Temecula Medical Center
Temecula, CA

Technical Assignment #2

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Architectural Engineering – Structural Option
Senior Thesis Project

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Executive Summary

Building Description

The Temecula Medical Center is a 6-story hospital which features a 2-story Drug and Therapy center (D&T) as well as a 6-story bed tower. The engineers decided to resist the heavy west coast lateral forces with various concrete shear walls placed systematically throughout the plan. By using this approach, along with a concrete floor system, money was saved while still provided more than adequate force resisting systems. Hospital designs come with additional safety factors which had to be taken into consideration throughout the design of the structural system.

Report Summary

The purpose of this report is to discuss possible alternatives to the existing floor system of the Temecula Medical Center, using analytical methods and a comparison of industry system information. While there are two floor systems used in the existing structure (Prestressed double-tees, and Two-way flat plate slab), I will compare alternatives to the Two-way system primarily because it is used more frequently.

Existing System:

Two-way flat plate slab with f'_c = 5000 psi

Alternative Systems:

Two-way slab with beams
Non-Composite steel frame
Steel beam framing with light weight concrete deck

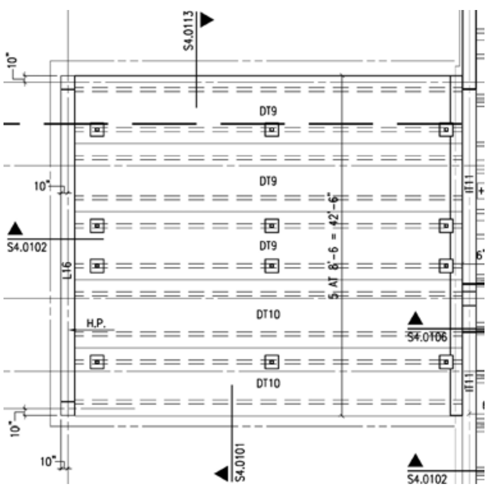
Alternative floor systems were analyzed based on criteria such as overall weight of the system, fire proofing, vibration control, relative cost, and ease of construction. The systems were then compared to the existing floor system's performance based criteria.

Existing Structural System

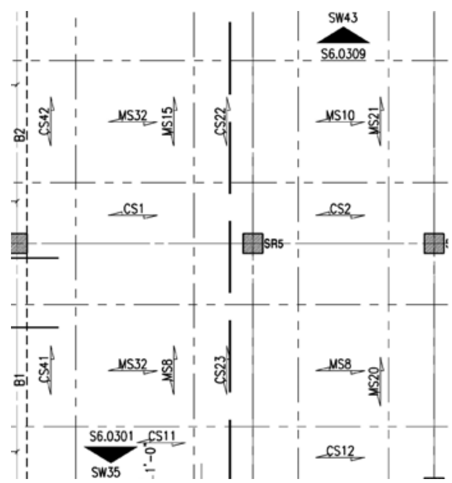
Floor System

The floor system of the first floor consists of a 5″ slab-on-grade while the remaining floors of the Drug and Therapy Center (D&T) are supported by various sized precast, prestressed double-tees. The 6-story bed tower consists of two-way, 10″ reinforced concrete flat slabs. Slab reinforcement ranges from #4 bars to #6 bars, spaced from 6″ to 9″ on center.

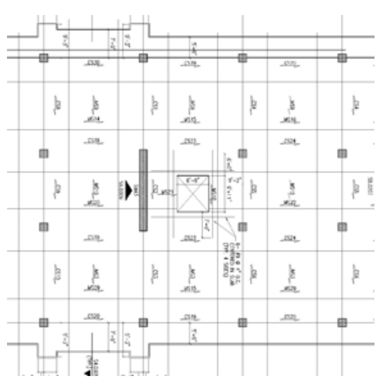
Topping slabs of the double tees in the D&T consists of 6″ normal weight concrete, typically reinforced with #4 at 9″ o.c. Typical spans between tee's is 6'-0 but vary on location (See image 1). Two-way flat slab reinforcement sizes for the 6-story bed tower vary but are placed equally across designed column and middle strips (See images 2 and 3). The two-way flat slab layout shown will be used in the comparison of alternative floor systems. Calculations and comparisons to the original design are available in the appendix.



[1]Prestressed Double Tee Layout



[2]Two-Way Flat Slab Layout


[3]Two-Way Flat Slab Layout

Roof System

The lower roof over the 6-story bed tower is composite slab with 4 ½″ normal weight concrete over 2″, 16 gage composite metal deck (galvanized), reinforced with #3 at 9″ o.c. each way. Supporting the 1 ½″, 20 gage metal deck on the high roof are rolled steel W-shapes, typically W10x17, 33, or 45. The roof system over the 2-story D&T is very similar and consists of a 1 ½″, 20 gage metal deck held up by rolled steel W-shapes, varying in size from W8 to W18.

Lateral System

The lateral forces are resisted predominantly by concrete shear walls placed throughout the plan. The elevator shafts serve as the main resistance system. Shear walls are typically 27′-9″ long, and 2′ thick with varying reinforcement sizing and spacing. Each wall is built with a minimum 28-day compressive strength of 7000 psi. Specifically labeled walls have a compressive strength of 9000 psi. The shear walls are anchored to the supporting soil by footings, typically 6′ deep and reinforced with #9 at 9″ o.c.

Foundation

The foundation is a combination of spread footings and drilled piers with concrete pier caps. The spread footings vary in size from 5′x5′ to 18′x18′, depending on location, and are labeled F5-F18 accordingly. The reinforcement for these footings goes from 16 #5 each way in the F5 to 18 #9 each way in the F18.

Foundations for the shear walls feature footings anchored to the supporting soil by drilled piers, typically being 42″ in diameter. Each pier is spirally reinforced, varying in size while the pier caps are typically reinforced with #9 - #11 at 9″ o.c.

Columns

Vertical supports for the first level consist of 26″ x 26″ cast-in-place columns as well as 20″ x 20″ precast columns, however the upper floors (2-6) have only the 26″ x 26″ cast-in-place columns. A typical bay size is 54′ x 27′, although they vary depending on location and demand.

The cast-in-place columns typically run from spread footing through each floor while being reinforced with 12 #9′s vertically and #4 at 6″ o.c. horizontally. Pre-cast columns are reinforced with 4 #9′s vertically and #4 at 5″ o.c. horizontally. The compressive strength for the C.I.P. columns is 5000 psi and 6000 psi for the P.C. columns.

Material Strengths

Concrete

Slab-on-Grade, Piers, Pier Caps…………………………………… $f'_c = 4000$ psi

Grade Beams, Footings……………………………………………...$f'_c = 4000$ psi

Pilasters, Walls……………………………………………………….$f'_c = 4000$ psi

Beams, Slabs, Topping Slabs……………………………………… $f'_c = 5000$ psi

Columns……………………………………………………………... $f'_c = 5000$ psi

Shear Walls (U.N.O)………………………………………………... $f'_c = 7000$ psi

Shear Walls (where noted)………………………………………….$f'_c = 9000$ psi

Precast Concrete

Beams, Girders……………………………………………………… $f'_c = 6000$ psi

Columns……………………………………………………………... $f'_c = 6000$ psi

Double Tees…………………………………………………………..$f'_c = 6000$ psi

Reinforcement

Reinforcing Bars…………………………………………………….. $F_y = 60$ ksi

Welded Wire Fabric………………………………………………… $F_y = 70$ ksi

Structural Steel

Beams and Girders, WF Columns………………………………… $F_y = 50$ ksi

Channels, Tees, Angles, Bars, Plates……………………………… $F_y = 36$ ksi

Steel Tubing (Rectangle HSS)……………………………………….$F_y = 46$ ksi

Steel Pipe (Round HSS)……………………………………………..$F_y = 42$ ksi

Anchor Bolts………………………………………………………… $F_y = 60$ ksi

Concrete Masonry

Design Strength……………………………………………………... $f'_m = 1500$ psi

Loads

Gravity Loads

Live loads were found in ASCE 7-05 in table 4-1 under the Hospital category. The design loads are those used in the original design.

Live Loads		
Occupancy	ASCE 7-05 Load	Design Loads
Patient Rooms	40 psf	40 psf
Corridors	80 psf	100 psf
Light Storage Areas	125 psf	125 psf
Kitchens	150 psf	150 psf
Roof	20 psf	20 psf

Dead Loads		
Material/Occupancy	Load	Reference
Normal Weight Concrete	150 pcf	ACI 318
Steel	Per Shape	AISC 13th Ed.
Steel Deck	2 psf	USD
Plaster on Concrete	5 psf	ASCE 7
Miscellaneous	10 psf	
Exterior Wall	45 psf	ASCE 7

[1]United Steel Deck

[2]Includes building components such as duct work, lighting, telecommunications, etc.

[3]See Appendix for detailed load calculations

The live load comparisons show that the minimum design loads were used besides in designing the corridors which might have been elevated due to the heavy equipment and high traffic present in a hospital corridor. For the other loads, the designer did not use anything higher than the minimum required.

When choosing loads to design the typical floor systems, the higher loads were chosen to ensure that spaces could be used for multiple occupancies. This is a very conservative approach.

Floor Systems

Alternative System #1: **Two-way slab with beams**

The two-way slab system with beams is much like the floor system used in the original design. The slab thickness used in the calculations is 10", helping make accurate comparisons to the original design. The boundary beams help aid in torsional-force resistance, therefore reducing the amount of required slab reinforcement. Calculations located in the appendix detail the need for #5 bars at 16" on center which is sparse compared to the #6 bars at 9" required in the original flat-plate design. While money is saved in the reduction of steel reinforcement required, it is well made up for in the increase of concrete needed for the 26"x26" beams. See Figure 1 and appendix for beam layout and detailed calculations.

27' x 26' Edge Bay

Reinforcing:

	Column Strip	Middle Strip	
Top Ext.	#6 @ 16"	#6 @ 17"	**Col Size:** 26"x26"
Bottom	#6 @ 16"	#6 @ 17"	**Conc. Wt:** 150psf
Top Int.	#6 @ 16"	#6 @ 17"	

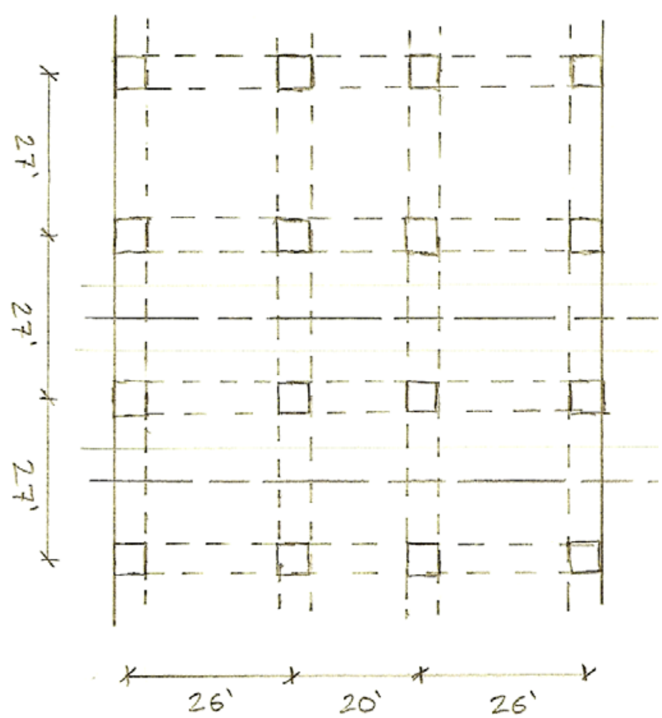


Figure 1

Alternative System #2: **Non-Composite Steel Frame**

A RAM model was used to design the beams, see Figure 2. The original beam layout was preserved for purposes of direct comparison. The slab depth used in this system was 10" to match the total slab depth of the original floor. While it is difficult to compare steel and concrete sizes, the steel members came to be W8x10's on the interior beams and W10x33's on the exterior. While W8x10's are rarely used in building floor system, I believe the use of a 10" slab is the primary reason for this because the slab will provide a large amount of the gravity load resistance. While the price of shear studs and connection systems will drive up the price, this system still appears to be a cheaper option, but may not be the most efficient choice when lateral systems are explored.

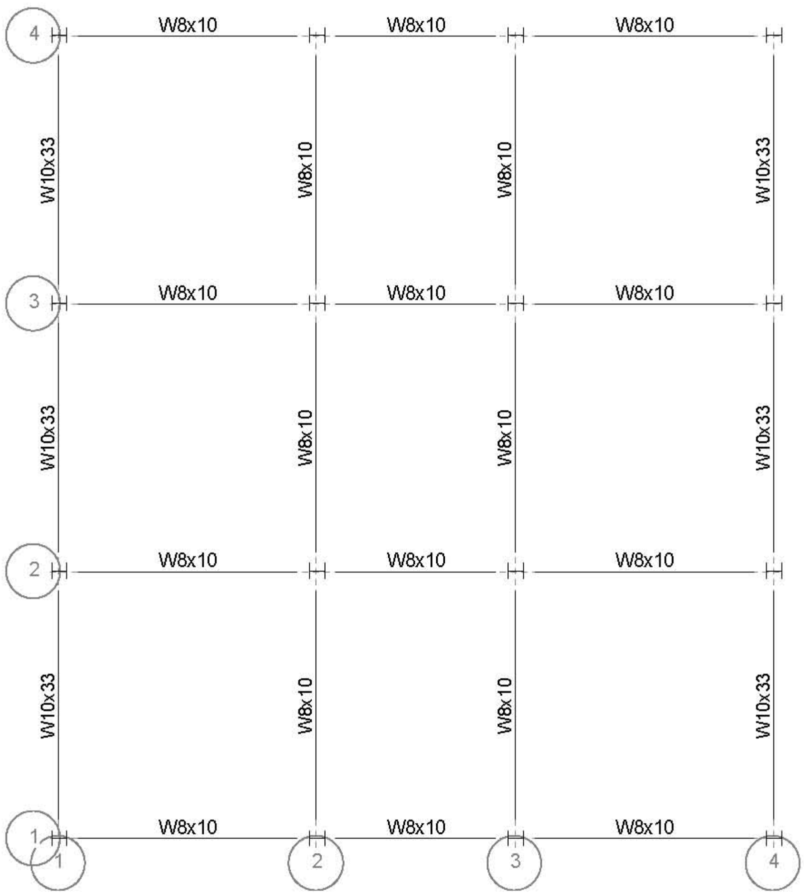


Figure 2

Alternative System #3: **Steel beam framing with light weight Concrete deck**

With the idea of lighter being better, light weight concrete is the focal point of this alternative floor system. The drop in concrete deck weight from 50 psf to 39 psf is a considerable advantage in weight and while it will require larger W steel members, this system still serves as a viable option. The disadvantages of this system are the requirement of a 2-hour fire protection as well as the added cost to produce light weight concrete. With the metal deck spanning left to right in figure 3, members serving as the primary supports are W16x26, while the other members are reduced to W8x10's. While W8x10's are rarely used in building floor system, I believe the use of a 10" slab is the primary reason for this because the slab will provide a large amount of the gravity load resistance.

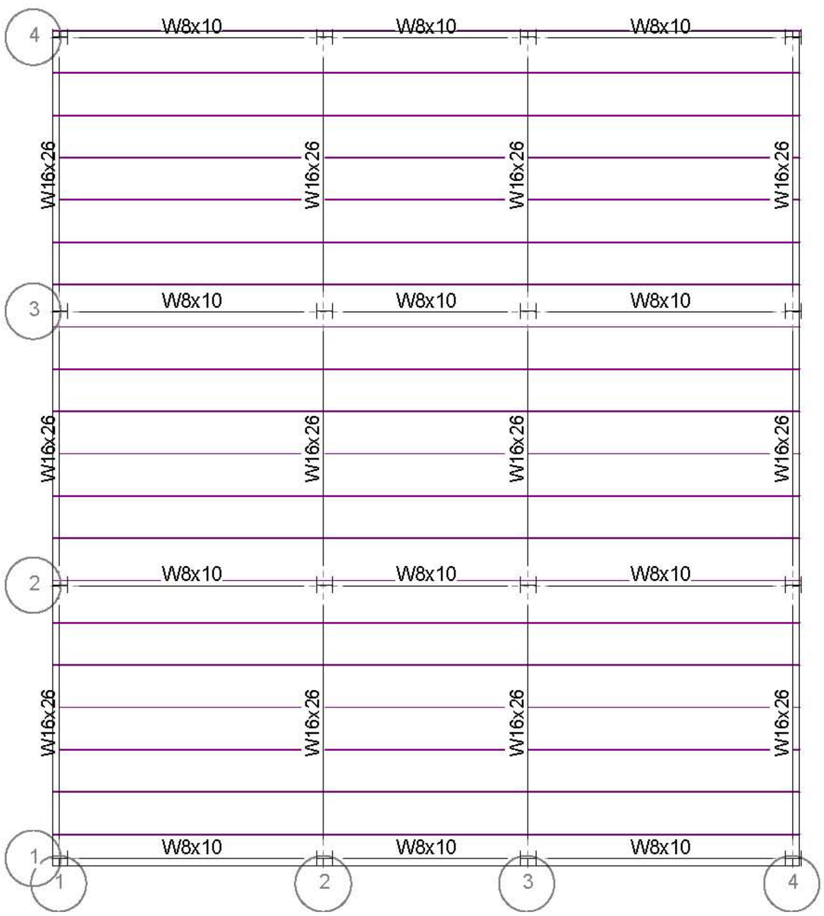


Figure 3

Summary and Conclusions

Alternative System Comparison:

The results of the alternative floor system analysis and preliminary design for the Temecula Medical Center are shown in the comparison chart that follows (Figure 4).

	Two-Way Flat Slab	Two-Way w/ Beams	Steel NonComposite	Steel Beam Framing w/ light wt. conc. deck
Relative Cost	Low	High	Medium	Medium
Weight	Low	High	Average	Low
Approx. Depth (in)	10	36	22	26
Vibration	Low	Low	High	Average
Fire Proofing	None	None	Easy	Easy
Constructability	Average	Difficult	Easy	Average
Alternative to Existing?	Original	NO	YES	YES

Figure 4

Alternative System Conclusions:

In comparing the alternative floor systems, factors such as weight, cost, depth, vibration, and ease of construction were taken into account. Not all of these factors hold the same significance, although each is used to determine the feasibility of the varying systems. These results are all based on preliminary analysis and would need to be looked at further before any final conclusions could be made.

Weight
The weight factor comes from heavy steel members and/or large amounts of concrete. Total weight of the structure plays a large part in determining vibration control as well as seismic loading. A heavy structure will produce little vibration but will eventually cost more in required overall structure. A lighter structure will allow larger vibrations and have higher light weight concrete cost, but will be cheaper to design/construct the structure.

Depth
The depth of the systems was determined by adding the steel (if applicable) to the slab depth. This factor plays an important role in selecting an alternative system when selecting architectural components as well as determining the final height of each floor.

Cost
From an owners perspective, the cost of a building is the deciding factor more times than not. While a cost analysis of the entire building would be very extensive to perform, a rough estimate of the cost of each floor system was made in figure 4. While aesthetics play a large part in finishing each floor system, each alternative would require the same components to hide in the ceiling.

Without doing a full analysis of each system, final conclusions are hard to make but the detailed summaries of each alternative system shows which choices can be eliminated all together. This was the case with the two-way slab with beams primarily because it failed to excel in any category, most likely because of the large amount of concrete required. On the other side of things are the alternative systems 2 and 3 which proved to be efficient in each category. A 10" slab was used in each of the floor systems to help aid in better comparisons with the original system. If the slab depth was reduced, the cost, weight, and depth of each system might have decreased. After analyzing each alternative floor system, it is very evident that the original design with a two-way flat plate slab is the most efficient option.

References

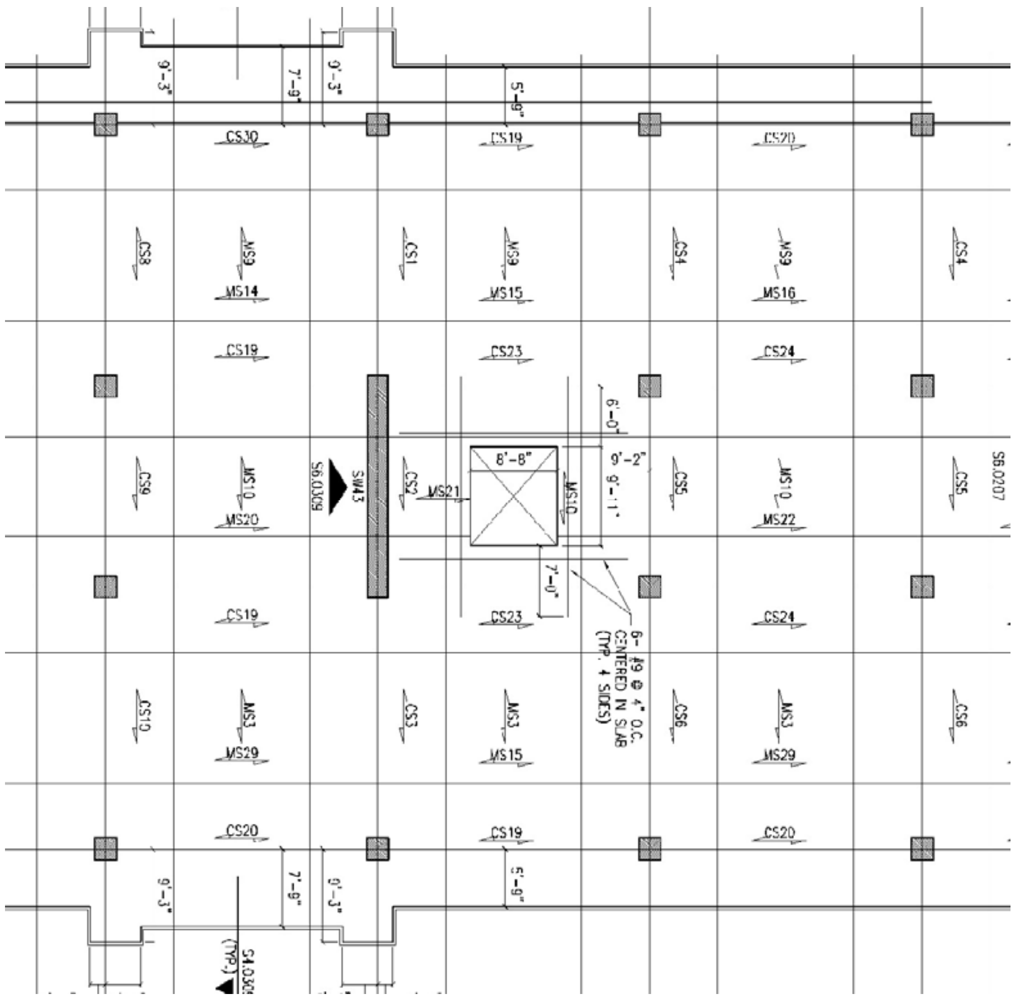
AISC Manual of Steel Construction, LRFD, Thirteenth Edition 2005

ACI 318 – 05

Design of Concrete Structures, Nilson/Darwin/Dolan

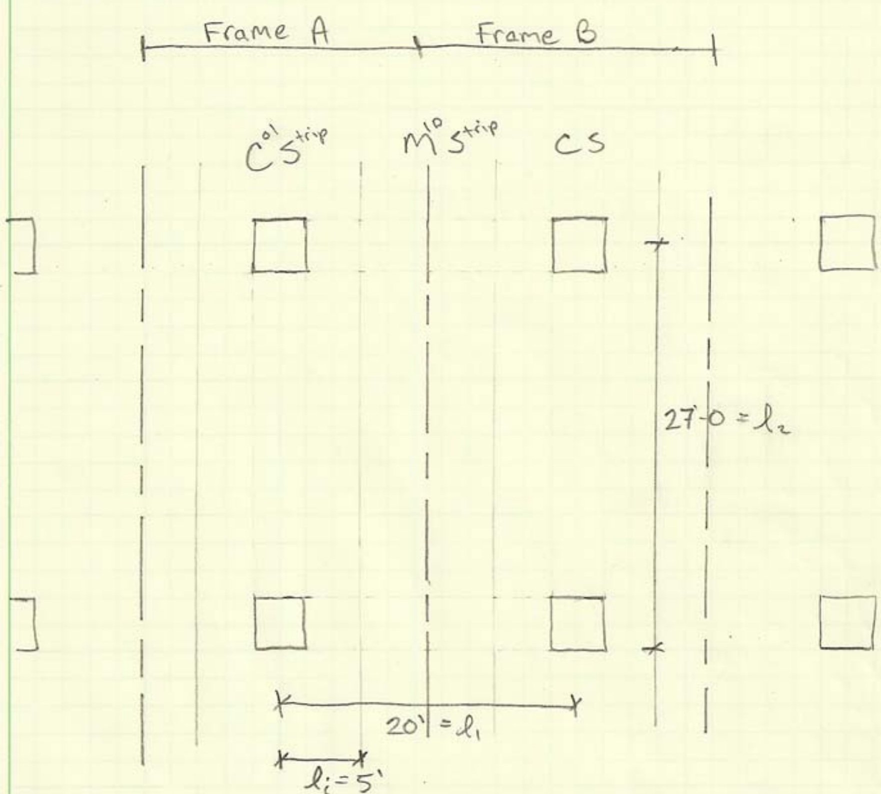
Appendix

Below is the typical 9-bay floor system that was examined in this report. Followed in the appendix are calculations and RAM results that were used to make the floor system comparisons.



Analysis of Existing Two-way Flat Plate Slab

ORG. SYSTEM	FLAT PLATE TWO-WAY SLAB	1 of 6



$\rightarrow \ell_i =$ smaller of $\begin{cases} \ell_1/4 = 20/4 = 5' \ * \\ \ell_2/4 = 27/4 = 6.75' \end{cases}$

slab = 10"

$\omega_L = 40$ PSF $\qquad \omega_D = \frac{10"}{12} \times 150$ PCF $= 125$ PSF

$\omega_D = 5$ PSF (finishes)

$\omega_U = 1.2\,(130 \text{ PSF}) + 1.6\,(40 \text{ PSF})$

$\rightarrow \quad = 220$ PSF

FRAME A:

$M_o = \frac{1}{8} w_u l_1 l_2^2$

$= \frac{1}{8}(.220)(20')(27')^2$

$= 400.9^{ft\text{-}k}$

FRAME B:

$M_o = \frac{1}{8} w_u l_1 l_2^2$

$= \frac{1}{2}(.22)(20)(27)^2$

$= 400.9^{ft\cdot k}$

Negative Factored Moment: $M_u^- = 0.65\, M_o$

$= 0.65(400.9) = {}^-260.6^{'k}$

Positive Factored Moment: $M_u^+ = 0.35\, M_o$

$= 0.35(400.9) = {}^+140.3^{'k}$

Transverse Distribution

a) Aspect Ratio $l_2/l_1 = \frac{27'}{20'} = 1.35$

b) $\alpha_1 = \frac{E_{cb} I_b}{E_{cs} I_s} = \frac{I_b}{I_s} = 0$

c) $\beta_t = \frac{C}{2 I_s} = \frac{38400}{2(20000)} = .96$

$I_s = \frac{(20 \times 12)(10)^3}{12} = 20000 \text{ in}^4$

$C = (1 - .63 \frac{l_1}{l_2})(\frac{l_1 l_2^3}{3}) = 38400$

FROM DISTRIBUTION TABLE

$M^- $ — $90\%\ CS \times 260.2 = 234.2^{1k}$

— $10\%\ MS \times 260.2 = 26.02^{1k}$

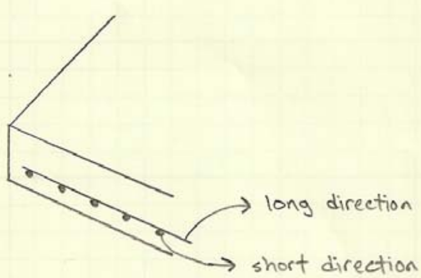
M^+ — $60\%\ CS \times 140.3 = 84.2^{1k}$

— $40\%\ MS \times 140.3 = 56.12^{1k}$

CS	234.2	84.2	234.2
MS	26.02	56.12	26.02

FRAME A-B MOMENTS

DESIGN REINFORCEMENT



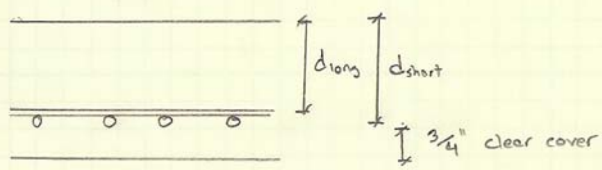
max. spacing = 2× slab Thick. = 20"

min. steel = temp/shrink

$A_{s_{min}} = 0.0018\ b \cdot t$

$A_{s_{min}} = .0018 \cdot 10" \cdot 20 \times 12 = 4.32\ in^2$

$A_{s_{min}} = .0018 \cdot 10" \cdot 27 \times 12 = 5.83\ in^2$



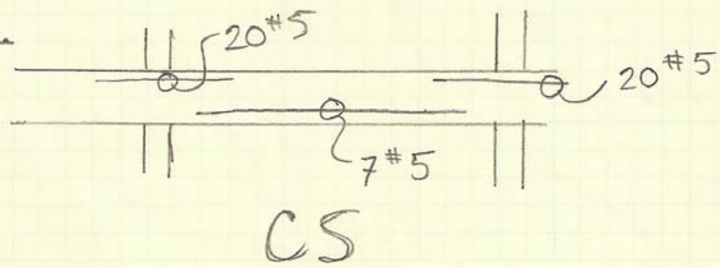
$d_{short} = 10" - 3/4" - \frac{1}{2}(0.625) = 8.94"$

$d_{long} = 8.94 - .625 = 8.315"$

Design of Reinf. in CS

		M^-	M^+	M^-
1	M	-234.2	84.2	-234.2
2	CS width (in)	120"	120"	120"
3	Eff. Depth d (in)	8.32	8.32	8.32
4	$M_n = \frac{M_u}{\phi} = \frac{M_u}{.9}$ =	-260.2	93.6	-260.2
5	$\frac{M_n \times 12}{b}$ $(\frac{k\cdot in}{in})$	-26	9.4	-26
6	$R = \frac{M_n}{bd^2}$	-338.3	121.6	-338.3
7	ρ from A-5a	.006	.002	.006
8	$A_{s\,min} = .002\,b\cdot t$ =	$2.4 in^2$	$2.4 in^2$	$2.4 in^2$
9	$A_{s\,req} = \rho \cdot b \cdot d\ (in^2)$ =	$5.99 in^2$	$1.99 in^2$	$5.99 in^2$
10	$N_{bars} = \frac{A_s}{.31} \rightarrow$ No. 5 =	19.3	6.4	19.3
11	$N_{min} = \frac{CS\,width}{24}$	6	6	6

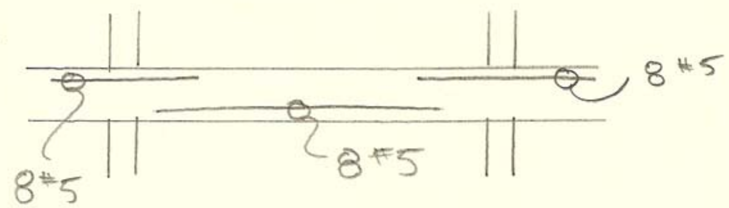
DIAG.



Design of Reinf. in MS

		M^-	M^+	M^-
1	M_n	26.02	56.12	26.02
2	MS width (in)	120"	120"	120"
3	d (in)	8.32"	8.32"	8.32"
4	$M_u = \frac{M_n}{.9}$ =	28.9^{1k}	62.4^{1k}	28.9^{1k}
5	$\frac{M_u \times 12}{b}$ =	2.89	6.24	2.89
6	$R = \frac{M_n}{b \cdot d^2}$ =	37.6	81.1	37.6
7	ρ from A-5a	.0008	.0013	.0008
8	$A_{s_{min}} = .002 \cdot b \cdot t$ =	$2.4 in^2$	$2.4 in^2$	$2.4 in^2$
9	$A_{s_{req}} = \rho \cdot b \cdot d$ =	$0.79 in^2$	$1.29 in^2$	$.79 in^2$
10	$N_{bars} = \frac{A_s}{.31} \to \#5$ =	7.79	7.74	7.74
11	$N_{min} = \frac{MS_{width}}{2t}$ =	6	6	6

DIAG.



MS

AS DESIGNED COMPARISON

For CS

20#5 ≈ #5 @ 6"

Compared to #6 @ 9"

* Very close in $A_{s\,req}$

7#5 ≈ #5 @ 17"

Compared to #4 @ 9"

* Very close in $A_{s\,req}$

For MS

8#5 ≈ #5 @ 15"

Compared to #5 @ 9" (TOP BARS)

to #4 @ 9" (BOT BARS)

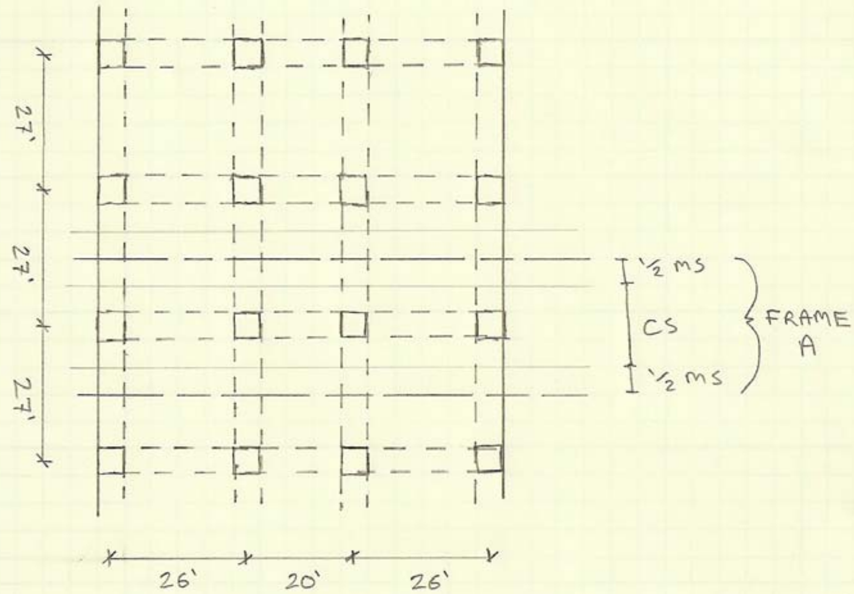
* TOP BARS ARE LIBERALLY SPACED

(most likely due to percent of M_o chosen)
Moment Adjusted

* BOT. BARS VERY CLOSE IN Area

Analysis of Two-way Slab with Interior Beams

System # 1 | TWO-WAY SLAB | 1 of 7



Design of Frame A

$\frac{1}{2}$ CS = smaller of $\begin{cases} \ell_1/4 = 27/4 = 6.75 \\ \ell_2/4 = 26/4 = 6.5'^{*} \end{cases}$

$\omega_L = 150$ PSF

slab thickness = 10"
beams = 26" × 26"

$\omega_u = 1.2\left(\frac{10}{12} \times 150 \text{ PCF}\right) + 1.6(150)$

$\boxed{= .390 \text{ KSF}}$

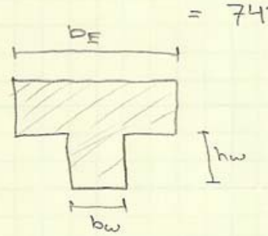
FOR INT

$M_o = \frac{1}{8}\, \omega_u\, \ell_2\, \ell_n^2$

$= \frac{1}{8}(.39)(27')\left(20' - \frac{26}{12}\right)^2 = 397.1'^{k}$

FOR EXT

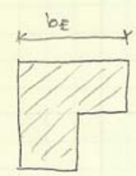
$$M_o = \tfrac{1}{8} w_u \ell_2 \ell_n^2$$
$$= \tfrac{1}{8}(.390)(27')\left(26' - \tfrac{26}{12}\right)^2$$
$$= 747.7^{'k}$$



INT

$b_E = b_w + 2h_w$

$b_E = 78''$



EXT

$b_E = b_w + h_w$

$b_E = 52''$

$$K_{int} = 1 + \frac{\left(\frac{78}{26}-1\right)\left(\frac{10}{36}\right)\left[4 - 6\left(\frac{10}{36}\right) + 4\left(\frac{10}{36}\right)^2 + \left(\frac{78}{26}-1\right)\left(\frac{10}{36}\right)^3\right]}{1 + \left(\frac{78}{26}-1\right)\left(\frac{10}{36}\right)}$$
$$= 1.642$$

$$K_{ext} = 1 + \frac{\left(\frac{52}{26}-1\right)\left(\frac{10}{36}\right)\left[4 - 6\left(\frac{10}{36}\right) + 4\left(\frac{10}{36}\right)^2 + \left(\frac{52}{26}-1\right)\left(\frac{10}{36}\right)^2\right]}{1 + \left(\frac{52}{26}-1\right)\left(\frac{10}{36}\right)}$$
$$= 1.374$$

INT

$\alpha = I_b / I_s$

$I_b = \dfrac{(1.642)(26)(26)^3}{12} = 62530$

$I_s = \dfrac{(27\times 12)(10)^3}{12} = 27000$

$\alpha_{int} = 2.32$

EXT

$\alpha = I_b / I_s$

$I_b = \dfrac{(1.374)(26)(26)^3}{12} = 52324$

$I_s = 27000$

$\alpha_{EXT} = 1.94$

Endspan Moments

$\underline{EXT}$: $M^-_{int} = 0.70 M_o = 0.7(747.7) = -523.4^{'k}$

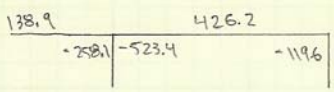
$M^+ = 0.57 M_o = 0.57(747.7) = 426.2^{'k}$

$M^-_{ext} = 0.16 M_o = 0.16(747.7) = -119.6^{'k}$

Interior Moments

INT: $M^- = 0.65 M_o = 0.65(397.1) = -258.1^{'k}$

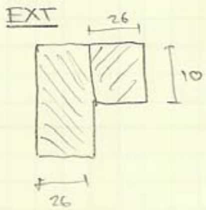
$M^+ = 0.35 M_o = 0.35(397.1) = 138.9^{'k}$



TORSIONAL CONSTANT

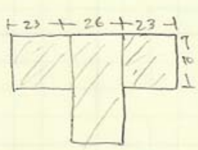
$$C = \Sigma(1 - 0.63\,x/y)\left(\frac{x^3 y}{3}\right)$$

$\underline{EXT}$



$$C = \left[(1-0.63)\left(\tfrac{26}{36}\right)\left(\tfrac{26^3\,36}{3}\right)\right] + \left[(1-0.63)\left(\tfrac{10}{26}\right)\left(\tfrac{10^3\,26}{3}\right)\right]$$

$$\boxed{= 57251.1}$$



$$C = 2\left[(1-0.63)\left(\tfrac{10}{23}\right)\left(\tfrac{10^3\,23}{3}\right)\right] + \left[(1-0.63)\left(\tfrac{26}{36}\right)\left(\tfrac{26^3\,36}{3}\right)\right]$$

$$\boxed{= 58827}$$

INT

$\alpha = 2.32$

$\beta = \frac{C}{2 I_s} = \frac{58827}{2(27000)} = 1.09$

$\alpha \frac{l_2}{l_1} = 1.72$

EXT

$\alpha = 1.94$

$\beta = \frac{57251}{2(27000)} = 1.06$

$\alpha \frac{l_2}{l_1} = 1.87$

M^-_{int} to CS

l_2/l_1	0.5	.963	1.0
$(\alpha \frac{l_2}{l_1} \geq 1.0)$	90	$\boxed{76.11}$	75

$-523.4 \rightarrow$ 76.11% CS $= -398.4$ — 85% BM $= \boxed{-339^{1k}}$; 15% slab $= \boxed{-59.7^{1k}}$

23.89% MS $= -125$

$-258.1 \rightarrow$ 76.11% CS $= -196.4$ — 85% BM $= \boxed{-166.9^{1k}}$; 15% slab $= \boxed{-29.5^{1k}}$

23.9% MS $= -61.7$

M^-_{ext} to CS

l_2/l_1	0.5	0.963	1.0
$(\alpha \frac{l_2}{l_1} \geq 1.0)$			
$\beta = 0$	100	100	100
$\beta = 1.06$		$\boxed{89.9}$	
$\beta \geq 2.5$	90	76.11	75

$-119.6 \rightarrow$ 89.9% CS $= -107.5^{k}$ — 85% BM $= \boxed{91.4^{1k}}$; 15% SL $= \boxed{16.1^{1k}}$

10.1% MS $= -12.1^{k}$

M^+ to CS

ℓ_2/ℓ_1	0.5	.963	1.0
$(\alpha \frac{\ell_2}{\ell_1} \geq 1.0)$	90	$\boxed{76.11}$	75

$426.2 \rightarrow 76.11\%$ CS $= 324$ — 85% BM $= \boxed{275.4^{1k}}$; 15% SL $= \boxed{48.6^k}$

23.89% MS $= 101.8$

$138.9 \rightarrow 76.11\%$ CS $= 105.7$ — 85% BM $= \boxed{89.8^{1k}}$; 15% SL $= \boxed{15.9^{1k}}$

23.9% MS $= 33.2$

FRAME A : WIDTH = 27', CS = 13' MS = 14'

	M^+	M^-	M^-_{int}	M^+	M^-_{ext}
Total M	138.9	-258.1	-523.4	426.2	-119.6
BM	89.8	-166.9	-339	275.4	-91.4
CS slab	15.9	-29.5	-59.7	48.6	-16.1
MS slab	33.2	-61.7	-125	101.8	-12.1

#5 clear cover

$d_{short} = 10 - 0.75 - \frac{1}{2}(0.625) = 8.94$

$d_{long} = 8.94 - .625 = 8.31''$

SLAB REINF. CS

Item	Desc	M^+	M^-	M^-_{int}	M^+	M^-_{ext}
1	M_u	15.9	-29.5	-59.7	48.6	-16.1
2	CS width	156	156	156	156	156
3	d	8.31	8.31	8.31	8.31	8.31
4	$M_n = \frac{M_u}{0.9}$	17.7	32.8	63.3	54	17.9
5	$\frac{M_n(12)}{b}$	1.36	2.52	4.87	4.15	1.38
6	$R = \left(\frac{M_n}{bd^2}\right)12000$	19.7	36.5	70.5	60.2	19.9
7	ρ from A-5	.0005	.0006	.0014	.001	.0005
8	$A_s = \rho \cdot b \cdot d$	0.648	0.78	1.81	1.29	0.648
9	$A_{s_{min}} = .0018 \cdot b \cdot t$	2.8	2.8	2.8	2.8	2.8
10	$N = \frac{a \text{ or } 9}{0.31} \leftarrow \#5$	10	10	10	10	10
11	$N_{min} = \frac{b}{2t}$	8	8	8	8	8

USE 10 #5 $\approx$ #5 @ 16"

AS DESIGNED

* Compared to #6 @ 9" in flat plate slab

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SLAB REINF. MS

Item	Desc	M^+	M^-	M^-_{int}	M^+	M^-_{ext}
1	M_u	33.2	-61.7	-125	101.8	-12.1
2	MS WIDTH	168	168	168	168	168
3	d	8.31	8.31	8.31	8.31	8.31
4	$M_n = \frac{M_u}{.9}$	36.9	-68.6	-138.9	113.1	-13.4
5	$\frac{M_n(12)}{b}$	2.64	4.9	9.92	8.08	0.96
6	$R = \left(\frac{M_n}{bd^2}\right)12000$	38.2	70.9	143.7	116.9	13.8
7	ρ from A-5	.0007	.0013	.0024	.002	.0005
8	$A_s = \rho \cdot b \cdot d$	.977	1.81	3.35	2.8	0.69
9	$A_{s\,min} = .0018 \cdot b \cdot t$	3.02	3.02	3.02	3.02	3.02
10	$N = \frac{3.01}{.31} \leftarrow \#5$	10	10	11	10	10
11	$N_{min} = \frac{b}{2t}$	9	9	9	9	9

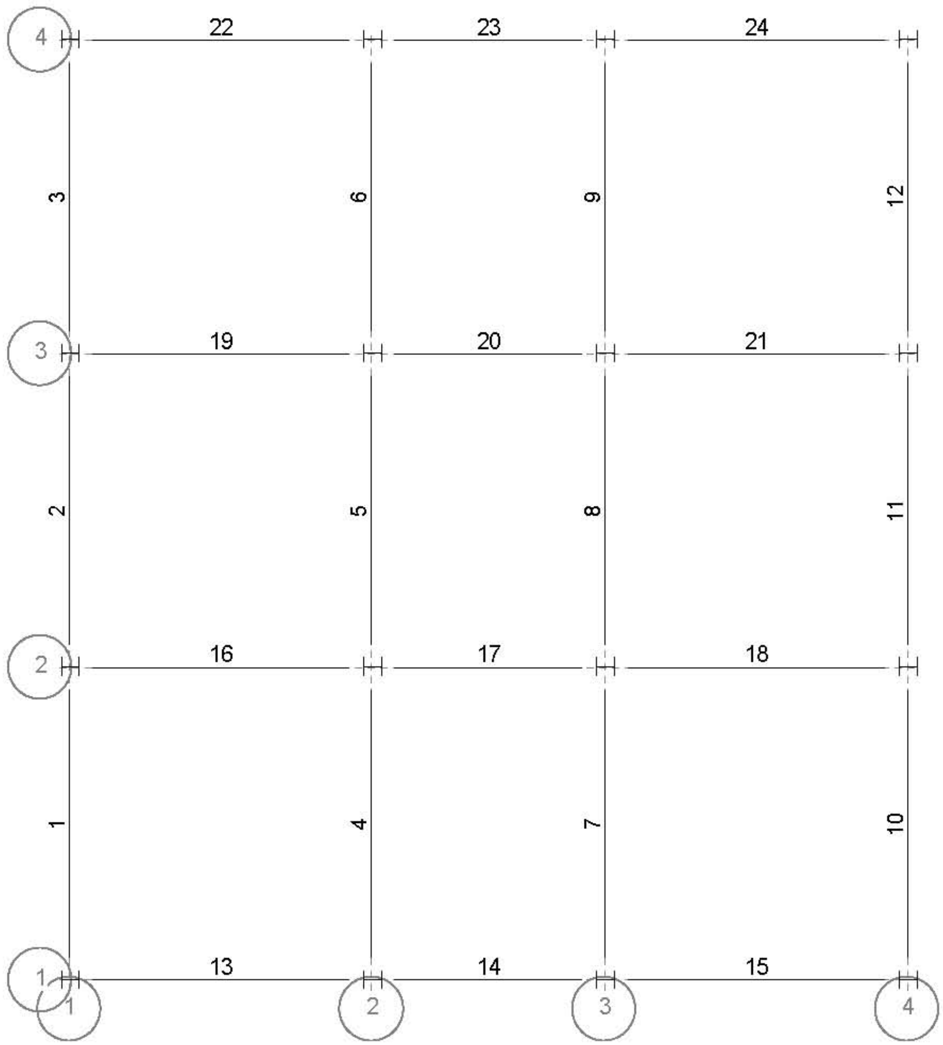
USE 10 #5 OR 11 #5 ≈ #5 @ 17"

AS DESIGNED

Compared to #6 @ 9" in flat plate slab

RAM Analysis of Non-Composite Steel Floor System

Beam Numbers



STEEL BEAM DESIGN SUMMARY:

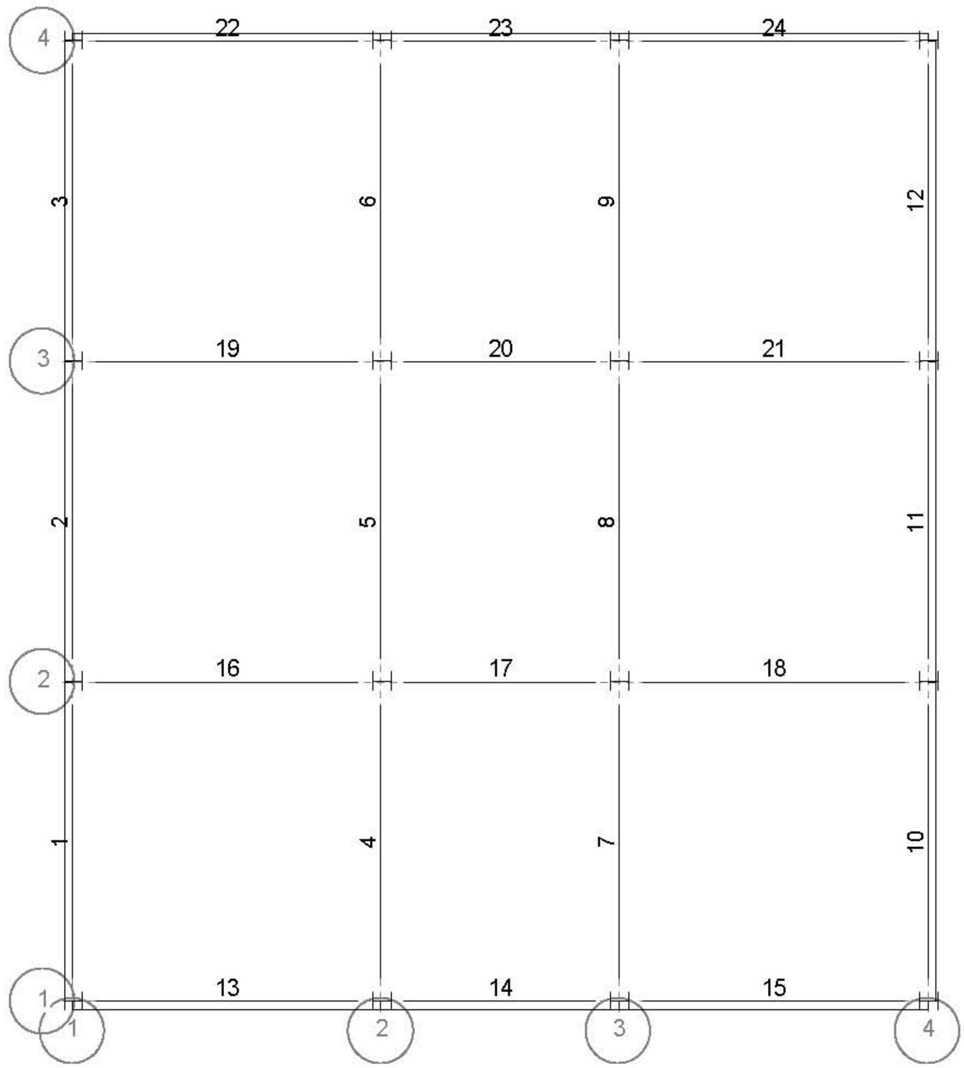
Floor Type: Typical Floor

Bm #	Length ft	+Mu kip-ft	-Mu kip-ft	Mn kip-ft	Fy ksi	Beam Size
1	27.00	76.0	0.0	161.7	50.0	W10X33
13	26.00	1.2	0.0	37.0	50.0	W8X10
2	27.00	76.0	0.0	161.7	50.0	W10X33
16	26.00	1.2	0.0	37.0	50.0	W8X10
3	27.00	76.0	0.0	161.7	50.0	W10X33
19	26.00	1.2	0.0	37.0	50.0	W8X10
22	26.00	1.2	0.0	37.0	50.0	W8X10
4	27.00	1.3	0.0	37.0	50.0	W8X10
14	20.00	0.7	0.0	37.0	50.0	W8X10
5	27.00	1.3	0.0	37.0	50.0	W8X10
17	20.00	0.7	0.0	37.0	50.0	W8X10
6	27.00	1.3	0.0	37.0	50.0	W8X10
20	20.00	0.7	0.0	37.0	50.0	W8X10
23	20.00	0.7	0.0	37.0	50.0	W8X10
7	27.00	1.3	0.0	37.0	50.0	W8X10
15	26.00	1.2	0.0	37.0	50.0	W8X10
8	27.00	1.3	0.0	37.0	50.0	W8X10
18	26.00	1.2	0.0	37.0	50.0	W8X10
9	27.00	1.3	0.0	37.0	50.0	W8X10
21	26.00	1.2	0.0	37.0	50.0	W8X10
24	26.00	1.2	0.0	37.0	50.0	W8X10
10	27.00	76.0	0.0	161.7	50.0	W10X33
11	27.00	76.0	0.0	161.7	50.0	W10X33
12	27.00	76.0	0.0	161.7	50.0	W10X33

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

RAM Analysis of Composite Steel Floor System

Beam Numbers



STEEL BEAM DESIGN SUMMARY:

Floor Type: Typical Floor

Bm #	Length ft	+Mu kip-ft	-Mu kip-ft	Mn kip-ft	Fy ksi	Beam Size	Studs
1	27.00	308.5	0.0	363.2	50.0	W16X26	18
13	26.00	14.5	0.0	104.0	50.0	W8X10	6
2	27.00	308.5	0.0	363.2	50.0	W16X26	18
16	26.00	1.2	0.0	104.4	50.0	W8X10	6
3	27.00	308.5	0.0	363.2	50.0	W16X26	18
19	26.00	1.2	0.0	104.4	50.0	W8X10	6
22	26.00	14.5	0.0	104.0	50.0	W8X10	6
4	27.00	342.7	0.0	413.5	50.0	W16X26	24
14	20.00	8.6	0.0	103.7	50.0	W8X10	6
5	27.00	342.7	0.0	413.5	50.0	W16X26	24
17	20.00	0.7	0.0	104.2	50.0	W8X10	6
6	27.00	342.7	0.0	413.5	50.0	W16X26	24
20	20.00	0.7	0.0	104.2	50.0	W8X10	6
23	20.00	8.6	0.0	103.7	50.0	W8X10	6
7	27.00	342.7	0.0	413.5	50.0	W16X26	24
15	26.00	14.5	0.0	104.0	50.0	W8X10	6
8	27.00	342.7	0.0	413.5	50.0	W16X26	24
18	26.00	1.2	0.0	104.4	50.0	W8X10	6
9	27.00	342.7	0.0	413.5	50.0	W16X26	24
21	26.00	1.2	0.0	104.4	50.0	W8X10	6
24	26.00	14.5	0.0	104.0	50.0	W8X10	6
10	27.00	308.5	0.0	363.2	50.0	W16X26	18
11	27.00	308.5	0.0	363.2	50.0	W16X26	18
12	27.00	308.5	0.0	363.2	50.0	W16X26	18

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.