COMPOSITE BEAM DESIGN

Developed by

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FOR

OLIVETTI P602

Program No. 27

PROGRAM COMMENTARY

Program gives engineer a tool for rapidly designing a composite beam. It is written in accordance with Seventh Edition, AISC Steel Handbook. This Commentary will help the designer understand input and output items used in the program.

Composite beam design program requires 16 input items, if cover plate on steel beam is not included. When cover plate is used, 23 input items are required. Commentary explains the 23 input items, the majority of the 31 output items and states assumptions behind the program.

Input item #1 is concrete slab thickness. Any slab thickness that has known composite properties can be input. The units are inches.

Input item #2 is span length of the composite beam, in feet.

Input item #3 is uniform live load in k/ft.

Input item #4 is allowable bending stress for steel member, which is $f_b = .66\ F_y$ where F_y is the yield strength of the steel member. Both terms have ksi as units.

Input item #5 is uniform dead load, including weight of the slab. It would also include weight of the steel beam and plate. Units should be k/ft.

Input item #6 is modular ratio, which is the ratio of modulus of elasticity of steel to modulus of elasticity of concrete. Modulus of elasticity for steel is 29000 ksi. Modulus of elasticity of concrete is defined as $w_c^{1.5}(.033)\sqrt{f'_c}$ where w_c is the weight of the concrete (lbs/ft^3) and f'_c is the compressive strength of the concrete in 28 days.

Input item #7 is transformed section modulus for the composite section, with respect to the bottom. Its symbol is S_{tr} in the steel tables, pages 2-152 thru 2-191 AISC Manual.

Input item #8 is transformed section modulus for composite section, with respect to the top. Its symbol is S_t as found on pages 2-152 thru 2-191.

Input item #9 is bare section modulus for the bottom. Its symbol is S_s in the AISC Manual.

Input item #10 y_{bs} is centroid of the bare section with respect to base for unshored beams, and is the composite centroid with respect to base for shored beams.

PROGRAM COMMENTARY

Input item #11 y_b is centroid of composite section with respect to the bottom.

Input item #12 b is the effective width of the slab. The value of b should be the smallest of the three computed by equations below.

Interior Beams	Spandrel Beams
b = L/4	b = L/12
b = (beam spacing)	b = (beam spacing)/2
b = 16(t) + b_f	b = 6(t) + b_f

The term b_f is width of the flange of steel member. L is the span length. Care should be taken in solving for the effective width "b". All values in the above listed equations should have units in inches so that "b" will come out in inches. The span length is entered in feet. The concrete slab thickness "t" is entered in inches.

Input item #13 is the flange thickness of steel member, in inches.

Input item #14 is weight per foot of steel section, in pounds. If beam is coverplated, W_s is weight of section and coverplate. Units are lbs./ft.

Input item #15 - C_s - is stud coefficient used in computing N_s. (This coefficient can be found in AISC Manual, Page 2-142).

Input item #16 - C_c - is stud coefficient used in computing N_c. (Page 2-142 of AISC Steel Manual lists the values.) To aid in reading the tables, the following example is shown.

When f'c = 4 ksi, fy = 50 psi and a 3/4 x 3 stud size is desired - N_s = .553 N_c = .128

Input item #17 is web thickness of the steel member, in inches. (Used for shear check on web).

Input item #18 is depth of steel member, in inches. Do not add plate thickness to member depth.

Input item #19 is the theoretical coverplate length factor k. (This value is listed on pages 2-168 thru 2-191, AISC Manual.)

Input item #20 is 12Q/I factor which is listed on pages 2-168 thru 2-191 AISC Manual.

PROGRAM COMMENTARY

Input item #21 - z is weld capacity. If 5/16" weld is used with E70 electrode, z = (.795 k/in.(16th)) 5 (16th) = 4.64 k/in.

If E60 electrode is used, z = (.795 k/in. (16th)) 5 (16th) = 3.97 k/in. Thus, a decision to use E60 or E70 electrode weld must first be made; then the size weld is multiplied by the proper factor - .928 or .795.

Input item #22 - w_p - is the width of the coverplate to be added to wide flange, in inches.

Input item #23 is length of intermediate weld to be made on bottom flange, to attach steel plate.

Output item #3 is number of studs to be used in connecting slab to steel member. They should be equally spaced on the member.

Output item #9 is required section modulus for transformed composite section with respect to the bottom, and steel stressed to allowable (f_b).

Output item #10 is required section modulus for steel section with respect to bottom. The steel is stressed to allowable (f_b) if the modulus is used.

Output item #11 - the maximum S_{tr} for unshored construction is computed. If required value computed in Output item #10 is larger, consideration should be given to shoring the beam. Deflection check will aid in this decision.

Output item #12 is actual compressive stress in the concrete. This value should be less than .45 f'c, where f'c is compressive strength of concrete at 28 days.

Output items #13 and #14 are ratios that allow the designer to quickly check stresses in steel and concrete. Charts on even pages - 2-152 thru 2-190 - are used with this output.

Output items #18 and #19 are allowable web shear and actual web shear, respectively.

COMPUTER INSTRUCTIONS

Program Composite Beam Design   Program No. 27

Upper decimal wheel 0
Lower decimal wheel 4

INPUT		OUTPUT	
1.	"Record Program" button out.	1.	Number of studs N_s
2.	"Print Program" button out.	2.	Number of studs N_c
3.	Depress "general reset" key	3.	Number of studs to use N
4.	Enter Card 27 A	4.	Maximum stud diameter (in)
5.	Depress "second side" switch	5.	Total uniform load (k/ft)
6.	Enter Card 27 B	6.	Moment due to dead load (k-ft)
7.	Release second side switch	7.	Moment due to live load (k-ft)
8.	Depress "V"	8.	Moment due to total load (k-ft)
9.	Enter slab thickness (in.)	9.	Required S_{tr} (in.^{3})
10.	Depress "S"	10.	Required S_s (in.^{3})
11.	Enter span length (ft)	11.	Maximum S_{tr} for unshored construction (in.^{3})
12.	Depress "S"	12.	Concrete stress (ksi)
13.	Enter uniform live load (k/ft)	13.	Ratio M_{ll}/M_{dl}
14.	Depress "S"	14.	Ratio S_{tr}/S_t
15.	Enter allowable steel stress (ksi)	15.	Steel stress f_{dl} (ksi)
16.	Depress "S"	16.	Steel stress f_{ll} (ksi)
17.	Enter uniform dead load (k/ft)	17.	Total stress $f_{dl} + f_{ll}$

COMPUTER INSTRUCTIONS

18.	Enter modular ratio n	18.	Deflection due to deal load (in)
19.	Depress "S"	19.	Deflection due to live load (in)
20.	Enter transformed section modulus for bottom (in.^{3})	20.	Shear in web (k)
21.	Depress "S"	21.	Maximum reaction (k)
22.	Enter transformed section modulus for top (in.^{3})	22.	Length of cover plate (ft.)
23.	Depress "S"	23.	Distance from support to cut off point (ft)
24.	Enter bare section modulus for bottom (in.^{3})	24.	Moment at cut off point (k-ft)
25.	Depress "S"	25.	Force for welds (k)
26.	Enter bare section centroid with respect to bottom (in)	26.	Weld length (in.)
27.	Depress "S"	27.	Weld length required by spec. (in.)
28.	Enter composite section centroid bottom (in)	28.	Vertical shear at cut off point (k)
29.	Depress "S"	29.	Horizontal shear at cut off (k/in)
30.	Enter effective width of slab (in)	30.	Required spacing for welds (in)
31.	Depress "S"	31.	Maximum spacing allowed (in)
32.	Enter flange thickness of steel section (in)		
33.	Depress "S"		
34.	Enter weight per foot of beam (lbs/ft)		
35.	Depress "S"		
36.	Enter stud coefficient N_s computations		

COMPUTER INSTRUCTIONS

INPUT

37. Depress "S"

38. Enter stud coefficient N_C computations

39. Depress "S"

40. Enter Web thickness (in)

41. Depress "S"

42. Enter depth of steel section (in)

43. Depress "S"

44. Enter theoretical cover plate length factor

45. Depress "S"

46. Enter term 12Q/I (1/ft)

47. Depress "S"

48. Enter weld capacity (k/in) - See Chart

49. Depress "S"

50. Enter width of cover plate (in.)

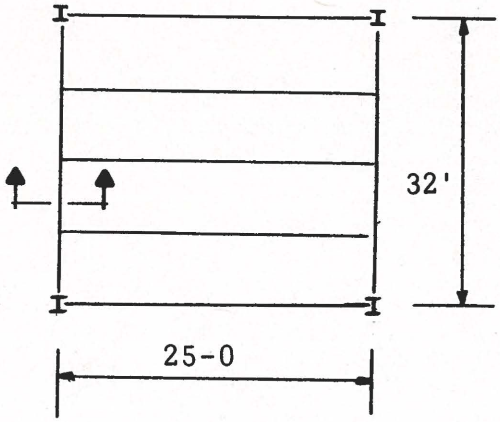
51. Depress "S"

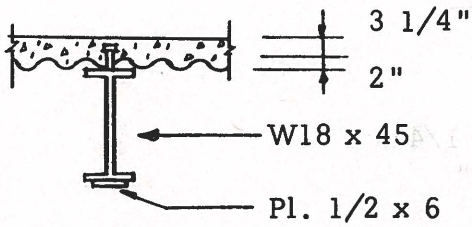
52. Enter length of intermediate welds (in)

COMPOSITE BEAM DESIGN

SAMPLE PROBLEM:

Given:





DL = 1.2489 k/ft.   LL = 1.5 k/ft.
Span length = 31 ft.
f'c = 3 ksi   A36 Steel

Conclusions:

Use 48 - 3/4 ϕ" Studs.
Unshored construction ok $177 < 209$
Stress ok, $165 < 177$
$75 < 118$
Dead load deflection = .98 in.
Live load deflection = .35 in.
Web shear ok $42.6 < 86.2$ kips
Use W18 x 45 with Plate on flange
PL. 1/2 x 6"   Length = 17-8

COMPOSITE BEAM DESIGN

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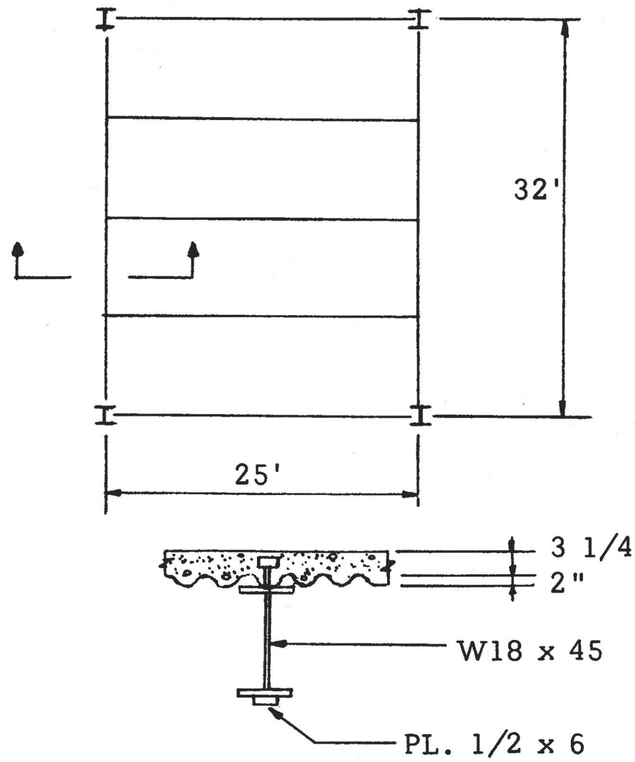

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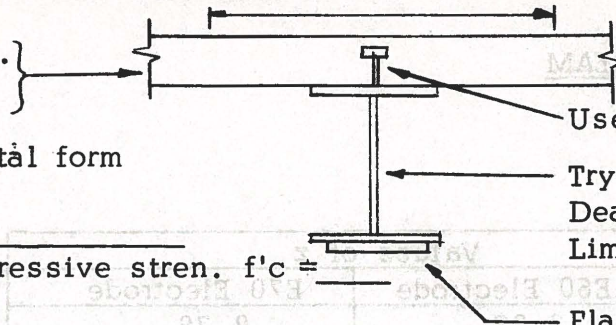
COMPOSITE BEAM



Reg. wt. conc.
Lt. wt. conc.

Use ______ studs

Plywood or metal form

Try –

Dead load deflection
Limit = ________ in.

Grade steel ____________

Concrete compressive stren. f'c = ______

Flange plate if required.

Data: C.P. 27

Slab thickness (t)	=	5	in.
Span length (L)	=	31	ft.
Uniform live load (w_{ll})	=	1.5	k/ft.
Allowable steel stress (f_b)	=	24	ksi
Uniform dead load (w_{dl})	=	1.2489	k/ft.
Modular ratio n = Es / Ec	=	10.7	
Transformed section modulus bottom (S_{tr})	=	177	$in.^3$
Transformed section modulus top (S_t)	=	537	$in.^3$
Bare section modulus for bottom (S_s)	=	118	$in.^3$
Bare section centroid respect to bottom (y_{bs})	=	7.73	in.
Composite section centroid-bottom (y_b)	=	17.58	in.
Effective width of slab (b)	=	85	in.
Flange thickness of steel section (t_f)	=	0.499	in.
Weight per foot of beam including PL. (W_s)	=	51	lbs/ft.
Stud coefficient for N_s (C_s)	=	0.461	
Stud coefficient for N_c (C_c)	=	0.111	

Computations:

$N_s = W_s(C_s)$	=	23.5110	studs
$N_c = t(b)C_c$	=	47.1750	studs
Use N studs equally spaced where N	=	48.0000	studs
Maximum stud diameter	=	1.2475	in.
$w_t = w_{dl} + w_{ll}$	=	2.7489	k/ft.
$M_{dl} = w_{dl}(L)(L)/8$	=	150.0241	k-ft.
$M_{ll} = w_{ll}(L)(L)/8$	=	180.1875	k-ft.
$M_t = M_{dl} + M_{ll}$	=	330.2116	k-ft.
Required $S_{tr} = 12(M_t)/f_b$	=	165.1058	$in.^3$
Required $S_s = 12(M_{dl})/f_b$	=	75.0120	$in.^3$
Max. S_{tr} for unshored const. $= (1.35 + .35\frac{M_{ll}}{M_{dl}})S_s$	=	208.8954	in.
Concrete stress $= f_t = 12(M_t)/nS_t$	=	0.6896	ksi.
M_{ll}/M_{dl}	=	1.2010	
S_{tr}/S_t	=	0.3296	
Steel stress: $f_{dl} = M_{dl}(12)/S_s$	=	15.2566	ksi.
$f_{ll} = M_{ll}(12)/S_{tr}$	=	12.2161	ksi.
$f_{tot} = f_{dl} + f_{ll}$	=	27.4727	ksi.
Deflection check $D_{dl} = M_{dl}(L)^2/160S_s y_{bs}$	=	0.9878	in.
$D_{ll} = M_{ll}(L)^2/160S_{tr}y_b$	=	0.3478	in.

COMPOSITE BEAM

Weld Size	Values of z	
	E60 Electrode	E70 Electrode
3/16	2.38	2.78
1/4	3.18	3.71
5/16	3.97	4.64
3/8	4.77	5.57
7/16	5.56	6.50
1/2	6.36	7.42

Data: C.P. 27 continued.

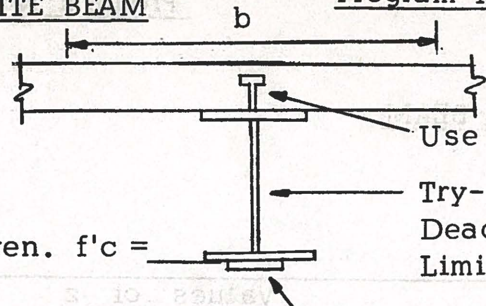
Web thickness of steel section (t_w)	=	0.335	in.
Depth of steel section (d)	=	17.86	in.
Theoretical cover plate length factor (k)	=	0.57	
12 Q/I	=	0.21	1/ft.
Weld capacity (z)	=	4.64	k/in.
Width of cover plate (w_p)	=	6	in.
Length of intermediate welds (j)	=	1.5	in.

Computations:

Check shear in web.			
$F_v = .4f_y(t_w)(d)$	=	86.1566	k.
$V_{max.} = w_t(L)/2$	=	42.6079	k.
Length of cover plate = kL	=	17.6700	ft.
Distance from support X = (L-kL)/2	=	6.6650	ft.
Moment at cut-off point = $w_t(X)(L-X)/2$	=	222.9257	k-ft.
Force for welds F = M(12Q)/I	=	46.8143	k.
Weld length = F/z	=	5.5000	in.
Weld length required by specifications = $2w_p$	=	12.0000	in.
Vertical shear at cut off $V_v = w_t(L/2-X)$	=	24.2865	k.
Horizontal shear $V_h = V_v(12Q)/(12I)$	=	0.4250	k/in.
Required spacing for welds = $z(j)\ 2/V_h$	=	32.7529	in.
Maximum spacing allowed = $24\ t_f$	=	11.9760	in.

COMPOSITE BEAM

Program No. 27 A & B



Reg. wt. conc.
Lt. wt. conc.

Plywood or metal form

Grade steel ____________

Concrete compressive stren. f'c = ____

Use ____________ studs

Try-

Dead load deflection

Limit = __________ in.

Flange plate if required

Data: C.P. 27

Slab thickness (t)	=	in.
Span length (L)	=	ft.
Uniform live load (w_{ll})	=	k/ft.
Allowable steel stress (f_b)	=	ksi
Uniform dead load (w_{dl})	=	k/ft.
Modular ratio n = Es / Ec	=	
Transformed section modulus bottom (S_{tr})	=	in.^{3}
Transformed section modulus top (S_t)	=	in.^{3}
Bare section modulus for bottom (S_s)	=	in.^{3}
Bare section centroid respect to bottom (y_{bs})	=	in.
Composite section centroid-bottom (y_b)	=	in.
Effective width of slab (b)	=	in.
Flange thickness of steel section (t_f)	=	in.
Weight per foot of beam including PL. (W_s)	=	lbs/ft.
Stud coefficient for N_s (C_s)	=	
Stud coefficient for N_c (C_c)	=	

Computations:

$N_s = W_s(C_s)$	=	studs
$N_c = t(b)C_c$	=	studs
Use N studs equally spaced where N	=	studs
Maximum stud diameter	=	in.
$w_t = w_{dl} + w_{ll}$	=	k/ft.
$M_{dl} = w_{dl}(L)(L)/8$	=	k-ft.
$M_{ll} = w_{ll}(L)(L)/8$	=	k-ft.
$M_t = M_{dl} + M_{ll}$	=	k-ft.
Required $S_{tr} = 12(M_t)/f_b$	=	in.^{3}
Required $S_s = 12(M_{dl})/f_b$	=	in.^{3}
Max. S_{tr} for unshored const. = $(1.35+.35\frac{M_{ll}}{M_{dl}})S_s$	=	in.^{3}
Concrete stress = $f_t = 12(M_t)/nS_t$	=	ksi.
M_{ll}/M_{dl}	=	
S_{tr}/S_t	=	
Steel stress: $f_{dl} = M_{dl}(12)/S_s$	=	ksi.
$f_{ll} = M_{ll}(12)/S_{tr}$	=	ksi.
$f_{tot} = f_{dl} + f_{ll}$	=	ksi.
Deflection check: $D_{dl} = M_{dl}(L)^2/160S_s y_{bs}$	=	in.
$D_{ll} = M_{ll}(L)^2/160S_{tr}y_b$	=	in.

COMPOSITE BEAM

Weld Size	Values of z	
	E60 Electrode	E70 Electrode
3/16	2.38	2.78
1/4	3.18	3.71
5/16	3.97	4.64
3/8	4.77	5.57
7/16	5.56	6.50
1/2	6.36	7.42

Data: C.P. 27 continued.

Web thickness of steel section (t_w)	=	in.
Depth of steel section (d)	=	in.
Theoretical cover plate length factor (k)	=	
12Q/I	=	1/ft.
Weld capacity (z)	=	k/in.
Width of cover plate (w_p)	=	in.
Length of intermediate welds (j)	=	in.

Computations:

Check shear in web.		
$F_v = .4f_y(t_w)(d)$	=	k.
$V_{max.} = w_t(L)/2$	=	k.
Length of cover plate = kL	=	ft.
Distance from support X = (L-kL)/2	=	ft.
Moment at cut-off point = $w_t(X)(L-X)/2$	=	k-ft.
Force for welds F= M(12Q)/I	=	k.
Weld length = F/z	=	in.
Weld length required by specifications = $2w_p$	=	in.
Vertical shear at cut off $V_v = w_t(L/2-X)$	=	k.
Horizontal shear $V_h = V_v(12Q)/(12I)$	=	k/in.
Required spacing for welds = $z(j)2/V_h$	=	in.
Maximum spacing allowed = 24 t_f	=	in.