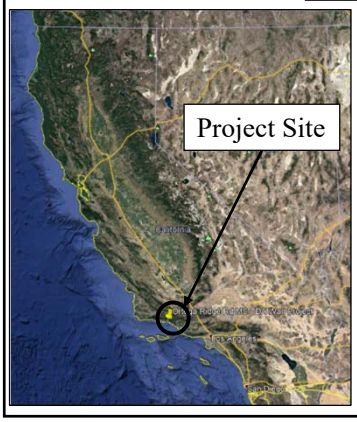
Reconstruction of Failed Roadway Embankments Using Tire-Derived Aggregate Mechanically Stabilized Earth Walls: Ortega Ridge Road MS-TDA Case Study

IFAI Geosynthetics Conference

1

ORTEGA RIDGE RD MS-TDA WALL - LOCATION

PROJECT LOCATION:
Town of Summerland
Santa Barbara County
State of California



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ORTEGA RIDGE RD MS-TDA WALL - LOCATION

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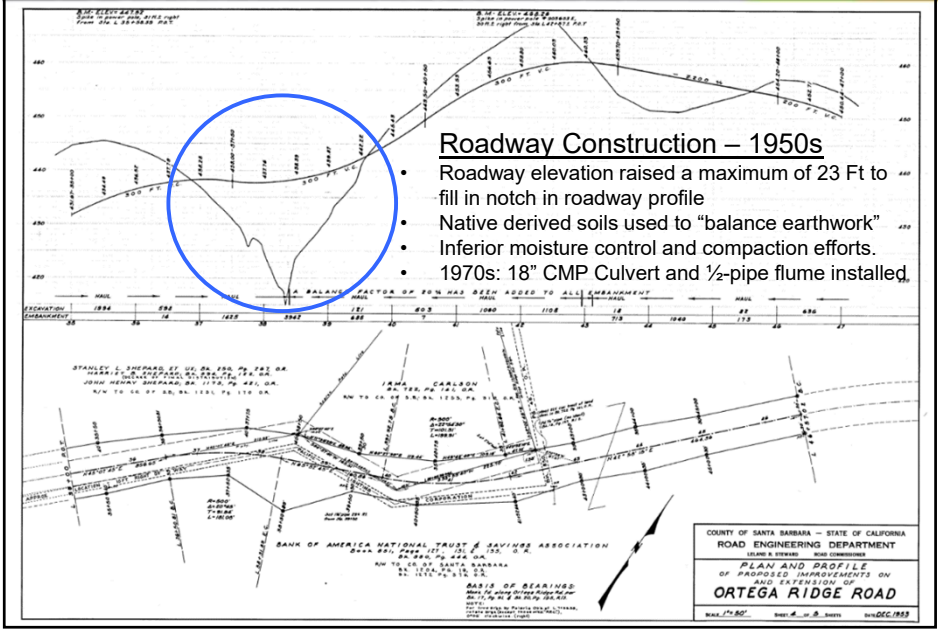
ORTEGA RIDGE RD MS-TDA WALL - HISTORY



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ORTEGA RIDGE RD MS-TDA WALL - GEOLOGY

Existing Conditions and Geology

- Rincon Formation underlies project site.
- Massive to poorly bedded shale, mudstone, and siltstone.
- Weathers to black clayey loamy soil.
- High expansion-contraction potential.
- Landslides and soil slumps frequent, typically limited to about 15 feet depth.
- Failures often occur at boundary between weathered and un-weathered material.

Geologic Map of Santa Barbara Quadrangle, Dibblee and Ehrenspeck, 1986

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ORTEGA RIDGE RD MS-TDA WALL - CONDITIONS

Existing Conditions – Summer 2015

- Sloughing and Settlement of weathered shale embankment soils
- Maintenance: Crack-sealing and Asphalt overlays over several decades
- Over 30” of Asphalt at the downslope edge of pavement.
- Failing HMA Dike allows storm water to drain over slope.

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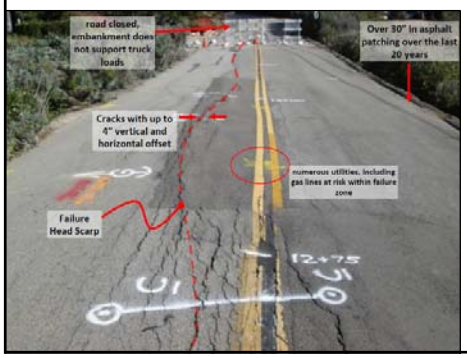
ORTEGA RIDGE RD MS-TDA WALL - CONDITIONS

Existing Conditions – November 2015

- More Asphalt overlays to smooth out cracks for driver comfort and safety.
- Sloughing and Settlement of weathered shale embankment soils accelerate and failure extends further into far lane.
- Road Closed to all traffic for a period of 2 months.
- Temporary roadway realignment, additional 7 FT of pavement, and alternating stop-controlled single traffic lane constructed.
- Utilities within failure area – no known impacts (flowing by)



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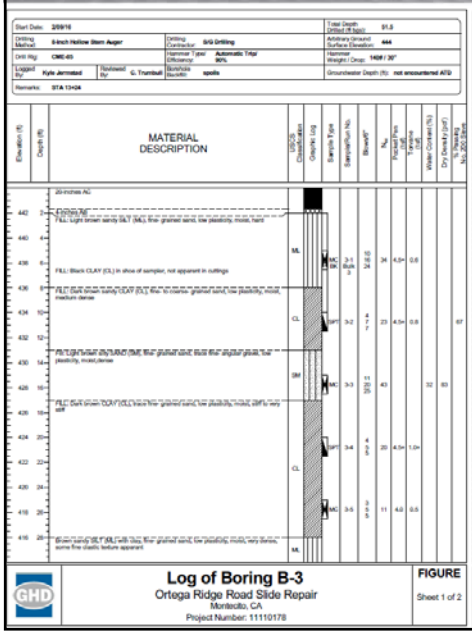
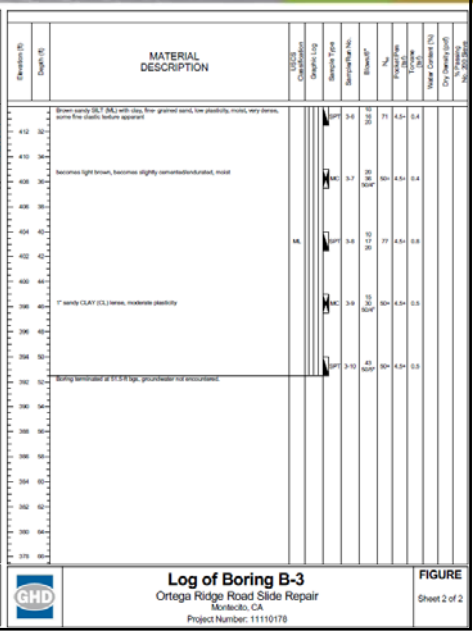
ORTEGA RIDGE RD MS-TDA WALL - DESIGN





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ORTEGA RIDGE RD MS-TDA WALL - DESIGN

Geotechnical Investigation and Design

- County Geologic Investigation Report - 2 HSA borings to ~30 FT depth (2006)
  - Indicated soils are oversaturated at depth, relatively low compaction, and high void ratio.
  - Rincon Shale
    - Dry Unit Weight = 73-96 PCF, Max Density = 99-14 PCF.
    - Existing soils = 78%-84% compaction
    - Optimum moisture content (MC) = 15-23%. Existing soils = 25%-39%
    - High Void Ratio = additional settlement anticipated.
    - Initial recommended mitigation of over-excavation of 3 FT, and reconstruction with granular backfill with geosynthetic reinforcement.
- GHD Geotechnical Report – 2 HSA borings to ~52 FT depth (2016)
  - Confirmed earlier investigation, extended depth of observation, and provided additional lab testing for the proposed MS-TDA wall design.
  - Slope Stability Analysis provided soil and strength parameters for the MS-TDA Wall design.

Table 1 Material Parameters

Material	ϕ' (deg)	c' (psf)	γ_t (pcf)
Sandy CLAY (historical fill)	5	1,000	110
Native Clay (historical fill)	5	550	110
Sandy SILT (native)	36	500	125
TDA	35	0	45
Engineered Fill (above TDA)	34	0	125
Pavement Section	36	0	140
Uniaxial Geogrid (Tensar UX1100): Pullout = 1,000 psf; Tensile = 742 lbs			

Table 3 Local Stability and MSE Wall Results

Analysis Condition	Factor of Safety		Acceptable
	Result	Criteria	
Overturning - Static	22.7	2	Yes
Overturning - Seismic	8.6	1.5	Yes
Sliding on Base - Static	6.0	1.5	Yes
Sliding on Base - Seismic	3.2	1.1	Yes
Bearing Capacity - Static	10.2	2.5	Yes
Bearing Capacity - Seismic	5.8	2	Yes
Internal Stability - See attachment	varies	varies	Yes

As shown in the table above, the local stability results meet the project criteria, the proposed geometry stated above is acceptable, and local instability within the MSE wall is not expected.

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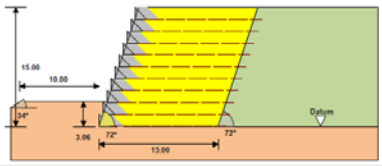
ORTEGA RIDGE RD MS-TDA WALL - DESIGN

Tensar software output
TensarSoil® Version 2.06
Calculations in accordance with: NCMA (1997) (seismic loading)

Input data and Section Project: Ortega Ridge Slide Repair



Tensar Structural Systems SierraScape® Slope Retention System

Seismic loading case — All dimensions in feet — Scale 1:100

Fill/foundation properties — Design soil strength parameters are peak values

Soil zone	Drained/ undrained	c' (lb/ft²)	φ' (°)	γbulk (lb/ft³)
Reinforced soil	Drained	0	35.0	45.0
Retained soil	Drained	0	30.0	45.0
Foundation soil	Undrained	550	5.0	110.0

Seismic design data — g = acceleration due to gravity

Input	Limiting deformation	External mechanisms	Internal mechanisms
A_h = 0.34g	2.0 inches	k_h(ext) = 0.17g	k_h(int) = 0.38g
A_v = 0.03g	2.0 inches	k_v(ext) = 0.01g	k_v(int) = 0.04g

Vertical accelerations may act either downwards or upwards

Tensar software output
TensarSoil® Version 2.06
Calculations in accordance with: NCMA (1997) (seismic loading)

Water pressure data

Location	Height of water level above datum (m)	r_u
In front of structure	No water pressures	
Within fill	No water pressures	NA

Verification of external stability

Mechanism	Result	Max/Min	Critical case	OK?
Overturning	FS = 8.57	1.5 min	Seismic	OK
Sliding on base	FS = 3.16	1.13 min	Seismic	OK
Bearing capacity	FS = 5.794	2.5 min	Static	OK

Verification of internal stability

Mechanism	OK?	Mechanism	OK?
Rupture check	OK	Pullout check	OK
Internal sliding	OK	Connection check	OK

Reinforcement layout — Starting and finishing levels are related to datum

Tensar Geogrid	No of layers	Starting level (ft)	Vertical spacing (ft)	Finishing level (ft)	Coverage C_g (%)	
UX1100MSE	9	1.50	1.50	13.50	94	0.8
UX1100MSE	1	0.00	-	-	94	0.8

Required minimum factors of safety — As given in Table 6.1 for static and Table 6.1 for seismic.

Mechanism	Static loading	Seismic loading
Overturning	FS = 2.0	FS = 1.5
Sliding on base	FS = 1.5	FS = 1.1
Bearing capacity	FS = 2.0	FS = 1.5
Geogrid rupture	FS = 1.5	FS = 1.1
Geogrid pullout	FS = 1.5	FS = 1.1
Connection with facing (ultimate)	FS = 1.5	FS = 1.1
Connection with facing (serviceability)	FS = 1.0	NA
Internal sliding on geogrid	FS = 1.5	FS = 1.1

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ORTEGA RIDGE RD MS-TDA WALL - DESIGN

Tensar
Calculations in accordance with: NCMA (1997) (seismic loading)

Tensar software output
TensarSoil® Version 2.06

Geogrid reinforcement design data for static design
Strength values quoted are per metre width of geogrid, and do not take into account percentage coverage
Geogrid strength is calculated following Section3.5.1.
Connection data given below is defined in Section3.5.1 and the values given are for the facing system indicated on Page 2.

Design temperature (°C)	20			Design life (years)		120	
Tensar geogrid	Ultimate strength (lb/ft)	Creep factor	Durability factor	Installation damage	FS	Design strength (lb/ft)	Connection data (lb/ft)
	T_{ult}	RF_{cr}	RF_d	RF_{id}		T_a	T_{ultcon} $T_{servcon}$
UX1100MSE	3974	2.6	1.1	1.1	1.5	1265	3974 3974

Geogrid reinforcement design data for seismic design
Strength values quoted are per metre width of geogrid, and do not take into account percentage coverage
Geogrid strength is calculated following Section6.3.2.
Connection data given below is defined in Section6.3.2 and the values given are for the facing system indicated on Page 2.

Design temperature (°C)	20						
Tensar geogrid	Ultimate strength (lb/ft)	Creep factor	Durability factor	Installation damage	FS	Design strength (lb/ft)	Connection data (lb/ft)
	T_{ult}	RF_{cr}	RF_d	RF_{id}		T_a	T_{ultcon}
UX1100MSE	3974	1.00	1.1	1.1	1.5	2856	3974

Geogrid coordinates and design data
Levels are measured from the datum and horizontal location is measured from the toe of the wall

Tensar geogrid	Level	Left end	Right end	Length	Coverage	Pullout interaction factor C_i
UX1100MSE	13.50	4.50	20.50	16.00	94.0	0.800
UX1100MSE	12.00	4.00	20.00	16.00	94.0	0.800
UX1100MSE	10.50	3.50	19.50	16.00	94.0	0.800
UX1100MSE	9.00	3.00	19.00	16.00	94.0	0.800
UX1100MSE	7.50	2.50	18.50	16.00	94.0	0.800
UX1100MSE	6.00	2.00	18.00	16.00	94.0	0.800
UX1100MSE	4.50	1.50	17.50	16.00	94.0	0.800
UX1100MSE	3.00	1.00	17.00	16.00	94.0	0.800
UX1100MSE	1.50	0.50	16.50	16.00	94.0	0.800
UX1100MSE	0.00	0.00	16.00	16.00	94.0	0.800

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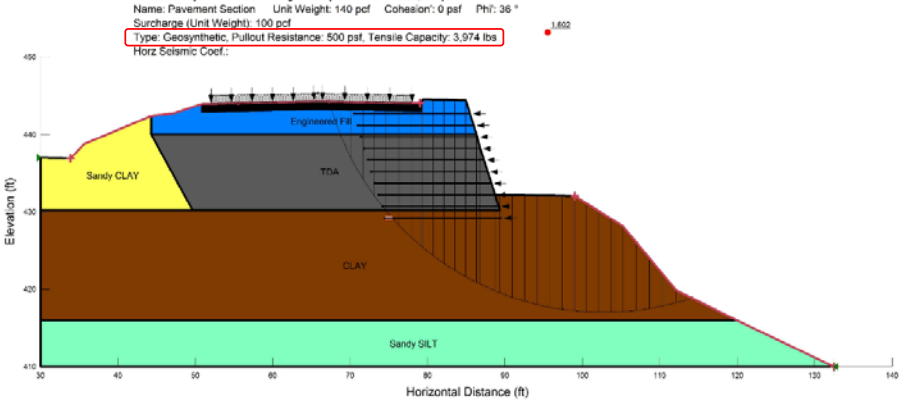
ORTEGA RIDGE RD MS-TDA WALL - DESIGN

Ortega Ridge Slide Repair Slope Stability - Static
Last Edited By: Chris Trumbull
Date: 3/26/2016
File Name: OR MSTDA 01.gsz

Material Summary:
Name: TDA Unit Weight: 45 pcf Cohesion': 0 psf Phi': 35 °
Name: Engineered Fill Unit Weight: 125 pcf Cohesion': 0 psf Phi': 34 °
Name: CLAY Unit Weight: 110 pcf Cohesion': 550 psf Phi': 5 °
Name: Sandy SILT Unit Weight: 125 pcf Cohesion': 500 psf Phi': 36 °
Name: Sandy CLAY Unit Weight: 110 pcf Cohesion': 1,000 psf Phi': 5 °
Name: Pavement Section Unit Weight: 140 pcf Cohesion': 0 psf Phi': 36 °
Surcharge (Unit Weight): 100 pcf
Type: Geosynthetic, Pullout Resistance: 500 psf, Tensile Capacity: 3,974 lbs
Horz Seismic Coef.:



Slope Stability Analysis of MS-TDA

- GeoStudio Slope/W (2012) utilized
- Long Term Static FS = 1.6 (Min = 1.5)
- Pseudo-Static FS = 1.1 (Min = 1.1)

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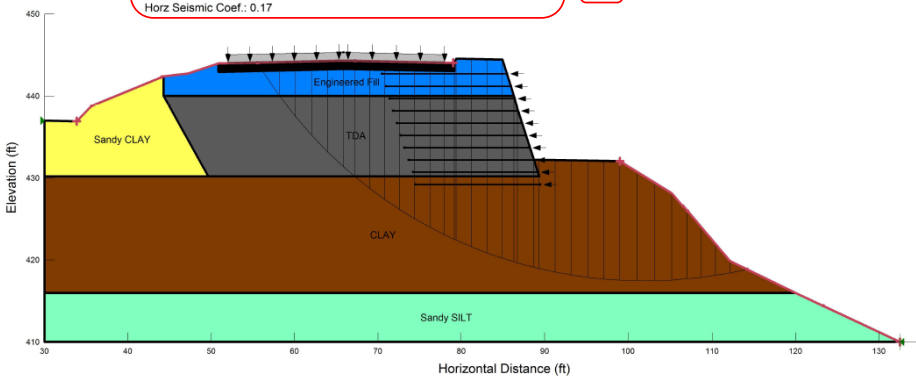
ORTEGA RIDGE RD MS-TDA WALL - DESIGN

Ortega Ridge Slide Repair Slope Stability - Pseudo Static 1
Last Edited By: Chris Trumbull
Date: 3/28/2016
File Name: OR MSTDA 01.gsz

Material Summary:
Name: TDA Unit Weight: 45 pcf Cohesion': 0 psf Phi': 35 °
Name: Engineered Fill Unit Weight: 125 pcf Cohesion': 0 psf Phi': 34 °
Name: CLAY Unit Weight: 110 pcf Cohesion': 550 psf Phi': 5 °
Name: Sandy SILT Unit Weight: 125 pcf Cohesion': 500 psf Phi': 36 °
Name: Sandy CLAY Unit Weight: 110 pcf Cohesion': 1,000 psf Phi': 5 °
Name: Pavement Section Unit Weight: 140 pcf Cohesion': 0 psf Phi': 36 °
Surcharge (Unit Weight): 100 pcf
Type: Geosynthetic, Pullout Resistance: 1,000 psf, Tensile Capacity: 742 lbs
Horz Seismic Coef.: 0.17

Slope Stability Analysis of MS-TDA

- GeoStudio Slope/W (2012) utilized
- Long Term Static FS = 1.6 (Min = 1.5)
- Pseudo-Static FS = 1.1 (Min = 1.1)



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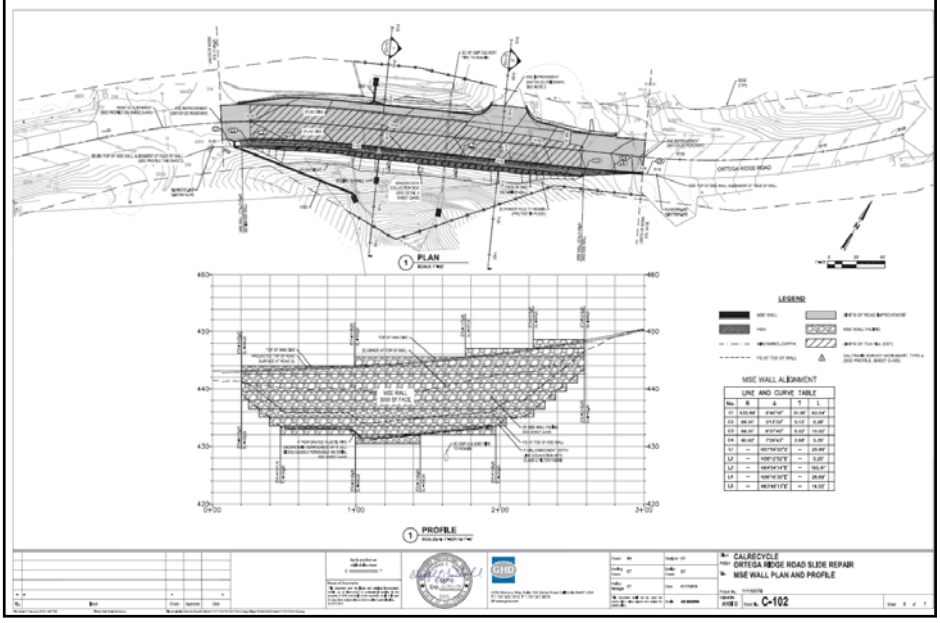
ORTEGA RIDGE RD MS-TDA WALL - DESIGN



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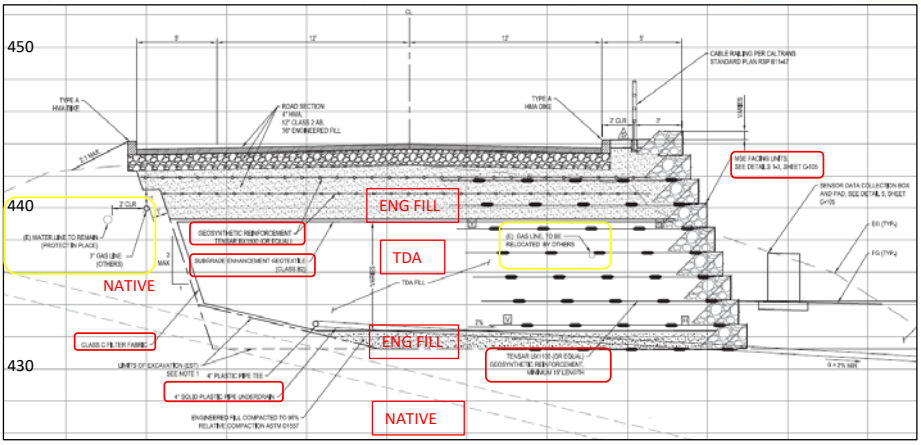
ORTEGA RIDGE RD MS-TDA WALL - DESIGN



- Tensar SierraScape (or equal) MSE Wall Facing (max of 14 FT height)
- TDA lightweight backfill up to 9 FT thick, with Caltrans Class C Filter Fabric at native soil interface
- Tensar UX1100 (or equal) uniaxial geosynthetic reinforcement @ 15 FT Min embedment length
- Engineered Fill, free draining material, 1 FT at bottom (drainage), 3 FT at top (bridging)
- B2 Subgrade Enhancement Geotextile separates TDA from Engineered Fill
- Tensar BX1500 (or equal) biaxial geosynthetic reinforcement within engineered fill zone

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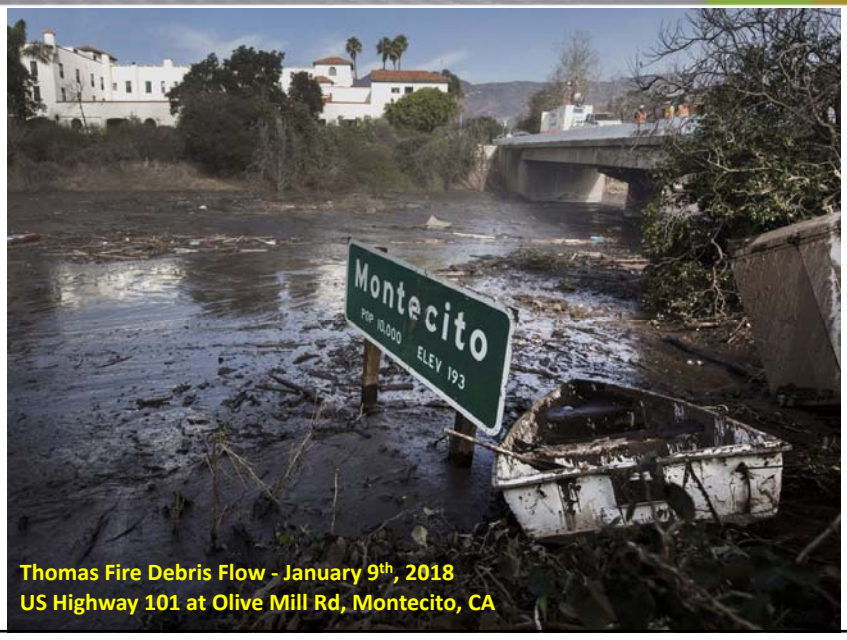
ORTEGA RIDGE RD MS-TDA WALL – CON DELAY



Thomas Fire Debris Flow - January 9th, 2018
US Highway 101 at Olive Mill Rd, Montecito, CA

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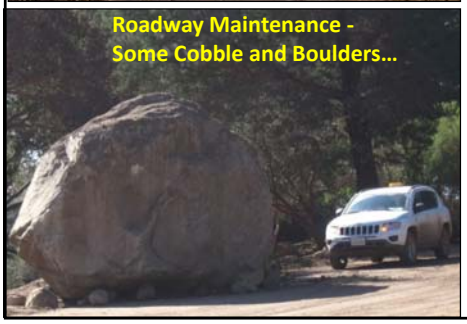
ORTEGA RIDGE RD MS-TDA WALL – CON DELAY


US HWY 101 NB Lane Traffic delays…


Channel Clearing…


Roadway Maintenance -
Some Cobble and Boulders…


Bridge Maintenance…

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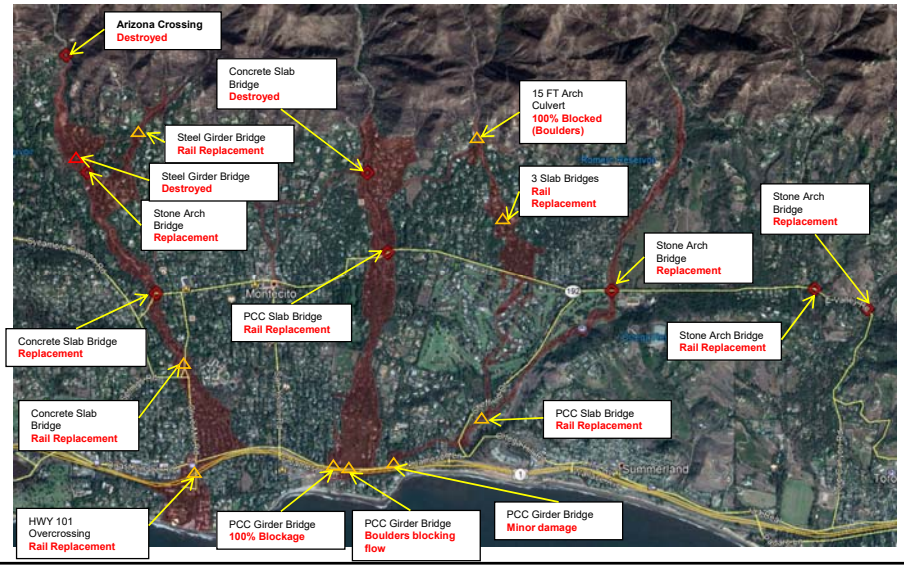
ORTEGA RIDGE RD MS-TDA WALL – CON DELAY

Major Bridge and Culvert Structures Damaged/Destroyed



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ORTEGA RIDGE RD MS-TDA WALL - COMPARED

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ORTEGA RIDGE RD MS-TDA WALL - CON

Excavation to base of engineered fill, approximately 15 FT Max

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ORTEGA RIDGE RD MS-TDA WALL - CON

Placing the first level of MSE Wall welded wire facing on engineered fill, and placement of Tensar UX1100 (or equal) uniaxial geosynthetic reinforcement.

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ORTEGA RIDGE RD MS-TDA WALL - CON

Placement of engineered fill, first level of MS-TDA Wall facing, stone fill, and Geosynthetic reinforcement.

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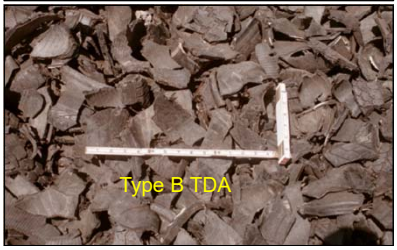
ORTEGA RIDGE RD MS-TDA WALL - CON



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ORTEGA RIDGE RD MS-TDA WALL - CON

Separation of materials is important. Some lessons must be learned first hand.

24

ORTEGA RIDGE RD MS-TDA WALL - CON

Contractor initially used smaller, lighter equipment to move and place TDA.
Rubber tired equipment is not suitable, as the TDA and steel strands will often puncture tires or otherwise foul up the equipment. Tracked equipment and smooth drum rollers are required.

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ORTEGA RIDGE RD MS-TDA WALL - CON

Lighter equipment is required within the first 5 FT of the retaining surface, so as not to damage facing and geosynthetic reinforcement connections.

26

ORTEGA RIDGE RD MS-TDA WALL - CON

Contractor must maintain multiple operations at same time to progress the work.

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ORTEGA RIDGE RD MS-TDA WALL - CON

Subgrade Enhancement Geotextile **(TerraTex HPG-16ca)** is placed on top of the TDA prior to engineered fill placement.

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ORTEGA RIDGE RD MS-TDA WALL - CON

3 FT of engineered fill is brought on top of TDA, to bridge over material and provide stable base for structure section. Tensar UX1100 (or equal) specified. TerraGrid U350 Used.

29

ORTEGA RIDGE RD MS-TDA WALL - CON

2 layers of biaxial geosynthetic reinforcement are placed within engineered fill to full width of excavation. Tensar BX1500 (or equal) was specified. TerraGrid SX3030 used.

30

ORTEGA RIDGE RD MS-TDA WALL - CON

Final Level of MSE Wall and rock fill is placed. TerraGrid RX1100 biaxial geogrid was used to line the back of the welded wire facing, as contractor utilized facing aperture and rock size were not entirely compatible…

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ORTEGA RIDGE RD MS-TDA WALL - COMPLETED

Completed project, open for traffic.

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ORTEGA RIDGE RD MS-TDA WALL - COMPLETED

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ORTEGA RIDGE RD MS-TDA WALL – CON COST

Construction Contract Info:

- Raminha Construction Inc, Atascadero, CA was lowest responsible bidder (**6 bids**)
- $646,570 Engineers Estimate
- **$666,535 Contract Amount (3% over EE)**
- 50 Working Days given
- Contract completed on time and on-budget

Construction Funding:

- $330,800 CalRecycle Pilot Project Funds
- $100,000 CalRecycle TDA Grant Funds
- $235,735 County of Santa Barbara Local Funds

Quantities

- 3040 CY Roadway Excavation
  - Asphalt concrete and base was recycled locally
  - Highly expansive shale embankment materials
- 990 CY **Select Engineered Backfill @ $50/CY**
- 851 TONS Import Borrow (Tire Derived Aggregate)
  - Approximately 80,000 tires diverted from landfill or use as power plant fuel.
  - **$68/TON processed and delivered** to site (Lakin Tire, CA)
  - **$140/TON Bid Item Price** to SB County (Includes labor, equipment to install and compact)
- 3270 SY Geosynthetic Reinforcement (**Uniaxial) @ $4.50/SY** **(TerraGrid U350)**
- 1450 SY Geosynthetic Reinforcement **(Biaxial) @ $3.00/SY** **(TerraGrid SX3030)**
- 920 SY **Non-Woven Geotextile (Filter Fabric - Class C) @ $3.00/SY** **(TerraTex N06)**
- 720 SY **Subgrade Enhancement Geotextile (Woven) @ $4.00/SY**

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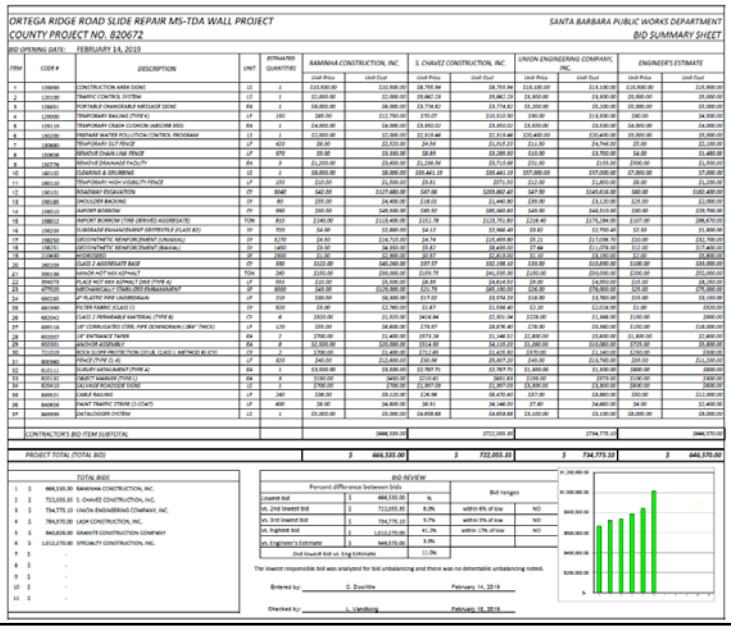
ORTEGA RIDGE RD MS-TDA WALL – CON COST



ORTEGA RIDGE ROAD SLIDE REPAIR MS-TDA WALL PROJECT
COUNTY PROJECT NO. 820672
SANTA BARBARA PUBLIC WORKS DEPARTMENT
BID SUMMARY SHEET

BID OPENING DATE: FEBRUARY 14, 2019

ITEM	CODE #	DESCRIPTION	UNIT	ESTIMATED QUANTITIES	RAMONA CONSTRUCTION, INC.		S. CHAVEZ CONSTRUCTION, INC.		UNION ENGINEERING COMPANY, INC.		ENGINEER'S ESTIMATE	
					Unit Price	Unit Cost	Unit Price	Unit Cost	Unit Price	Unit Cost	Unit Price	Unit Cost
1	130040	CONSTRUCTION AREA SIGNS	LS	1	$10,000.00	$10,000.00	$8,703.94	$8,703.94	$18,100.00	$18,100.00	$20,000.00	$20,000.00
2	130100	TRAFFIC CONTROL SYSTEM	LS	1	$7,000.00	$7,000.00	$9,867.19	$9,867.19	$9,800.00	$9,800.00	$5,000.00	$5,000.00
3	130651	PORTABLE CHANGEABLE MESSAGE SIGNS	EA	1	$6,000.00	$6,000.00	$3,774.82	$3,774.82	$5,200.00	$5,200.00	$3,000.00	$3,000.00
4	129000	TEMPORARY RAILING (TYPE K)	LF	150	$65.00	$12,750.00	$70.07	$10,510.50	$90.00	$13,500.00	$90.00	$4,500.00
5	129110	TEMPORARY CRASH CUSHION (ARRAY EA)	EA	1	$4,000.00	$4,000.00	$3,950.02	$3,950.02	$5,500.00	$5,500.00	$4,000.00	$4,000.00
6	130100	PREPARE WATER POLLUTION CONTROL PROGRAM	LS	1	$7,000.00	$7,000.00	$2,919.48	$2,919.48	$20,400.00	$20,400.00	$5,000.00	$5,000.00
7	130680	TEMPORARY SILT FENCE	LF	420	$4.00	$1,920.00	$4.54	$1,918.20	$11.80	$4,746.00	$5.00	$2,100.00
8	130838	SENSITIVE ENVIRONMENTAL FENCE	LF	370	$5.00	$1,850.00	$5.03	$1,586.10	$15.00	$5,700.00	$4.00	$1,480.00
9	150776	REMOVE DRAINAGE FACILITY	EA	3	$1,200.00	$3,600.00	$1,746.54	$5,719.69	$31.00	$103.00	$500.00	$1,500.00
10	160103	CLEARING & GRUBBING	LS	1	$8,000.00	$8,000.00	$10,441.19	$10,441.19	$37,000.00	$37,000.00	$7,000.00	$7,000.00
11	160110	TEMPORARY HIGH VISIBILITY FENCE	LF	150	$10.00	$1,500.00	$5.61	$771.93	$12.00	$1,800.00	$9.00	$1,350.00
12	190101	ROADWAY EXCAVATION	CY	8540	$42.00	$127,680.00	$47.06	$201,867.40	$47.00	$149,458.00	$60.00	$192,400.00
13	190185	SHOULDER BACKING	SY	80	$55.00	$4,400.00	$18.01	$1,440.80	$39.00	$3,120.00	$25.00	$2,000.00
14	190610	IMPORT BORROW	CY	980	$60.00	$58,800.00	$85.60	$83,948.80	$49.00	$48,020.00	$80.00	$78,400.00
15	198010	IMPORT BORROW (TIRE DERIVED AGGREGATE)	TON	810	$140.00	$113,400.00	$151.78	$122,941.80	$134.40	$108,864.00	$107.00	$86,670.00
16	198200	SUBGRADE ENHANCEMENT GEOTEXTILE (CLASS 8D)	SY	700	$4.00	$2,800.00	$4.13	$2,891.40	$3.83	$2,681.00	$3.00	$2,100.00
17	198250	GEOSYNTHETIC REINFORCEMENT (UNIAXIAL)	SY	3,170	$4.00	$12,680.00	$4.74	$15,025.80	$5.21	$16,515.70	$10.00	$31,700.00
18	198251	GEOSYNTHETIC REINFORCEMENT (BIAXIAL)	SY	1,401	$5.00	$7,005.00	$5.82	$8,155.02	$7.44	$10,426.44	$11.00	$15,411.00
19	203430	HYDROSEED	SF	2600	$1.00	$2,600.00	$0.97	$2,522.00	$1.03	$2,678.00	$1.00	$2,600.00
20	260104	CLASS 2 AGGREGATE BASE	CY	330	$122.00	$40,260.00	$97.57	$32,198.10	$110.00	$36,300.00	$100.00	$33,000.00
21	390136	MINOR HOT MIX ASPHALT	TON	240	$150.00	$36,000.00	$169.70	$40,728.00	$150.00	$36,000.00	$200.00	$48,000.00
22	394079	PLACE HOT MIX ASPHALT DIKE (TYPE A)	LF	650	$10.00	$6,500.00	$8.89	$5,778.50	$20.00	$13,000.00	$15.00	$9,750.00
23	477010	GEOTECHNICAL FABRIC FOR PAVEMENT	SF	8000	$0.65	$5,200.00	$0.71	$5,680.00	$0.78	$6,240.00	$0.50	$4,000.00
24	480240	4" PLASTIC PIPE UNDERDRAIN	LF	310	$30.00	$9,300.00	$17.07	$5,292.17	$18.00	$5,580.00	$15.00	$4,650.00
25	481040	FILTER FABRIC (CLASS C)	CY	820	$3.00	$2,460.00	$1.67	$1,369.40	$2.30	$1,886.00	$1.00	$820.00
26	482042	CLASS 2 PERMEABLE MATERIAL (TYPE B)	CY	4	$820.00	$3,280.00	$414.94	$1,659.76	$338.00	$1,352.00	$560.00	$2,240.00
27	490516	18" CORRUGATED STEEL PIPE DOWNDRAIN (.064" THICK)	LF	120	$55.00	$6,600.00	$76.97	$9,236.40	$78.00	$9,360.00	$150.00	$18,000.00
28	492007	18" ENTRANCE TAPER	EA	2	$700.00	$1,400.00	$573.34	$1,146.68	$1,600.00	$3,200.00	$1,800.00	$3,600.00
29	492191	ANCHOR ASSEMBLY	EA	8	$2,500.00	$20,000.00	$714.50	$5,716.00	$1,260.00	$10,080.00	$1,875.00	$15,000.00
30	520509	ROCK SLOPE PROTECTION (CLASS 8, METHOD B) (CY)	CY	2	$700.00	$1,400.00	$713.40	$1,426.80	$370.00	$740.00	$250.00	$500.00
31	800380	FENCE (TYPE CL-6)	LF	820	$40.00	$32,800.00	$40.04	$32,827.20	$19.00	$15,580.00	$50.00	$41,000.00
32	810511	SURVEY MONUMENT (TYPE A)	EA	1	$3,500.00	$3,500.00	$2,787.71	$2,787.71	$1,800.00	$1,800.00	$800.00	$800.00
33	820110	OBJECT MARKER (TYPE L)	EA	3	$100.00	$300.00	$113.41	$340.23	$109.00	$327.00	$100.00	$300.00
34	820410	CALTRANS ROADSIDE SIGNS	LS	1	$700.00	$700.00	$1,307.09	$1,307.09	$3,300.00	$3,300.00	$600.00	$600.00
35	839570	CABLE RAILING	LF	240	$38.00	$9,120.00	$36.98	$8,875.40	$37.00	$8,880.00	$50.00	$12,000.00
36	840658	PAINT TRAFFIC STRIPE (2-COAT)	LF	600	$8.00	$4,800.00	$8.91	$5,346.00	$7.80	$4,680.00	$4.00	$2,400.00
37	999999	DATALOGGER SYSTEM	LS	1	$5,000.00	$5,000.00	$4,458.68	$4,458.68	$5,100.00	$5,100.00	$8,000.00	$8,000.00
		CONTRACTOR'S BID ITEM SUBTOTAL				$666,535.00		$722,055.35		$734,775.10		$646,570.00
		PROJECT TOTAL (TOTAL BID)				$ 666,535.00		$ 722,055.35		$ 734,775.10		$ 646,570.00

TOTAL BIDS

1	$ 666,535.00	RAMONA CONSTRUCTION, INC.
3	$ 722,055.35	S. CHAVEZ CONSTRUCTION, INC.
5	$ 734,775.10	UNION ENGINEERING COMPANY, INC.
4	$ 784,570.00	LADA CONSTRUCTION, INC.
6	$ 840,826.00	GRANITE CONSTRUCTION COMPANY
2	$ 1,012,270.00	SPECIALTY CONSTRUCTION, INC.

BID REVIEW

Percent difference between bids

			Bid ranges	
Lowest bid	$ 666,535.00	%		
vs. 2nd lowest bid	$ 722,055.35	8.3%	within 6% of low	NO
vs. 3rd lowest bid	$ 734,775.10	9.7%	within 9% of low	NO
vs. highest bid	$ 1,012,270.00	41.2%	within 17% of low	NO
vs. Engineer's Estimate	$ 646,570.00	3.0%		
2nd lowest bid vs. Eng Estimate		11.0%		

The lowest responsible bid was analyzed for bid unbalancing and there was no detectable unbalancing noted.

Entered by: C. Doolittle February 14, 2019

Checked by: L. Vandberg February 18, 2019

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If you have any questions, please contact me:

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