Nevada Stateline to Stateline Bikeway Phase 3

FROM SAND HARBOR TO SPOONER JUNCTION

STRUCTURE TYPE SELECTION MEMORANDUM

PREPARED FOR:

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WOOD RODGERS

DECEMBER 18, 2018
(Version #2)

DATE:	December 18, 2018
TO:	Mr. Carl Hasty Tahoe Transportation District
FROM:	Dennis D. Pecchia, P.E., Senior Bridge Project Manager Wood Rodgers, Inc.
SUBJECT:	**Nevada Stateline to Stateline Bikeway Phase 3 Project** **STRUCTURE TYPE SELECTION MEMORANDUM**
PROJECT #'s:	____

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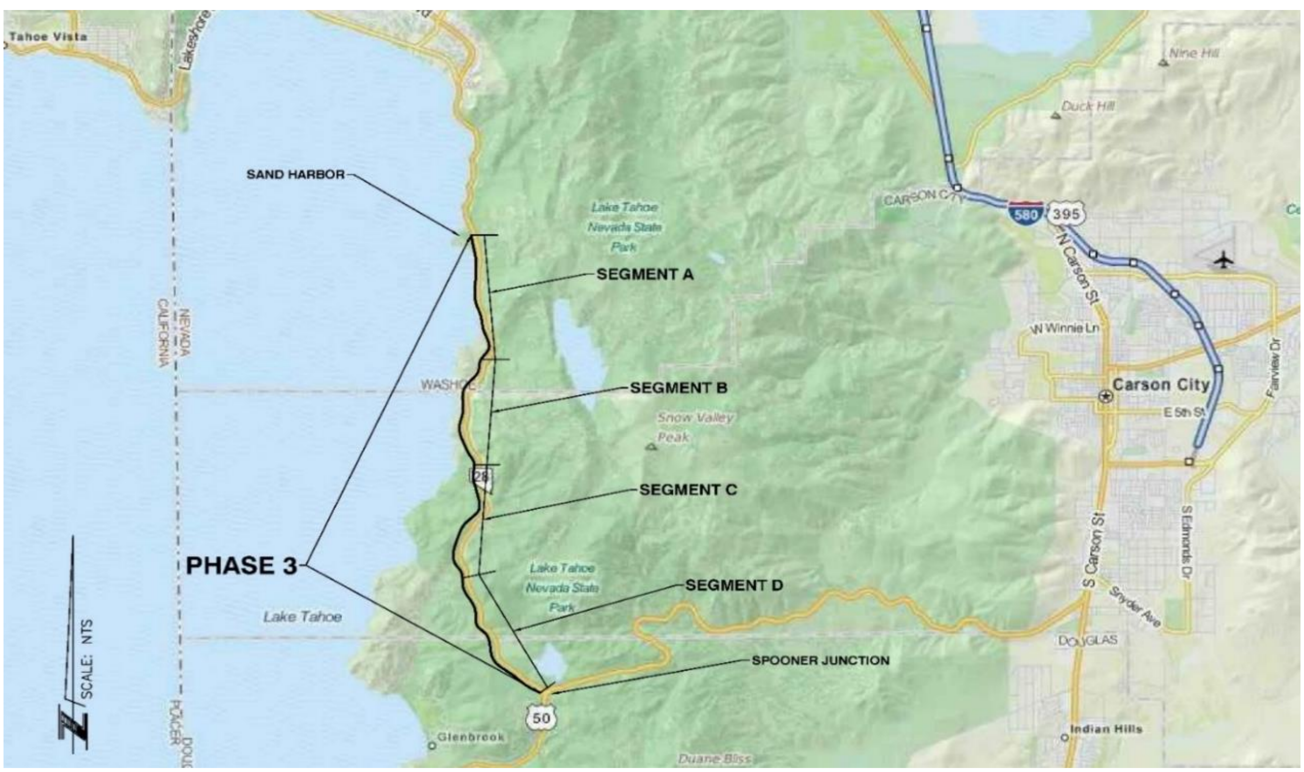
1.) INTRODUCTION

The proposed **Nevada Stateline to Stateline Bikeway Phase 3 Project**, located along the northeast shoreline of Lake Tahoe and the west side of State Route (SR) 28, is an 8 mile stretch of the overall 30 mile bikeway. The project extends from San Harbor south to Spooner Junction; and connects to the North Demonstration Project bikeway project, which is currently under construction from Incline Village to Sand Harbor. The Tahoe Transportation District (TTD) is the lead agency for the project along with other local partners and stakeholders. Key partners and stakeholders include:

- Tahoe Transportation District (TTD)
- Tahoe Regional Planning Agency (TRPA)
- Nevada Division of State Parks
- Nevada Division of State Lands
- Nevada Department of Transportation (NDOT)
- United States Forest Service (USFS)

The project is being funded by a mix of private, local, state, and federal dollars. The project will improve bicycle and pedestrian access, parking, safety, and environmental issues within this shoreline corridor.

The purpose of this ***Structure Type Selection Memorandum*** is to investigate the various alternatives for retaining walls and bridges needed along the bikeway trail. The memorandum constitutes part of the preliminary engineering 30% complete phase of the project and is intended to present only high-level concepts and construction costs for the alternatives. Subsequent phases of the project will include more detailed preliminary engineering and final design, plans, specifications, and estimates (PS&E). Advantages and disadvantages for the various alternatives will be presented with specific recommendations made for the varying terrain conditions along the bikeway trail. Recommendations will take into consideration the steepness of the site terrain, soil and rock subsurface conditions, construction equipment limitations, clearance to shoreline, proximity to SR 28, aesthetic treatments, utilities, etc. At other locations along the bikeway trail where the site terrain is flatter, retaining walls and bridges may not be needed; and side slopes of the bikeway trail may only need rock slope protection or planted vegetation for protection.



Project Location

The structural discussions in this memorandum reflect reviews of the other bikeway trail plans currently under design and/or construction and different conversations, meetings, and site visits including:

- Review of the current Nevada Stateline to Stateline Bikeway Phase 3 Preliminary 30% Plans, dated May 2015, by Lumos & Associates.
- Review of the North Demonstration Project Construction Plans, dated 1/31/17, by CH2M and NDOT and the Geotechnical Report by Shannon & Wilson.
- Site visit on 8/16/17 to observe construction on the North Demonstration Project and to walk the Phase 3 site. Talked to NDOT and Granite staff about constructability issues. Partial list of attendees included: Russ Nygaard, TTD; Jesse Ruzicka, NDOT; Lumos Representative; John O'Day, Granite; Derek Kirkland, Mark Rayback, and Dennis Pecchia, Wood Rodgers.
- Meeting on 4/23/18 with NDOT staff in Carson City, NV to present a project overview and to discuss retaining wall and bridge concepts in general. Partial list of attendees included: Russ Nygaard, TTD; Jesse Ruzicka, Mike Mayberry, Pedro Rodriguez, NDOT; Mike Gabor, USFS; Brad Johnson, IVGID; Derek Kirkland, Chris Hodge, Mark Rayback, and Dennis Pecchia, Wood Rodgers.

2.) DESIGN AND CONSTRUCTION CONSIDERATIONS

2.1) STRUCTURE DESIGN STANDARDS

The structural design of the retaining walls and bridges will follow the *NDOT Structures Manual*, dated 2008, and the American Association of State Highway Transportation Officials' *AASHTO LRFD Bridge Design Specifications* (edition to be decided upon). Additionally, the *AASHTO Guide Specifications for Design of Pedestrian Bridges* will be applied to the bikeway trail bridges when appropriate. Seismic design will follow the requirements of Section 3 "Loads and Load Factors" of the *AASHTO LRFD Bridge Design Specifications*.

All structures are in a "freeze-thaw area". To account for freeze thaw and de-icing chemicals, appropriate details and specifications will be incorporated including such measures as a polyester concrete overlay, increased concrete cover to reinforcing bars for deck slabs, epoxy-coated reinforcing bars, non-corrosive fiber reinforced polymer (FRP) decks, increased backfill cover over footings, snow plow deflectors on all bridge deck joints, etc.

2.2) GEOTECHNICAL INVESTIGATION AND RECOMMENDATIONS

As previously noted, the retaining wall and bridge details presented in this memorandum are high-level concept details only and are subject to change depending upon the geotechnical investigation and recommendations. The geotechnical part of the Bikeway Phase 3 Project has yet to be started and will include the field borings, laboratory analysis, and foundation recommendation reports. The foundation recommendation reports will be needed prior to starting final design phase of the project. The reports will, amongst general recommendations, include the following:

- Allowable slopes for cut and fill sections.
- Limitations on the size of construction equipment considering steepness of terrain and access.
- Recommendations for footings, ground anchors, micropiles, and/or piles in difficult subsurface conditions consisting of loose to dense sands and gravels, cobbles, and boulders under lain by bedrock. There will be a considerable amount of rock excavation required to build the retaining walls and bridges.
- Maximum size and capacities of micropiles possibly limited to about 6-12 inch diameter due to equipment limitations.
- Maximum size and capacities of cast-in-drilled-holes (CIDH) piles possibly limited to about 24 inch diameter due to equipment limitations.
- Recommendation for drilling holes and/or installing soil nails in difficult subsurface conditions.
- Seismic loads to be applied to retaining walls and bridges.
- Corrosion potential, including exposure to deicing salts, and measures needed to protect structural elements from corrosion.

2.3) CONSTRUCTABILITY

Steep terrain and the loose to dense sands and gravels, cobbles, boulders, and bedrock conditions along the bikeway trail pose challenging design and construction problems. Following are considerations that need to be made so that retaining walls and bridges are constructible and feasible:

Loose Cohesionless Soils

Terrain and Equipment Limitations: At locations where there is steeper terrain and limited room for graded work benches in front of the retaining wall, construction equipment will be limited to smaller size track mounted drill rigs and walking "spider" excavator drill rigs. Ideally, work benches should be a minimum of 15 feet wide (per John O'Day, Granite's Project Manager on the North Demonstration Project); although smaller width benches are currently being used on the North Demonstration Project. Because of the smaller equipment size, drilling capabilities will be limited to about 24 inch diameter maximum vertical holes and to about 6-12 inch diameter maximum holes for micropiles, tieback ground anchors, and soil nails. At locations where the bikeway is adjacent to SR 28 or where there is flatter terrain and more room for work platforms – larger track excavator drill rigs can be used. These rigs, due to the longer reach of their booms, can operate from the outer lane of SR 28 (provided adequate traffic control systems are in place) and behind the wall by reaching over and down to the hole locations.

Difficult Soil Conditions: Due to loose cohesionless soil conditions at some locations, it becomes difficult to maintain vertical or near vertical cut faces. Also, drill holes for tieback ground anchors and soil nails may have a tendency to collapse and will require the use of temporary casing to install. Cobbles and boulders may cause additional installation difficulties at some locations.

Track Mounted

Walking "Spider"

Track Excavator

Other Soil Nail Systems: Another soil nail system that will be given consideration is the compressed air cannon system from GeoStabilization International (GSI). Installation of soil nails is fast. Soil nails are shot into the ground at 250 miles per hour; i.e., no drilled holes are necessary. Smaller construction equipment can be used which has worked well at difficult terrain locations. However, this system could be problematic given the rocky boulder subsurface conditions. With regard to corrosion, soil nails can have 1-4 layers of corrosion protection or be fabricated of fiberglass. More consultation with GSI is needed if this system is to be given further consideration. There is another soil nail system that uses hollow bar soil nails (HBSN), but NDOT staff has indicated these have been problematic on projects they have been involved with. NDOT standard specifications do not allow this system. Hollow bar soil nails will not be considered for this project.

2.4) RAILINGS AND BARRIERS
Railings along the bikeway trail will be 3'-6" high, and may consist of weathering steel tube posts and rails with closely spaced horizontal galvanized steel cable strands. Railing along the bikeway trail may also consist of timber post and steel cable strands. Both of these railings are currently being constructed on the North Demonstration Project.

2.5) UTILITIES
Various utilities are being planned along the bikeway trail, including a 16 inch diameter treated effluent line by the Incline Village General Improvement District (IVGID). Other possible utilities that are still to be determined include: NV Energy Power electrical lines, and AT&T and/or Charter Communications (Spectrum) television cable and fiber optic lines. It is assumed that the treated effluent line will be in one trench while the cable and fiber optic lines will be in a second joint trench. Digging trenches into the loose rocky subsurface will be difficult and costly. These trenches will pose a potential conflict with any retaining wall geosynthetic reinforcing mats, tieback ground anchors, or soil nails that might be needed. Also, it has yet to be determined as to whether or not snow removal during the winter will be needed for utility company access. More discussion with the utility companies is also needed regarding their share of the construction cost. More details of the utilities is presented in the following Section "3.) Proposed Retaining Wall Alternatives".

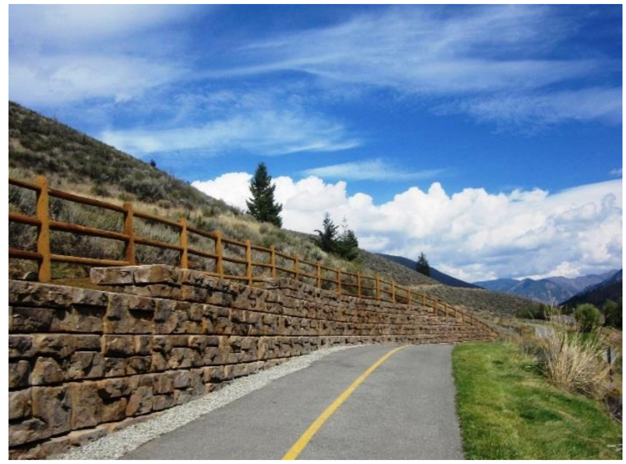
2.6) AESTHETICS
Aesthetic treatments for the retaining walls and bridges are amongst the most important considerations to be made. Treatments along the bikeway trail need to blend and compliment with the surrounding Lake Tahoe environment. Also, the treatments currently being constructed along the North Demonstration Project will be taken into consideration – however, different and varying treatments are likely to be used for this Bikeway Phase 3 Project. TRPA, USFS, and TTD are amongst the key agencies, local partners, and stakeholders (see previous Section "1.) Introduction") for determining all aesthetic treatments. At various locations in the Lake Tahoe Region, TRPA has promoted the use of rockery retaining walls as they blend well with the existing natural rocky terrain. However, NDOT will not approve the use of rockery walls in close proximity to SR 28 and within their right of way because of concerns with past poor performance and questionable structural stability. With regard to the Redi-Rock retaining walls, the USFS has already reviewed the various textures and colors; and they prefer the ledgestone texture with natural colors similar those shown in the following photographs. It is recommended that test samples of all aesthetic treatments be submitted for review and approval prior to production and construction of the retaining walls and bridges.

Following is a sampling of possible aesthetic treatments for retaining walls and bridges along the bikeway trail:

Soil Nail Wall
Sculpted Stained Shotcrete

North Demonstration Project – Soil Nail Wall
Sculpted Shotcrete

Soldier Pile Wall
Expose H Pile/Lagging



Redi-Rock Wall
Stained Ledgestone

Rockery Wall
Varying Color Rock

Granite Rock Wall

North Demonstration Project – Bridge Abutment
With Granite Veneer & Rock Slope Protection

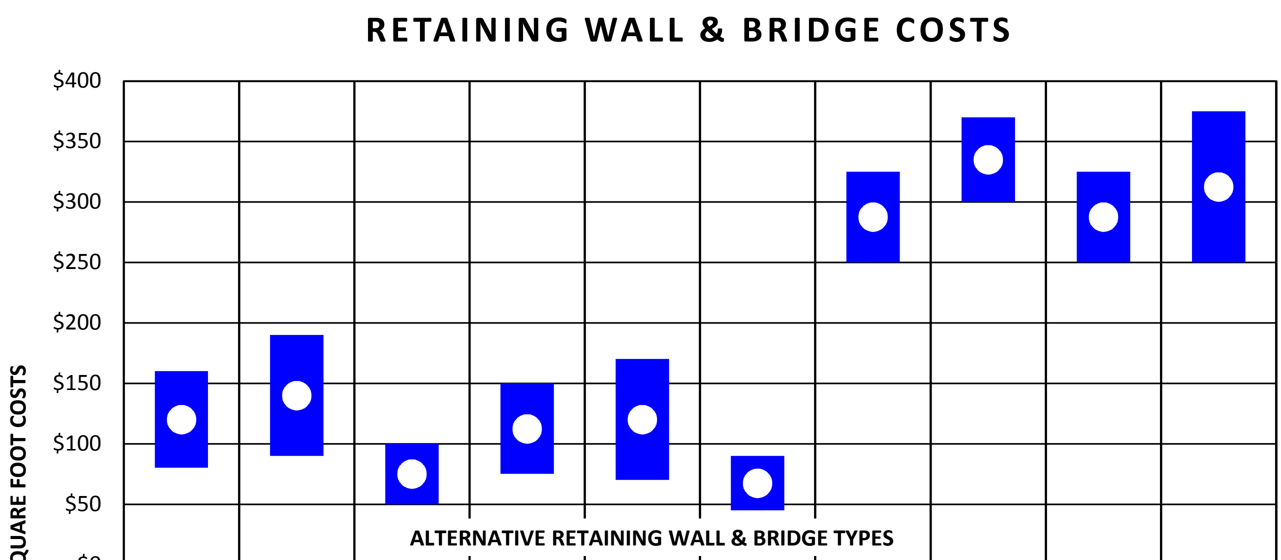
Prefabricated Steel Truss Bridge

Prefabricated Steel Truss Bridge

Precast Concrete Girder Bridge

2.7) CONSTRUCTION COST ESTIMATES

Construction costs presented in this memorandum are intended to be only high-level ballpark construction cost estimates. More detailed estimates will be prepared in subsequent phases of this project when final design and quantity take-off have been completed. The costs presented in the following table are based on experience from other similar construction projects, public agency and manufacturer websites, assorted design manuals, and recent bid tabulations from the North Demonstration Project. The cost ranges are representative of typical retaining wall heights expected along the bikeway trail ranging from about a minimum of 4 feet to a maximum of 24 feet. Square foot cost ranges for the retaining wall and bridge alternatives are as follow:



	R1 Soil Nail Wall	R2 Soldier Pile Lagging Wall	R3 Redi-Rock MSE Wall	R3 Concrete Faced MSE Wall	R4 Cantilever Concrete Wall	R5 Rockery Wall	B1 Prefabricated Steel Truss Bridge	B2 Fiber Reinforced Polymer (FRP) Steel Bridge	B3 Precast Prestressed Concrete Voided Slab Bridge	B4 Precast Prestressed Concrete Girder Bridge
MAX $	$160	$190	$100	$150	$170	$90	$325	$370	$325	$375
MIN $	$80	$90	$50	$75	$70	$45	$250	$300	$250	$250
AVG $	$120	$140	$75	$113	$120	$68	$288	$335	$288	$313

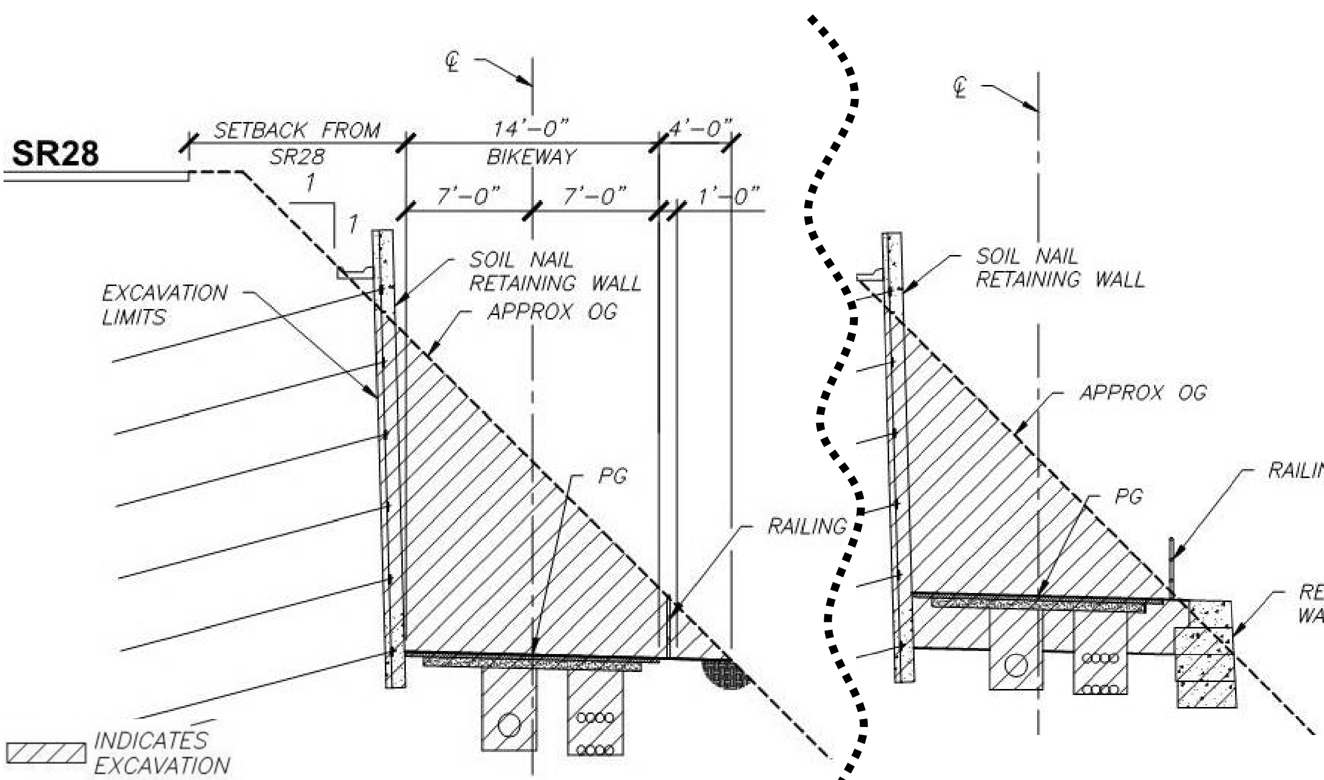
3.) PROPOSED RETAINING WALL ALTERNATIVES

This section of the memorandum covers various retaining wall alternatives that are feasible for the bikeway trail. At locations where existing terrain is flatter, retaining walls will not be needed and rock slope protection and/or vegetated side slopes may be all that is needed.

3.1) ALTERNATIVE R1 – SOIL NAIL RETAINING WALL ADJACENT TO SR 28

A soil nail retaining wall system is constructed by "top-down" cut methods and is feasible where the site consists of steeper terrain (slopes of $1^1/_2$H:1V and steeper) in close proximity to SR 28. The soil nails will provide sufficient strength against slope failure and will provide underpinning to the SR 28 roadway at locations where the bikeway trail is near or at the roadway. The retaining wall system consist of high strength steel soil nails and a reinforced shotcrete wall. Aesthetic wall treatments can include sculpted and stained rock-like textures. These walls will be similar in type and appearance as those currently being constructed in the North Demonstration Project.

Advantages	*Disadvantages*
✓ Suitable for cut locations having steeper terrain ($1^1/_2$H:1V and steeper). ✓ Provides strengthening and underpinning of SR 28 when bikeway trail is adjacent to the roadway. ✓ Sculpted shotcrete aesthetic treatment to compliment surrounding environment. ✓ Wall components are smaller and more easily transported to the job site. ✓ Drilled holes for soil nails are smaller 6 inches to 8 inches in diameter. ✓ No excavation required behind the wall. ✓ NDOT approved system.	✗ Difficult construction access for horizontal drilling equipment due to step terrain and limited bench in front of wall. Ideally, bench should be a minimum of 15 feet wide. ✗ Difficult excavations and drilled holes due to loose cohesionless soil, rock, and boulder conditions. ✗ More expensive retaining wall system.

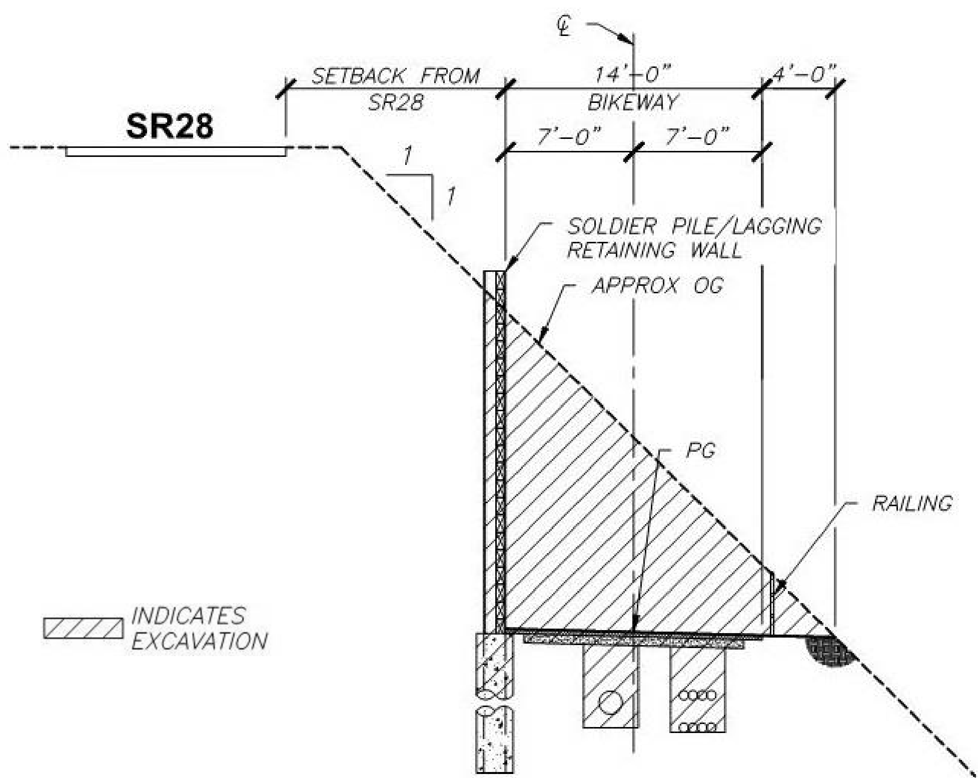


Trail at Top of Bench

Raised Trail above Top of Bench With Short Redi-Rock Wall

3.2) ALTERNATIVE R2 – SOLDIER PILE/LAGGING RETAINING WALL ADJACENT TO SR 28
In addition to the soil nail retaining wall, a steel soldier pile/lagging retaining wall system is also a "top-down" cut wall and also appears feasible for sites consisting of steeper slopes (slopes of $1^1/_2$H:1V and steeper) in close proximity to SR 28. For shorter height walls only cantilevered soldier piles are needed; but for taller walls, tieback prestressed ground anchors will be needed. The retaining wall system consists of steel HP piles installed either by impact driving or in drilled concreted holes spaced approximately 8 feet on center. Preservative treated timber lagging is installed horizontally between the piles. The tieback ground anchors (if needed) are installed in drilled holes, grouted, and post-tensioned as the construction of the wall progresses from "top-down". Aesthetic treatment of the wall system can be left at exposed steel HP pile and timber lagging or a shotcrete/concrete stained decorative fascia wall can be constructed. In some cases, this type of wall system can also be constructed by "bottom-up" methods and backfilled.

Advantages	*Disadvantages*
✓ Suitable for cut locations having steeper terrain ($1^1/_2$H:1V and steeper). ✓ Provides strengthening and underpinning of SR 28 when bikeway trail is adjacent to the roadway. ✓ No excavation required behind the wall. ✓ Utility trenches easily constructed. ✓ NDOT approved system.	✗ Larger diameter drilled holes (24 inch to 30 inch diameter) for HP piles will be needed. Difficult drilling in loose cohesionless soil, rock, and boulder conditions is anticipated. ✗ Special construction and safety considerations needed for installing lengthy steel soldier piles especially along SR 28. ✗ Exposed steel soldier piles and timber lagging may not be a desirable aesthetic treatment for surrounding environment. ✗ Most expensive retaining wall system.



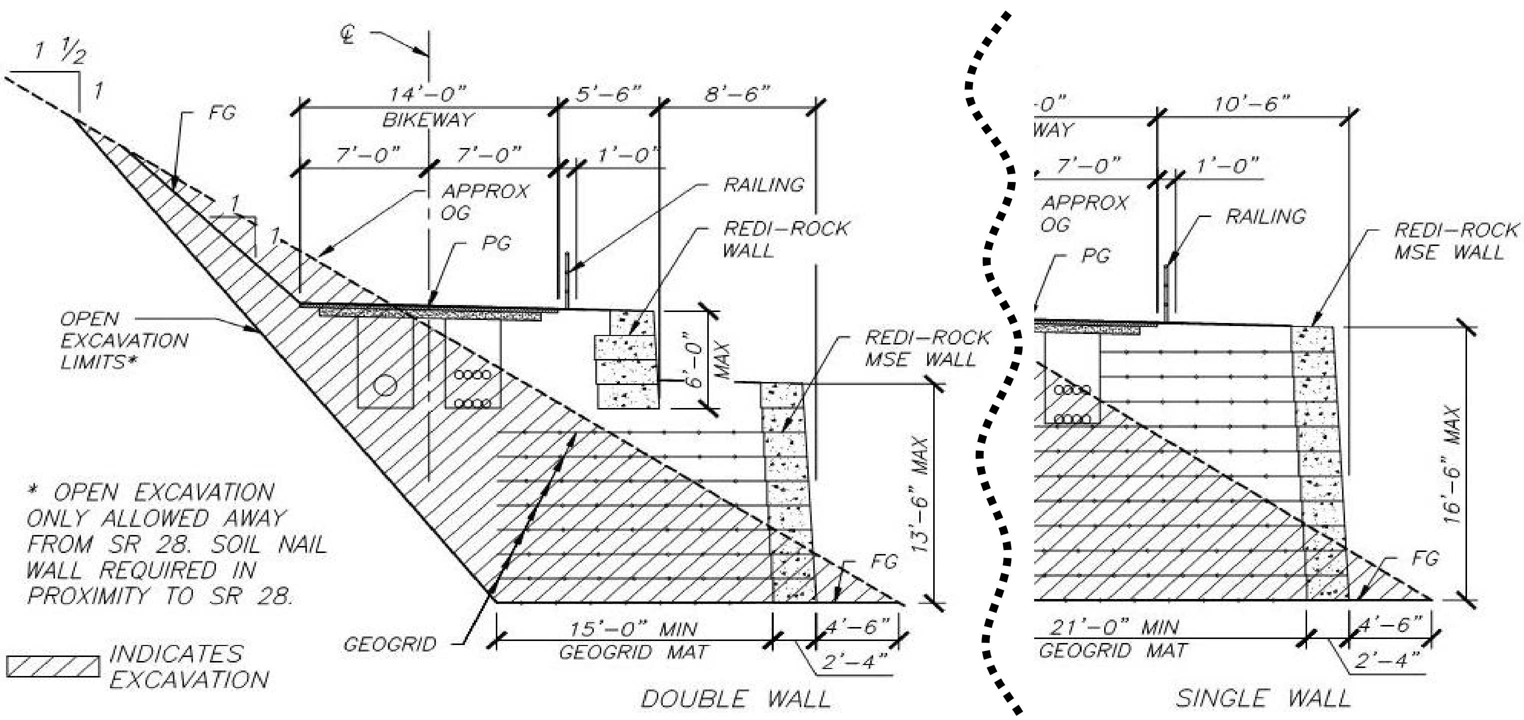
3.3) ALTERNATIVE R3 – REDI-ROCK MECHANICALLY STABILIZED EMBANKMENT (MSE) RETAINING WALLS

The Redi-Rock concrete modular block retaining wall system is constructed by "bottom-up" fill methods. This retaining wall is suitable for sites having flatter slopes (slopes of $1^1/_2$H:1V and flatter). The concrete modular blocks vary in width from 28 inches to 60 inches and in weight from 1,200 pounds to 3,500 pounds. The retaining wall will require geosynthetic reinforcing (geogrid) mats for expected seismic loads. With mats the wall is designed as a mechanically stabilized embankment (MSE) wall. In lieu of the Redi-Rock blocks, the MSE wall can also be constructed using precast reinforced concrete panel units. Wood Rodgers has met with the USFS and they prefer the ledgestone texture as shown in the photograph with exact colors and shades yet to be determined.

Ledgestone Aesthetics Preferred by USFS

The open excavation slope as shown will only be allowed away from SR 28 and outside of NDOT right of way and only if allowed by the pending geotechnical report. The open excavation slope will not be allowed in proximity to SR 28. A soil nail wall as shown in Section "3.1) Alternative R1 -- Soil Nail Retaining Wall Adjacent To SR28" will always be required on the excavated slope in proximity to SR 28.

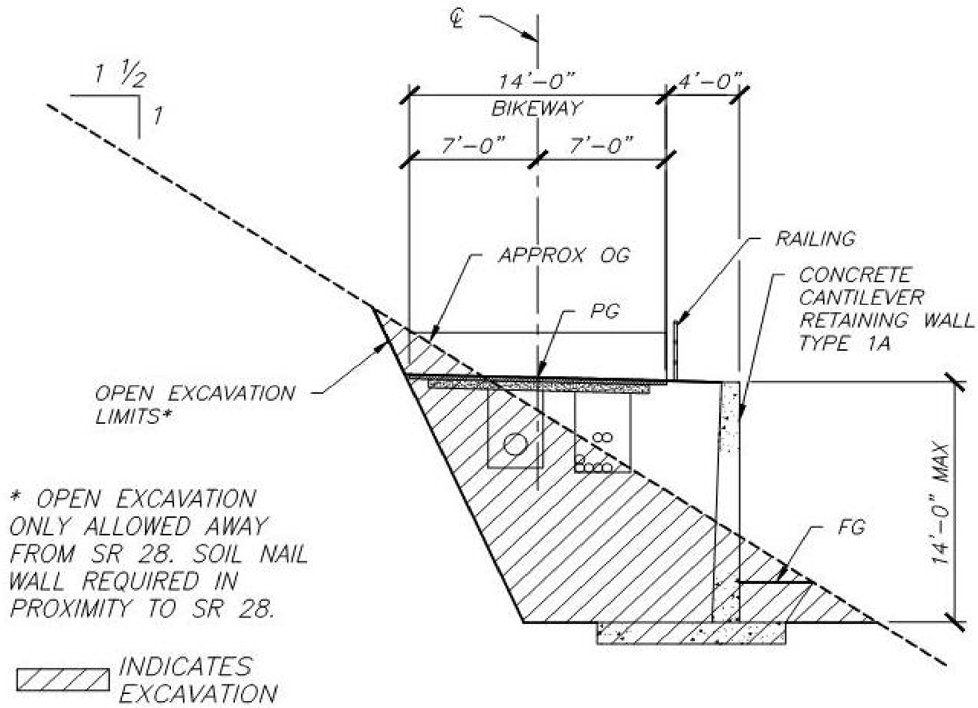
Advantages	*Disadvantages*
✓ Suitable for fill locations having flatter terrain (slopes of $1^1/_2$H:1V and flatter). ✓ Modular system using smaller easily-handled building elements. ✓ Ledgestone aesthetic treatment compliments surrounding environment and is preferred by USFS. ✓ Less expensive retaining wall system. ✓ On NDOT's Qualified Products List.	✗ Seismic loading will dictate that geosynthetic reinforcing mats (geogrid) are needed to strengthen the wall. ✗ Large excavation required to accommodate reinforcing mats. ✗ Cantilever retaining wall segment (without reinforcing mats) needed for utility trenches. ✗ Not for retaining cut slopes.



3.4) ALTERNATIVE R4 – CANTILEVER CONCRETE RETAINING WALL

At locations where fill heights are smaller, cast-in-place (CIP) cantilever concrete retaining walls per NDOT Standard Plans for Road and Bridge Construction may be a feasible alternative. This retaining wall is suitable for sites having flatter slopes (slopes of $1^1/_2$H:1V and flatter). As fill heights become larger, bigger footings and more excavation behind the wall is required making this alternative not as feasible as the others.

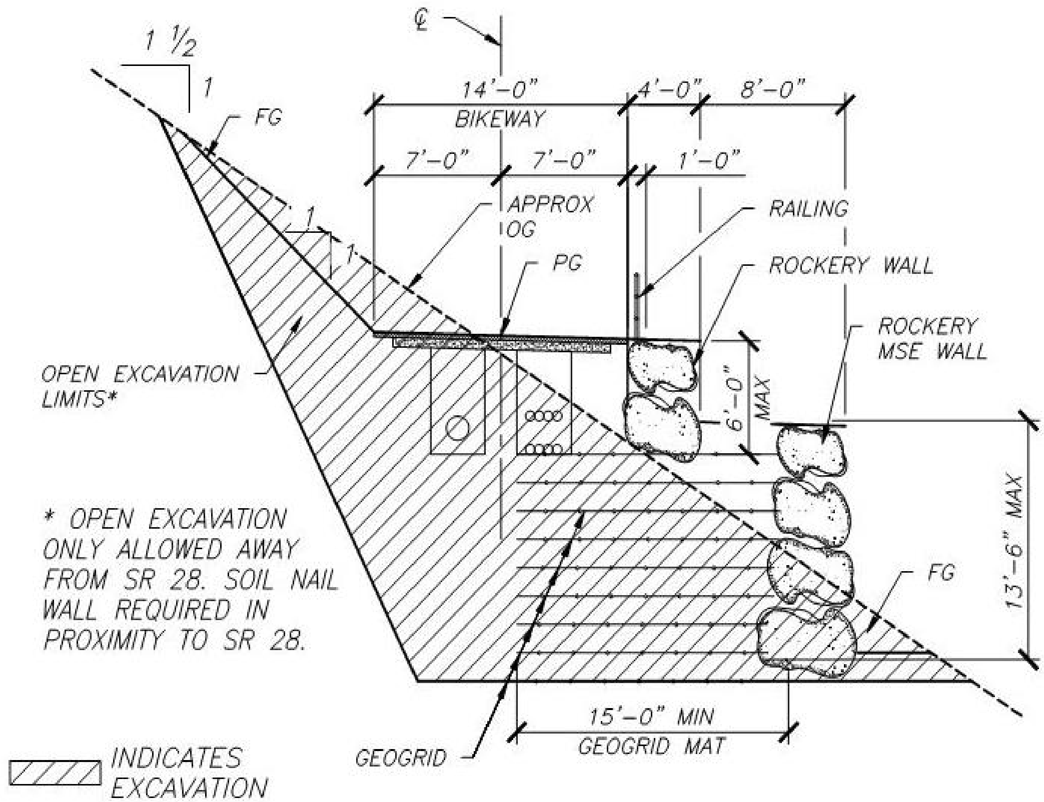
Advantages	*Disadvantages*
✓ Suitable for fill locations having flatter terrain (slopes of $1^1/_2$H:1V and flatter). ✓ Suitable for heights to 14 feet. ✓ Moderately expensive retaining wall system. ✓ Aesthetic treatments can consist of formliners or adhered veneers in a multitude of texture choices ranging from cobble, granite block, fractured fin, etc. ✓ Utility trenches easily constructed. ✓ Approved by NDOT – one of their Standard Plan retaining wall systems.	✗ Excavation needed behind wall for construction. ✗ Not for retaining cut slopes.



3.5) ALTERNATIVE R5 – ROCKERY MECHANICALLY STABILIZED EMBANKMENT (MSE) RETAINING WALL

Rockery walls are a gravity wall system comprised of interlocking, dry stacked rocks without mortar or steel reinforcement. Mechanically Stabilized Embankment (MSE) is used in conjunction with the rockery wall for taller retaining wall heights. NDOT has not approved use of rockery walls for the state highway system due to the uncertainty of their seismic performance. These walls will not be allowed in close proximity to and at any location where they could jeopardized the stability of the SR 28 roadway. There may be locations far enough away from SR 28 and NDOT's jurisdiction where they might be used if properly engineered.

Advantages	*Disadvantages*
✓ Suitable for fill locations up to 13'-6" feet. ✓ Fast construction.	✗ Not allowed by NDOT within their right of way and/or adjacent to SR 28. ✗ Susceptible to rocks shifting and potentially failing due to seismic loading. ✗ Availability of specific size rocks in large volumes.



4.) PROPOSED BRIDGE ALTERNATIVES

4.1) ALTERNATIVE B1 – PREFABRICATED STEEL TRUSS BRIDGE

A pre-engineered prefabricated steel truss superstructure with cast-in-place (CIP) reinforced concrete substructure may be a feasible choice for bikeway trail locations that require a longer-span bridge. Prefabricated steel truss bridges have been used on other bikeway trails within the Lake Tahoe area.

Advantages	*Disadvantages*
✓ Faster construction for a clear span bridge. ✓ No falsework – less impact to environmentally sensitive areas below bridge. ✓ Longer clear spans. ✓ Lighter weight better accommodates seismic loads. ✓ Low maintenance – weathering steel. ✓ Less expensive of the long span bridge alternatives.	✗ Not feasible where short span bridges are needed.

Prefabricated Truss Style Steel Bridge

Prefabricated Arch Style Steel Bridge

4.2) ALTERNATIVE B2 – FIBER REINFORCED POLYMER (FRP)/STEEL BRIDGE

Currently, several fiber reinforced polymer (FRP) bridges/rolled steel superstructure with CIP reinforced concrete substructure founded upon micropiles are being constructed as part of the North Demonstration Project. This FRP alternative will be given consideration at bikeway trail locations where shorter-span bridges are required. If constructed in steeper terrain, this alternative can also function as a "sidehill viaduct" eliminating need for excavation and retaining walls.

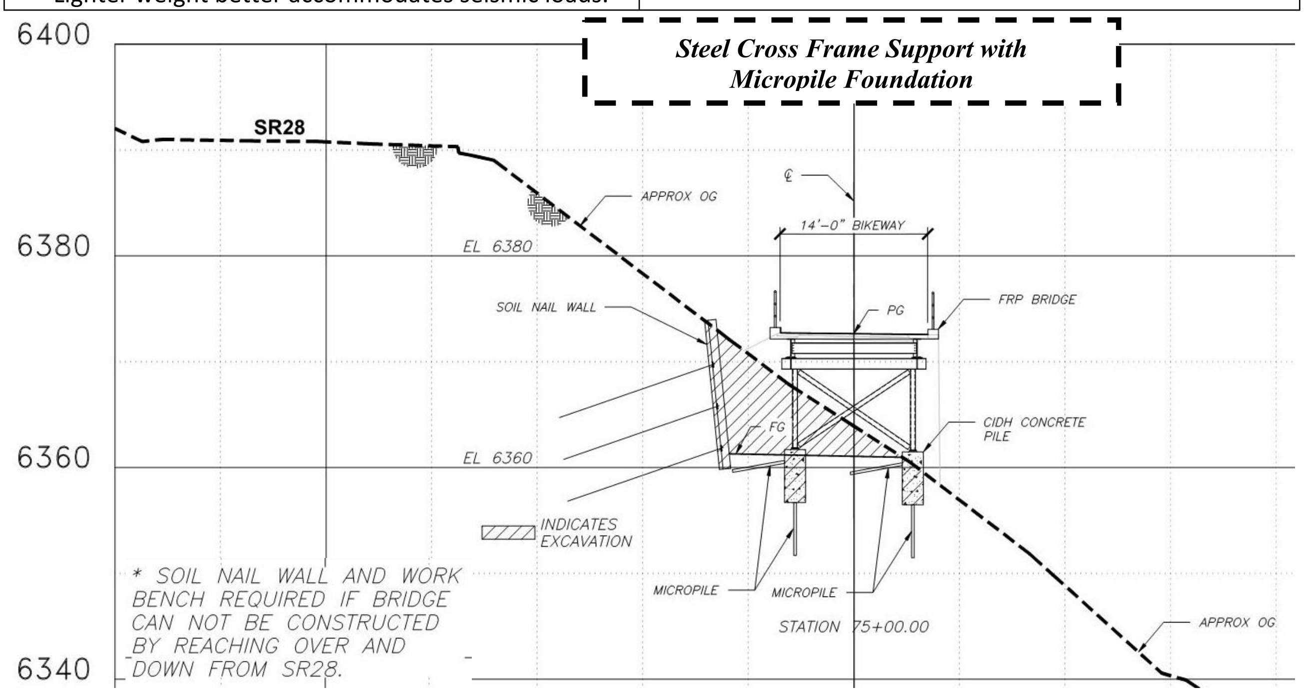
FRP Bridge Constructed of FRP Structural Shapes

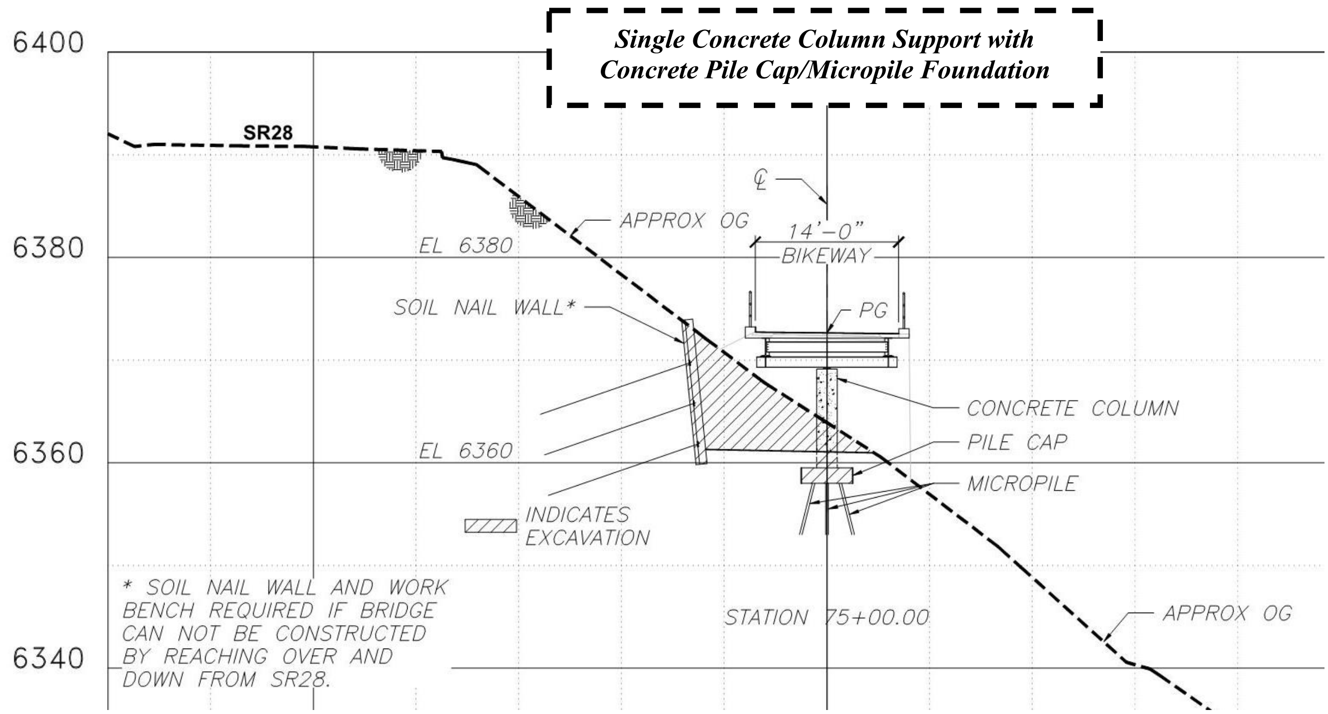
Different foundation and support systems will be considered as shown in the following three figures. Micropiles and/or cast-in-drilled-hole (CIDH) concrete pile rock sockets in combination with steel cross frame, single concrete column, and two concrete column supports can be used. Additional information is presented in the preceding Section "2.2) Geotechnical Investigation and Recommendations".

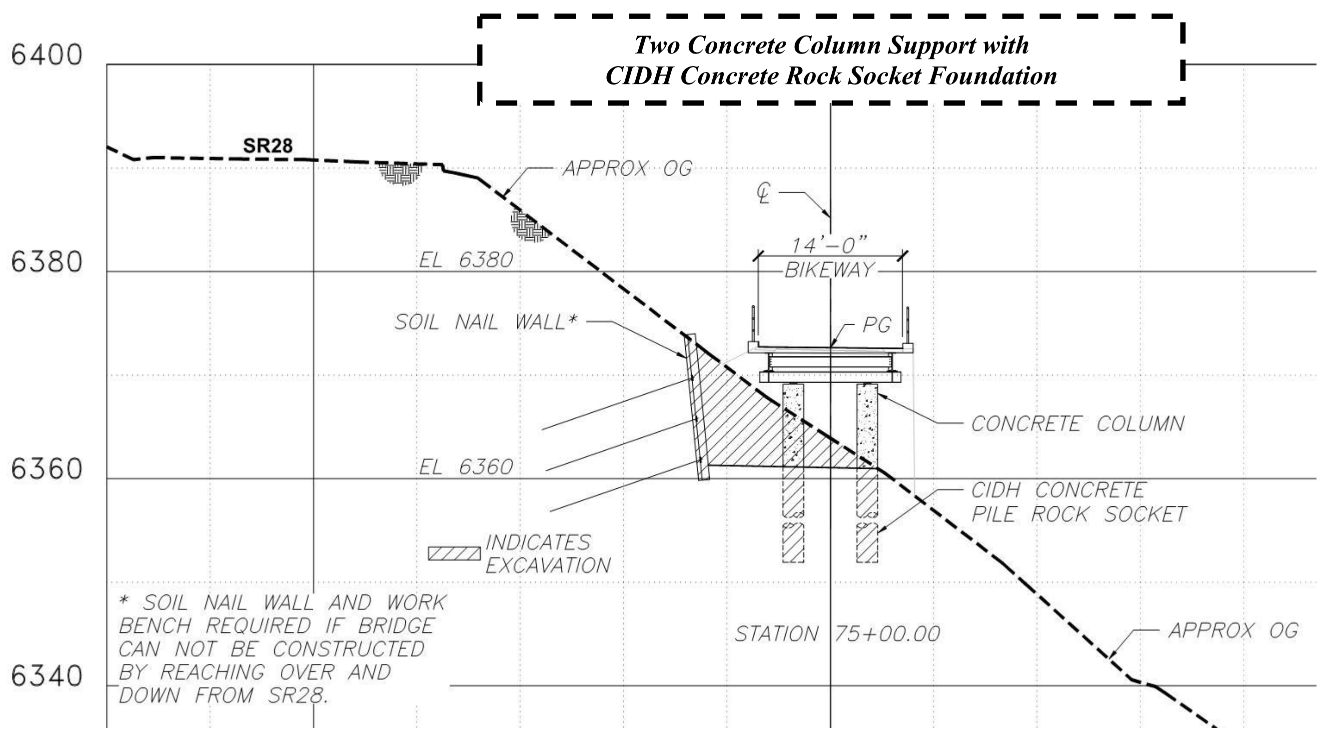
Note that the following figures show construction of a soil nail wall for excavation to create a work bench for construction equipment. If the bikeway trail is located in close proximity to SR 28, construction equipment may be able to operate from the outer lane of SR 28 (provided adequate traffic control systems are in place) reaching over and down and constructing the foundations on the sidehill without the need for the soil nail wall and excavation. In any case, contractor's construction working drawings will have to be reviewed and approved.

FRP Deck Panels North Demonstration Project

Advantages	***Disadvantages***
✓ No falsework – less impact to environmentally sensitive areas below bridge. ✓ Feasible for short span (single-span or multi-span) bridges. Up to 50 foot spans. ✓ Lighter weight better accommodates seismic loads.	✗ Slower construction for a multiple span bridge. ✗ More expensive of the short span bridge alternatives.




Single Concrete Column Support with
Concrete Pile Cap/Micropile Foundation
6400
6380
6360
6340
SR28
APPROX OG
EL 6380
14'-0"
BIKEWAY
SOIL NAIL WALL*
PG
CONCRETE COLUMN
EL 6360
PILE CAP
MICROPILE
INDICATES
EXCAVATION
* SOIL NAIL WALL AND WORK
BENCH REQUIRED IF BRIDGE
CAN NOT BE CONSTRUCTED
BY REACHING OVER AND
DOWN FROM SR28.
STATION 75+00.00
APPROX OG


Two Concrete Column Support with
CIDH Concrete Rock Socket Foundation
6400
6380
6360
6340
SR28
APPROX OG
EL 6380
14'-0"
BIKEWAY
SOIL NAIL WALL*
PG
CONCRETE COLUMN
EL 6360
CIDH CONCRETE
PILE ROCK SOCKET
INDICATES
EXCAVATION
* SOIL NAIL WALL AND WORK
BENCH REQUIRED IF BRIDGE
CAN NOT BE CONSTRUCTED
BY REACHING OVER AND
DOWN FROM SR28.
STATION 75+00.00
APPROX OG

4.3) ALTERNATIVE B3 – PRECAST PRESTRESSED CONCRETE VOIDED SLAB BRIDGE

A precast prestressed concrete voided slab bridge is another alternative that will be given consideration for locations where a shorter-span is required. The foundation and support systems can be the same as presented for the preceding Section "4.2) Alternative B2 – Fiber Reinforced Polymer (FRP)/Steel Bridge".

Advantages	*Disadvantages*
✓ Fast construction. ✓ No falsework – less impact to environmentally sensitive areas below bridge. ✓ Feasible for short span (single-span or multi-span) bridges. Up to 50 foot spans. ✓ Low maintenance. ✓ Less expensive of the short span bridge alternatives.	✗ Heavier weight requires larger substructure to resist seismic loads.

4.4) ALTERNATIVE B4 – PRECAST PRESTRESSED CONCRETE GIRDER BRIDGE

Precast prestressed concrete I girder superstructure with CIP reinforced concrete substructure on cast-in-drilled-hole (CIDH) piling. This alternative is feasible for when a longer-span bridge is needed.

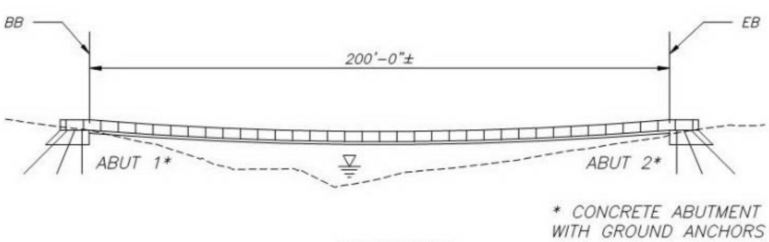
Advantages	*Disadvantages*
✓ Fast construction. ✓ No falsework – less impact to environmentally sensitive areas below bridge. ✓ Longer clear spans up to and over approximately 100 feet. ✓ Low maintenance.	✗ Heavier weight requires larger substructure to resist seismic loads. ✗ Not feasible where short span bridges are needed. ✗ More expensive of the long span bridge alternatives.

Trail Bridge over Truckee River Near Tahoe City

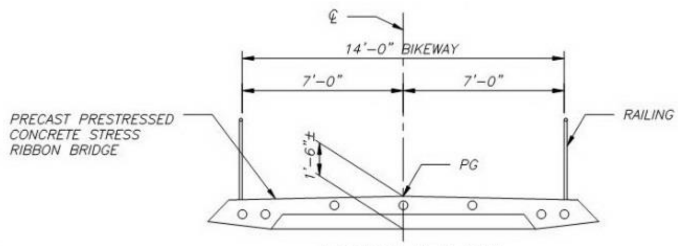
4.5) ALTERNATIVE B5 – "SIGNATURE" BRIDGE

Alternative B5 presents an opportunity to provide a "signature" bridge type that would be a statement and unique to not only the bikeway but the Lake Tahoe area as well. If TTD, local partners, and stakeholders want such a bridge, then a "signature" bridge type such as the concrete stress ribbon bridge would be appropriate. The concrete stress ribbon bridge has a shallow depth prestressed concrete superstructure supported by suspension cables anchored at each end of the bridge by concrete abutments and ground anchors. The bridge deck follows a catenary arc profile between the abutments. While the concrete stress ribbon bridge would be the most costly of the bridge alternatives to be considered, it could be aesthetically the best compliment to the existing rocky forested terrain. The "signature" bridge type would be well suited for the various creek crossings along the bikeway.

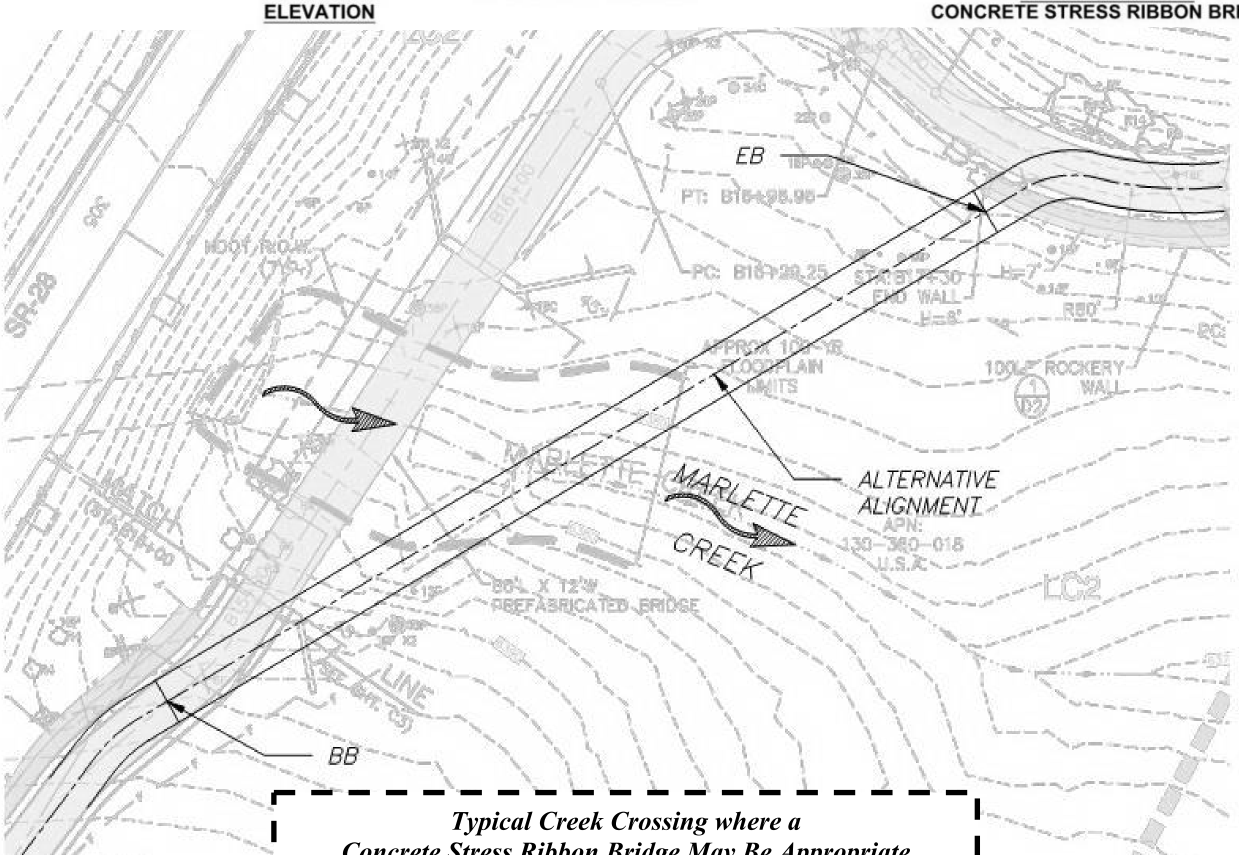
Advantages	*Disadvantages*
✓ Aesthetically could be the best compliment to existing terrain. ✓ Long clear span over the creek channel.	✗ Most expensive. ✗ Temporary erection support along the superstructure is needed.



ELEVATION



TYPICAL SECTION
CONCRETE STRESS RIBBON BRIDGE



Typical Creek Crossing where a
Concrete Stress Ribbon Bridge May Be Appropriate

5.) PROPOSED UNDERCROSSING (TUNNEL)

5.1) ALTERNATIVE T1 – CONCRETE BOX CULVERT UNDERCROSSING

At the main entrance to Sand Harbor Park, it is proposed that the trail crosses underneath the entrance road. A concrete box culvert having inside clearances of 14 feet wide and 10 feet high and a length of approximately 100 feet is the proposed structure type for the undercrossing (tunnel). Both a cast-in-place reinforced concrete and a precast reinforced concrete box culvert will be considered. This undercrossing is similar to the one recently constructed in the North Demonstration Project.

Typical Section of Culvert Undercrossing
Beneath Main Entrance to Sand Harbor Park