4_05 SUPERELEVATION PRESENTATION FROM 2015 NCLUG WINTER CONFERENCE

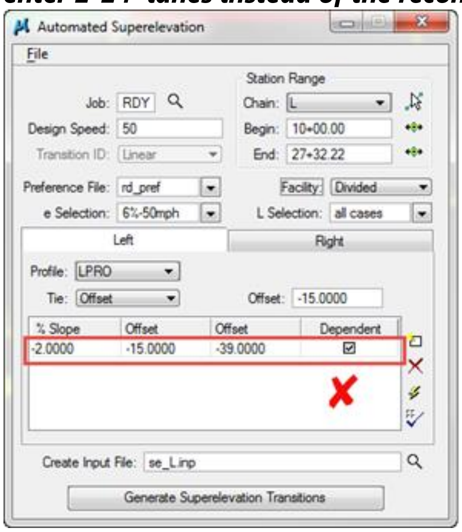
Question:
I was wondering if there is any information from the 2015 NCLUG Winter conference superelevation presentation that could be shared.

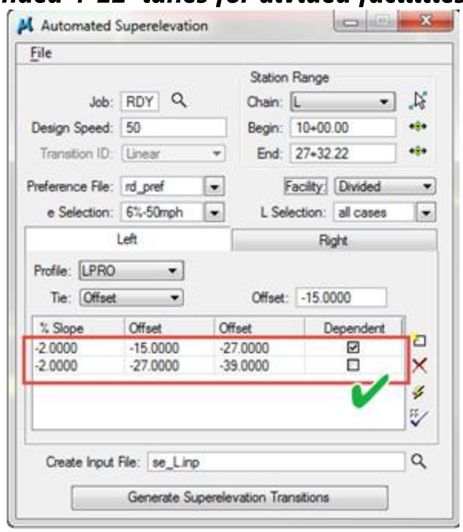
Answer:
We already have a wealth of information designing superelevation on our website:

Corridor Modeling Design Process - Roadway Designer - Superelevation

It is important for me to provide some clarifications in my notes based on some of questions that were asked.

1. To save time from editing the input file, in the Automated Superelevation fields, why can I not enter 2-24' lanes instead of the recommended 4-12' lanes for divided facilities?





This will cause an error in your superelevation computation. Remember that AASHTO Equation 3-23 is used in superelevation computation. The three important variables are:

- Lane Width (w)
- Number of Lanes Rotated (n1)
- Adjustment Factor for NoLR (bw)

U.S. Customary

$$L_r = \frac{(wn_1)\,e_d}{\Delta}(b_w) \qquad (3\text{-}23)$$

where:

L_r = minimum length of superelevation runoff, ft

w = width of one traffic lane, ft (typically 12 ft)

n_1 = number of lanes rotated

e_d = design superelevation rate, percent

b_w = adjustment factor for number of lanes rotated

Δ = maximum relative gradient, percent

Given1:

w=12′ Lanes
n1=2 lanes rotated (4 lanes total)
e=6%
bw=0.75
50 MPH Design Speed à MRG = 0.5

LRoff = ((12x2)6/0.5)x0.75= **<u>216′</u>**

Given2:

w=24′ Lanes
n1=1 lane rotated (2 lanes total)
e=6%
bw=1
50 MPH Design Speed à MRG = 0.5

LRoff = ((24x1)6/0.5)x1= **<u>288′</u>**

Note that Geopak will determine a **<u>LRoff = 144′</u>** for the second computation above. Its logic can be explained in the next question.

2. What is the difference between selecting the Length of Runoff from the AASHTO Tables versus calculating with the Maximum Relative Gradients (MRG) formula, Equation 3-23?

The main difference being the tables assume a nominal 12′ wide lane. The MRG formula can be used for computation of any lane widths. However, it is important to note that we have set the default parameters for the Geopak Superelevation Preferences file (.sep) to adhere to the nominal 12′ lane rule. This is in compliance with AASHTO guidelines.

> Chapter 3—Elements of Design | 3-63
>
> Elimination of the 2.0-s travel-time criterion previously discussed results in shorter runoff lengths for smaller superelevation rates and higher speeds. However, even the shortest runoff lengths (corresponding to a superelevation rate of 2.0 percent) correspond to travel times of 0.6 s, which is sufficient to provide a smooth edge-of-pavement profile.
>
> For high-type alignments, superelevation runoff lengths longer than those shown in Table 3-17 may be desirable. In this case, drainage needs or the desire for smoothness in the traveled-way-edge profiles may call for a small increase in runoff length.
>
> The superelevation runoff lengths given in Table 3-17 are based on 3.6-m [12-ft] lanes. For other lane widths, the appropriate runoff length should vary in proportion to the ratio of the actual lane width to 3.6 m [12 ft]. Shorter lengths could be applied for designs with 3.0- and 3.3-m [10- and 11-ft] lanes, but considerations of consistency and practicality suggest that the runoff lengths for 3.6-m [12-ft] lanes should be used in all cases.

Thus Given3:

w=24′ Lanes
n1=1 lane rotated (2 lanes total)
e=6%
bw=1
50 MPH Design Speed à MRG = 0.5

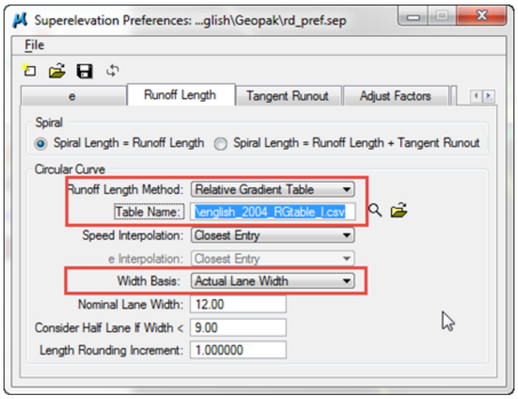
LRoff = ((**12**x1)6/0.5)x1= **<u>144′</u>**

Either way, both computations #2 and #3 are incorrect and not recommended.

3. How do I override the default AASHTO tables method? I want to use the MRG formula for all cases.

In the *rd_pref.sep*, change these three configurations:

- **Runoff Length Method:** e Table à Relative Gradient Table
- **Table Name:** english_2004_eTable_I.csv à english_2004_RGtable_I.csv
- **Width Basis:** Nominal Lane Width à Actual Lane Width



Note other default configurations:

- **e Interpolation (AASHTO Tables):** Closest Entry (Round to nearest, up or down)
- **Considered Half Lane if Width** < 9.00 (for undivided facilities middle turning lane usually 14'-16' wide, 7'-8' off centerline. It determines the number of lanes rotated and the adjustment factor, e.g. 1.5 lanes rotated, bw=0.83)
- **Length Rounding Increment:** 1 , so you do not have a LRoff = 134.3'

4. Are there any newer than 2004 AASHTO superelevation tables delivered by Bentley Geopak?

No. There is no need.

I've spoken with Ron Allen, Roadway Manager then, in 2005 on the topic. There has been little change in the Green Book for superelevation, except for starting from 2004 to 2011 the side friction factor (f) has changed for low speed urban street, less than 45 MPH design speed. This small change does not have an affected on how we compute our standard superelevation using the AASHTO Tables Method. The 2004 table values have been verified and consistent with the 2011 Green Book. I've also used a "retro-fitted" superelevation table from Sum Lim of Geopak at the time.

5. If my typical is a 4-lane divided facility and I am adding and dropping outside turning lanes, should I compute for 3 lanes rotated or stick with the typical section of 2-lane rotation?

This is common for superstreet and R-CUT projects. Engineering judgement should be exercised. There is nothing in the book which mention this situation. For my recommendation, three scenarios to consider:

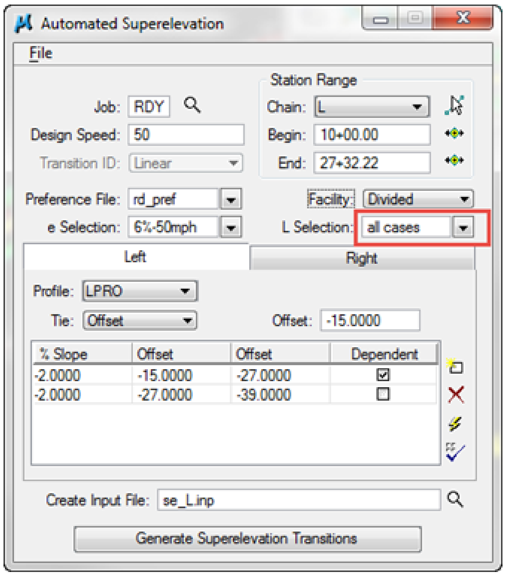
- If it's an undivided facility, where the superelevation sections are joined at the centerline, what is done to one side has a direct effect on the other side. In other words, if the length of runoff is adjusted for the additional lane of the right side, then same transition (consistent length and rate) must be applied to the left side, even though there are no additional lanes on the left.

- If it's a divided facility, the superelevation sections are not joined. Therefore, the transition can be independent. Care should be taken for excessive deviation from the normal superelevation transition.

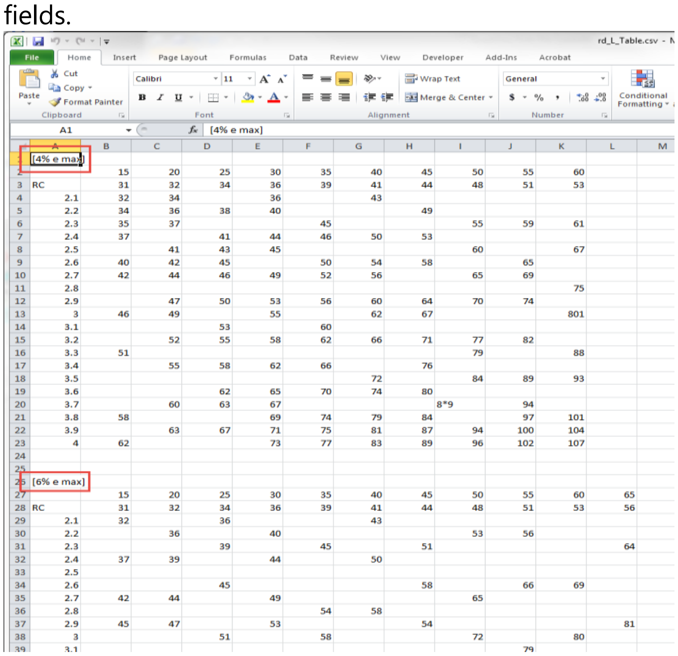
- Whether to even adjust for the additional lanes really depends where lane tapers occur. If the additional lane(s) occur more than 50% of the transition (Length of Runoff + Tangent Runout), then this is conservative number worth considering. 66-75% is probably more practical.

These are just my recommendations. Your Project Engineers/Squad Leaders may other preferences and criteria to use.

6. What is the "all-cases" in the **L Section** *field mean (Automated Superelevation)?*



Prior to the 2004 Green Book, LRunoff was selected from various emax tables. Notice the "gap" in certain fields.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	[4% e max]												
2		15	20	25	30	35	40	45	50	55	60		
3	RC	31	32	34	36	39	41	44	48	51	53		
4	2.1	32	34		36		43						
5	2.2	34	36	38	40			49					
6	2.3	35	37			45			55	59	61		
7	2.4	37		41	44	46	50	53					
8	2.5		41	43	45				60		67		
9	2.6	40	42	45		50	54	58		65			
10	2.7	42	44	46	49	52	56		65	69			
11	2.8										75		
12	2.9		47	50	53	56	60	64	70	74			
13	3	46	49		55		62	67			801		
14	3.1			53		60							
15	3.2		52	55	58	62	66	71	77	82			
16	3.3	51							79		88		
17	3.4		55	58	62	66		76					
18	3.5						72		84	89	93		
19	3.6			62	65	70	74	80					
20	3.7		60	63	67				8*9	94			
21	3.8	58			69	74	79	84		97	101		
22	3.9		63	67	71	75	81	87	94	100	104		
23	4	62			73	77	83	89	96	102	107		
24													
25													
26	[6% e max]												
27		15	20	25	30	35	40	45	50	55	60	65	
28	RC	31	32	34	36	39	41	44	48	51	53	56	
29	2.1	32		36			43						
30	2.2		36		40				53	56			
31	2.3			39		45		51				64	
32	2.4	37	39		44		50						
33	2.5												
34	2.6			45				58		66	69		
35	2.7	42	44		49				65				
36	2.8					54	58						
37	2.9	45	47		53			54				81	
38	3			51		58			72		80		
39	3.1									79			

Starting with 2004 and 2011, all emax tables are combined into one with consistent LRunoff values (no gaps)… thus “all cases”?

english_2004_eTable_l.csv - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	[all cases]														
2		15	20	25	30	35	40	45	50	55	60	65	70	75	80
3	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	2	31	32	34	36	39	41	44	48	51	53	56	60	63	69
5	2.2	34	36	38	40	43	46	49	53	56	59	61	66	69	75
6	2.4	37	39	41	44	46	50	53	58	61	64	67	72	76	82
7	2.6	40	42	45	47	50	54	58	62	66	69	73	78	82	89
8	2.8	43	45	48	51	54	58	62	67	71	75	78	84	88	96
9	3	46	49	51	55	58	62	67	72	77	80	84	90	95	103
10	3.2	49	52	55	58	62	66	71	77	82	85	89	96	101	110
11	3.4	52	55	58	62	66	70	76	82	87	91	95	102	107	117
12	3.6	55	58	62	65	70	74	80	86	92	96	100	108	114	123
13	3.8	58	62	65	69	74	79	84	91	97	101	106	114	120	130
14	4	62	65	69	73	77	83	89	96	102	107	112	120	126	137
15	4.2	65	68	72	76	81	87	93	101	107	112	117	126	133	144
16	4.4	68	71	75	80	85	91	98	106	112	117	123	132	139	151
17	4.6	71	75	79	84	89	95	102	110	117	123	128	138	145	158
18	4.8	74	78	82	87	93	99	107	115	123	128	134	144	152	165
19	5	77	81	86	91	97	103	111	120	128	133	140	150	158	171
20	5.2	80	84	89	95	101	108	116	125	133	139	145	156	164	178
21	5.4	83	88	93	98	105	112	120	130	138	144	151	162	171	185
22	5.6	86	91	96	102	108	116	124	134	143	149	156	168	177	192
23	5.8	89	94	99	105	112	120	129	139	148	155	162	174	183	199
24	6	92	97	103	109	116	124	133	144	153	160	167	180	189	206
25	6.2	95	101	106	113	120	128	138	149	158	165	173	186	196	213
26	6.4	98	104	110	116	124	132	142	154	163	171	179	192	202	219
27	6.6	102	107	113	120	128	137	147	158	169	176	184	198	208	226
28	6.8	105	110	117	124	132	141	151	163	174	181	190	204	215	233
29	7	108	114	120	127	135	145	156	168	179	187	195	210	221	240
30	7.2	111	117	123	131	139	149	160	173	184	192	201	216	227	247
31	7.4	114	120	127	135	143	153	164	178	189	197	207	222	234	254
32	7.6	117	123	130	138	147	157	169	182	194	203	212	228	240	261
33	7.8	120	126	134	142	151	161	173	187	199	208	218	234	246	267
34	8	123	130	137	145	155	166	178	192	204	213	223	240	253	274
35	8.2	126	133	141	149	159	170	182	197	209	219	229	246	259	281
36	8.4	129	136	144	153	163	174	187	202	214	224	234	252	265	288

Should be *mostly* consistent with the 2011 AASHTO Tables.

Table 3-17b. Superelevation Runoff L_r (ft) for Horizontal Curves

	V_d = 15 mph		V_d = 20 mph		V_d = 25 mph		V_d = 30 mph		V_d = 35 mph		V_d = 40 mph		V_d = 45 mph		V_d = 50 mph		V_d = 55 mph	
	Number of Lanes Rotated. Note that 1 lane rotated is typical for a 2-lane highway, 2 lanes rotated is typical																	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
e (%)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)
1.5	23	35	24	37	26	39	27	41	29	44	31	47	33	50	36	54	38	58
2.0	31	46	32	49	34	51	36	55	39	58	41	62	44	67	48	72	51	77
2.2	34	51	36	54	38	57	40	60	43	64	46	68	49	73	53	79	56	84
2.4	37	55	39	58	41	62	44	65	46	70	50	74	53	80	58	86	61	92
2.6	40	60	42	63	45	67	47	71	50	75	54	81	58	87	62	94	66	100
2.8	43	65	45	68	48	72	51	76	54	81	58	87	62	93	67	101	71	107
3.0	46	69	49	73	51	77	55	82	58	87	62	93	67	100	72	108	77	115
3.2	49	74	52	78	55	82	58	87	62	93	66	99	71	107	77	115	82	123
3.4	52	78	55	83	58	87	62	93	66	99	70	106	76	113	82	122	87	130
3.6	55	83	58	88	62	93	65	98	70	105	74	112	80	120	86	130	92	138
3.8	58	88	62	92	65	98	69	104	74	110	79	118	84	127	91	137	97	146
4.0	62	92	65	97	69	103	73	109	77	116	83	124	89	133	96	144	102	153
4.2	65	97	68	102	72	108	76	115	81	122	87	130	93	140	101	151	107	161
4.4	68	102	71	107	75	113	80	120	85	128	91	137	98	147	106	158	112	169
4.6	71	106	75	112	79	118	84	125	89	134	95	143	102	153	110	166	117	176
4.8	74	111	78	117	82	123	87	131	93	139	99	149	107	160	115	173	123	184
5.0	77	115	81	122	86	129	91	136	97	145	103	155	111	167	120	180	128	191
5.2	80	120	84	126	89	134	95	142	101	151	108	161	116	173	125	187	133	199
5.4	83	125	88	131	93	139	98	147	105	157	112	168	120	180	130	194	138	207
5.6	86	129	91	136	96	144	102	153	108	163	116	174	124	187	134	202	143	214
5.8	89	134	94	141	99	149	105	158	112	168	120	180	129	193	139	209	148	222
6.0	92	138	97	146	103	154	109	164	116	174	124	186	133	200	144	216	153	230
6.2	95	143	101	151	106	159	113	169	120	180	128	192	138	207	149	223	158	237
6.4	98	148	104	156	110	165	116	175	124	186	132	199	142	213	154	230	163	245
6.6	102	152	107	161	113	170	120	180	128	192	137	205	147	220	158	238	169	253
6.8	105	157	110	165	117	175	124	185	132	197	141	211	151	227	163	245	174	260
7.0	108	162	114	170	120	180	127	191	135	203	145	217	156	233	168	252	179	268
7.2	111	166	117	175	123	185	131	196	139	209	149	223	160	240	173	259	184	276
7.4	114	171	120	180	127	190	135	202	143	215	153	230	164	247	178	266	189	283
7.6	117	175	123	185	130	195	138	207	147	221	157	236	169	253	182	274	194	291
7.8	120	180	126	190	134	201	142	213	151	226	161	242	173	260	187	281	199	299
8.0	123	185	130	195	137	206	145	218	155	232	166	248	178	267	192	288	204	306

Note that Geopak first computes the length of runoff for one lane rotation. Then later on finalize the value with the adjustment factor for the actual number of lanes rotated, e.g. 144’ (1-lane rotation) x 1.5 (2-lane rotation) = 216’. The “1” and “2” lanes columns in the AASHTO table above do not have anything to do with whether it is an undivided or divided facility. Median width is not part of the superelevation computation.