

12 February 2020

Mr. Steve Minden
Mission Rock Partners, LLC
c/o Tishman Speyer
One Bush Street, Suite 450
San Francisco, California 94104

**Subject: Supplemental Geotechnical Recommendations
Permeable LCC Design Elevations
Mission Rock – Phase 1 Horizontal Development
San Francisco, California
Langan Project No.: 750604203**

Dear Mr. Minden:

This letter presents our geotechnical evaluation and recommendations regarding raising street grades with lightweight cellular concrete for the Mission Rock Phase 1 Horizontal Development project in San Francisco, California. The results of our geotechnical investigation for the horizontal improvements for the Mission Rock Phase 1 project were presented in a report dated 31 October 2019. Information provided herein are based the subsurface conditions documented in the 31 October 2019 report as well as the conclusions and recommendations provided therein. Anyone relying on the recommendations provided herein should be familiar the subsurface conditions, assumptions, and conclusions provided in the 31 October 2019 report.

Background

Existing site grades within the Phase 1 Development area range from about Elevation 97 feet to about 101.5 feet¹. Based on our review of the project improvement plans prepared by BKF dated 3 February 2020, site grades for the future streets and sidewalks will be raised to accommodate future sea level rise, with planned street grades sloping up from 3rd Street to about Elevation 104.5 feet. To prevent settlement of future streets and improvements the grades will be raised using permeable lightweight cellular concrete (LCC). Because the LCC and street improvements would add load, some existing soil will need to be overexcavated and replaced with LCC to offset all proposed new loads.

Subsurface Conditions

The subsurface conditions below the Mission Rock Phase 1 Vertical site consist of approximately 8 to 32 feet of heterogeneous, undocumented fill underlain by approximately 26 to 71 feet of weak, soft to medium stiff, compressible clay, locally referred to as Bay Mud. The Bay Mud is generally underlain by an older marine clay, known as Old Bay Clay that is about 60 to 110 feet

¹ Elevations based on topographic survey by Martin Ron, dated 2 July 2019, Mission Bay Datum (Old San Francisco City Datum plus 100 feet).

thick where explored. Old Bay Clay is typically stiff to very stiff and overconsolidated. A 1- to 38-foot-thick layer of dense to very dense sand with varying amounts of fines was encountered between the Bay Mud and Old Bay Clay over much of the Phase 1 site. Alluvial dense to very dense sand and stiff to hard clay layers were typically encountered below the Old Bay Clay. The top of the bedrock was encountered at depths of about 195 to 257 feet below the ground surface.

Lightweight Cellular Concrete Discussion and Recommendations

To offset the additional weight caused by raising site grades for the new street sections, existing fill will be removed to a specified depth. The resulting overexcavation and fill used to raise grades will consist of permeable lightweight cellular concrete (LCC). LCC is a low density material that is a mixture of cement, water, and foam. Within the new 60- to 70-foot-wide Right of Way (ROW), there will be new utilities, streets, sidewalks, light poles, and tree planting areas between the blocks to be developed. LCC is adequate for support of the improvements listed above in the new ROW provided the LCC has the appropriate compressive strength. In addition, it can be excavated in vertical cuts using standard equipment for future improvements. Therefore, using LCC is beneficial for future work in the streets.

To determine the depth of overexcavation needed to fully offset the new loads, the loads from new utilities (assumed to be filled with water), bedding and shading, the street and sidewalk sections (concrete, asphalt, and base sections), trees, light poles, tree-planting structural soil, the increased density of underlying improved fill, and other collateral loading need to be included. The following are some of the assumptions included in calculating the required depth of the compensating open cell (permeable) LCC section:

- existing observed average groundwater level is at Elevation 93 feet
- unit weight of brackish groundwater is 63 pounds per cubic foot (pcf)
- target cast unit weight of the open cell (porous) LCC is 26+/- 2 pounds per cubic foot (pcf) with a minimum compressive strength of 50 pounds per square inch (psi) at 28 days and a maximum compressive strength of 200 psi
- target cast unit weight of the upper two feet of LCC is 30+/- 2 pcf with a minimum compressive strength of 50 psi at 28 days and a maximum compressive strength of 200 psi
- long-term (potentially fully saturated) unit weight of porous LCC below groundwater is 68 pcf, resulting in a new buoyant (effective) unit weight of 5 pcf (68 pcf minus 63 pcf). This buoyant unit weight is based on vacuum-pressure laboratory saturation testing, which indicates a saturated unit weight of 63 pcf and adding 5 pcf to account for potential variability.

- unit weight of the existing fill varies from 110 (very loose sand) to 140 pcf (concrete and brick debris), with an average of approximately 125 to 130 pcf; a unit weight of 125 pcf is used for load offset calculations. Improved fill (beneath the new LCC section), will have a unit weight of 131 pcf, an increase of 6 pcf above the existing conditions.
- pavement section is comprised of 8 inches of Portland cement concrete overlain by 4 inches of asphalt concrete, both with a unit weight of approximately 150 pcf, underlain by 4 inches of gravel material such as aggregate base as a buffer before encountering LCC, with a unit weight of approximately 130 pcf.
- City sidewalks will consist of 4 inches of Portland cement concrete with a unit weight of approximately 150 pcf, underlain by 4 inches of Caltrans Class 2 aggregate base with a unit weight of approximately 130 pcf.
- public underground utilities including storm drain, sanitary sewer, auxiliary water supply system, and water will include sand bedding and cover which will have a unit weight of approximately 125 pcf.
- structural soil (for tree planting) has a unit weight of 110 pcf will be placed in the planter strips. The widths of the planting strips is different for each street section.

Using this information, we performed calculations to evaluate the appropriate elevation to overexcavate the existing fill to fully offset the new improvement loads and also reduce the calculated effective stress at the top of the Bay Mud by at least 10 percent compared to the existing conditions. We judge that, in utilizing this approach, there would be a net unloading of the Bay Mud across the site; the potential for consolidation settlement will therefore be low. In addition, the net unloading will likely significantly slow and possibly stop any ongoing secondary compression settlement of the Bay Mud under existing loading within the street sections.

In addition to the estimated weights of the items listed above, the calculations for minimum LCC depth are based on the estimated change in surface elevations as well as the thickness of the fill beneath the street sections. We therefore performed this calculation for individual street sections and at various stations along the street alignments. The results of our calculations and recommended bottom elevation of the LCC fill section are shown in Tables 1 through 5. Examples of our calculations, which further document the assumptions as the basis of our recommendations are presented in Appendix.

Using the calculated bottom elevation of the permeable LCC sections, we checked that the planned future street sections are not susceptible to hydrostatic uplift. To prevent significant hydrostatic uplift, open cell (porous) LCC has been specified to be used at Mission Rock. The open cell LCC will allow water to flow through the material, preventing significant hydrostatic pressure from building up at the bottom of the LCC section. The critical condition for hydrostatic uplift is where the LCC is only partially saturated, therefore the partially saturated density was

used for uplift calculations. The assumptions used as the design criteria for the hydrostatic uplift check include:

- future (year 2100) mid-range groundwater level of Elevation 97 feet and high-range groundwater level is 99.5 feet²
- short-term (partially saturated) unit weight of porous LCC below groundwater is 50 pcf, resulting in a net buoyant unit weight of -13 pcf (50 pcf minus 63 pcf).

The check for hydrostatic uplift compares the total stress at the base of the LCC against the theoretical hydrostatic pressure at the LCC base based on the figure high groundwater levels. Each section of LCC should be considered safe provided the factor of safety against hydrostatic uplift is at least 1.1 when checking the high range groundwater level of Elevation 99.5 feet, and a factor of safety of 1.2 when checking the mid-range groundwater level of Elevation 97 feet. Based on our calculations, all of the recommended sections provided in attached tables meet this criteria.

The appendix includes representative calculations for the required overexcavation for net unloading and resistance to hydrostatic uplift for example street sections. The information presented in the spreadsheets includes assumptions used in the analysis and demonstrates that adequate factors of safety are calculated for net unloading as well as hydrostatic uplift conditions.

We appreciate the opportunity to assist you with this project, please call with any questions.

Sincerely,

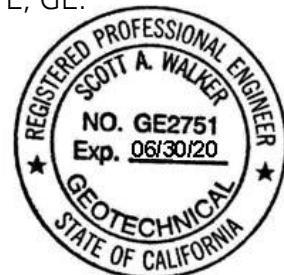
Langan Engineering & Environmental Services, Inc.



Peter Brady, PE
Project Engineer



Scott A. Walker, PE, GE.
Senior Associate



750604203.21_PDB_Bottom of LCC Elevations_2020-02-12

Attachment: Tables
Appendix

² Groundwater levels have been taken from potential sea level rise levels provided in FEMA Guidelines.

TABLES

TABLE 1

Bridgeview Street Profile ¹				
Station (feet)	Current Grade Elevation ² (ft, SFCD+100')	Finished Grade Elevation ³ (ft, SFCD+100')	Bottom of Fill Elevation ⁴ (ft, SFCD+100')	Recommended Elevation of Bottom of LCC (ft, SFCD+100')
3060	99.5	104.5	85.0	92.5
3080	99.5	104.5	85.0	92.5
3100	100.0	104.0	85.0	93.0
3120	100.0	104.0	84.0	93.0
3140	100.0	104.0	82.0	93.0
3160	100.0	104.0	75.0	91.5
3180	100.0	104.0	75.0	91.5
3200	100.0	104.0	75.0	91.5
3220	100.0	104.0	70.0	91.0
3240	99.5	104.0	70.0	90.0
3260	99.5	104.0	70.0	90.0
3280	99.0	104.0	75.0	90.5
3300	99.0	104.0	75.0	90.5
3320	99.5	104.0	75.0	91.0
3340	99.5	104.0	75.0	91.0
3360	99.5	104.0	75.0	91.0
3380	99.5	103.5	75.0	92.0
3400	99.5	103.5	75.0	92.0
3420	99.0	103.5	75.0	91.0
3440	98.5	104.0	75.0	90.0
3460	98.0	103.5	75.0	89.0

- Notes:
1. See attached example calculation sheet that include weight estimates that make up the street section characteristics.
 2. Existing elevations based on topographic map prepared by Martin M. Ron Associates dated 2 July 2019. All elevations reference Old San Francisco City Datum plus 100 feet.
 3. Estimated finished grade elevations obtained from the Street Improvement Plans by BKF Engineers, Inc. dated 3 February 2020.
 4. Bottom of fill elevation based on data contained in the project Geotechnical Investigation Report dated 31 October 2019 and engineering judgement.

31-Jan-20

LANGAN

TABLE 2

Shared Public Way Profile ¹				
Station (feet)	Current Grade Elevation ² (ft, SFCD+100')	Finished Grade Elevation ³ (ft, SFCD+100')	Bottom of Fill Elevation ⁴ (ft, SFCD+100')	Recommended Elevation of Bottom of LCC (ft, SFCD+100')
2080	100.0	104.0	90.0	94.5
2100	100.0	104.0	90.0	94.5
2120	99.5	104.0	88.0	93.5
2140	99.5	104.0	86.0	93.5
2160	99.5	104.0	85.0	93.5
2180	99.5	104.0	88.0	93.0
2200	100.0	104.0	90.0	94.5
2220	100.0	104.0	90.0	94.5
2240	100.0	104.0	90.0	94.5
2260	99.5	103.5	90.0	94.0
2280	99.5	103.5	90.0	94.0
2300	99.5	103.5	90.0	94.0
2320	99.0	103.5	90.0	93.5
2340	99.0	103.5	90.0	93.5
2360	99.0	104.0	90.0	93.0
2380	99.0	104.0	90.0	93.0
2400	99.5	104.0	90.0	93.5
2420	99.5	104.0	90.0	93.5
2440	99.5	104.0	90.0	93.5
2460	99.5	104.0	87.0	93.5
2480	99.0	104.5	85.0	91.5
2500	99.0	104.5	84.0	91.5
2520	98.5	104.5	82.0	90.0
2540	98.5	104.5	80.0	89.5
2560	98.0	104.5	85.0	89.5
2580	98.5	104.5	88.0	91.0
2600	98.5	104.5	88.0	91.0
2620	98.5	104.5	88.0	91.0

- Notes:
1. See attached example calculation sheet that include weight estimates that make up the street section characteristics.
 2. Existing elevations based on topographic map prepared by Martin M. Ron Associates dated 2 July 2019. All elevations reference Old San Francisco City Datum plus 100 feet.
 3. Estimated finished grade elevations obtained from the Street Improvement Plans by BKF Engineers, Inc. dated 3 February 2020.
 4. Bottom of fill elevation based on data contained in the project Geotechnical Investigation Report dated 31 October 2019 and engineering judgement.

31-Jan-20

LANGAN

TABLE 3

Exposition Street Profile ¹				
Station (feet)	Current Grade Elevation ² (ft, SFCD+100')	Finished Grade Elevation ³ (ft, SFCD+100')	Bottom of Fill Elevation ⁴ (ft, SFCD+100')	Recommended Elevation of Bottom of LCC (ft, SFCD+100')
1080	99.5	99.5	77.0	94.0
1100	99.0	99.5	77.0	93.0
1120	99.0	100.0	80.0	93.5
1140	98.5	100.0	82.0	93.0
1160	98.5	100.5	86.0	93.5
1180	98.5	101.0	88.0	93.5
1200	98.5	102.0	90.0	93.5
1220	98.5	103.0	90.0	93.0
1240	99.0	103.5	90.0	93.5
1260	99.0	103.5	90.0	93.5
1280	99.0	103.5	90.0	93.5
1300	99.0	103.5	90.0	93.5
1320	99.5	104.0	89.0	94.0
1340	99.5	104.0	87.0	93.5
1360	100.0	104.0	85.0	94.0
1380	100.0	104.0	80.0	93.5
1400	100.0	104.0	80.0	93.5
1420	100.0	104.5	86.0	94.0
1440	100.0	104.5	86.0	94.0
1460	100.0	104.5	86.0	94.0
1480	100.0	104.5	86.0	94.0
1500	100.0	104.0	86.0	94.0
1520	100.0	104.0	70.0	92.0
1540	100.0	104.0	70.0	92.0
1560	100.0	104.0	70.0	92.0
1580	100.0	104.0	70.0	92.0
1600	100.0	104.0	75.0	93.0
1620	100.0	103.5	75.0	93.0
1640	99.0	103.0	75.0	91.5
1660	98.5	102.5	75.0	91.0
1680	98.0	102.0	75.0	90.0
1700	98.5	101.5	75.0	91.5

- Notes:
1. See attached example calculation sheet that include weight estimates that make up the street section characteristics.
 2. Existing elevations based on topographic map prepared by Martin M. Ron Associates dated 2 July 2019. All elevations reference Old San Francisco City Datum plus 100 feet.
 3. Estimated finished grade elevations obtained from the Street Improvement Plans by BKF Engineers, Inc. dated 3 February 2020.
 4. Bottom of fill elevation based on data contained in the project Geotechnical Investigation Report dated 31 October 2019 and engineering judgement.

31-Jan-20

LANGAN

TABLE 4

Channel Street Profile ¹				
Station (feet)	Current Grade Elevation ² (ft, SFCD+100')	Finished Grade Elevation ³ (ft, SFCD+100')	Bottom of Fill Elevation ⁴ (ft, SFCD+100')	Recommended Elevation of of Bottom of LCC (ft, SFCD+100')
1120	99.5	100.0	85.0	94.5
1140	99.0	100.5	85.0	94.0
1160	98.5	101.0	85.0	94.0
1180	98.0	101.0	90.0	94.0
1200	98.0	101.5	90.0	93.5
1220	98.0	102.5	88.0	93.0
1240	98.0	103.0	85.0	92.5
1260	98.0	104.0	85.0	92.5
1280	98.0	104.5	86.0	92.5
1300	98.5	104.5	87.0	91.0
1320	98.5	104.5	88.0	91.0
1340	99.0	105.0	88.0	91.0

- Notes:
1. See attached example calculation sheet that include weight estimates that make up the street section characteristics.
 2. Existing elevations based on topographic map prepared by Martin M. Ron Associates dated 2 July 2019. All elevations reference Old San Francisco City Datum plus 100 feet.
 3. Estimated finished grade elevations obtained from the Street Improvement Plans by BKF Engineers, Inc. dated 3 February 2020.
 4. Bottom of fill elevation based on data contained in the project Geotechnical Investigation Report dated 31 October 2019 and engineering judgement.

31-Jan-20

LANGAN

TABLE 5

Pormenade ¹				
Station (feet)	Current Grade Elevation ² (ft, SFCD+100')	Finished Grade Elevation ³ (ft, SFCD+100')	Bottom of Fill Elevation ⁴ (ft, SFCD+100')	Recommended Elevation of Bottom of LCC (ft, SFCD+100')
1060	99.5	101.0	80.0	94.0
1080	99.5	101.0	80.0	94.0
1100	99.5	101.0	80.0	94.0
1120	99.5	101.0	80.0	94.0
1140	100.0	101.5	81.0	94.5
1160	100.0	102.0	83.0	94.5
1180	100.0	102.5	84.0	94.5
1200	100.0	103.5	85.0	94.5
1220	100.0	104.0	86.0	94.5
1240	100.0	104.5	86.0	94.5
1260	100.0	104.5	86.0	94.5
1280	100.0	104.5	86.0	94.5
1300	100.0	104.5	86.0	94.5
1320	100.0	104.5	85.0	94.0
1340	100.0	104.5	85.0	94.0
1360	100.0	104.5	85.0	94.0
1380	100.0	104.5	82.0	94.0
1400	100.0	104.5	80.0	93.5
1420	100.0	104.5	80.0	93.5
1440	100.0	104.5	80.0	93.5
1460	100.0	104.5	80.0	93.5
1480	100.0	104.5	80.0	93.5
1500	100.0	104.5	80.0	93.5
1520	99.5	104.5	80.0	93.0
1540	100.0	104.5	80.0	93.5
1560	100.0	104.5	83.0	94.0
1580	100.0	104.5	84.0	94.0
1600	100.0	104.0	84.0	94.0
1620	99.5	104.0	83.0	93.5
1640	99.0	103.5	83.0	93.0
1660	99.0	103.0	82.0	93.0
1680	99.0	102.5	81.0	93.0
1700	99.0	102.0	81.0	93.5
1720	99.0	100.0	80.0	93.5
1740	99.5	99.0	80.0	94.0
1760	99.5	99.0	80.0	94.0
1780	100.0	99.5	80.0	94.5

- Notes:
1. See attached example calculation sheet that include weight estimates that make up the street section characteristics.
 2. Existing elevations based on topographic map prepared by Martin M. Ron Associates dated 2 July 2019. All elevations reference Old San Francisco City Datum plus 100 feet.
 3. Estimated finished grade elevations obtained from the Street Improvement Plans by BKF Engineers, Inc. dated 3 February 2020.
 4. Bottom of fill elevation based on data contained in the project Geotechnical Investigation Report dated 31 October 2019 and engineering judgement.

31-Jan-20

LANGAN

APPENDIX

MISSION ROCK COMPENSATING FILL SECTION:		Original ground surface elevation		Chanel Street		Existing fill thickness		11 ft
		Bottom of existing fill elevation		87 ft MBD		Grades raised		6.0 ft
		Observed average high groundwater elevation		93 ft MBD		Final Fill Thickness		17.0 ft
		Effective Unit Wt (pcf)		Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)		
New Section								
Proposed final grade				104.0				
Composite section unit weight -- upper 6 feet of new section		62		98.0	6.0	372.0		
LCC between composite section (upper 6 ft) and groundwater		26		93.0	5.0	130.0		
LCC below groundwater		5		92.5	0.5	2.5		
Improved fill below LCC		68		87.0	5.5	374.0		
Effective stress at top of Bay Mud						878.5		
		Effective Unit Wt (pcf)		Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)		
Existing Conditions								
Existing grade				98.0				
Existing fill above groundwater		125		93.0	5.0	625.0		
Existing fill below groundwater		62		87.0	6.0	372.0		
Effective stress at top of Bay Mud						997.0		

<<<---- new composite section that combines structural soil, utilities, pavements, and LCC in upper 6 feet (calculated on sheet F-

<<<---- iterate thickness of LCC below groundwater to achieve at least 10% unload (if needed, LCC above El. 93 feet can be itera

Check Load Compensation

Existing conditions-effective stress at top of Bay Mud (psf)	997.0
New conditions -effective stress at top of Bay Mud (psf)	878.5
Ratio of stress offset (existing stress/new stress): Target > 110%	113.5% ✓

OK if greater than 110%

Hydrostatic Uplift check if groundwater rises to: Elevation 97 feet.

Elevation of new groundwater (feet, MBD)	97.0	ft
Change in water level (feet)	4.0	ft
Total stress at bottom of LCC	598.0	psf
Hydrostatic head acting on base of LCC (psf)	283.5	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	2.1	✓

OK if greater than 1.1

Hydrostatic Uplift check if groundwater rises to: Elevation 99.5 feet.

Elevation of new groundwater table (feet, MBD)	99.5	ft
Change in water level (feet)	6.5	ft
Total stress at base of LCC	523.5	psf
Hydrostatic uplift acting on base of LCC	441.0	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	1.2	✓

OK if greater than 1.1

Notes:

1. MBD = Mission Bay Datum, which is old San Francisco Datum +100'
2. Unit weights of materials are as follows:
 - LCC total unit weight above water: 26 pcf
 - LCC total unit weight below water for load offset: 68 pcf (heavier value conservative for load offset)
 - LCC effective unit weight for load offset: 68 pcf -63 pcf = 5 pcf
 - LCC saturated unit weight for uplift: 50 pcf (lighter value, conservative for uplift evaluation)
 - Existing fill: 125 pcf
 - Existing fill below water: 125 pcf - 63 pcf = 62 pcf
 - Improved fill: 125 + 6 pcf = 131 pcf
 - Improved fill below water: 131 pcf - 63 pcf = 68 pcf

Channel Street Weight in upper 6 feet calculation

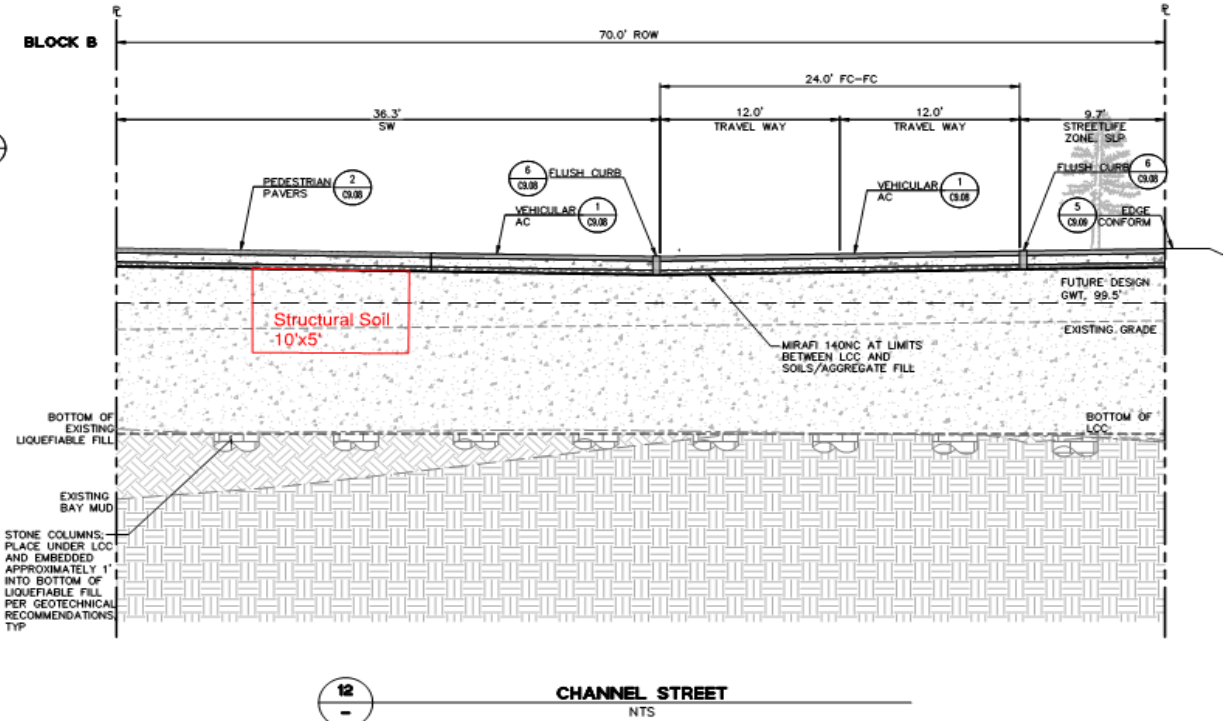
Right of Way width =	70 ft
Total length of structural soil Sections =	10 ft
Total sidewalk width (excluding the structural soil section) =	36 ft
Total roadway width =	24 ft

New Composite Fill Average Unit Weight Calculation

	Area (sf)	Total Unit Weight (psf/ft)	Total Weight (plf)	
Structural soil	50	110	5500	<--area of typical structural soil (see below)
Trees, light poles, and other collateral weight	14	86	1204	<--average line load placed on top of Structural Soil area (trees/poles/additional weight); provided by team
Utilities, bedding, and shading (See calc. below for area)	32	-	3486	<--assumed to be within the upper 6 feet for ease in calculation
Joint Trench	0	110	0	<--no JT in this street
Sidewalk and pavers	12	150	1798	<--4 inches thick over sidewalk length
4" AB under sidewalk, pavers, streets	20	130	2600	<--assumed under the entire ROW minus structural soil section
Street pavement section (thickness of 4" AC, 8" PCC x 35')	24	150	3600	area of LCC subtracted by the area of utilities, bedding, and shading
Remainder of ROW is lightweight fill (in upper 6 feet only)	282	28	7896	total unit weight based on 27 and 30 pcf for permeable LCC
Total	420	-	26084	<-- total area and estimated weight in the upper 6 feet of the section
Average unit weight (total weight/total area)		62		

Notes:

1. Typical street section prepared by BKF Engineers
2. Calculation averages the unit weight of the upper 6 feet of the lightweight fill section below the new pavement section and assumes the structural soil, utility bedding, utility shading, utilities, and lightweight fill are in that 6 foot section
3. Area of utilities and utility bedding and shading taken from a typical street section prepared by BKF Engineers
4. Assumes the entire unit weight of the utilities, bedding, and shading is 110 pcf
5. Unit weight of saturated structural soil assumed to be 110 pcf



Mission Rock Horizontal Improvements
750604203
1/17/2020

LANGAN

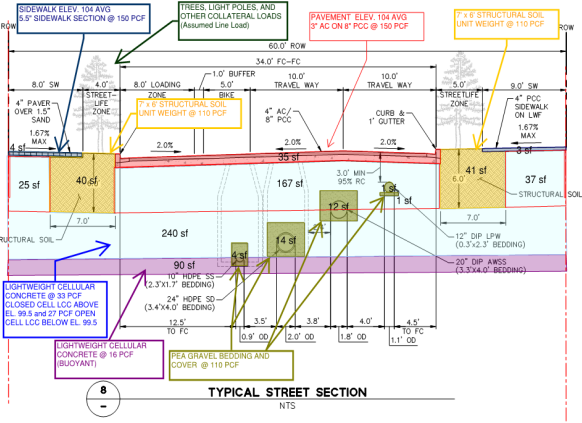
	Bedding and cushion				Unit wt = 110 PCF				
	Width (ft)	Depth (ft)	Pipe diameter (ft)	Area of bedding and shading (sf)	Area of pipe (sf)	Weight of bedding and shading (plf)	Weight of pipe (plf)	Weight of fluid in pipe assuming full (plf)	Total weight (plf)
10" SS*	1.7	2.3	0.9	3.3	0.6	360	65	48	473
24" SD*	4.0	3.4	2.0	10.5	3.1	1,151	253	236	1,404
20" AWSS*	4.0	3.3	1.8	10.7	2.5	1,172	265	191	1,437
12" LPW	2.3	0.3	1.0	0.7	0.8	76	96	59	172
Total				25.1	7.1				3,486

*Assumed unit weight of bedding and shading = 110 pcf

Total Area (sf) = 32

*Assumed unit weight of fluid in pipe = 75 pcf

Total Weight (plf) = 3,486



MISSION ROCK COMPENSATING FILL SECTION:		Shared Public Way			
	Original ground surface elevation	99	ft MBD	Existing fill thickness	15
	Bottom of existing fill elevation	84	ft MBD	Grades raised	5.5
	Observed average high groundwater elevation	93	ft MBD	Final Fill Thickness	20.5
		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
New Section					
Proposed final grade			104.5		
Composite section unit weight -- upper 6 feet of new section		84	98.5	6.0	504.0
LCC between composite section (upper 6 ft) and groundwater		26	93.0	5.5	143.0
LCC below groundwater		16	91.5	1.5	24.0
Improved fill below LCC		68	84.0	7.5	510.0
Effective stress at top of Bay Mud					1,181.0
Existing Conditions		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
Existing grade			99.0		
Existing fill above groundwater		125	93.0	6.0	750.0
Existing fill below groundwater		62	84.0	9.0	558.0
Effective stress at top of Bay Mud					1,308.0

Check Load Compensation

Existing conditions-effective stress at top of Bay Mud (psf)	1,308.0
New conditions -effective stress at top of Bay Mud (psf)	1,181.0
Ratio of stress offset (existing stress/new stress): Target > 110%	110.8% ✓

OK if greater than 110%

Hydrostatic Uplift check if groundwater rises to: Elevation 97 feet.

Elevation of new groundwater (feet, MBD)	97.0	ft
Change in water level (feet)	4.0	ft
Total stress at bottom of LCC	743.0	psf
Hydrostatic head acting on base of LCC (psf)	346.5	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	2.1	✓

OK if greater than 1.1

Hydrostatic Uplift check if groundwater rises to: Elevation 99.5 feet.

Elevation of new groundwater table (feet, MBD)	99.5	ft
Change in water level (feet)	6.5	ft
Total stress at base of LCC	803.0	psf
Hydrostatic uplift acting on base of LCC	504.0	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	1.6	✓

OK if greater than 1.1

Notes:

1. MBD = Mission Bay Datum, which is old San Francisco Datum +100'
2. Unit weights of materials are as follows:

LCC total unit weight above water: 26 pcf

LCC total unit weight below water for load offset: 68 pcf (heavier value conservative for load offset)

LCC effective unit weight for load offset: 68 pcf -63 pcf = 5 pcf

LCC saturated unit weight for uplift: 50 pcf (lighter value, conservative for uplift evaluation)

Existing fill: 125 pcf

Existing fill below water: 125 pcf - 63 pcf = 62 pcf

Improved fill: 125 + 6 pcf = 131 pcf

Improved fill below water: 131 pcf - 63 pcf = 68 pcf

<<<---- new composite section that combines structural soil, utilities, pavements, and LCC in upper 6 feet (calculated on

<<<---- iterate thickness of LCC below groundwater to achieve at least 10% unload (if needed, LCC above El. 93 feet can

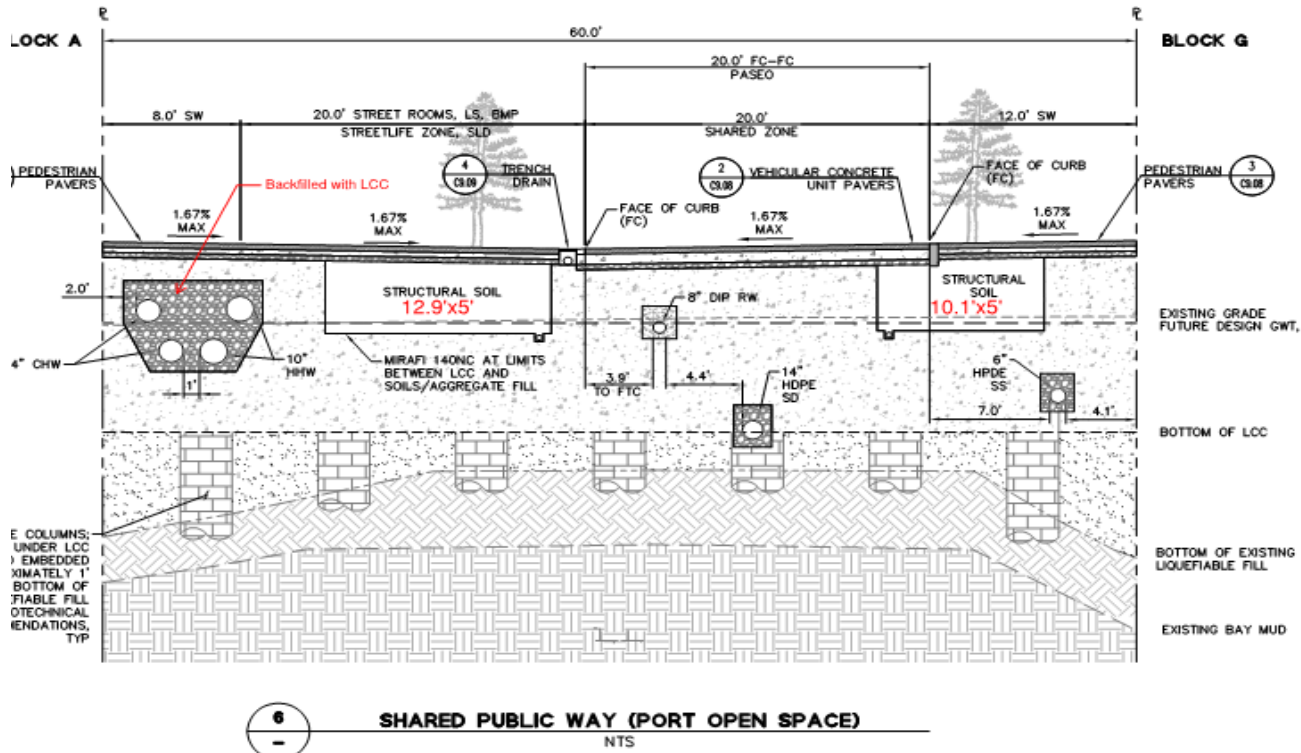
Total Length of Structural Soil Sections = 23 ft
Total Sidewalk Width (excluding the structural soil section) = 20 ft
Total Roadway Width = 40 ft

New Composite Fill Average Unit Weight Calculation

	Area (sf)	Total Unit Weight (psf/ft)	Total Weight (plf)	
Structural Soil	115	110	12650	<--area of typical structural soil (see below)
Trees, light poles, and other collateral weight	14	86	1204	<--average line load placed on top of Structural Soil area (trees/poles/additional weight); provided by team
Utilities, bedding, and shading (See calc. below for area)	32	-	3486	<--assumed to be within the upper 6 feet for ease in calculation
Joint Trench	0	110	0	<--no JT in this street
Sidewalk and Pavers	7	150	999	<--4 inches thick over sidewalk length
4" AB under Sidewalk, Pavers, Streets	12	130	1603	<--assumed under the entire ROW minus structural soil section
Street Pavement Section (thickness of 4" AC, 8" PCC x 35')	40	150	6000	area of LCC subtracted by the area of utilities, bedding, and shading total unit weight based on 27 and 30 pcf for permeable LCC
Remainder of ROW is lightweight fill (in upper 6 feet only)	154	28	4312	
Total	360	-	30255	<-- total area and estimated weight in the upper 6 feet of the section
Average unit weight (total weight/total area)		84		

Notes:

1. Typical Street Section prepared by BKF Engineers
2. Calculation averages the unit weight of the upper 6 feet of the lightweight fill section below the new pavement
3. Area of utilities and utility bedding and shading taken from a typical street section prepared by BKF Engineers
4. Assumes the entire unit weight of the utilities, bedding, and shading is 110 pcf
5. Unit weight of saturated structural soil assumed to be 110 pcf



Mission Rock Horizontal Improvements
750604203
1/17/2020

LANGAN

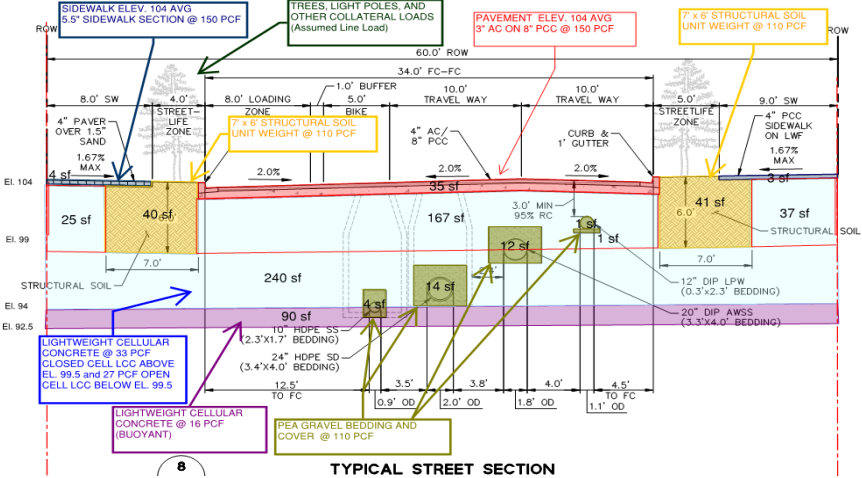
	Bedding and cushion		Unit wt =	110 PCF					
	Width (ft)	Depth (ft)	Pipe diameter (ft)	Area of bedding and shading (sf)	Area of pipe (sf)	Weight of bedding and shading (plf)	Weight of pipe (plf)	Weight of fluid in pipe assuming full (plf)	Total weight (plf)
10" SS*	1.7	2.3	0.9	3.3	0.6	360	65	48	473
24" SD*	4.0	3.4	2.0	10.5	3.1	1,151	253	236	1,404
20" AWSS*	4.0	3.3	1.8	10.7	2.5	1,172	265	191	1,437
12" LPW	2.3	0.3	1.0	0.7	0.8	76	96	59	172
Total				25.1	7.1	3,486			

*Assumed unit weight of bedding and shading = 110 pcf

Total Area (sf) = 32

*Assumed unit weight of fluid in pipe = 75 pcf

Total Weight (plf) = 3,486



MISSION ROCK COMPENSATING FILL SECTION:		Bridgeview North			
	Original ground surface elevation	100	ft MBD	Existing fill thickness	15
	Bottom of existing fill elevation	85	ft MBD	Grades raised	4.0
	Observed average high groundwater elevation	93	ft MBD	Final Fill Thickness	19.0
		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
New Section					
Proposed final grade			104.0		
Composite section unit weight -- upper 6 feet of new section		87	98.0	6.0	522.0
LCC between composite section (upper 6 ft) and groundwater		26	93.0	5.0	130.0
LCC below groundwater		6	93.0	-	-
Improved fill below LCC		68	85.0	8.0	544.0
Effective stress at top of Bay Mud					1,196.0
Existing Conditions		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
Existing grade			100.0		
Existing fill above groundwater		125	93.0	7.0	875.0
Existing fill below groundwater		62	85.0	8.0	496.0
Effective stress at top of Bay Mud					1,371.0

<<<---- new composite section that combines structural soil, utilities, pavements, and LCC in upper 6 feet (calculated c

<<<---- iterate thickness of LCC below groundwater to achieve at least 10% unload (if needed, LCC above El. 93 feet ca

Check Load Compensation

Existing conditions-effective stress at top of Bay Mud (psf)	1,371.0
New conditions -effective stress at top of Bay Mud (psf)	1,196.0
Ratio of stress offset (existing stress/new stress): Target > 110%	114.6% ✓

OK if greater than 110%

Hydrostatic Uplift check if groundwater rises to: Elevation 97 feet.

Elevation of new groundwater (feet, MBD)	97.0	ft
Change in water level (feet)	4.0	ft
Total stress at bottom of LCC	748.0	psf
Hydrostatic head acting on base of LCC (psf)	252.0	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	3.0	✓

OK if greater than 1.1

Hydrostatic Uplift check if groundwater rises to: Elevation 99.5 feet.

Elevation of new groundwater table (feet, MBD)	99.5	ft
Change in water level (feet)	6.5	ft
Total stress at base of LCC	808.0	psf
Hydrostatic uplift acting on base of LCC	409.5	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	2.0	✓

OK if greater than 1.1

Notes:

1. MBD = Mission Bay Datum, which is old San Francisco Datum +100'
2. Unit weights of materials are as follows:
 - LCC total unit weight above water: 26 pcf
 - LCC total unit weight below water for load offset: 68 pcf (heavier value conservative for load offset)
 - LCC effective unit weight for load offset: 68 pcf -63 pcf = 5 pcf
 - LCC saturated unit weight for uplift: 50 pcf (lighter value, conservative for uplift evaluation)
 - Existing fill: 125 pcf
 - Existing fill below water: 125 pcf - 63 pcf = 62 pcf
 - Improved fill: 125 + 6 pcf = 131 pcf
 - Improved fill below water: 131 pcf - 63 pcf = 68 pcf

Bridgeview (North Section) Weight in upper 6 feet calculation

Right of Way Width =	60	ft
Total Length of Structural Soil Sections =	21	ft
Total Sidewalk Width (excluding the structural soil section) =	17	ft
Total Roadway Width =	43	ft

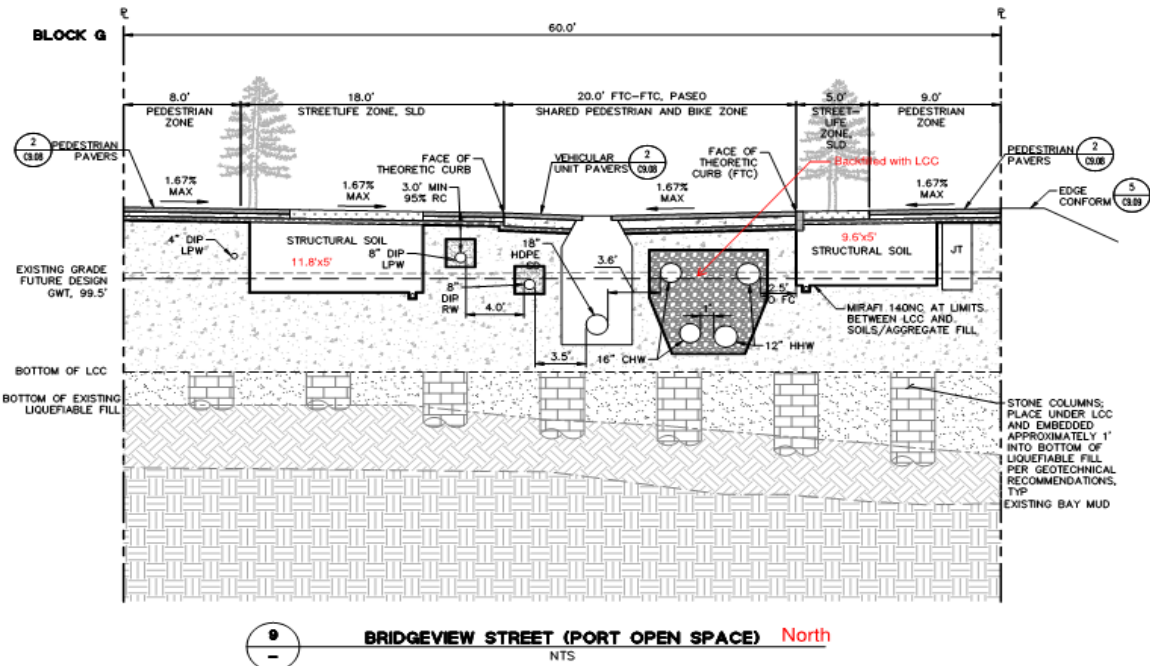
New Composite Fill Average Unit Weight Calculation

	Area (sf)	Total Unit Weight (psf/ft)	Total Weight (plf)	
Structural Soil	107	110	11770	<--area of typical structural soil (see below)
Trees, light poles, and other collateral weight	14	86	1204	<--average line load placed on top of Structural Soil area (trees/poles/additional weight); provided by team
Utilities, bedding, and shading (See calc. below for area)	32	-	3486	<--assumed to be within the upper 6 feet for ease in calculation
Joint Trench	19	110	2090	<--JT in this street
Sidewalk and Pavers	6	150	849	<--4 inches thick over sidewalk length
4" AB under Sidewalk, Pavers, Streets	13	130	1673	<--assumed under the entire ROW minus structural soil section
Street Pavement Section (thickness of 4" AC, 8" PCC x 35')	43	150	6450	area of LCC subtracted by the area of utilities, bedding, and shading
Remainder of ROW is lightweight fill (in upper 6 feet only)	140	28	3933	total unit weight based on 27 and 30 pcf for permeable LCC
Total	360	-	31455	<-- total area and estimated weight in the upper 6 feet of the section
Average unit weight (total weight/total area)		87		

Notes:

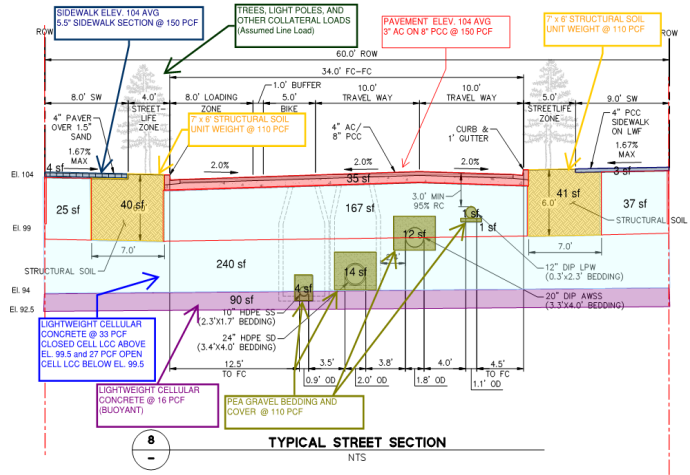
1. Typical Street Section prepared by BKF Engineers
2. Calculation averages the unit weight of the upper 6 feet of the lightweight fill section below the new pavement
3. Area of utilities and utility bedding and shading taken from a typical street section prepared by BKF Engineers
4. Assumes the entire unit weight of the utilities, bedding, and shading is 110 pcf
5. Unit weight of saturated structural soil assumed to be 110 pcf

	Bedding and cushion		Unit wt =		PCF					
	Width (ft)	Depth (ft)	Pipe diameter (ft)	Area of bedding and shading (sf)	Area of pipe (sf)	Weight of bedding and shading (plf)	Weight of pipe (plf)	Weight of fluid in pipe assuming full (plf)	Total weight (plf)	
10" SS*	1.7	2.3	0.9	3.3	0.6	360	65	48	473	
24" SD*	4.0	3.4	2.0	10.5	3.1	1,151	253	236	1,404	
20" AWSS*	4.0	3.3	1.8	10.7	2.5	1,172	265	191	1,437	
12" LPW	2.3	0.3	1.0	0.7	0.8	76	96	59	172	
Total				25.1	7.1				3,486	
*Assumed unit weight of bedding and shading = 110 pcf									Total Area (sf) =	32
*Assumed unit weight of fluid in pipe = 75 pcf									Total Weight (plf) =	3,486



Mission Rock Horizontal Improvements
750604203
1/17/2020

LANGAN



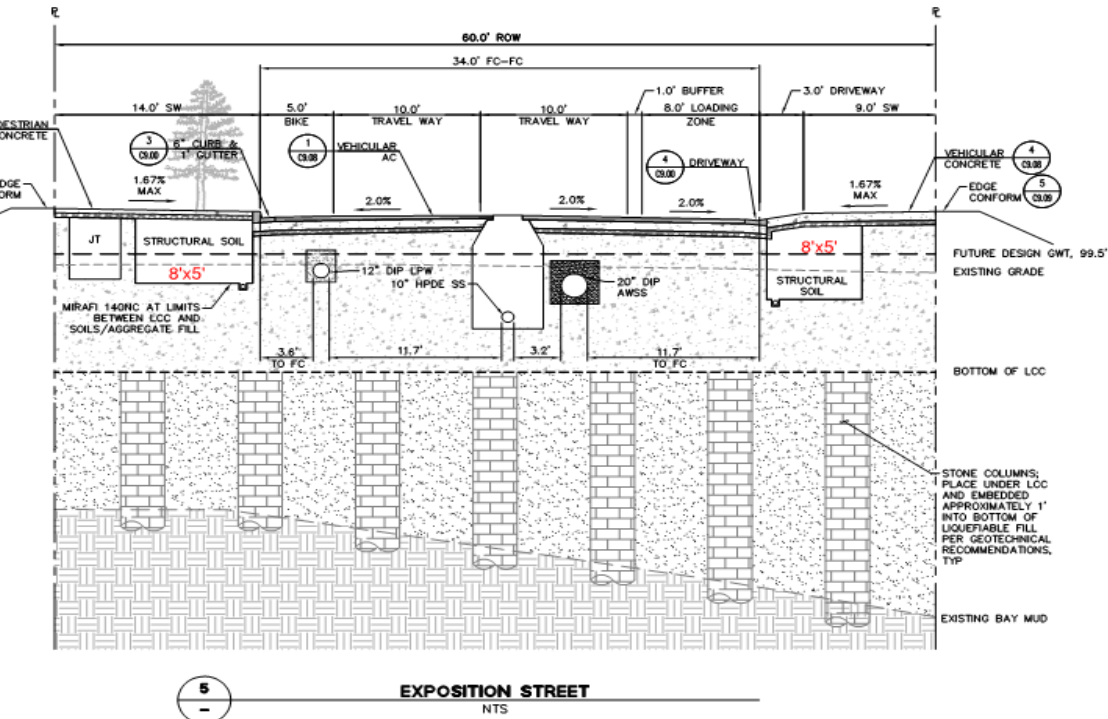
Total Length of Structural Soil Sections =	10.8 ft
Total Sidewalk Width (excluding the structural soil section) =	26 ft
Total Roadway Width =	34 ft

New Composite Fill Average Unit Weight Calculation

	Area (sf)	Total Unit Weight (psf/ft)	Total Weight (plf)	
Structural Soil	54	110	5940	<--area of typical structural soil (see below)
Trees, light poles, and other collateral weight	14	86	1204	<--average line load placed on top of Structural Soil area (trees/poles/additional weight); provided by team
Utilities, bedding, and shading (See calc. below for area)	32	-	3486	<--assumed to be within the upper 6 feet for ease in calculation
Joint Trench	19	110	2090	<-- JT in this street
Sidewalk and Pavers	9	150	1299	<--4 inches thick over sidewalk length
4" AB under Sidewalk, Pavers, Streets	16	130	2132	<--assumed under the entire ROW minus structural soil section
Street Pavement Section (thickness of 4" AC, 8" PCC x 35')	34	150	5100	area of LCC subtracted by the area of utilities, bedding, and shading
Remainder of ROW is lightweight fill (in upper 6 feet only)	196	28	5486	total unit weight based on 27 and 30 pcf for permeable LCC
Total	360	-	26737	<-- total area and estimated weight in the upper 6 feet of the section
Average unit weight (total weight/total area)		74		

Notes:

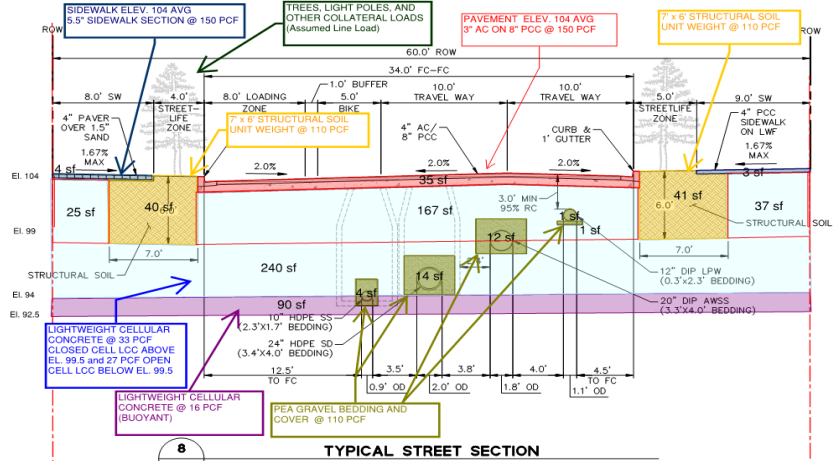
1. Typical Street Section prepared by BKF Engineers
2. Calculation averages the unit weight of the upper 6 feet of the lightweight fill section below the new pavement
3. Area of utilities and utility bedding and shading taken from a typical street section prepared by BKF Engineers:
4. Assumes the entire unit weight of the utilities, bedding, and shading is 110 pcf
5. Unit weight of saturated structural soil assumed to be 110 pcf



Mission Rock Horizontal Improvements
750604203
1/17/2020

LANGAN

	Bedding and cushion		Unit wt = 110		PCF		Weight of bedding and shading (plf)	Weight of pipe (plf)	Weight of fluid in pipe assuming full (plf)	Total weight (plf)
	Width (ft)	Depth (ft)	Pipe diameter (ft)	Area of bedding and shading (sf)	Area of pipe (sf)					
10" SS*	1.7	2.3	0.9	3.3	0.6		360	65	48	473
24" SD*	4.0	3.4	2.0	10.5	3.1		1,151	253	236	1,404
20" AWSS*	4.0	3.3	1.8	10.7	2.5		1,172	265	191	1,437
12" LPW	2.3	0.3	1.0	0.7	0.8		76	96	59	172
Total				25.1	7.1					3,486
*Assumed unit weight of bedding and shading = 110 pcf										Total Area (sf) = 32
*Assumed unit weight of fluid in pipe = 75 pcf										Total Weight (plf) = 3,486



MISSION ROCK COMPENSATING FILL SECTION:		Promenade			
	Original ground surface elevation	98.5	ft MBD	Existing fill thickness	12
	Bottom of existing fill elevation	87	ft MBD	Grades raised	3.5
	Observed average high groundwater elevation	93	ft MBD	Final Fill Thickness	15.0
		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
New Section					
Proposed final grade			102.0		
Composite section unit weight -- upper 6 feet of new section		68	96.0	6.0	408.0
LCC between composite section (upper 6 ft) and groundwater		26	94.5	1.5	39.0
LCC below groundwater		16	94.5	-	-
Improved fill below LCC		68	87.0	7.5	510.0
Effective stress at top of Bay Mud					957.0
Existing Conditions		Effective Unit Wt (pcf)	Bottom Elev. (MBD)	Thickness (feet)	Effective stress (psf)
Existing grade			98.5		
Existing fill above groundwater		125	93.0	5.5	687.5
Existing fill below groundwater		62	87.0	6.0	372.0
Effective stress at top of Bay Mud					1,059.5

<<<---- new composite section that combines structural soil, utilities, pavements, and LCC in upper 6 feet (calculated c

<<<---- iterate thickness of LCC below groundwater to achieve at least 10% unload (if needed, LCC above El. 93 feet ca

Check Load Compensation

Existing conditions-effective stress at top of Bay Mud (psf)	1,059.5
New conditions -effective stress at top of Bay Mud (psf)	957.0
Ratio of stress offset (existing stress/new stress): Target > 110%	110.7% ✓

OK if greater than 110%

Hydrostatic Uplift check if groundwater rises to: Elevation 97 feet.

Elevation of new groundwater (feet, MBD)	97.0	ft
Change in water level (feet)	4.0	ft
Total stress at bottom of LCC	507.0	psf
Hydrostatic head acting on base of LCC (psf)	157.5	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	3.2	✓

OK if greater than 1.1

Hydrostatic Uplift check if groundwater rises to: Elevation 99.5 feet.

Elevation of new groundwater table (feet, MBD)	99.5	ft
Change in water level (feet)	6.5	ft
Total stress at base of LCC	567.0	psf
Hydrostatic uplift acting on base of LCC	315.0	psf
Factor of Safety against hydrostatic uplift (total stress at base / hydrostatic head at base)	1.8	✓

OK if greater than 1.1

Notes:

1. MBD = Mission Bay Datum, which is old San Francisco Datum +100'
2. Unit weights of materials are as follows:

LCC total unit weight above water: 26 pcf

LCC total unit weight below water for load offset: 68 pcf (heavier value conservative for load offset)

LCC effective unit weight for load offset: 68 pcf -63 pcf = 5 pcf

LCC saturated unit weight for uplift: 50 pcf (lighter value, conservative for uplift evaluation)

Existing fill: 125 pcf

Existing fill below water: 125 pcf - 63 pcf = 62 pcf

Improved fill: 125 + 6 pcf = 131 pcf

Improved fill below water: 131 pcf - 63 pcf = 68 pcf

0 ft
0 ft
30 ft

	Area (sf)	Total Unit Weight (psf/ft)	Total Weight (plf)
Structural Soil	0	110	0
Trees, light poles, and other collateral weight	14	86	0
Utilities, bedding, and shading (See calc. below for area)	32	-	3486
Joint Trench	0	110	0
Sidewalk and Pavers	0	150	0
4" AB under Sidewalk, Pavers, Streets	10	130	1300
Street Pavement Section (thickness of 4" AC, 8" PCC x 35')	30	150	4500
Remainder of ROW is lightweight fill (in upper 6 feet only)	108	28	3024
Total	180	-	12310
Average unit weight (total weight/total area)		68	

1. Typical Street Section prepared by BKF Engineers
2. Calculation averages the unit weight of the upper 6 feet of the lightweight fill section below the new pavement
3. Area of utilities and utility bedding and shading taken from a typical street section prepared by BKF Engineers
4. Assumes the entire unit weight of the utilities, bedding, and shading is 110 pcf
5. Unit weight of saturated structural soil assumed to be 110 pcf

**LANGAN**

*Assumed unit weight of bedding and shading = 110 pcf	Total Area (sf) =	32
*Assumed unit weight of fluid in pipe = 75 pcf	Total Weight (plf) =	3,486

