Calculation of Wind Drift in Staggered-Truss Buildings

R. E. LEFFLER

The important feature of a staggered-truss framing system is the story-high steel trusses that span the full width of the building. These trusses are used in a staggered arrangement, so that they occur at every other column row on each story. The floors, typically precast prestressed concrete, span from the bottom chord of one truss to the top chord of the adjacent truss, so that the span of the floor system is half the truss spacing.

As the height of steel-framed staggered-truss buildings is extended beyond 20 stories, the need for calculating wind deflection (drift) becomes more important. However, because the staggered-truss system differs from conventional framing systems, the appropriate method for calculating drift may not have been apparent. Consequently, a method was developed for calculating drift in staggered-truss buildings and, through finite-element computer analysis, the accuracy of the method was verified. Specifically, a NASTRAN model was made for the building described in this paper, and a complete analysis was made to calculate the deflections on each floor. The result showed that the difference in results between the handwork calculations and the NASTRAN analysis was generally less than 1.5%. A design example is presented to illustrate the hand-calculating method.

Appendix B, Sheets 1 through 24, show the drift calculations for a typical interior bay from the building described in Ref. 1. (Appendix A presents the Nomenclature and Equations used in the analysis.) Although the drift of an end bay would be somewhat different, for most practical buildings the drift is considered to be governed by the behavior of the interior bays.

Sheet 1 shows the building selected for the design example.[1] Sections 1 and 2 show the arrangement of the structural framing on adjacent column rows. As illustrated on Sheet 2, the horizontal wind load is transferred alternately between the trusses in Section 1 and the trusses in Section 2 (by the floor slabs acting as diaphragms) as it accumulates down the building. However, the vertical reactions from the wind accumulate directly on each column in the section where they are first developed. An understanding of this load-transfer system is important in following the drift calculations and in checking the resistance to overturning as described in the following section.

In general, only the calculations of overturning and wind drift are considered; all other conditions must be examined independently.

R. E. Leffler is Senior Research Engineer, U.S. Steel Corporation, Research Laboratory, Monroeville, Pennsylvania.

OVERTURNING

An important step in the early stages of building design is to check the resistance of the structure to overturning. The wind load acting on the vertical face of the building causes an overall bending moment on any horizontal cross section of the building. This moment, which reaches its maximum value at the base of the building, causes the building to tend to rotate about the leeward column and is called the overturning moment. The overturning moment causes compression in the leeward columns and tension (uplift) in the windward columns. The dead load generally causes compression in all columns, thus reducing the tension in the windward columns and providing resistance to overturning. Although the foundation weight could be used to provide resistance to overturning, it is usually considered desirable for all columns to be in a state of compression under the combined action of the wind load and dead load, with the compression load exceeding the tension load by a suitable margin in accord with building code requirements.

In the staggered-truss system, the wind-induced tension in the columns is found by summing the vertical-truss reactions caused by the horizontal wind loads. From Sheet 2,

$$R = 2W \times (D/L) \tag{1}$$

where R is the vertical-truss reaction caused by the horizontal wind load W; D is the depth of the truss (story height); and L is the span of the truss. The factor of 2 arises because each truss resists the wind load of a two-bay width.

Summing the vertical-truss reactions leads to the following two equations for the vertical-column forces at the base of the building caused by the wind load:

$$R_{b1} = 2(D/L)\,[W_{20} + W_{18} \ldots + W_2] + F_{VKB} \quad (2)$$

$$R_{b2} = 2(D/L)\,[W_{19} + W_{17} + \ldots + W_3] \quad (3)$$

R_{b1} and R_{b2} are the vertical-column forces at the base of the building for Sections 1 and 2, respectively, caused by the wind load; W is the total wind load transferred by the truss in the story denoted by the subscript; F_{VKB} is the vertical component of the axial force in the wind brace caused by the wind load; and D and L are as defined in Eq. (1).

The incremental wind loads, W_i, in Eqs. (2) and (3) are summed on the wind-load diagram[1] on Sheet 3 and are shown as cumulative wind loads. The vertical-column reactions (tension on the windward column) are determined on Sheet 4. For Section 2, the final vertical-column reactions at the base are ±191.0 kips. However, the total wind load for the building in Section 1 (209.9 kips) is passed to the foundation by the wind braces. The vertical component of the axial force in the wind brace (267.4 kips) adds to the vertical-column force at the base in Section 1, resulting in final vertical-column reactions at the base equal to 477.3 kips as shown in the diagram on Sheet 4. Dead loads are taken from the design example,[1] and the total dead load in the columns is determined. The ratio of the dead load to the vertical-column force caused by wind is 3.12 for Section 1 and 7.80 for Section 2.

WIND-LOAD DISTRIBUTION

A pattern of shear flow through the floor slab caused by the wind loads is shown on Sheet 5. The wind shear shown is for one bay. The total wind shear in the trusses is twice this value because of the contribution from the adjacent bay. By using this pattern, the wind shear in the floor slabs and trusses throughout the building is tabulated on Sheet 6.

COMPONENT DISPLACEMENT

The deflection-force relationships for the structural components are determined first. These relationships are then used to tabulate the total drift. Equations used in the following calculations are shown in Appendix A.

Floor Slab—The hollow, precast floor plank shown on Sheet 7, which is typical of those available, will be used in this example. Only the continuous thickness of the floor slab (the top 1¼-in. and the bottom 1¾-in.) is considered effective. Because the displacement of the floor slab is dominated by shear, with a small additional contribution from bending, fixed-boundary conditions are appropriate for an interior bay.

Properties are calculated in accordance with the American Concrete Institute Code,[2] Sheet 7. The shear component of the displacement is found by first determining the angular shear distortion and then multiplying it by the span of the floor, Sheet 8. Because the floor slab acts as a beam with a depth of 2.5 times the span (depth = 60.0 ft; span = 24.0 ft), ordinary equations for bending deflection are not strictly correct. However, because the bending component of the displacement is only about 5% of the total, results obtained by using ordinary deflection equations are adequate. The total displacement is determined by summing the bending and shear displacement, as shown on Sheet 8. Because a unit load was assumed to act on the slab, the resulting displacement is the unit-deflection-force relationship for the slab.

Trusses—The deflection-force relationship for the trusses, determined by using the method of virtual work,[3] is shown on Sheets 9 through 13. In this method, the reactions and internal forces must be determined for both the "real load" and a dimensionless "virtual load." Sheet 10 represents both loads, including their reactions and forces. The total deflection is the sum of that caused by bending effects in the top and bottom chords, Sheet 11, and that caused by axial effects, Sheet 12. The appropriate equations for calculating the deflection are shown on Sheets 11 and 12, and further explanation is presented as follows.

A finite-element computer analysis used in verifying this calculation method indicated that the shear flow between the trusses and the floor slabs is such that the force in the truss chords can be considered to be zero except for the bottom chord of the second-story truss. Consequently, the wind load applied to the truss top chord and the reactions in the bottom chord, Sheet 10, are distributed so that the axial force in the chords is zero; the horizontal component of the diagonals balances the applied load (or reaction) at each truss panel point.

With the virtual-work method, a unit virtual load is placed at the point where the deflection is to be determined. In the truss chords for which the axial force is zero, the horizontal displacement is the same everywhere along these chords, and the placement of the unit virtual load and its reactions is not important.

In Ref. 1, the vertical shear in the center panel of the truss was distributed in accordance with the moment of inertia of the top and bottom chords. However, the computer analysis showed a nearly equal distribution of vertical shear between the top and bottom chords, which can be attributed to the flexibility of the truss verticals flanking the center panel. (The effect of this vertical shear distribution on the resulting truss displacement was found to be very small for the usual variation in moment of inertia.) Therefore, the vertical shear is equally divided between the top and bottom chords in the present example.

Because of the symmetry of the truss, certain simplifying assumptions can be made in determining bending effects of the truss. These assumptions eliminate the need for an indeterminate analysis of the truss chords. First, an inflection point (point of zero moment) is assumed at the midpoint of the Vierendeel panel. Second, an investigation showed that the effect of the chords in the panels not adjacent to the Vierendeel panel was negligible. Therefore, truss-chord bending effects were only considered in the Vierendeel panel and those adjacent to it (Sheets 10, bottom, and 11). The calculation for the bending displacement and the axial displacement is shown on Sheets 11 and 12, respectively. The total displacement is the sum of the axial and bending displacements. The total displacement for a typical truss (except the second story) is 0.0079 in./kip as shown on Sheet 12. Because a 1-kip wind shear load was assumed, the resulting displacement is the unit-deflection-force ratio for the truss.

At the second floor, the wind shear is transferred to the wind braces. Therefore, the axial force is not zero in the bottom chord of the second-story truss. The bottom-chord axial forces are deduced from the axial-force diagram on Sheet 10 and are shown at the bottom of Sheet 12. The bottom-chord contribution to the displacement is calculated on Sheet 12 and is combined with the previously determined truss displacement to find the total unit-deflection-force ratio for the second-story truss, which is 0.001057 in./kip, as shown on Sheet 13.

Wind Brace—Displacement of the wind braces results from the horizontal wind shear and the vertical-column reactions to the wind-induced moment. The method of virtual work was used to determine these displacements. Calculations are shown for one wind brace on Sheets 13 and 14. The horizontal and vertical loads result in both horizontal and vertical displacements of the knee brace. Because of the symmetry of the building, the total horizontal displacement of the other wind brace is identical to that of the one shown (0.4594 in.). The total vertical displacement of the other wind brace is equal to magnitude and opposite in sign to that of the one shown (0.0325 in.).

TABULATION OF STRUCTURAL DRIFT

The drift of the structure resulting from the displacement of the trusses and floor slabs (structural drift) is tabulated on Sheets 15 (Section 1) and 16 (Section 2). First the appropriate wind shears, taken from Sheet 6, are entered in the table. Then the unit-deflection-force ratios, shown at the top of the sheet, are used to find the drift contribution of each element. Finally, the drift of the elements in each story is summed to find the total story drift.

In a story where a truss occurs in the section being tabulated, the drift is that of the truss, and the floor slabs do not enter into the calculations. Where a truss does not occur in the story, the floor slabs above and below the story enter into the calculations along with the truss from the opposite section. For completeness, the drift associated with the wind braces is included in the tabulation.

COLUMN-LENGTH CHANGE

The vertical-truss reactions to the horizontal wind shears cause the columns to lengthen on the windward face of the building and shorten on the leeward face of the building. This column-length change causes the trusses to rotate and results in a component of drift (Sheet 17). Vertical-truss reactions are calculated for each truss and summed down the building (Sheet 18). The main reaction points for the trusses in this example are at the top chord, and the columns below the truss top chord contribute to its rotation and the associated drift. The per-story drift associated with column-length changes is determined for Sections 1 and 2 on Sheets 19 and 20, respectively, on the basis of the equations shown on Sheet 17. The drift caused by column-length change in each story is determined on the basis of the truss in that story for Sections 1 and 2.

FINAL DRIFT DETERMINATION

The final drift determinations for Sections 1 and 2 are shown on Sheets 21 and 22. The structural drift and the drift caused by the column-length change are combined to find the total drift per story. The total per-story drift is summed, starting at the base of the building to find the total drift for each story. The per-story drift ratio is also determined by dividing the total drift per story by the corresponding story height. Except in the lower few stories, the drift ratio is 0.002 or less. Comparison of the total drift for each story in Section 1 with that in Section 2 indicates only a small variation between the two sections; the difference for stories 2 and 3 is about 1.6% and the difference for all the other stories is less than 1%. Consequently, final tabulation of drift for only one section would be an adequate procedure for most structures.

CONTROL OF DRIFT

In some instances the engineer may desire to reduce the drift ratio to 0.002, especially in the first and second stories. In the present example, this can be accomplished with a few changes in member sizes as will be described.

For the first story, previous calculations indicated that the wind braces provide the dominant control of drift. Therefore, as shown on Sheet 23, an increase in the size of the wind brace with no change in column size reduces the first-story drift ratio to 0.002.

To reduce the drift ratio for the second story to 0.002 or less, Sheet 24, the bottom chord of the truss is increased to the size of the top chord, and the verticals and diagonals are increased to the size of the largest vertical and diagonal.

CONCLUSIONS

A method has been developed for the hand calculation of drift in a staggered-truss building. The accuracy of the method, which was verified through finite-element computer analysis of a typical building is excellent. A design example was presented in detail to illustrate the application of the calculation method. Also, details of calculating resistance to the overturning moment from wind were reviewed.

DISCLAIMER

The material in this paper is intended for general information only. Any use of this material in relation to any specific application should be based on independent examination and verification of its unrestricted availability for such use, and a determination of suitability for the application by professionally qualified personnel. No license under any United States Steel Corporation patents or other proprietary interest is implied by the publication of this paper. Those making use of or relying upon the material assume all risks and liability arising from such use or reliance.

REFERENCES

1. Staggered Truss Framing Systems for High-Rise Buildings *U.S. Steel Corp., ADUSS 27-5227-01, 1971.*
2. Building Code Requirements for Reinforced Concrete (ACI 318-77) *American Concrete Institute, 1977.*
3. *McGuire, W. and R. H. Gallagher* Matrix Structural Analysis *John Wiley and Sons, Inc., New York, New York, 1979.*

APPENDIX A

EQUATIONS AND NOMENCLATURE

Δ_{ss} = Shear displacement of floor slab = $B\gamma = BV/AG_c$

B = Bay width or width of slab

γ = Angular shear distortion = V/AG_c

V = Wind load acting in shear on the floor slab

A = Cross-sectional area of the floor slab

G_c = Shear modulus of concrete

Δ_{sB} = Bending displacement of floor slab = $VB^3/12E_cI$

I = Moment of inertia

E_c = Modulus of elasticity of concrete

Δ_{slab} = Total displacement of floor slab = $\Delta_{ss} + \Delta_{sB}$

Δ_{BT} = Displacement of truss caused by bending

$$= \sum_{i=1}^{n} \int_l \frac{M_i m_i}{EI_i} dx$$

M_i = Bending moment caused by real load in the ith element

m_i = Bending moment caused by virtual load in the ith element.

I_i = Moment of inertia of the ith element

E = Modulus of elasticity

Δ_{AT} = Displacement of truss caused by axial loads

$$= \sum_{i=1}^{n} \frac{F_i U_i L_i}{A_i E}$$

F_i = Real axial force acting on the ith member

U_i = Virtual axial force acting on the ith member

L_i = Length of the ith member

A_i = Cross-sectional area of the ith member

Δ_{TT} = Total displacement of the truss = $\Delta_{BT} + \Delta_{AT}$

$\Delta_{BH/H}$ = Horizontal wind-brace displacement caused by a horizontal load

$$= \sum_{i=1}^{n} \frac{F_{Hi} U_{Hi} L_i}{A_i E}$$

F_{Hi} = Axial force in the ith member caused by a real horizontal force on the wind brace

U_{Hi} = Axial force in the ith member caused by a horizontal virtual force on the wind brace

$\Delta_{BH/V}$ = Horizontal wind-brace displacement caused by vertical load

$$= \sum_{i=1}^{n} \frac{F_{Bi} U_{Hi} L_i}{A_i E}$$

F_{Vi} = Axial force in the ith member caused by a real vertical force on the wind brace

$\Delta_{BV/H}$ = Vertical wind-brace displacement caused by a horizontal load

$$= \sum_{i=1}^{n} \frac{F_{Hi} U_{vi} L_i}{A_i E}$$

U_{vi} = Axial force in the ith member caused by a vertical virtual force on the wind brace

$\Delta_{BV/V}$ = Vertical wind-brace displacement caused by a vertical load

$$= \sum_{i=1}^{n} \frac{F_{vi} U_{vi} L_i}{A_i E}$$

$\Delta_{D/CLC}$ = Displacement of a truss in a particular story (drift per story) caused by the length change in the total length of column segments supporting that truss

$$= 2\,[\Sigma\Delta C]\,\frac{D_T}{L_T}$$

$\Sigma\Delta C$ = Length change of supported-column segment

D_T = Truss depth (story height)

L_T = Truss length (span)

APPENDIX B

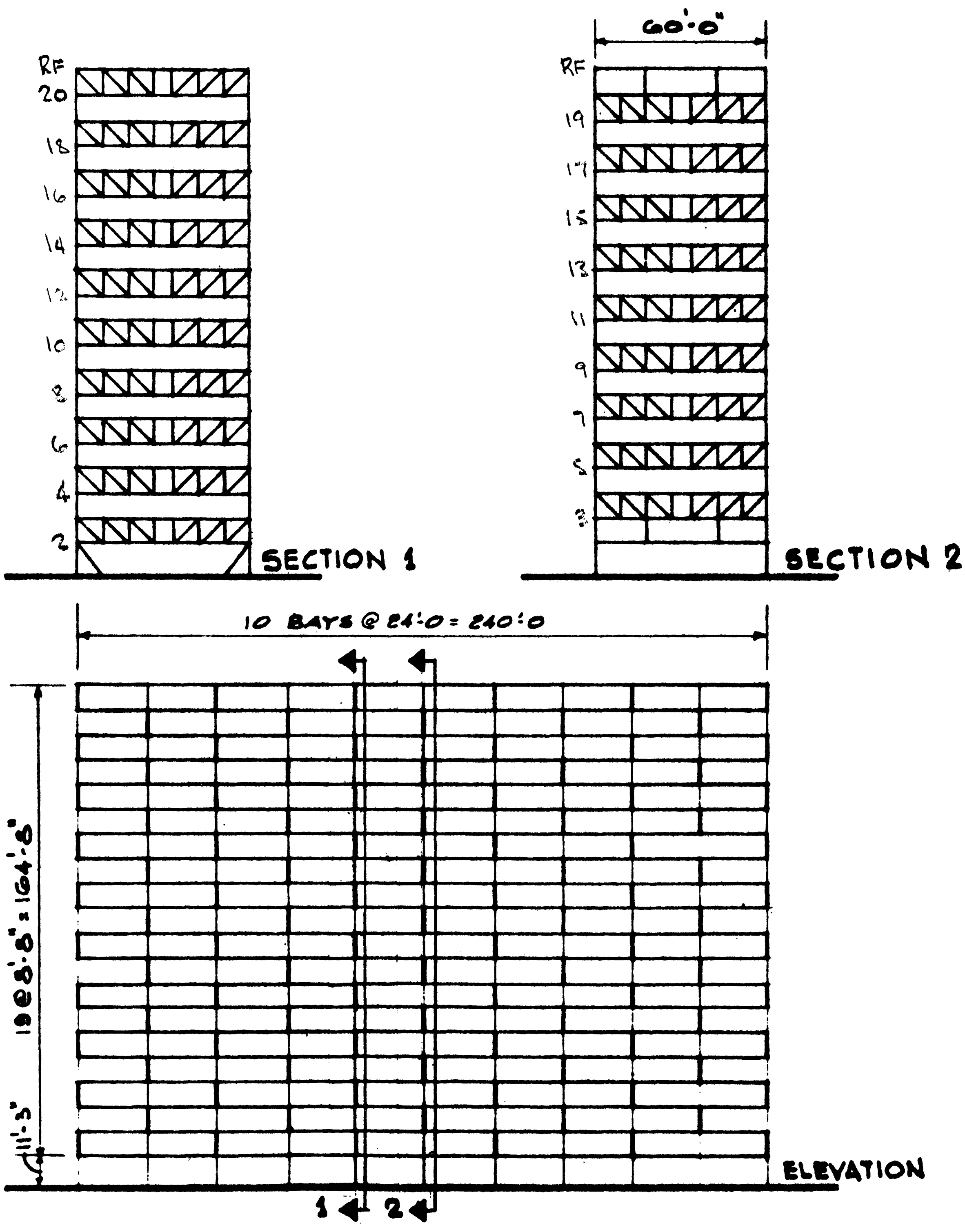
DRIFT CALCULATIONS

See Calculation Sheets 1 through 24, following:

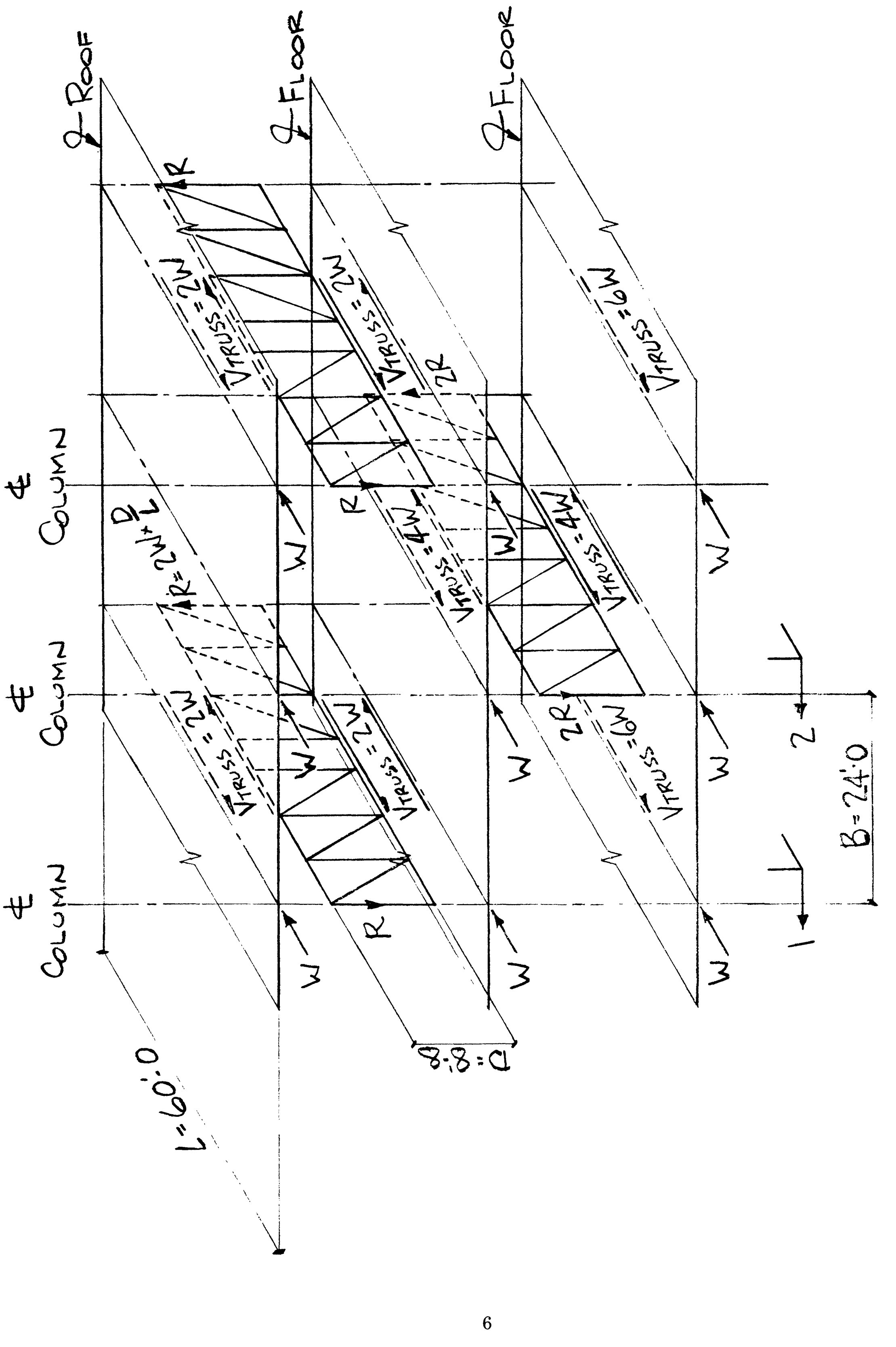
BY REL. DATE SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS SHEET NO. 1 OF 24

CHKD. BY DATE JOB NO.

GENERAL ARRANGEMENT



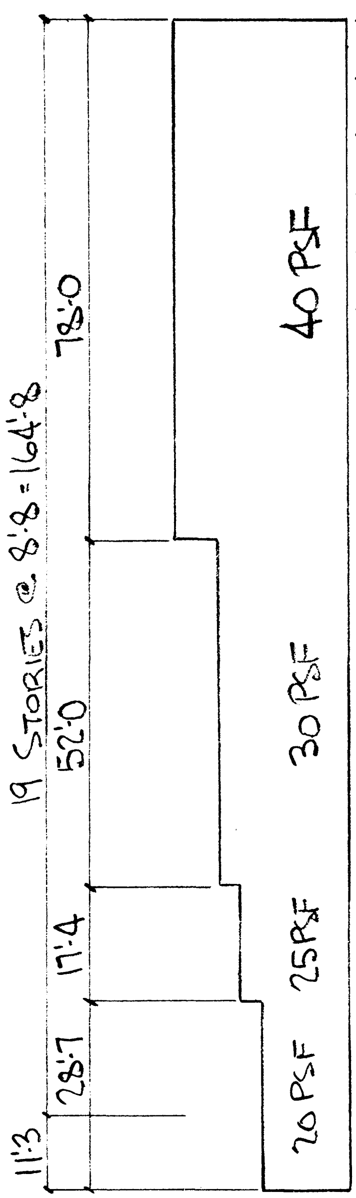
BY REL DATE ______ SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS SHEET NO. 2 OF 24
CHKD. BY ______ DATE ______ JOB NO. ______



WIND LOAD DISTRIBUTION
THROUGH A STAGGERED-TRUSS BUILDING

BY REL	DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 3 OF 24
CHKD. BY	DATE		JOB NO.

WIND LOAD



Level	INCREMENTAL WIND LOAD, Wi	CUMULATIVE WIND LOAD, ΣW SECTION 1	SECTION 2
ROOF	4.16^K	4.16^K	
20	8.32^K		12.48^K
19	8.32^K	20.80	
18	8.32^K		29.12
17	8.32^K	37.44	
16	8.32^K		45.76
15	8.32^K	54.08	
14	8.32^K		62.40
13	8.32^K	70.72	
12	7.28^K		78.00
11	6.24^K	84.24	
10	6.24^K		90.48
9	6.24^K	96.72	
8	6.24^K		102.96
7	6.24^K	109.20	
6	5.72^K		114.92
5	5.20^K	120.12	
4	4.68^K		124.80
3	4.16^K	128.96	
2	4.78^K	133.74*	
1	2.70^K		
TOTAL OF TRUSS SHEARS - 1 BAY		726.44^K	660.92^K
		×2	×2
TOTAL TRUSS SHEAR (2 BAYS)		1452.88^K	1321.84^K

BAY WIDTH = 24'-0 TYPICAL

* 1ST STORY WIND LOAD IS RESISTED BY THE WIND BRACE. IT IS NOT INCLUDED IN THE TRUSS SHEAR TOTALS

BY REL DATE ______ SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS SHEET NO. 4 OF 24
CHKD. BY ______ DATE ______ JOB NO. ______

OVERTURNING

SECTION 1 | **SECTION 2**

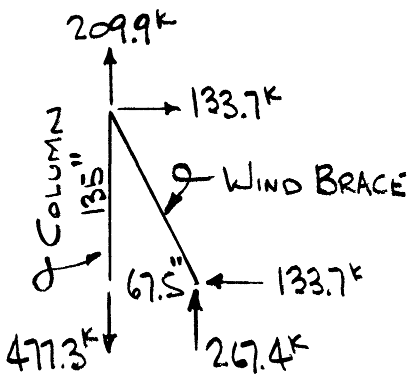
VERTICAL COLUMN LOAD DUE TO WIND (1 BAY)

2ND STORY

Section 1: $1452.88^k @ \frac{8.67^*}{60} = 209.9^k$

Section 2: $1321.84^k @ \frac{8.67}{60} = 191.0^k$

1ST STORY



Section 2: NO CHANGE = 191.0^k

DEAD LOADS (SEE REF. 1)

ROOF: $0.065^k/\text{FT}^2 @ 24\,\text{FT} \times 60\,\text{FT} \times \frac{1}{2} = 46.8^k$

WALL: $0.050^k/\text{FT}^2 @ 24\,\text{FT} \times 8.67\,\text{FT} = 10.4^k/\text{STORY}$

FLOOR: $0.093^k/\text{FT}^2 @ 24\,\text{FT} \times 27\,\text{FT} = 60.3^k/\text{FLOOR}$
$0.073^k/\text{FT}^2 @ 24\,\text{FT} \times 3\,\text{FT} = \underline{5.2}$
$65.5^k/\text{FLOOR}$

DEAD LOAD IN 1ST STORY COLUMNS

1 ROOF @ 46.8 = 46.8^k
19 FLOORS @ 65.5 = 1244.5
19 WALLS @ 10.4 = $\underline{197.6}$
TOTAL DL/1ST STORY = 1488.9^k

OVERTURNING CHECK

SECT. 1 $\frac{DL}{WL} = \frac{1489}{477} = 3.12$ OK

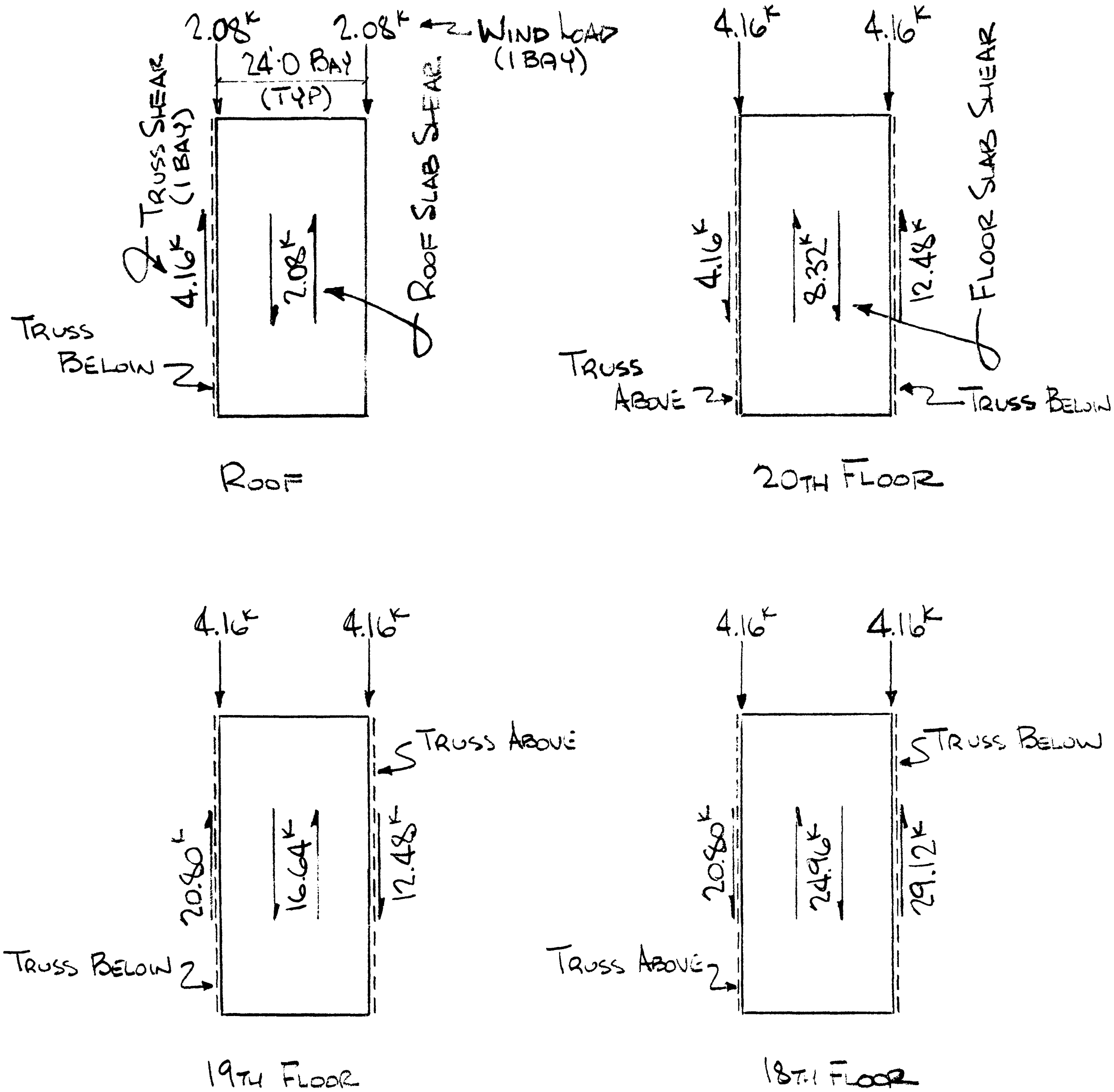
SECT. 2 $\frac{DL}{WL} = \frac{1489}{191} = 7.80$ OK

* NOTE: SUMMING TRUSS SHEARS AND MULTIPLYING BY THE TRUSS DEPTH TO SPAN RATIO IS ALGEBRAICALLY EQUIVALENT TO SUMMING INDIVIDUAL TRUSS REACTIONS CAUSED BY THE WIND SHEARS.

BY REL DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 5 OF 24
CHKD. BY DATE		JOB NO.

WIND LOAD DISTRIBUTION

ASSUME WIND TO BE DISTRIBUTED EQUALLY TO EACH COLUMN ROW. THE WIND LOAD SHOWN IS FOR AN INDIVIDUAL BAY.



WIND LOAD AND SHEAR DISTRIBUTION

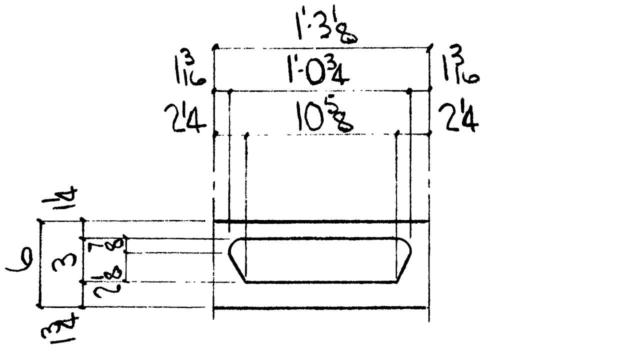
FOLLOWING THE PATTERN ESTABLISHED ON PAGE 5, TABULATE TRUSS AND FLOOR WIND LOADS FOR THE BUILDING.

		SECTION 1			SECTION 2	
FLOOR	STORY	WIND LOAD @ FLOOR	TRUSS ⌖ WIND SHEAR	FLOOR SLAB WIND SHEAR	WIND LOAD @ FLOOR	TRUSS ⌖ WIND SHEAR
ROOF		2.08^K		2.08^K	2.08^K	
	20		4.16^K			
20		4.16		8.32	4.16	
	19					12.48^K
19				16.64		
	18		20.80			
18				24.96		
	17					29.12
17				33.28		
	16		37.44			
16				41.60		
	15					45.76
15				49.92		
	14		54.08			
14				58.24		
	13					62.40
13		4.16		66.56	4.16	
	12		70.72			
12		3.64		74.36	3.64	
	11					78.00
11		3.12		81.12	3.12	
	10		84.24			
10				87.36		
	9					90.48
9				93.60		
	8		96.72			
8				99.84		
	7					102.96
7		3.12		106.08	3.12	
	6		109.20			
6		2.86		112.06	2.86	
	5					114.92
5		2.60		117.52	2.60	
	4		120.12			
4		2.34		122.46	2.34	
	3					124.80
3		2.08		126.88	2.08	
	2		128.96			
2		2.39		2.39*	2.39	
	1		133.74*			
1		1.35		—	1.35	

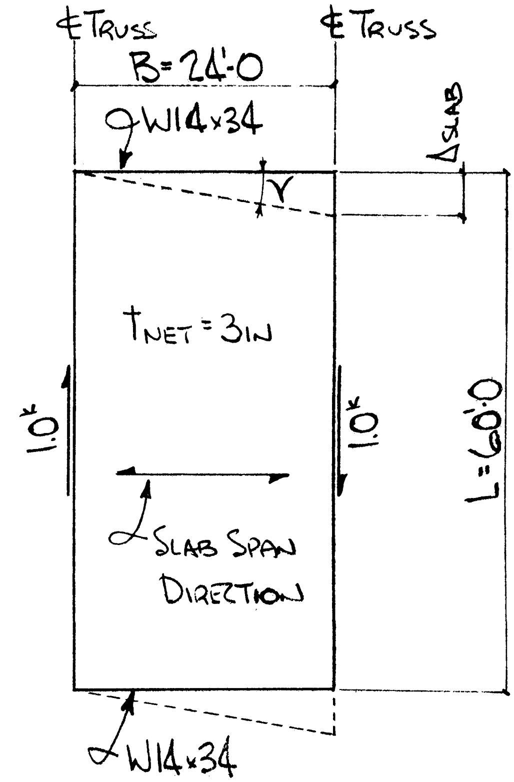
⌖ TRUSS WIND SHEAR FOR 1 BAY. TOTAL TRUSS SHEAR INCLUDES WIND LOAD FROM ADJACENT BAY.

* WIND SHEAR IN 2ND STORY TRUSS TRANSFERS TO THE WIND BRACE IN THE 1ST STORY. 2ND FLOOR SLAB TRANSFERS ONLY WIND LOAD FROM SECTION 2, 2ND FLOOR TO SECTION 1.

SLAB DISPLACEMENT - WIND LOAD RELATIONSHIP



TYPICAL SECTION THROUGH FLOOR SLAB



PLAN OF FLOOR SLAB

MATERIAL PROPERTIES

UNIT WEIGHT OF CONCRETE - $W_c = 145\ \#/FT^3$
CONCRETE 28-DAY COMPRESSIVE STRENGTH - $f'_c = 4000$ PSI

MODULUS OF ELASTICITY - CONCRETE - $E_c = W_c^{1.5}\, 33\sqrt{f'_c}$
$= 145 \times 33\sqrt{4000} \cong 3.6 \times 10^3\ K/IN^2$

ASSUME POISSON'S RATIO, $\upsilon = 0.2$

SHEAR MODULUS - CONCRETE - $G_c = \dfrac{E}{2(1+\upsilon)} = \dfrac{3.6\times10^3\ K/IN^2}{2(1+0.2)} = 1.5\times10^3\ K/IN^2$

MODULUS OF ELASTICITY - STEEL - $E_s = 29.\times10^3\ K/IN^2$

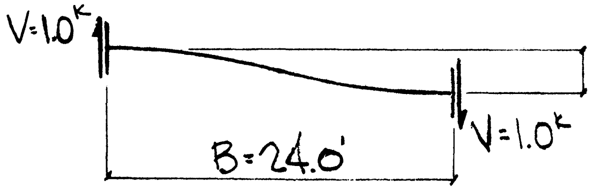
MODULAR RATIO OF ELASTICITY - $n = \dfrac{E_s}{E_c} = \dfrac{29\times10^3\ K/IN^2}{3.6\times10^3\ K/IN^2} \cong 8$

BY REL DATE ______ SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS SHEET NO. 8 OF 24
CHKD. BY ______ DATE ______ JOB NO. ______

SLAB DISPLACEMENT - WIND LOAD RELATIONSHIP

$$\Delta_{SS} = B\gamma = \frac{BV}{AG_c} = \frac{(24 \times 12_{IN})\,1.0^k}{3_{IN}\,(60 \times 12_{IN})(1.5 \times 10^3\,K/_{IN^2})} = 8.89 \times 10^{-5}\ IN$$

BENDING DISPLACEMENT



$$\Delta_{BS} = \frac{VB^3}{12 E_c I}$$

$$
\begin{aligned}
I_{CONC} &= \tfrac{1}{12}(3_{IN})(60 \times 12_{IN})^3 &&= 93.3 \times 10^6\ IN.^4 \\
I_{STL} &= 2\,(10_{IN^2})(30 \times 12_{IN})^2\ \underset{n}{8} &&= \underline{20.7 \times 10^6} \\
I_{TOT} &= &&= 114.0 \times 10^6\ IN.^4
\end{aligned}
$$

$$\Delta_{SB} = \frac{1.0^k\,(12 \times 24_{IN})^3}{12(3.6 \times 10^3\,K/_{IN^2})(114 \times 10^6\,IN^4)} = 0.485 \times 10^{-5}\ IN$$

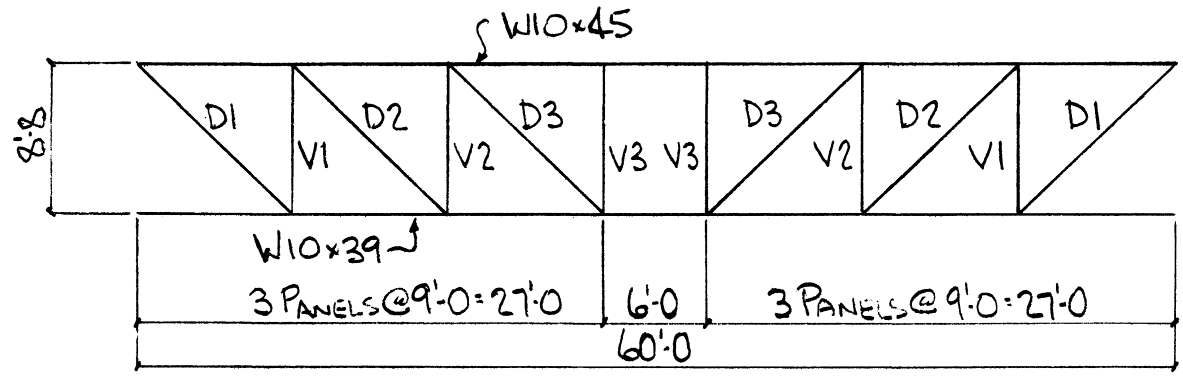
TOTAL DISPLACEMENT

$$
\begin{aligned}
\Delta_{SS} &= 8.89 \times 10^{-5}\ IN \\
\Delta_{SB} &= \underline{0.49 \times 10^{-5}\ IN} \\
\Delta_{SLAB} &= 9.38 \times 10^{-5}\ IN
\end{aligned}
$$

DEFLECTION-FORCE RELATIONSHIP - FLOOR SLAB = 0.0000938 IN./KIP

TRUSS DISPLACEMENT - WIND LOAD RELATIONSHIP

PROPERTIES OF TRUSS



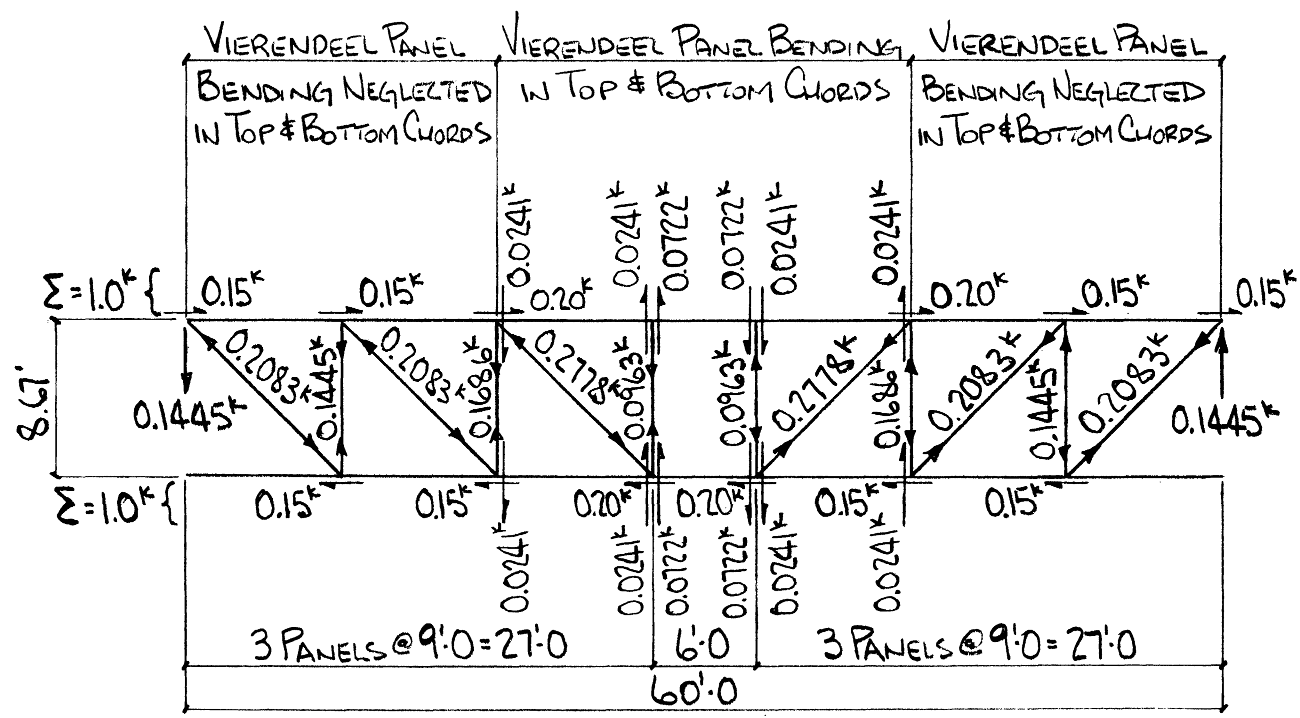
MEMBER PROPERTIES

MEMBER	SECTION		A (IN.²)	Ix (IN.⁴)	Iy (IN.⁴)
TOP CHORD	W10×45		13.3	248.	53.4
BOTT. CHORD	W10×39		11.5	209.	45.0
DIAGONAL D1	2C8×11.5	][	6.76	65.2	4.84
D2	2C6×8.2	][	4.80	26.2	2.64
D3	2C3×4.1	][	2.42	3.32	0.854
VERTICAL V1	2C6×10.5	[ ]	6.18	30.4	21.4
V2	2C5×6.7	[ ]	3.94	14.98	10.0
V3	2C3×4.1	[ ]	2.42	3.32	4.02

TRUSS DISPLACEMENT - WIND LOAD RELATIONSHIP

1.0^K WIND LOAD AND UNIT VIRTUAL LOAD - TYPICAL TRUSS

DISTRIBUTE WIND LOAD AND REACTIONS TO CAUSE ZERO AXIAL FORCE IN THE TOP AND BOTTOM CHORDS.
USE THE SAME FORCE DIAGRAM FOR THE 1.0^K WIND LOAD AND THE HORIZONTAL UNIT VIRTUAL LOAD.



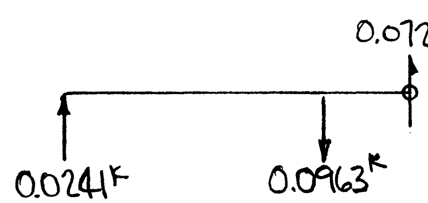
VERTICAL REACTION $= 1.0^K \times \frac{8.67}{60}$

$= 0.1445^K$

TRUSS MEMBER FORCES ARE CALCULATED ON THE SKETCH STARTING AT THE REACTIONS BY USING THE METHOD OF JOINTS.

CHORD REACTIONS

DIVIDE SHEAR EQUALLY BETWEEN TOP AND BOTTOM CHORDS. NEGLECT OUTER TWO PANELS EACH END.



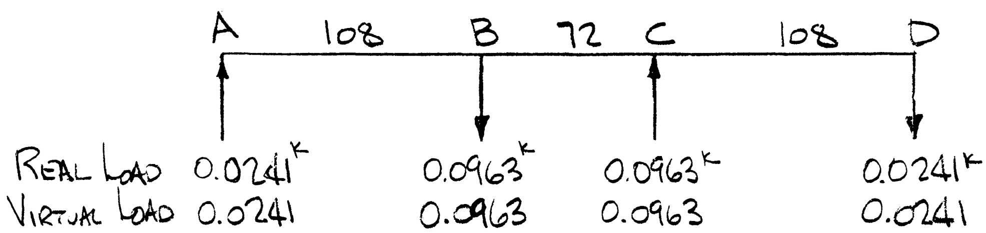
$0.0722 \times \frac{12}{9} = 0.0963^K$

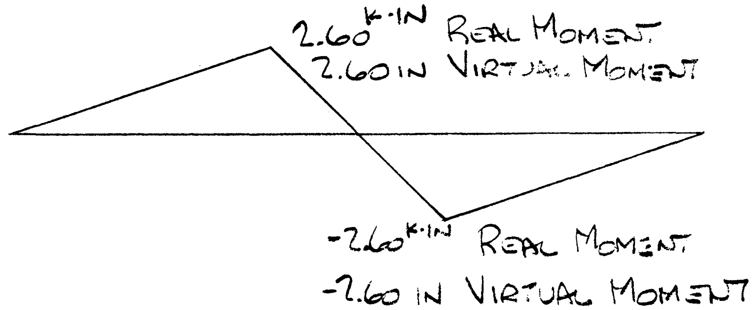
$0.0722 \times \frac{3}{9} = 0.0241^K$

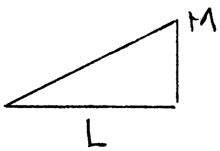
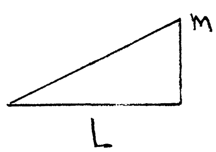
TRUSS DISPLACEMENT - WIND LOAD RELATIONSHIP

CHORD BENDING (VIRTUAL WORK)

$$\Delta_{BT} = \sum_{i=1,n} \int \frac{M_i m_i}{E I_i} dx$$





FOR  AND  , THE $\int_0^L \frac{Mm}{EI} dx = \frac{MmL}{3EI}$

$$\Delta_{BT} = 2\left[\frac{(2.60)^2 \text{ K-IN}^2 (108\text{IN} + 36\text{IN})}{3(2.9\times10^4 \text{ K/IN}^2) I}\right] = \frac{0.02233}{I}$$

$$\Delta_{BT} = 0.02238\left[\frac{1}{I_{TOP}} + \frac{1}{I_{BOTT}}\right] = 0.02238\left[\frac{1}{248} + \frac{1}{209}\right]$$

$$\Delta_{BT} = 1.973\times10^{-4} \text{ IN}$$

TRUSS DISPLACEMENT - WIND LOAD RELATIONSHIP

AXIAL EFFECTS (VIRTUAL WORK)

$$\Delta_{AT} = \sum_{i=1,n} \frac{F_i u_i L_i}{A_i E}$$

MEMBER	F	u	L	A	$\frac{FuL}{A}$
DIAGONAL	0.2083^k	0.2083	149.93	$6.76 in^2$	0.962 k/in
↓	0.2083	0.2083	↓	4.80	1.355
	0.2778	0.2778		2.42	4.781
VERTICAL	0.1445	0.1445	104	6.18	0.351
↓	0.1686	0.1686	↓	3.94	0.750
	0.0963	0.0963		2.42	0.399

$\Sigma \frac{FuL}{A}$ FOR ½ TRUSS 8.598 k/in

$E\Delta_A = \Sigma \frac{FuL}{A}$ FOR FULL TRUSS 17.196 k/in

COMBINED DISPLACEMENT

$\Delta_{AT} = 17.196 \text{ k/in} / 29000 = 5.930 \times 10^{-4}$ in.

$\Delta_{BT} = 1.973 \times 10^{-4}$

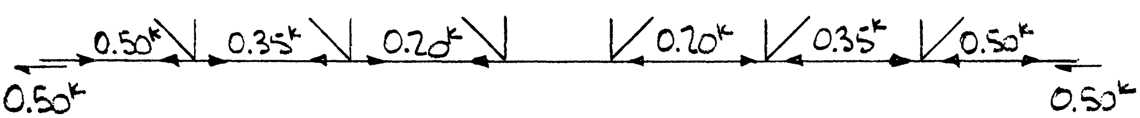
$\Delta_{TT} = 0.790 \times 10^{-3}$ in.

$$\underline{\underline{\Delta_{TR} = 0.000790 \text{ in/kip}}}$$

2ND FLOOR TRUSS

REACTIONS @ ENDS OF BOTTOM CHORD. REAL AND VIRTUAL LOAD

ADD BOTTOM CHORD FORCES - OTHER MEMBER FORCES DO NOT CHANGE.



TRUSS DISPLACEMENT DUE TO WIND SHEAR

2ND FLOOR TRUSS

MEMBER	F	U	L	A	$\frac{FUL}{A}$
BOTT. CHD	0.50^K	0.50	108. IN.	11.5 IN²	2.348 K/IN
↓	0.35	0.35	↓	11.5	1.150
↓	0.20	0.20	↓	11.5	0.376

$\left.\begin{matrix}2.348\\1.150\\0.376\end{matrix}\right\}3.874 \times 2 = 7.748\ ^K/_{IN.}$

$\left.\begin{matrix}\Sigma\Delta A = 17.196\ ^K/_{IN}\\ 7.748\end{matrix}\right\} 24.944\ ^K/_{IN.}$

COMBINED DISPLACEMENT

$\left.\begin{matrix}\Delta_{AXIAL} = 24.944/29000 = 8.601\times10^{-4}\ IN\\ \Delta_{BENDING} = (\text{FROM SHT. } 11) = 1.973\times10^{-4}\end{matrix}\right\} \Delta_{TOTAL} = 1.057\times10^{-3}\ IN.$

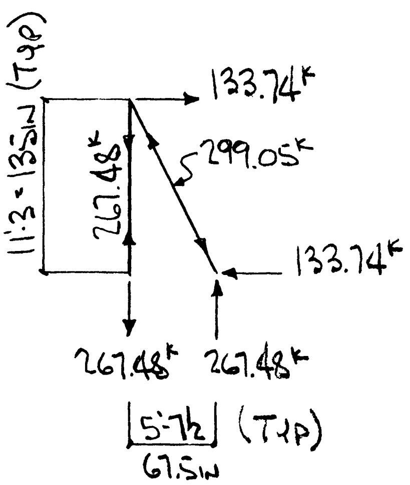
$\underline{\Delta_{TR\cdot 2ND} = 0.001057\ IN./KIP}$

WIND BRACE

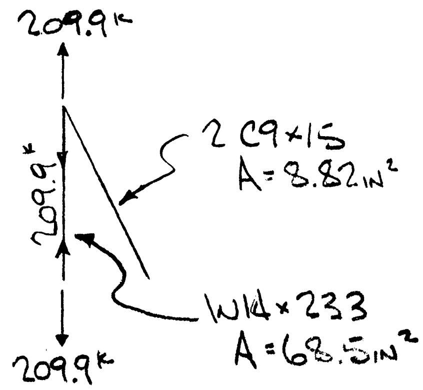
FROM SHEET 3, 1ST STORY WIND LOAD 133.74 K/BAY × 2 BAYS = 267.48^K
DUE TO SYMMETRY - ½ PER KNEE BRACE = = 133.74^K

FROM SHEET 4, 2ND STORY COL. LOAD (2 BAYS) = 209.9^K

HORIZONTAL LOAD

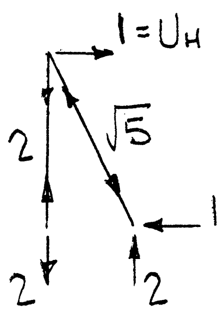


VERTICAL LOAD

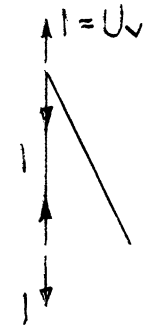


WIND BRACE - DISPLACEMENTS

HORIZONTAL VIRTUAL LOAD



VERTICAL VIRTUAL LOAD



HORIZONTAL DISPLACEMENT

HORIZ LOAD

MEMB	F	U	L	A
COL.	+267.48^K	+2	135 IN.	68.5 IN.^{2}
W.B.	-299.05	$-\sqrt{5}$	150.93	8.82

$$\Delta_{BH/H} = \Sigma \frac{FuL}{AE} = \frac{12497 \text{ K/IN.}}{29000 \text{ K/IN.}^2} = \underline{0.4309 \text{ IN.}}$$

VERT LOAD

MEMB	F	U	L	A
COL	+209.9^K	+2	135. IN.	68.5 IN.^{2}
W.B.	0	$-\sqrt{5}$	150.93	8.82

$$\Delta_{BH/V} = \Sigma \frac{FuL}{AE} = \frac{827.3 \text{ K/IN.}}{29000 \text{ K/IN.}^2} = \underline{0.0285 \text{ IN.}}$$

$$\Delta_{BH/TOT} = 0.4309 + 0.0285 = \underline{0.4594 \text{ IN.}}$$

VERTICAL DISPLACEMENT

HORIZ LOAD

MEMB	F	U	L	A
COL	+267.48^K	+1	135. IN.	68.5 IN.^{2}
W.B.	-299.05	0	150.93	8.82

$$\Delta_{BV/H} = \Sigma \frac{FuL}{AE} = \frac{527.2 \text{ K/IN.}}{29000 \text{ K/IN.}^2} \approx \underline{0.0182 \text{ IN.}}$$

VERT LOAD

MEMB	F	U	L	A
COL.	+209.9^K	+1	135. IN.	68.5 IN.^{2}
W.B.	0	0	150.93	8.82

$$\Delta_{BV/V} = \Sigma \frac{FuL}{AE} = \frac{413.7 \text{ K/IN.}}{29000 \text{ K/IN.}^2} = \underline{0.0143 \text{ IN.}}$$

$$\Delta_{BV/TOT} = 0.0182 + 0.0143 = \underline{0.0325 \text{ IN.}}$$

BY REL	DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 15 OF 24
CHKD. BY	DATE		JOB NO.

STRUCTURAL DRIFT - SECTION 1

FOR SLAB AND TRUSS SHEARS, SEE SHT. 6

SLAB DISPLACEMENT = SLAB SHEAR × 0.938×10^{-4} IN./KIP SEE SHT. 8
TRUSS DISP. EXCEPT 2ND STORY = TRUSS SHEAR × 0.790×10^{-3} IN./KIP SEE SHT. 12
TRUSS DISP. - 2ND STORY = TRUSS SHEAR × 1.057×10^{-3} IN./KIP SEE SHT. 13.

	SLAB ABOVE		TRUSS		SLAB BELOW		DRIFT PER STORY,
STORY	SHEAR, KIPS	DRIFT, IN.	SHEAR,* KIPS	DRIFT, IN.	SHEAR, KIPS	DRIFT, IN.	IN.
20	-	-	8.32	0.0066	-	-	0.0066
19	8.32	0.0008	24.96	0.0197	16.64	0.0016	0.0221
18	-	-	41.60	0.0329	-	-	0.0329
17	24.96	0.0023	58.24	0.0460	33.28	0.0031	0.0514
16	-	-	74.88	0.0592	-	-	0.0592
15	41.60	0.0039	91.52	0.0723	49.92	0.0047	0.0809
14	-	-	108.16	0.0854	-	-	0.0854
13	58.24	0.0055	124.80	0.0986	66.56	0.0062	0.1103
12	-	-	141.44	0.1117	-	-	0.1117
11	74.36	0.0070	156.00	0.1232	81.12	0.0076	0.1378
10	-	-	168.48	0.1331	-	-	0.1331
9	87.36	0.0082	180.96	0.1430	93.60	0.0088	0.1600
8	-	-	193.44	0.1528	-	-	0.1528
7	99.84	0.0094	205.92	0.1627	106.08	0.0100	0.1821
6	-	-	218.40	0.1725	-	-	0.1723
5	112.06	0.0105	229.84	0.1816	117.52	0.0110	0.2031
4	-	-	240.24	0.1898	-	-	0.1898
3	122.46	0.0115	249.60	0.1972	126.88	0.0119	0.2206
2	-	-	257.92	0.2726	-	-	0.2726
1	WIND BRACE - SEE SHT. 14						0.4309

* TRUSS SHEAR FOR 2 BAYS

BY REL	DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 16 OF 24
CHKD. BY	DATE		JOB NO.

STRUCTURAL DRIFT - SECTION 1

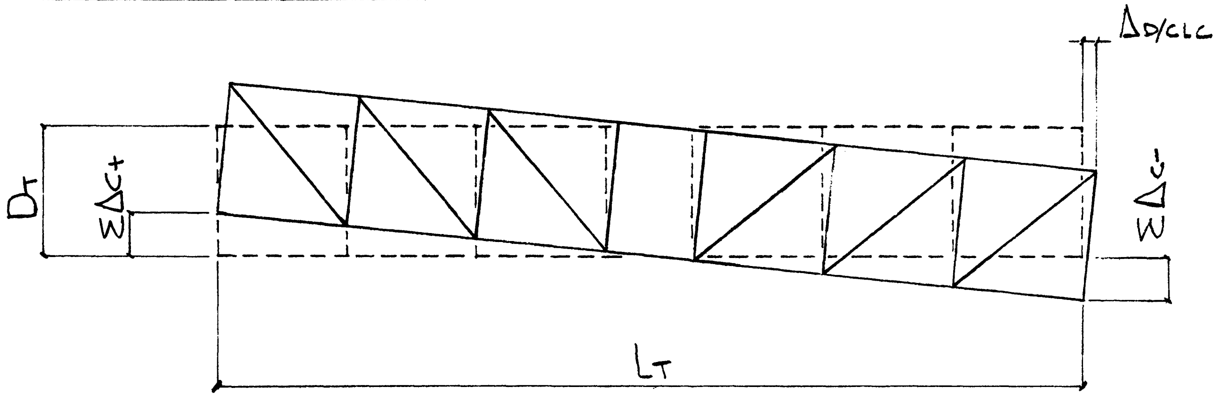
FOR SLAB AND TRUSS SHEARS, SEE SHT. 6

SLAB DISPLACEMENT = SLAB SHEAR × 0.938×10^{-4} IN./K SEE SHT. 8
TRUSS DISP EXCEPT 2ND STORY = TRUSS SHEAR × 0.790×10^{-3} IN./K SEE SHT. 12
TRUSS DISP - 2ND STORY = TRUSS SHEAR × 1.057×10^{-3} IN./K SEE SHT. 13

	SLAB ABOVE		TRUSS		SLAB BELOW		DRIFT PER
STORY	SHEAR, KIPS	DRIFT, IN.	SHEAR,* KIPS	DRIFT, IN.	SHEAR, KIPS	DRIFT, IN.	STORY, IN.
20	2.08	0.0002	8.32	0.0066	8.32	0.0008	0.0076
19	-	-	24.96	0.0197	-	-	0.0197
18	16.64	0.0016	41.60	0.0329	24.96	0.0023	0.0368
17	-	-	58.24	0.0460	-	-	0.0460
16	33.28	0.0031	74.88	0.0592	41.60	0.0039	0.0662
15	-	-	91.52	0.0723	-	-	0.0723
14	49.92	0.0047	108.16	0.0854	58.24	0.0055	0.0956
13	-	-	124.80	0.0986	-	-	0.0986
12	66.56	0.0062	141.44	0.1117	74.36	0.0070	0.1249
11	-	-	156.00	0.1232	-	-	0.1232
10	81.12	0.0076	168.48	0.1331	87.36	0.0082	0.1489
9	-	-	180.96	0.1430	-	-	0.1430
8	93.60	0.0088	193.44	0.1528	99.84	0.0094	0.1710
7	-	-	205.92	0.1627	-	-	0.1627
6	106.08	0.0100	218.40	0.1725	112.06	0.0105	0.1930
5	-	-	229.84	0.1816	-	-	0.1816
4	117.52	0.0110	240.24	0.1898	122.46	0.0115	0.2123
3	-	-	249.60	0.1972	-	-	0.1972
2	126.88	0.0119	257.92	0.2726	-2.39	-0.0002	0.2843
1	2.39	0.0002	DRIFT/WIND BRACE-SECT. 1 →			0.4309	0.4311

* TRUSS SHEAR FOR 2 BAYS.

COLUMN-LENGTH CHANGE



$$\Delta_{C+/STORY} = \frac{\Sigma \text{VERT REACT} \times \text{STORY HEIGHT}}{\text{COL AREA} \times 29000} = \frac{\Sigma \text{VERT REACT} \times 104^{*}}{\text{COL AREA} \times 29000}$$

$\Sigma\Delta_{C+} = \sum_{i=1,n}(\Delta_{C+/STORY})_i$ WHERE n IS THE NUMBER OF STORIES BELOW THE TRUSS REACTION POINTS.

$\Sigma\Delta_{C-} = -\Sigma\Delta_{C+}$ (LIKE COLUMNS SUPPORTING EACH END OF THE TRUSS ARE ASSUMED.)

$$\Delta_{D/CLC} = \left[\,|\Sigma\Delta_{C+}| + |\Sigma\Delta_{C-}|\,\right]\frac{D_T}{L_T} = 2\left[\Sigma\Delta_{C+}\right]\frac{D_T}{L_T}$$

$$\Delta_{D/CLC} = 2\left[\Sigma\Delta_{C+}\right]\frac{8'\text{-}8}{60'\text{-}0}$$

Σ VERT REACT = TOTAL COLUMN LOAD IN A PARTICULAR STORY AS A RESULT OF WIND LOADS ACTING ON ALL THE TRUSSES SUPPORTED BY THAT COLUMN SEGMENT.

$\Delta_{C+/STORY}$ = POSITIVE LENGTH CHANGE IN A PARTICULAR COLUMN SEGMENT CAUSED BY Σ VERT. REACT.

$\Sigma\Delta_{C+}$ = THE SUM OF THE POSITIVE LENGTH CHANGES OF THE COLUMN SEGMENTS SUPPORTING A PARTICULAR TRUSS

$\Delta_{D/CLC}$ = THE DISPLACEMENT OF A TRUSS IN A PARTICULAR STORY (DRIFT PER STORY) CAUSED BY THE SUM OF THE LENGTH CHANGES OF THE COLUMN SEGMENTS SUPPORTING THAT TRUSS.

* 1ST STORY = 135. Δ_{C+} CALCULATED AS PART OF THE WIND BRACE.

BY REL DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 18 OF 24
CHKD. BY DATE		JOB NO.

COLUMN LENGTH CHANGE

VERTICAL COLUMN REACTIONS DUE TO WIND SHEAR

$$\text{VERT. REACTION} = \text{TRUSS SHEAR} \times \frac{8'\text{-}8}{60\text{ FT.}}$$

SECTION 1

STORY	TRUSS SHEAR, K*	VERT REACT, K	Σ VERT REACT, K
20	8.32	1.202	1.202
18	41.60	6.009	7.211
16	74.88	10.816	18.027
14	108.16	15.623	33.650
12	141.44	20.430	54.080
10	168.48	24.336	78.416
8	193.44	27.941	106.357
6	218.40	31.547	137.904
4	240.24	34.701	172.605
2	257.92	37.255	209.860

SECTION 2

STORY	TRUSS SHEAR, K*	VERT REACT, K	Σ VERT REACT, K
19	24.96	3.605	3.605
17	58.24	8.412	12.017
15	91.52	13.220	25.237
13	124.80	18.027	43.264
11	156.00	22.533	65.797
9	180.96	26.139	91.936
7	205.92	29.744	121.680
5	229.84	33.199	154.879
3	249.60	36.053	190.932

* INCLUDES TRUSS SHEAR FROM THE ADJACENT BAY.

BY REL DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 19 OF 24
CHKD. BY DATE		JOB NO.

COLUMN LENGTH CHANGE

SECTION 1 (FOR DEFINITION OF SYMBOLS, SEE SHEET 17.)

STORY	COLUMN SECTION	COLUMN AREA, IN^2	Σ VERT REACT, K	ΔC+ STORY, IN.	ΣΔC+, IN.	PER STORY DRIFT (ΔD/CLC), IN.
1	W14×233	68.5	209.86	0.0325*	0.0325	0.0285*
2	W14×233	68.5	209.86	0.0110	0.0435	0.0126
3	W14×211	62.0	172.61	0.0100	0.0535	
4	W14×211	62.0	172.61	0.0100	0.0635	0.0183
5	W14×193	56.8	137.90	0.0087	0.0722	
6	W14×193	56.8	137.90	0.0087	0.0809	0.0234
7	W14×159	46.7	106.36	0.0082	0.0891	
8	W14×159	46.7	106.36	0.0082	0.0973	0.0281
9	W14×145	42.7	78.42	0.0066	0.1039	
10	W14×145	42.7	78.42	0.0066	0.1105	0.0319
11	W14×120	35.3	54.08	0.0055	0.1160	
12	W14×120	35.3	54.08	0.0055	0.1215	0.0351
13	W14×90	26.5	33.65	0.0046	0.1261	
14	W14×90	26.5	33.65	0.0046	0.1307	0.0378
15	W14×74	21.8	18.03	0.0030	0.1337	
16	W14×74	21.8	18.03	0.0030	0.1367	0.0395
17	W14×53	15.6	7.21	0.0017	0.1384	
18	W14×53	15.6	7.21	0.0017	0.1401	0.0405
19	W14×43	12.6	1.20	0.0003	0.1404	
20	W14×43	12.6	1.20	0.0003	0.1407	0.0406

*WIND BRACE, SEE SHEET 14.

BY RLL DATE ______ SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS SHEET NO. 20 OF 24

CHKD. BY ______ DATE ______ JOB NO. ______

COLUMN LENGTH CHANGE

SECTION 2 (FOR DEFINITION OF SYMBOLS, SEE SHT. 17)

STORY	Σ VERT REACT, K	COLUMN* AREA, IN^2	Δc+ STORY, IN.	$\Sigma\Delta$c+, IN.	PER STORY DRIFT (ΔDICLC), IN.	DRIFT/STORY, IN.** SECT. 1 & SECT. 2
1	190.93	68.5	0.0130	0.0130	-	0.0285
2	190.93	68.5	0.0100	0.0230	-	0.0126
3	190.93	62.0	0.0110	0.0340	0.0098	0.0098
4	154.88	62.0	0.0090	0.0430	-	0.0183
5	154.88	56.8	0.0098	0.0528	0.0153	0.0153
6	121.68	56.8	0.0077	0.0605	-	0.0234
7	121.68	46.7	0.0093	0.0698	0.0202	0.0202
8	91.94	46.7	0.0071	0.0769	-	0.0281
9	91.94	42.7	0.0077	0.0846	0.0244	0.0244
10	65.80	42.7	0.0055	0.0901	-	0.0319
11	65.80	35.3	0.0067	0.0968	0.0280	0.0280
12	43.26	35.3	0.0044	0.1012	-	0.0351
13	43.26	26.5	0.0059	0.1071	0.0309	0.0309
14	25.24	26.5	0.0034	0.1105	-	0.0375
15	25.24	21.8	0.0042	0.1147	0.0331	0.0331
16	12.02	21.8	0.0020	0.1167	-	0.0395
17	12.02	15.6	0.0028	0.1195	0.0345	0.0345
18	3.61	15.6	0.0008	0.1203	-	0.0405
19	3.61	12.6	0.0010	0.1213	0.0350	0.0350
20	-	12.6	-	0.1213	-	0.0406

* FOR COLUMN SECTION, SEE SHT. 19

** BECAUSE THE FLOORS FUNCTION AS VERY EFFICIENT DIAPHRAGMS, THE DRIFT CAUSED BY THE LENGTH CHANGE OF THE COLUMNS IS THE SAME FOR SECTION 1 AND SECTION 2. IT IS DETERMINED IN EACH STORY BY THE TRUSS IN THAT STORY.

BY REL DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 21 OF 24
CHKD. BY DATE		JOB NO.

FINAL DRIFT DETERMINATION

SECTION 1

STORY	STRUCT DRIFT	COL LGTH CHG	TOTAL DRIFT PER STORY	TOTAL DRIFT	DRIFT RATIO PER STORY
1	0.4309	0.0285	0.4594	0.4594	0.0034
2	0.2726	0.0126	0.2852	0.7446	0.0027
3	0.2206	0.0098	0.2304	0.9750	0.0022
4	0.1898	0.0183	0.2081	1.1831	0.0020
5	0.2031	0.0153	0.2184	1.4015	0.0021
6	0.1723	0.0234	0.1957	1.5972	0.0019
7	0.1821	0.0202	0.2023	1.7995	0.0019
8	0.1528	0.0281	0.1809	1.9804	0.0017
9	0.1600	0.0244	0.1844	2.1648	0.0018
10	0.1331	0.0319	0.1650	2.3298	0.0016
11	0.1378	0.0280	0.1658	2.4956	0.0016
12	0.1117	0.0351	0.1468	2.6424	0.0014
13	0.1103	0.0309	0.1412	2.7836	0.0014
14	0.0854	0.0378	0.1232	2.9068	0.0012
15	0.0809	0.0331	0.1140	3.0208	0.0011
16	0.0592	0.395	0.0987	3.1195	0.0009
17	0.0514	0.0345	0.0859	3.2054	0.0008
18	0.0329	0.0405	0.0734	3.2788	0.0007
19	0.0221	0.0350	0.0571	3.3359	0.0005
20	0.0066	0.0406	0.0472	3.3831	0.0005

HEIGHT = 164'-8 + 11'-3 = 175'-11 = 2111 IN.

$$\text{OVERALL DRIFT RATIO} = \frac{3.3831}{2111.} = 0.0016$$

ALL DIMENSIONS ARE IN INCHES.

BY REL	DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 22 OF 24
CHKD. BY	DATE		JOB NO.

FINAL DRIFT DETERMINATION

SECTION 2

STORY	STRUCT DRIFT	COL LGTH CHANGE	TOTAL DRIFT PER STORY	TOTAL DRIFT	DRIFT RATIO PER STORY
1	0.4311	0.0285	0.4596	0.4596	0.0034
2	0.2843	0.0126	0.2969	0.7565	0.0029
3	0.1972	0.0098	0.2070	0.9635	0.0020
4	0.2123	0.0183	0.2306	1.1941	0.0022
5	0.1816	0.0153	0.1969	1.3910	0.0019
6	0.1930	0.0234	0.2164	1.6074	0.0021
7	0.1627	0.0202	0.1829	1.7903	0.0018
8	0.1710	0.0281	0.1991	1.9894	0.0019
9	0.1430	0.0244	0.1674	2.1568	0.0016
10	0.1489	0.0319	0.1808	2.3376	0.0017
11	0.1232	0.0280	0.1512	2.4888	0.0015
12	0.1249	0.0351	0.1600	2.6488	0.0015
13	0.0986	0.0309	0.1295	2.7783	0.0012
14	0.0956	0.0378	0.1334	2.9117	0.0013
15	0.0723	0.0331	0.1054	3.0171	0.0010
16	0.0662	0.0395	0.1057	3.1228	0.0010
17	0.0460	0.0345	0.0805	3.2033	0.0008
18	0.0368	0.0405	0.0773	3.2806	0.0007
19	0.0197	0.0350	0.0547	3.3353	0.0005
20	0.0076	0.0406	0.0482	3.3835	0.0005

HEIGHT = 164'-8 + 11'-3 = 175'-11 = 2111. IN.

$$\text{OVERALL DRIFT RATIO} = \frac{3.3835}{2111.} = 0.0016$$

ALL DIMENSIONS ARE IN INCHES.

BY REL	DATE	SUBJECT CALCULATION OF WIND DRIFT IN STAGGERED-TRUSS BUILDINGS	SHEET NO. 23 OF 24
CHKD. BY	DATE		JOB NO.

CONTROL OF DRIFT

1ST STORY

KNEE BRACE - 2C9×15   INCREASE TO 2C10×30

REFER TO SHEET 14. CONSIDER ONLY HORIZONTAL DISPLACEMENT OF THE KNEE BRACE CAUSED BY HORIZONTAL LOAD.

HORIZ. LOAD

MEMB	F	U	L	A	$\frac{FUL}{A}$
COL	+267.42^k	+2	135 IN.	68.5 IN.^{2}	1054.3
K.BR.	-299.05	$-\sqrt{5}$	150.93	17.64	5721.4
				$\Sigma \frac{FUL}{A}$ =	6775.7

$$\delta_{H/H} = \Sigma \frac{FUL}{AE} = \frac{6775.7}{29000} = 0.2336 \text{ IN.}$$

$$\Delta \text{1ST STORY DRIFT} \left.\begin{array}{l} = -0.4309 \text{ (SH. 14)} \\ +0.2336 \end{array}\right\} -0.1973 \text{ IN.}$$

REVISED DRIFT.

SECTION 1

ORIGINAL DRIFT = 0.4594 IN.
Δ 1ST STORY DRIFT = -0.1973
IMPROVED DRIFT = 0.2621 IN.

$$\text{DRIFT RATIO} = \frac{0.2621}{135} = 0.0019$$

SECTION 2

ORIGINAL DRIFT = 0.4596 IN.
Δ 1ST STORY DRIFT = -0.1973
IMPROVED DRIFT = 0.2623 IN.

$$\text{DRIFT RATIO} = \frac{0.2623}{135} = 0.0019$$

CONTROL OF DRIFT

2ND STORY - TRUSS

2ND STORY DRIFT RATIO APPROACHES 0.003
TO ATTAIN A DRIFT RATIO OF 0.002, USE 2C8×11.5 FOR ALL DIAGS
2C6×10.5 FOR ALL VERTS
W10×45 FOR BOTT. CHD

NOTE: NO NEW SHAPES ADDED TO THE PROJECT.

AXIAL EFFECTS (VIRTUAL WORK)

MEMBER	F	U	L	A	$\frac{FUL}{A}$
TOP CHORD	0				
DIAGONAL	0.2083^k	0.2083	149.93 IN	$6.76\,IN^2$	0.962 K/IN.
↓	0.2083	0.2083	↓	↓	0.962
↓	0.2778	0.2778	↓	↓	1.712
VERTICAL	0.1445	0.1445	104	6.18	0.351
↓	0.1686	0.1686	↓	↓	0.478
↓	0.0963	0.0963	↓	↓	0.156
BOTT. CHORD	0.5000	0.5000	108	13.3	2.030
↓	0.3500	0.3500	↓	↓	0.995
↓	0.2000	0.2000	↓	↓	0.325

$\Sigma \frac{FUL}{A}$ (½ TRUSS) 7.971 K/IN.

$E\Delta_A = \Sigma \frac{FUL}{A}$ (FULL TRUSS) 15.942 K/IN.

COMBINED DISPLACEMENT

$\Delta_{AXIAL} = 15.942 / 29000 = 0.550 \times 10^{-3}$ IN
$\Delta_{BENDING} = 2 \times 0.902 \times 10^{-4}$ (SHT. 11) $= 0.180 \times 10^{-3}$

$\Delta_{TR} = 0.730 \times 10^{-3}$ IN

$\Delta_{TR\text{-}2ND\,FL.} = 0.730 \times 10^{-3}$ IN/K

SECTION 1

TRUSS $= 257.92 \times 0.730 \times 10^{-3} = 0.1883$ IN.
COL L.GIG $= 0.0126$
0.2009 IN.

DRIFT RATIO $= \frac{0.2009}{104} = 0.0019$

SECTION 2

TRUSS : 0.1883
SLAB : 0.0117 → 0.2000
COL L.GIG 0.0126
→ 0.2126 IN.

DRIFT RATIO $= \frac{0.2126}{104} = 0.0020$