PROGRAM DESCRIPTION I

Made in USA
Software Product of USA

Program Title SUPERELEVATED ROADWAY DESIGN WITH ELEVATIONS

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Program Description, Equations, Variables The SUPER program solves for the centerline and shoulder elevations of a superelevated roadway curve of a normal crown roadway section. The solution is for superelevation attained by rotation about the roadway centerline, and the transition from crown section to superelevated section is made without the use of spirals.

The input phase of the program is divided into two sections: "Vert Align" and "Horiz Align". The "Vert Align" section is patterned after the HP Surveying Module "VERT" program, and input prompts and required data are exactly the same as for the "VERT" program. The SUPER program has been developed to allow use of the "VERT" program "*" subroutines if the Surveying Module is in place. This enables the program to run with one less memory module than is required without the Surveying Module. The "*" subroutines are included as a separate program in case the Surveying

Necessary Accessories 3 memory modules*. Printer optional; card reader helpful.

Operating Limits and Warnings The user must be aware of changes in alignment that could cause bad output data, i.e. a grade change or new horizontal or vertical curve. The program assumes that if a printer is connected it will be turned on.

*Only two memory modules are required if the HP Surveying Module is used.

Reference(s) American Association of State Highway Officials. A Policy on Geometric Design of Rural Highways. Washington D.C. 1966

Idaho Transportation Department, Division of Highways. Survey and Plans Manual.

Module is not available.

The "Vert Align" section prompts until sufficient parameters have been entered to define either a straight grade vertical alignment or a vertical curve connecting two different grades. Once the alignment has been defined, the centerline elevation of any station within the range of the defined alignment can be calculated. The SUPER program contains modifications to the "VERT" program to also allow calculation of stations outside the limits of vertical curves, provided the alignment either side of the curve remains as initially defined. If a grade change or new vertical curve is encountered, the "Vert Align" input must be changed.

The "Horiz Align" section of the input phase is required to establish the limits of horizontal curvature and to determine the necessary superelevation and tangent runout lengths for the given design speed, superelevation rate and shoulder widths. Because the horizontal alignment is generally firmly established at the time superelevation grade data is required, the program assumes that all of the necessary horizontal alignment parameters have been previously calculated and therefore the "Horiz Align" inputting does not have the flexibility of the "Vert Align" section.

The program allows different shoulder widths either side of centerline and makes the calculation of runoff length(RL) to accomodate the shoulder that is the greatest distance from the axis of rotation, which in this case is the "centerline". This way the runoff length provides the smoothest transition from normal crown section to full superelevated section, regardless of differences in lane widths. The runoff length is calculated using the input values for design speed, superelevation rate and shoulder widths, and the calculated value is compared against the minimum acceptable value for the given design speed. If the calculated runoff length is less than the minimum standard, the minimum value is used; otherwise the calculated value is used and rounded to the nearest multiple of 10 or 25. The runoff length, superelevation rate and crown rate are then used to calculate the corresponding tangent runout length(Z), and RL and Z are displayed. The runoff and runout length can be calculated independently of the other program sections without the need for input of any vertical alignment data by executing the subroutine "HA".

Prior to the initial calculation of any roadway grades, it is a good idea to check the superelevation rate to verify that it is adequate for the design speed and the degree of curve. The SUPER program provides this check through a subroutine that calculates the safe speed and compares it to the design speed, adjusts the design speed to equal the calculated safe speed, calculates a new safe speed based on the adjusted design speed, and continues the process until the two values are within 0.5 miles per hour of each other.

Elevation data can be obtained for any individual location within the defined alignment through the use of the G key as in the "VERT" program, or after the initial station has been entered, a specific interval for spacing of points can be input by using the I key, again as in the "VERT" program. The SUPER program will then prompt for the last station desired for output. This allows calculation of grades beyond the end of vertical curves.

The program calculates the shoulder elevations by first calculating and storing the centerline elevation at the input station, and then determining the location of the station with respect to the superelevation rotation. Any station must satisfy one of the following cases: (1) Located at either end of the horizontal curve, before or after any tangent runout occurs. This would be: Station<=(PC-2RL/3-Z) or Station>(PT+2RL/3+Z); (2) Located within the tangent runout at either end of the curve: (PC-2RL/3-Z)<=Station <=(PC-2RL/3+Z) or (PT+2RL/3-Z)<=Station<=(PT+2RL/3+Z); (3) Located at either end of the curve in a partially superelevated section: (PC-2RL/3+Z)<= Station<=(PC+RL/3) or (PT-RL/3)<=Station<=(PT+2RL/3-Z); (4) Located within the fully superelevated section: (PC+RL/3)<=Station<=(PT-RL/3). Once the program determines which range the station is within, it calculates the proper values to be added to or subtracted from the centerline elevation to get the shoulder elevations. The decision to add or subtract is controlled by the status of Flag 05 and ensures that for a curve right the left shoulder will rise and the right shoulder will drop. The opposite is true for a curve left.

A special subroutine has been included for outputting the station in a form familiar to civil engineers and surveyors. The global label "STA" was used for the subroutine so that it could be used with other programs if desired. The subroutine takes the numerical value of the station (which must be stored in register seven) and outputs it as "STA XXX+XX.XX". For instance, 52254.06 stored in R07 would be output as "STA 522+54.06".

Much of the "Vert Align" section of the input phase of the SUPER program, and also the sections for calculation of the centerline elevation, consist of portions of the HP Surveying Module "VERT" program that were either used exactly as they appear in that program or modified somewhat to better suit the needs of the SUPER program. Following is a list of the SUPER program lines that were used from the "VERT" program, along with the corresponding line number from the "VERT" program:

SUPER Line Number	Corresponding "VERT" Line Number
12-74	02-64
76-116	66-106
117-124	108-115
125-142	187-204
144-190	116-162
308	237
312-316	238-242
322-324	243-245
325-326	247-248
328-331	250-253
342-358	254-270
447-449	283-285
592-593	286-287
595	289
600	288
601	290

Since the SUPER program was set up to be used with or without the Surveying Module, XEQ commands have been used in the progam in all cases. When the Surveying Module is in use, those XEQ commands that call for one of the subroutine sets contained in the Module would execute faster if changed to XROM. This can be easily accomplished by deleting the particular line and then replacing it; using the XEQ key with the Module in place will give the XROM command in the new line.

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DEFINITION OF TERMS AND VARIABLES

P.C. - Point of curvature
P.I. - Point of intersection of tangents or grades
P.T. - Point of tangency
V - Design speed
D - Degree of horizontal curvature
R - Radius of horizontal curve, in feet
EL - Centerline elevation at station STA
STA - Station with centerline elevation EL
STA1 - Beginning station
G1 - Beginning grade of vertical curve or grade of straight grade, in percent
EL1 - Beginning centerline elevation
G_n - Ending grade of vertical curve, in percent
L - Length of curve, in feet
EL0 - Centerline elevation of high or low point of vertical curve
ELI - Centerline elevation of vertical curve at P.I.
EL_i - Inside shoulder elevation
EL_o - Outside shoulder elevation
W_i - Width from centerline to inside shoulder, in feet
W_o - Width from centerline to outside shoulder, in feet
e - Superelevation rate, ft/ft (interchangeable with S)
S - Superelevation rate, ft/ft (interchangeable with e)
c - Normal crown rate, ft/ft
f - Safe side friction factor
e+f - Centrifugal factor
RL - Superelevation runoff length, in feet
Z - Tangent runout (crown runoff) length, in feet
M - Multiplying factor for width of road
R_s - Distance from axis of superelevation rotation to farthest edge of pavement, in feet
r - Runoff ratio, or maximum relative grade between profiles of edge and centerline of a 24' pavement
W_L - Width from centerline to left shoulder, in feet
W_R - Width from centerline to right shoulder, in feet
W_T - Shoulder to shoulder width, in feet
B.F.S.- Begin full superelevation
E.F.S.- End full superelevation

FORMULAS FOR VERTICAL ALIGNMENT

For straight grade and beginning grade prior to vertical PC station:

(1) $EL=(STA-STA1)(G1/100)+EL1$

For vertical curves, when L and PC are known:

(2) $[(G_n-G1)/200L](STA-PC)^2+(G1/100)(STA-PC)+(EL1-EL)=0$

When L and PI are known:

(3) $PC=PI-(L/2)$ Substitute in equation 2

When EL0 and PC are known:

(4) $L=200(EL1-EL0)(G_n-G1)(1/G1^2)$

When EL0 and PI are known:

(5) $L=200(EL1-EL0)(G_n-G1)(1/G_nG1)$

When a specified point and PC are known:

(6) $L=\{(STA-PC)^2/[(G1/100)(STA-PC)-(EL-EL1)]\}[200/(G1-G_n)]$

When a specified point and PI are known:

(7) $(L^2/4)+\{(STA-PI)-[200/(G1-G_n)][(G1/100)(STA-PI)-(EL-ELI)]\}L+(STA-PI)^2=0$

(8) $EL1=ELI-(G1/100)(L/2)$

For a station beyond the vertical PT station:

(9) $EL=[L(G_n+G1)/200]+[STA-(PC+L)](G_n/100)+EL1$

FORMULAS FOR HORIZONTAL ALIGNMENT

(10) $PT=PC+L$

(11) $R=5729.58/D$

(12) $f=0.09+(100-V)/1000$

(13) $e+f=V^2/15R$

(14) $r=1/[2.5(V-30)+150]$

(15) $M=[(R_s-12)/24]+1$

(16) $RL=(12eM)/r$

(17) $Z=(12cM)/r$

FORMULAS FOR SHOULDER ELEVATIONS

For Case 1:

(18) $EL_i=EL-W_ic$

(19) $EL_o=EL-W_oc$

For Case 2:

(20) $EL_i=EL-W_ic$

(21) $EL_o=EL_i+cW_T[STA-(PC-2RL/3-Z)]/2Z$

or

(21a) $EL_o=EL_i+cW_T[(PT+2RL/3+Z)-STA]/2Z$

FORMULAS FOR SHOULDER ELEVATIONS(CONT'D)

For Case 3:

(22) $EL_i = EL - \{eW_i\ [STA-(PC-2RL/3)]\ /RL\}$

(23) $EL_o = EL + \{eW_o\ [STA-(PC-2RL/3)]\ /RL\}$

or

(22a) $EL_i = EL - [eW_i (PT+2RL/3-STA)/RL]$

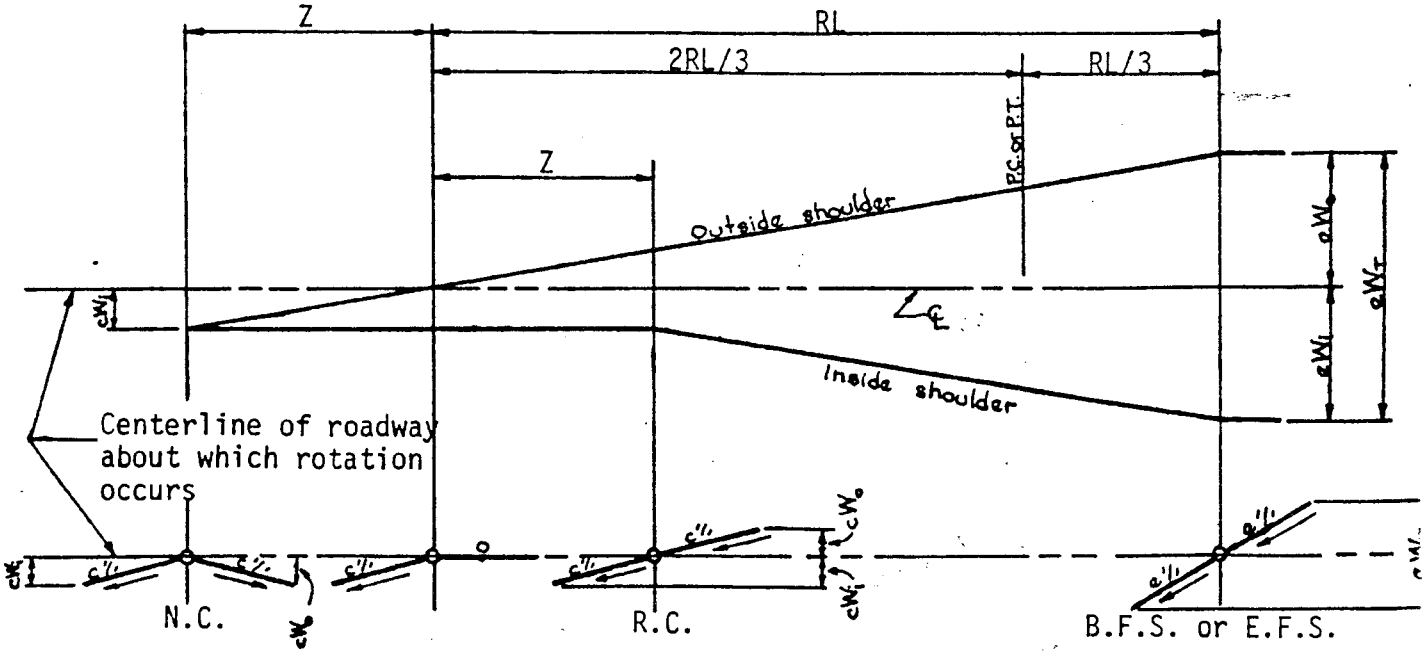
(23a) $EL_o = EL + [eW_o (PT+2RL/3-STA)/RL]$

For Case 4:

(24) $EL_i = EL - eW_i$

(25) $EL_o = EL + eW_o$

SUPERELEVATION RUNOFF ON CENTER CROWN ROADWAY
(WHEN AXIS OF ROTATION IS CENTERLINE OF ROADWAY)



VALUES FOR DESIGN SUPERELEVATION RATE RELATED
TO DESIGN SPEED AND HORIZONTAL CURVATURE

D	V=30mph	V=40mph	V=50mph	V=60mph	V=65mph	V=70mph
0°15'	NC	NC	NC	NC	NC	NC
0°30'	NC	NC	NC	RC	RC	RC
0°45'	NC	NC	RC	0.024	0.027	0.029
1°00'	NC	RC	0.023	0.032	0.035	0.039
1°30'	RC	0.021	0.033	0.046	0.052	0.058
2°00'	RC	0.028	0.042	0.058	0.066	0.074
2°30'	0.021	0.034	0.051	0.069	0.077	0.086
3°00'	0.025	0.040	0.059	0.079	0.087	0.094
3°30'	0.029	0.046	0.067	0.087	0.093	0.099
4°00'	0.033	0.051	0.073	0.093	0.098	0.100
5°00'	0.040	0.061	0.084	0.099	0.100	0.100
6°00'	0.046	0.070	0.092	0.100	D_{max}=4.5°	D_{max}=4.0°
7°00'	0.053	0.077	0.098	D_{max}=5.5°		
8°00'	0.059	0.084	0.100			
9°00'	0.064	0.089	0.100			
10°00'	0.068	0.093	D_{max}=8.5°			
11°00'	0.073	0.097				
12°00'	0.077	0.099				
13°00'	0.080	0.100				
14°00'	0.083	0.100				
16°00'	0.089	D_{max}=13.5°				
18°00'	0.093					
20°00'	0.097					
22°00'	0.099					
24°00'	0.100					
	0.100					
	D_{max}=25.0°					

$e_{max} = 0.10$

STANDARD SUPERELEVATION CRITERIA

D - Degree of curve
V - Assumed design speed
e - Rate of superelevation

NC - Normal crown section
RC - Remove adverse crown, superelevate at normal crown slope

VALUES FOR DESIGN SUPERELEVATION RATE RELATED
TO DESIGN SPEED AND HORIZONTAL CURVATURE

D	V=30mph	V=40mph	V=50mph	V=60mph	V=65mph	V=70mph
0°15'	NC	NC	NC	NC	NC	NC
0°30'	NC	NC	NC	RC	RC	RC
0°45'	NC	NC	RC	0.022	0.025	0.029
1°00'	NC	RC	0.021	0.029	0.033	0.038
1°30'	RC	0.021	0.030	0.040	0.046	0.053
2°00'	RC	0.027	0.038	0.051	0.057	0.065
2°30'	0.021	0.033	0.046	0.060	0.066	0.073
3°00'	0.025	0.038	0.053	0.067	0.073	0.078
3°30'	0.028	0.043	0.058	0.073	0.077	0.080
4°00'	0.032	0.047	0.063	0.077	0.079	0.080
5°00'	0.038	0.055	0.071	0.080	0.080	D_{max}=3.5°
6°00'	0.043	0.061	0.077	0.080	D_{max}=4.5°	
7°00'	0.048	0.067	0.079	D_{max}=5.0°		
8°00'	0.052	0.071	0.080			
9°00'	0.056	0.075	D_{max}=7.5°			
10°00'	0.059	0.077				
11°00'	0.063	0.079				
12°00'	0.066	0.080				
13°00'	0.068	0.080				
14°00'	0.070	D_{max}=12.5°				
16°00'	0.074					
18°00'	0.077					
20°00'	0.079					
22°00'	0.080					
	0.080					
	D_{max}=23.0°					

$e_{max} = 0.08$

SUPERELEVATION CRITERIA WHERE EXCEPTIONAL SNOW AND ICE CONDITIONS ARE ENCOUNTERED IN CONJUNCTION WITH MODERATE TO STEEP GRADES.

D - Degree of curve
V - Assumed design speed
e - Rate of superelevation

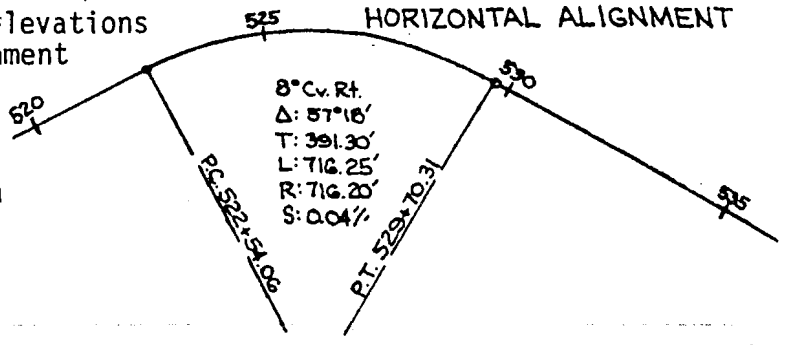
NC - Normal crown section
RC - Remove adverse crown, superelevate at normal crown slope

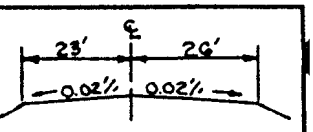
PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

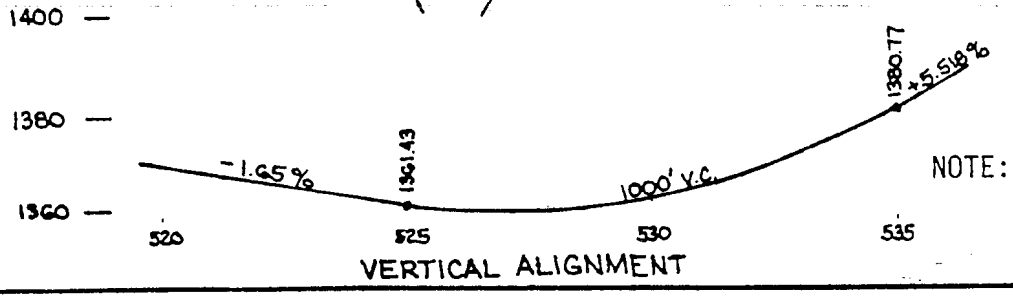
Calculate roadway elevations for the given alignment from Sta.521+00 to Sta.536+00

Design Speed=40 mph





TYPICAL SECTION



NOTE: Substandard S. Should be 0.07 based on criteria.

SOLUTION:

Input	Function	Display	Comments
	XEQ SIZE 025		Minimum size
	XEQ SUPER	VERT ALIGN	Begin vertical alignment input
		CURVE?	
Y	R/S	PC=?	
52500	R/S	EL=?	
1361.43	R/S	GRADE BEG%=?	
1.65	CHS R/S	GRADE END%=?	
5.518	R/S	L=?	
1000	R/S	HORIZ ALIGN	Begin horizontal alignment input
		CV R OR L?	
R	R/S	PC=?	
52254.06	R/S	L=?	
716.25	R/S	DESIGN SP=?	
40	R/S	LT SH W=?	
23	R/S	RT SH W=?	
26	R/S	SUPER=?	
.04	R/S	CROWN=?	
.02	R/S	RL=130/Z=65	Display runoff and runout lengths
	H	D=?	Check safe speed
8	R/S	SAFE SP=44.55	
52100	G	STA 521+0.00	
	R/S *	LT SH EL=1367.57	
	R/S *	C.L. EL=1368.03	
	R/S *	RT SH EL=1367.51	
100	I	LAST STA=?	Set spacing interval and last station for output
53600	R/S	STA 522+0.00	
	R/S *	LT SH EL=1366.60	
	R/S *	C.L. EL=1366.38	
	R/S *	RT SH EL=1365.86	
	R/S *	STA 523+0.00	
	R/S *	LT SH EL=1365.65	
	R/S *	C.L. EL=1364.73	
	R/S *	RT SH EL=1363.69	
	R/S *	STA 524+0.00	
	R/S *	LT SH EL=1364.00	

*Not required when using printer

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(CONTINUATION PAGE)

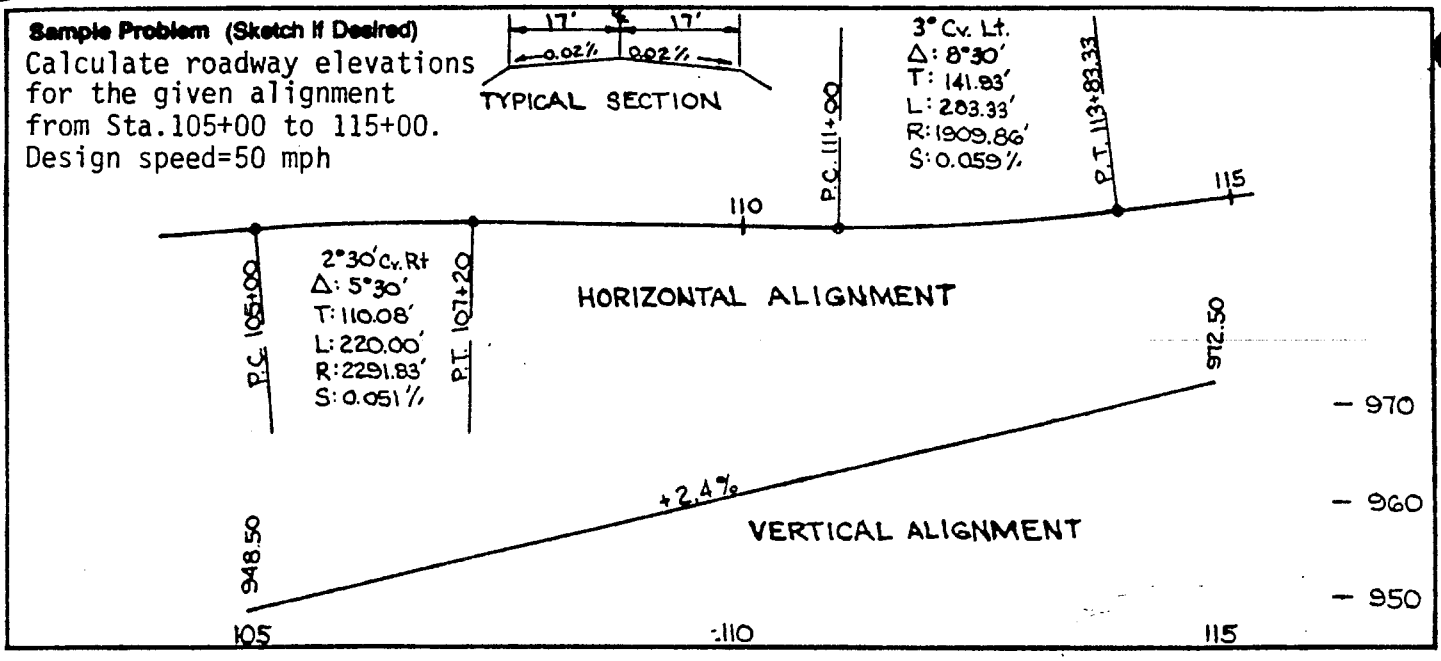
Input	Function	Display	Comments
	R/S *	C.L. EL=1363.08	
	R/S *	RT SH EL=1362.04	
	R/S *	STA 525+0.00	
	R/S *	LT SH EL=1362.35	
	R/S *	C.L. EL=1361.43	
	R/S *	RT SH EL=1360.39	
	R/S *	STA 526+0.00	
	R/S *	LT SH EL=1361.06	
	R/S *	C.L. EL=1360.14	
	R/S *	RT SH EL=1359.10	
	R/S *	STA 527+0.00	
	R/S *	LT SH EL=1360.48	
	R/S *	C.L. EL=1359.56	
	R/S *	RT SH EL=1358.52	
	R/S *	STA 528+0.00	
	R/S *	LT SH EL=1360.63	
	R/S *	C.L. EL=1359.71	
	R/S *	RT SH EL=1358.67	
	R/S *	STA 529+0.00	
	R/S *	LT SH EL=1361.48	
	R/S *	C.L. EL=1360.56	
	R/S *	RT SH EL=1359.52	
	R/S *	STA 530+0.00	
	R/S *	LT SH EL=1362.54	
	R/S *	C.L. EL=1362.14	
	R/S *	RT SH EL=1361.62	
	R/S *	STA 531+0.00	
	R/S *	LT SH EL=1364.08	
	R/S *	C.L. EL=1364.43	
	R/S *	RT SH EL=1363.91	
	R/S *	STA 532+0.00	
	R/S *	LT SH EL=1366.98	
	R/S *	C.L. EL=1367.44	
	R/S *	RT SH EL=1366.92	
	R/S *	STA 533+0.00	
	R/S *	LT SH EL=1370.71	
	R/S *	C.L. EL=1371.17	
	R/S *	RT SH EL=1370.65	
	R/S *	STA 534+0.00	
	R/S *	LT SH EL=1375.15	
	R/S *	C.L. EL=1375.61	
	R/S *	RT SH EL=1375.09	
	R/S *	STA 535+0.00	
	R/S *	LT SH EL=1380.31	
	R/S *	C.L. EL=1380.77	
	R/S *	RT SH EL=1380.25	
	R/S *	STA 536+0.00	
	R/S *	LT SH EL=1385.83	
	R/S *	C.L. EL=1386.29	
	R/S *	RT SH EL=1385.77	
52254.06	G	STA 522+54.06	Calculate elevations at horizontal P.C. station
	R/S *	LT SH EL=1366.10	
	R/S *	C.L. EL=1365.49	
	R/S *	RT SH EL=1364.79	

*Not required when using printer

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

Calculate roadway elevations for the given alignment from Sta.105+00 to 115+00.
Design speed=50 mph



SOLUTION:

Input	Function	Display	Comments
	XEQ SIZE 025		Minimum size
	XEQ SUPER	VERT ALIGN	Begin vertical alignment input
		CURVE?	
N	R/S	STA1=?	
10500	R/S	EL1=?	
948.5	R/S	GRADE%=?	
2.4	R/S	HORIZ ALIGN	Begin horizontal alignment input
		CV R OR L?	
R	R/S	PC=?	
10500	R/S	L=?	
220	R/S	DESIGN SP=?	
50	R/S	LT SH W=?	
17	R/S	RT SH W=?	
17	R/S	SUPER=?	
.051	R/S	CROWN=?	
.02	R/S	RL=150/Z=59	Display runoff and runout lengths
	H	D=?	Check safe speed
2.5	R/S	SAFE SP=75.72	
10500	G	STA 105+0.00	
	R/S *	LT SH EL=949.08	
	R/S *	C.L. EL=948.50	
	R/S *	RT SH EL=947.92	
100	I	LAST STA=?	Set spacing interval and last station for output
10900	R/S	STA 106+0.00	
	R/S *	LT SH EL=951.77	
	R/S *	C.L. EL=950.90	
	R/S *	RT SH EL=950.03	
	R/S *	STA 107+0.00	
	R/S *	LT SH EL=953.99	
	R/S *	C.L. EL=953.30	
	R/S *	RT SH EL=952.61	
	R/S *	STA 108+0.00	
	R/S *	LT SH EL=955.82	
	R/S *	C.L. EL=955.70	
	R/S *	RT SH EL=955.36	

*Not required when using printer

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(CONTINUATION PAGE)

Input	Function	Display	Comments
	R/S *	STA 109+0.00	
	R/S *	LT SH EL=957.76	
	R/S *	C.L. EL=958.10	
	R/S *	RT SH EL=957.76	
10720	G	STA 107+20.00	Calculate elevations at PT station
	R/S *	LT SH EL=954.36	
	R/S *	C.L. EL=953.78	
	R/S *	RT SH EL=953.20	
	XEQ 99	HORIZ ALIGN	Same vertical alignment; new
		CV R OR L?	horizontal curve
L	R/S	PC=?	
11100	R/S	L=?	
283.33	R/S	DESIGN SP=?	
50	R/S	LT SH W=?	
17	R/S	RT SH W=?	
17	R/S	SUPER=?	
.059	R/S	CROWN=?	
.02	R/S	RL=170/Z=58	Display runoff and runout lengths
11000	G	STA 110+0.00	
	R/S *	LT SH EL=960.16	
	R/S *	C.L. EL=960.50	
	R/S *	RT SH EL=960.58	
100	I	LAST STA=?	Set spacing interval and last
11500	R/S	STA 111+0.00	station for output
	R/S *	LT SH EL=962.23	
	R/S *	C.L. EL=962.90	
	R/S *	RT SH EL=963.57	
	R/S *	STA 112+0.00	
	R/S *	LT SH EL=964.30	
	R/S *	C.L. EL=965.30	
	R/S *	RT SH EL=966.30	
	R/S *	STA 113+0.00	
	R/S *	LT SH EL=966.70	
	R/S *	C.L. EL=967.70	
	R/S *	RT SH EL=968.70	
	R/S *	STA 114+0.00	
	R/S *	LT SH EL=969.53	
	R/S *	C.L. EL=970.10	
	R/S *	RT SH EL=970.67	
	R/S *	STA 115+0.00	
	R/S *	LT SH EL=972.16	
	R/S *	C.L. EL=972.50	
	R/S *	RT SH EL=972.48	
11383.33	G	STA 113+83.33	Calculate elevations at PT station
	R/S *	LT SH EL=969.03	
	R/S *	C.L. EL=969.70	
	R/S *	RT SH EL=970.37	

*Not required when using printer

USER INSTRUCTIONS

SIZE: 025 (HP-41C)

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Enter the program			
2	For complete solution with elevations, begin the SUPER program. Or,		XEQ SUPER	VERT ALIGN CURVE?
2a	To use as only as a check of design data, begin HA subroutine. Then go to step 7.		XEQ HA	HORIZ ALIGN CV R OR L?
3	If calculating a vertical curve, input Y. Then go to step 4.	Y	R/S	PC=?
3a	If calculating a grade, input N. Then call prompting and input beginning station,	N	R/S	STA1=?
	beginning elevation and grade. Then go to step 7.	STA1	R/S	EL1=?
		EL1	R/S	GRADE%=?
		GRADE%	R/S	HORIZ ALIGN *** CV R OR L?
4	Input vertical PC station. If PC is not known, press R/S and then input the	PC	R/S	EL=?
	vertical PI station.	___	R/S	PI=?
		PI	R/S	EL=?
5	Input elevation at PC or PI (whichever was input above) and beginning and ending	EL	R/S	GRADE BEG%=?
	grades.	GRADE BEG%	R/S	GRADE END%=?
		GRADE END%	R/S	L=?
6	Input length of vertical curve, if known. Or, if unknown, press R/S and input	L	R/S	HORIZ ALIGN *** CV R OR L?
	elevation of high or low point if known. Or, if unknown, press R/S and input a	___	R/S	EL0=?
	station and elevation through which the vertical curve passes.	EL0	R/S	HORIZ ALIGN *** CV R OR L?
		___	R/S	STA=?
		STA	R/S	EL=?
		EL	R/S	HORIZ ALIGN *** CV R OR L?
7	If a curve right, input R. If a curve left, input L.	L or R	R/S	PC=?
8	Input horizontal curve PC station.	PC	R/S	L=?
9	Input length of horizontal curve.	L	R/S	DESIGN SP=?
10	Input design speed.	DESIGN SP	R/S	LT SH W=?
11	Input width to left shoulder.	LT SH W	R/S	RT SH W=?
12	Input width to right shoulder.	RT SH W	R/S	SUPER=?
13	Input superelevation rate.	SUPER	R/S	CROWN=?

SIZE: 025 (HP-41C)

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
14	Input crown rate.	CROWN	R/S	RL= /Z=
15	To check the design speed against the safe speed for the input parameters, go			
	to step 16. To calculate elevations at a specific station, go to step 17.			
16	Begin safe speed check and input degree of curve of horizontal curve.(Minutes		H	D=?
	must be input as a decimal of a degree. Ex. 2°45' would be 2.75)	D	R/S	SAFE SP=
17	Input station and calculate its elevations.	STA	G	STA +
	Repeat step 17 for next station or, go to step 18 for automatic stationing.		R/S *	LT SH EL=
			R/S *	C.L. EL=
			R/S *	RT SH EL=
18	Input stationing interval and input last station desired for output; automatically	INT	I	LAST STA=?
	calculate successive stations and elevations beginning from the current station.	LAST STA	R/S	STA +
			R/S *	LT SH EL=
			R/S *	C.L. EL=
			R/S *	RT SH EL=
			etc.	
19	For a totally new alignment, or for the same horizontal alignment with a change			
	in vertical alignment, go to step 2.			
19a	For the same vertical alignment with a change in the horizontal alignment, XEQ 99		XEQ 99	HORIZ ALIGN CV R OR I ?
	then go to step 7.			
	*** After completion of vertical alignment input, if using the same horizontal			
	alignment from the previous solution, take the calculator out of ALPHA mode		ALPHA	
	and go to step 15.			
	* This R/S not required when using printer.			

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
* 01	LBL"SUPER"		
	CF 21		
	FS? 55		
	SF 21		
	SF 12		
	"VERT ALIGN"		Begin input of
	AVIEW		vertical alignment
	PSE		parameters.
	PSE		
10	CLD		
	CF 12		
	XEQ "*IN"		
	ASTO 13		
	ASTO 12		
	SF 02		
	"GRADE"		
	ASTO 01		
	"CURVE"		
	XEQ "*YN"		
20	FS? 10		If vertical curve,
	GTO 08		GTO 08, else input
	SF 10		beginning station
	1		and elevation and
	STO 13		then GTO 03.
	XEQ "*S"		
	XEQ "*EL"		
	CLA		
	ARCL 01		
	"⊢%=?"		
30	PROMPT		
	SF 01		
	0		
	GTO 03		
*	LBL 08		For vertical curve
	CF 22		input P.C. station
	"PC=?"		if known, else in-
	PROMPT		put vertical P.I.
	FS?C 22		station.
	GTO 09		
40	"PI=?"		
	PROMPT		
	FC?C 22		
	GTO 08		
	CF 02		
*	LBL 09		Input either vert-
	XEQ "*EL"		ical curve P.C.
	CLA		elevation or P.I.
	ARCL 01		elevation depend-
	"⊢ BEG%=?"		ing on which is
50	PROMPT		known.
	CLA		
	ARCL 01		
	"⊢ END%=?"		
	PROMPT		
	CF 22		
*	LBL 03		
	R↓		
	STO 07		Store beginning
	STO 00		station (or vertical
60	CLX		curve P.C. station)
	1 E2		
	/		Store decimal form
	STO 03		of ending grade of
	X<>Y		vertical curve.
	LAST X		
	/		Store decimal form
	STO 02		of beginning grade.
	R↓		Store beginning el-
	STO 01		evation(or vertical
70	FC? 01		curve P.C. elev.)
	GTO 10		If vertical curve,
	CF 10		prompt for length,
	CLA		else begin horizon-
	ASTO 13		tal alignment in-
	GTO 99		put.
*	LBL 10		
	"L=?"		If length of vert-
	PROMPT		ical curve is known
	FS?C 22		GTO C, else prompt
80	GTO C		for elevation of
	0		of low or high pt.
	STO 13		on curve if known,
	XEQ "*EL"		else prompt for
	FS?C 22		station and eleva-
	GTO a		tion of a point on
	CLA		the curve.
	ASTO 13		
	XEQ "*S"		
	FC?C 22		
90	GTO 10		
	XEQ "*EL"		
*	LBL b		Calculate length of
	RCL 01		vertical curve when
	-		the station and el-
	X<>Y		evation of a point
	RCL 00		on the curve are
	-		known.
	STO 08		
	RCL 08		
100	RCL 02		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
101	*		
	R↓		
	-		
	RCL 02		
	RCL 03		
	-		
	/		
	2		
	*		
10	FS? 02		
	GTO 06		
	-		
	RCL 08		
	X↑2		
	4		
	1/X		
	XEQ 04		
	X<0?		
	X<>Y		
20	GTO C		
*	LBL 06		
	/		
	*		
	GTO 01		
*	LBL 04		
	/		
	X<>Y		
	LAST X		
	/		
30	2		
	/		
	CHS		
	ENTER↑		
	ENTER↑		
	X↑2		
	R↓		
	-		
	SQRT		
	-		
40	LAST X		
	R↓		
	+		
	RTN		
*	LBL a		Calculate length of vertical curve when the elevation of the low point or high point on the curve is known.
	RCL 12		
	STO 13		
	RDN		
	RCL 01		
	X<>Y		
50	-		
51	2		
	*		
	RCL 03		
	RCL 02		
	-		
	*		
	RCL 02		
	X↑2		
	/		
60	FS? 02		
	GTO 01		
	RCL 02		
	*		
	RCL 03		
	/		
*	LBL C		Store length of vertical curve.
	STO 05		
	FS? 02		
	GTO 01		
70	2		
	/		
	RCL 00		
	X<>Y		
	-		
	STO 00		
	STO 07		
	LAST X		
	RCL 02		
	*		
80	ST-01		
	RCL 05		
*	LBL 01		
	RCL 03		
	RCL 02		
	-		
	X<>Y		
	STO 05		
	/		Store algebraic difference of grades divided by length of vertical curve.
	STO 06		
90	ADV		
*	LBL 99		
	CLA		
	CF 21		
	FS? 55		
	SF 21		
	SF 12		
	"HORIZ ALIGN"		Begin input of horizontal alignment parameters.
	AVIEW		
	PSE		
200	PSE		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
201	CLD		
	CF 12		
	"CV R OR L?"		
	AON		
	PROMPT		
	AOFF		
	ASTO X		
	"R"		
	ASTO Y		
10	CLA		
	CF 05		
	X=Y?		If curve right,
	SF 05		set flag 05.
	"PC=?"		
	PROMPT		
	STO 15		
	"L=?"		
	PROMPT		
	RCL 15		
20	+		
	STO 16		
*	LBL "HA"		SUBROUTINE TO CAL-
	"DESIGN SP=?"		CULATE RUNOFF
	PROMPT		LENGTH AND Z DIST-
	STO 09		ANCE.
	30		
	-		
	2.5		
	*		
30	1.5 E2		Calculate 1/r and
	+		store.
	STO 14		
	"LT SH W=?"		
	PROMPT		
	STO 17		
	"RT SH W=?"		
	PROMPT		
	STO 18		
	"SUPER=?"		
40	PROMPT		
	STO 10		
	RCL 14		
	*		
	12		
	*		
	RCL 17		Compare shoulder
	RCL 18		widths and use
	X>Y?		larger value to
	X<>Y		calculate width
50	RDN		multiplying factor

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
51	12		Calculate width
	-		multiplying factor,
	24		then use it and 1/r
	/		to calculate runoff
	1		length and store.
	+		
	*		
	STO 19		
	RCL 14		
60	50		
	-		
	X>Y?		Compare runoff
	GTO 13		length to minimum
	X<>Y		standard. If RL is
	25		larger, calculate
	MOD		rounded value of
	2.5		RL that is closest
	X>Y?		to either a multi-
	GTO 12		ple of 25 or 10
70	RCL 19		and store.
	10		
	/		
	.5		
	+		
	INT		
	10		
	*		
	GTO 13		
*	LBL 12		
80	X<>Y		
	RCL 19		
	-		
	CHS		
*	LBL 13		
	STO 19		
	"CROWN=?"		
	PROMPT		
	STO 22		
	*		
90	RCL 10		
	/		
	.5		Calculate Z dist-
	+		ance and store.
	INT		
	STO 20		
	ADV		
	ADV		
	FIX 0		
	CF 29		
300	"RL="		Display runoff

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	ARCL 19		length and Z distance.
	"Ŧ/"		
	"ŦZ="		
	ARCL X		
	AVIEW		
	ADV		
	RTN		
*	LBL G		
	FS? 10		
10	CF 01		
	FIX 2		
	FS?C 22		If a station has been entered, then GTO 02 to calculate centerline elevation, else add interval to previous-station for new station and check to see if station is within limits of vertical curve.
	GTO 02		
	RCL 04		
	RCL 07		
	+		
	RCL 00		
	X>Y?		
	SF 01		
20	FS? 01		
	X<>Y		
	FS? 01		
	GTO 05		
	RCL 05 -		
	+		
	X<=Y?		If station is beyond vertical P.T., GTO 21, else calculate centerline elevation.
	GTO 21		
	X<>Y		
	GTO 05		
* 30	LBL 02		
	SF 00		
	RCL 00		
	X>Y?		
	SF 01		
	RCL 05		
	+		
	X<>Y		
	X<=Y?		If station is beyond vertical P.T., GTO 23, else store station and calculate centerline elevation.
	GTO 05		
40	FS? 10		
	GTO 23		
*	LBL 05		
	STO 07		
	RCL 00		
	-		
	ENTER↑		
	ENTER↑		
	RCL 06		
	FS? 01		
50	CLX		

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
51	*		
	2		
	/		
	RCL 02		
	+		
	*		
	RCL 01		
	+		
*	LBL 14		Store centerline elevation.
60	STO 21		
	ADV		
	SF 21		
	RCL 07		
	RCL 15		
	RCL 19		
	2		
	*		
	3		
	/		
70	-		
	RCL 20		
	-		
	X<=Y?		If station is beyond point where tangent runout begins(PC-2RL/3-Z), then GTO 07, else display station, then calculate and display shoulder elevations.
	GTO 07		
*	LBL 27		
	XEQ 98		
	XEQ 17		
	XEQ 15		
	XEQ 22		
80	XEQ 18		
	GTO 19		
*	LBL 21		
	X<>Y		
*	LBL 23		
	STO 07		Calculate centerline elevation of station beyond vertical P.T.
	X<>Y		
	-		
	RCL 03		
	*		
90	RCL 03		
	RCL 02		
	+		
	2		
	/		
	RCL 05		
	*		
	+		
	RCL 01		
	+		
400	GTO 14		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
* 401	LBL 07		
	RCL 20		
	2		
	*		
	+		
	X<=Y?		If station is beyond PC-2RL/3+Z, GTO 16, else calculate elevation difference of high shoulder above low shoulder (ΔE).
	GTO 16		
	RCL 20		
	2		
10	*		
	-		
	-		
*	LBL 28		
	RCL 20		
	2		
	*		
	/		
	RCL 17		
	RCL 18		
20	+		
	RCL 22		
	*		
	*		
	XEQ 98		
	X<>Y		
	FS? 05		If curve right, calculate right shoulder elevation and add ΔE to get left shoulder elevation, else calculate left shoulder elevation and add ΔE to get right shoulder elevation.
	GTO 11		
	XEQ 17		
	XEQ 15		
30	XEQ 22		
	+		
	GTO 19		
*	LBL 11		
	XEQ 18		
	+		
	XEQ 15		
	XEQ 22		
	XEQ 18		
*	LBL 19		
40	CLA		
	"RT"		Display right shoulder elevation
	XEQ 20		
	RCL 07		
	RCL 23		If station is equal to or greater than ending station or if not auto execution, STOP, else next station.
	X<=Y?		
	SF 00		
	FS? 00		
	STOP		
	GTO G		
* 50	LBL 17		

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
51	RCL 21		Calculate left shoulder elevation for normal crown section.
	RCL 17		
	RCL 22		
	*		
	-		
	RTN		
*	LBL 18		Calculate right shoulder elevation for normal crown section.
	RCL 21		
	RCL 18		
60	RCL 22		
	*		
	-		
	RTN		
*	LBL 15		
	CLA		
	"LT"		Display left shoulder elevation.
*	LBL 20		
	"L SH EL="		
	ARCL X		
70	AVIEW		
	RTN		
*	LBL 22		
	"C.L. EL="		Display centerline elevation.
	ARCL 21		
	AVIEW		
	RTN		
*	LBL 16		
	X<>Y		
	RCL 15		
80	RCL 19		
	3		
	/		
	+		
	X<=Y?		If station is beyond start of full superelevation, (PC+RL/3), GTO 00, else calculate amount of super of left shoulder.
	GTO 00		
	-		
	RCL 19		
	/		
	1		
90	+		
*	LBL 25		
	RCL 17		
	*		
	RCL 10		
	*		
	FC? 05		If curve left, subtract from centerline elevation, else add to centerline elevation.
	CHS		
	RCL 21		
	+		
500	XEQ 98		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
501	X<>Y		
	XEQ 15		
	XEQ 22		
	RCL 21		Calculate superel-
	-		evation of right
	RCL 17		shoulder and add
	/		to centerline el-
	RCL 18		evation with oppo-
	*		site sign of left
10	CHS		shoulder superel-
	RCL 21		evation.
	+		
	GTO 19		
*	LBL 00		
	X<>Y		
	RCL 16		
	RCL 19		
	3		
	/		
20	-		
	X<=Y?		If station is be-
	GTO 24		yond end of full
	XEQ 98		superelevation
	RCL 21		(PT-RL/3), GTO 24
	RCL 17		else calculate
	RCL 10		amount of superel-
	*		evation of left
	FC? 05		shoulder. If curve
	CHS		left, subtract from
30	+		centerline eleva-
	XEQ 15		tion, else add to
	XEQ 22		centerline eleva-
	RCL 21		tion.
	RCL 18		Calculate superel-
	RCL 10		evation of right
	*		shoulder.
	FS? 05		If curve right,
	CHS		subtract from cen-
	+		terline elevation,
40	GTO 19		else add to center-
*	LBL 24		line elevation.
	RCL 19		
	+		
	RCL 20		
	-		
	X<=Y?		If station is be-
	GTO 26		yond PT+2RL/3-Z,
	RCL 20		GTO 26, else calcu-
	+		late percentage of
50	-		superelevation.

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
51	RCL 19		
	/		
	CHS		
	GTO 25		
*	LBL 26		
	RCL 20		
	2		
	*		
	+		
60	X<=Y?		If station is be-
	GTO 27		yond end of tangent
	-		runout(PT+2RL/3+Z),
	CHS		GTO 27, else calcu-
	GTO 28		late ΔE.
*	LBL "STA"		SUBROUTINE TO OUT-
*	LBL 98		PUT STATION IN
	CLA		COMMON ENGINEERING
	RCL 07		AND SURVEYING FOR-
	FIX 0		MAT OF "STA XXX+XX.XX"
70	1 E2		
	/		
	ENTER↑		
	ENTER↑		
	CF 29		
	INT		
	ARCL X		
	ASTO 11		
	CLA		
	X<>Y		
80	RCL T		
	X<>Y		
	FIX 2		
	FRC		
	1 E2		
	*		
	"STA "		
	ARCL 11		
	"+"		
	ARCL X		
90	AVIEW		
	RTN		
*	LBL I		Store interval for
	CF 00		automatic spacing
	ADV		of points.
	STO 04		
	ADV		
	"LAST STA=?"		Store last station
	PROMPT		required for output.
	STO 23		
600	CF 22		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
601	GTO G		
*	LBL H		SUBROUTINE TO CHECK
	ADV		DESIGN SPEED
	ADV		AGAINST SAFE SPEED
	"D=?"		BASED ON DESIGN
	PROMPT		PARAMETERS OF SUPER-
	STO 24		ELEVATION, DEGREE
*	LBL 29		OF CURVE, AND SAFE
	1.9 E2		SIDE FRICTION FAC-
10	RCL 09		TOR.
	-		
	RCL 10		
	1 E3		
	*		
	+		
	1.164 E-2		
	/		
	RCL 24		
	/		
20	SQRT		
	RCL 09		
	-		
	ENTER↑		
	ENTER↑		
	ABS -		
	.5		
	X>Y?		
	GTO 30		
	X<>Z		
30	ST+09		
	GTO 29		
*	LBL 30		
	ADV		
	FIX 2		
	"SAFE SP="		
	ARCL 09		
	AVIEW		
	END		
40			
50			

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
51			
60			
70			
80			
90			
00			

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SUBROUTINE SET

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
* 01	LBL "*IN"		Initialize program	51			
	SF 27						
	SF 21						
	SF 24						
	SF 29						
	FIX 2						
	CLA						
	CF 00						
	CF 01						
10	CF 02			60			
	CF 22						
	RTN						
*	LBL "*YN"						
	"├?"						
	AON						
	PROMPT						
	AOFF						
	ASTO X						
	"Y"						
20	ASTO Y			70			
	CLA						
	CF 10						
	X=Y?		If answer is yes,				
	SF 10 -		set flag 10.				
	RTN						
*	LBL "*EL"						
	"EL"						
	GTO 01						
*	LBL "*S"						
30	"STA"			80			
*	LBL 01						
	CF 29						
	FIX 0						
	ARCL 13						
	"├="						
	FIX 2						
	SF 29						
	FS? 10						
	"├?"						
40	FC? 10			90			
	ARCL X						
	FC? 10						
	RTN						
	PROMPT						
	RTN						
50				00			

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. The Function Index is found at the very back of the Handbook. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

01768C

REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS

00	P.C. station of vertical curve or STA1 of straight grade
01	P.C. elevation of vertical curve or STA1 elevation of straight grade
02	Decimal form of straight grade or beginning grade for vertical curve
03	Decimal form of ending grade of vertical curve
04	Interval between points
05	Length of vertical curve
06	(R03-R02)/R05
07	Current station
08	Distance of station from vertical P.C. (Used when L is unknown, and the station and elevation of a point on the vertical curve are input.)
09	Design speed
10	Superelevation rate (ft/ft)
11	Alpha designation of hundreds portion of station in R07
12	Blank (Used to reset R13)
13	Blank, 0, or 1
14	1/r
15	P.C. station of horizontal curve
16	P.T. station of horizontal curve
17	Left shoulder width
18	Right shoulder width
19	Superelevation runoff length (RL)
20	Tangent runout length (Z)
21	Centerline elevation of station in R07
22	Crown rate (ft/ft)
23	Last station to calculate
24	Degree of curve of horizontal curve

STATUS

SIZE	025	TOT. REG.	206*	USER MODE	
ENG		FIX 0,2	SCI	ON X	OFF
DEG		RAD	GRAD		

*190 if HP Surveying Module used

FLAGS

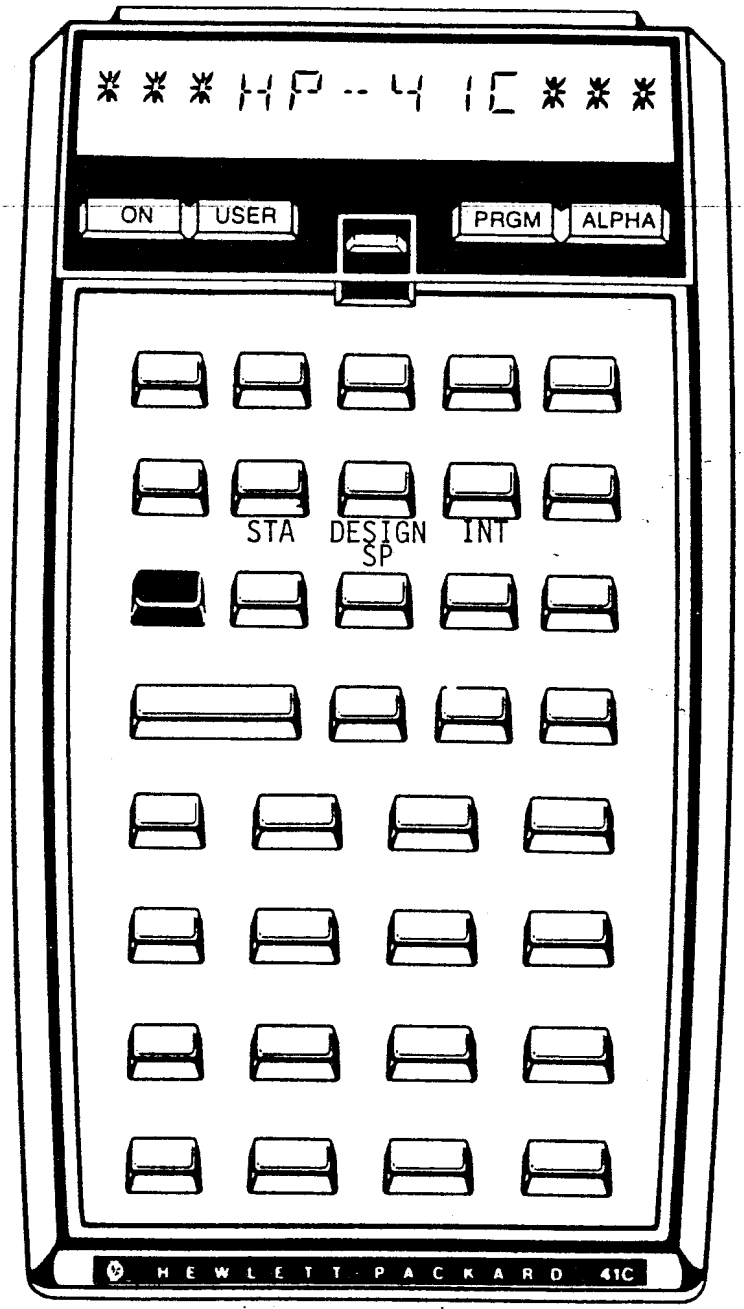
#	INIT S/C	SET INDICATES	CLEAR INDICATES
00	C	Interval execution	No interval execution
01	C	Station outside limits of the vertical curve	Station within limits of the vertical curve
02	C	Vertical P.C. known	Vertical P.C. unknown
05	C	Horizontal curve right	Horizontal curve left
10	C	Vertical curve	No vertical curve
12	C	Double wide print	Normal width print
21	S	Printer enabled	Printer disabled
22	C	Digit entered	No digit entered
24	S	Ignore range error	Display range error
27	S	USER mode in	USER mode out
29	S	Digit grouping	Suppresses decimal point in FIX 0 mode
55	C	Printer connected	No printer

ASSIGNMENTS

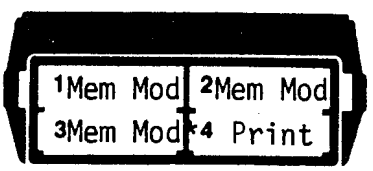
FUNCTION	KEY	FUNCTION	KEY

KEYBOARD CARD LABELING

KEYBOARD



SYSTEM CONFIGURATION



*or Survey Mod

CARD