

## Slopes for Skewed Culvert Sections

THESE TABLES ARE BASED ON THE FOLLOWING FORMULA

$$S = \frac{\text{SECANT } \Theta}{R \pm (0.01G \cdot \text{TAN} \Theta)}$$

$\Theta$  = SKEW ANGLE

S = SKEWED SLOPE

$$R = \frac{1}{\text{NORMAL ROADWAY SLOPE}}$$

Use + for downgrade side of skew

Use - for upgrade side of skew

G = % GRADE AT SHOULDER

IF SKEWED SECTION IS ON VERTICAL CURVE, THE "G" ABOVE MAY BE OBTAINED BY THE FOLLOWING FORMULA:

$$G = G_b \pm (Y/K)$$

G = % OF GRADE AT SHOULDER

G<sub>b</sub> = % OF GRADE BACK FROM PC OF VERTICAL CURVE. (USE ALGEBRAIC SIGN OF THIS GRADE)

Use + for A + Vertical Curve

Use - for A - Vertical Curve

Y = DISTANCE IN FEET FROM PC OF VERTICAL CURVE TO THE POINT WHERE THE SKEWED SECTION INTERSECTS WITH THE SHOULDER.

### EXPLANATION OF TABLE

THE SLOPES FOR ANY GRADE MAY BE OBTAINED BY INTERPOLATION.

SLOPES IN COLUMNS "U" ARE TO BE USED ON THE SIDE OF SECTION WHICH IS UPGRADE.

SLOPES IN COLUMNS "D" ARE TO BE USED ON THE SIDE OF SECTION WHICH IS DOWNGRADE.

FOR NORMAL SLOPES OTHER THAN THOSE SHOWN OR ODD SKEW ANGLES - USE FORMULA.

% OF GRADE	SKEW ANGLE																	
	5°		10°		15°		20°		25°		30°		35°		40°		45°	
	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D
0	2.01		2.03		2.07		2.13		2.21		2.31		2.44		2.61		2.83	
1	2.01	2.00	2.04	2.02	2.08	2.06	2.14	2.11	2.23	2.19	2.34	2.28	2.48	2.41	2.66	2.57	2.89	2.77
2	2.01	2.00	2.05	2.02	2.09	2.05	2.16	2.10	2.25	2.17	2.36	2.26	2.51	2.38	2.70	2.53	2.95	2.72
3	2.02	2.00	2.05	2.01	2.10	2.04	2.18	2.08	2.27	2.15	2.39	2.23	2.55	2.34	2.75	2.49	3.01	2.67
4	2.02	1.99	2.06	2.00	2.12	2.03	2.19	2.07	2.29	2.13	2.42	2.21	2.59	2.31	2.80	2.45	3.07	2.62
5	2.03	1.99	2.07	2.00	2.13	2.02	2.21	2.05	2.31	2.11	2.45	2.18	2.63	2.28	2.85	2.41	3.14	2.57
6	2.03	1.99	2.07	1.99	2.14	2.01	2.23	2.04	2.34	2.09	2.48	2.16	2.67	2.25	2.90	2.37	3.21	2.53
7	2.03	1.98	2.08	1.98	2.15	2.00	2.24	2.03	2.36	2.07	2.51	2.14	2.71	2.22	2.96	2.34	3.29	2.48
8	2.04	1.98	2.09	1.98	2.16	1.99	2.26	2.01	2.38	2.05	2.54	2.11	2.75	2.20	3.02	2.30	3.37	2.44
9	2.04	1.98	2.10	1.97	2.18	1.98	2.28	2.00	2.41	2.04	2.58	2.09	2.79	2.17	3.08	2.27	3.45	2.40
10	2.04	1.97	2.11	1.96	2.19	1.97	2.30	1.98	2.43	2.02	2.61	2.07	2.84	2.14	3.14	2.24	3.54	2.36
11	2.05	1.97	2.11	1.96	2.20	1.96	2.31	1.97	2.46	2.00	2.65	2.05	2.89	2.12	3.20	2.20	3.63	2.32
12	2.05	1.97	2.12	1.95	2.21	1.95	2.33	1.96	2.48	1.98	2.68	2.03	2.93	2.09	3.27	2.17	3.72	2.28

2:1 NORMAL ROADWAY SLOPE

0	3.01		3.05		3.11		3.19		3.31		3.46		3.66		3.92		4.24	
1	3.02	3.00	3.06	3.03	3.13	3.08	3.23	3.16	3.36	3.26	3.53	3.41	3.74	3.59	4.02	3.82	4.37	4.12
2	3.03	3.00	3.08	3.01	3.16	3.06	3.26	3.12	3.41	3.22	3.59	3.35	3.82	3.51	4.12	3.73	4.51	4.00
3	3.04	2.99	3.10	3.00	3.18	3.03	3.30	3.09	3.46	3.18	3.65	3.29	3.91	3.45	4.24	3.64	4.66	3.89
4	3.04	2.98	3.11	2.98	3.21	3.01	3.34	3.06	3.51	3.13	3.72	3.24	4.00	3.38	4.35	3.56	4.82	3.79
5	3.05	2.97	3.13	2.97	3.24	2.99	3.38	3.03	3.56	3.09	3.79	3.19	4.09	3.31	4.48	3.48	4.99	3.69
6	3.06	2.96	3.15	2.95	3.26	2.96	3.42	3.00	3.61	3.05	3.87	3.14	4.19	3.25	4.61	3.40	5.17	3.60
7	3.07	2.96	3.16	2.94	3.29	2.94	3.46	2.97	3.67	3.01	3.94	3.09	4.29	3.19	4.75	3.33	5.37	3.51
8	3.08	2.95	3.18	2.92	3.32	2.92	3.50	2.94	3.73	2.98	4.02	3.04	4.40	3.14	4.90	3.26	5.58	3.42
9	3.08	2.94	3.20	2.91	3.35	2.90	3.54	2.91	3.79	2.94	4.10	3.00	4.52	3.08	5.06	3.19	5.81	3.34
10	3.09	2.93	3.22	2.89	3.38	2.87	3.58	2.88	3.85	2.90	4.19	2.95	4.64	3.03	5.23	3.13	6.06	3.26
11	3.10	2.93	3.23	2.88	3.41	2.85	3.63	2.85	3.91	2.87	4.28	2.91	4.76	2.97	5.42	3.07	6.33	3.19
12	3.11	2.92	3.25	2.86	3.44	2.83	3.67	2.82	3.98	2.83	4.37	2.87	4.90	2.93	5.61	3.01	6.63	3.12

3:1 NORMAL ROADWAY SLOPE

0	4.02		4.06		4.14		4.26		4.41		4.62		4.88		5.22		5.66	
1	4.03	4.00	4.09	4.03	4.19	4.10	4.32	4.20	4.50	4.33	4.73	4.51	5.02	4.75	5.40	5.05	5.89	5.44
2	4.04	3.99	4.12	4.01	4.23	4.05	4.38	4.14	4.58	4.25	4.84	4.41	5.17	4.62	5.60	4.89	6.15	5.24
3	4.06	3.97	4.15	3.98	4.28	4.01	4.45	4.08	4.68	4.18	4.96	4.32	5.33	4.50	5.81	4.74	6.43	5.05
4	4.07	3.96	4.18	3.95	4.33	3.97	4.52	4.02	4.77	4.11	5.09	4.23	5.50	4.39	6.03	4.60	6.73	4.88
5	4.09	3.95	4.21	3.92	4.38	3.93	4.59	3.97	4.87	4.04	5.22	4.14	5.68	4.28	6.27	4.47	7.07	4.71
6	4.10	3.93	4.24	3.90	4.43	3.89	4.66	3.91	4.97	3.97	5.36	4.06	5.87	4.18	6.54	4.35	7.44	4.56
7	4.12	3.92	4.27	3.87	4.48	3.85	4.74	3.86	5.08	3.90	5.51	3.98	6.07	4.08	6.83	4.23	7.86	4.42
8	4.13	3.91	4.30	3.84	4.53	3.81	4.82	3.81	5.19	3.84	5.67	3.90	6.29	3.99	7.14	4.12	8.32	4.29
9	4.15	3.89	4.34	3.82	4.58	3.78	4.90	3.76	5.30	3.78	5.83	3.82	6.53	3.90	7.48	4.01	8.84	4.16
10	4.16	3.88	4.37	3.79	4.64	3.74	4.98	3.72	5.43	3.72	6.01	3.75	6.78	3.81	7.86	3.91	9.43	4.04
11	4.18	3.87	4.40	3.77	4.69	3.70	5.07	3.67	5.55	3.66	6.19	3.68	7.06	3.73	8.28	3.81	10.10	3.93
12	4.19	3.85	4.44	3.74	4.75	3.67	5.16	3.62	5.69	3.61	6.39	3.62	7.36	3.65	8.74	3.72	10.88	3.82

4:1 NORMAL ROADWAY SLOPE

0	5.02		5.08		5.18		5.32		5.52		5.77		6.1		6.53		7.07	
1	5.04	5.00	5.12	5.03	5.25	5.11	5.42	5.23	5.65	5.39	5.95	5.61	6.33	5.90	6.81	6.26	7.44	6.73
2	5.06	4.98	5.17	4.99	5.32	5.04	5.52	5.13	5.79	5.27	6.13	5.46	6.56	5.70	7.12	6.02	7.86	6.43
3	5.09	4.95	5.22	4.95	5.39	4.98	5.63	5.05	5.93	5.16	6.32	5.31	6.82	5.52	7.47	5.80	8.32	6.15
4	5.11	4.93	5.26	4.90	5.47	4.91	5.74	4.96	6.08	5.05	6.53	5.18	7.10	5.35	7.84	5.59	8.84	5.89
5	5.13	4.91	5.31	4.86	5.55	4.85	5.85	4.88	6.24	4.94	6.75	5.05	7.40	5.19	8.26	5.40	9.43	5.66
6	5.15	4.89	5.36	4.82	5.63	4.79	5.97	4.80	6.41	4.84	6.98	4.92	7.73	5.04	8.72	5.21	10.10	5.44
7	5.18	4.87	5.41	4.78	5.71	4.73	6.10	4.72	6.59	4.74	7.24	4.80	8.09	4.90	9.24	5.05	10.88	5.24
8	5.20	4.85	5.46	4.74	5.80	4.68	6.23	4.64	6.78	4.65	7.51	4.69	8.48	4.77	9.82	4.89	11.79	5.05
9	5.22	4.83	5.51	4.70	5.89	4.62	6.36	4.57	6.98	4.56	7.80	4.58	8.91	4.64	10.49	4.74	12.86	4.88
10	5.25	4.81	5.57	4.67	5.98	4.56	6.50	4.50	7.19	4.47	8.12	4.48	9.39	4.52	11.24	4.60	14.14	4.71
11	5.27	4.79	5.62	4.63	6.07	4.51	6.65	4.43	7.42	4.39	8.46	4.38	9.93	4.41	12.12	4.47	15.71	4.56
12	5.30	4.77	5.68	4.59	6.17	4.46	6.81	4.37	7.66	4.31	8.83	4.29	10.53	4.30	13.15	4.34	17.68	4.42

5:1 NORMAL ROADWAY SLOPE

5 5 10 10 15 15 20 20 25 25 30 30 35 35 40 40 45 45