

April 11, 2018

To: Brian P. Kelly
Chief Executive Officer
California High Speed Rail Authority
770 L Street, Suite 620
Sacramento, CA 95814

RE: REQUEST FOR IMMEDIATE STOP WORK ORDER FOR MERCED TO FRESNO SECTION

Public Safety should be paramount in any track design for High Speed Rail (HSR), but the design for the track curves across the Herndon Overpass structure north of Fresno is a public safety hazard and poses a serious threat to derailment.

Background

Building straight tracks along the UPRR corridor from Merced to Fresno was the shortest route for HSR.

In 2012, the track route called the Hybrid was chosen by the Authority. This route veers from the UPRR corridor and zig-zags across open farmland. The sixty mile straight route now contains nearly 25 miles of high speed curves and horizontal super-elevated spirals with an additional ten miles of track. Trains will travel over the curves and spirals on ballasted track built on alluvial soil at 220 mph. The California High Speed Rail Authority (CHSRA) officials continue to state that this route between Merced and Fresno is the backbone of the high speed rail system, yet this backbone has developed scoliosis, or curvature of the spine; the area in question will need a spinal brace.

(See Attachments 1A and 1B for Merced to Fresno Section alignment.)

This is a request for an immediate Stop Work Order for the Fresno to Merced section to reevaluate the curve designs. This report focuses only on the curve north of Fresno between Herndon Drive and the San Joaquin River. However, similar alignment flaws are shown on the Authority's construction drawings in Madera County for the Chowchilla Boulevard/UPRR Bridge, the Fresno River Bridge, the two single track crossovers between Avenue 10 and 12, and the entire Wye complex surrounding the storage facility site. Each of these high speed rail curves should be re-evaluated, realigned and reconfigured as they each contain similar alignment problems that will lead to future operational and maintenance hazards and derailments.

Dangerous Design

North of Herndon Drive in Fresno, near the San Joaquin River, there is a wide support structure for high speed rail currently being constructed over a single UPRR track. (See Attachments 2 and 3.) As the HSR tracks curve northwards, this wide track support

structure transitions into tall support columns. (See Attachments 4 and 5.) The trains will travel at 220 mph on top of these 60 to 100 foot tall structures. Near the transitional area between the wide deck and the support columns, the track design calls for a combination of overlapping horizontal and vertical curves. This combination violates the Authority's own Criteria for safe track design. The track design is extremely dangerous; this track design cannot be easily built or safely maintained, thereby creating a significant risk of derailment.

The Draft Environmental Report, the Final Environmental Report and the Construction Documents all use the same curve design for this track; the two sets of environmental documents are identical. This is non-standard practice for good curve design. Usually, in critical locations such as this, between the draft, final and construction documents, multiple track designs are evaluated in order to determine the best and safest fit. For this alignment, there was only one proposal. A single drawing from the Final EIR will be used for ease of argument.

For five years, I was the Manager of Metro's Green Line track contracts in Los Angeles. This included the Aviation Wye, which is located on the southern boundary of the Los Angeles International Airport (LAX). The size and type of the structures near LAX are similar to the size and type structures from Herndon Drive to the San Joaquin River. On the Los Angeles project, there were many track alternatives studied before the trackway was built. There is not any evidence of any other track design proposed for this critical structure near the San Joaquin River.

At the overlap of vertical and horizontal curves, the tracks begin to curve away from the large structure; three mathematical models are needed to construct the tracks, an unsafe track engineering practice. (See Attachments 6, 7 and 8.) A horizontal spiral curving outwards is built on top of a vertical curve going downwards. (See Attachment 9.) The tracks will be super-elevated from zero to six inches on one side, while the trains are spiraling downwards on a maximum grade slope across the top of a vertical curve. Normal track design does not allow this combination except in amusement parks and coal mines; this is not Disneyland and all of the curvature for HSR should be seriously investigated. The northbound train has the greatest potential for derailment when traveling across the peak of the vertical curve. Maintaining a slower speed may actually make things worse.

This combination of curves is avoided in rail and roadway design criteria, including the CHSRA Criteria. (See Attachment 10A, 10B, 10C and 10D.)

For high speed rail, due to the large radius and length of curves, there can be some overlap at the edges. But in this case, the horizontal spiral and the vertical curve are on top of one another. It will be impossible to build, maintain and operate trains safely over this combination.

Fresno suffers from extreme heat and cold. This will result in extremes in the expansion and contraction of the rail and the structures. Rail and concrete expand and contract at different rates. Has this been taken into account in the curve designs that are built on the structures? (See Attachment 11.)

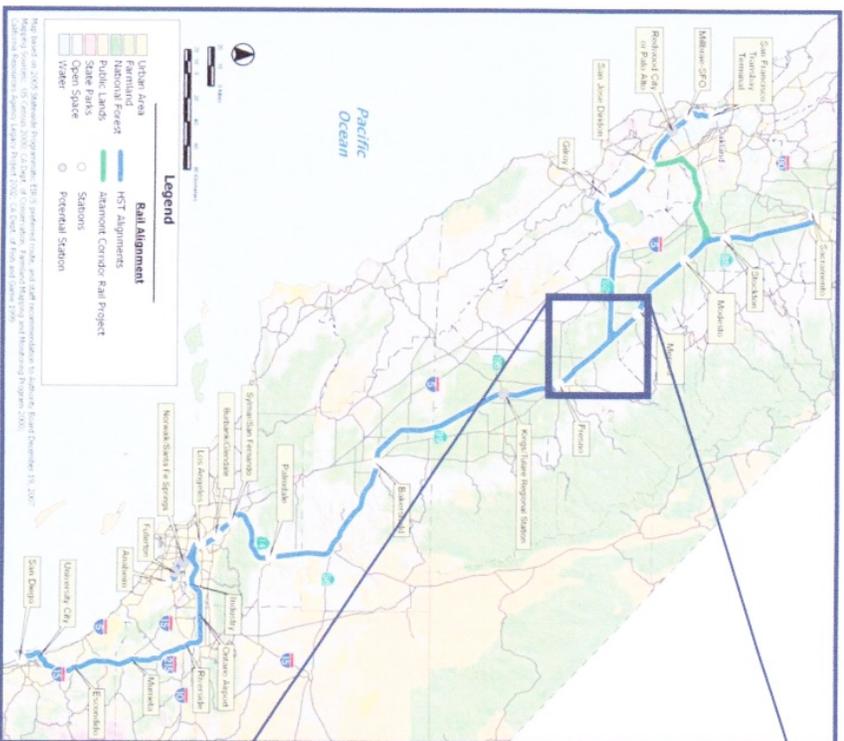
Summary: Combining a horizontal spiral that increases from zero to six inches of super-elevation with a maximum grade vertical curve built on top of a transitional structural support system in a geographical area that experiences extreme temperature range is very dangerous for trains traveling at any speed. This is a request to immediately issue a Stop Work Order to the Contractor for all structures on the Merced to Fresno segment of California High Speed Rail.

Please see additional attachments for further information.

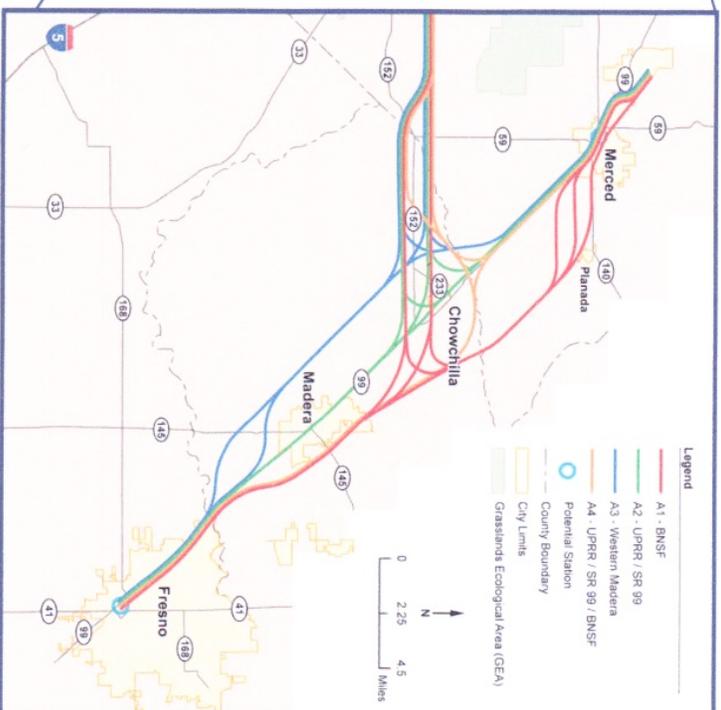
Thank you for your cooperation in this matter.

Susan MacAdams
Track and Alignment Expert
Former High Speed Rail Planning Manager,
Los Angeles County Metropolitan Transportation Authority (Metro)
Metro Red, Blue and Green Lines, Los Angeles
Light and Heavy Rail Track Design and Construction: Baltimore, Boston, & Washington
DC

Merced-to-Fresno Section



Statewide Map



Project Vicinity



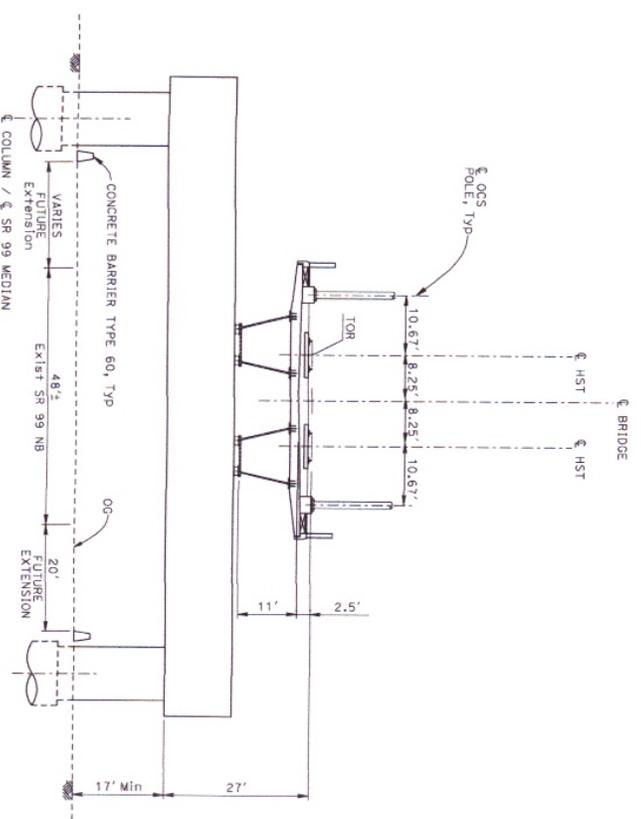
ATTACHMENT 2



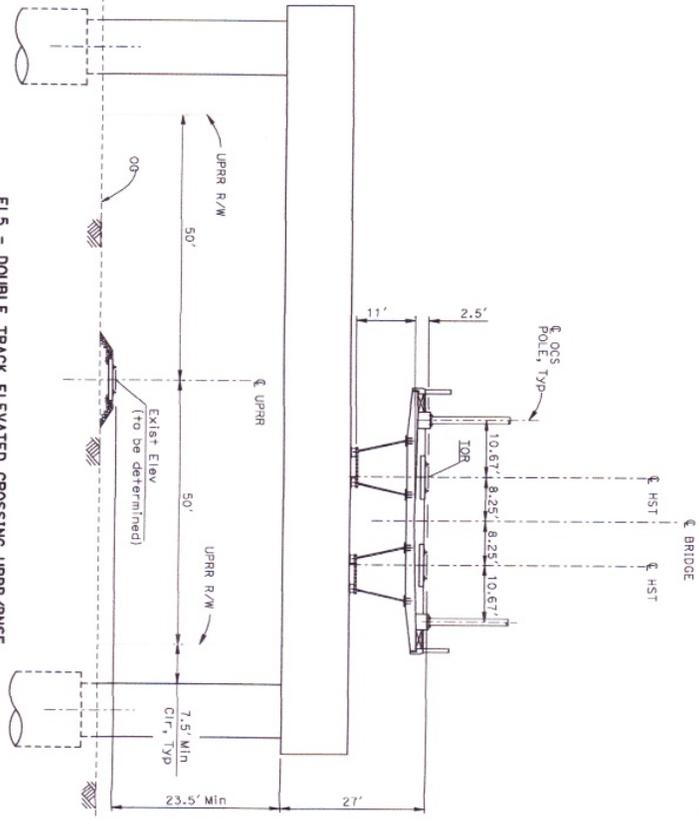
HSR STRUCTURE OVER UPRR TRACKS NEAR HERNDON DRIVE, FRESNO
LOOKING NORTHWEST

CHANGE IN TRACK STRUCTURE

ATTACHMENT 3



EL4 - DOUBLE TRACK ELEVATED CROSSING SR99



EL5 - DOUBLE TRACK ELEVATED CROSSING UPRR/BNSF

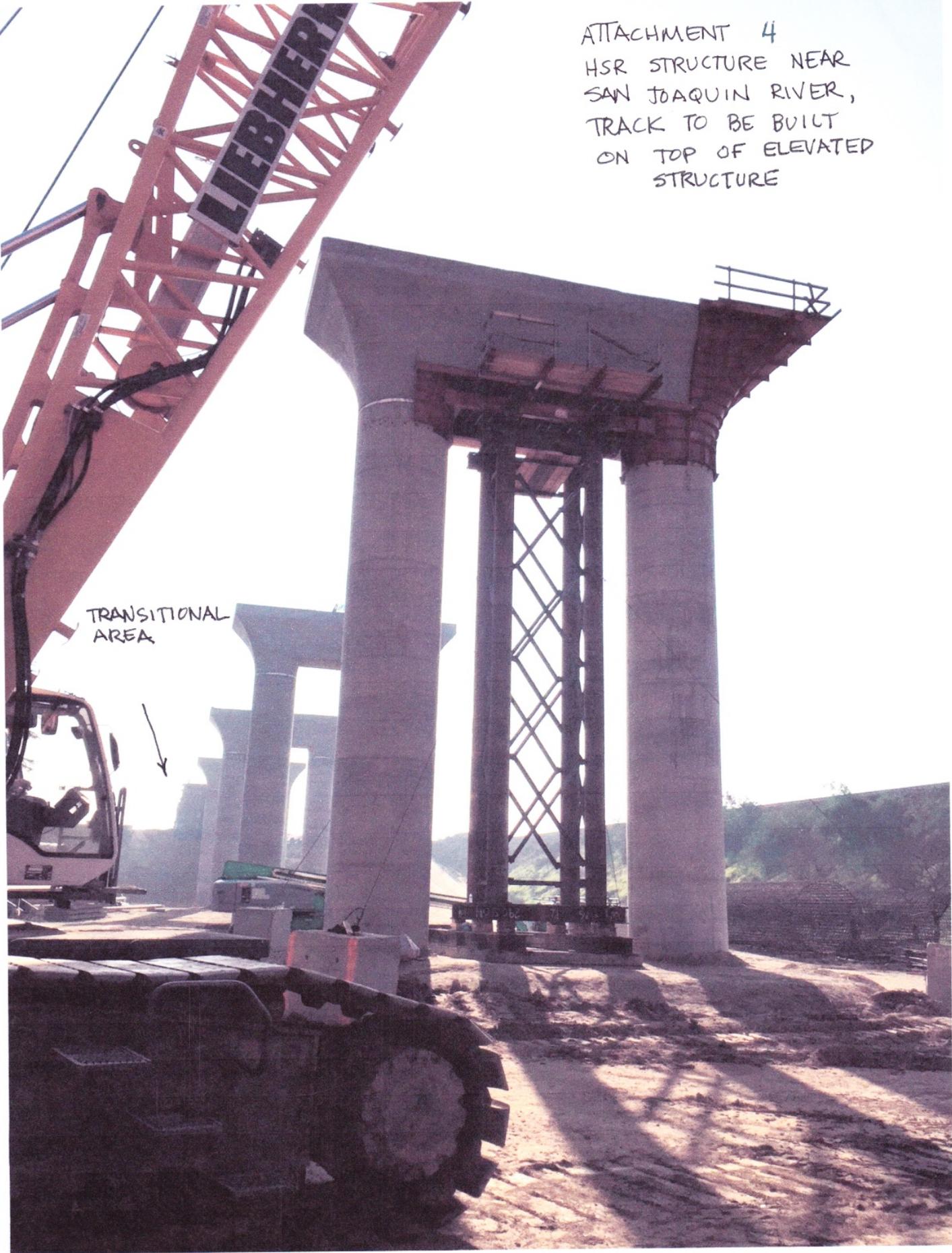
LOOKING NORTHWEST

- NOTES:
1. TRACK OCS POLES AND FOUNDATIONS, CABLE TOWER FOUNDATIONS, AND FOUNDATIONS SHALL BE SHOWN AS NOT REPRESENTED DESIGN.
 2. RIGHT-OF-WAY REQUIRED FOR THE HIGH-SPEED RAIL GIDEMAY WILL DEPEND UPON CONDITIONS ALONG THE ALIGNMENT INCLUDING TERRAIN, STRUCTURES, AND ACCESS ARE REQUIRED.
 3. POTENTIAL SOUND BARRIERS NOT SHOWN IN CROSS SECTIONS FOR THE EXTENT OF POTENTIAL SOUND BARRIERS. SEE ALIGNMENT PLAN AND PROFILE SHEETS.

DATE	BY	CHK	APP	DESCRIPTION	DESIGNED BY C. VALADAO	CHECKED BY A. BOONE	RECORD SET NECESSARY NOT FOR CONSTRUCTION	AECOM 2200 L STREET, SUITE 300 CHESMARE HILL	CALIFORNIA HIGH-SPEED RAIL AUTHORITY	CALIFORNIA HIGH-SPEED TRAIN PROJECT MERCED TO FRESNO	CONTRACT NO. HSR06-007
					DRAWN BY T3006-A	SCALE NO SCALE				TYPICAL SECTIONS SHEET 6 OF 11	SHEET NO. OF ###

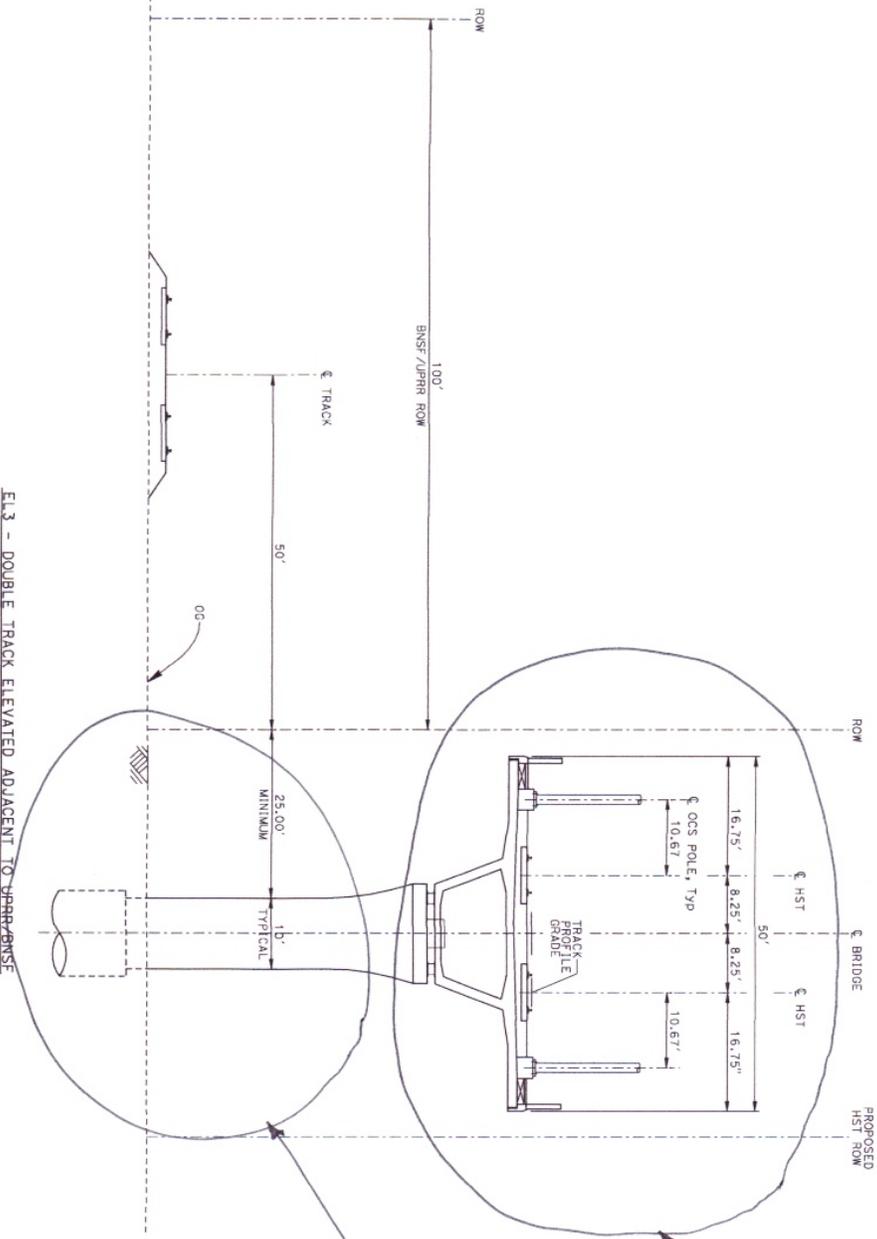
ATTACHMENT 4
HSR STRUCTURE NEAR
SAN JOAQUIN RIVER,
TRACK TO BE BUILT
ON TOP OF ELEVATED
STRUCTURE

TRANSITIONAL
AREA



CHANGE IN TRACK STRUCTURE

ATTACHMENT 5



THE AERIAL DECK WILL NEED TO BE RE-DESIGNED TO ACCOMMODATE ACCEPTABLE CURVATURE

THE COLUMN FOOTINGS MAY REQUIRE RE-LOCATION

EL 3 - DOUBLE TRACK ELEVATED ADJACENT TO BNSF/UPRR

- NOTES:
1. TRACK, OCS POLES AND FOUNDATIONS, CABLE NOT REPRESENTED ARE SCHEMATIC AND DO NOT REPRESENT DESIGN.
 2. RIGHT-OF-WAY REQUIRED FOR THE HIGH-SPEED TRAIN SHALL BE DETERMINED BY THE ALIGNMENT INCLUDING TERRAIN, SLOPES, DRAINAGE, RETAINING WALLS, EROSION CONTROL, AND ACCESS ARE REQUIRED.
 3. POTENTIAL SOUND BARRIERS NOT SHOWN IN THIS SECTION. SOUND BARRIERS, SEE ALIGNMENT PLAN AND PROFILE SHEETS.

DATE	BY	CHK	APP	DESCRIPTION	APPROVED BY G. VALADAO A. BOONE A. BOONE 07/20/2011	RECORD SET 185 DRAWING SUBMITTAL NOT FOR CONSTRUCTION	AECOM 2555 L Street, Suite 200 CH2M HILL	CALIFORNIA HIGH-SPEED RAIL AUTHORITY	CALIFORNIA HIGH-SPEED TRAIN PROJECT MERCED TO FRESNO TYPICAL SECTIONS SHEET 5 OF 17	CONTRACT NO. HS-R06-007 DRAWING NO. T-3005-A SCALE NO SCALE SHEET NO. OF ###
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REV	DATE	BY	SCALE	APP	DESCRIPTION
0003	10/0/03				35% DESIGN SUBMITTAL
0004					25% DESIGN SUBMITTAL

DESIGNED BY	DATE	SCALE	APP	DESCRIPTION
CHECKED BY	DATE	SCALE	APP	DESCRIPTION
IN CHARGE	DATE	SCALE	APP	DESCRIPTION

 NATIONAL RAILROAD PASSENGER CORPORATION	 STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	CONTRACT NO.
		DRAWING NO. HC-1
 HDR Engineering, Inc.	PROJECT NO.	SCALE N/A
LOS ANGELES UNION STATION RUN-THROUGH TRACKS	HORIZONTAL CURVE GEOMETRY	SHEET NO. 10

ATTACHMENTS 6, 7, & 8 TO BE APPLIED SIMULTANEOUSLY WHERE TRAINS TRAVEL AT 220MPH

HORIZONTAL SPIRAL DESIGN

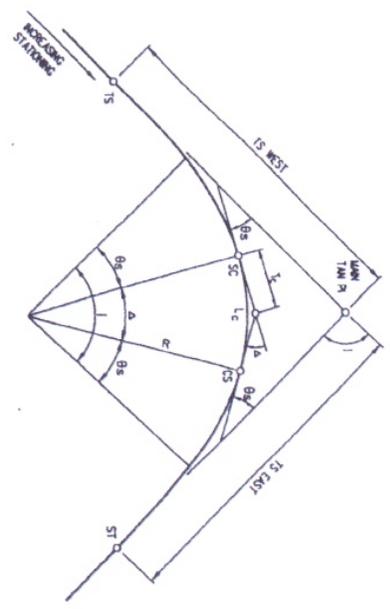


FIGURE A
CIRCULAR CURVES
WITH SPIRAL TRANSITION

- I - TOTAL INTERSECTION ANGLE
- Bs - SPIRAL ANGLE = $\frac{L_s \cdot D_c}{200}$
- A - CENTRAL ANGLE OF CIRCULAR CURVE - 1-2 BS
- R - RADIUS OF CIRCULAR CURVE
- T - TANGENT LENGTH OF CIRCULAR CURVE = $R \cdot \tan \frac{A}{2}$
- Lc - LENGTH OF CIRCULAR CURVE = $\frac{\pi}{180} R A$
- TS - TANGENT TO SPIRAL
- SC - SPIRAL TO CURVE
- CS - CURVE TO SPIRAL
- ST - SPIRAL TO TANGENT
- MAIN TAN P - POINT OF INTERSECTION OF MAIN TANGENTS (TS WEST) - TANGENT LENGTH OF COMPLETE CURVE (TS EAST)

Ds, Bc, Δ and L are in degrees. All other dimensions are in feet. If conditions permit the degree of curve chosen should be an even number. Degree and feet should be rounded up and feet rounded up to the next whole number.

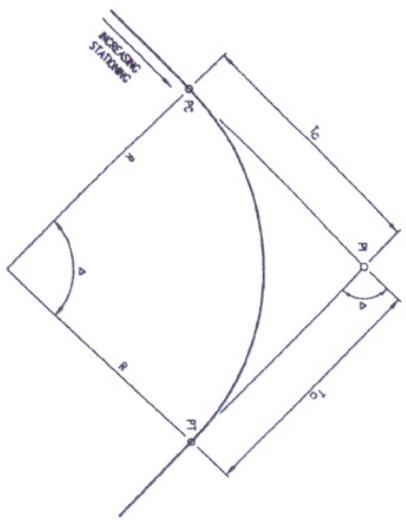


FIGURE B
SIMPLE CIRCULAR CURVE

Circle curves are defined by the arc direction of the curve and specified by their degree.

- A - CENTRAL ANGLE OF CIRCULAR CURVE
- R - RADIUS OF CIRCULAR CURVE
- TC - $R \cdot \tan \frac{A}{2}$
- Lc = $\frac{\pi}{180} R A$
- Dc = $\frac{5729.58}{R}$
- TC - TANGENT TO SIMPLE CURVE
- CC - COMPOUND CURVE TO CURVE
- CI - SIMPLE CURVE TO TANGENT

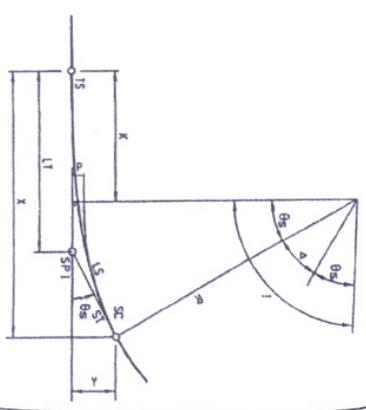
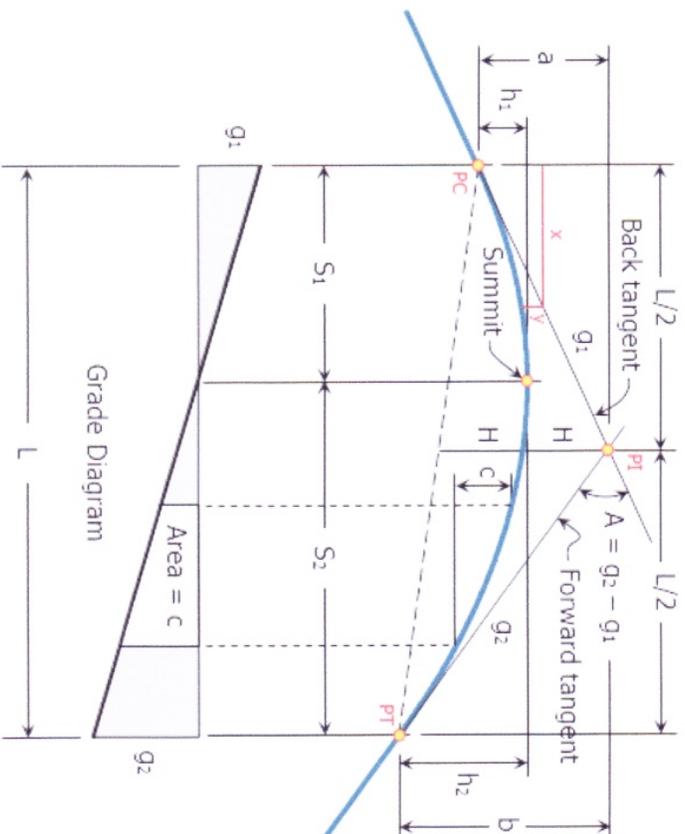


FIGURE C
SPIRAL TRANSITION CURVE

To be used in new construction, reconstruction, and whenever alignment is surveyed in the field. The length of the spiral curve should be determined by the engineer (optional) or by the contractor. The latter calculation should be used if it is used. Refer to 612.02.

- Ls = LENGTH OF SPIRAL (TS TO SC)
- Bs = $\frac{L_s \cdot D_c}{200}$
- ST = $\frac{L_s^2}{240}$
- Lt = $X - \tan \frac{A}{2}$

ATTACHMENT 6



ATTACHMENT 7
VERTICAL CURVE
DESIGN

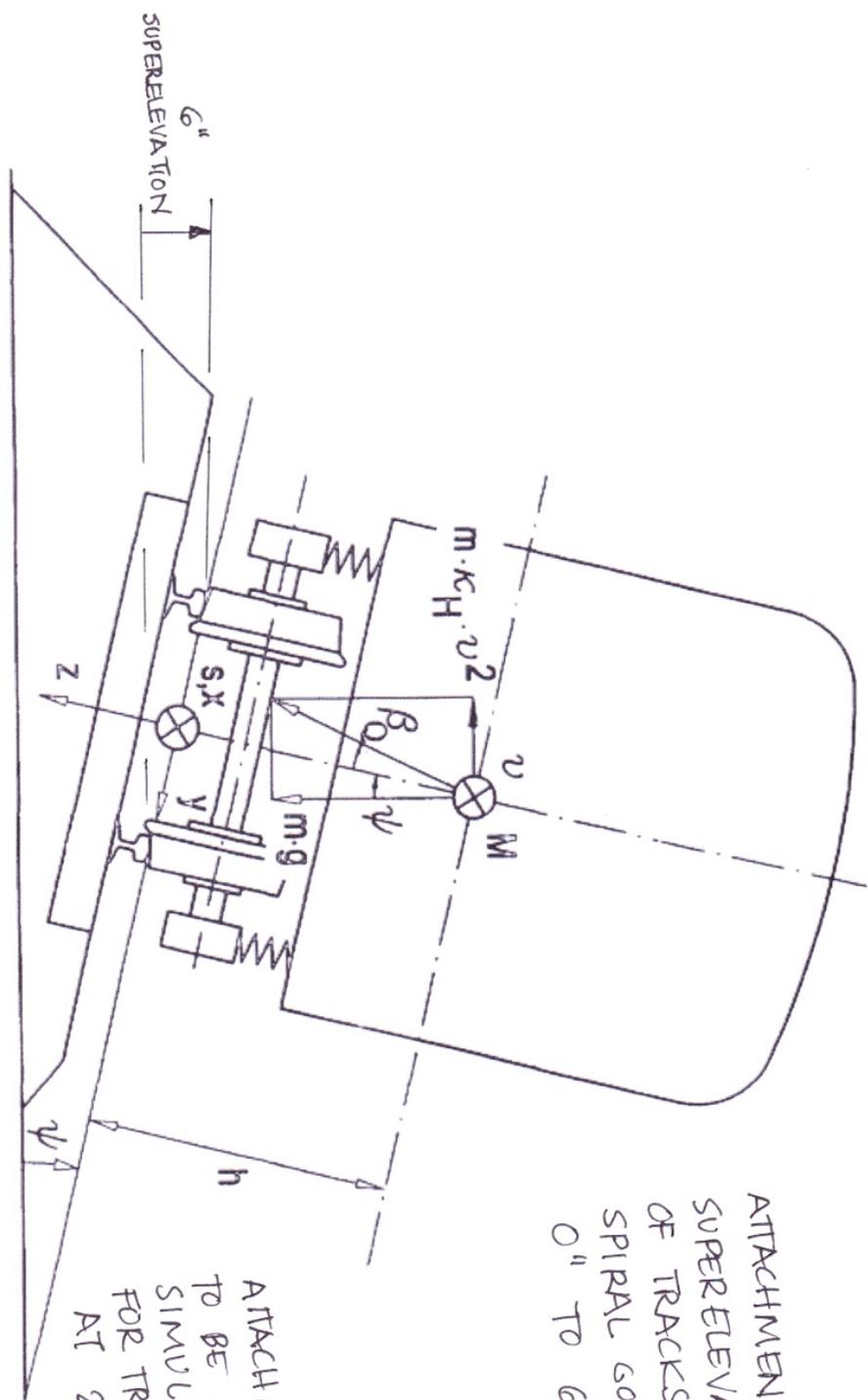
ATTACHMENTS 6, 7, & 8
TO BE APPLIED SIMULTANEOUSLY,
VERTICAL CURVE IS
COMBINED WITH
HORIZONTAL SPIRAL
WHILE TRACKS ARE
SUPERELEVATED FROM
0" TO 6"
WHERE TRAINS TRAVEL
AT 220 mph

Properties of Parabolic Curve and its Grade Diagram

1. The length of parabolic curve L is the horizontal distance between PI and PT .
2. PI is midway between PC and PT .
3. The curve is midway between PI and the midpoint of the chord from PC to PT .
4. The vertical distance between any two points on the curve is equal to area under the grade diagram. The vertical distance $c = \text{Area}$.
5. The grade of the curve at a specific point is equal to the offset distance in the grade diagram under that point. The grade at point Q is equal to g_Q .

Formulas for Symmetrical Parabolic Curve

The figure shown above illustrates the following geometric properties of parabolic curve. Note that the principles and formulas can be applied to both summit and sag curves.



ATTACHMENT 8
 SUPERELEVATION
 OF TRACKS THRU
 SPIRAL GOES FROM
 0" TO 6" MAX

ATTACHMENTS 6, 7, & 8
 TO BE APPLIED
 SIMULTANEOUSLY
 FOR TRAINS TRAVELING
 AT 220 mph.

$$\kappa_H(s) = \frac{\kappa_C}{\psi_c} \cdot \psi(s) - h \cdot \frac{d^2\psi}{ds^2} \quad (1)$$

SIX CHANGES IN ONE HALF MILE:

- ① SUPERELEVATION: 0" TO 6" VARIES
 - ② BVC: Begin vertical curve
 - ③ EVC: End vertical curve
 - ④ ST: SPIRAL TO TANGENT
 - ⑤ CS: Curve to Spiral
 - ⑥ MAXIMUM VERTICAL GRADE
- Curve radius 28,000'

3.0 ASSESSMENT/ANALYSIS

3.1 ALIGNMENT CRITERIA

The alignment of the railroad shall be as smooth as practical with minimal changes in both the horizontal and vertical direction. Appearance, ease of maintenance, and ride quality are all enhanced by a smooth alignment with infrequent and gentle changes in direction. Over four changes in direction per mile shall constitute an Exceptional condition.

All alignment element segments (vertical curves, lengths of grade between vertical curves, horizontal curves, spirals) shall have a minimum length sufficient to attenuate changes in the motion of the rolling stock. This length is defined by the time elapsed over the segment, and therefore varies directly with design speed. Not all systems have the same time requirements. This attenuation time varies from 1.0 to 2.4 seconds, and on the SNCF, up to 3.1 seconds at higher speeds. Segment length requirements will govern only where design considerations for the various elements do not require longer segment lengths.

Vertical and horizontal alignment sections may overlap. Overlap of horizontal spirals and vertical curves shall be an Exceptional condition. Based on European high-speed rail standards, the Minimum distance between the end of a spiral and the beginning of a vertical curve or the end of a vertical curve and the beginning of a spiral is 50 meters (160 feet) with an Exceptional limit of 30 meters (100 feet).

3.1.1 Minimum Segment Length due to Attenuation Time

Attenuation time, based on the most conservative requirements, shall be:

- For $V < 300$ km/h (Under 186 mph)
 - Desirable attenuation time: not less than 2.4 seconds
 - Minimum attenuation time: not less than 1.8 seconds
 - Exceptional attenuation time: not less than 1.5 seconds
 - An attenuation time of 1.0 seconds on the diverging route in curves adjacent to or between turnouts
- For $300 \text{ km/h} \leq V$ (Over 186 mph)
 - Desirable attenuation time: not less than 3.1 seconds
 - Minimum attenuation time: not less than 2.4 seconds
 - Exceptional attenuation time: not less than 1.8 seconds

Minimum segment length is calculated by the formula: $L_{\text{feet}} = V_{\text{mph}} \times 44/30 \times t_{\text{sec}}$ and $L_{\text{m}} = V_{\text{km/h}} / 3.6 \times t_{\text{sec}}$. Sample minimum segment lengths are presented in Tables 3.1.1 and 3.1.2.

Table 3.1.1: Minimum Segment Lengths at Various Speeds of 300 km/h (186 mph) and higher

Design Speed		Minimum Segment Lengths for times of							
		3.1 seconds		2.4 seconds		1.8 seconds		1.5 seconds	
miles per hour	km/h	feet	meters	feet	meters	feet	meters	feet	meters
250	400	1137	346	880	268	660	201	550	168
220	355	1000	305	774	236	581	177	484	148
200	320	909	277	704	215	528	161	440	134
186	300	846	258	655	200	491	150	409	125
175	280	796	243	616	188	462	141	385	117
150	240	682	208	528	161	396	121	330	101

4.0 SUMMARY AND RECOMENDATIONS

The primary objective in setting alignment is to develop the smoothest practical alignment within the limitations imposed by location of stations, urban areas, mountain crossings and major stream crossings as well as environmental and political constraints. It is also important to consider the optimization of earthworks movement, tunnel length, drainage and structures. The radii of horizontal curves, in particular, should be larger than "Desirable" values wherever it is practical to do so. Going below "Desirable" values for the various portions of the alignment should not be treated lightly. Very seldom will an alignment as finally designed and built be better than that set out initially. Quite frequently points will be "locked in" very early in the study process. This is particularly true for the horizontal component of alignment.

Use of Minimum and Exceptional values should be held back to the greatest extent practical for use in the adjustments due to unanticipated constraints that will always occur.

It is very easy to get into a "can't see the forest for the trees" situation. At frequent intervals the designer should step back and look at things globally. This, in particular, means plotting condensed profiles, and looking at the layout over long segments. When transitioning from low speed areas to high-speed areas, consider the operating characteristics of both presently available trains and characteristics of trains with anticipated improvements in power, acceleration and braking. Sudden jumps in speed do not happen with trains.

There should be a relationship between horizontal and vertical alignment standards. For example, there is no point in using vertical curves designed for 250 mph which are adjacent to curves or other constraining elements that permanently restrict speeds to a much lower value. However, the speed used in developing vertical curves should never be lower than that possible under "Exceptional" conditions on adjacent horizontal curves.

It is not possible for this document to anticipate all eventualities, nor to be a textbook in alignment design practices, nor is it intended to be used as a substitute for good engineering judgment.

Table 3.3.2-2: Minimum Vertical Curves – Rates of Change and Equivalent Radii (0.90 ft/s² = 2.80% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.045%	2150	215,000	66,000
250	400	0.065%	1500	150,000	46,000
220	355	0.085%	1160	116,000	36,000
200	320	0.100%	960	96,000	30,000
175	280	0.130%	740	74,000	22,500
150	240	0.180%	540	54,000	16,500
125	200	0.260%	375	37,500	11,500

Table 3.3.2-3: Exceptional Vertical Curves – Rates of Change and Equivalent Radii (1.4 ft/s² = 4.35% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.070%	1400	140,000	43,000
250	400	0.100%	970	97,000	30,000
220	355	0.130%	750	75,000	23,000
200	320	0.150%	620	62,000	19,000
175	280	0.200%	480	48,000	15,000
150	240	0.250%	350	35,000	11,000
125	200	0.400%	250	25,000	7,500

The lengths developed in the preceding tables and formulae are the shortest allowed lengths for each scenario. Vertical curve lengths shall always be rounded up, usually to an even 100 feet multiple. Rate of change and other parameters shall then be derived from that length.

Where the difference between gradients is small, the minimum segment length requirements described in Section 3.1.1 shall determine the minimum length of vertical curve. Rate of change, radius and other parameters of the vertical curve shall then be derived from the length.

3.3.3 Vertical Curve / Horizontal Curve Combinations

Vertical and horizontal curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced is sufficient to allow for this effect.

3.3.4 Other Vertical Curve Restrictions

It is neither practical nor possible to provide a set of rules that cover all situations. It is anticipated that the information in this document will be applied with good engineering judgment.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.

NO OTHER PRACTICAL ALTERNATIVES SUBMITTED IN DEIR OR FEIR EXCEPT
FOR UPRR ALIGNMENT.

6.1.7 Horizontal Curves in Vertical Curves

Unbalanced Superelevation Limits: Horizontal and vertical curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced superelevation is sufficient to allow for this effect.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.

Table 1-3: Weather Conditions by Segment

ATTACHMENT II
 TEMPERATURE EXTREMES
 FRESNO

	Record Extreme Maximum Temperature (°F)	Record Extreme Minimum Temperature (°F)	Mean Number of Days with Freezing Temperatures	Mean Maximum Daily Precipitation (Inches)	Annual Record Total Snowfall (Inches)	Mean Maximum Daily Snowfall (Inches)	Annual Fastest Mile of Wind (mph)	Annual Mean Occurrence of Gust >50 mph	Annual Mean Number of Days with Heavy Fog
San Francisco – San Jose	106–110°	11–20°	0.5–30.4	2.01–2.50"	2.1–6.0"	0.1–3.0"	41–45	2.5–3.4	15.5–20.4
San Jose – Merced	111–115°	11–20°	30.5–60.4	2.01–2.50"	6.1–12.0"	3.1–6.0"	41–45	0.5–1.4	25.5–30.4
Merced – Fresno	116–120°	11–20°	30.5–60.4	1.00–1.50"	2.1–6.0"	0.1–3.0"	41–45	0.5–1.4	30.5–35.4
Fresno – Bakersfield	111–115°	11–20°	30.5–60.4	1.00–1.50"	0.1–2.0"	0.1–3.0"	41–45	0.5–1.4	30.5–35.4
Bakersfield – Palmdale	111–115°	-9–0°	90.5–120.4	1.51–2.00"	48.1–72.0"	12.1–15.0"	41–45	0.5–1.4	20.5–25.4
Palmdale – Los Angeles	111–115°	1–10°	30.5–60.4	3.01–3.50"	12.1–24.0"	6.1–9.0"	41–45	0.5–1.4	15.5–20.4
Los Angeles – Anaheim	111–115°	21–32°	0.5–30.4	2.01–2.50"	0.0"	0.0"	41–45	0.5–1.4	20.5–25.4
Los Angeles – San Diego	111–115°	11–20°	30.5–60.4	2.51–3.00"	0.1–2.0"	0.1–3.0"	41–45	0.5–1.4	30.5–35.4
Sacramento – Merced	111–115°	11–20°	30.5–60.4	1.51–2.00"	0.1–2.0"	0.1–3.0"	41–45	1.5–2.4	30.5–35.4
Altamont	111–115°	11–20°	30.5–60.4	1.51–2.00"	0.1–2.0"	0.1–3.0"	41–45	1.5–2.4	25.5–30.4

This data is included as general information and not for use in application of these design criteria.

Source: National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA), Climate Atlas of the United States: Data Documentation, April 2010. <http://www.ncdc.noaa.gov/about/odm/climate/maps2/dataloc.html>

Weather Condition Definitions:

- Record Extreme Maximum Temperature – Highest temperature recorded in the segment
- Record Extreme Minimum Temperature – Lowest temperature recorded in the segment
- Mean Number of Days with Freezing Temperatures – Number of days per year on average that temperatures in the segment are below 32°F (maximum value for the segment)
- Mean Maximum Daily Precipitation – Maximum precipitation in one day during an average year (maximum value for the segment)
- Annual Record Total Snowfall – Maximum amount of snowfall recorded over one year in the segment (maximum value for the segment)
- Mean Maximum Daily Snowfall – Maximum snowfall in one day during an average year (maximum value for the segment)
- Annual Fastest Mile of Wind – Average speed obtained during the passage of one mile of wind (maximum value for the segment)
- Annual Mean Occurrence of a Gust > 50 mph – Frequency of gusts of over 50 mph in 1 year during an average year (maximum value for the segment)
- Annual Mean Number of Days with Heavy Fog – Frequency of days with fog resulting in visibility of less than 0.25 miles in an average year (maximum value for the segment)

Notes:

- Data is provided in ranges consistent with the source data. Specific values will fall within the range provided by more discrete information is not provided.
- Numbers in bold represent system-wide extreme (maximum/minimum)
- NCDC archives weather data from the National Weather Service, Military Services, Federal Aviation Administration, the Coast Guard, and volunteer observers. NCDC has a database of U.S. climate data and maps that portray the climate of the U.S. by such elements as temperature, precipitation, snow, wind, and pressure. The period of record for most of this data is 1961 to 1990. National Climatic Data Center, National Oceanic and Atmospheric Administration. Climate Maps of the United States. <http://cdo.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl>

inside lane and the midpoint of the sight line is from 0.5 to 1.5 m [1.5 to 4.5 ft] greater than that for stopping sight distance. It is obvious that for many cut sections, design for passing sight distance should, for practical reasons, be limited to tangents and very flat curves. Even in level terrain, provision of passing sight distance would need a clear area inside each curve that would, in some instances, extend beyond the normal right-of-way line.

In general, the designer should use graphical methods to check sight distance on horizontal curves. This method is presented in Exhibit 3-8 and described in the accompanying discussion.

General Controls for Horizontal Alignment

In addition to the specific design elements for horizontal alignment discussed under previous headings, a number of general controls are recognized in practice. These controls are not subject to theoretical derivation, but they are important for efficient and smooth-flowing highways. Excessive curvature or poor combinations of curvature limit capacity, cause economic losses because of increased travel time and operating costs, and detract from a pleasing appearance. To avoid such poor design practices, the general controls that follow should be used where practical:

- Alignment should be as directional as practical, but should be consistent with the topography and with preserving developed properties and community values. A flowing line that conforms generally to the natural contours is preferable to one with long tangents that slashes through the terrain. With curvilinear alignment, construction scars can be kept to a minimum and natural slopes and growth can be preserved. Such design is desirable from a construction and maintenance standpoint. In general, the number of short curves should be kept to a minimum. Winding alignment composed of short curves should be avoided because it usually leads to erratic operation. Although the aesthetic qualities of curving alignment are important, long tangents are needed on two-lane highways so that sufficient passing sight distance is available on as great a percentage of the highway length as practical.
- In alignment developed for a given design speed, the minimum radius of curvature for that speed should be avoided wherever practical. The designer should attempt to use generally flat curves, saving the minimum radius for the most critical conditions. In general, the central angle of each curve should be as small as the physical conditions permit, so that the highway will be as directional as practical. This central angle should be absorbed in the longest practical curve, but on two-lane highways the exception noted in the preceding paragraph applies.
- Consistent alignment should always be sought. Sharp curves should not be introduced at the ends of long tangents. Sudden changes from areas of flat curvature to areas of sharp curvature should be avoided. Where sharp curvature is introduced, it should be approached, where practical, by a series of successively sharper curves.
- For small deflection angles, curves should be sufficiently long to avoid the appearance of a kink. Curves should be at least 150 m [500 ft] long for a central angle of 5 degrees, and the minimum length should be increased 30 m [100 ft] for each 1-degree decrease in the central angle. The minimum length for horizontal curves on main highways, $L_{c\text{-min}}$, should be about three times the design speed expressed in km/h [15 times the

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radius of curvature and minimum sight distance for that design speed, Figure 201.6 gives the clear distance (m) from centerline of inside lane to the obstruction.

See Index 1003.1(12) for bikeway stopping sight distance on horizontal curve guidance.

When the radius of curvature and the clear distance to a fixed obstruction are known, Figure 201.6 also gives the sight distance for these conditions.

See Index 101.1 for technical reductions in design speed caused by partial or momentary horizontal sight distance restrictions. See Index 203.2 for additional comments on glare screens.

Cuts may be widened where vegetation restricting horizontal sight distance is expected to grow on finished slopes. Widening is an economic trade-off that must be evaluated along with other options. See Index 902.2 for sight distance requirements on landscape projects.

201.7 Decision Sight Distance

At certain locations, sight distance greater than stopping sight distance is desirable to allow drivers time for decisions without making last minute erratic maneuvers (see Chapter III of AASHTO, A Policy on Geometric Design of Highways and Streets, for a thorough discussion of the derivation of decision sight distance.)

On freeways and expressways the decision sight distance values in Table 201.7 should be used at lane drops and at off-ramp noses to interchanges, branch connections, roadside rests, vista points, and inspection stations. When determining decision sight distance on horizontal and vertical curves, Figures 201.4, 201.5, and 201.6 can be used. Figure 201.7 is an expanded version of Figure 201.4 and gives the relationship among length of crest vertical curve, design speed, and algebraic difference in grades for much longer vertical curves than Figure 201.4.

Decision sight distance is measured using the 3 1/2-foot eye height and 1/2-foot object height. See Index 504.2 for sight distance at secondary exits on a collector-distributor road.

Table 201.7
Decision Sight Distance

Design Speed (mph)	Decision Sight Distance (ft)
30	450
35	525
40	600
45	675
50	750
55	865
60	990
65	1,050
70	1,105
75	1,180
80	1,260

Topic 202 - Superelevation

202.1 Basic Criteria

When a vehicle moves in a circular path, it undergoes a centripetal acceleration that acts toward the center of curvature. This force is countered by the perceived centrifugal force experienced by the motorist.

On a superelevated highway, this force is resisted by the vehicle weight component parallel to the superelevated surface and by the side friction developed between the tires and pavement. It is impractical to balance centrifugal force by superelevation alone, because for any given curve radius a certain superelevation rate is exactly correct for only one driving speed. At all other speeds there will be a side thrust either outward or inward, relative to the curve center, which must be offset by side friction.

If the vehicle is not skidding, these forces are in equilibrium as represented by the following simplified curve equation, which is used to design a curve for a comfortable operation at a particular speed:

wide. See Chapter 7 of the Traffic Manual for glare screen criteria.

203.3 Alignment Consistency

Sudden reductions in alignment standards should be avoided. Where physical restrictions on curve radius cannot be overcome and it becomes necessary to introduce curvature of lower standard than the design speed for the project, the design speed between successive curves should change not more than 10 miles per hour. Introduction of curves with lower design speeds should be avoided at the end of long tangents, steep downgrades, or at other locations where high approach speeds may be anticipated.

The horizontal and vertical alignments should be coordinated such that horizontal curves are not hidden behind crest vertical curves. Sharp horizontal curves should not follow long tangents because some drivers tend to develop higher speeds on the tangent and could over drive the curve.

See "Combination of Horizontal and Vertical Alignment" in Chapter 3 of AASHTO, A Policy on Geometric Design of Highways and Streets, for further guidance on alignment consistency.

203.4 Curve Length and Central Angle

The minimum curve length for central angles less than 10 degrees should be 800 feet to avoid the appearance of a kink. For central angles larger than 30 minutes, a curve is required without exception. Above a 20,000-foot radius, a parabolic curve may be used. Sight distance or other safety considerations are not to be sacrificed to meet the above requirements.

On 2-lane roads a curve should not exceed a length of one-half mile and should be no shorter than 500 feet.

203.5 Compound Curves

Compound curves should be avoided because drivers who have adjusted to the first curve could over drive the second curve if the second curve has a smaller radius than the first. Exceptions can occur in mountainous terrain or other situations where use of a simple curve would result in excessive cost. Where compound curves are necessary, the shorter radius should be at least two-thirds the longer radius when the shorter radius is 1,000 feet or less. On one-way

roads, the larger radius should follow the smaller radius.

The total arc length of a compound curve should be not less than 500 feet.

203.6 Reversing Curves

When horizontal curves reverse direction the connecting tangents should be long enough to accommodate the standard superelevation runoffs given on Figure 202.5. If this is not possible, the 6 percent per 100 feet rate of change should govern (see Index 202.5(3)). When feasible, a minimum of 400 feet of tangent should be considered.

203.7 Broken Back Curves

A broken back curve consists of two curves in the same direction joined by a short tangent. Broken back curves are unsightly and undesirable.

203.8 Spiral Transition

Spiral transitions are used to transition from a tangent alignment to a circular curve and between circular curves of unequal radius. Spiral transitions may be used whenever the traffic lane width is less than 12 feet, the posted speed is greater than 45 miles per hour, and the superelevation rate exceeds 8 percent. The length of spiral should be the same as the Superelevation Runoff Length shown in Figure 202.5A. In the typical design, full superelevation occurs where the spiral curve meets the circular curve, with crown runoff being handled per Figure 202.5A. For a general discussion of spiral transitions see AASHTO *A Policy on the Geometric Design of Streets and Highways*. When used, spirals transitions should conform to the Clothoid definition.

203.9 Alignment at Bridges

Due to the difficulty in constructing bridges with superelevation rates greater than 10 percent, the curve radii on bridges should be designed to accommodate superelevation rates of 10 percent or less. See Index 202.2 for standard superelevation rates.

Superelevation transitions on bridges are difficult to construct and almost always result in an unsightly appearance of the bridge and the bridge railing. Therefore, if possible, horizontal curves should begin and end a sufficient distance from the bridge so that no part of the superelevation transition extends onto the bridge.

Cornell Law School

ADDITIONAL ATTACHMENT
STOP WORK ORDER

CFR › Title 48 › Chapter 1 › Subchapter G › Part 42 › Subpart 42.13 › Section 42.1303

48 CFR 42.1303 - Stop-work orders.

42.1303 Stop-work orders.

(a) Stop-work orders may be used, when appropriate, in any negotiated fixed-price or cost-reimbursement supply, research and development, or service contract if work stoppage may be required for reasons such as advancement in the state-of-the-art, production or engineering breakthroughs, or realignment of programs.

(b) Generally, a stop-work order will be issued only if it is advisable to suspend work pending a decision by the Government and a supplemental agreement providing for the suspension is not feasible. Issuance of a stop-work order shall be approved at a level higher than the contracting officer. Stop-work orders shall not be used in place of a termination notice after a decision to terminate has been made.

(c) Stop-work orders should include -

- (1) A description of the work to be suspended;
- (2) Instructions concerning the contractor's issuance of further orders for materials or services;
- (3) Guidance to the contractor on action to be taken on any subcontracts; and
- (4) Other suggestions to the contractor for minimizing costs.

(d) Promptly after issuing the stop-work order, the contracting officer should discuss the stop-work order with the contractor and modify the order, if necessary, in light of the discussion.

(e) As soon as feasible after a stop-work order is issued, but before its expiration, the contracting officer shall take appropriate action to -

- (1) Terminate the contract;
- (2) Cancel the stop-work order (any cancellation of a stop-work order shall be subject to the same approvals as were required for its issuance); or
- (3) Extend the period of the stop-work order if it is necessary and if the contractor agrees (any extension of the stop-work order shall be by a supplemental agreement).

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THE PHYSICS OF HIGH-SPEED TRAINS

By Patrick Di Justo July 25, 2013

On Wednesday evening, a train travelling from Madrid to Ferrol, in northwestern Spain, derailed just as it was about to enter the Santiago de Compostela station. At least seventy-eight people were killed, and dozens were injured. Video of the accident shows the train entering the curve at what seems to be a high speed; the passenger cars detach from the engine and derail, while the engine stays on the tracks for a few more seconds before it, too, leaves the rails and hits a wall. Unofficial reports claim that the train was going as fast as a hundred and twenty miles per hour on track rated for only fifty m.p.h.

Unlike Japan's Shinkansen or France's T.G.V., which run on dedicated tracks, the Madrid-Ferrol route is a hybrid line, much like Amtrak's Acela Express. Only part of the track is configured for high-speed travel; the rest is shared with slower trains, and can handle only their more restricted speeds.

High-speed rail is a catchall term with several definitions. The Federal Railroad Administration says it starts at a hundred and ten m.p.h., while the International Union of Railways says a hundred and fifty-five. But whichever definition one favors, the rails themselves must be carefully designed to handle the physical forces imposed upon them by multi-ton trains moving at high velocity.

One of those forces is centrifugal (“to flee from the center”) force, the inertia that makes a body on a curved path want to continue outward in a straight line. It’s what keeps passengers in their seats on a looping roller coaster and throws unsecured kids off carousels. Centrifugal force is a function of the square of the train’s velocity divided by the radius of the curve; the smaller and tighter the curve, or the faster the train, the greater the centrifugal force. As it increases, more and more of the weight of the train is transferred to the wheels on the outermost edge of the track, something even the best-built trains have trouble coping with. That’s where the concepts of minimum curve radius and super-elevation, or banking, come in.

Banked curves, in which the outer edge of the track is higher than the inner edge, balance the load on the train’s suspension. Since gravity pulls a train downward and centrifugal force pulls it outward, a track banked at just the right angle can spread the forces more evenly between a train’s inner and outer wheels, and help to keep it on the track.

But banking the tracks isn’t a cure-all—a passenger train can tilt only so far before people fall out of their seats. So the minimum curve radius comes into play. Imagine that a curved portion of track is actually running along the outer edge of a large circle. How big must that circle be to insure that a train’s centrifugal force can be managed with only a reasonable amount of banking?

It’s relatively easy to calculate these forces and the ways to counteract them, so it’s relatively easy to set a safe maximum speed for a certain kind of track. Yes, badly maintained tracks, trains, or signals can sometimes contribute to a derailment. Historically, however, many of the world’s worst train accidents on sharp curves—the 1918 Malbone Street wreck in the New York City subway system, which killed at least ninety-three people (figures vary), or the Metro

derailment in Valencia, Spain, in 2006, which killed forty-three—were simply caused by the trains going too fast.

That seems to be the case in the Santiago de Compostela accident: tracks rated for fifty miles per hour need almost no banking and can have a curve radius of fifteen hundred feet, while a train traveling at a hundred and twenty miles per hour needs a track with significant banking, and a minimum curve radius of more than a mile and a half. The laws of physics all but insured that in this particular battle between gravity and centrifugal force, the latter would win.

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