	all free	all free	Global	Yes
76	29.0833	0.0000	10.6250	all free	all free	Global	Yes

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
1	1	2	-	Beam	Slab	(same as	Fc_5	0.0000	.4167	0.0000	0.0000	0.0000	0	(none)
2	2	3	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
3	3	4	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
4	4	5	-	Beam	Slab	(same as	Fc_5	0.0000	.08	0.0000	0.0000	0.0000	0	(none)
5	5	6	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.42	0.0000	0.0000	0.0000	0	(none)
6	6	7	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.1667	0.0000	0.0000	0.0000	0	(none)
7	7	8	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.3333	0.0000	0.0000	0.0000	0	(none)
8	8	9	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
9	9	10	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
10	10	11	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
11	11	12	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
12	12	13	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
13	13	14	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
14	14	15	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
15	15	16	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
16	16	17	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
17	17	18	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
18	18	19	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
19	19	20	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
20	20	21	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
21	21	22	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
22	22	23	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
23	23	24	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
24	24	25	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
25	25	26	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
26	26	27	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
27	27	28	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
28	28	29	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
29	29	30	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
30	30	31	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
31	31	32	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
32	32	33	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
33	33	34	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
34	34	35	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
35	35	36	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
36	36	37	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
37	37	38	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
38	38	39	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
39	39	40	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
40	40	41	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
41	41	42	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
42	42	43	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
43	43	44	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
44	44	45	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
45	45	46	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
46	46	47	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
47	47	48	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
48	48	49	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
49	49	50	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
50	50	51	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
51	51	52	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
52	52	53	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
53	53	54	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
54	54	55	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
55	55	56	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
56	56	57	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
57	57	58	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
58	58	59	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
59	59	60	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
60	60	61	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
61	61	62	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
62	62	63	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
63	63	64	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.33	0.0000	0.0000	0.0000	0	(none)
64	64	65	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.17	0.0000	0.0000	0.0000	0	(none)
65	65	66	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.42	0.0000	0.0000	0.0000	0	(none)
66	66	67	-	Beam	Slab	(same as	Fc_5	0.0000	.08	0.0000	0.0000	0.0000	0	(none)
67	67	68	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
68	68	69	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
69	69	70	-	Beam	Slab	(same as	Fc_5	0.0000	.4167	0.0000	0.0000	0.0000	0	(none)
70	7	71	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
71	71	72	-	Beam	Wall	(same as	Fc_5	0.0000	3.3333	0.0000	0.0000	0.0000	0	(none)
72	72	73	-	Beam	Wall	(same as	Fc_5	0.0000	6.6667	0.0000	0.0000	0.0000	0	(none)
73	64	74	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
74	74	75	-	Beam	Wall	(same as	Fc_5	0.0000	3.3333	0.0000	0.0000	0.0000	0	(none)
75	75	76	-	Beam	Wall	(same as	Fc_5	0.0000	6.6667	0.0000	0.0000	0.0000	0	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compression (lb/in)	Maximum Tension (lb or lb-in)	Maximum Compression (lb or lb-	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
2	2	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
3	3	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
4	4	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
6	6	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
8	8	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
10	10	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
11	11	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
12	12	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
13	13	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
14	14	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
15	15	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
16	16	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
17	17	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
18	18	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
19	19	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
20	20	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
21	21	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
22	22	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
23	23	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
24	24	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
25	25	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
26	26	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
27	27	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
28	28	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
29	29	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
30	30	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
31	31	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
32	32	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
33	33	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
34	34	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
35	35	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compression (lb/in)	Maximum Tension (lb)	Maximum Compression (lb)	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
36	36	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
37	37	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
38	38	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
39	39	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
40	40	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
41	41	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
42	42	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
43	43	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
44	44	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
45	45	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
46	46	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
47	47	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
48	48	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
49	49	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
50	50	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
51	51	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
52	52	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
53	53	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
54	54	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
55	55	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
56	56	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
57	57	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
58	58	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
59	59	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
60	60	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
61	61	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
63	63	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
65	65	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
67	67	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
68	68	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
69	69	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

LOAD COMBINATION 1.1

Load Case	Factor
D	1.40

LOAD COMBINATION 1.2

Load Case	Factor
D	1.20
H1	1.60

LOAD COMBINATION 1.3

Load Case	Factor
D	1.20

LOAD COMBINATION 1.3

Load Case	Factor
H1	0.60

LOAD COMBINATION 1.4

Load Case	Factor
D	1.20
H1	1.60
L1	1.60

LOAD COMBINATION 1.5

Load Case	Factor
D	0.90
H1	1.60

LOAD COMBINATION 1.6

Load Case	Factor
D	0.90
H1	0.60

LOAD COMBINATION 2.1

Load Case	Factor
D	1.20
H1	1.60
F	1.20

LOAD COMBINATION 2.2

Load Case	Factor
D	1.20
H1	0.60
F	1.20

LOAD COMBINATION 2.3

Load Case	Factor
D	1.20
H1	1.60
F	1.20
L1	1.60

LOAD COMBINATION 2.4

Load Case	Factor
D	0.90
H1	1.60
F	1.20

LOAD COMBINATION 2.5

Load Case	Factor
D	0.90
H1	0.60
F	1.20

LOAD COMBINATION 3.1

Load Case	Factor
D	1.20
H2	1.60
F	1.20

LOAD COMBINATION 3.2

Load Case	Factor
D	1.20
H2	0.60
F	1.20

LOAD COMBINATION 3.3

Load Case	Factor
D	1.20
H2	1.60
F	1.20
L2	1.60

LOAD COMBINATION 3.4

Load Case	Factor
D	0.90
H2	1.60
F	1.20

LOAD COMBINATION 3.5

Load Case	Factor
D	0.90

LOAD COMBINATION 3.5

Load Case	Factor
H2	0.60
F	1.20

LOAD COMBINATION 4.1

Load Case	Factor
D	1.20
H2	1.60

LOAD COMBINATION 4.2

Load Case	Factor
D	1.20
H2	0.60

LOAD COMBINATION 4.3

Load Case	Factor
D	1.20
H2	1.60
L2	1.60

LOAD COMBINATION 4.4

Load Case	Factor
D	0.90
H2	1.60

LOAD COMBINATION 4.5

Load Case	Factor
D	0.90
H2	0.60

LOAD COMBINATION S.1

Load Case	Factor
D	1.00
H1	1.00
L1	1.00

LOAD COMBINATION S.2

Load Case	Factor
D	1.00

LOAD COMBINATION S.2

Load Case	Factor
H1	1.00
F	1.00
L1	1.00

LOAD COMBINATION S.3

Load Case	Factor
D	1.00
H2	1.00
F	1.00
L2	1.00

LOAD COMBINATION S.4

Load Case	Factor
D	1.00
H2	1.00
L2	1.00

B-3: Design Section 3

Lake Quivira Spillway - Design Section 3

Thursday, June 29, 2023

Tel:

PROJECT SUMMARY

INPUT PROPERTIES	Count
Universal Restraints	Ty Rxz
Materials	4
Sections	4
User Coordinate System	NONE
Spring Curves	3
Isolater Property	NONE
Creep Definitions	NONE

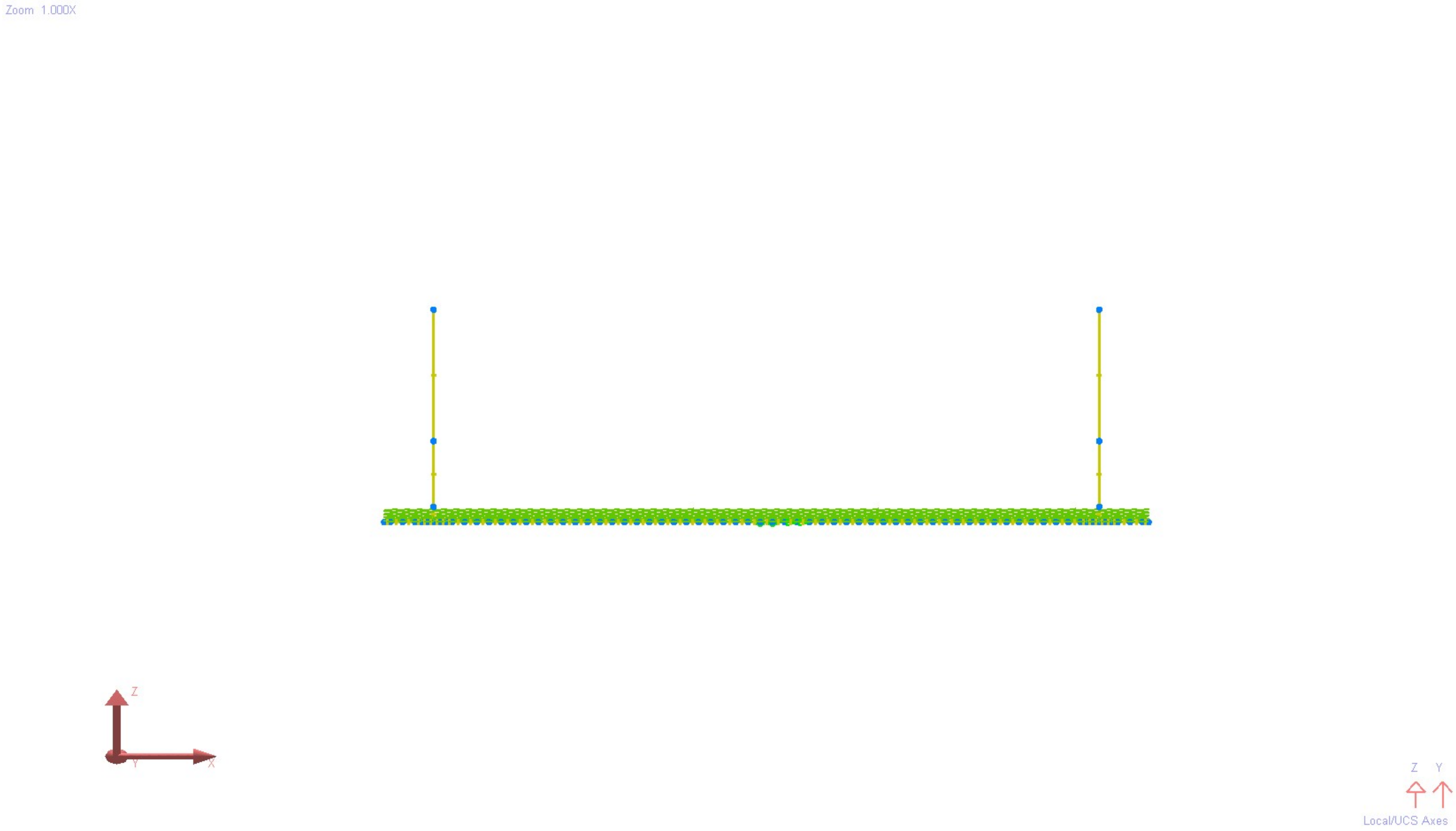
INPUT GEOMETRY	Count
Joints	76
Members	75
Plates	NONE
Springs	62
Isolaters	NONE
Mass Elements	NONE
Slave / Masters	NONE
Tendons	NONE

Load Cases	Count
Load Cases	6
Combination Cases	29
Construction Stages	NONE
Linked Databases	NONE

TABLE OF CONTENTS

INPUTS	Page#	Results	Page#
- INPUT : Material Properties	Page 5		
- INPUT : Spring Properties	Page 5		
- INPUT : Clay Spring Curve	Page 5		
- INPUT : Shale Spring Curve	Page 5		
- INPUT : Limestone Spring Curve	Page 5		
- INPUT : Joints	Page 5		
- INPUT : Members	Page 7		
- INPUT : Springs	Page 9		

Graphics View 1



INPUT : Material Properties

Name	Modulus of Elasticity (kips/in²)	Poisson Ratio	Shear Modulus (kips/in²)	Unit Weight (kips/in³)	Thermal Expansion (1/ °F *10^-6)	Assigned
Fc_4	3,605.00	0.1697	1,541.00	0.0001	5.500000	No
Fc_4_wtls	3,605.00	0.1697	1,541.00	0.0000	5.500000	No
Fc_5	4,031.00	0.1704	1,722.00	0.0001	5.500000	Yes
Fc_5_wtls	4,031.00	0.1704	1,722.00	0.0000	5.500000	Yes

INPUT : Spring Properties

Name	Type	Backbone	Polygonal Hysteretic Model	Alpha	Beta 1	Beta 2	Gamma	Mu	Assigned	Number of Points
Clay	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Shale	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No	3
Limestone	Curve: Translational	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Yes	3

INPUT : Clay Spring Curve

Displacement (in)	Force (lb)
-1.0000	-8,640.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Shale Spring Curve

Displacement (in)	Force (lb)
-1.0000	-12,960.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Limestone Spring Curve

Displacement (in)	Force (lb)
-1.0000	-1,800.0000
0.0000	0.0000
1.0000	0.0000

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
1	0.0000	0.0000	0.0000	all free	all free	Global	Yes
2	0.2500	0.0000	0.0000	all free	all free	Global	Yes
3	0.7500	0.0000	0.0000	all free	all free	Global	Yes
4	1.2500	0.0000	0.0000	all free	all free	Global	Yes
5	1.5000	0.0000	0.0000	all free	all free	Global	Yes
6	1.7500	0.0000	0.0000	all free	all free	Global	Yes
7	2.0000	0.0000	0.0000	all free	all free	Global	Yes
8	2.2500	0.0000	0.0000	all free	all free	Global	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
9	2.5000	0.0000	0.0000	all free	all free	Global	Yes
10	2.7500	0.0000	0.0000	all free	all free	Global	Yes
11	3.2500	0.0000	0.0000	all free	all free	Global	Yes
12	3.7500	0.0000	0.0000	all free	all free	Global	Yes
13	4.2500	0.0000	0.0000	all free	all free	Global	Yes
14	4.7500	0.0000	0.0000	all free	all free	Global	Yes
15	5.2500	0.0000	0.0000	all free	all free	Global	Yes
16	5.7500	0.0000	0.0000	all free	all free	Global	Yes
17	6.2500	0.0000	0.0000	all free	all free	Global	Yes
18	6.7500	0.0000	0.0000	all free	all free	Global	Yes
19	7.2500	0.0000	0.0000	all free	all free	Global	Yes
20	7.7500	0.0000	0.0000	all free	all free	Global	Yes
21	8.2500	0.0000	0.0000	all free	all free	Global	Yes
22	8.7500	0.0000	0.0000	all free	all free	Global	Yes
23	9.2500	0.0000	0.0000	all free	all free	Global	Yes
24	9.7500	0.0000	0.0000	all free	all free	Global	Yes
25	10.2500	0.0000	0.0000	all free	all free	Global	Yes
26	10.7500	0.0000	0.0000	all free	all free	Global	Yes
27	11.2500	0.0000	0.0000	all free	all free	Global	Yes
28	11.7500	0.0000	0.0000	all free	all free	Global	Yes
29	12.2500	0.0000	0.0000	all free	all free	Global	Yes
30	12.7500	0.0000	0.0000	all free	all free	Global	Yes
31	13.2500	0.0000	0.0000	all free	all free	Global	Yes
32	13.7500	0.0000	0.0000	all free	all free	Global	Yes
33	14.2500	0.0000	0.0000	all free	all free	Global	Yes
34	14.7500	0.0000	0.0000	all free	all free	Global	Yes
35	15.2500	0.0000	0.0000	x, y fixed	all free	Global	Yes
36	15.7500	0.0000	0.0000	x, y fixed	all free	Global	Yes
37	16.2500	0.0000	0.0000	all free	all free	Global	Yes
38	16.7500	0.0000	0.0000	all free	all free	Global	Yes
39	17.2500	0.0000	0.0000	all free	all free	Global	Yes
40	17.7500	0.0000	0.0000	all free	all free	Global	Yes
41	18.2500	0.0000	0.0000	all free	all free	Global	Yes
42	18.7500	0.0000	0.0000	all free	all free	Global	Yes
43	19.2500	0.0000	0.0000	all free	all free	Global	Yes
44	19.7500	0.0000	0.0000	all free	all free	Global	Yes
45	20.2500	0.0000	0.0000	all free	all free	Global	Yes
46	20.7500	0.0000	0.0000	all free	all free	Global	Yes
47	21.2500	0.0000	0.0000	all free	all free	Global	Yes
48	21.7500	0.0000	0.0000	all free	all free	Global	Yes
49	22.2500	0.0000	0.0000	all free	all free	Global	Yes
50	22.7500	0.0000	0.0000	all free	all free	Global	Yes
51	23.2500	0.0000	0.0000	all free	all free	Global	Yes
52	23.7500	0.0000	0.0000	all free	all free	Global	Yes
53	24.2500	0.0000	0.0000	all free	all free	Global	Yes
54	24.7500	0.0000	0.0000	all free	all free	Global	Yes
55	25.2500	0.0000	0.0000	all free	all free	Global	Yes
56	25.7500	0.0000	0.0000	all free	all free	Global	Yes
57	26.2500	0.0000	0.0000	all free	all free	Global	Yes

INPUT : Joints

ID	X (ft)	Y (ft)	Z (ft)	Translation DOF [y fixed]	Rotation DOF [x, z fixed]	Displacement UCS	Assignment
58	26.7500	0.0000	0.0000	all free	all free	Global	Yes
59	27.2500	0.0000	0.0000	all free	all free	Global	Yes
60	27.7500	0.0000	0.0000	all free	all free	Global	Yes
61	28.2500	0.0000	0.0000	all free	all free	Global	Yes
62	28.5000	0.0000	0.0000	all free	all free	Global	Yes
63	28.7500	0.0000	0.0000	all free	all free	Global	Yes
64	29.0000	0.0000	0.0000	all free	all free	Global	Yes
65	29.2500	0.0000	0.0000	all free	all free	Global	Yes
66	29.5000	0.0000	0.0000	all free	all free	Global	Yes
67	29.7500	0.0000	0.0000	all free	all free	Global	Yes
68	30.2500	0.0000	0.0000	all free	all free	Global	Yes
69	30.7500	0.0000	0.0000	all free	all free	Global	Yes
70	31.0000	0.0000	0.0000	all free	all free	Global	Yes
71	2.0000	0.0000	0.6250	all free	all free	Global	Yes
72	2.0000	0.0000	3.2900	all free	all free	Global	Yes
73	2.0000	0.0000	8.6250	all free	all free	Global	Yes
74	29.0000	0.0000	0.6250	all free	all free	Global	Yes
75	29.0000	0.0000	3.2900	all free	all free	Global	Yes
76	29.0000	0.0000	8.6250	all free	all free	Global	Yes

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
1	1	2	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
2	2	3	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
3	3	4	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
4	4	5	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
5	5	6	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
6	6	7	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
7	7	8	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
8	8	9	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
9	9	10	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
10	10	11	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
11	11	12	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
12	12	13	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
13	13	14	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
14	14	15	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
15	15	16	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
16	16	17	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
17	17	18	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
18	18	19	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
19	19	20	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
20	20	21	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
21	21	22	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
22	22	23	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
23	23	24	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
24	24	25	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
25	25	26	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
26	26	27	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
27	27	28	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
28	28	29	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
29	29	30	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
30	30	31	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
31	31	32	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
32	32	33	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
33	33	34	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
34	34	35	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
35	35	36	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
36	36	37	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
37	37	38	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
38	38	39	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
39	39	40	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
40	40	41	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
41	41	42	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
42	42	43	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
43	43	44	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
44	44	45	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
45	45	46	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
46	46	47	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
47	47	48	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
48	48	49	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
49	49	50	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
50	50	51	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
51	51	52	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
52	52	53	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
53	53	54	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
54	54	55	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
55	55	56	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
56	56	57	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
57	57	58	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
58	58	59	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
59	59	60	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
60	60	61	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
61	61	62	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
62	62	63	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
63	63	64	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
64	64	65	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
65	65	66	-	Beam	Slab - Stiff	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
66	66	67	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
67	67	68	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
68	68	69	-	Beam	Slab	(same as	Fc_5	0.0000	.5	0.0000	0.0000	0.0000	0	(none)
69	69	70	-	Beam	Slab	(same as	Fc_5	0.0000	.25	0.0000	0.0000	0.0000	0	(none)
70	7	71	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
71	71	72	-	Beam	Wall	(same as	Fc_5	0.0000	2.665	0.0000	0.0000	0.0000	0	(none)
72	72	73	-	Beam	Wall	(same as	Fc_5	0.0000	5.335	0.0000	0.0000	0.0000	0	(none)
73	64	74	-	Beam	Wall - Stiff	(same as	Fc_5_wtls	0.0000	.625	0.0000	0.0000	0.0000	0	(none)
74	74	75	-	Beam	Wall	(same as	Fc_5	0.0000	2.665	0.0000	0.0000	0.0000	0	(none)

INPUT : Members

ID	I-Joint	J-Joint	Span	Type	Section at Start	Section at End	Material	Prestress Force	Length (ft)	Rigid Zone from	Rigid Zone from	Orientation Angle	Casting (day	Structure Group
75	75	76	-	Beam	Wall	(same as	Fc_5	0.0000	5.335	0.0000	0.0000	0.0000	0	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compression (lb/in)	Maximum Tension (lb or lb-in)	Maximum Compression (lb or lb-	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
1	2	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
2	3	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
3	4	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
4	6	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
5	8	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
6	10	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
7	11	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
8	12	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
9	13	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
10	14	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
11	15	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
12	16	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
13	17	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
14	18	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
15	19	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
16	20	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
17	21	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
18	22	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
19	23	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
20	24	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
21	25	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
22	26	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
23	27	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
24	28	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
25	29	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
26	30	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
27	31	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
28	32	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
29	33	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
30	34	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
31	35	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
32	36	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
33	37	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
34	38	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
35	39	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
36	40	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
37	41	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
38	42	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
39	43	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
40	44	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
41	45	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
42	46	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
43	47	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

INPUT : Springs

ID	I-Joint	J-Joint	Type	Direction	K Tension (lb/in)	K Compression (lb/in)	Maximum Tension (lb)	Maximum Compression (lb)	Hook (in)	Gap (in)	Properties Definition	Structure / Construction Group
44	48	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
45	49	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
46	50	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
47	51	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
48	52	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
49	53	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
50	54	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
51	55	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
52	56	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
53	57	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
54	58	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
55	59	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
56	60	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
57	61	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
58	63	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
59	65	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
60	67	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
61	68	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)
62	69	(none	Nonlinear	Trans. Z	0	0	0	0	0	0	Limestone	(none)

LOAD COMBINATION 1.1

Load Case	Factor
D	1.40

LOAD COMBINATION 1.2

Load Case	Factor
D	1.20
H1	1.60

LOAD COMBINATION 1.3

Load Case	Factor
D	1.20
H1	0.60

LOAD COMBINATION 1.4

Load Case	Factor
D	1.20
H1	1.60
L1	1.60

LOAD COMBINATION 1.5

Load Case	Factor
D	0.90
H1	1.60

LOAD COMBINATION 1.6

Load Case	Factor
D	0.90
H1	0.60

LOAD COMBINATION 2.1

Load Case	Factor
D	1.20
H1	1.60
F	1.20

LOAD COMBINATION 2.2

Load Case	Factor
D	1.20
H1	0.60
F	1.20

LOAD COMBINATION 2.3

Load Case	Factor
D	1.20
H1	1.60
F	1.20
L1	1.60

LOAD COMBINATION 2.4

Load Case	Factor
D	0.90
H1	1.60
F	1.20

LOAD COMBINATION 2.5

Load Case	Factor
D	0.90
H1	0.60
F	1.20

LOAD COMBINATION 3.1

Load Case	Factor
D	1.20
H2	1.60
F	1.20

LOAD COMBINATION 3.2

Load Case	Factor
D	1.20
H2	0.60
F	1.20

LOAD COMBINATION 3.3

Load Case	Factor
D	1.20
H2	1.60
F	1.20
L2	1.60

LOAD COMBINATION 3.4

Load Case	Factor
D	0.90
H2	1.60
F	1.20

LOAD COMBINATION 3.5

Load Case	Factor
D	0.90
H2	0.60
F	1.20

LOAD COMBINATION 4.1

Load Case	Factor
D	1.20
H2	1.60

LOAD COMBINATION 4.2

Load Case	Factor
D	1.20
H2	0.60

LOAD COMBINATION 4.3

Load Case	Factor
D	1.20
H2	1.60
L2	1.60

LOAD COMBINATION 4.4

Load Case	Factor
D	0.90
H2	1.60

LOAD COMBINATION 4.5

Load Case	Factor
D	0.90
H2	0.60

LOAD COMBINATION 5.1

Load Case	Factor
D	1.40
F	1.40

LOAD COMBINATION 5.2

Load Case	Factor
D	1.20
F	1.20

LOAD COMBINATION 5.3

Load Case	Factor
D	0.90
F	1.20

LOAD COMBINATION S.1

Load Case	Factor
D	1.00
H1	1.00
L1	1.00

LOAD COMBINATION S.2

Load Case	Factor
D	1.00
H1	1.00
F	1.00
L1	1.00

LOAD COMBINATION S.3

Load Case	Factor
D	1.00
H2	1.00
F	1.00
L2	1.00

LOAD COMBINATION S.4

Load Case	Factor
D	1.00
H2	1.00
L2	1.00

LOAD COMBINATION S.5

Load Case	Factor
D	1.00
F	1.00

C - Structural Design

C-1: Design Section 1

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023

Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 1 - 8

STRENGTH DESIGN PARAMETERS:

Conc. Compressive Strength: f'c =	5.00	ksi	
Yield Strength of Reinf.: fy =	60.00	ksi	
Conc. Unit Weight: w_c =	0.145	kcf	
Modulus of Elasticity of Reinf.: E_s =	29000	ksi	
Modulus of Elasticity of Concrete:			
$Ec = 33{,}000w_c^{1.5}\sqrt{f'c}$ =	4074.28	ksi	ACI-350-0 (C5.4.2.4-2)
Modular Ratio: $n = E_s/E_c$ =	7.12		
Compression Zone Factor: β_1 =	0.80		ACI-350-06 §10.2.7.3
Resistance Factor for Flexural-Tension Control:			
φ_f =	0.90		ACI-350-06 §9.3.2.1
Resistance Factor for Shear-Tension Control:			
φ_v =	0.75		ACI-350-06 §9.3.2.2
Design Width: b =	12.00	in	
Environmental Durability Factor, S_d =	1.30		Design Standards No. 14 §3.8.4.6

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 2 - 8

WALL FLEXURE DESIGN - FILL FACE

Member Depth: $h =$ 14.00 in
Factored Applied Moment: $M_u =$ 23.06 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 29.98 k-ft/ft

Try #7 @ 9" on center:

Bar Size: Bar # = 7
Spacing: $s =$ 9.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.875 in
Bar Area: $A_b =$ 0.600 in^2
Effective Depth: $d =$ 11.56 in
Design Steel Area: $A_s =$ 0.800 in^2/ft
Equivalent Stress Block: $a =$ 0.94 in
$c =$ 1.18 in
$\varepsilon_s =$ 0.03
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2) =$ 44.37 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 39.93 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.75**
Check $\varphi_f M_n > 4/3*M_{u,mod}$: <4/3*Mu

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 7.00 in
Stem Moment of Inertia: $I_g =$ 2744.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g/y_t =$ 17.09 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 30.67 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c}*b*d/f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min} =$ 0.49 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.006
$k = \sqrt{[2n\rho+(n\rho)^2]}-n\rho =$ 0.248
$j = 1-k/3 =$ 0.917
Service Applied Moment: $M_s =$ 14.41 k-ft/ft
Tensile Stress in Steel: $f_s =$ 20.38 ksi
$\beta = (h-c)/(d-c) =$ 1.23
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)}) =$ 25.32 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 3 - 8

WALL FLEXURE DESIGN - STREAM FACE

Member Depth: h = 14.00 in
Factored Applied Moment: M_u = 7.29 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 9.47 k-ft/ft

Try #5 @ 9" on center:

Bar Size: Bar # = 5
Spacing: s = 9.00 in
Clear Cover: r = 2.00 in
Bar Diameter: d_b = 0.625 in
Bar Area: A_b = 0.310 in^2
Effective Depth: d = 11.69 in
Design Steel Area: A_s = 0.413 in^2/ft
Equivalent Stress Block: a = 0.49 in
c = 0.61 in
ε_s = 0.05
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: M_n = 23.65 k-ft ACI 350-06 §9.3.2.2
Factored Flex. Resist.: $\varphi_f M_n$ = 21.29 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.44**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 7.00 in
Stem Moment of Inertia: I_g = 2744.00 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t$ = 17.09 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u$ = 9.69 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min}$ = 0.50 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: ρ = 0.003
$k = \sqrt{[2n\rho+(n\rho)^2]} - n\rho$ = 0.185
$j = 1-k/3$ = 0.938
Service Applied Moment: M_s = 0.00 k-ft/ft
Tensile Stress in Steel: f_s = 0.00 ksi
$\beta = (h-c)/(d-c)$ = 1.21
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})$= 26.16 in ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:

$\rho_{h,min}$ = 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 4 - 8

WALL SHEAR DESIGN - FILL FACE IN TENSION

Factored Shear Load: V_u = 6.48 k/ft
Factored Applied Moment: M_u = 276.71 k-in/ft
d = 11.56 in
V_c = 19.18 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c$ = 14.39 k

Confirm Transverse Reinforcement is not Required by Design:
$0.5V_R$ = 7.19 k ACI 350-06 §11.5.5
Check: OK Utilization: **0.90**

WALL SHEAR DESIGN - STREAM FACE IN TENSION

Factored Shear Load: V_u = 2.19 k/ft
Factored Applied Moment: M_u = 7.29 k-in/ft
d = 11.69 in
V_c = 19.88 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c$ = 14.91 k

Confirm Transverse Reinforcement is not Required by Design:
$0.5V_R$ = 7.45 k ACI 350-06 §11.5.5
Check: OK Utilization: **0.29**

WALL SHRINKAGE & TEMPERATURE REINFORCEMENT:

Min. Reinf. Ratio: $\rho_{h,min}$= 0.0040 ACI 350-06 Table 7.12.2.1

Try #5 @ 10" on center on each face horizontal:

Bar Size: Bar # = 5
Spacing: s = 10.00 in
Horizontal Steel Area: A_s = 0.744 in^2
ρ_h = 0.0044
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 5 - 8

FOOTING FLEXURE DESIGN - TOP FACE NEAR WALL:

Member Depth: $h =$ 15.00 in
Factored Applied Moment: $M_u =$ 8.91 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 11.58 k-ft/ft

Try #6 @ 9" on center:

Bar Size: Bar # = 6
Spacing: $s =$ 9.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.750 in
Bar Area: $A_b =$ 0.440 in^2
Effective Depth: $d =$ 12.63 in
Design Steel Area: $A_s =$ 0.587 in^2/ft
Equivalent Stress Block: $a =$ 0.69 in
$c =$ 0.86 in
$\varepsilon_s =$ 0.04
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n =$ 36.02 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 32.42 k-ft
Check: OK Utilization:
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK **0.36**

Minimum Reinforcement: AASHTO §5.6.3.3

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 7.50 in
Stem Moment of Inertia: $I_g =$ 3375.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 11.85 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than $200 * b * d / fy$
$A_{s,min} =$ 0.54 in^2/ft ACI 350-06 §10.5.1
OK

Control of Cracking by Distribution of Reinforcement: AASHTO §5.6.7
Reinforcement Ratio: $\rho =$ 0.004
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho =$ 0.209
$j = 1 - k/3 =$ 0.930
Service Applied Moment: $M_s =$ 1.65 k-ft/ft
Tensile Stress in Steel: $f_s =$ 2.87 ksi
$\beta = (h-c)/(d-c) =$ 1.20
$f_{s.max} = 320/(\beta\sqrt{(s^2 + 4(2 + d_b/2)^2)}) =$ 26.16 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 6 - 8

FOOTING FLEXURE DESIGN - TOP FACE NEAR CENTER:

Member Depth: $h =$ 8.76 in
Factored Applied Moment: $M_u =$ 10.63 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 13.82 k-ft/ft

Try #7 @ 9" on center:

Bar Size: Bar # = 7
Spacing: $s =$ 9.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.875 in
Bar Area: $A_b =$ 0.600 in^2
Effective Depth: $d =$ 6.32 in
Design Steel Area: $A_s =$ 0.800 in^2/ft
Equivalent Stress Block: $a =$ 0.94 in
$c =$ 1.18 in
$\varepsilon_s =$ 0.01
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2) =$ 23.41 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 21.07 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.66**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 4.38 in
Stem Moment of Inertia: $I_g =$ 672.22 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} =$ 6.69 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 14.14 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min} =$ 0.27 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.011
$k = \sqrt{[2n\rho+(n\rho)^2]}-n\rho =$ 0.320
$j = 1-k/3 =$ 0.893
Service Applied Moment: $M_s =$ 4.96 k-ft/ft
Tensile Stress in Steel: $f_s =$ 13.18 ksi
$\beta = (h-c)/(d-c) =$ 1.47
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})=$ 21.21 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:

$\rho_{h,min} =$ 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 7 - 8

FOOTING FLEXURE DESIGN - BOTTOM FACE NEAR WALL:

Member Depth: h = 15.00 in
Factored Applied Moment: M_u = 22.38 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 29.10 k-ft/ft

Try #7 @ 9" on center:

Bar Size: Bar # = 7
Spacing: s = 9.00 in
Clear Cover: r = 3.00 in
Bar Diameter: d_b = 0.875 in
Bar Area: A_b = 0.600 in^2
Effective Depth: d = 11.56 in
Design Steel Area: A_s = 0.800 in^2/ft
Equivalent Stress Block: a = 0.94 in
c = 1.18 in
ε_s = 0.03
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: M_n = 44.37 k-ft
Factored Flex. Resist.: $\varphi_f M_n$ = 39.93 k-ft
Check: OK Utilization: **0.73**
Check $\varphi_f M_n$>4/3*$M_{u,mod}$: OK

Minimum Reinforcement: AASHTO §5.6.3.3
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of 1.33M_u or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 7.50 in
Stem Moment of Inertia: I_g = 3375 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r{*}I_g/y_t$ = 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
1.33M_u = 29.77 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min}$ = 3√f'$_c$*b*d/f_y and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min}$ = 0.49 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: ρ = 0.006
k = √[2nρ+(nρ)^2]-nρ = 0.248
j = 1-k/3 = 0.917
Service Applied Moment: M_s = 14.03 k-ft/ft
Tensile Stress in Steel: f_s = 19.84 ksi
β = (h-c)/(d-c) = 1.33
$f_{s.max}$ = 320/(β√(s^2+4(2+d_b/2)^2))= 23.49 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min}$ = 0.0010 ACI 350-06 Table 7.12.2.1
Check: OK (Reduce by half for bottom of footing)

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 1 **Checked By:** ENO **Sheet** 8 - 8

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR WALL:

Factored Shear Load:	V_u =	0.62	k/ft	
Factored Applied Moment:	M_u =	0.76	k-in/ft	
	d =	12.63	in	
	V_c =	21.82	k	ACI 350-06 Eqn. 11-5
	$V_R = \varphi_v V_c$ =	16.37	k	
	Check:	OK		Utilization: **0.04**

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR CENTER:

Factored Shear Load:	V_u =	1.37	k/ft	
Factored Applied Moment:	M_u =	21.75	k-in/ft	
	d =	6.32	in	
	V_c =	10.99	k	ACI 350-06 Eqn. 11-5
	$V_R = \varphi_v V_c$ =	8.24	k	
	Check:	OK		Utilization: **0.17**

FOOTING SHEAR DESIGN - BOTTOM FACE IN TENSION NEAR WALL:

Factored Shear Load:	V_u =	4.66	k/ft	
Factored Applied Moment:	M_u =	240.97	k-in/ft	
	d =	11.56	in	
	V_c =	19.09	k	ACI 350-06 Eqn. 11-5
	$V_R = \varphi_v V_c$ =	14.32	k	
	Check:	OK		Utilization: **0.33**

FOOTING SHRINKAGE & TEMPERATURE REINFORCEMENT DESIGN:

Min. Reinf. Ratio:	$\rho_{min,\ tot}$ =	0.0040	ACI 350-06 Table 7.12.2.1
Min. Reinf. Ratio for Top Face:	$\rho_{min,\ top}$ =	0.0020	
Min. Reinf. Ratio Bottom Face:	$\rho_{min,\ bot}$ =	0.0010	Reinforcement in bottom of slab may be reduced by half per ACI §350-06 7.12.2.1

Try #5 @ 9" on center on top face longitudinal:

Bar Size:	Bar # =	5	
Spacing:	s =	9.00	in
Longitudinal Steel Area:	$A_{l,top}$ =	0.413	in^2
	$\rho_{l,top}$ =	0.0023	
	Check:	OK	

Try #5 @ 12" on center on bottom face longitudinal:

Bar Size:	Bar # =	5
Spacing:	s =	12.00
Longitudinal Steel Area:	$A_{l,bot}$ =	0.310
	$\rho_{l,bot}$ =	0.0017
	Check:	OK

C-2: Design Section 2

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023

Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 1 - 8

STRENGTH DESIGN PARAMETERS:

Conc. Compressive Strength: f'c =	5.00	ksi	
Yield Strength of Reinf.: fy =	60.00	ksi	
Conc. Unit Weight: w_c =	0.145	kcf	
Modulus of Elasticity of Reinf.: E_s =	29000	ksi	
Modulus of Elasticity of Concrete:			
$Ec = 33{,}000w_c^{1.5}\sqrt{f'c}$ =	4074.28	ksi	ACI-350-0 (C5.4.2.4-2)
Modular Ratio: $n = E_s/E_c$ =	7.12		
Compression Zone Factor: β_1 =	0.80		ACI-350-06 §10.2.7.3
Resistance Factor for Flexural-Tension Control:			
φ_f =	0.90		ACI-350-06 §9.3.2.1
Resistance Factor for Shear-Tension Control:			
φ_v =	0.75		ACI-350-06 §9.3.2.2
Design Width: b =	12.00	in	
Environmental Durability Factor, S_d =	1.30		Design Standards No. 14 §3.8.4.6

WALL FLEXURE DESIGN - FILL FACE

Member Depth: h = 14.00 in
Factored Applied Moment: M_u = 23.05 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 29.97 k-ft/ft

Try #7 @ 9" on center:

Bar Size: Bar # = 7
Spacing: s = 9.00 in
Clear Cover: r = 2.00 in
Bar Diameter: d_b = 0.875 in
Bar Area: A_b = 0.600 in^2
Effective Depth: d = 11.56 in
Design Steel Area: A_s = 0.800 in^2/ft
Equivalent Stress Block: a = 0.94 in
c = 1.18 in
ε_s = 0.03
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2)$ = 44.37 k-ft
Factored Flex. Resist.: $\varphi_f M_n$ = 39.93 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.75**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: <4/3*Mu

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 7.00 in
Stem Moment of Inertia: I_g = 2744.00 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t$ = 17.09 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u$ = 30.66 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min}$ = 0.49 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: ρ = 0.006
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho$ = 0.248
$j = 1-k/3$ = 0.917
Service Applied Moment: M_s = 14.41 k-ft/ft
Tensile Stress in Steel: f_s = 20.38 ksi
$\beta = (h-c)/(d-c)$ = 1.23
$f_{s,max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})$ = 25.32 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:

$\rho_{h,min}$ = 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 3 - 8

WALL FLEXURE DESIGN - STREAM FACE

Member Depth: $h =$ 14.00 in
Factored Applied Moment: $M_u =$ 7.29 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 9.47 k-ft/ft

Try #5 @ 9" on center:

Bar Size: Bar # = 5
Spacing: $s =$ 9.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.625 in
Bar Area: $A_b =$ 0.310 in^2
Effective Depth: $d =$ 11.69 in
Design Steel Area: $A_s =$ 0.413 in^2/ft
Equivalent Stress Block: $a =$ 0.49 in
$c =$ 0.61 in
$\varepsilon_s =$ 0.05
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n =$ 23.65 k-ft ACI 350-06 §9.3.2.2
Factored Flex. Resist.: $\varphi_f M_n =$ 21.29 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.44**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 7.00 in
Stem Moment of Inertia: $I_g =$ 2744.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 17.09 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 9.69 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min} =$ 0.50 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.003
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho =$ 0.185
$j = 1 - k/3 =$ 0.938
Service Applied Moment: $M_s =$ 0.00 k-ft/ft
Tensile Stress in Steel: $f_s =$ 0.00 ksi
$\beta = (h-c)/(d-c) =$ 1.21
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)}) =$ 26.16 in ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:

$\rho_{h,min} =$ 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 4 - 8

WALL SHEAR DESIGN - FILL FACE IN TENSION

Factored Shear Load: $V_u =$ 6.48 k/ft
Factored Applied Moment: $M_u =$ 276.63 k-in/ft
$d =$ 11.56 in
$V_c =$ 19.18 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 14.39 k

Confirm Transverse Reinforcement is not Required by Design:
$0.5V_R =$ 7.19 k ACI 350-06 §11.5.5
Check: OK Utilization: **0.90**

WALL SHEAR DESIGN - STREAM FACE IN TENSION

Factored Shear Load: $V_u =$ 2.19 k/ft
Factored Applied Moment: $M_u =$ 7.29 k-in/ft
$d =$ 11.69 in
$V_c =$ 19.88 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 14.91 k

Confirm Transverse Reinforcement is not Required by Design:
$0.5V_R =$ 7.45 k ACI 350-06 §11.5.5
Check: OK Utilization: **0.29**

WALL SHRINKAGE & TEMPERATURE REINFORCEMENT:

Min. Reinf. Ratio: $\rho_{h,min}=$ 0.0040 ACI 350-06 Table 7.12.2.1

Try #5 @ 10" on center on each face horizontal:

Bar Size: Bar # = 5
Spacing: $s =$ 10.00 in
Horizontal Steel Area: $A_s =$ 0.744 in^2
$\rho_h =$ 0.0044
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 5 - 8

FOOTING FLEXURE DESIGN - TOP FACE NEAR WALL:

Member Depth: h = 15.00 in
Factored Applied Moment: M_u = 9.01 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 11.71 k-ft/ft

Try #6 @ 9" on center:

Bar Size: Bar # = 6
Spacing: s = 9.00 in
Clear Cover: r = 2.00 in
Bar Diameter: d_b = 0.750 in
Bar Area: A_b = 0.440 in^2
Effective Depth: d = 12.63 in
Design Steel Area: A_s = 0.587 in^2/ft
Equivalent Stress Block: a = 0.69 in
c = 0.86 in
ε_s = 0.04
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: M_n = 36.02 k-ft
Factored Flex. Resist.: $\varphi_f M_n$ = 32.42 k-ft
Check: OK Utilization:
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK **0.36**

Minimum Reinforcement: AASHTO §5.6.3.3
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 7.50 in
Stem Moment of Inertia: I_g = 3375.00 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t$ = 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u$ = 11.98 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy
$A_{s,min}$ = 0.54 in^2/ft ACI 350-06 §10.5.1
OK

Control of Cracking by Distribution of Reinforcement: AASHTO §5.6.7
Reinforcement Ratio: ρ = 0.004
$k = \sqrt{[2n\rho+(n\rho)^2]}-n\rho$ = 0.209
j = 1-k/3 = 0.930
Service Applied Moment: M_s = 1.65 k-ft/ft
Tensile Stress in Steel: f_s = 2.87 ksi
β = (h-c)/(d-c) = 1.20
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})$= 26.16 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min}$ = 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

FOOTING FLEXURE DESIGN - TOP FACE NEAR CENTER:

Member Depth: h = 8.76 in
Factored Applied Moment: M_u = 10.49 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 13.64 k-ft/ft

Try #6 @ 9" on center:

Bar Size: Bar # = 6
Spacing: s = 9.00 in
Clear Cover: r = 2.00 in
Bar Diameter: d_b = 0.750 in
Bar Area: A_b = 0.440 in^2
Effective Depth: d = 6.39 in
Design Steel Area: A_s = 0.587 in^2/ft
Equivalent Stress Block: a = 0.69 in
c = 0.86 in
ε_s = 0.02
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2)$ = 17.72 k-ft
Factored Flex. Resist.: $\varphi_f M_n$ = 15.95 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.86**
Check $\varphi_f M_n > 4/3*M_{u,mod}$: <4/3*Mu

Minimum Reinforcement:
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 4.38 in
Stem Moment of Inertia: I_g = 672.22 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: M_{cr} = 6.69 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u$ = 13.95 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c}*b*d/f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min}$ = 0.27 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: ρ = 0.008
$k = \sqrt{[2n\rho+(n\rho)^2]}-n\rho$ = 0.280
$j = 1-k/3$ = 0.907
Service Applied Moment: M_s = 5.56 k-ft/ft
Tensile Stress in Steel: f_s = 19.63 ksi
$\beta = (h-c)/(d-c)$ = 1.43
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})$= 21.99 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min}$ = 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 7 - 8

FOOTING FLEXURE DESIGN - BOTTOM FACE NEAR WALL:

Member Depth: $h =$ 15.00 in
Factored Applied Moment: $M_u =$ 22.36 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 29.07 k-ft/ft

Try #7 @ 9" on center:

Bar Size: Bar # = 7
Spacing: $s =$ 9.00 in
Clear Cover: $r =$ 3.00 in
Bar Diameter: $d_b =$ 0.875 in
Bar Area: $A_b =$ 0.600 in^2
Effective Depth: $d =$ 11.56 in
Design Steel Area: $A_s =$ 0.800 in^2/ft
Equivalent Stress Block: $a =$ 0.94 in
$c =$ 1.18 in
$\varepsilon_s =$ 0.03
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n =$ 44.37 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 39.93 k-ft
Check: OK Utilization: **0.73**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement: AASHTO §5.6.3.3
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 7.50 in
Stem Moment of Inertia: $I_g =$ 3375 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 29.74 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than $200 * b * d / f_y$ ACI 350-06 §10.5.1
$A_{s,min} =$ 0.49 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.006
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho =$ 0.248
$j = 1 - k/3 =$ 0.917
Service Applied Moment: $M_s =$ 14.02 k-ft/ft
Tensile Stress in Steel: $f_s =$ 19.82 ksi
$\beta = (h-c)/(d-c) =$ 1.33
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)}) =$ 23.49 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0010 ACI 350-06 Table 7.12.2.1
Check: OK (Reduce by half for bottom of footing)

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 2 **Checked By:** ENO **Sheet** 8 - 8

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR WALL:

Factored Shear Load: $V_u =$ 0.78 k/ft
Factored Applied Moment: $M_u =$ 2.96 k-in/ft
$d =$ 12.63 in
$V_c =$ 21.82 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 16.37 k
Check: OK Utilization: **0.05**

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR CENTER:

Factored Shear Load: $V_u =$ 0.94 k/ft
Factored Applied Moment: $M_u =$ 67.41 k-in/ft
$d =$ 6.39 in
$V_c =$ 10.42 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 7.82 k
Check: OK Utilization: **0.12**

FOOTING SHEAR DESIGN - BOTTOM FACE IN TENSION NEAR WALL:

Factored Shear Load: $V_u =$ 4.69 k/ft
Factored Applied Moment: $M_u =$ 240.49 k-in/ft
$d =$ 11.56 in
$V_c =$ 19.09 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 14.32 k
Check: OK Utilization: **0.33**

FOOTING SHRINKAGE & TEMPERATURE REINFORCEMENT DESIGN:

Min. Reinf. Ratio: $\rho_{min,\ tot} =$ 0.0040 ACI 350-06 Table 7.12.2.1
Min. Reinf. Ratio for Top Face: $\rho_{min,\ top} =$ 0.0020
Min. Reinf. Ratio Bottom Face: $\rho_{min,\ bot} =$ 0.0010

Reinforcement in bottom of slab may be reduced by half per ACI §350-06 7.12.2.1

Try #5 @ 9" on center on top face longitudinal:

Bar Size: Bar # = 5
Spacing: s = 9.00 in
Longitudinal Steel Area: $A_{l,top} =$ 0.413 in^2
$\rho_{l,top} =$ 0.0023
Check: OK

Try #5 @ 12" on center on bottom face longitudinal:

Bar Size: Bar # = 5
Spacing: s = 12.00
Longitudinal Steel Area: $A_{l,bot} =$ 0.310
$\rho_{l,bot} =$ 0.0017
Check: OK

C-3: Design Section 3

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3 **Checked By:** ENO **Sheet** 1 - 8

STRENGTH DESIGN PARAMETERS:

Conc. Compressive Strength: f'c =	5.00	ksi	
Yield Strength of Reinf.: fy =	60.00	ksi	
Conc. Unit Weight: w_c =	0.145	kcf	
Modulus of Elasticity of Reinf.: E_s =	29000	ksi	
Modulus of Elasticity of Concrete: $Ec = 33{,}000w_c^{1.5}\sqrt{f'c}$ =	4074.28	ksi	ACI-350-0 (C5.4.2.4-2)
Modular Ratio: $n = E_s/E_c$ =	7.12		
Compression Zone Factor: β_1 =	0.80		ACI-350-06 §10.2.7.3
Resistance Factor for Flexural-Tension Control: φ_f =	0.90		ACI-350-06 §9.3.2.1
Resistance Factor for Shear-Tension Control: φ_v =	0.75		ACI-350-06 §9.3.2.2
Design Width: b =	12.00	in	
Environmental Durability Factor, S_d =	1.30		Design Standards No. 14 §3.8.4.6

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3 **Checked By:** ENO **Sheet** 2 - 8

WALL FLEXURE DESIGN - FILL FACE

Member Depth: $h =$ 12.00 in
Factored Applied Moment: $M_u =$ 12.80 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 16.64 k-ft/ft

Try #7 @ 12" on center:

Bar Size: Bar # = 7
Spacing: $s =$ 12.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.875 in
Bar Area: $A_b =$ 0.600 in^2
Effective Depth: $d =$ 9.56 in
Design Steel Area: $A_s =$ 0.600 in^2/ft
Equivalent Stress Block: $a =$ 0.71 in
$c =$ 0.88 in
$\varepsilon_s =$ 0.03
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2) =$ 27.63 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 24.87 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.67**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement:
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 6.00 in
Stem Moment of Inertia: $I_g =$ 1728.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 12.56 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 17.03 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min} =$ 0.41 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.005
$k = \sqrt{[2n\rho+(n\rho)^2]} - n\rho =$ 0.238
$j = 1-k/3 =$ 0.921
Service Applied Moment: $M_s =$ 8.00 k-ft/ft
Tensile Stress in Steel: $f_s =$ 18.17 ksi
$\beta = (h-c)/(d-c) =$ 1.28
$f_{s,max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)}) =$ 19.29 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3 **Checked By:** ENO **Sheet** 3 - 8

WALL FLEXURE DESIGN - STREAM FACE

Member Depth: $h =$ 12.00 in
Factored Applied Moment: $M_u =$ 3.78 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 4.91 k-ft/ft

Try #5 @ 12" on center:

Bar Size: Bar # = 5
Spacing: $s =$ 12.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.625 in
Bar Area: $A_b =$ 0.310 in^2
Effective Depth: $d =$ 9.69 in
Design Steel Area: $A_s =$ 0.310 in^2/ft
Equivalent Stress Block: $a =$ 0.36 in
$c =$ 0.46 in
$\varepsilon_s =$ 0.06
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n =$ 14.73 k-ft ACI 350-06 §9.3.2.2
Factored Flex. Resist.: $\varphi_f M_n =$ 13.26 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.37**
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK

Minimum Reinforcement:
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 6.00 in
Stem Moment of Inertia: $I_g =$ 1728.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 12.56 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 5.02 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than $200 * b * d / fy$ ACI 350-06 §10.5.1
$A_{s,min} =$ 0.41 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.003
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho =$ 0.177
$j = 1 - k/3 =$ 0.941
Service Applied Moment: $M_s =$ 0.00 k-ft/ft
Tensile Stress in Steel: $f_s =$ 0.00 ksi
$\beta = (h-c)/(d-c) =$ 1.25
$f_{s.max} = 320/(\beta\sqrt{(s^2 + 4(2 + d_b/2)^2)}) =$ 19.90 in ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0015 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation		**Designed By:** LAH	**Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3		**Checked By:** ENO	**Sheet** 4 - 8

WALL SHEAR DESIGN - FILL FACE IN TENSION

Factored Shear Load:	V_u =	4.44	k/ft	
Factored Applied Moment:	M_u =	153.61	k-in/ft	
	d =	9.56	in	
	V_c =	15.83	k	ACI 350-06 Eqn. 11-5
	$V_R = \varphi_v V_c$ =	11.87	k	

Confirm Transverse Reinforcement is not Required by Design:

$0.5V_R$ =	5.94	k	ACI 350-06 §11.5.5	
Check:	OK		Utilization:	**0.75**

WALL SHEAR DESIGN - STREAM FACE IN TENSION

Factored Shear Load:	V_u =	1.42	k/ft	
Factored Applied Moment:	M_u =	3.78	k-in/ft	
	d =	9.69	in	
	V_c =	16.39	k	ACI 350-06 Eqn. 11-5
	$V_R = \varphi_v V_c$ =	12.29	k	

Confirm Transverse Reinforcement is not Required by Design:

$0.5V_R$ =	6.15	k	ACI 350-06 §11.5.5	
Check:	OK		Utilization:	**0.23**

WALL SHRINKAGE & TEMPERATURE REINFORCEMENT:

Min. Reinf. Ratio:	$\rho_{h,min}$=	0.0040	ACI 350-06 Table 7.12.2.1

Try #5 @ 1" on center on each face horizontal:

Bar Size:	Bar # =	5	
Spacing:	s =	1.00	in
Horizontal Steel Area:	A_s =	7.440	in^2
	ρ_h =	0.0517	
	Check:	OK	

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3 **Checked By:** ENO **Sheet** 5 - 8

FOOTING FLEXURE DESIGN - TOP FACE NEAR WALL:

Member Depth: $h =$ 15.00 in
Factored Applied Moment: $M_u =$ 5.21 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 6.77 k-ft/ft

Try #5 @ 6" on center:

Bar Size: Bar # = 5
Spacing: $s =$ 6.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.625 in
Bar Area: $A_b =$ 0.310 in^2
Effective Depth: $d =$ 12.69 in
Design Steel Area: $A_s =$ 0.620 in^2/ft
Equivalent Stress Block: $a =$ 0.73 in
$c =$ 0.91 in
$\varepsilon_s =$ 0.04
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n =$ 38.20 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 34.38 k-ft
Check: OK Utilization:
Check $\varphi_f M_n > 4/3 * M_{u,mod}$: OK **0.20**

Minimum Reinforcement: AASHTO §5.6.3.3

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 7.50 in
Stem Moment of Inertia: $I_g =$ 3375.00 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} = f_r * I_g / y_t =$ 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 6.93 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c} * b * d / f_y$ and not less than 200*b*d/fy
$A_{s,min} =$ 0.54 in^2/ft ACI 350-06 §10.5.1
OK

Control of Cracking by Distribution of Reinforcement: AASHTO §5.6.7
Reinforcement Ratio: $\rho =$ 0.004
$k = \sqrt{[2n\rho + (n\rho)^2]} - n\rho =$ 0.214
$j = 1 - k/3 =$ 0.929
Service Applied Moment: $M_s =$ 1.21 k-ft/ft
Tensile Stress in Steel: $f_s =$ 1.99 ksi
$\beta = (h-c)/(d-c) =$ 1.20
$f_{s.max} = 320/(\beta\sqrt{(s^2 + 4(2 + d_b/2)^2)}) =$ 35.31 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min} =$ 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

FOOTING FLEXURE DESIGN - TOP FACE NEAR CENTER:

Member Depth: $h =$ 8.76 in
Factored Applied Moment: $M_u =$ 8.94 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod} =$ 11.62 k-ft/ft

Try #5 @ 6" on center:

Bar Size: Bar # = 5
Spacing: $s =$ 6.00 in
Clear Cover: $r =$ 2.00 in
Bar Diameter: $d_b =$ 0.625 in
Bar Area: $A_b =$ 0.310 in^2
Effective Depth: $d =$ 6.45 in
Design Steel Area: $A_s =$ 0.620 in^2/ft
Equivalent Stress Block: $a =$ 0.73 in
$c =$ 0.91 in
$\varepsilon_s =$ 0.02
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: $M_n = A_s f_y(d-a/2) =$ 18.86 k-ft
Factored Flex. Resist.: $\varphi_f M_n =$ 16.97 k-ft
Check $\varphi_f M_n > M_u$: OK Utilization: **0.68**
Check $\varphi_f M_n > 4/3*M_{u,mod}$: OK

Minimum Reinforcement:

The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of $1.33M_u$ or M_{cr}.

Member Width: $b =$ 12.00 in
Dist. To Neutral Axis: $y_t =$ 4.38 in
Stem Moment of Inertia: $I_g =$ 672.22 in^4
Concrete Modulus of Rupture: $f_r =$ 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: $M_{cr} =$ 6.69 k-ft/ft ACI 350-06 Eqn. 9-10
$1.33M_u =$ 11.89 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min} = 3\sqrt{f'_c}*b*d/f_y$ and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min} =$ 0.27 in^2/ft
N/A φfMn>4/3*Mu,mod, therefore As,min is not required

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: $\rho =$ 0.008
$k = \sqrt{[2n\rho+(n\rho)^2]}-n\rho =$ 0.285
$j = 1-k/3 =$ 0.905
Service Applied Moment: $M_s =$ 5.06 k-ft/ft
Tensile Stress in Steel: $f_s =$ 16.77 ksi
$\beta = (h-c)/(d-c) =$ 1.42
$f_{s.max} = 320/(\beta\sqrt{(s^2+4(2+d_b/2)^2)})=$ 29.79 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:

$\rho_{h,min} =$ 0.0020 ACI 350-06 Table 7.12.2.1
Check: OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Structural Design - Section 3 **Checked By:** ENO **Sheet** 7 - 8

FOOTING FLEXURE DESIGN - BOTTOM FACE NEAR WALL:

Member Depth: h = 15.00 in
Factored Applied Moment: M_u = 12.39 k-ft/ft
Mod. Hydraulic Factored Moment: $M_{u,mod}$ = 16.11 k-ft/ft

Try #7 @ 12" on center:

Bar Size: Bar # = 7
Spacing: s = 12.00 in
Clear Cover: r = 3.00 in
Bar Diameter: d_b = 0.875 in
Bar Area: A_b = 0.600 in^2
Effective Depth: d = 11.56 in
Design Steel Area: A_s = 0.600 in^2/ft
Equivalent Stress Block: a = 0.71 in
c = 0.88 in
ε_s = 0.04
Check if Tension Controlled: OK ACI 350-06 §9.3.2.2
Nom. Flexural Resist.: M_n = 33.63 k-ft
Factored Flex. Resist.: $\varphi_f M_n$ = 30.27 k-ft
Check: OK Utilization: **0.53**
Check $\varphi_f M_n$>4/3*$M_{u,mod}$: OK

Minimum Reinforcement: AASHTO §5.6.3.3
The amount of flexural reinforcement shall be adequate to develop a factored flexural resistance, M_R, at least equal to the lesser of 1.33M_u or M_{cr}.

Member Width: b = 12.00 in
Dist. To Neutral Axis: y_t = 7.50 in
Stem Moment of Inertia: I_g = 3375 in^4
Concrete Modulus of Rupture: f_r = 0.52 ksi ACI 350-06 Eqn. 9-11
Cracking Moment: M_{cr} = f_r*I_g/y_t = 19.62 k-ft/ft ACI 350-06 Eqn. 9-10
1.33M_u = 16.48 k-ft/ft
Check: OK
Minimum Reinforcement: $A_{s,min}$ = 3√f'$_c$*b*d/f_y and not less than 200*b*d/fy ACI 350-06 §10.5.1
$A_{s,min}$ = 0.49 in^2/ft
OK

Control of Cracking by Distribution of Reinforcement: ACI 350-06 §10.6
Reinforcement Ratio: ρ = 0.004
k = √[2nρ+(nρ)^2]-nρ = 0.219
j = 1-k/3 = 0.927
Service Applied Moment: M_s = 7.78 k-ft/ft
Tensile Stress in Steel: f_s = 14.51 ksi
β = (h-c)/(d-c) = 1.32
$f_{s.max}$ = 320/(β√(s^2+4(2+d_b/2)^2))= 18.69 ksi ACI 350-06 Eqn. 10-4
Check: OK

Temperature and Shrinkage:
$\rho_{h,min}$ = 0.0010 ACI 350-06 Table 7.12.2.1
Check: OK (Reduce by half for bottom of footing)

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR WALL:

Factored Shear Load: $V_u =$ 0.61 k/ft
Factored Applied Moment: $M_u =$ 2.29 k-in/ft
$d =$ 12.69 in
$V_c =$ 22.00 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 16.50 k
Check: OK Utilization: **0.04**

FOOTING SHEAR DESIGN - TOP FACE IN TENSION NEAR CENTER:

Factored Shear Load: $V_u =$ 0.58 k/ft
Factored Applied Moment: $M_u =$ 70.61 k-in/ft
$d =$ 6.45 in
$V_c =$ 10.48 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 7.86 k
Check: OK Utilization: **0.07**

FOOTING SHEAR DESIGN - BOTTOM FACE IN TENSION NEAR WALL:

Factored Shear Load: $V_u =$ 3.30 k/ft
Factored Applied Moment: $M_u =$ 129.19 k-in/ft
$d =$ 11.56 in
$V_c =$ 19.08 k ACI 350-06 Eqn. 11-5
$V_R = \varphi_v V_c =$ 14.31 k
Check: OK Utilization: **0.23**

FOOTING SHRINKAGE & TEMPERATURE REINFORCEMENT DESIGN:

Min. Reinf. Ratio: $\rho_{min,\ tot} =$ 0.0040 ACI 350-06 Table 7.12.2.1
Min. Reinf. Ratio for Top Face: $\rho_{min,\ top} =$ 0.0020
Min. Reinf. Ratio Bottom Face: $\rho_{min,\ bot} =$ 0.0010

Reinforcement in bottom of slab may be reduced by half per ACI §350-06 7.12.2.1

Try #5 @ 9" on center on top face longitudinal:

Bar Size: Bar # = 5
Spacing: s = 9.00 in
Longitudinal Steel Area: $A_{l,top} =$ 0.413 in^2
$\rho_{l,top} =$ 0.0023
Check: OK

Try #5 @ 12" on center on bottom face longitudinal:

Bar Size: Bar # = 5
Spacing: s = 12.00
Longitudinal Steel Area: $A_{l,bot} =$ 0.310
$\rho_{l,bot} =$ 0.0017
Check: OK

D - Uplift and Sliding Check

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Flotation Check **Checked By:** ENO **Sheet** 1 - 4

SPILLWAY CHANNEL FLOTATION CHECK

Conc. Unit Weight:	0.150	kcf
Water Unit Weight:	0.062	kcf
Soil Unit Weight:	0.120	kcf
Soil Buoyand Unit Weight:	0.06	kcf
Sliding Friction Coefficient:	0.65	
Required Factor of Safety for Flotation:	1.2	
Required Factor of Safety for Sliding:	1.5	

Sta. 10+45.00 to Sta. 10+65.00

Section Length:	20.00	ft	
Average Slope:	0.01	ft/ft	
Footing Width:	29.33	ft	(average)
Channel Opening Width:	24.00	ft	(average)
Wall Height:	10.00	ft	
Wall Thickness:	1.17	ft	
Out-to-Out Channel Wall Width:	26.33	ft	(average)
Max. Footing Thickness:	1.25	ft	
Min. Footing Thickness:	0.73	ft	
Footing Heel Width:	1.50	ft	
Water Height Above Top of Footing	3.33	ft	(1/3rd of wall height)
Soil Height Above Top of Footing:	9.00	ft	(min, for uplift resistance)
Soil Height Above Top of Footing:	10.00	ft	(max, for sliding force)

Flotation Check:

Uplift Force:	155.3	k
Weight of Concrete Channel:	161.3	k
Weight of Soil on Footing:	52.3	k
Total Uplift Resistance:	213.6	k
Factor of Safety for Flotation:	1.4	OK

Sliding Check:

Weight of Concrete Parallel to Slope:	2.04	k
Weight of Concrete Normal to Slope:	161.24	k
Weight of Soil Parallel to Slope:	0.66	k
Weight of Soil Normal to Slope:	71.99	k
Uplift Normal to Slope:	155.29	k
Total Force Parallel to Slope:	2.70	k
Total Force Normal to Slope:	77.94	k
Sliding Resistance:	50.66	k
Factor of Safety for Sliding:	18.8	OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023

Subject Spillway Wall Flotation Check **Checked By:** ENO **Sheet** 2 - 4

Sta. 10+65.00 to Sta. 11+85.00

Section Length:	120.00	ft	
Average Slope:	0.02	ft/ft	
Footing Width:	31.33	ft	
Channel Opening Width:	26.00	ft	
Wall Height:	8.89	ft	(average)
Wall Thickness:	1.17	ft	
Out-to-Out Channel Wall Width:	28.33	ft	
Max. Footing Thickness:	1.25	ft	
Min. Footing Thickness:	0.73	ft	
Footing Heel Width:	1.50	ft	
Water Height Above Top of Footing	2.96	ft	(1/3rd of wall height)
Soil Height Above Top of Footing:	7.89	ft	(min, for uplift resistance)
Soil Height Above Top of Footing:	8.89	ft	(max, for sliding force)

Flotation Check:

Uplift Force:	921.9	k
Weight of Concrete Channel:	956.4	k
Weight of Soil on Footing:	274.2	k
Total Uplift Resistance:	1230.6	k
Factor of Safety for Flotation:	1.3	OK

Sliding Check:

Weight of Concrete Parallel to Slope:	17.64	k
Weight of Concrete Normal to Slope:	956.27	k
Weight of Soil Parallel to Slope:	5.06	k
Weight of Soil Normal to Slope:	383.90	k
Uplift Normal to Slope:	921.70	k
Total Force Parallel to Slope:	22.70	k
Total Force Normal to Slope:	418.47	k
Sliding Resistance:	272.01	k
Factor of Safety for Sliding:	12.0	OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Flotation Check **Checked By:** ENO **Sheet** 3 - 4

Sta. 11+85.00 to Sta. 12+92.50

Section Length:	107.50	ft	
Average Slope:	0.09	ft/ft	
Footing Width:	31.00	ft	
Channel Opening Width:	26.00	ft	
Wall Height:	7.43	ft	(average)
Wall Thickness:	1.00	ft	
Out-to-Out Channel Wall Width:	28.00	ft	
Max. Footing Thickness:	1.25	ft	
Min. Footing Thickness:	0.73	ft	
Footing Heel Width:	1.50	ft	
Water Height Above Top of Footing	2.48	ft	(1/3rd of wall height)
Soil Height Above Top of Footing:	6.43	ft	(min, for uplift resistance)
Soil Height Above Top of Footing:	10.00	ft	(max, for sliding force)

Flotation Check:

Uplift Force:	725.4	k
Weight of Concrete Channel:	755.4	k
Weight of Soil on Footing:	199.1	k
Total Uplift Resistance:	954.6	k
Factor of Safety for Flotation:	1.3	OK

Sliding Check:

Weight of Concrete Parallel to Slope:	67.34	k
Weight of Concrete Normal to Slope:	752.42	k
Weight of Soil Parallel to Slope:	17.75	k
Weight of Soil Normal to Slope:	385.46	k
Uplift Normal to Slope:	722.51	k
Total Force Parallel to Slope:	85.09	k
Total Force Normal to Slope:	415.37	k
Sliding Resistance:	269.99	k
Factor of Safety for Sliding:	3.2	OK

Project: Lake Quivira Dam Spillway Rehabilitation **Designed By:** LAH **Date:** 6/28/2023
Subject Spillway Wall Flotation Check **Checked By:** ENO **Sheet** 4 - 4

Sta. 12+92.50 to Sta. 14+00.00

Section Length:	107.50	ft	
Average Slope:	0.09	ft/ft	
Footing Width:	31.00	ft	
Channel Opening Width:	26.00	ft	
Wall Height:	6.27	ft	(average)
Wall Thickness:	1.00	ft	
Out-to-Out Channel Wall Width:	28.00	ft	
Max. Footing Thickness:	1.25	ft	
Min. Footing Thickness:	0.73	ft	
Footing Heel Width:	1.50	ft	
Water Height Above Top of Footing	2.09	ft	(1/3rd of wall height)
Soil Height Above Top of Footing:	0.50	ft	(min, for uplift resistance on south side)
Soil Height Above Top of Footing:	6.27	ft	(max, for sliding force and uplift resistance on north side)

Flotation Check:

Uplift Force:	652.5	k
Weight of Concrete Channel:	717.9	k
Weight of Soil on Footing:	104.9	k
Total Uplift Resistance:	822.8	k
Factor of Safety for Flotation:	1.3	OK

Sliding Check:

Weight of Concrete Parallel to Slope:	63.99	k
Weight of Concrete Normal to Slope:	715.02	k
Weight of Soil Parallel to Slope:	9.35	k
Weight of Soil Normal to Slope:	241.69	k
Uplift Normal to Slope:	649.90	k
Total Force Parallel to Slope:	73.34	k
Total Force Normal to Slope:	306.81	k
Sliding Resistance:	199.43	k
Factor of Safety for Sliding:	2.7	OK

Transverse Sliding Check For Location Without Backfill Behind South Wall:

Avg. Wall Height:	6.00	ft	
Resultant Horizontal Earth Pressure on North Wall with 1/3 of Height Undrained:	0.99	k	(see channel loads and analysis for lateral earth pressure coefficients)
Weight of Concrete Channel:	6.60	k	
Sliding Resistance:	4.29	k	
Factor of Safety for Sliding:	4.3	OK	

LAKE QUIVIRA SPILLWAY REHABILITATION

Lake Quivira, Kansas

July 2023

Olsson Project No. 021-08019