ANALYSIS OF MULTI-STORY STEEL FRAMES

by

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INTRODUCTION

For an exact elastic analysis of a statically indeterminate structure to be performed, the structural dimensions, loads and member properties must be known. To obtain the member properties, the members must be designed based on the forces imposed on them; however, these member forces are the end products of the exact analysis. To cope with this situation a preliminary, approximate analysis is often performed first, a preliminary design of the members is then carried out based on the forces obtained from the preliminary analysis, and the resulting member properties are used for an exact analysis. Results of the latter can then be used to modify as required the members chosen during the preliminary design.

The purpose of this report is to examine the assumptions commonly used in a preliminary, approximate analysis. A six story, three bay steel frame is selected as an example, gravity and wind loads are assumed, a preliminary analysis is performed, the preliminary design of the members is carried out, and the resulting member properties used in an exact, computer-based analysis. The results of the latter are compared with the results of the preliminary analysis to determine the adequacy of the assumptions upon which the preliminary analysis is based.

DEFINITION OF PROBLEM

Frame

The six story frame selected as an example for this report is shown in Fig. 1. The column supports are assumed to be pinned, and girder-column connections are assumed to be rigid. The frame is an interior bent, and the spacing between bents is 24 feet.

Loading

The following loads are assumed:

1. Roof dead load = 60 psf.
2. Roof live load = 35 psf.
3. Floor dead load = 80 psf. (including girder dead load)
4. Floor live load = 100 psf.
5. Exterior wall load = 45 psf.
6. Wind load = 40 psf.
7. Column dead load = 250 lb./ft. (including insulation)

These loads are summarized in Figs. 2 and 3.

Two loading conditions are considered for the design: gravity loads only and gravity plus wind load. For the latter condition, the AISC Specification (1) permits a one-third increase in allowable stresses. In order to compare member forces due to the two loading conditions directly, it is convenient to use three-fourths of the gravity plus wind loads rather than the corresponding one-third increase in allowable stresses. Therefore, the two loading cases considered here will be gravity load and 3/4 (gravity plus wind load).

Live Load Reduction

Live load reduction is used as provided in Uniform Building Code (2). In general, the reduction is the smallest of:

$$R_1 = 40\%$$

$$R_2 = 23.1\ (1 + \frac{DL}{LL})\%$$

$$R_3 = 0.08\ (\text{area supported})\%$$

For the girders R_2 and R_3 are:

$$R_2 = 23.1\ (1 + \frac{80}{100}) = 41.58\%$$

$$R_3 = 0.08\ (24 \times 24) = 46.08\%$$

Therefore $R_1 = 40\%$ controls. Figure 4 shows the reduced floor loads for the girders.

For the columns the reduction is the same as for the girders except that $R_1 = 60\%$. The reduction for Column A at Level 2 is:

$$R_1 = 60\%$$

$$R_2 = 23.1\ (1 + \frac{80}{100}) = 41.58\%$$

$$R_3 = 0.08\ (15 \times 24) = 28.8\%$$

So, R_3 controls. For Level 3 and below R_2 will control:

$$R_2 = 41.58\%$$

$$R_3 = 0.08\ (15 \times 24 \times 2) = 57.6\%$$

For Columns B and C the reduction is 41.58%, and for Column D at Level 2, R_3 = 23.04% controls, while for lower levels, R_2 = 41.58% controls. The reduced floor loads used to calculate the column axial loads are summarized in Fig. 5.

APPROXIMATE ANALYSIS

For the approximate analysis of wind load on the structure the portal method is used (3). This method is based on two major assumptions. First, the inflection points are assumed to be at the mid-points of the members. Second, column shears are assumed to be proportional to the width of aisle supported. The portal method calculations are shown in Table 1.

For the approximate analysis of gravity loads it is assumed that the girder end moments are 0.045 wL^2 (5), where w is the uniformly distributed load on the girder and L is the span, taken as the center-to-center distance between columns. Values of the maximum moments and shears for the girders are summarized in Table 2. These maximums are the controlling values of the two conditions: 3/4 (gravity + wind) or gravity load only.

It is assumed that axial loads on the columns are one-half of the span loads which are supported by the columns. It is also assumed that the wall loads are applied at the exterior surfaces of the columns, and that the column dead loads are applied at the top of each column segment. The column axial loads are shown in Table 3; the controlling values are the larger of the two: gravity of 3/4 (gravity plus wind).

Column end moments are calculated in Fig. 6 based on the assumption that one-half of the total moment on a girder-column joint will be resisted by the column above the joint and one-half by the column below the joint. The controlling values of the column end moments are summarized in Table 4.

PRELIMINARY DESIGN

Using the member forces from the preliminary analysis the frame members are designed using A36 steel and based on the AISC Specification (1). It is also assumed that a 3% overstress is acceptable.

Girder Design

Assuming that the slab will provide full lateral support to the compression flange and using the maximum moments of Table 2, the girders are designed for an allowable bending stress of $F_b = 24$ ksi. The results are shown in Fig. 7.

Column Design

W14 sections are used for all column sections. Column splices are assumed at two story intervals, and it is assumed that the effective length factor is one for buckling out of the plane of the frame. The design calculations are presented in Table 5. Section A of Table 5 contains the maximum moments and axial forces, Section B shows the trial member and its properties, and Section C presents the calculated axial and bending stresses. Section D shows the check of Formula (1.6-1b), of the AISC Specification (1), and Section E contains the calculation of effective length factors. Section F presents the allowable axial stress, and Section G is a check of Formula (1.6-1a) of the AISC Specification (1). The final column sections are summarized in Fig. 7.

STRUDL ANALYSIS

The Structural Design Language, known by the acronym STRUDL, is a series of computer programs for solving problems in structural engineering (4). In this problem the stiffness analysis is carried out by computer using STRUDL. For this purpose the joints and members are numbered as shown in Fig. 1. Then joint coordinates, member incidences, member properties and loadings are input into the computer. Due to different live load reduction factors for girders and columns, extra joint loads are required. These extra joint loads are shown in Fig. 8, and a summary of all the loads is presented in Fig. 9.

STRUDL output is obtained for three loadings: wind, gravity and 3/4 (gravity + wind). For each loading the member shears, axial forces and moments are printed. The portions of the STRUDL output which show these results are reproduced in the Appendix.

COMPARISON OF RESULTS AND DISCUSSION

There are two major assumptions in the portal method for analysis of wind loads.

First it is assumed that the column shears are proportional to the width of aisle supported. This assumption is compared with the STRUDL results in Table 7, and the maximum difference is 1.68%. Therefore the shear distribution assumption is very accurate for this structure and loading.

The second assumption is that the inflection points are at the mid-lengths of the members. Calculated inflection point positions based on the STRUDL girder end moments and column end moments are shown in Figs. 10 and 11, respectively. For the girders, the difference between the assumed location of inflection points and STRUDL results is relatively small with the maximum difference equal to 7%. For the columns, this difference is quite large in some cases, with a maximum at 52.3% for column D_{1-2} and 10.4% for C_{3-4}. Therefore, the assumption on location of inflection points for the columns is not very good.

For gravity loading it was assumed in the preliminary analysis that the girder end moments are 0.045 wL^2, but the STRUDL results shows that this is not a good assumption. The comparison is shown in Fig. 12, where the difference ranges from 27.7% to 52.3%. To design the girders, positive moments equal to 0.08 wL^2 were used, but with large changes in negative end moments some of the girders would have to be redesigned. The revisions in the girder design are shown in Table 7. Five girders have to be changed to the next larger section, and one girder has to be changed to a section three sizes larger. Also, two sections have to be reduced to the next smaller section, and one member has to change three sizes smaller.

Also, it was assumed that each column carries one-half of spans loads which are supported by the column. In Fig. 13 the axial loads based on this assumption are compared to the column axial loads from the STRUDL analysis. The average difference is within 3%; therefore, this is a reasonable assumption.

The last assumption made in the preliminary load analysis was that 1/2 of the unbalanced joint moment is taken by column above the joint and 1/2 by the column below the joint. To check this assumption, Fig. 14 is drawn. For Columns A and D the difference between assumption and STRUDL result is fairly small, with an average difference of about 13%, but for Column B it is 21.8% and for Column C it is 61.0%. Therefore, the assumption is not very accurate in these latter cases.

SUMMARY

Five major assumptions were made in the preliminary analysis:

1. Column shear due to wind load is proportional to the width of aisle supported by the column.
2. Inflection points in the wind load moment diagram are at the midpoints of the members.
3. Girder end moments due to gravity loads are $0.045\ wL^2$.
4. Columns carry axial loads equal to the span loads which are supported by the column under gravity loads.
5. The column ends will resist one-half of the unbalanced joint moments due to gravity loads.

In conclusion, it is easy to see that Assumptions one and four are close and reasonable since the percent differences between the preliminary analysis and the STRUDL results are small. For the girders, Assumption two is relatively close, but for Columns D and C the difference is large, while for Columns A and B the difference is smaller. Therefore, Assumption two is not very good. Assumption three is not close, and most of the girder end moments from the STRUDL results are two times larger than those assumed; therefore it is not a reasonable assumption.

These conclusions are limited to the structural geometry and loading of this problem, and could change if other geometry and loading were used.

RECOMMENDATIONS FOR FURTHER STUDY

For additional study in the future it is possible to use the STRUDL program for a preliminary analysis, and use the output of this analysis to design the members. Then the properties of these members could be used as input data for the stiffness analysis. After the first stiffness analysis the results could be used to redesign the members, with the resulting member properties used as input data for a second STRUDL analysis.

A key factor in this problem is the assumed geometry of the structure and the loading. The effect of changes in these two assumptions on the accuracy of the preliminary analysis assumptions could be investigated.

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NOMENCLATURE

A = Cross-sectional area, (in.^{2})

C_m = Moment reduction coefficient

F_a = Allowable axial stress, (ksi.)

F_b = Allowable bending stress, (ksi.)

F_e' = Euler stress divided by factor of safety, (ksi.)

F_y = Specified minimum yield stress of the type of steel being used, (ksi.)

F' = The theoretical maximum yield stress, (ksi.) based on the width-thickness ratio of one-half of the unstiffened compression flange

F''' = The theoretical maximum yield stress (ksi.) based on the depth-thickness ratio of the web for which a particular shape may be considered "compact" for combined bending and axial stresses

G = Nomograph designation of end condition used in column design

I = Moment of inertia of a section, (in.^{4})

K = Effective length factor

L = Span length, (ft.)

L_c = Maximum unbraced length of the compression flange at which the allowable bending stress may be taken at 0.66 F_y (ft.)

L_u = Maximum unbraced length of the compression flange at which the allowable bending stress may be taken at 0.6 F_y (ft.)

M = Moment (Kip-ft.)

P = Applied load (Kips)

S = Elastic section modulus (in.^{3})

f_a = Computed axial stress (ksi.)

NOMENCLATURE (continued)

f_b = Computed bending stress (ksi.)

r_x = Radius of gyration with respect to the x-x axis (in.)

r_y = Radius of gyration with respect to the y-y axis (in.)

TABLES

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

QUANTITY	WIND SHEAR		COLUMN			
	INCREMENT	TOTAL	A	B	C	D
Aisle width (ft)			15	27	24	12
% of total shear			19.23	34.61	30.77	15.39
Level 1-2	5.76	5.76				
Column shear (K)			11.1	1.99	1.77	0.89
Column moment (K')			-6.66	-11.94	-10.62	-5.34
Girder moment (K')			6.66	5.28	5.34	
Girder shear (K)			0.44	0.44	0.44	
Column thrust (K)			0.44	0.00	0.00	0.44
Level 2-3	11.52	17.28				
Column shear (K)			3.32	5.98	5.32	2.66
Column moment (K')			-19.92	-35.88	-31.91	-15.96
Girder moment (K')			26.58	21.23	21.30	
Girder shear (K)			1.77	1.77	1.77	
Column thrust (K)			2.21	0.00	0.00	2.21
Level 3-4	11.52	28.8				
Column shear (K)			5.54	9.97	8.86	4.43
Column moment (K')			-33.24	-59.81	-53.16	-26.58
Girder moment (K')			53.16	42.53	42.54	
Girder shear (K)			3.54	3.54	3.54	
Column thrust (K)			5.75	0.00	0.00	5.75
Level 4-5	11.52	40.32				
Column shear (K)			7.75	13.95	12.41	6.21
Column moment (K')			-46.5	-83.7	-74.46	-37.26
Girder moment (K')			79.74	63.78	63.84	
Girder shear (K)			5.32	5.32	5.32	
Column thrust (K)			11.07	0.00	0.00	11.07
Level 5-6	11.52	51.84				
Column shear (K)			9.97	17.94	15.95	7.98
Column moment (K')			-59.82	-107.64	-95.7	-47.88
Girder moment (K')			106.32	85.0	85.2	
Girder shear (K)			7.1	7.1	7.1	
Column thrust (K)			18.16	0.00	0.00	18.16
Level 6-7	11.52	63.36				
Column shear (K)			12.18	21.93	19.50	7.75
Column moment (K')			-146.1	-263.2	-234.0	-117.1
Girder moment (K')			205.99	164.8	164.9	
Girder shear (K)			13.74	13.74	13.74	
Column thrust (K)			31.89	0.00	0.00	31.89
Shear at level 7	5.76	69.12	13.29	23.92	21.27	10.64

Table 1: Portal Method Calculations

Member	M_g (k-ft.)	$3/4(M_g+M_w)$ (k-ft.)	V_g (k)	$3/4(V_g+V_w)$ (k)
1	164.1*	-74.3	34.2*	25.9
2	241.9*	-122.0	50.4*	39.1
3	241.9*	-141.9	50.4*	40.5
4	241.9*	-161.9	50.4*	41.8
5	241.9*	-181.8	50.4*	43.1
6	241.9	-256.6*	50.4*	48.1
7	105.1*	-48.3	27.4*	20.9
8	154.8*	-81.3	40.3*	31.6
9	154.8*	-97.2	40.3*	32.9
10	154.8*	-113.2	40.3*	34.2
11	154.8*	-129.1	40.3*	35.6
12	154.8	-188.9*	40.3	40.5*
13	105.1*	-48.3	27.4*	20.9
14	154.8*	-81.3	40.3*	31.6
15	154.8*	-97.2	40.3*	32.9
16	154.8*	-113.2	40.3*	34.2
17	154.8*	-129.1	40.3*	35.6
18	154.8	-188.9*	40.3	40.5*

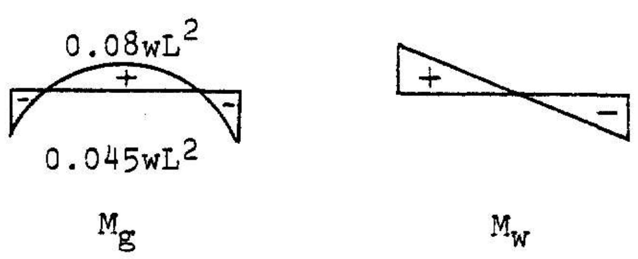


Table 2: Maximum Girder Moment (controlling values are indicated with asterisks)

Column	A		B		C		D	
Level	P_g (k)	$3/4(P_g+P_w)$ (k)	P_g (k)	$3/4(P_g+P_w)$ (k)	P_g (k)	$3/4(P_g+P_w)$ (k)	P_g (k)	$3/4(P_g+P_w)$ (k)
1-2	37.2*	28.2	64.6*	48.4	57.7*	43.3	30.4*	23.2
2-3	102.9*	78.9	157.2*	117.9	140.4*	105.3	86.2*	66.3
3-4	168.7*	130.9	249.8*	187.4	223.1*	167.3	141.9*	110.8
4-5	234.5*	184.2	342.5*	256.9	305.8*	229.3	197.8*	156.6
5-6	300.2*	238.8	435.1*	326.3	388.4*	291.3	253.6*	203.8
6-7	366.0*	298.4	527.8*	395.8	471.1*	353.3	309.4*	263.9

Table 3: Column Axial Loads (controlling values are indicated with asterisks)

Column	A		B		C		D	
Level	M_g (k-ft.)	$3/4(M_g+M_w)$ (k-ft.)	M_g (k-ft.)	$3/4(M_g+M_w)$ (k-ft.)	M_g (k-ft.)	$3/4(M_g+M_w)$ (k-ft.)	M_g (k-ft.)	$3/4(M_g+M_w)$ (k-ft.)
1-2	112.3*	89.2	-37.2*	36.9	0	7.9*	-75.1*	60.3
2-3	78.9*	74.6	-27.4	47.5*	0	23.9*	-51.5*	50.6
3-4	78.9	84.2*	-27.4	65.4*	0	39.9*	-51.5	58.6*
4-5	78.9	94.1*	-27.4	83.4*	0	55.8*	-51.5	66.6*
5-6	78.9	104.1*	-27.4	101.3*	0	71.8*	-51.5	74.6*
6-7	78.9	168.8*	-27.4	218.0*	0	175.5*	-51.5	126.5*

Table 4: Column End Moments (controlling values are indicated with asterisks)

Sec	Column	A_{2-3}	A_{1-2}	B_{2-3}	B_{2-3}	C_{2-3}
A	Loading	gravity	gravity	gravity	3/4(g+w)	3/4(g+w)
	M (k')	78.96	112.29	27.44	47.49	23.93
	P (k)	102.96	37.20	157.20	117.90	105.30
B	Try. Sec.	W14X48	W14X48	W14X43	W14X43	W14X43
	I (in^4)	485.0	485.0	429.0	429.0	429.0
	S (in^3)	70.2	70.2	62.7	62.7	62.7
	A (in^2)	14.1	14.1	12.6	12.6	12.6
	r_x (in)	5.86	5.86	5.82	5.82	5.82
	r_y (in)	1.91	1.91	1.89	1.89	1.89
C	f_a=P/A (ksi)	7.30	2.64	12.48	9.36	8.36
	f_b=M/S (ksi)	13.50	19.19	5.25	9.09	4.58
	F' (ksi)	---	---	---	---	---
	F''' (ksi)	---	---	33.5	33.5	33.5
	L_c (ft)	8.5	8.5	8.4	8.4	8.4
	L_u (ft)	16.0	16.0	14.3	14.3	14.3
	F_b (ksi)	22.0	22.0	22.0	22.0	22.0
D	$f_a/0.6F_y$	0.338	0.122	0.578	0.433	0.387
	f_b/F_b	0.614	0.872	0.239	0.413	0.208
	Sum	0.952	0.994	0.816	0.847	0.595
	OK	yes	yes	yes	yes	yes
E	G_t	1.57	1.44	0.827	0.827	1.02
	G_b	1.57	1.57	0.827	0.827	1.02
	K_x	1.47	1.46	1.20	1.20	1.33
F	KL/r_x	36.1	35.9	31.18	31.18	32.91
	KL/r_y	75.4	75.4	76.19	76.19	76.19
	F_a (ksi)	15.86	15.86	15.77	15.77	15.77
	F'_e (ksi)	114.61	115.90	153.70	153.70	137.91
G	Part I	0.557	0.166	0.791	0.594	0.530
	Part II	0.460	0.759	0.226	0.374	0.188
	Sum	1.017	0.925	1.017	0.968	0.718
	OK	yes	yes	yes	yes	yes

$$\underbrace{\frac{f_a}{F_a}}_{I} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{II} \leq 1.0$$

C_m=0.85

K_y=1.0

Table 5: Column Design

Table 5 (continued)

Sec	Column	C_{2-3}	D_{2-3}	D_{1-2}	A_{4-5}	A_{4-5}
A	Loading	gravity	gravity	gravity	gravity	gravity
	M (k')	0.00	51.53	75.06	78.96	78.96
	P (k)	1.40	86.16	30.34	234.48	234.48
B	Try. Sec.	W14X43	W14X43	W14X43	W14X68	W14X74
	I (in^4)	429.0	429.0	429.0	724.0	797.0
	S (in^3)	62.7	62.7	62.7	103.0	112.0
	A (in^2)	12.6	12.6	12.6	20.0	21.8
	r_x (in)	5.82	5.82	5.82	6.02	6.05
	r_y (in)	1.89	1.89	1.89	2.46	2.48
C	$f_a=P/A$ (ksi)	11.14	6.84	2.41	11.72	10.76
	$f_b=M/S$ (ksi)		9.86	14.35	9.20	8.46
	F' (ksi)		---	---	---	---
	F''' (ksi)		33.5	33.5	---	---
	L_c (ft)		8.4	8.4	10.6	10.6
	L_u (ft)		14.3	14.3	23.7	25.7
	F_b (ksi)		22.0	22.0	22.0	22.0
D	$f_a/0.6F_y$		0.317	0.111	0.543	0.498
	f_b/F_b		0.448	0.652	0.418	0.385
	Sum		0.765	0.764	0.961	0.88.3
	OK		yes	yes	yes	yes
E	G_t	1.02	2.03	1.67	2.35	2.59
	G_b	1.02	2.03	2.03	2.35	2.59
	K_x	1.33	1.61	1.54	1.69	1.74
F	KL/r_x	32.91	39.84	38.1	40.4	41.41
	KL/r_y	76.19	76.19	76.19	58.54	58.06
	F_a (ksi)	15.77	15.77	15.77	17.57	17.61
	F'_e (ksi)		94.11	102.90	91.53	87.1
G	Part I		0.434	0.153	0.667	0.661
	Part II		0.412	0.568	0.408	0.373
	Sum		0.846	0.721	1.075	0.984
	OK		Yes	yes	no	yes

$$\underbrace{\frac{f_a}{F_a}}_{I} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{II} \leqq 1.0$$

$C_m=0.85$

$K_y=1.0$

Table 5 (continued)

Sec	Column	A_{4-5}	B_{4-5}	B_{4-5}	B_{4-5}	C_{4-5}
A	Loading	3/4(g+w)	gravity	3/4(g+w)	3/4(g+w)	3/4(g+w)
	M (k')	94.11	27.44	83.36	83.30	55.84
	P (k)	184.16	342.48	256.86	256.86	229.32
B	Try. Sec.	W14X74	W14X74	W14X74	W14X78	W14X61
	I (in^4)	797.0	797.0	797.0	851.0	641.0
	S (in^3)	112.0	112.0	112.0	121.0	92.2
	A (in^2)	21.8	21.8	21.8	22.9	17.9
	r_x (in)	6.05	6.05	6.05	6.09	5.98
	r_y (in)	2.48	2.48	2.48	3.00	2.45
C	f_a=P/A (ksi)	8.45	15.71	11.78	11.22	12.8
	f_b=M/S (ksi)	10.08	2.94	8.93	8.27	7.27
	F' (ksi)	---	---	---	---	---
	F''' (ksi)	---	---	---	---	---
	L_c (ft)	10.6	10.6	10.6	12.7	10.6
	L_u (ft)	25.7	25.7	25.5	28.4	21.4
	F_b (ksi)	22.0	22.0	22.0	24.0	22.0
D	$f_a/0.6F_y$	0.391	0.727	0.545	0.512	0.593
	f_b/F_b	0.458	0.134	0.406	0.345	0.330
	Sum	0.849	0.861	0.951	0.866	0.923
	OK	yes	yes	yes	yes	yes
E	G_t	2.59	1.54	1.54	1.64	1.52
	G_b	2.59	1.54	1.54	1.64	1.52
	K_x	1.74	1.48	1.48	1.49	1.48
F	KL/r_x	41.41	35.22	35.22	35.23	35.64
	KL/r_y	58.06	58.06	58.06	48.00	58.78
	F_a (ksi)	17.61	17.61	17.61	18.53	17.55
	F'_e (ksi)	87.10	120.4	120.40	120.40	16.71
G	Part I	0.480	0.892	0.669	0.606	0.730
	Part II	0.431	0.131	0.382	0.323	0.315
	Sum	0.911	1.020	1.051	0.929	1.050
	OK	yes	yes	no	yes	no

$$\underbrace{\frac{f_a}{F_a}}_{\text{I}} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{\text{II}} \leqslant 1.0$$

C_m=0.85

K_y=1.0

Table 5 (continued)

Sec	Column	C_{4-5}	C_{4-5}	D_{4-5}	D_{4-5}	D_{4-5}
A	Loading	3/4(g+w)	gravity	gravity	gravity	3/4(g+w)
	M (k')	55.88	0.00	51.53	51.53	66.60
	P (k)	229.32	305.76	197.76	197.76	156.62
B	Try. Sec.	W14X68	W14X68	W14X61	W14X53	W14X61
	I (in^4)	724.0	724.0	641.0	542.0	641.0
	S (in^3)	103.0	103.0	92.2	77.8	92.2
	A (in^2)	20.0	20.0	17.9	15.6	17.9
	r_x (in)	6.02	6.02	5.98	5.9	5.98
	r_y (in)	2.46	2.46	2.45	1.92	2.45
C	f_a=P/A (ksi)	11.47	15.29	11.05	12.68	8.45
	f_b=M/S (ksi)	6.51	---	6.71	7.95	8.67
	F' (ksi)	---		---	---	---
	F''' (ksi)	---		---	---	---
	L_c (ft)	10.6		10.6	8.50	10.6
	L_u (ft)	23.7		21.4	17.6	21.4
	F_b (ksi)	22.0		22.0	22.0	22.0
D	$f_a/0.6F_y$	0.531		0.511	0.587	0.405
	f_b/F_b	0.296		0.305	0.361	0.394
	Sum	0.827		0.816	0.948	0.799
	OK	yes		yes	yes	yes
E	G_t	1.72	1.72	3.04	2.57	3.04
	G_b	1.72	1.72	3.04	2.57	3.04
	K_x	1.51	1.51	1.84	1.72	1.84
F	KL/r_x	36.12	36.12	43.59	41.98	53.59
	KL/r_y	58.54	58.54	58.77	75.00	58.77
	F_a (ksi)	17.57	17.57	17.55	15.90	17.55
	F'_e (ksi)	114.48		78.62	84.73	78.62
G	Part I	0.653		0.630	0.797	0.481
	Part II	0.280		0.302	0.361	0.375
	Sum	0.933		0.932	1.158	0.857
	OK	yes	yes	yes	no	yes

$$\underbrace{\frac{f_a}{F_a}}_{I} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{II} \leq 1.0$$

$C_m = 0.85$

$K_y = 1.0$

Table 5 (continued)

Sec	Column	A6-7	A6-7	B6-7	B6-7	B6-7
A	Loading	3/4(g+w)	gravity	3/4(g+w)	3/4(g+w)	gravity
	M (k')	168.8	78.96	218.0	218.0	27.44
	P (k)	298.4	366.0	359.8	359.8	527.8
B	Try. Sec.	W14X111	W14X111	W14X136	W14X142	W14X142
	I (in^4)	1270.00	1270.0	1590.0	1670.0	1670.0
	S (in^3)	176.0	176.0	216.0	227.0	227.0
	A (in^2)	32.7	32.7	40.0	41.8	41.8
	r_x (in)	6.23	6.23	6.31	6.32	6.32
	r_y (in)	3.73	3.73	3.77	3.97	3.97
C	f_a=P/A (ksi)	9.13	11.19	9.89	9.47	12.63
	f_b=M/S (ksi)	11.51	5.38	12.11	11.52	1.45
	F' (ksi)	---	---	---	---	---
	F''' (ksi)	---	---	---	---	---
	L_c (ft)	15.4	15.4	15.6	16.4	16.4
	L_u (ft)	41.0	41.0	49.2	51.8	51.8
	F_b (ksi)	24.0	24.0	24.0	24.0	24.0
D	$f_a/0.6F_y$	0.422	0.518	0.458	0.438	0.585
	f_b/F_b	0.479	0.224	0.505	0.488	0.060
	Sum	0.902	0.742	0.963	0.919	0.645
	OK	yes	yes	yes	yes	yes
E	G_t	4.12	4.12	2.89	3.03	3.03
	G_b	10.0	10.0	10.0	10.0	10.0
	K_x	2.45	2.45	2.27	2.30	2.30
F	KL/r_x	56.63	56.63	51.80	52.41	52.41
	KL/r_y	38.61	38.61	38.20	36.27	36.27
	F_a (ksi)	17.75	17.75	18.19	18.13	18.13
	F'_e (ksi)	46.57	46.57	55.67	54.38	54.38
G	Part I	0.514	0.630	0.544	0.520	0.697
	Part II	0.507	0.214	0.521	0.494	0.067
	Sum	1.021	0.845	1.065	1.016	0.764
	OK	yes	yes	no	yes	yes

$$\underbrace{\frac{f_a}{F_a}}_{I} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{II} \leq 1.0$$

$C_m=0.85$

$K_y=1.0$

Table 5 (continued)

Sec	Column	C_{6-7}	C_{6-7}	C_{6-7}	D_{6-7}	D_{6-7}
A	Loading	3/4(g+w)	3/4(g+w)	gravity	3/4(g+w)	gravity
	M (k')	175.50	175.50	0.00	126.5	51.53
	P (k)	353.34	353.34	471.12	263.9	309.36
B	Try. Sec.	W14X119	W14X127	W14X127	W14X95	W14X95
	I (in^4)	1370.0	1480.0	1480.0	1060.0	1060.0
	S (in^3)	189.0	202.0	202.0	151.0	151.0
	A (in^2)	35.0	37.3	37.3	27.9	27.9
	r_x (in)	6.26	6.29	6.29	6.17	6.17
	r_y (in)	3.75	3.76	3.76	3.71	3.71
C	$f_a=P/A$ (ksi)	10.10	9.47	12.63	9.46	11.09
	$f_b=M/S$ (ksi)	11.14	10.43		10.05	4.10
	F' (ksi)	---	---		---	---
	F''' (ksi)	---	---		---	---
	L_c (ft)	15.5	13.2		15.40	15.4
	L_u (ft)	43.70	33.5		35.60	35.6
	F_b (ksi)	24.00	24.0		24.00	24.0
D	$f_a/0.6F_y$	0.467	0.439		0.438	0.513
	f_b/F_b	0.464	0.434		0.419	0.171
	Sum	0.932	0.873		0.857	0.684
	OK	yes	yes		yes	yes
E	G_t	2.82	3.05	3.05	4.37	4.37
	G_b	10.00	10.00	10.00	10.00	10.00
	K_x	2.26	2.30	2.30	2.49	2.49
F	KL/r_x	51.99	52.66	52.66	58.11	58.11
	KL/r_y	38.40	38.30	38.30	38.81	38.81
	F_a (ksi)	18.18	18.11	18.11	17.61	17.61
	F'_e (ksi)	55.28	53.16		44.23	44.23
G	Part I	0.555	0.523		0.537	0.630
	Part II	0.482	0.449		0.453	0.194
	Sum	1.040	0.972		0.990	0.824
	OK	no	yes		yes	yes

$$\underbrace{\frac{f_a}{F_a}}_{\text{I}} + \underbrace{\frac{C_m f_{bx}}{\left(1-\frac{f_a}{F'_e}\right)F_b}}_{\text{II}} \leq 1.0$$

$C_m=0.85$

$K_y=1.0$

Level	Col. A	Col. B	Col. C	Col. D	Total
1-2	1.03 17.9%	2.12 36.8%	1.84 31.9%	0.77 13.4%	5.76
2-3	4.05 23.4%	5.32 30.8%	4.84 28.0%	3.08 17.8%	17.29
3-4	6.06 21.1%	10.25 35.6%	8.31 28.9%	4.18 14.5%	28.80
4-5	9.35 23.2%	13.42 33.3%	10.94 27.1%	6.61 16.4%	40.32
5-6	9.42 18.2%	19.24 37.1%	16.40 31.6%	6.78 13.1%	51.84
6-7	13.78 21.8%	20.45 32.3%	18.03 28.5%	11.10 17.5%	63.36
Average	20.9%	34.3%	29.3%	15.5%	
Portal	19.2%	34.6%	30.8%	15.4%	
Difference	1.7%	0.3%	1.4%	0.1%	

Table 6: Shear on Column (kips) and % Difference From Shear Assumption

Member	STRUDL M_g (k-ft.)	STRUDL $3/4(M_g+M_w)$ (k-ft.)	Calculated M_g (k-ft.)	Calculated $3/4(M_g+M_w)$ (k-ft.)	Change in Size
1	-171.87*	-134.56	164.16*	-74.25	+one
2	-249.01*	-207.46	241.92*	-122.01	none
3	-251.79*	-232.19	241.92*	-141.95	none
4	-253.58	-255.59*	241.92*	-161.88	none
5	-257.35	-287.87*	241.92*	-181.82	none
6	-259.72	-337.21*	241.92	-256.60*	+three
7	-106.47*	-84.85	105.10*	-48.30	none
8	-156.77*	-132.77	154.83*	-81.30	none
9	-157.44*	-147.67	154.83*	97.20	none
10	-158.34	-162.28*	154.83*	113.16	none
11	-158.36	-184.28*	154.83*	129.10	+one
12	-158.14	-226.27*	154.83	188.94*	+one
13	-81.76*	-66.57	105.10*	-48.30	-three
14	-136.85*	-120.89	154.83*	-81.30	-one
15	-138.45*	-137.76	154.83*	97.20	-one
16	-140.57	-154.65*	154.83*	113.16	none
17	-142.72	-175.51*	154.83*	129.10	+one
18	-136.51	-218.91*	154.83	188.94*	+one

Table 7: Changes in Maximum Moments and Girder Sizes (controlling values are indicated with asterisks)

FIGURES

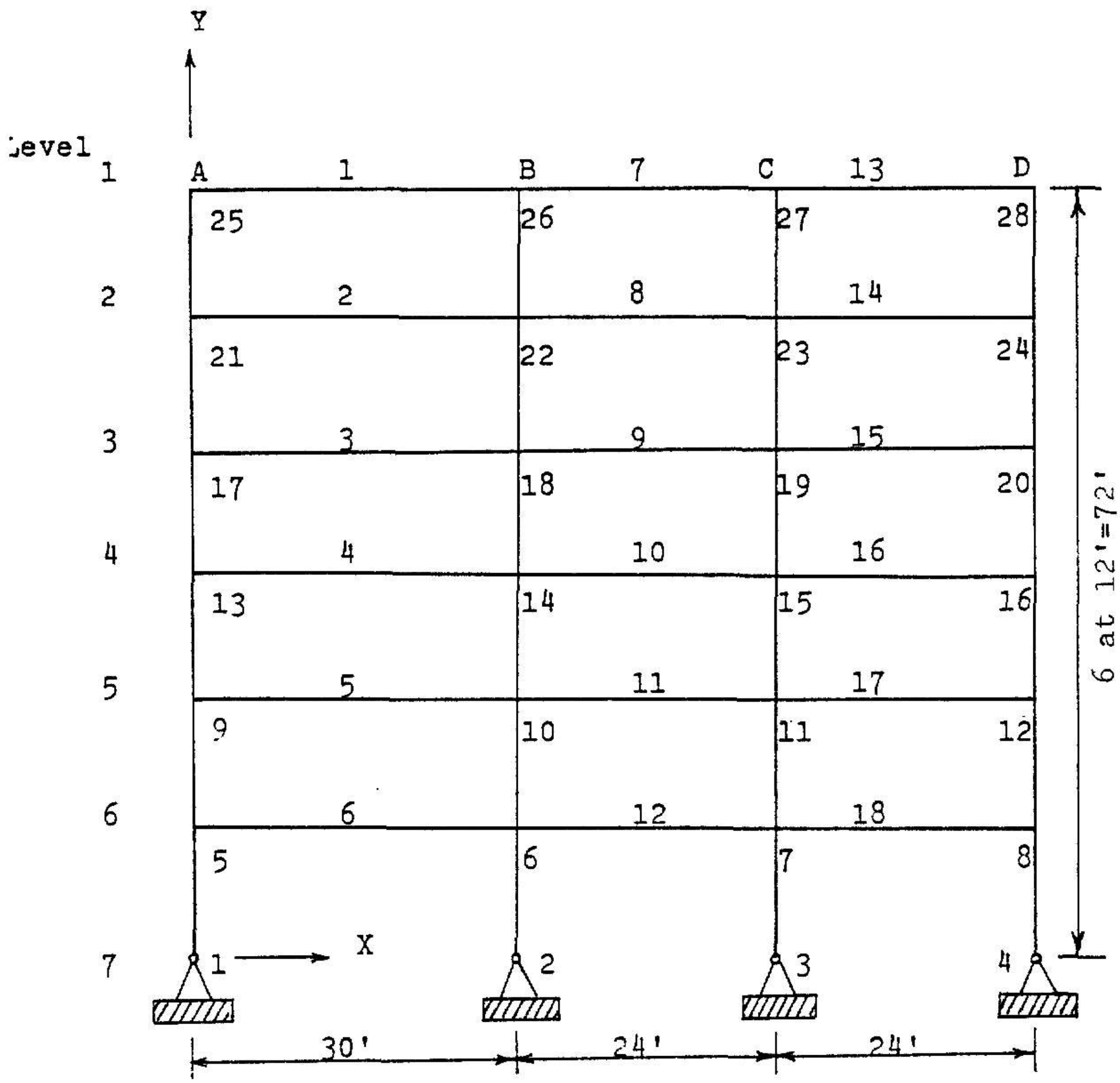


Fig. 1: Example Frame

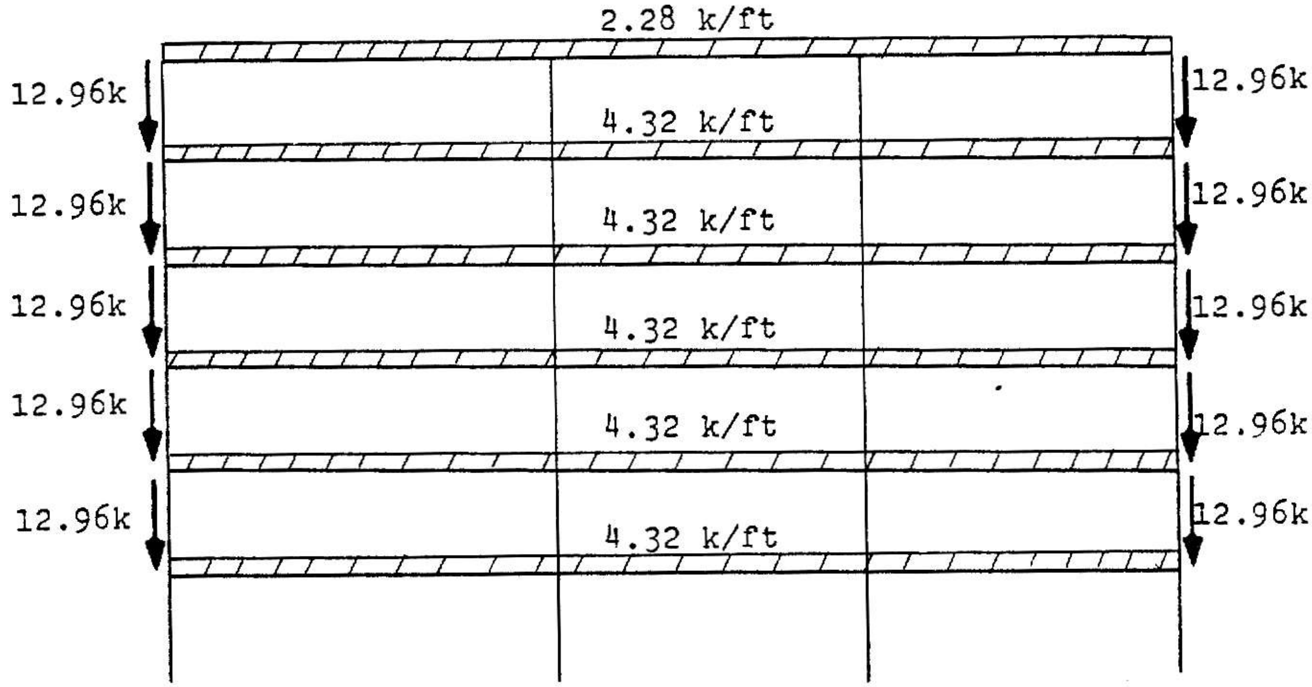


Fig. 2: External Wall Load and Floor Load

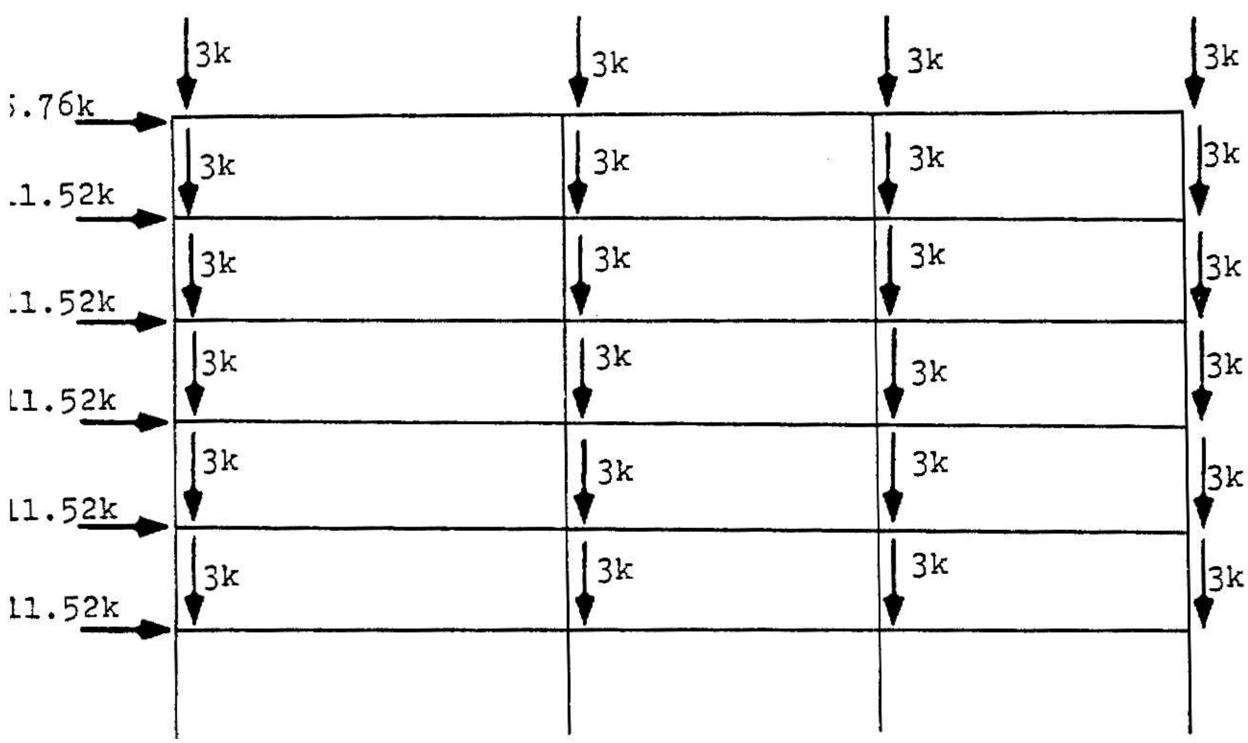


Fig. 3: Wind Load and Column Dead Load

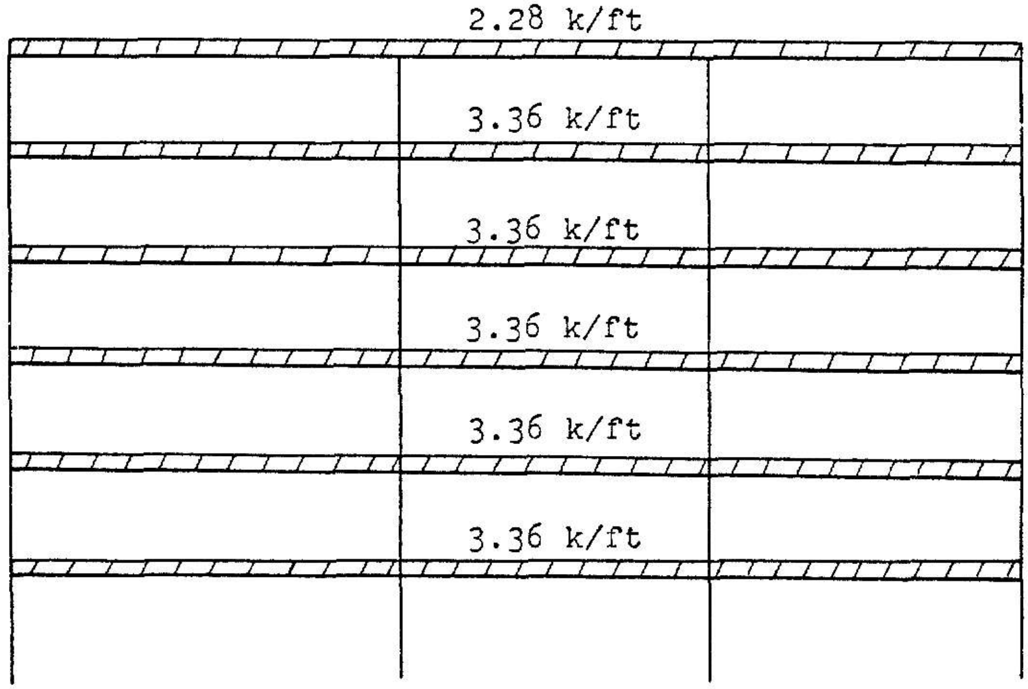


Fig. 4: Reduced Floor Load for Girders

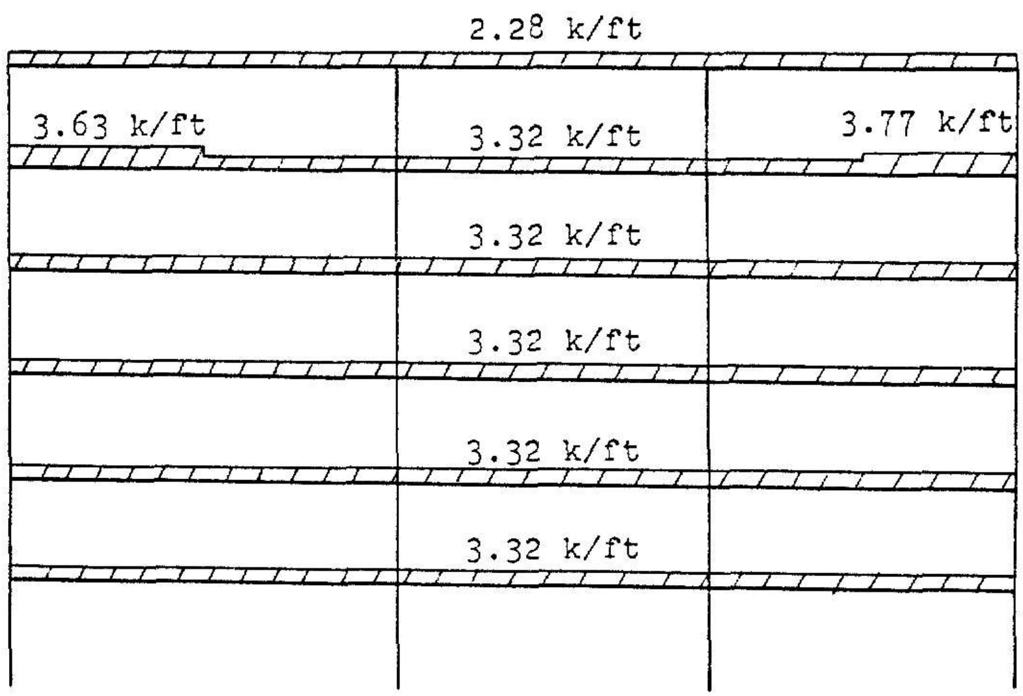
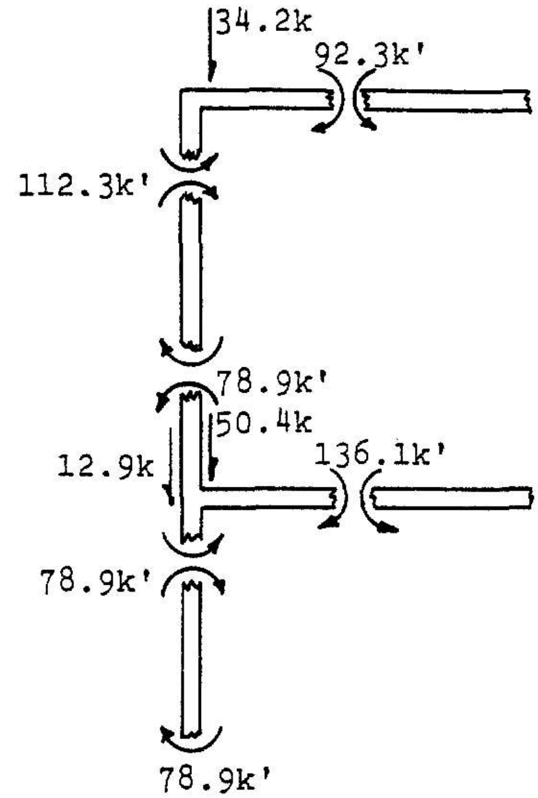


Fig. 5: Reduced Floor Load for Columns

COLUMN A



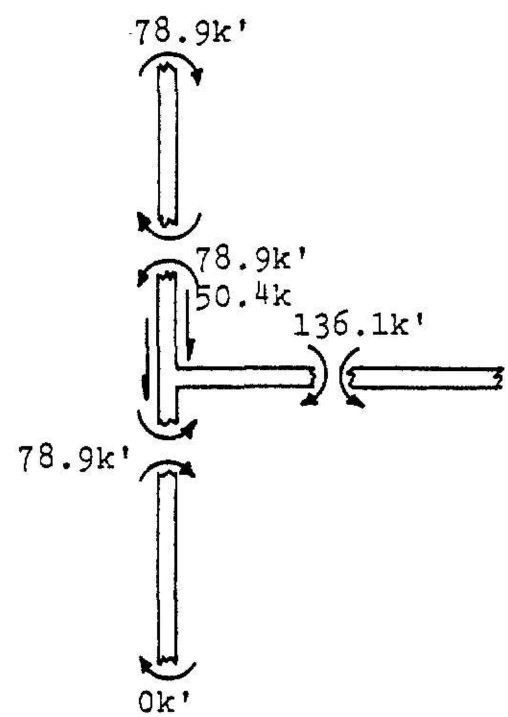
Level 1

$$M=92.3+34.2\left(\frac{7}{12}\right)=112.3k'$$

Level 2

$$M=\left(\frac{1}{2}\right)\left[(136.1)+(50.4-12.9)\left(\frac{7}{12}\right)\right]$$
$$=78.9k'$$

Levels 3 to 5-same as level 2



Level 6

Level 7

Fig. 6: Calculation of Column End Moments

Fig. 6 (continued)

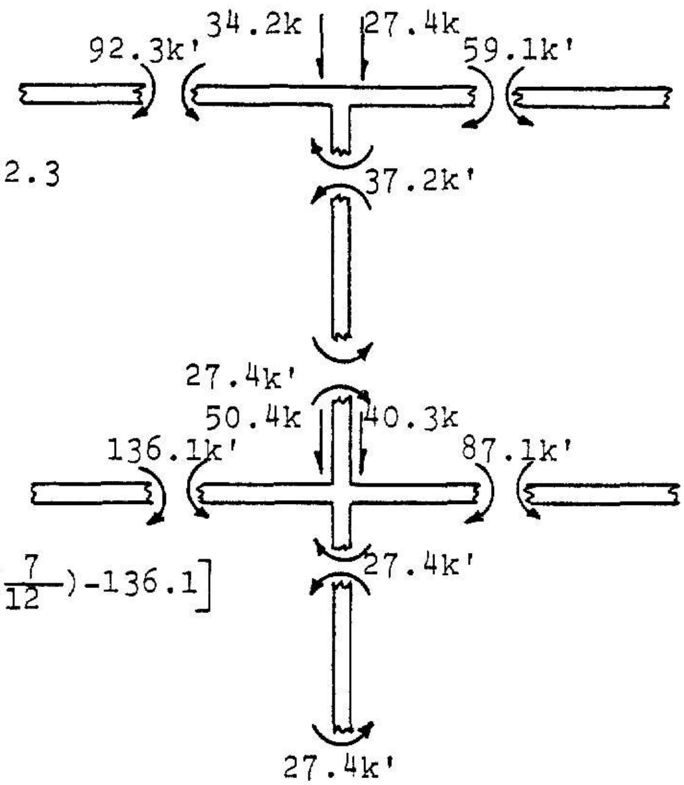
COLUMN B

Level 1

$$M=59.1+(27.4-34.2)\left(\frac{7}{12}\right)-92.3$$
$$=-37.2k'$$

Level 2

$$M=\left(\frac{1}{2}\right)\left[87.1+(40.3-50.4)\left(\frac{7}{12}\right)-136.1\right]$$
$$=-27.4k'$$



Levels 3 to 5-same as level 2

Level 6

Level 7

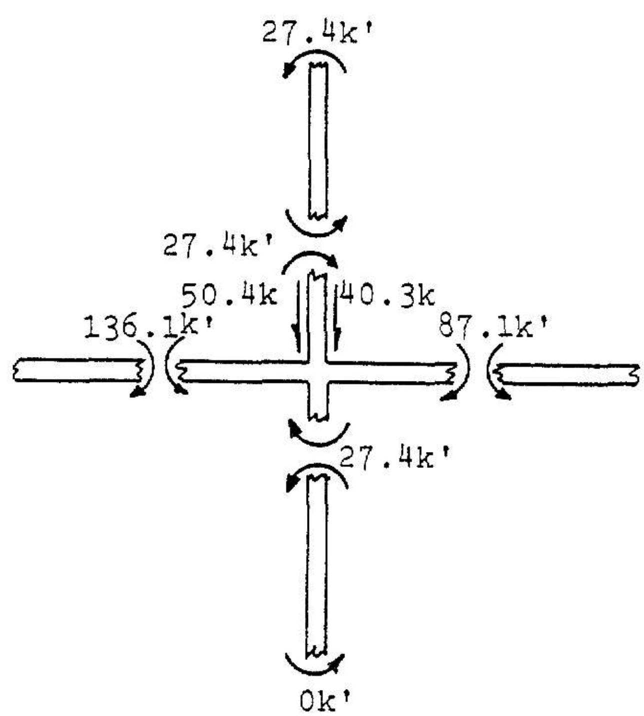
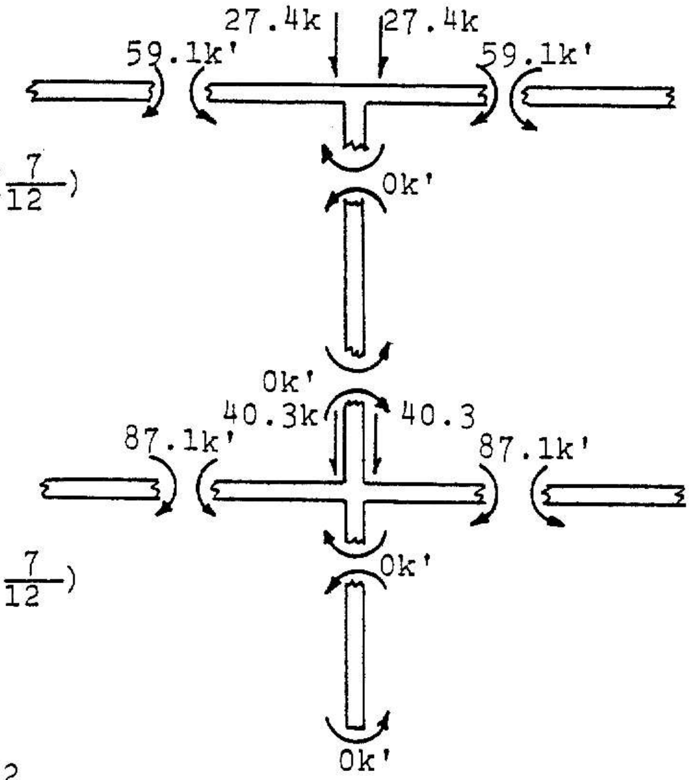


Fig. 6 (continued)

COLUMN C



Level 1

$$M=59.1-59.1+(27.4-27.4)\left(\frac{7}{12}\right)$$
$$=0.0k'$$

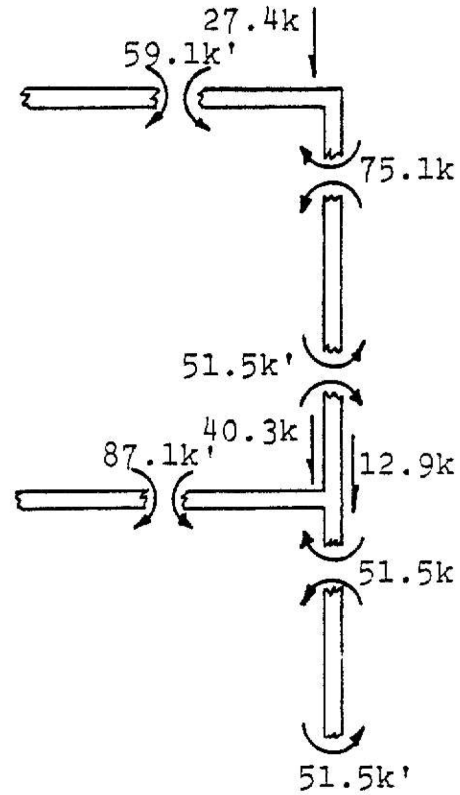
Level 2

$$M=87.1-87.1+(40.3-40.3)\left(\frac{7}{12}\right)$$
$$=0.0k'$$

Levels 3 to 7-same as level 2

Fig. 6 (continued)

COLUMN D



Level 1

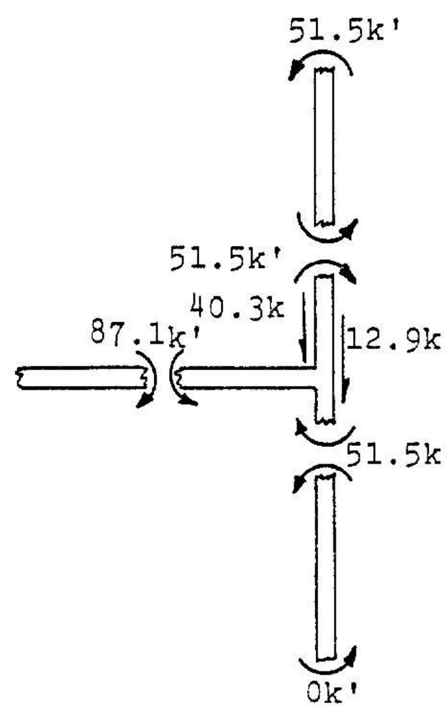
$M=59.1+(\frac{7}{12})27.4=75.1$

Level 2

$M=(\frac{1}{2})\left[-87.1-(40.3-12.9)(\frac{7}{12})\right]$

$=-51.5k'$

Levels 3 to 5-same as level 2



Level 6

Level 7

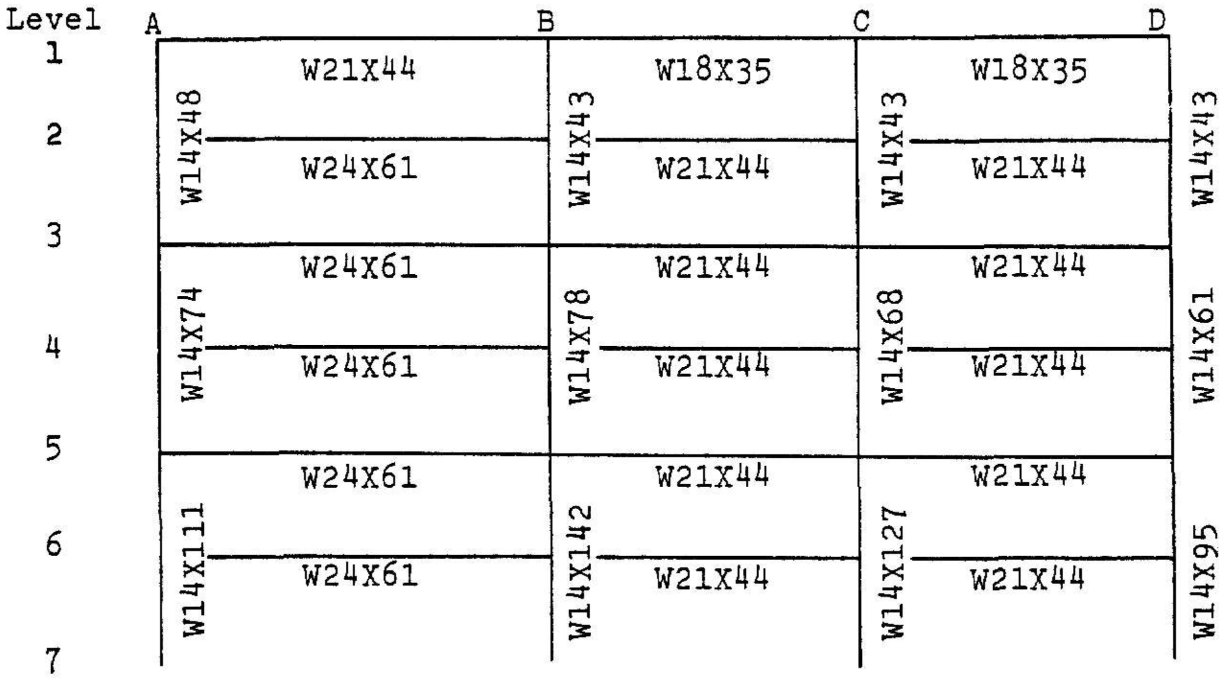


Fig. 7: Members From Preliminary Design

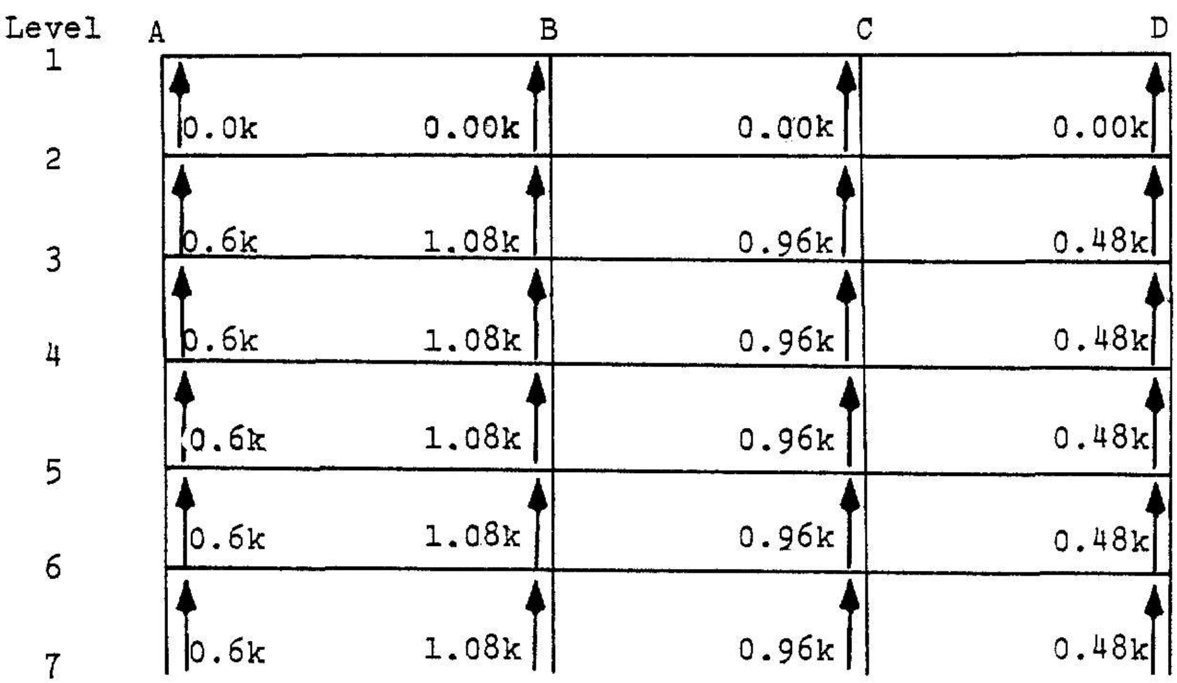


Fig. 8: Difference Between Live Load Reduction and Girder Live Load Reduction

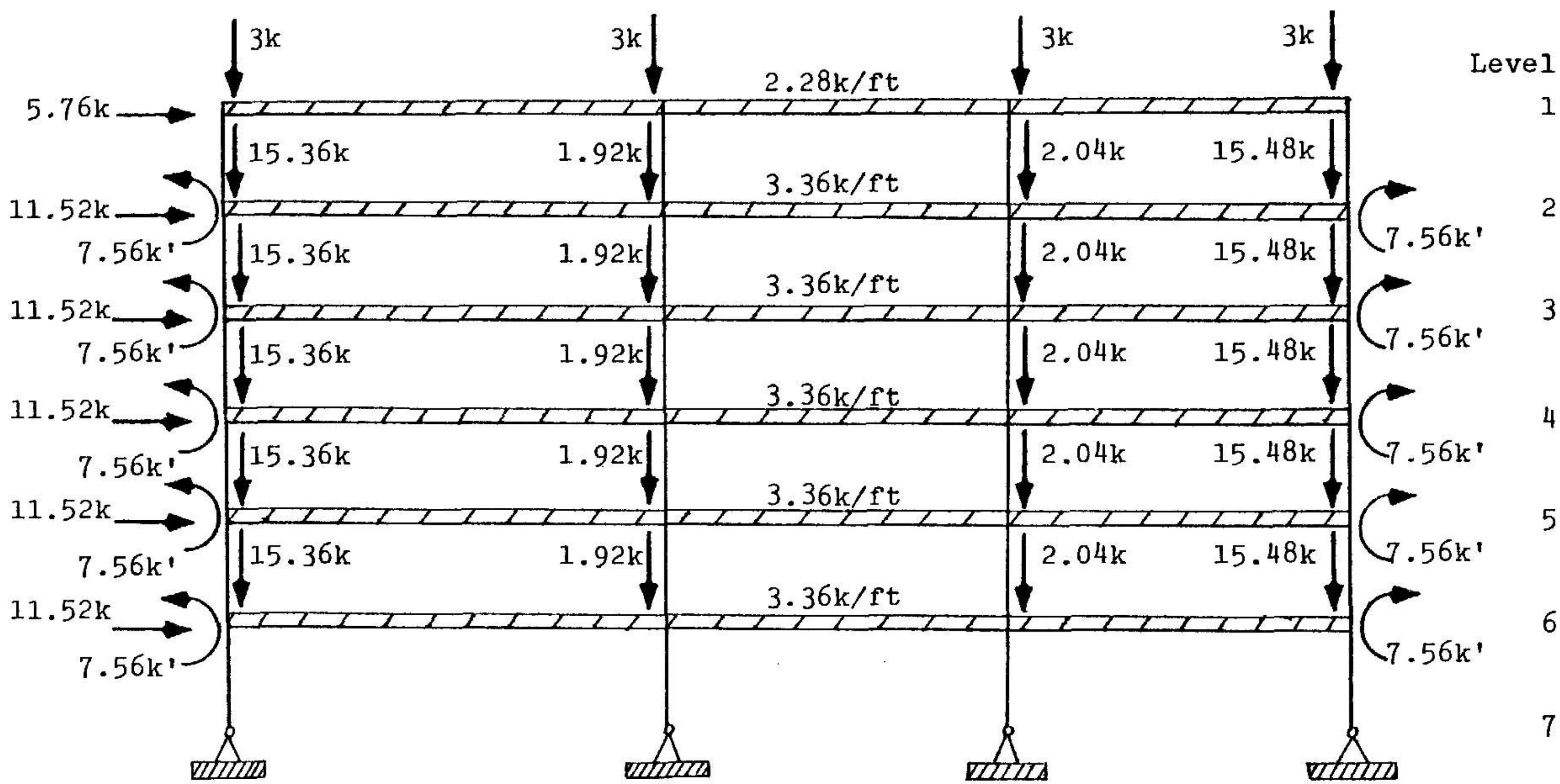


Fig. 9: Summary of Loads

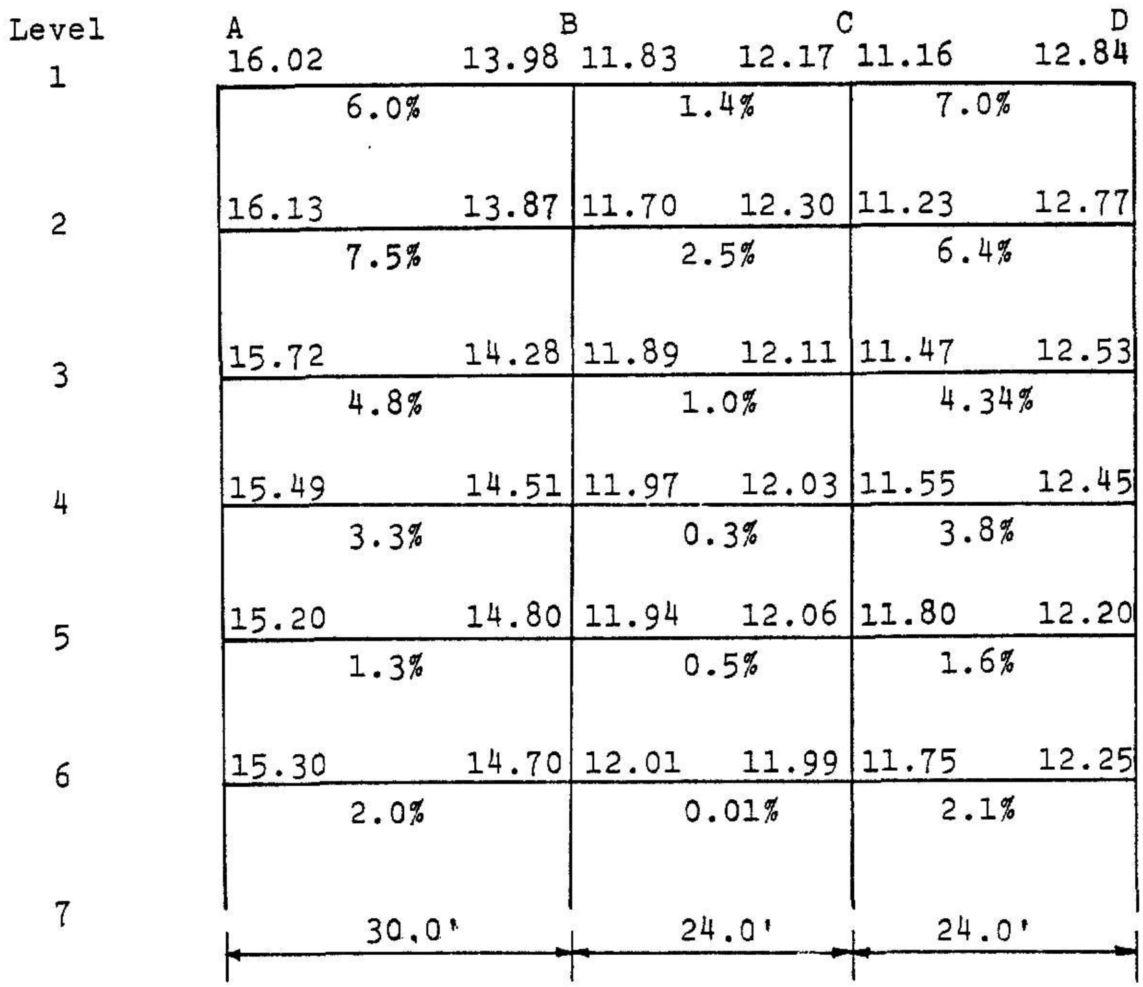


Fig. 10: Location of Inflection Points (ft.) and % Distance from Midpoint for Girders

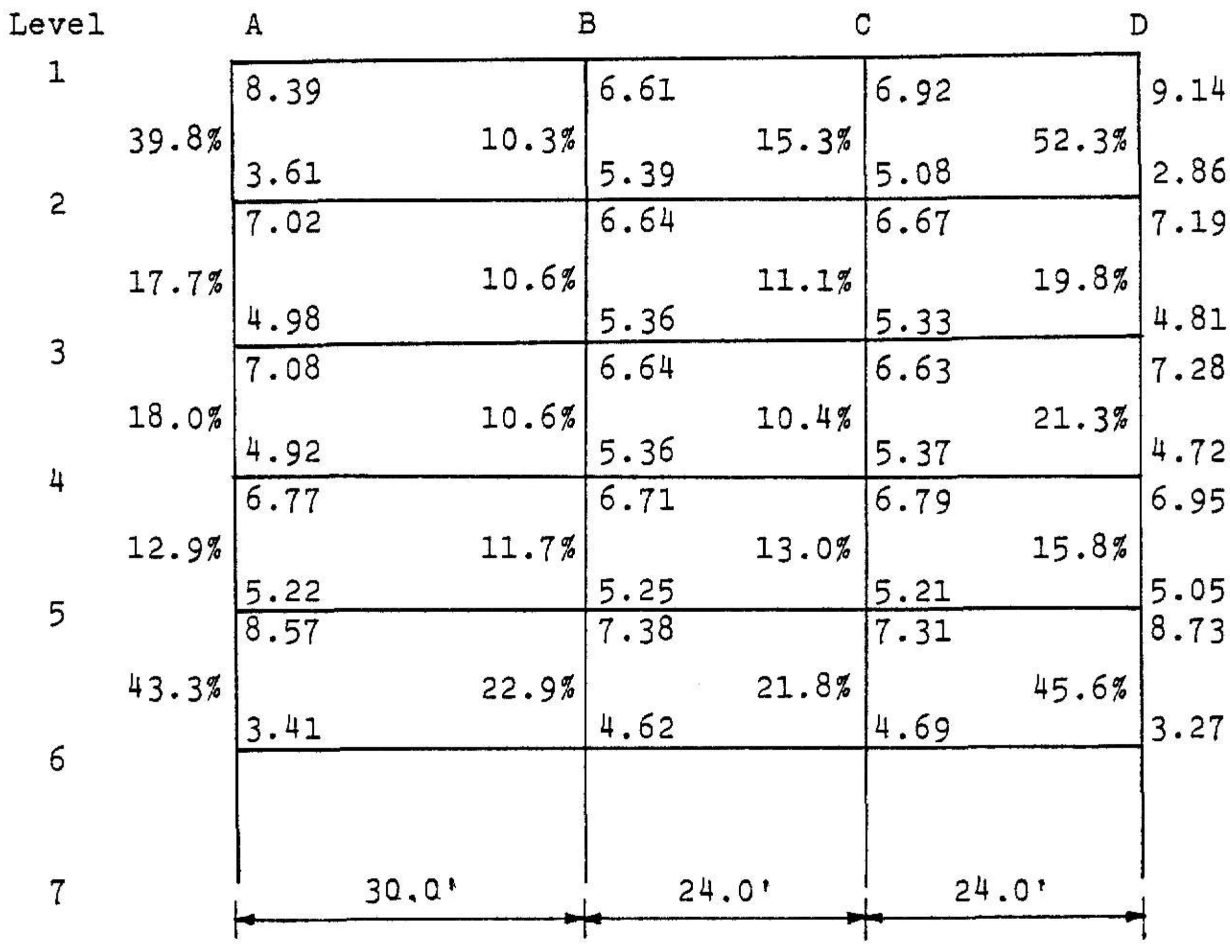


Fig. 11: Location of Inflection Points (ft.) and % Distance from Midpoint for Columns

Level	A			B			C		D
1	121.8	(92.34)	-171.9	124.6	(59.1)	-106.5	115.2	(59.1)	-81.8
2	199.9	(136.1)	-249.0	177.2	(87.1)	-156.8	164.8	(87.1)	-136.9
3	207.2	(136.1)	-251.8	174.8	(87.1)	-157.4	165.7	(87.1)	-138.5
4	213.9	(136.1)	-253.6	171.9	(87.1)	-158.3	166.4	(87.1)	-140.6
5	219.5	(136.1)	-257.4	168.8	(87.1)	-158.4	168.6	(87.1)	-142.7
6	213.2	(136.1)	-259.7	171.2	(87.1)	-158.2	171.2	(87.1)	-136.5
7									

Fig. 12: Actual and Assumed Girder End Moments (Kip-ft.)
(numbers in parentheses are assumed values)

Level		A		B		C		D
1–2	4.5%	35.5* 37.2	3.7%	66.9* 64.6	1.1%	58.4* 57.7	4.8%	28.9* 30.4
2–3	7.0%	99.7* 107.6	3.1%	162.1* 157.2	0.7%	141.4* 140.4	8.6%	83.6* 91.6*
3–4	3.0%	163.9* 168.7	2.8%	257.0* 249.8	0.6%	224.4* 223.1	2.7%	138.3* 141.9
4–5	2.6%	228.4* 234.5	2.6%	351.5* 342.5	0.6%	307.7* 305.8	2.5%	193.0* 197.8
5–6	2.4%	292.9* 300.2	2.1%	445.8* 435.1	0.6%	390.9* 388.4	2.3%	247.7* 253.6
6–7	6.6%	341.7* 366.0	2.3%	540.6* 527.8	0.7%	474.5* 471.1	2.4%	301.2* 309.4

Fig. 13: Actual and Assumed Column Axial Loads (Kips)
(STRUDL values are indicated with asterisks)

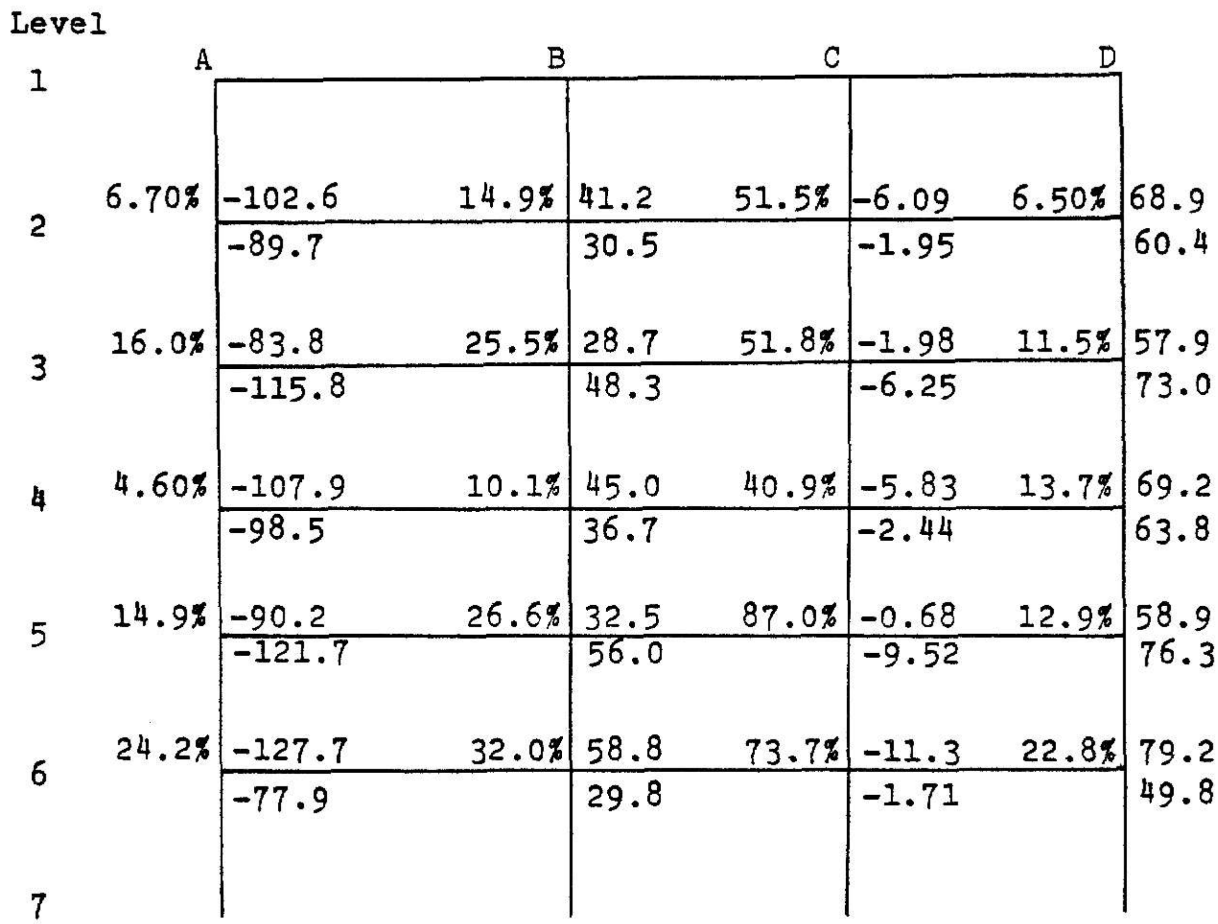


Fig. 14: Actual Column End Moments (Kip-ft.) and % Difference From Assumed Values

APPENDIX

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

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MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
01-2	24	0.5457040	0.7668774				2.1935520
01-2	28	-0.5457040	-0.7668774				7.0069722
1	25	4.7287254	-0.5401418				-8.6542597
1	26	-4.7287254	0.5401418				-7.5499516
2	21	8.5048618	-1.9912353				-32.1316477
2	22	-8.5048618	1.9912353				-27.6065975
3	17	9.5074406	-4.0287733				-63.0637207
3	18	-9.5074406	4.0287733				-57.7594690
4	13	8.2277298	-6.0117531				-93.1403046
4	14	-8.2277298	6.0117531				-67.2122650
5	9	11.4474211	-8.5446119				-129.6592587
5	10	-11.4474211	8.5446119				-126.4790497
6	5	7.1626282	-12.9120264				-197.4635315
6	6	-7.1626282	12.9120264				-189.8971252
7	26	2.6099957	-0.5472912				-6.4716177
7	27	-2.6099957	0.5472912				-6.6623625
8	22	5.3054953	-1.6367140				-19.1051483
8	23	-5.3054953	1.6367140				-20.1759756
9	18	4.5781164	-3.2587555				-36.7471466
9	19	-4.5781164	3.2587555				-39.4630585
10	14	5.0552959	-4.8237257				-57.7303434
10	15	-5.0552959	4.8237257				-58.0330658
11	10	5.6312923	-7.2411280				-86.4430389
11	11	-5.6312923	7.2411280				-87.3440704
12	6	5.9532604	-12.0223465				-144.3839722
12	7	-5.9532604	12.0223465				-144.1522217
13	27	0.7668774	-0.5457040				-6.0879202
13	28	-0.7668774	0.5457040				-7.0089722
14	23	2.3127241	-1.9066744				-21.4212646
14	24	-2.3127241	1.9066744				-24.3388977
15	19	1.0957810	-3.6110792				-41.4318065
15	20	-1.0957810	3.6110792				-45.2340698
16	15	2.4294329	-5.2714996				-60.8751373
16	16	-2.4294329	5.2714996				-65.6408644
17	11	0.1719482	-7.5935658				-69.6284720
17	12	-0.1719482	7.5935658				-92.6171417
18	7	4.3221245	-12.6856937				-145.0789642
18	8	-4.3221245	12.6856937				-155.3775482

STRUDL Output for Wind Loading

MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
A6-7	1	-34.0295550	13.7811546				0.0000000
A6-7	5	34.0295550	-13.7811546				165.3737946
A5-6	5	-21.1165619	9.4237881				32.0657369
A5-6	9	21.1165619	-9.4237881				80.9957123
A4-5	9	-12.5719557	9.3512135				48.8636322
A4-5	13	12.5719557	-9.3512135				63.2509369
A3-4	13	-6.5601978	6.0589523				29.7894135
A3-4	17	6.5601978	-6.0589523				42.5179953
A2-3	17	-2.5314274	4.0463982				20.1457214
A2-3	21	2.5314274	-4.0463982				23.4110413
A1-2	21	-0.5401418	1.0312672				3.7205044
A1-2	25	0.5401418	-1.0312672				8.6542997
B6-7	2	4.4986238	20.4454193				0.0000000
B6-7	6	-4.4986238	-20.4454193				245.3450317
B5-6	6	3.6039478	19.2360687				88.9361420
B5-6	10	-3.6039478	-19.2360687				141.8467133
B4-5	10	2.3054638	13.4195476				71.0253296
B4-5	14	-2.3054638	-13.4195476				90.0139771
B3-4	14	1.1174355	10.2475147				54.9345551
B3-4	18	-1.1174355	-10.2475147				68.0356445
B2-3	18	0.3474218	5.3181944				28.5105663
B2-3	22	-0.3474218	-5.3181944				35.3073578
B1-2	22	-0.0071493	2.1188316				11.4043965
B1-2	26	0.0071493	-2.1188316				14.0215750
C6-7	3	-2.0842552	18.0305786				0.0000000
C6-7	7	2.0842552	-18.0305786				216.3670349
C5-6	7	-1.4209089	16.3994293				76.8641663
C5-6	11	1.4209089	-16.3994293				119.9290466
C4-5	11	-1.0684671	10.9399910				57.0435333
C4-5	15	1.0684671	-10.9399910				74.2363739
C3-4	15	-0.6206921	8.3141279				44.6718292
C3-4	19	0.6206921	-8.3141279				55.0977020
C2-3	19	-0.2663725	4.8357387				25.7971649
C2-3	23	0.2663725	-4.8357387				32.2323151
C1-2	23	0.0015872	1.8430185				9.3649302
C1-2	27	-0.0015872	-1.8430185				12.7512836
D6-7	4	31.6142273	11.1027918				0.0000000
D6-7	8	-31.6142273	-11.1027918				133.2334747
D5-6	8	18.9255278	6.7806635				22.1440867
D5-6	12	-18.9255278	-6.7806635				59.2233770
D4-5	12	11.3349600	6.6088152				33.3932953
D4-5	16	-11.3349600	-6.6088152				45.9124908
D3-4	16	6.0634565	4.1793823				15.7263783
D3-4	20	-6.0634565	-4.1793823				30.4242096
D2-3	20	2.4523763	3.0796022				14.8058612
D2-3	24	-2.4523763	-3.0796022				22.1453552

STRUDL Output for Wind Loading

MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
A6-7	1	341.7087402	-6.4902534				-0.0000000
A6-7	5	-341.7087402	6.4902534				-77.8830414
A5-6	5	292.8603516	-20.7863007				-127.7316284
A5-6	9	-292.8603516	20.7863007				-121.7039642
A4-5	9	228.3630981	-15.7226706				-90.2132263
A4-5	13	-228.3630981	15.7226706				-98.4587250
A3-4	13	163.9263000	-18.6379242				-107.8887286
A3-4	17	-163.9263000	18.6379242				-115.7862244
A2-3	17	99.6534271	-14.4623537				-83.8377390
A2-3	21	-99.6534271	14.4623537				-89.7104797
A1-2	21	35.5314789	-18.7015991				-102.5995636
A1-2	25	-35.5314789	18.7015991				-121.8156411
B6-7	2	540.5634766	2.4856100				0.0000000
B6-7	6	-540.5634766	-2.4856100				29.8273163
B5-6	6	445.8303223	9.5649014				58.7554169
B5-6	10	-445.8303223	-9.5649014				56.0233917
B4-5	10	351.4914551	5.7592611				32.4925690
B4-5	14	-351.4914551	-5.7592611				36.6185608
B3-4	14	256.5628906	7.7797174				45.0423279
B3-4	18.	-256.5628906	-7.7797174				48.3142853
B2-3	18	162.1123505	4.9328785				28.6763494
B2-3	22	-162.1123505	-4.9328785				30.5176649
B1-2	26	-66.9817963	-7.3801785				47.3154449
C6-7	3	474.5351563	-0.1427504				0.0000000
C6-7	7	-474.5351563	0.1427504				-1.7130051
C5-6	7	390.9531250	-1.7364635				-11.3118830
C5-6	11	-390.9531250	1.7364635				-9.5256748
C4-5	11	307.6328125	-0.2600827				-0.6794751
C4-5	15	-307.6328125	0.2600827				-2.4415178
C3-4	15	224.4415436	-0.9902260				-5.6353264
C3-4	19	-224.4415436	0.9902260				-6.2473841
C2-3	19	141.3515472	-0.3279955				-1.5816158
C2-3	23	-141.3515472	0.3279955				-1.9543266
C1-2	23	58.3583069	-1.2322721				-6.0584411
C1-2	27	-58.3583069	1.2322721				-8.6888313
D6-7	4	302.0698242	4.1473942				0.0000000
D6-7	8	-302.0698242	-4.1473942				49.7667225
D5-6	8	247.7139740	12.9578695				79.1827850
D5-6	12	-247.7139740	-12.9578695				76.3116455
D4-5	12	192.9907990	10.2234907				58.8517151
D4-5	16	-192.9907990	-10.2234907				63.8301544
D3-4	16	138.2680511	11.8484325				69.1777954
D3-4	20	-138.2680511	-11.8484325				73.0023569
D2-3	20	83.6019287	9.8574677				57.8890991
D2-3	24	-83.6019287	-9.8574677				66.4005127

STRUDL Output for Gravity Loading

MEMBER	JOINT	FORCE			MOMENT		
		AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
31-2	24	28.9681702	12.5537014				68.8840790
31-2	28	-28.9681702	-12.5537014				81.7603149
1	25	18.7015991	22.5314789				121.8196411
1	26	-18.7015991	35.8684235				-171.8734589
2	21	-4.2392492	48.7615781				159.8701172
2	22	4.2392492	52.0378723				-249.0080261
3	17	4.1755655	48.3128275				207.1839600
3	18	-4.1755655	51.8870239				-251.7563562
4	13	-2.9152546	49.0768127				213.8875427
4	14	2.9152546	51.7230377				-253.5800122
5	9	5.0636396	49.1374664				219.4772034
5	10	-5.0636396	51.6623840				-257.3503419
6	5	-14.2960529	48.8483429				213.1746979
6	6	14.2960529	51.9515076				-259.7214355
7	26	11.3214283	28.1134186				124.5580597
7	27	-11.3214283	26.6065216				-166.4745156
8	22	-1.7919540	41.1726074				177.2436215
8	23	1.7919540	39.4672394				-150.7768845
9	18	1.3287306	41.0430554				174.8052063
9	19	-1.3287306	39.5561914				-157.4354706
10	14	-0.8947980	40.8855743				171.9157083
10	15	0.8947980	39.7542877				-158.3440395
11	10	1.2579994	40.7563629				168.8344574
11	11	-1.2579994	39.8834839				-158.2558765
12	6	-7.2167606	40.8015570				171.1387939
12	7	7.2167606	39.7783051				-158.1355416
13	27	12.5537014	28.7517700				115.1028031
13	28	-12.5537014	25.9691702				-91.7603149
14	23	-2.6962309	41.4860535				164.6316345
14	24	2.6962309	39.1539066				-136.8445435
15	19	1.9909611	41.4537506				165.6644592
15	20	-1.9909611	39.1860962				-138.4524689
16	15	-1.6249409	41.3571252				166.4209595
16	16.	1.6249409	39.2427216				-140.5078864
17	11	2.7343807	41.3966522				168.5650492
17	12	-2.7343807	39.2421946				-142.7232971
18	7	-8.8104753	41.7637939				171.1644592
18	8	8.8104753	38.8760529				-136.5114746

STRUDL Output for Gravity Loading

MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
A6-7	1	230.7601624	5.4681767				0.0000000
A6-7	5	-230.7601624	-5.4681767				65.6180115
A5-6	5	203.8079224	-8.5218935				-71.7314148
A5-6	9	-203.8079224	8.5218935				-30.5311890
A4-5	9	161.8432922	-4.7785931				-31.0121918
A4-5	13	-161.8432922	4.7785931				-26.3306411
A3-4	13	118.0244904	-9.4342251				-58.5554768
A3-4	17	-118.0244904	9.4342251				-54.6511536
A2-3	17	72.8414307	-7.9119640				-47.7685572
A2-3	21	-72.8414307	7.9119640				-45.5745636
A1-2	21	26.2434958	-13.2527523				-74.1585813
A1-2	25	-26.2434958	13.2527523				-84.6740682
B6-7	2	408.7963867	17.1982574				0.0000000
B6-7	6	-408.7963867	-17.1982574				206.3751199
B5-6	6	337.0793457	21.6007233				110.7666310
B5-6	10	-337.0793457	-21.6007233				148.4399719
B4-5	10	265.3476562	14.3844051				77.6384277
B4-5	14	-265.3476562	-14.3844051				94.5743958
B3-4	14	193.5602875	13.5204248				74.5826506
B3-4	18	-193.5602875	-13.5204248				87.2624512
B2-3	18	121.8448029	7.6883039				42.8908644
B2-3	22	-121.8448029	-7.6883039				49.3667857
B1-2	22	50.2309875	7.1242533				35.4882965
B1-2	26	-50.2309875	-7.1242533				46.0027618
C6-7	3	354.3381348	13.4158773				0.0000000
C6-7	7	-354.3381348	-13.4158773				160.9904633
C5-6	7	292.1489258	10.9572258				49.1641958
C5-6	11	-292.1489258	-10.9572258				82.8024750
C4-5	11	229.9233551	8.0099287				42.2730255
C4-5	15	-229.9233551	-8.0099287				53.8461456
C3-4	15	167.8655396	5.4929209				25.2773590
C3-4	19	-167.8655396	-5.4929209				36.6377411
C2-3	19	105.8123016	3.3806441				17.8616486
C2-3	23	-105.8123016	-3.3806441				22.7084908
C1-2	23	43.7699127	0.4580593				2.4496653
C1-2	27	-43.7699127	-0.4580593				3.0468378
D6-7	4	250.2631073	11.4376354				0.0000000
D6-7	8	-250.2631073	-11.4376354				137.2515564
D5-6	8	199.9818573	14.8036969				75.5551630
D5-6	12	-199.9818573	-14.8036969				101.6516418
D4-5	12	153.2442322	12.6242256				65.1637616
D4-5	16	-153.2442322	-12.6242256				82.3069763
D3-4	16	108.2485504	12.0208578				66.6796417

STRUDL Output for 3/4 (gravity plus wind)

MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
D3-4	20	-108.2435504	-12.0208578				77.5106787
D2-3	20	64.5407257	9.7027958				54.5242157
D2-3	24	-64.5407257	-9.7027998				61.5053933
D1-2	24	22.1354065	9.9904327				53.3082123
D1-2	28	-22.1354065	-9.9904327				66.5769653
1	25	17.5727386	23.9934959				84.8740082
1	26	-17.5727386	27.3064270				-134.5674764
2	21	3.1792064	35.0780182				125.8035553
2	22	-3.1792064	40.5218658				-207.4608765
3	17	10.2622528	33.6630402				108.0901337
3	18	-10.2622528	41.9368439				-232.1967773
4	13	3.9843550	32.2987023				90.5603943
4	14	-3.9843550	43.3010864				-255.5546045
5	9	12.3832960	30.4446411				67.2123942
5	10	-12.3832960	45.1552429				-287.6718262
5	5	-5.3500690	26.9522400				11.7833309
6	6	5.3500690	48.6476440				-337.2136672
7	26	10.4484911	20.6745911				88.5647278
7	27	-10.4484911	20.3653564				-84.6537445
8	22	2.6351557	29.5519165				118.6028055
8	23	-2.6351557	30.8275572				-132.7160492
7	18	4.4301319	28.3386688				102.0424723
9	19	-4.4301319	32.1412048				-147.6737976
10	14	3.1203737	27.0463715				85.6374664
10	15	-3.1203737	33.4335022				-162.2827146
11	10	5.1669636	25.1364288				61.7935181
11	11	-5.1669636	35.3434601				-184.2776778
12	6	-0.9476093	21.6294093				20.0660706
12	7	0.9476093	38.8504751				-226.7167805
13	27	9.9904327	21.1545410				81.8069153
13	28	-9.9904327	19.8854065				-66.5769653
14	23	-0.2876301	29.6945245				107.5577240
14	24	0.2876301	30.7953491				-120.6875560
15	19	2.3180571	28.3820038				93.1143927
15	20	-2.3180571	32.0978851				-137.7648010
16	15	0.6033691	27.0942230				75.1553626
16	16	-0.6033691	33.3856659				-154.6565395
17	11	2.1796713	25.3523102				55.2023621
17	12	-2.1796713	35.1275635				-176.5052948
18	7	-3.3662615	21.8085765				16.5640717
18	8	3.3662615	38.6713104				-218.9167023

STRUDL Output for 3/4 (gravity plus wind)

ANALYSIS OF MULTI-STORY
STEEL FRAMES

by

KOUROS SASSANI

B.S., Kansas State University, 1977

AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

The basic assumptions made in the preliminary analysis of multi-story steel frames are examined in this report. A six story, three bay frame is selected as an example, and a preliminary analysis of this structure is carried out. Using the member forces obtained from the preliminary analysis, a preliminary design of the girders and columns is completed. The properties of the members selected in the preliminary design are used as imput data for a computer-based, exact analysis of the frame. The resulting member forces are compared with those of the preliminary analysis to determine the adequacy of the assumptions upon which the preliminary analysis is based. It is concluded that some of these assumptions do not provide a very accurate estimate of the actual member forces.