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Guidelines for Developing a Successful Solution for the Peninsula Rail Corridor

These are guidelines for technical issues which must be considered in the planning of a rail corridor. The challenge for the San Francisco to San Jose segment of California High Speed Rail (referred to as the Peninsula Rail Corridor) is that Caltrain commute period operations and freight access must be maintained during and after construction.

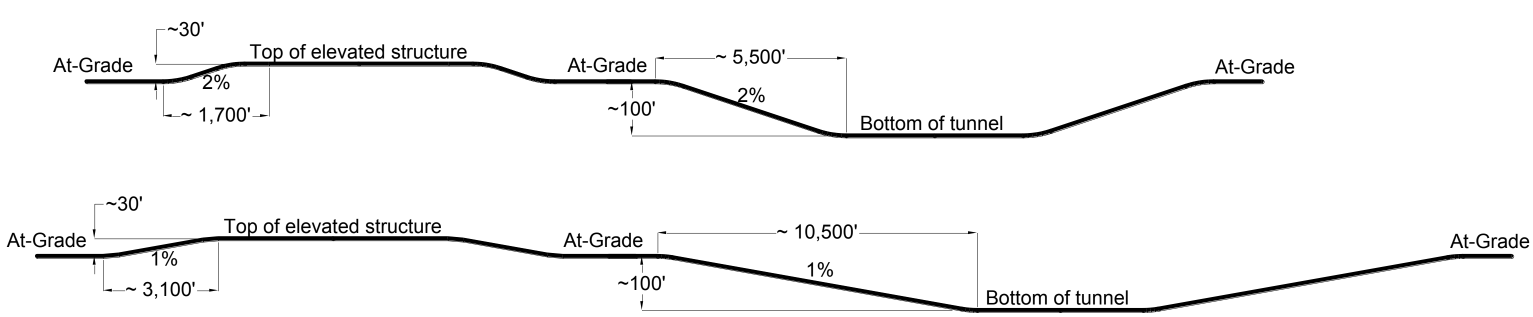
1. Consider systemwide implications for passenger and freight operations.

a. Both HSR and Caltrain have plans to electrify and run on grade separated corridors, therefore separating the two systems (i.e. HSR in a tunnel, Caltrain/freight at grade) will increase the project cost for electrification and grade separations.

b. A straighter (vertical and horizontal) track profile is preferred for train operations, passenger comfort, and construction/cost efficiencies. Consider what the profile will be in adjacent segments of the corridor to minimize the "roller coaster effect." Elevated or underground railroad tracks require:

- A one percent grade change (approximately one foot in vertical elevation every 100 feet of horizontal distance) to accommodate freight trains, which translates to over 10,000 feet of distance for a train to surface from a 100-foot deep tunnel.
- A two percent grade change (approximately two feet in vertical elevation every 100 feet of horizontal distance) for diesel-hauled passenger trains, which translates to over 5,000 feet of distance for a train to surface from a 100-foot deep tunnel.

PROFILE VIEW



c. The corridor will continue to be used by freight trains that must access industries along the corridor. If the railroad is elevated or located underground, there will be limited access to freight customers along the corridor who are currently served by tracks at-grade.

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2. Consider the pros and cons of different construction methods:

The following charts and information sheets have been developed to provide a qualitative comparison of different construction methods that will be considered on the Peninsula:

- Elevated – Aerial Structure
- Elevated – Raised Earth / Berm
- At grade – Street level
- Below ground – Trench (Shallow tunnel, open air)
- Below ground – Cut and Cover Tunnel (Shallow tunnel, covered)
- Below ground – Bored Tunnel (Deep tunnel)

Each construction method has been given a qualitative rating (small to large circles) based on different criteria. A small circle represents more favorable outcomes than a large circle. The criteria shown in the following charts include:

1. Length of Construction Period
2. Construction Impact to Caltrain Service
3. Width of Right of Way (construction)
4. Width of Right of Way (final configuration)
5. Project Cost
6. Incompatibility with Freight
7. Requires Station Relocation (above or below ground)
8. Time Required for Emergency Response
9. Noise from Operations (without mitigation)
10. Visual Impact/Obstruction
11. Delays to Automobile Traffic

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COMPARISON OF CONSTRUCTION METHODS - CONSTRUCTION IMPACTS					
Option	**Length of Construction Period**	**Construction Impact to Caltrain Service**	**Width of Right of Way Needed (Construction)**	**Width of Right of Way Needed (Final)**	**Caveats**
Aerial					
Raised Earth					
At-Grade					
Trench					
Cut and Cover Tunnel					
Bored Tunnel					- Greater right of way width needed at tunnel entrance/exit both during construction and for final configuration

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COMPARISON OFCONSTRUCTION METHODS				
Option	**Project Cost**	**Incompatibility with Freight**	**Requires Relocation of Caltrain Stations**	**Caveats**
Aerial	●	◉	●	- Elevating heavier freight trains necessitates stronger structural requirements. - Elevated tracks make access to freight customers challenging. Longer distances required to make elevation changes.
Raised Earth	●	◉	●	- Elevated tracks make access to freight customers challenging. Longer distances required to make elevation changes.
At-Grade	●	no issues	●	
Trench	●	◉	●	- Below-grade tracks make access to freight customers challenging. Longer distances required to make elevation changes.
Cut and Cover Tunnel	●	●	●	- Underground freight operations limit access to freight customers along the corridor. Longer distances required to make elevation changes. - Above ground ventilation shafts required every 300 to 500 feet for diesel-powered freight operations.
Bored Tunnel	●	●	●	- Underground freight operations limit access to freight customers along the corridor. Longer distances required to make elevation changes. - Above ground ventilation shafts required every 300 to 500 feet for diesel-powered freight operations.

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COMPARISON OF CONSTRUCTION METHODS - ULTIMATE ENVIRONMENTAL AND NEIGHBORHOOD IMPACTS					
Option	**Time Required for Emergency Response**	**Noise from Operations (w/o mitigation)**	**Visual Impact / Obstruction**	**Delays to Automobile Traffic**	**Caveats**
Aerial	●	●	●	●	- Minimal delays to automobile traffic assumes no street closures. All existing roads crossing the tracks at grade would go under the aerial structure.
Raised Earth	●	●	●	●	- Minimal delays to automobile traffic assumes no street closures. All existing roads crossing the tracks at grade would go under the raised earth berm.
At-Grade	●	●	●	●	- Will require modification of existing grade crossing: road over tracks, road under tracks, or closure of crossing. - May limit roadway access for adjacent properties.
Trench	●	●	●	●	- Minimal delays to automobile traffic assumes no street closures. All existing roads crossing the tracks at grade would go over the trench.
Cut and Cover Tunnel	●	◉	◉	●	- Above ground ventilation shafts required, which will transmit noise. (every 300 to 500 feet for diesel-powered operations and 5,280 to 6,600 feet for electric vehicles)
Bored Tunnel	●	◉	◉	●	- Above ground ventilation shafts required, which will transmit noise. (every 300 to 500 feet for diesel-powered operations and 5,280 to 6,600 feet for electric vehicles)

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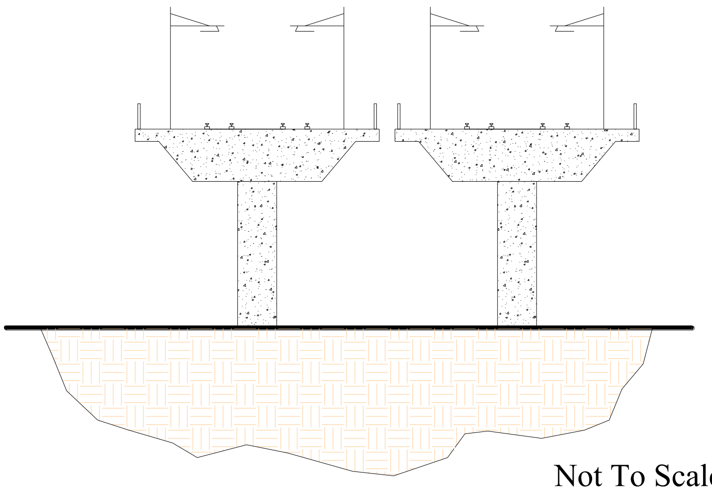
AERIAL STRUCTURES

The following provides basic information on construction of the aerial options. All dimensions provided are generic and are for informational purposes only. Actual dimensions are site and project specific and are dependent on the surrounding geographic and geological conditions, as well as construction methods and phasing.

Single Column

- Single column supporting an aerial structure
  - Requires approximately 20 feet on either side of column for foundation and column construction
- Two options for the aerial structure: cast-in-place or pre-cast
  - Cast-in-place: concrete poured into wooden frames
  - Pre-cast: segments of the aerial structure are pre-cast off-site and raised into position
  - Construction of aerial structure requires at a minimum the entire width beneath the structure for construction
- May require re-alignment of tracks and/or roads to maintain train and traffic service during construction (dependent on size of ROW)
  - May cause disruption to surrounding traffic and utilities
- May require private property takes (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Elevated stations needed
- To accommodate freight operations, vertical grades must be 1%. Diesel-powered passenger trains require 2% grade.
- Tracks/roads can be re-located below final aerial structure.
- Least expensive option – 3.5 times at-grade construction cost



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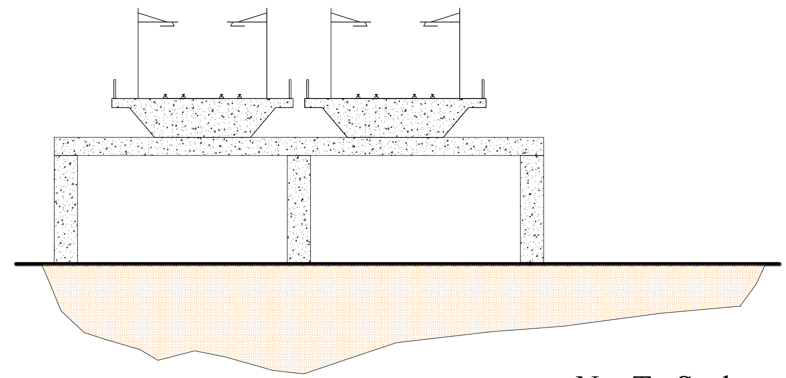
Straddle Bent

The straddle bent is an aerial track structure supported by a beams (i.e. bents) that span between two columns.

- Two columns (supporting a bent)
  - Requires approximately 20 feet on either side of each column for foundation and column construction
- Bent
  - Temporary columns are set-up around the permanent concrete columns to support wooden falsework
  - Requires approximately 5 to 10 feet on either side of each concrete column for temporary support columns
- Aerial structure
  - Cast-in-place: concrete poured into wooden falsework
  - Pre-cast: segments of the aerial structure are pre-cast off-site and raised into position
  - Construction of aerial structure requires at a minimum the entire width beneath the structure for construction
- May require re-alignment of tracks and/or roads to maintain train and traffic service during construction (dependent on size of ROW)
  - May cause disruption to surrounding traffic and utilities
- May require private property takes (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Elevated stations needed
- To accommodate freight operations, vertical grades must be 1%. Diesel-powered passenger trains require 2% grade.
- Tracks/roads can be re-located below final aerial structure (between two columns).
- More expensive option – 4.2 times at-grade construction cost



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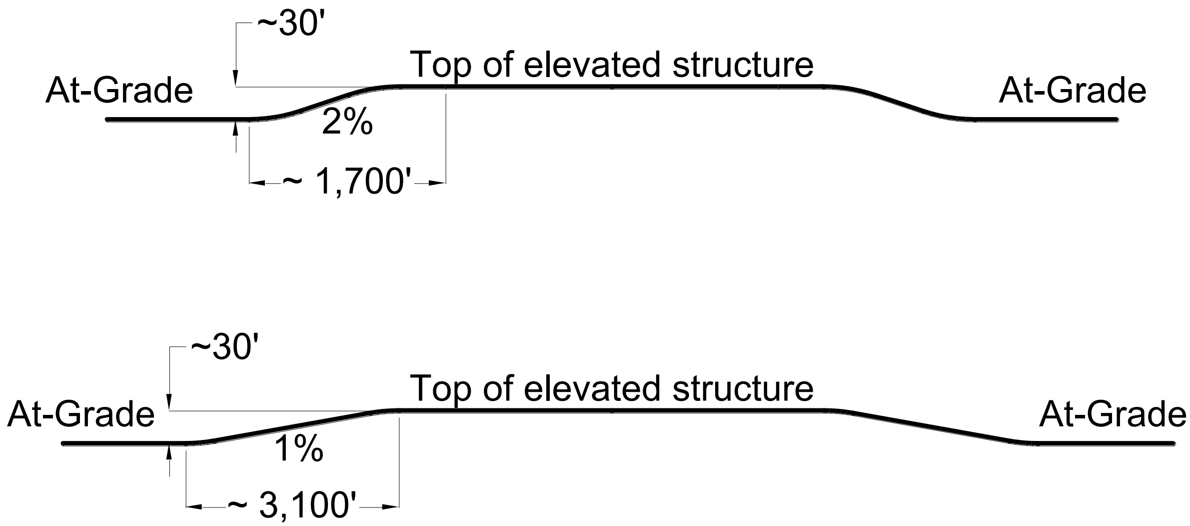
PROFILE VIEW



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Aerial Structures

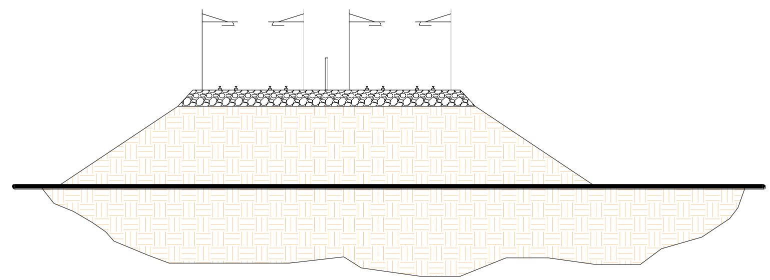
Aerial Structures

RAISED EARTH / BERM OPTIONS

The following provides basic information on construction of raised earth/berm options. All dimensions provided are generic and are for informational purposes only. Actual dimensions are site and project specific and are dependent on the surrounding geographic and geological conditions, as well as construction methods and phasing.

Berm

- Compacted raised earth with tracks located at the top
- Requires approximately 15 feet from the base for construction
- May require re-alignment of tracks and/or roads to maintain train and traffic service during construction (dependent on size of ROW)
  - May cause disruption to surrounding traffic and utilities
- May require private property takes (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Elevated stations needed
- Tracks can be re-located on top of final berm structure.
- Least expensive option – 1.5 times at-grade construction cost



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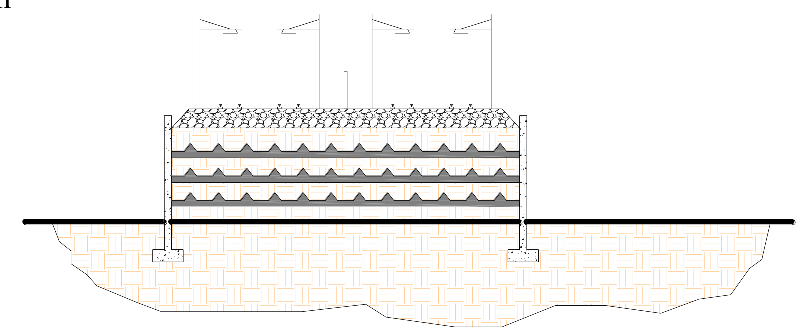
Mechanically Stabilized Earth (MSE)

- Compacted raised earth stabilized by metal "straps" and contained by walls on either side
- Requires approximately 20 feet from the walls for construction
- May require re-alignment of tracks and/or roads to maintain train and traffic service during construction (dependent on size of ROW)
  - May cause disruption to surrounding traffic and utilities
- May require private property takes (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Elevated stations needed
- Tracks can be re-located on top of final MSE structure
- More expensive option (comparable to Retained Fill option) – 2 times at-grade construction cost



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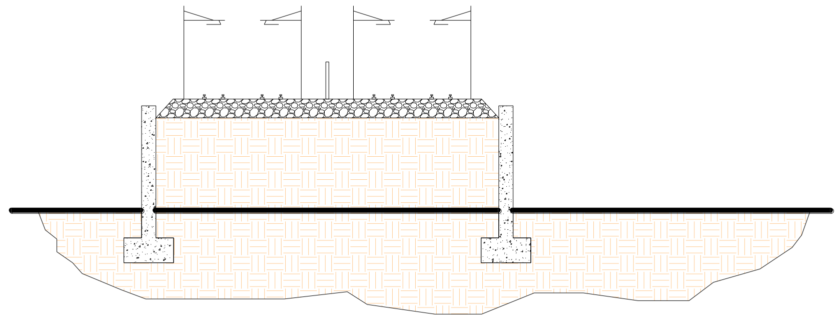
Retained Fill

- Compacted raised earth stabilized by retaining walls
- Requires approximately 30 feet from the retaining walls for construction
- May require re-alignment of tracks and/or roads to maintain train and traffic service during construction (dependent on size of ROW)
    - May cause disruption to surrounding traffic and utilities
- May require private property takes (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Elevated stations needed
- Tracks can be re-located on top of final retained fill structure.
- More expensive option (comparable to MSE option) – 2 times at-grade construction cost



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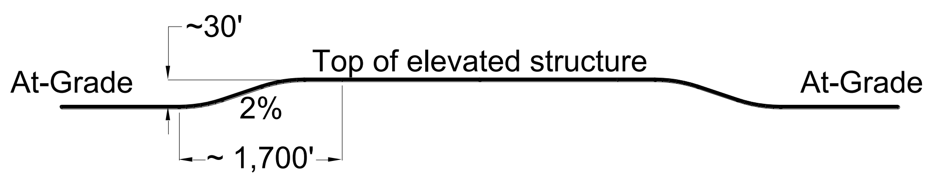
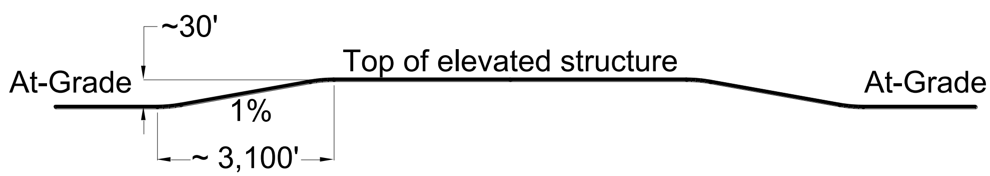
PROFILE VIEW





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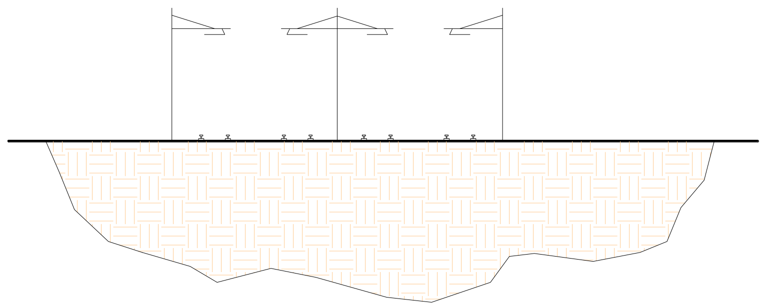
Raised Earth / Berm

AT-GRADE OPTION

The following provides basic information on construction of an at-grade option. This is an existing condition on most of the Caltrain right of way and is a viable option where the existing right of way can accommodate four tracks. All dimensions provided are generic and are for informational purposes only. Actual dimensions are site and project specific and are dependent on the surrounding geographic and geological conditions, as well as construction methods and phasing.

At-Grade

- Constructed on the existing Caltrain right of way, next to existing tracks
- Will require modification of existing grade crossings – road over, road under, or closure of crossing.
- Requires approximately 10 feet from track centerline for construction
- May require re-alignment of tracks and/or roads to maintain train service and traffic access during construction (dependent on size of right of way)
  - May cause disruption to surrounding traffic and utilities
- It is anticipated that construction of at-grade track will remain within the existing Caltrain right of way.
- Can be constructed in phases or segments to minimize construction footprint
- Least expensive option to construct



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At-Grade

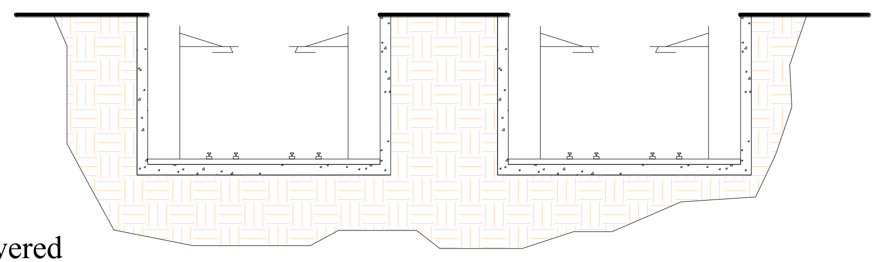
At-Grade Option

BELOW GROUND OPTIONS

The following provides basic information on below ground options, including trench construction and the two most common methods of tunnel construction, the cut and cover method and the bored method. All dimensions provided are generic and are for informational purposes only. Actual dimensions are site and project specific and are dependent on the surrounding geographic and geological conditions, as well as construction methods and phasing.

Trench

- Additional land takes required, in addition to the trench width, for construction process (equipment, soil disposal, etc.)
  - Requires approximately 15-20 feet from sheeting/trench wall to allow for construction equipment movement.
  - Requires periodic staging areas along the alignment, approximately 1 to 2 acres, every mile or so.
- May require re-alignment of tracks and/or roads to maintain train and traffic service during trench construction (dependent on size of ROW)
  - May cause disruption to surrounding traffic and utilities
- May require private property takes, as well, for construction and/or trench (dependent on size of ROW)
- Trenched stations needed
- To accommodate freight operations, vertical grades must be 1%. Diesel-powered passenger trains require 2% grade.
- Can be constructed in phases or segments to minimize construction footprint
- Least expensive option – 3.5 times at-grade construction cost
- Potentially requires most amount of permanent land takes.



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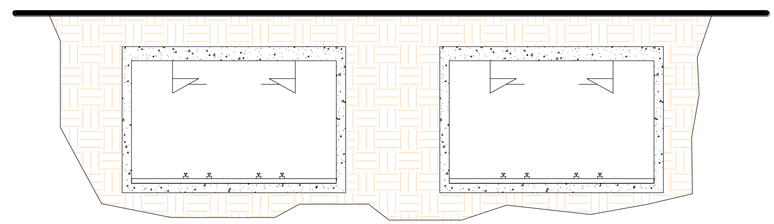
Cut and Cover Tunnel

The cut and cover method is a simple method for constructing shallow tunnels where a trench is excavated in a similar method as trenching and then roofed over.

- Additional land takes required, in addition to the tunnel width, for construction process (equipment, soil disposal, etc.)
    - Requires approximately 15-20 feet from sheeting/tunnel wall to allow for construction equipment movement.
- Requires re-alignment of tracks and/or roads to maintain train and traffic service during tunnel construction (dependent on size of ROW)
    - May cause disruption to surrounding traffic and utilities
- May require private property takes, as well, for construction (dependent on size of ROW)
- Can be constructed in phases or segments to minimize construction footprint
- Underground stations needed
- Freight operations will require short haul operators with electric locomotives and a maximum 1% gradient. (diesel-powered passenger trains require a 2% gradient)
- Property required for following safety requirements:
    - Ventilation shafts (distance between shafts dependent on expected fire loading)
        - Electric only: 1 shaft / all tunnels every 1-1.25 miles, i.e. 5,280-6,600 feet
        - With Diesel: 1 shaft / all tunnels every 300-500 feet
    - Cross passages between tunnels will be required approximately every 800 feet
    - Emergency evacuation: Located with the ventilation shafts or along alignment if tunnel is shallow enough.
- Shallower tunnels may see buoyancy issues, dependent on water table.
- No risk of subsidence to adjacent structures if located approximately 20 feet from excavation.
- HSR specific requirements (from Jan 2004 CHSRA Tunneling Issues report)
    - For twin single track tunnels over 6 miles long, a third tunnel is required for ventilation, evacuation, and construction access.
    - Cross passages required for tunnels longer than 3,280 feet
    - Cooling system needed for tunnels longer than 6 miles
- Least expensive tunnel construction method – 4 times at-grade construction cost



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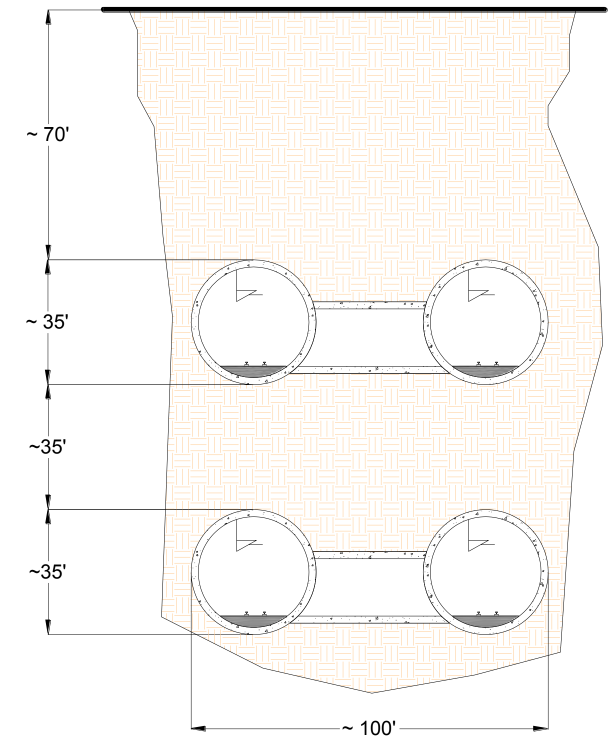
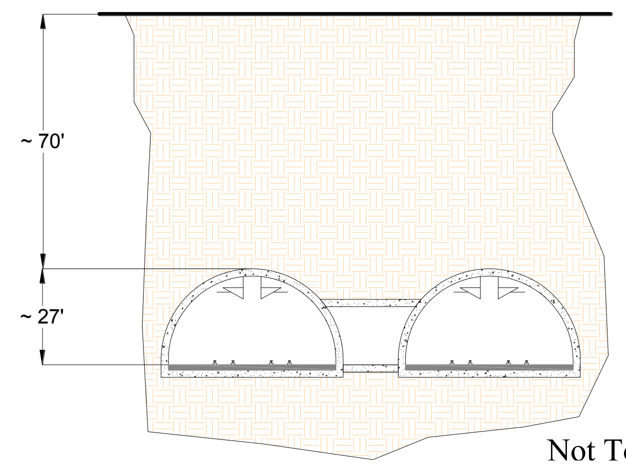
Bored Tunnel

This method uses a tunnel boring machine to cut the tunnels, which are then reinforced by various methods.

- Depth: 2 diameters from top of ground to top of tunnel. In order for the tunnel to reach it appropriate depth, cut and cover tunnel approaches will be required at each end of the bored tunnel.
- Approximately 4-5 acres of land takes will be required at the beginning of the tunnels for site preparation, construction lay down, storage and disposal of excavated material, and possibly for storage of pre-fabricated lining segments
- Approximately 2 acres of land takes will be required at the end to disassemble the TBM in addition to the area required to build the exit cut and cover tunnel
- Underground stations needed
- Freight operations will require short haul operators with electric locomotives and a maximum 1% gradient. (diesel-powered passenger trains require a 2% gradient)
- Property required for following safety requirements:
  - Ventilation shafts (distance between shafts dependent on expected fire loading)
    - Electric only: 1 shaft / all tunnels every 1-1.25 miles, i.e. 5,280-6,600 feet
    - With Diesel: 1 shaft / all tunnels every 300-500 feet
  - Cross passages between tunnels will be required approximately every 800 feet
  - Emergency evacuation: Located with the ventilation shafts
- Risk of settlement for all infrastructure above the tunnels (tracks, utilities, buildings, etc)
- No buoyancy issues due to depth of tunnels.
- HSR specific requirements (from Jan 2004 CHSRA Tunneling Issues report)
  - For twin single track tunnels over 6 miles long, a third tunnel is required for ventilation, evacuation, and construction access.
  - Cross passages required for tunnels longer than 3,280 feet
  - Cooling system needed for tunnels longer than 6 miles
  - TBM Speed: 30 ft/day
- Most expensive tunnel construction method – 6.5 times at-grade construction cost





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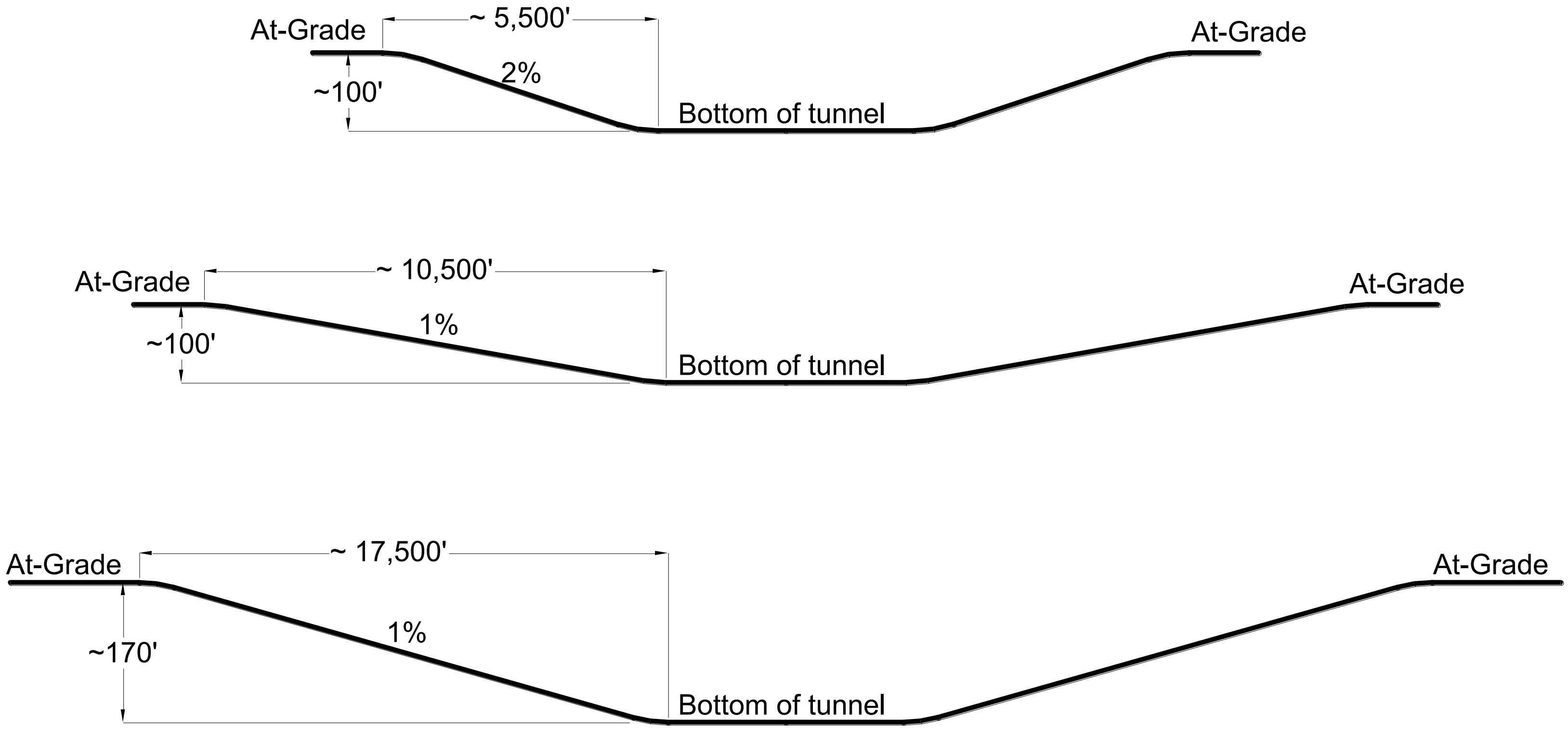
PROFILE VIEW



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Below Ground Options

Trench / Cut and Cover Tunnels

Bored Tunnels