5.0 AASHTO Controlling Design Criteria

5.1 Introduction

This section describes the non-conforming AASHTO controlling design elements of the existing highway and the existing service interchanges which will not be upgraded as part of the project, and non-conforming elements of the recommended alternative, for which design exceptions will be requested.

A complete analysis of all AASHTO controlling design elements for the existing facility is available in the *Initial AASHTO Controlling Design Criteria Report* (March 2010). Appendix A contains the I-40 mainline evaluation from that report, including horizontal and vertical data summaries and bridge evaluation forms.

ADOT's *Design Exceptions and Design Variances Process Guide* (December 2009) indicates that for major reconstruction, all design elements shall conform to the requirements of ADOT's RDG. In addition, it indicates RDG design values are equal to or more conservative than the design values specified by AASHTO in their *A Policy on Geometric Design of Highways and Streets*. Therefore, this evaluation will use the design values specified by ADOT as the basis for whether or not a design exception will be required.

A design exception request letter will be prepared with the Final DCR.

5.2 Evaluation of Controlling Design Criteria

Each of the AASHTO controlling design criteria elements are described below for the mainline and the existing traffic interchanges.

5.2.1 Lane Width

Proposed lane widths (12') along the mainline of the eastbound and westbound roadway in the study area meet design criteria requirements.

5.2.2 Shoulder Width

The existing inside and outside shoulder widths meet the recommended minimum of 4' and 10', respectively, along the mainline eastbound and westbound roadways. The following locations at existing traffic interchanges do not meet the recommended minimum widths:

Cosnino TI (MP 207.24): Cross road existing shoulder width is 2' less than the recommended 4' (Sta. 0+77.05 to Sta. 33+46.29)

Because the structure is to remain in place, a design exception will be requested for shoulder width.

5.2.3 Vertical Alignment/Stopping Sight Distance

Several vertical curves within the project limits have less vertical stopping sight distance than required. Each location within the three-lane section will be realigned to meet design criteria. A design exception will be requested for vertical alignment and stopping sight distance for one location within the eastern segment of westbound I-40 which is not recommended for widening to a three-lane section. The location is listed below:

I-40 westbound - Beginning at MP 209.45 (VPI 665+25.00) the vertical curve stopping sight distance is 62 feet less than the recommended 814 feet.

5.2.4 Horizontal Alignment, Superelevation, and Stopping Sight Distance

Seventeen of the twenty-five eastbound horizontal curves and ten of the twenty one westbound curves within the project limits have existing horizontal superelevation that is less than current design criteria. These locations will be upgraded to meet current design criteria as part of this project.

5.2.5 Design Speed

I-40's functional and terrain classifications, as well as posted speed, were used to determine the appropriate design speed. Design speeds were 65 mph (urban/fringe urban) and 75 mph (rural/rolling terrain).

5.2.6 Maximum Grade

Maximum grade design exceptions are described in two sections. The first section is in rural rolling terrain from MP 183.0 to MP 193.0 and from MP 203.0 to MP 214.0. The second section is in urban/fringe urban rolling terrain between MP 193.0 and MP 203.0.

MP 183.0- MP 193.0

The recommended alternative reconstructs the mainline profiles with a maximum grade of 4.0% where feasible. The westbound roadway will be re-profiled to a maximum grade of 4.0% where a 4.75% grade currently exists.

MP 193.0 to MP 203.0

In urban/fringe urban areas, the RDG allows a maximum grade of 3.0%. The proposed gradient is greater than the 3.0% maximum at the following locations:

I-40 eastbound, MP 194.27 to MP 194.93 – 2.02% greater than the maximum

I-40 westbound, MP 194.27 to MP 194.98 – 1.64% greater than the maximum

Justification for maintaining the existing grades includes the following:

- The existing grades are limited to a maximum of 5.02% and they occur for less than 2000 feet of alignment length.
- The terrain classification governing maximum grade changes from 4.0% to 3.0% two miles west of these grades.
- The adjacent land surrounding this segment of the interstate is heavily developed. Changes to the freeway elevation would likely require retaining walls. Noise levels on the adjacent properties may be affected.
- The traffic operations of the system interchange with I-17 would be affected due to the close proximity to these locations and the major reconstruction effort and extensive rock excavation of more than 60 feet in depth for the length of a re-profiling effort.
- The proposed roadway will have one additional lane in the eastbound direction and one additional lane in the westbound direction, including extended parallel ramp entrances from the system interchange in the westbound direction. The additional lanes will help separate slower-moving uphill traffic from faster traffic.
- Maintenance of traffic during construction may be problematic with vertical realignments.
- Construction duration would be increased due to substantial earthwork requirements.

MP 203.0- MP 214.0

The proposed gradient will be greater than the 4% maximum in the following location:

- I-40 WB MP 209.45 to MP 209.74 – 0.45% greater than the maximum

5.2.7 Cross Slope

The existing cross slopes of 1.5% to 2.0% conform to AASHTO's current design criteria. The proposed cross slopes will be 2.0%, as required by the RDG.

5.2.8 Vertical Clearance

ADOT bridge design guidelines call for a minimum vertical clearance of 16'-6" for structures that cross all highway types. AASHTO guidelines allow some local roads to have a vertical clearance of 14'-6". Both clearances include a 6" provision for future overlay improvements.

A minimum clearance of 16'-6" will be provided for all locations on the mainline. For all TI OP structures except the Flagstaff Ranch TI OP, a minimum clearance of 16'-6" will be provided on the cross road. A design exception will be requested.

5.2.9 Bridge Width

Each existing bridge to remain meets required design criteria. All new bridges will meet required design criteria.

5.2.10 Bridge Structural Capacity

Each existing bridge to remain meets required design criteria. All new bridges will meet required design criteria.

5.2.11 Bridge Barrier

The existing bridge rail geometry will be upgraded as required (A-1 Mountain TI) to meet required design criteria.

5.2.12 Horizontal Clearance to Obstructions

Mainline, ramp and cross road roadways meet required design criteria for horizontal clearance to obstructions.

5.3 Design Variances

Similar to design exceptions, ADOT's *Design Exceptions and Design Variances Process Guide* (September 2008) indicates that for major reconstruction, design variances are required for utilization of design values for major reconstruction that do not meet the design values prescribed in the RDG.

Reconstructed roadways will be designed to meet ADOT RDG design values with the following exceptions. Several existing features to remain are identified as having design values that do not conform to ADOT RDG design values. Design variances will be requested for these features.

Minimum Highway Grade Above 4000 Feet

Several segments in the project have an existing vertical grade of less than 0.50%. ADOT RDG specifies that grades above 4000 feet be 0.50% or higher. The vertical alignment for the recommended alternative follows the existing profile and maintains several segments with grades less than 0.50%:

I-40 EB MP 185.46 to MP 185.75 – 0.16% less than the minimum
I-40 EB MP 186.32 to MP 186.41 – 0.08% less than the minimum
I-40 EB MP 187.74 to MP 188.21 – 0.50% less than the minimum
I-40 EB MP 189.26 to MP 189.35 – 0.30% less than the minimum
I-40 EB MP 191.06 to MP 191.24 – 0.33% less than the minimum
I-40 EB MP 204.53 to MP 205.00 – 0.25% less than the minimum
I-40 EB MP 207.56 to MP 207.75 – 0.25% less than the minimum
I-40 WB MP 185.56 to MP 185.75 – 0.13% less than the minimum
I-40 WB MP 186.32 to MP 186.41 – 0.42% less than the minimum
I-40 WB MP 188.03 to MP 188.12 – 0.25% less than the minimum
I-40 WB MP 193.98 to MP 194.08 – 0.32% less than the minimum
I-40 WB MP 199.72 to MP 199.91 – 0.38% less than the minimum
I-40 WB MP 203.39 to MP 203.87 – 0.34% less than the minimum
I-40 WB MP 204.44 to MP 204.91 – 0.28% less than the minimum
I-40 WB MP 209.83 to MP 209.93 – 0.15% less than the minimum
I-40 WB MP 210.59 to MP 211.06 – 0.40% less than the minimum

5.4 Design Exception and Design Variance Summary

The following tables list the design features for mainline and interchanges requiring design exceptions based on *A Policy on Geometric Design of Highways and Streets* (AASHTO 2004) and *A Policy on Design Standards – Interstate System* (AASHTO 2005).

Tables 65 and 66 contain the controlling criteria, route and location, AASHTO/RDG controlling design value, and the proposed design value for all elements requiring a design exception.

Table 65 – Design Exception Request for Mainline

CONTROLLING CRITERION	LOCATION	CONTROLLING VALUE	PROPOSED VALUE
Vertical Grade	I-40 EB MP 194.27 to MP 194.93	3.00%	5.0218%
	I-40 WB MP 194.27 to MP 194.98	3.00%	4.6380%
	I-40 EB MP 194.27 to MP 194.93	4.00%	4.450%

Table 66 – Design Exception Request for Interchanges

CONTROLLING CRITERION	LOCATION	CONTROLLING VALUE	PROPOSED VALUE
Superelevation	A-1 Mountain TI – Cross road HPI Sta. 2+57.17	0.036 ft/ft	0.015 ft/ft
	Flagstaff Ranch TI – Cross road HPI Sta. 2+61.34	0.051 ft/ft	0.030 ft/ft
	I-40/I-17 System TI Ramp S-W – HPI Sta. 5+241.10	0.059 ft/ft	0.050 ft/ft
	I-40/I-17 System TI Ramp W-N – HPI Sta. 5+241.10	0.049 ft/ft	0.047 ft/ft
	I-40/I-17 System TI Ramp W-S – HPI Sta. 5+241.10	0.044 ft/ft	0.043 ft/ft
	Cosnino TI – Cross road HPI Sta. 2+57.17	0.045 ft/ft	0.015 ft/ft
	Cosnino TI – Cross road HPI Sta. 2+57.17	0.045 ft/ft	0.015 ft/ft
Degree of Curvature	West Flagstaff TI – Cross road HPI Sta. 18+64.60	11°49’	12°00’
	West Flagstaff TI – Cross road HPI Sta. 28+94.37	11°49’	12°00’
	I-40/I-17 System TI Ramp W-N – HPI Sta. 4+056.36	11°49’	20°14’
Shoulder Width	Cosnino TI - Cross road Sta. 0+77.05 to Sta. 33+46.29	4 ft	2 ft
Vertical SSD	I-40/I-17 System TI Ramp W-N – HPI Sta. 4+065.00	301 ft.	210 ft.
Vertical Clearance	Flagstaff Ranch TI OP	16'6"	15'10"

Table 67 lists the controlling criterion, route and location, RDG controlling design value, and the proposed design value for all elements requiring a design variance.

Table 67 – Design Variance Request

CONTROLLING CRITERION	LOCATION	CONTROLLING VALUE	PROPOSED VALUE
Minimum Highway Grade over 4000 ft	I-40 EB MP 185.46 to MP 185.75	0.50%	0.34%
	I-40 EB MP 186.32 to MP 186.41	0.50%	0.42%
	I-40 EB MP 187.74 to MP 188.21	0.50%	0.00%
	I-40 EB MP 189.26 to MP 189.35	0.50%	0.20%
	I-40 EB MP 191.06 to MP 191.24	0.50%	0.17%
Minimum Highway Grade over 4000 ft	I-40 EB MP 204.53 to MP 205.00	0.50%	0.25%
	I-40 EB MP 207.56 to MP 207.75	0.50%	0.25%
	I-40 WB MP 185.56 to MP 185.75	0.50%	0.37%
	I-40 WB MP 186.32 to MP 186.41	0.50%	0.08%
	I-40 WB MP 188.03 to MP 188.12	0.50%	0.25%
	I-40 WB MP 193.98 to MP 194.08	0.50%	0.18%
	I-40 WB MP 199.72 to MP 199.91	0.50%	0.12%
	I-40 WB MP 203.39 to MP 203.87	0.50%	0.16%
	I-40 WB MP 204.44 to MP 204.91	0.50%	0.32%
	I-40 WB MP 209.83 to MP 209.93	0.50%	0.35%
	I-40 WB MP 210.59 to MP 211.06	0.50%	0.10%