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Building: The Duncan Center
Location: Dover, DE
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TECHNICAL ASSIGNMENT 2

EXECUTIVE SUMMARY

Five systems were analyzed in this report to determine comparatively which floor system is most adequate to meet the requirements and needs of a typical floor framing bay of the Duncan Center, an office building in Dover, DE. The five systems analyzed were as follows:

1. Existing floor system of steel framing with composite metal deck
2. Two-way flat plate concrete slab
3. Two-way post-tensioned concrete slab
4. Steel framing with precast hollowcore planks
5. Steel and open web steel joist framing with composite metal deck

The systems were compared and contrasted on many different aspects such as cost, depth, deflection, system weight, and any constraints that the specific system required. Of the systems researched in this preliminary analysis, the existing system of steel framing with composite metal deck and the two-way flat plate concrete slab were found to be the most feasible. The two-way flat plate system therefore is a good candidate for further research and more in depth study in order to form a thesis proposal.

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I. INTRODUCTION

The Duncan Center is a premium office building located in Dover, DE. The building has a total of six floors reaching an overall height of 93'-0". The first four floors are open flex office spaces, the fifth floor is a reception and banquet hall, and the sixth floor penthouse holds building management offices and small electrical and mechanical rooms, the larger of which are located in the basement along with storage space. The fourth and fifth floors are augmented with sizable balconies and the overall structure is crowned with an arched penthouse.

The purpose of this report is to compare four preliminary designs of different floor systems, two-way flat plate concrete, one-way post-tensioned concrete, precast hollow core concrete planks, and open web steel joist with composite metal deck, that possibly may have been utilized versus the existing floor system, composite steel with composite metal deck, in order to provide ideas for a thesis proposal in which alternate ideas and building methods will be analyzed further. The structure of the Duncan Center is predominantly moment-framed steel with 5" thick composite metal deck slabs in typical bays of 24'-5" x 27'-8". The steel frame is supported by a concrete 40' deep auger-cast pile and deep grade beam system. The veneer of the building is non-loading bearing brick or stucco and glass panel, backed with cold-formed steel studs. The roof , including the arched penthouse roof, is comprised of 24" o.c. cold formed steel roof trusses. Additional calculations in support of the material presented in this report are available upon request.

II. DESIGN GUIDELINES

Design Codes

National Building Code: International Code Council (ICC) 2006
"International Building Code (IBC)"
Design Loads: American Society of Civil Engineers (ASCE) 7-05
"Minimum Design Loads for Buildings and Other Structures"
Steel Reference Standard: American Institute of Steel Construction (AISC) 13th Edition
"Specification for Structural Steel Buildings" (LRFD)
Concrete Reference Standard: American Concrete Institute (ACI) 318-05
"Building Code Requirements for Structural Concrete"
Reinforcement Reference Standard: American Concrete Institute (ACI) 315-05
"Details and Detailing of Concrete Reinforcement"
Open Web Steel Joist Standard: Vulcraft 2003
"Steel Joists & Joist Girders"
Metal Deck Reference Standard: United Steel Deck (USD) 2006
"Steel Decks for Floors and Roofs"

Design Live Loads

Space	Load	
Stairs and Exits	100	PSF
Corridor-First Floor	100	PSF
Corridor-Other Floors	80	PSF
Lobby	100	PSF
Dance Halls and Ballrooms	100	PSF
Office Space	50	PSF

Note: The floor systems to be analyzed in this report will be conservatively designed for the ultimate live load of 100 psf to analyze the worst case scenario that may be present.

Existing Structure Description

Foundation System

The foundation system begins with auger cast concrete piles as per the recommendation of the geotechnical engineer, John D. Hynes & Associates, Inc. The structural engineer was presented with the choice of several different diameters and depths of piles and a 16" dia., 40' long pile reinforced with a cage in the top 10" of the pile of 6-#6 and #3 ties at 12" o.c. was selected, with a bearing capacity of 85 tons.

On top of these piles rest the pile caps of variant cross section with a depth of 3'-1" each. Upon the pile caps rest the 24"x24" concrete piers with 8-#8 vertical bars with #3 ties at 12" o.c. The piers are enclosed by 1' wide by 2' deep grade beams with 4-#6 bars top and bottom with #3 ties at 12" o.c., which support the 12" CMU foundation walls with 4-#4 horizontal and 4-#4 vertical reinforcement The piers are finally topped off with 18"x18" steel baseplates ranging in thickness from 1" to 2-1/4" with 4-1" dia. A325N bolts.

Floor Systems

The floor system for the Duncan Center typical on all floors is 5" composite slab with 2" 20 gage composite metal deck reinforced with 6x6 W2.0xW2.0 welded wire fabric. The deck is welded to the structural steel members beneath with 23-3/4" x 4" long shear studs, where as the beams have 14-3/4" x 4" long shear studs. Giving the overall floor system a fire rating of 2 hours and forming a flexible diaphragm.

The typical floor bay has spans of 27'-8"x24'-5" with the beams running in the long direction, W16x31 interior and W18x35 between columns. The interior beams rest upon W24x55 girders which transfer the load to the columns which will be discussed in the Lateral Load Resisting System, see Figure 1: Second Floor Framing Plan and Figure 2: Typical Floor Framing Bay.

Lateral Force Resisting System

The Lateral Load Resisting System is singularly comprised of the moment connected frame as each beam between columns and each girder are moment connected by double angle connections and full penetration welds to the columns. Columns range from W12x45 to W12x120 and are spliced at the third and the fifth floor.

Existing Typical Framing Plan

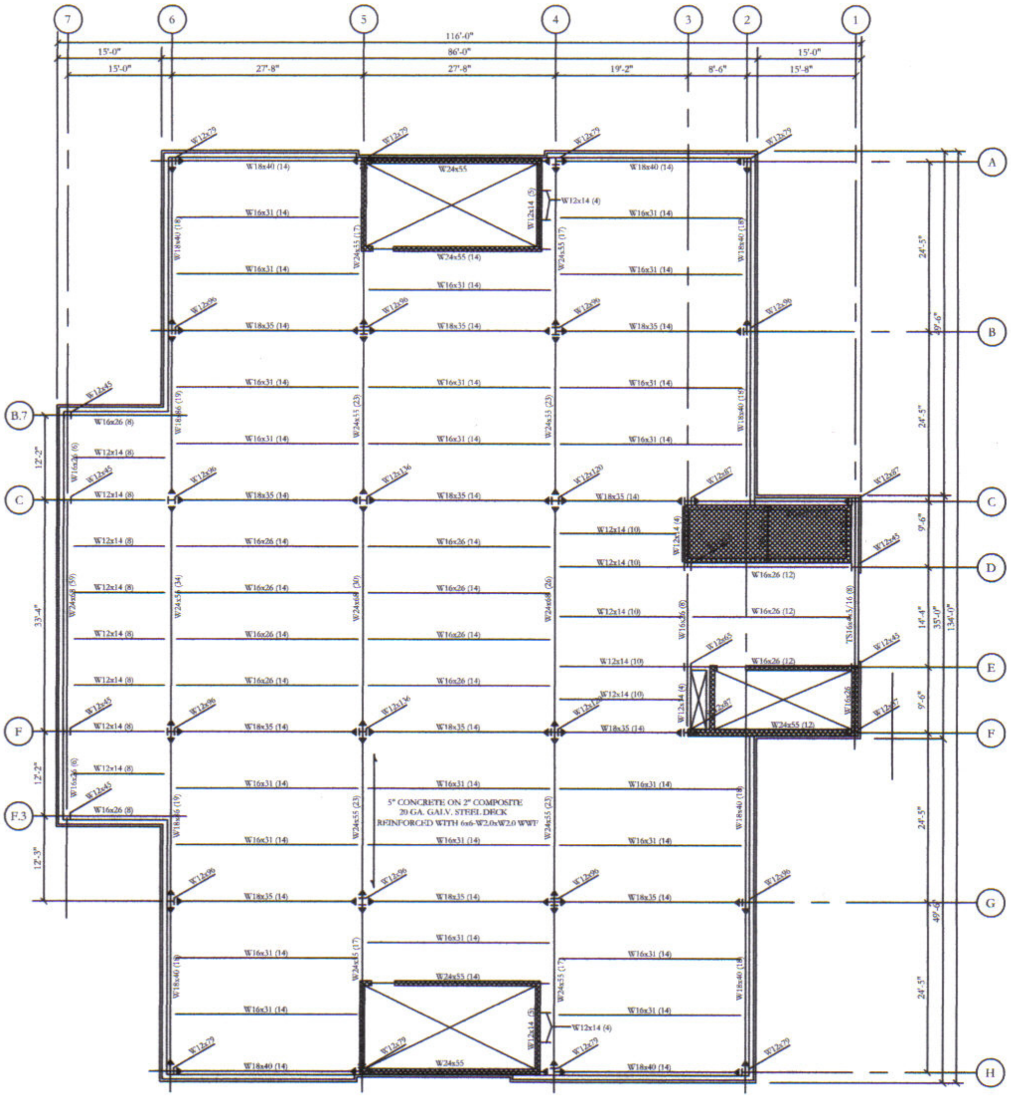


Figure 1: Existing Second Floor Framing Plan

Existing Typical Framing Bay

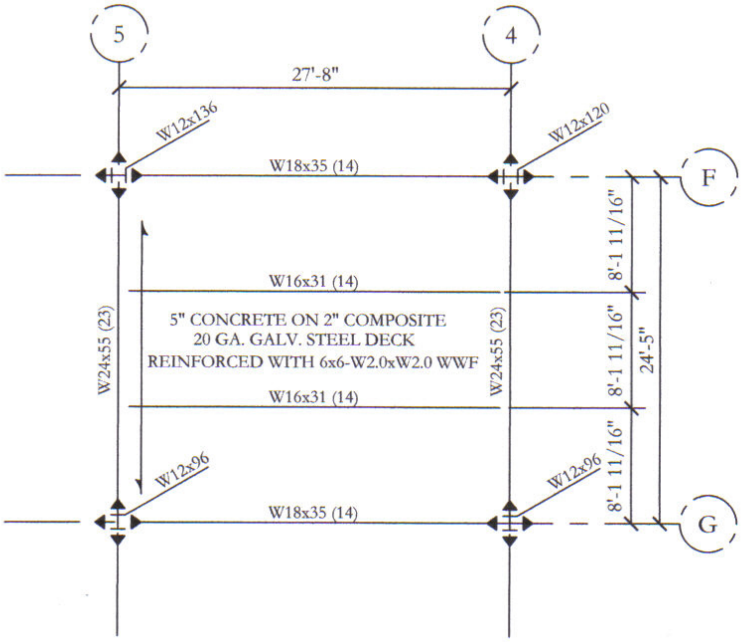


Figure 2: Existing Typical Floor Framing Bay

III. EXISTING STEEL WITH COMPOSITE METAL DECK FLOOR SYSTEM

Description

In order to achieve a more direct comparison between different floor systems, the existing floor system was analyzed based purely upon gravity loads. The modified floor system is 4.5” composite slab on 2” 20 gage composite metal deck reinforced with 6x6 W1.4xW1.4 welded wire fabric. The deck is welded to the structural steel members beneath consisting of W16x31 girders and W12x14 beams with approximately 20-3/4”x4” long shear studs on each member, see the typical floor framing bay below for clarification.

Material Properties

Concrete:	Normalweight, F_y=4000 psi
Welded Wire Fabric:	A185
Metal Deck:	A525 Grade 60
Structural Steel:	A572 Grade 50
Steel Studs:	A108

Design Dead Load

3/4" Quarry Tile Flooring	10	PSF
4.5" Reinforced Concrete Slab	42	PSF
20 Gage Steel Deck	2	PSF
HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF
Total	64	PSF

Note: Dead loads do not include supporting member self-weights.

Typical Floor Framing Bay

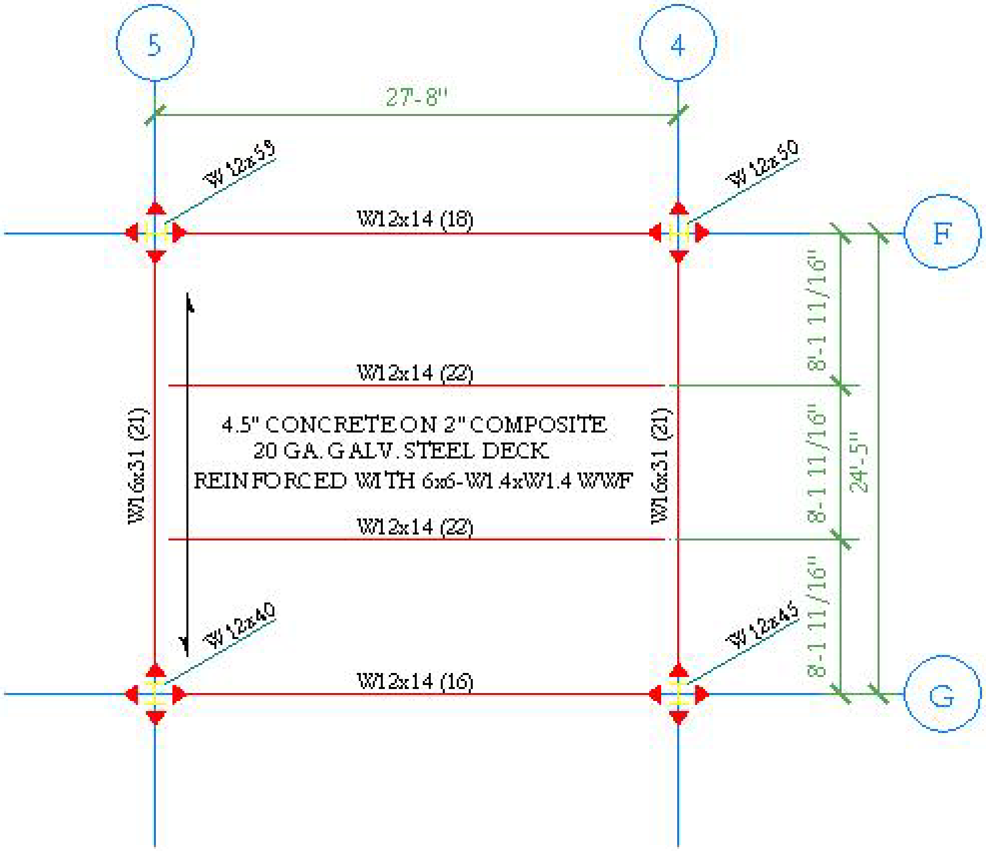


Figure 3: Existing Steel with Composite Steel Deck Typical Floor Framing Bay
See Appendix pg. 25 for calculations.

Advantages and Disadvantages

Framing System

This system, unlike many of the others investigated can support longer spans without the negligible effects of increased depth and weight. The system has an overall depth of 22" including the acoustical ceiling depth and a deflection of 0.1214", which is acceptable. Also, to reach the required two hour fire resistance rating, spray-on fireproofing must be utilized, an unfortunate necessity of most steel systems.

Lateral and Foundation System

Using steel members makes this system one of the lightest with only 64 psf and allows wind to control the lateral design.

Mechanical and Electrical

Performance acoustically is moderate, although improved with insulation placed above acoustical ceiling panels. Above the acoustical ceiling there is sufficient room for mechanical and electrical ductwork and piping to run, especially provided that the beams remain shallower than the girders.

Construction

In terms of construction this system is the middle of the road, unless one considers the moment frame which increases the in field labor and cost of the system dramatically. Putting the moment connections aside, the labor is moderate and the cost of the system is approximately $16.79/SF. For scheduling this systems can be fast tracked easier than some, with the steel able to be placed while the concrete slab is still curing. However the lead time for the steel must be taken into account, which if standard sections are selected should not be a major difficulty. Finally, openings can also be put in place later on after the building has been in use as long as the opening does not occur over a structural member.

Architectural

A moderate floor to floor height of 12’-2” can be maintained and the system does not interfere with any of the exterior façade with an extensive portion consisting of free band glass windows.

IV. TWO-WAY FLAT PLATE CONCRETE FLOOR SYSTEM

Description

A 9" thick two-way flat plate concrete system without beams supported 24"x24" concrete columns. The reinforcement is comprised only of #4 bars, and can be considered relatively heavy, with up to 18 continuous bars for positive reinforcement in the column strip. In addition to normal reinforcement, to control the effects of punching shear and the longer spans, 4.5" thick drop panels of 8' width and approximately 10' length were utilized, see the typical floor framing bay below for clarification.

Material Properties

Concrete:	Normalweight, F_y=4000 psi
Reinforcing Steel:	A615 Grade 60

Design Dead Load

3/4" Quarry Tile Flooring	10	PSF
9" Reinforced Concrete	109	PSF
HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF
Total	129	PSF

Note: Dead loads do not include supporting member self-weights.

Typical Floor Framing Bay

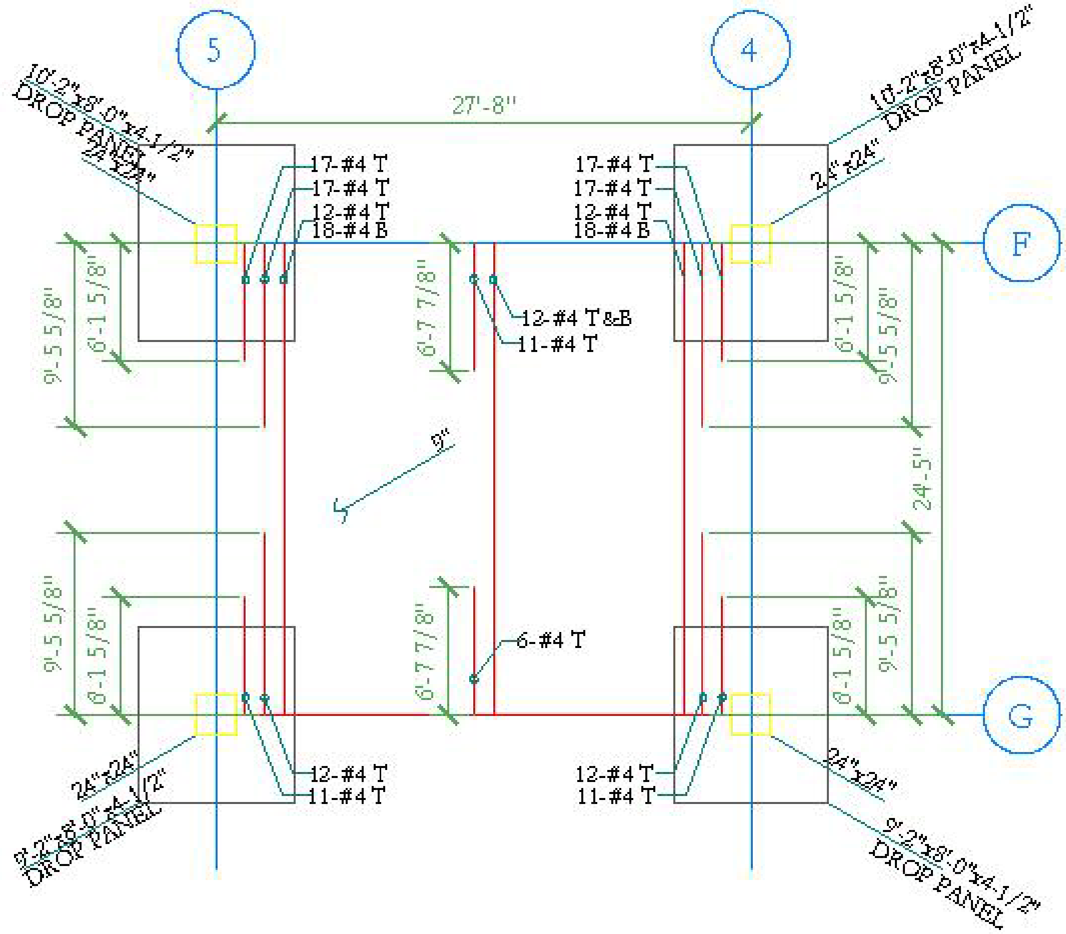


Figure 4: Two-way Flat Plate Concrete Typical Floor Framing Bay

See Appendix pg. 29 for calculations.

Note: Floor system only analyzed in the long span direction for simplicity of comparison and 24"x24" columns assumed.

Advantages and Disadvantages

Framing System

Changing from a steel moment frame building to an entirely concrete building is rather dramatic, but necessary if a two-way concrete flat plate is to be considered. The initial grid system based on the steel system is usable, but a grid with smaller spans is recommended to reduce the slab thickness. The overall depth of the system is 18.5", just a few inches under that of the existing. Also, there are not any complex connections to be placed in the field, but this advantage is counteracted by the complexity of the placement of the reinforcement.

The serviceability requirements are on par with that of the existing system with a 0.196" deflection and improved vibratory dampening. On the matter of fire proofing, this systems is highly recommendable with no extra fire proofing required to achieve a four hour fire resistance rating.

Unfortunately though, the acoustical ceiling may be difficult to attach to the concrete slab and alternate ceiling systems will need to be considered.

Lateral and Foundation System

A change in weight of the system such as between this system of 129 psf and that of the existing, 69 psf, near double has a dramatic impact on the foundation and lateral system of the building. The lateral system will require concrete shear walls and the foundations will need to be larger or driven deeper piles, which can add a great expense to a project depending upon soil conditions.

Mechanical and Electrical

Concrete has good insulative and acoustical properties, making the acoustical ceiling unnecessary for sound vibrational reasons. In terms of ductwork though, a flat plate does not accommodate space for ductwork to go unnoticed and drop panels may be visible and undesirable.

Construction

Cast-in place concrete requires much more labor than steel. The workers much place the concrete, make sure is sets correctly and vibrate it as necessary, and there is the formwork and reinforcement too. To make matters worse, it is also a time demanding system with the curing of the columns and drop panels necessary first, followed by the slab, and then the next floor may be constructed. The cost helps to recommend it with only $15.98/SF, but there is also the matter of visible cracking that may need to be repaired occasionally to be taken into consideration.

Architectural

Despite the fact that shear walls will be required, if placed properly within the building they may not have an impact upon the exterior façade by placing them in the middle of each floor and on the north and south sides which possess little glass. A floor to floor height of 12'-5", again a little more than the existing system can be maintained, even smaller if a dropped ceiling system is not necessary.

V. TWO-WAY POST-TENSIONED CONCRETE FLOOR SYSTEM

Description

The post-tensioned concrete floor is 10" thick with a minimal negative reinforcement of 9-#5 bars at the columns. Welded wire fabric, 6x6 W1.4xW1.4, is used for temperature and cracking reinforcement and to aid the 9 strands of 1/2" dia. post-tensioned tendons in the middle of the span. Similar to the two-way flat plate concrete system, drop caps were used to counter the effects of punching shear, see the typical floor framing bay below for clarification.

Material Properties

Concrete:	Normalweight, F_y=4000 psi
Welded Wire Fabric:	A185
Reinforcing Steel:	A615 Grade 60
Steel Post-Tensioned Tendons:	½" Unbonded

Design Dead Load

3/4" Quarry Tile Flooring	10	PSF
10" Post-Tensioned Concrete	121	PSF
HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF
Total	141	PSF

Note: Dead loads do not include supporting member self-weights and 24"x24" columns assumed.

Typical Floor Framing Bay

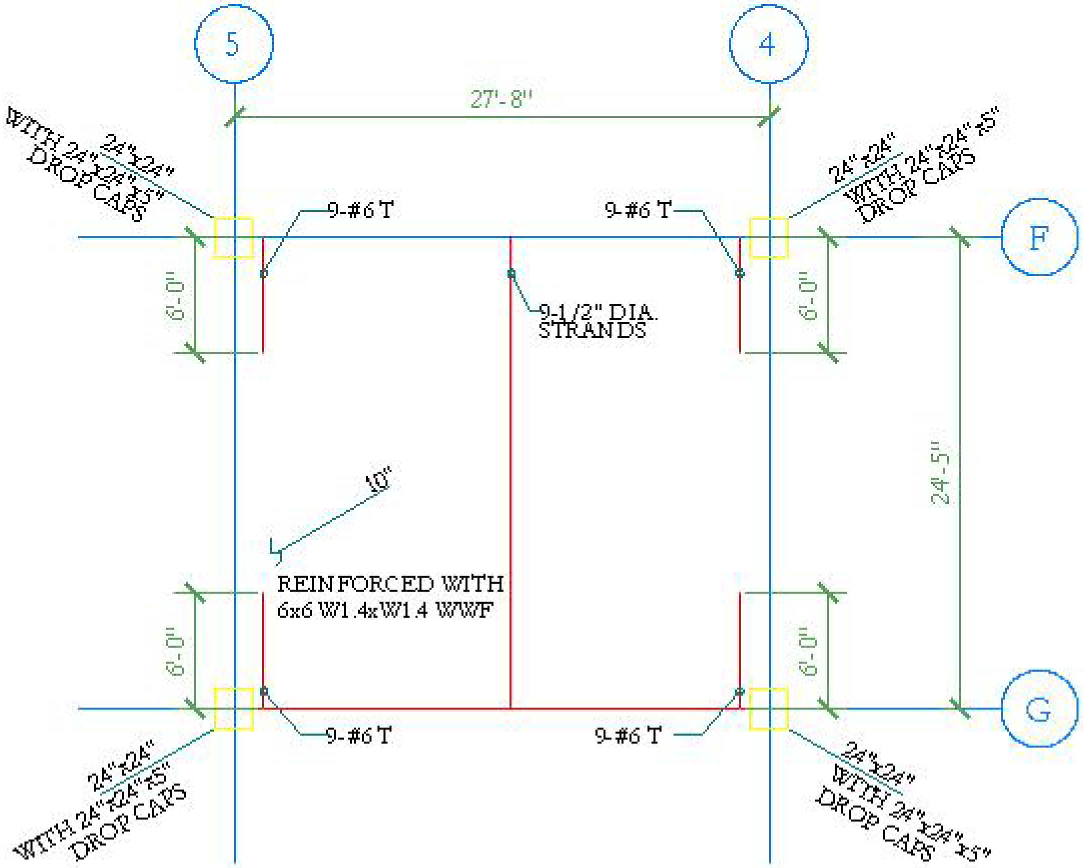


Figure 5: Two-way Post-Tensioned Concrete Typical Floor Framing Bay

See Appendix pg. 33 for calculations.

Note: Floor system only analyzed in the long span direction for simplicity of comparison.

Advantages and Disadvantages

Framing System

Similar to the two-way flat plate concrete system, the framing system will need to change over completely to concrete and smaller spans would be desirable for thinner slabs. Comparatively this system actually does not perform as well as the two-way slab with the longer bays with an increased depth of 21" and an increased concrete strength required.

Considering deflection, vibration, and fire proofing, the result are equivocal of the flat plate system with a deflection of 0.15" and easily achievable fire resistance rating of four hours.

Lateral and Foundation System

Deeper foundations will be required to support this systems heavy 141 psf dead load and the concrete shear wall lateral system will most likely be controlled by seismic forces.

Mechanical and Electrical

An acoustical tile system may be difficult to connect to the underside of the post-tensioned slab and alternative ceiling systems should be explored. A major disadvantage of post-tensioned concrete occurs at the location of openings, where tendons may need to be directed around the opening, using more material.

Construction

The labor intensity and long construction time is shared by the post-tensioned concrete and flat plate systems. Along with intense labor, there are also intense inspections with each tendon needing to be tested to guarantee that it has the proper amount of stress after placement for working with prestressing tendons can be highly dangerous should one snap. Along similar lines, placing an opening in a floor after construction can prove to be taxing. Extreme amounts of remediation and reconstruction may be necessary to move the tendons out of the opening's way, for if one is cut, it will not longer have the capacity to carry any load along its entire length and structural failure may be possible.

The cost of the post-tensioned system may be higher than a flat plate system, depending on the amount of regular reinforcement can be saved, an approximate cost is $18.98.

Architectural

Many of the architectural concerns are similar to a flat plate concrete system with a floor to floor height of 12'-3". Unlike a flat plate system, it is possible for post-tensioned concrete to be placed incorrectly or overstressed to the point that the tendons can be seen from above or below the slab. These unsightly appearances do not have structural ramifications but have the tendency to be disconcerting to the public and an additional top finish may need to be put into place. Slight cambers in the slab can also make the placement of floor tiles difficult as preferred in many office buildings, such as the Duncan Center.

VI. PRECAST HOLLOW CORE CONCRETE PLANKS FLOOR SYSTEM

Description

Thin hollowcore concrete precast concrete planks of 6” with a two inch topping and a two hour fire rating were selected. The planks are reinforced with 7 prestressed ½” dia. strands and are supported at every 4’ o.c with steel angles to be supported by the moment frame steel structure. In this case, there is no composite action involved as with other concrete supported and steel floor systems with moment frame W24x62 and W21x48 girders and W12x14 beams, the typical floor framing bay below for clarification.

Material Properties

Concrete Topping:	Normalweight, F_y=3000 psi
Precast Hollowcore Planks:	Normalweight, F_y=6000 psi
Prestressed Strands:	A416 Grade 270K
Structural Steel:	A572 Grade 50
Steel Studs:	A108

Design Dead Load

3/4"Quarry Tile Flooring	10	PSF
6"Hollowcore Concrete Plank	49	PSF
2" Topping	25	PSF
HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF
Total	94	PSF

Note: Dead loads do not include supporting member self-weights.

Typical Floor Framing Bay

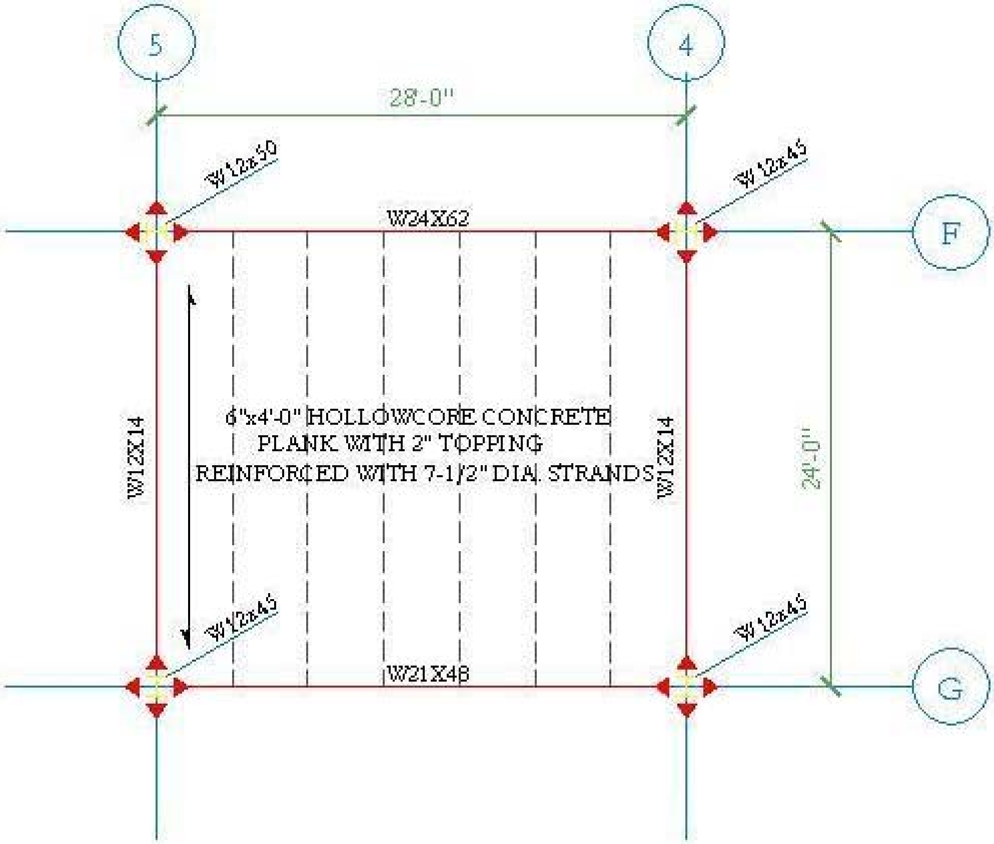


Figure 6: Precast Hollowcore Concrete Plank Typical Floor Framing Bay

See Appendix pg. 35 for calculations.

Advantages and Disadvantages

Framing System

Hollowcore plank is precast and produced in 4’-0” strips which should not be cut in excess to fit plan dimensions, hence the grid system for the existing structure should change so that the spans match most closely a dimension which is divisible by 4’ evenly. Doing this acquires a bay size of 24’-0”x28’-0”, which is relatively close to that of the original. Although the actual slab is not necessarily thick an increased depth of 30” occurs in due to the greatly increased amount of load that the steel girders are required to take.

Deflection of a hollowcore system is very low due to the voids which create a flange and web effect to add stiffness to the slab and a total deflection of 0.0003”. Another advantage of precast planks is that the designer may simply choose a fire resistance rating desired, in this case a two hour fire resistance.

Lateral and Foundation System

A hollowcore plank system falls in between the existing system and the two previously discussed concrete systems for lateral and foundation system. For the lateral system, this may remain the same as the existing and wind will probably control. For the foundation system, on the other hand, the weight of 94 psf is heavier than the existing, like the other concrete systems and will require deeper foundations to be designed.

Mechanical and Electrical

Due to the hollowcores inside the precast planks it is recommended that acoustical filler be placed in the voids in order to dampen any sounds that may disruptive to other occupants, especially beneath the fifth floor. An acoustical hanging ceiling tile system can also be easily utilized with hollowcore planks to help with noise pollution and also to conceal mechanical and electrical work.

Construction

It would be hard to beat this system in regards to ease of construction, nearly all the components for the framing come as a kit of parts that simple need to be assembled. Not only is the system easy to put together but it can go up very quickly as well, as long as there is ample time to account for the lead time required for both the steel and hollowcore planks. The cost of the hollowcore system is comparable as well at $17.20/SF.

No system is perfect and each has its own weaknesses and the weakness of this one is that no openings shall be cut into the planks after installation as there are prestressed and cutting of the tendons can cause failures and be very dangerous. If a new opening is required, almost nothing short of removing the entire plank and replacing it can be feasible.

Architectural

Surprisingly, due to the increased depth of the steel girders, the floor to floor height of the system is a low 11'-6", much lower than the other systems previously analyzed. An advantage to this system, despite its depth issue, is that it will produce a very level floor to place till upon, more so than the other systems are capable.

VII. OPEN WEB STEEL JOIST WITH COMPOSITE METAL DECK FLOOR SYSTEM

Description

Long span open web steel joists, 20LH08 spaced at 3' o.c., are supported by a steel moment frame with W12x40 to W12x53 columns, similar to that of the existing system. The W16x31 girders and W12x14 beams also still act compositely with the 5" concrete slab, with the girders benefiting from the composite action more than the beams with 31 shear studs versus the beams 9. A thicker and heavier slab was selected for the joist floor system to control vibrations. The decking is a 1.5" 22 gage metal deck and the concrete is reinforced with 6x6 W2.0xW2.0 welded wire fabric reinforcement, see the typical floor framing bay below for clarification.

Material Properties

Concrete:	Normalweight, F_y=4000 psi
Welded Wire Fabric:	A185
Metal Deck:	A525 Grade 60
Steel Joists:	A36
Structural Steel:	A572 Grade 50
Steel Studs:	A108

Design Dead Load

3/4" Quarry Tile Flooring	10	PSF
5" Reinforced Concrete Slab	51	PSF
22 Gage Steel Deck	2	PSF
HVAC	3	PSF
Acoustical Ceiling Tile	2	PSF
Miscellaneous	5	PSF
Total	73	PSF

Note: Dead loads do not include supporting member self-weights.

Typical Floor Framing Bay

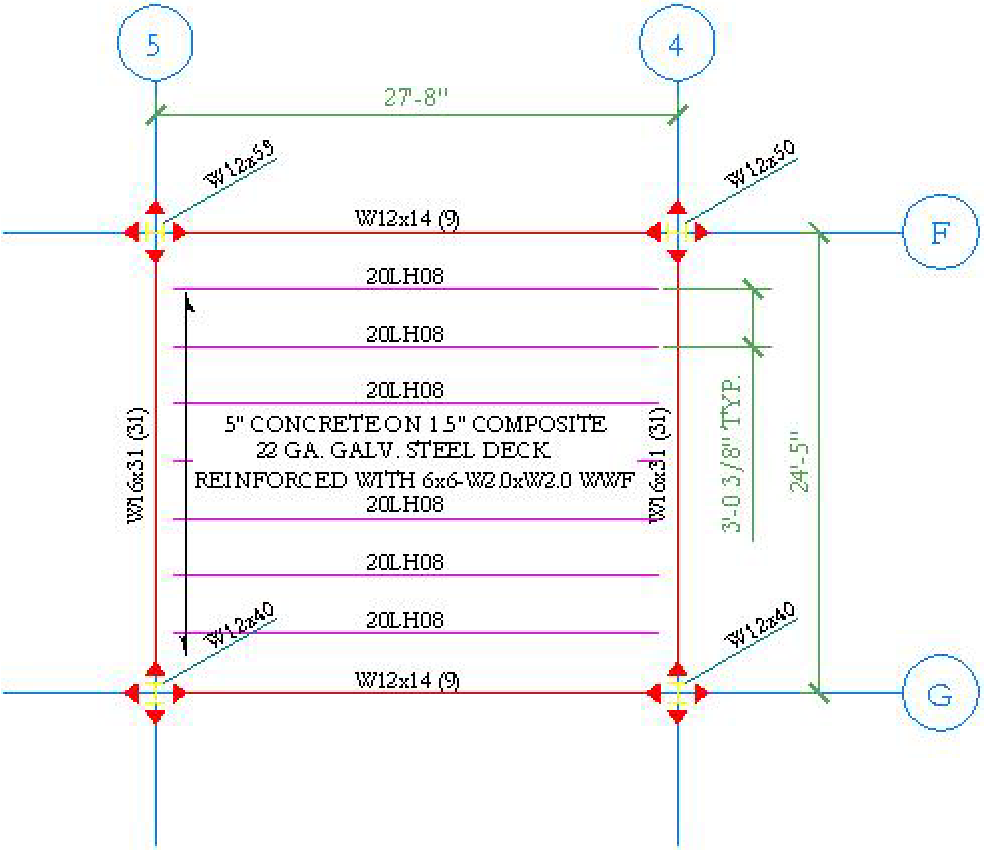


Figure 7: Open Web Steel Joist with Composite Metal Deck Typical Floor Framing Bay
See Appendix pg. 39 for calculations.

Advantages and Disadvantages

Framing System

An open web steel joist floor system possesses many of the attributes of the existing system. The grid spans for a joist system, however, are still rather long and should be made shorter in order to reduce the 20" depth of the system.

Steel beams possess better serviceability properties than that of open web joists. Vibration in steel joists is known to be poor if not taken into consideration for a floor system by thickening the slabs, hence why the majority of steel joists are used for roof. With a reception hall on the fifth floor of the building, joists should not be utilized in the system for that floor. Deflection is comparable to that of other systems, due to the close spacing of the joists, with a total deflection of 0.0018".

Again, the joists like the steel beams that they are supported by must have spray-on fire proofing in order to achieve the required 2 hour fire resistance rating.

Lateral and Foundation System

The lateral and foundation system may remain the same for a joist versus beam system as the total system weights are nearly equivalent with 73 psf for steel joists and 69 psf for steel beams, a small difference.

Mechanical and Electrical

Acoustical vibrations can resonate through steel joists, therefore every possible attempt to deaden the transfer of the sound waves should be taken. Thickening the slab, having longer spans, increasing the wavelength, fire proofing, and an acoustical ceiling with insulation are all measures that can be taken in order to help the situation. As for mechanical and electrical work, open web joists have the advantage of being "open", as ductwork and electrical conduit can run through the joists as long as the system is coordinated to allow each discipline adequate space.

Construction

As one might expect, the joist system construction is closely related to that of steel beams differing only in that a larger number of lighter members that are easier to connect to the supports are being put into place. These small differences are reflected in the comparative cost of the joist system with $16.45/SF, $0.35 less than that of the steel system.

Open web steel joists though, may not be as durable as steel beams and do not respond well to additional loading later on in the life of the structure. The live load being 100 psf helps in this respect as there is little chance that an occupancy with a greater demand will use the space. Openings in the floor slab are more difficult to place due to the close 3' o.c. spacing of the joists, but adding an opening after construction is feasible.

Architectural

The floor to floor height of the system is 12'-4" which is equivalent to each of the systems previously analyzed, with the exception of the hollowcore plank system. One disadvantage of the system architecturally is that the joists may be subjected to torsion due to unbalanced loading and twisted away from the original point of bearing. This may affect the deflection of the floor system and any flooring that is placed on top of the slab with tiles, in this case, potentially popping up, which may also be considered a safety hazard.

VIII. Comparative Floor System Analysis

	Existing	*Two-way*
Weight (psf)	64	129
Cost ($/SF)	$16.79	$15.98
Depth (inches)	22.0	18.5
Floor to Floor Height	12'-2"	12'-5"
Deflection (inches)	0.1214	0.1960
Grid	Long Spans	Smaller spans preferred
Fire Protection	Spray-on necessary	No extra protection required
Foundation	Moderate	Deeper foundations required
Seismic vs. Wind Prediction	Wind	Seismic
Mechanical and Electrical	Sufficient	Sufficient if acoustical ceiling can be utilized
Construction	Moderate time and labor	Long time and intense labor
Opening	Later placement feasible	Later placement difficult
Advantage	Capable of longer spans	Increased floor to floor height
Disadvantage	Connection cost	Visible Cracking
Potential Future System	Yes	Yes

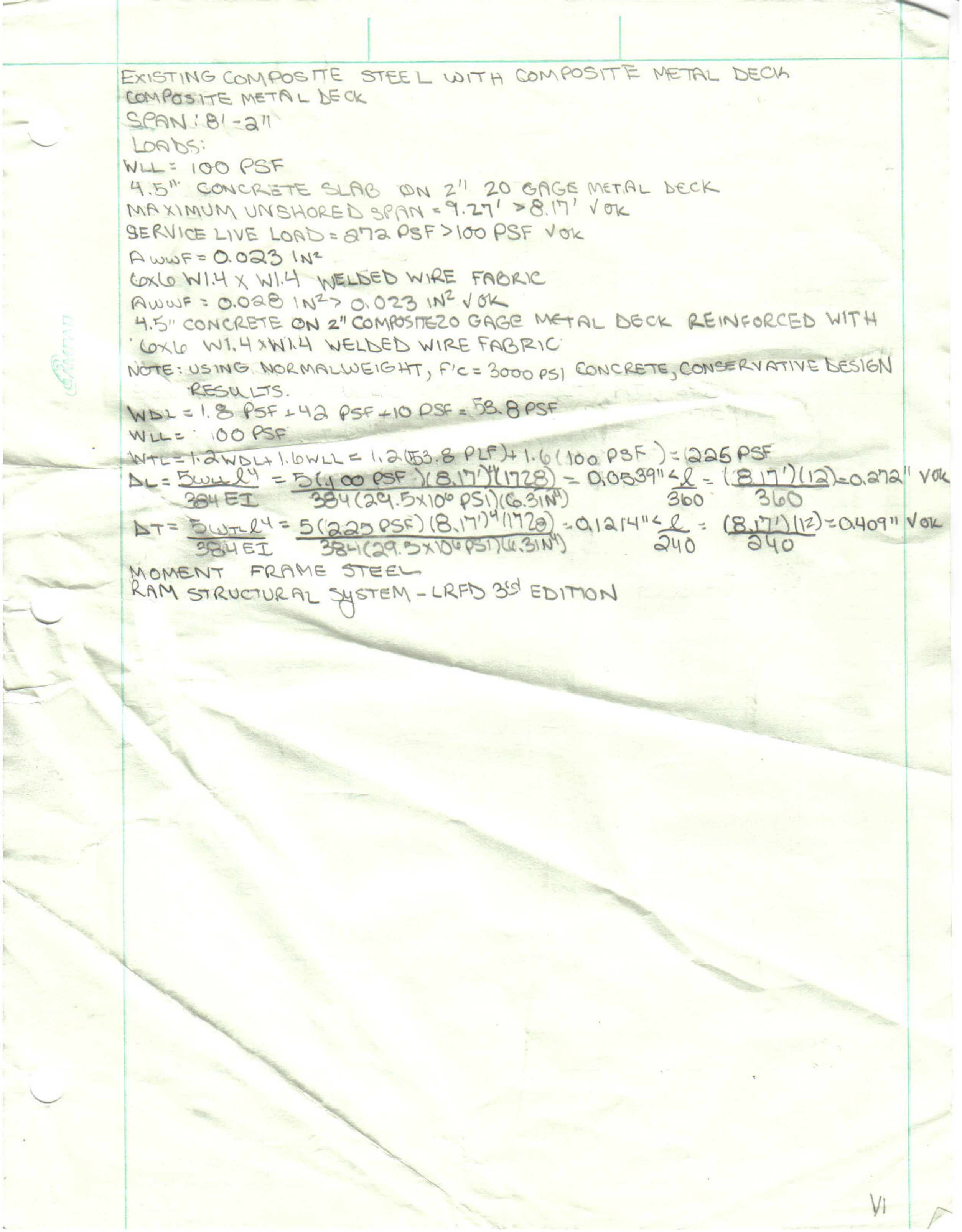
	Post-Tensioned	*Hollowcore*
Weight (psf)	141	94
Cost ($/SF)	$18.98	$17.20
Depth (inches)	21.0	30.0
Floor to Floor Height	12'-3"	11'-6"
Deflection (inches)	0.1500	0.0003
Grid	Smaller spans preferred	Spans with 4' dimensions required
Fire Protection	No extra protection required	Spray-on necessary
Foundation	Deeper foundations required	Deeper foundations required
Seismic vs. Wind Prediction	Seismic	Wind
Mechanical and Electrical	Sufficient if acoustical ceiling can be utilized	Acoustical core filler recommended
Construction	Long time and intense labor	Short time and light labor
Opening	Later placement remediation necessary	Later placement not recommended
Advantage	Less reinforcement than flat plate concrete	Easy construction
Disadvantage	Safety concerns	Increased vibration
Potential Future System	No	No

	Joist
Weight (psf)	73
Cost ($/SF)	$16.45
Depth (inches)	20.0
Floor to Floor Height	12'-4"
Deflection (inches)	0.0018
Grid	Smaller spans preferred
Fire Protection	Spray-on necessary
Foundation	Moderate
Seismic vs. Wind Prediction	Wind
Mechanical and Electrical	Thicker slab recommended
Construction	Moderate time and labor
Opening	Later placement feasible
Advantage	Less expensive than steel beams
Disadvantage	Increased vibration
Potential Future System	No

🟦	Better
▒	Neutral
🟨	Worse

IX. APPENDIX

Existing Steel with Composite Metal Floor System



EXISTING COMPOSITE STEEL WITH COMPOSITE METAL DECK

COMPOSITE METAL DECK

SPAN: 8'-2"

LOADS:

W_{LL} = 100 PSF

4.5" CONCRETE SLAB ON 2" 20 GAGE METAL DECK

MAXIMUM UNSHORED SPAN = 9.27' > 8.17' ✓OK

SERVICE LIVE LOAD = 272 PSF > 100 PSF ✓OK

A_{WWF} = 0.023 IN^2

6x6 W1.4 x W1.4 WELDED WIRE FABRIC

A_{WWF} = 0.028 IN^2 > 0.023 IN^2 ✓OK

4.5" CONCRETE ON 2" COMPOSITE 20 GAGE METAL DECK REINFORCED WITH 6x6 W1.4 x W1.4 WELDED WIRE FABRIC

NOTE: USING NORMALWEIGHT, F'c = 3000 PSI CONCRETE, CONSERVATIVE DESIGN RESULTS.

$W_{DL} = 1.8\ PSF + 42\ PSF + 10\ PSF = 53.8\ PSF$

$W_{LL} = 100\ PSF$

$W_{TL} = 1.2W_{DL} + 1.6W_{LL} = 1.2(53.8\ PLF) + 1.6(100\ PSF) = 225\ PSF$

$$\Delta L = \frac{5 w_{LL} \ell^4}{384 EI} = \frac{5(100\ PSF)(8.17')^4(1728)}{384(29.5\times10^6\ PSI)(6.31IN^4)} = 0.0539'' < \frac{\ell}{360} = \frac{(8.17')(12)}{360} = 0.272''\ \checkmark OK$$

$$\Delta T = \frac{5 w_{TL} \ell^4}{384 EI} = \frac{5(225\ PSF)(8.17')^4(1728)}{384(29.5\times10^6\ PSI)(6.31IN^4)} = 0.1214'' < \frac{\ell}{240} = \frac{(8.17')(12)}{240} = 0.409''\ \checkmark OK$$

MOMENT FRAME STEEL

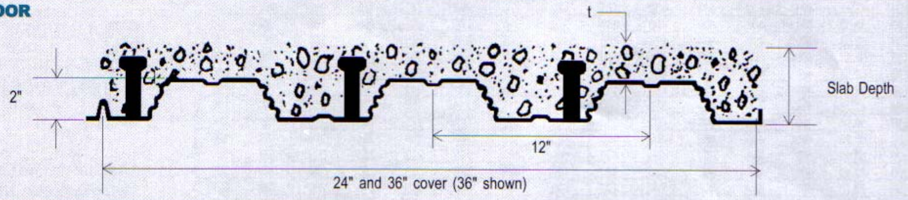
RAM STRUCTURAL SYSTEM - LRFD 3rd EDITION

VI

USD United Steel Deck, Inc.

LRFD

2" LOK-FLOOR



The **Deck Section Properties** are per foot of width. The **I** value is for positive bending (in.^{4}); **t** is the gage thickness in inches; **w** is the weight in pounds per square foot; $\mathbf{S_p}$ and $\mathbf{S_n}$ are the section moduli for positive and negative bending (in.^{3}); $\mathbf{R_b}$ and $\phi\mathbf{V_n}$. are the interior reaction and the shear in pounds (per foot of width); studs is the number of studs required per foot in order to obtain the full resisting moment, $\phi\mathbf{M_{nf}}$.

The **Composite Properties** are a list of values for the composite slab. The **slab depth** is the distance from the bottom of the steel deck to the top of the slab in inches as shown on the sketch. U.L. ratings generally refer to the cover over the top of the deck so it is important to be aware of the difference in names. $\phi\mathbf{M_{nf}}$ is the factored resisting moment provided by the composite slab when the "full" number of studs as shown in the upper table are in place; inch kips (per foot of width). $\mathbf{A_c}$ is the area of concrete available to resist shear, in.^{2} per foot of width. **Vol.** is the volume of concrete in ft.^{3} per ft.^{2} needed to make up the slab; no allowance for frame or deck deflection is included. **W** is the concrete weight in pounds per ft.^{2}. $\mathbf{S_c}$ is the section modulus of the "cracked" concrete composite slab; in.^{3} per foot of width. $\mathbf{I_{av}}$ is the average of the "cracked" and "uncracked" moments of inertia of the transformed composite slab; in.^{4} per foot of width. The $\mathbf{I_{av}}$ transformed section analysis is based on steel; therefore, to calculate deflections the appropriate modulus of elasticity to use is 29.5 **x** 10^6 psi. $\phi\mathbf{M_{no}}$ is the factored resisting moment of the composite slab if there are no studs on the beams (the deck is attached to the beams or walls on which it is resting) inch kips (per foot of width). $\phi\mathbf{V_{nt}}$ is the factored vertical shear resistance of the composite system; it is the sum of the shear resistances of the steel deck and the concrete but is not allowed to exceed $\phi\,4(f'_c)^{1/2}A_c$; pounds (per foot of width). The next three columns list the **maximum unshored spans** in feet; these values are obtained by using the construction loading requirements of the SDI; combined bending and shear, deflection, and interior reactions are considered in calculating these values. $\mathbf{A_{wwf}}$ is the minimum area of welded wire fabric recommended for temperature reinforcing in the composite slab; square inches per foot.

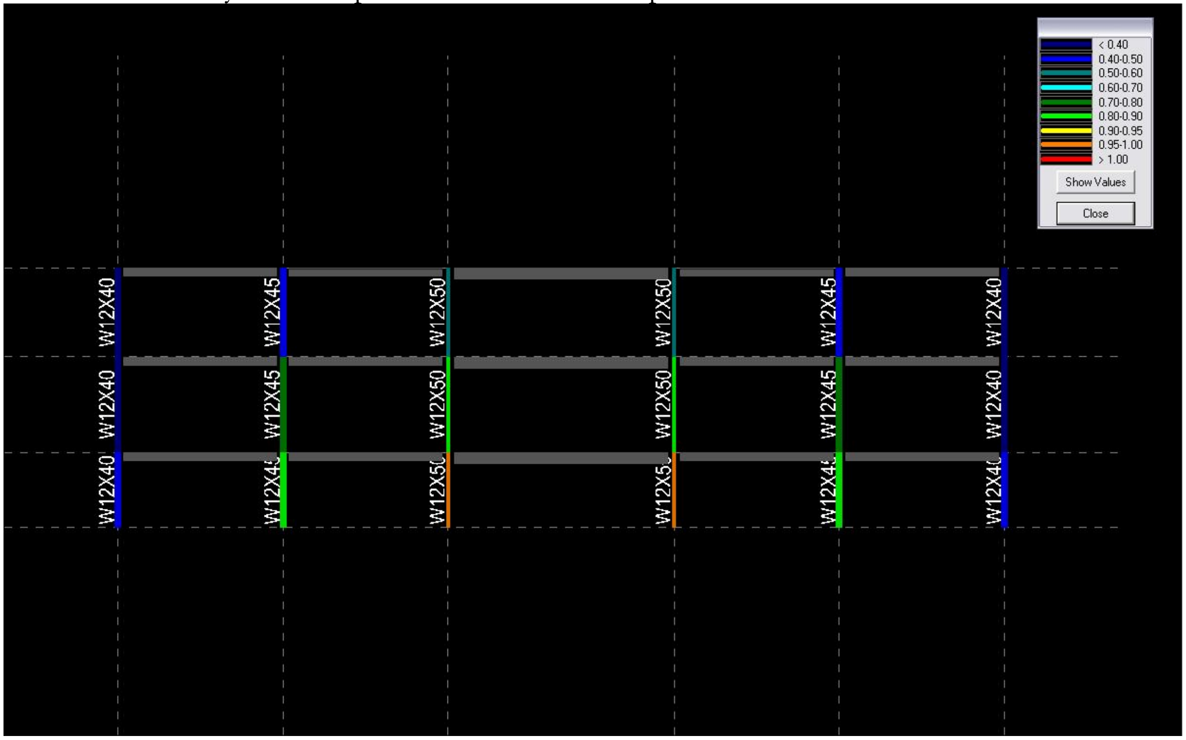
DECK PROPERTIES

Gage	t	w	As	I	S_p	S_n	R_b	ϕV_n	studs
22	0.0295	1.5	0.440	0.338	0.284	0.302	714	1990	0.36
20	0.0358	1.8	0.540	0.420	0.367	0.387	1010	2410	0.43
19	0.0418	2.1	0.630	0.490	0.445	0.458	1330	2810	0.51
18	0.0474	2.4	0.710	0.560	0.523	0.529	1680	3180	0.57
16	0.0598	3.1	0.900	0.700	0.654	0.654	2470	3990	0.72

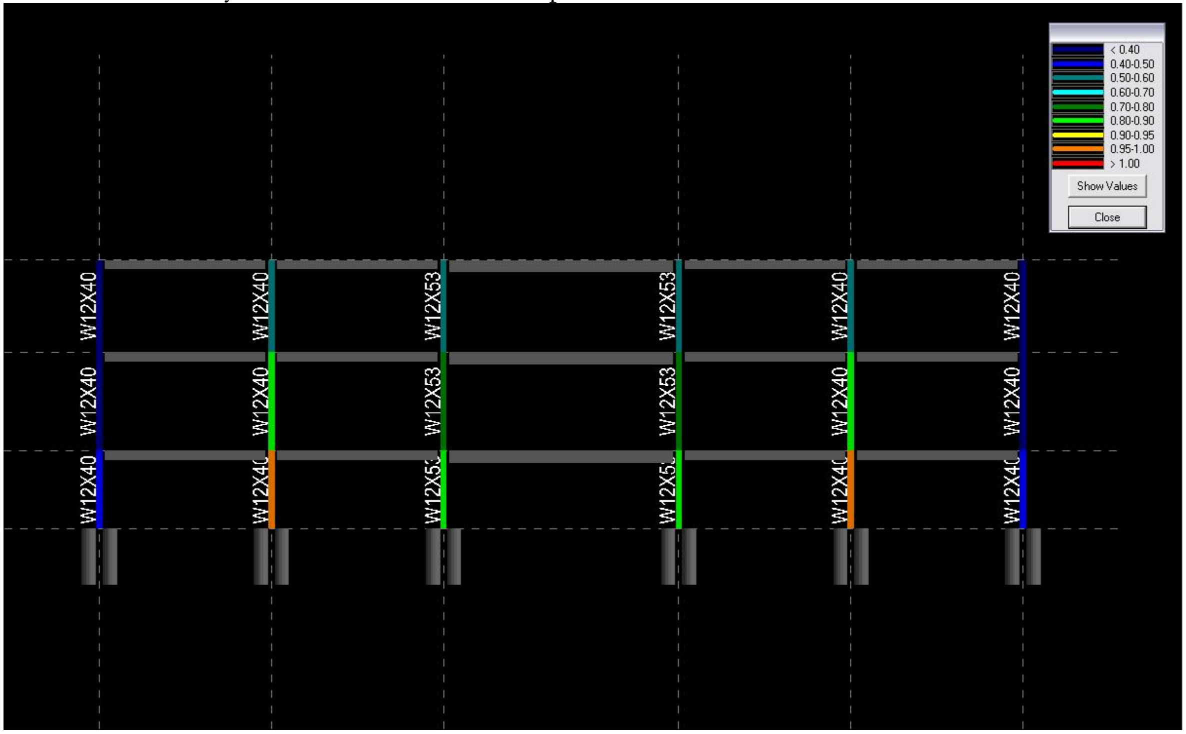
COMPOSITE PROPERTIES

	Slab Depth	ϕM_{nf} in.k	A_c in^2	Vol. ft^3/ft^2	W psf	S_c in^3	I_{av} in^4	ϕM_{no} in.k	ϕV_{nt} lbs.	Max. unshored spans, ft. 1span	2span	3span	A_{wwf}
22 gage	4.50	40.27	32.6	0.292	42	1.05	5.9	29.40	5030	5.82	7.83	7.92	0.023
	5.00	46.44	37.5	0.333	48	1.23	8.0	34.53	5480	5.54	7.47	7.56	0.027
	5.25	49.53	40.0	0.354	51	1.32	9.2	37.16	5720	5.41	7.31	7.39	0.029
	5.50	52.61	42.6	0.375	54	1.42	10.5	39.81	5960	5.30	7.16	7.24	0.032
	6.00	58.78	48.0	0.417	60	1.61	13.5	45.21	6460	5.09	6.89	6.97	0.036
	6.25	61.87	50.8	0.438	63	1.71	15.3	47.95	6720	5.03	6.76	6.84	0.038
	6.50	64.95	53.6	0.458	66	1.81	17.1	50.70	6980	4.97	6.65	6.72	0.041
	7.00	71.12	59.5	0.500	73	2.01	21.2	56.26	7530	4.85	6.43	6.51	0.045
	7.25	74.21	61.9	0.521	76	2.11	23.5	59.07	7750	4.79	6.32	6.41	0.047
	7.50	77.29	64.3	0.542	79	2.21	26.0	61.88	7970	4.74	6.22	6.31	0.050
20 gage	4.50	48.60	32.6	0.292	42	1.26	6.3	35.43	5450	6.81	8.97	9.27	0.023
	5.00	56.18	37.5	0.333	48	1.48	8.6	41.65	5900	6.47	8.55	8.83	0.027
	5.25	59.96	40.0	0.354	51	1.60	9.8	44.84	6140	6.32	8.36	8.63	0.029
	5.50	63.75	42.6	0.375	54	1.71	11.3	48.07	6380	6.18	8.18	8.45	0.032
	6.00	71.32	48.0	0.417	60	1.95	14.5	54.63	6880	5.94	7.85	8.11	0.036
	6.25	75.11	50.8	0.438	63	2.07	16.3	57.96	7140	5.86	7.70	7.95	0.038
	6.50	78.90	53.6	0.458	66	2.19	18.2	61.31	7400	5.79	7.56	7.80	0.041
	7.00	86.47	59.5	0.500	73	2.43	22.6	68.09	7950	5.65	7.29	7.53	0.045
	7.25	90.26	61.9	0.521	76	2.55	25.0	71.50	8170	5.58	7.17	7.41	0.047
	7.50	94.05	64.3	0.542	79	2.67	27.6	74.93	8390	5.52	7.05	7.28	0.050
19 gage	4.50	55.85	32.6	0.292	42	1.45	6.7	40.69	5850	7.65	9.76	10.08	0.023
	5.00	64.68	37.5	0.333	48	1.71	9.0	47.87	6300	7.26	9.30	9.61	0.027
	5.25	69.10	40.0	0.354	51	1.84	10.4	51.56	6540	7.09	9.09	9.39	0.029
	5.50	73.52	42.6	0.375	54	1.97	11.9	55.30	6780	6.93	8.90	9.19	0.032
	6.00	82.35	48.0	0.417	60	2.24	15.2	62.90	7280	6.65	8.54	8.83	0.036
	6.25	86.77	50.8	0.438	63	2.38	17.1	66.76	7540	6.56	8.38	8.66	0.038
	6.50	91.19	53.6	0.458	66	2.52	19.2	70.65	7800	6.48	8.23	8.50	0.041
	7.00	100.03	59.5	0.500	73	2.80	23.8	78.50	8350	6.32	7.94	8.20	0.045
	7.25	104.44	61.9	0.521	76	2.94	26.3	82.46	8570	6.24	7.81	8.07	0.047
	7.50	108.86	64.3	0.542	79	3.08	29.0	86.45	8790	6.17	7.68	7.94	0.050
18 gage	4.50	62.08	32.6	0.292	42	1.62	7.0	45.34	6080	8.42	10.48	10.83	0.023
	5.00	72.04	37.5	0.333	48	1.90	9.5	53.36	6670	7.98	9.99	10.32	0.027
	5.25	77.02	40.0	0.354	51	2.05	10.9	57.48	6910	7.79	9.77	10.10	0.029
	5.50	82.00	42.6	0.375	54	2.20	12.4	61.66	7150	7.61	9.56	9.88	0.032
	6.00	91.95	48.0	0.417	60	2.50	15.9	70.18	7650	7.30	9.18	9.49	0.036
	6.25	96.93	50.8	0.438	63	2.66	17.9	74.50	7910	7.20	9.01	9.31	0.038
	6.50	101.91	53.6	0.458	66	2.81	20.0	78.85	8170	7.11	8.85	9.14	0.041
	7.00	111.87	59.5	0.500	73	3.13	24.8	87.66	8720	6.93	8.54	8.82	0.045
	7.25	116.85	61.9	0.521	76	3.28	27.4	92.10	8940	6.85	8.40	8.68	0.047
	7.50	121.83	64.3	0.542	79	3.44	30.2	96.57	9160	6.77	8.26	8.54	0.050
16 gage	4.50	62.08	32.6	0.292	42	1.99	7.7	45.34	6080	9.58	11.63	12.02	0.023
	5.00	72.04	37.5	0.333	48	2.35	10.4	53.36	6980	9.08	11.10	11.47	0.027
	5.25	77.02	40.0	0.354	51	2.53	11.9	57.48	7450	8.85	10.85	11.22	0.029
	5.50	82.00	42.6	0.375	54	2.72	13.6	61.66	7940	8.65	10.63	10.98	0.032
	6.00	91.95	48.0	0.417	60	3.10	17.4	70.18	8460	8.29	10.21	10.55	0.036
	6.25	96.93	50.8	0.438	63	3.29	19.5	74.50	8720	8.17	10.02	10.35	0.038
	6.50	101.91	53.6	0.458	66	3.48	21.8	78.85	8980	8.07	9.84	10.17	0.041
	7.00	111.87	59.5	0.500	73	3.88	27.0	87.66	9530	7.86	9.50	9.82	0.045
	7.25	116.85	61.9	0.521	76	4.08	29.8	92.10	9750	7.77	9.35	9.66	0.047
	7.50	121.83	64.3	0.542	79	4.28	32.8	96.57	9970	7.67	9.20	9.50	0.050

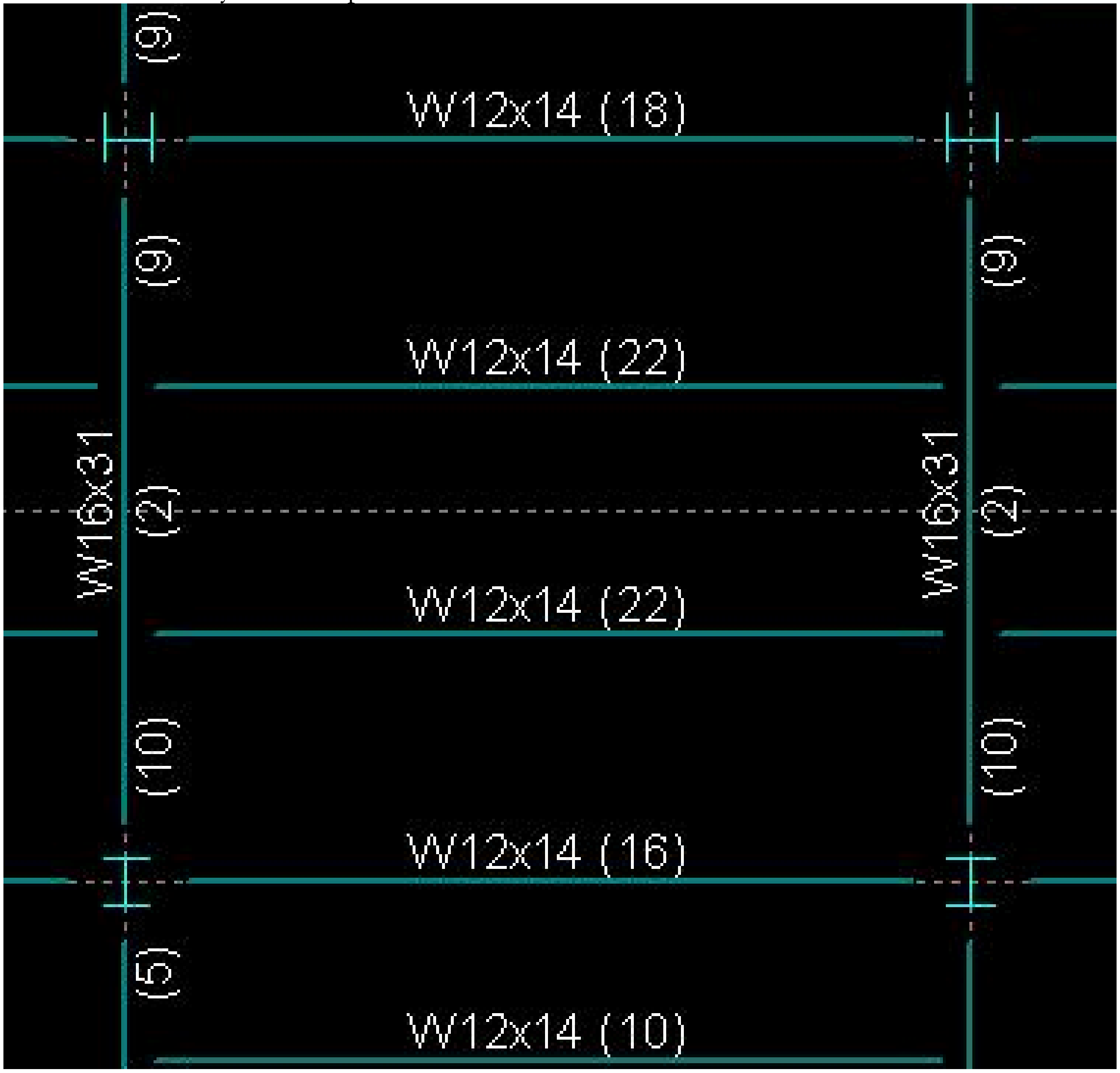
RAM Structural System Output Column Line 4 Output



RAM Structural System Column Line 5 Output



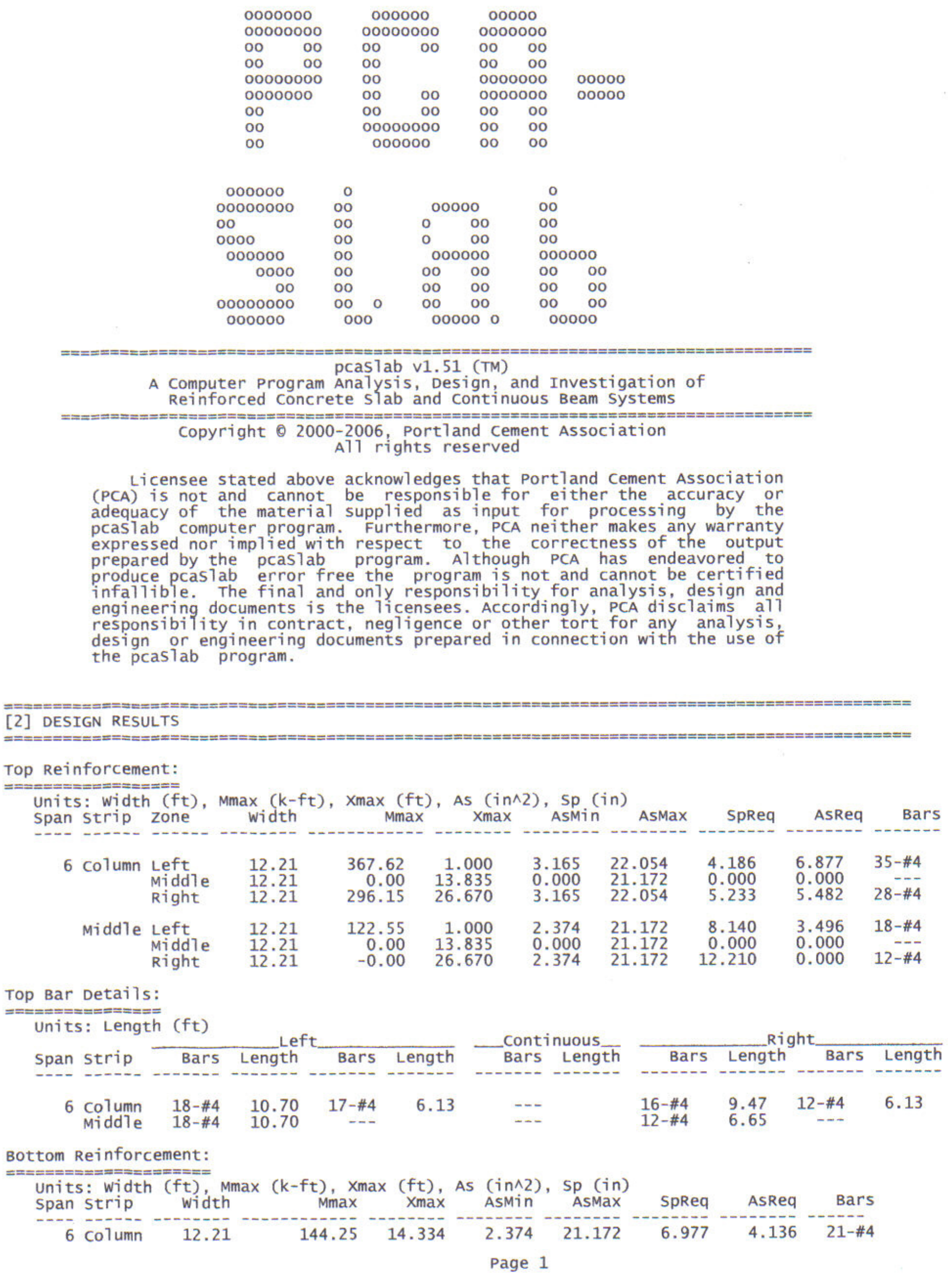
RAM Structural System Output Plan



TWO-WAY FLAT PLATE CONCRETE FLOOR SYSTEM
PCA SLAB- ACI 318-02
DROP PANEL DIMENSIONS BASED UPON PCA SLAB CALCULATION
TOP & BOTTOM REINFORCEMENT COVER = 3/4"
COVER TO CENTER OF STEEL = 1 1/4"

1/1

PCA Slab Long Direction Output



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      ==============================================================================
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                 Reinforced Concrete Slab and Continuous Beam Systems
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==============================================================================================
[2] DESIGN RESULTS
==============================================================================================

Top Reinforcement:
==================
   Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)
   Span Strip  Zone      Width         Mmax     Xmax    AsMin    AsMax    SpReq    AsReq    Bars
   ---- ------ ------ -------- ------------ -------- -------- -------- -------- -------- -------

      6 Column Left      12.21       367.62    1.000    3.165   22.054    4.186    6.877   35-#4
               Middle    12.21         0.00   13.835    0.000   21.172    0.000    0.000     ---
               Right     12.21       296.15   26.670    3.165   22.054    5.233    5.482   28-#4

        Middle Left      12.21       122.55    1.000    2.374   21.172    8.140    3.496   18-#4
               Middle    12.21         0.00   13.835    0.000   21.172    0.000    0.000     ---
               Right     12.21        -0.00   26.670    2.374   21.172   12.210    0.000   12-#4

Top Bar Details:
================
   Units: Length (ft)
                ____________Left_______________  ___Continuous__  _____________Right______________
   Span Strip      Bars  Length    Bars  Length     Bars  Length     Bars  Length     Bars  Length
   ---- ------  ------- ------- ------- -------  ------- -------  ------- ------- ------- -------

      6 Column    18-#4   10.70   17-#4    6.13      ---            16-#4   9.47    12-#4   6.13
        Middle    18-#4   10.70     ---              ---            12-#4   6.65      ---

Bottom Reinforcement:
=====================
   Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)
   Span Strip     Width         Mmax     Xmax    AsMin    AsMax    SpReq    AsReq    Bars
   ---- ------  -------- ------------ -------- -------- -------- -------- -------- ------
      6 Column    12.21        144.25   14.334    2.374   21.172    6.977    4.136   21-#4
                                                  Page 1
```

```
        Middle    12.21        96.17   14.334    2.374   21.172    10.466    2.727   14-#4

Bottom Bar Details:
===================
   Units: Start (ft), Length (ft)
                _______Long Bars_______ ______Short Bars_______
   Span Strip      Bars   Start  Length    Bars   Start  Length
   ---- ------- ------- ------- ------- ------- ------- -------
     5 Column     18-#4    0.00   27.67     ---
        Middle    12-#4    0.00   27.67     ---

Flexural Capacity:
==================
   Units: From, To (ft), As (in^2), PhiMn (k-ft)
   Span Strip       From        To AsTop AsBot       PhiMn-       PhiMn+
   ---- ------ --------- --------- ----- ----- ------------ ------------
     6 Column      0.000     1.000  7.00  4.20      -373.83       146.42
                   1.000     4.612  7.00  4.20      -373.83       146.42
                   4.612     4.970  7.00  4.20      -238.72       146.42
                   4.970     6.135  3.60  4.20      -126.09       146.42
                   6.135     9.538  3.60  4.20      -126.09       146.42
                   9.538     9.985  0.00  4.20         0.00       146.42
                   9.985    10.703  0.00  4.20         0.00       146.42
                  10.703    13.835  0.00  4.20         0.00       146.42
                  13.835    17.686  0.00  4.20         0.00       146.42
                  17.686    18.199  0.00  4.20         0.00       146.42
                  18.199    19.359  0.00  4.20         0.00       146.42
                  19.359    21.535  3.20  4.20      -112.43       146.42
                  21.535    22.696  3.20  4.20      -112.43       146.42
                  22.696    23.058  5.60  4.20      -193.10       146.42
                  23.058    26.670  5.60  4.20      -302.25       146.42
                  26.670    27.670  5.60  4.20      -302.25       146.42
        Middle     0.000     1.000  3.60  2.40      -126.09        84.84
                   1.000     4.151  3.60  2.40      -126.09        84.84
                   4.151     5.306  3.60  2.40      -126.09        84.84
                   5.306     9.551  3.60  2.80      -126.09        98.68
                   9.551     9.985  0.00  2.80         0.00        98.68
                   9.985    10.703  0.00  2.80         0.00        98.68
                  10.703    13.835  0.00  2.80         0.00        98.68
                  13.835    17.686  0.00  2.80         0.00        98.68
                  17.686    21.022  0.00  2.80         0.00        98.68
                  21.022    22.022  0.00  2.80         0.00        98.68
                  22.022    26.670  2.40  2.80       -84.84        98.68
                  26.670    27.670  2.40  2.80       -84.84        98.68

Slab Shear Capacity:
====================
   Units: b, d (in), Xu (ft), PhiVc, Vu(kip)
   Span        b        d   Vratio        PhiVc           Vu           Xu
   ---- -------- -------- -------- ------------ ------------ ------------
     4    293.04     8.00    1.000       222.40       111.56         1.67
     5    293.04     8.00    1.000       222.40        94.95         1.67

Flexural Transfer of Negative Unbalanced Moment at Supports:
============================================================
   Units: Width (in), Munb (k-ft), As (in^2)
   Supp    Width  GammaF*Munb Comb Pat      AsReq   AsProv Additional Bars
   ---- -------- ------------ ---- ---- -------- -------- ---------------
     4     64.50       207.75 U2   Even    3.856    4.050      ---
     5     64.50       148.51 U2   Even    2.721    3.081      ---

Punching Shear Around Columns:
==============================
   Units: Vu (kip), Munb (k-ft), vu (psi), Phi*vc (psi)
   Supp           Vu       vu         Munb Comb Pat  GammaV       vu   Phi*vc
   ---- ------------ -------- ------------ ---- ---- ------ -------- --------
     4        168.70     92.4      -346.26 U2   Even  0.400    165.2    189.7
     5        146.30     80.2       247.52 U2   Even  0.400    132.1    189.7

Punching Shear Around Drops:
============================
   Units: Vu (kip), vu (psi), Phi*vc (psi)
   Supp           Vu Comb Pat        vu   Phi*vc
   ---- ------------ ---- ---- -------- --------
     5        202.27 U2   S5        56.3    128.7

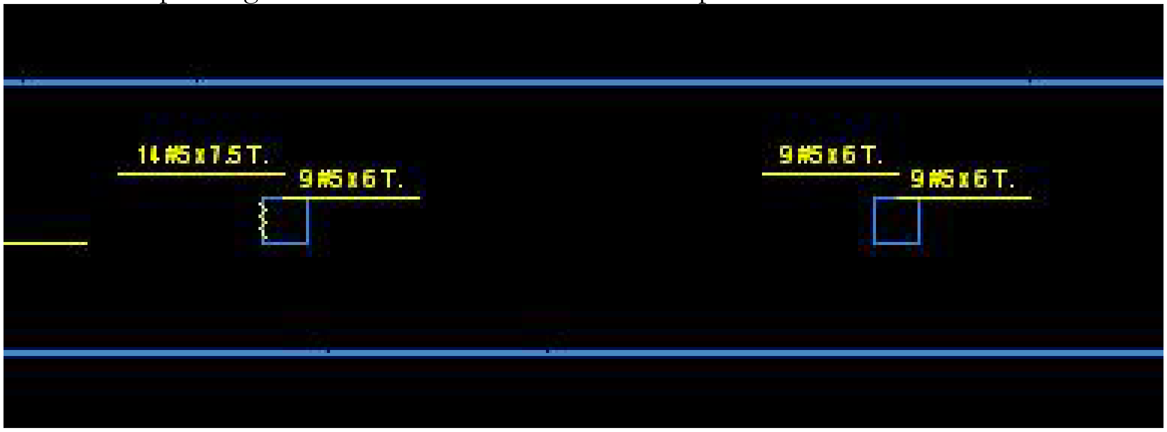
Maximum Deflections:
====================
   Units: Dz (in)
```

```
     ___________Frame___________  _______Column Strip________  ________Middle Strip_______
Span Dz(DEAD) Dz(LIVE) Dz(TOTAL)  Dz(DEAD) Dz(LIVE) Dz(TOTAL)  Dz(DEAD) Dz(LIVE) Dz(TOTAL)
---- -------- -------- ---------  -------- -------- ---------  -------- -------- ---------
   5   -0.050   -0.095    -0.145    -0.067   -0.129    -0.196    -0.032   -0.062    -0.094
```

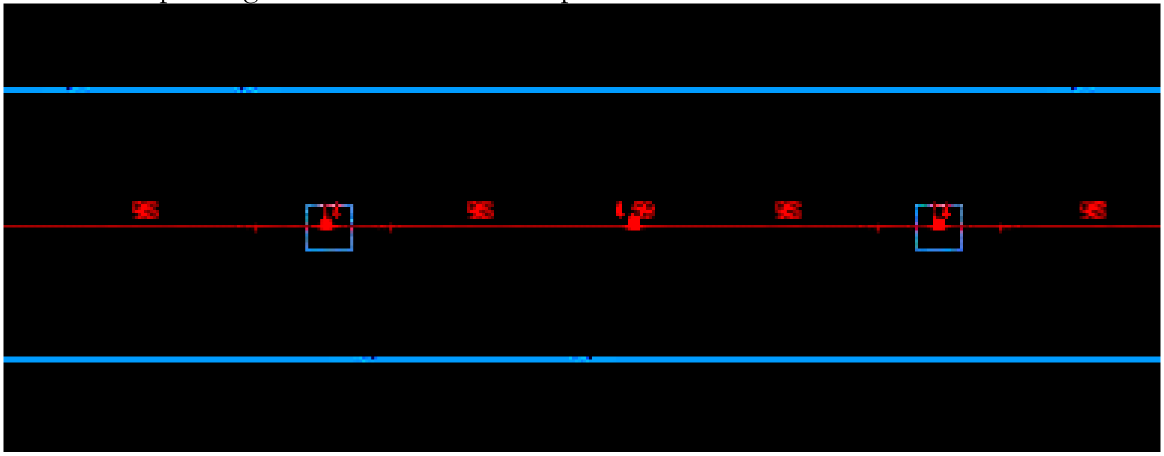
TWO-WAY POST-TENSIONED CONCRETE FLOOR SYSTEM
RAM CONCEPT - ACI 318-02
MINIMUM P/A = 150 PSI
MINIMUM BALANCE LOAD PERCENTAGE = 60% OF SELF-DEAD LOAD
TOP & BOTTOM REINFORCEMENT COVER = 3/4"
COVER TO CENTER OF STEEL = 1 3/8"

1/1

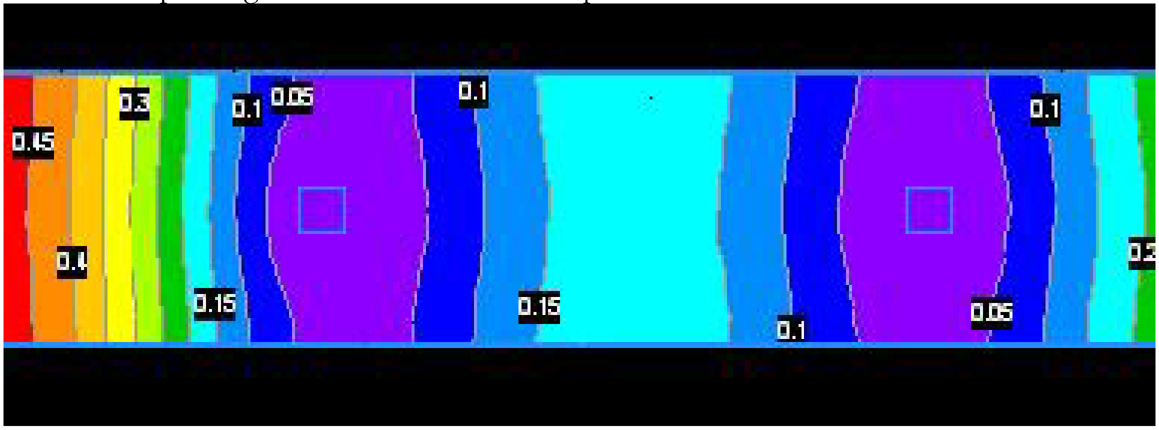
RAM Concept Long Direction Reinforcement Plan Output



RAM Concept Long Direction Tendons Output



RAM Concept Long Direction Deflection Output



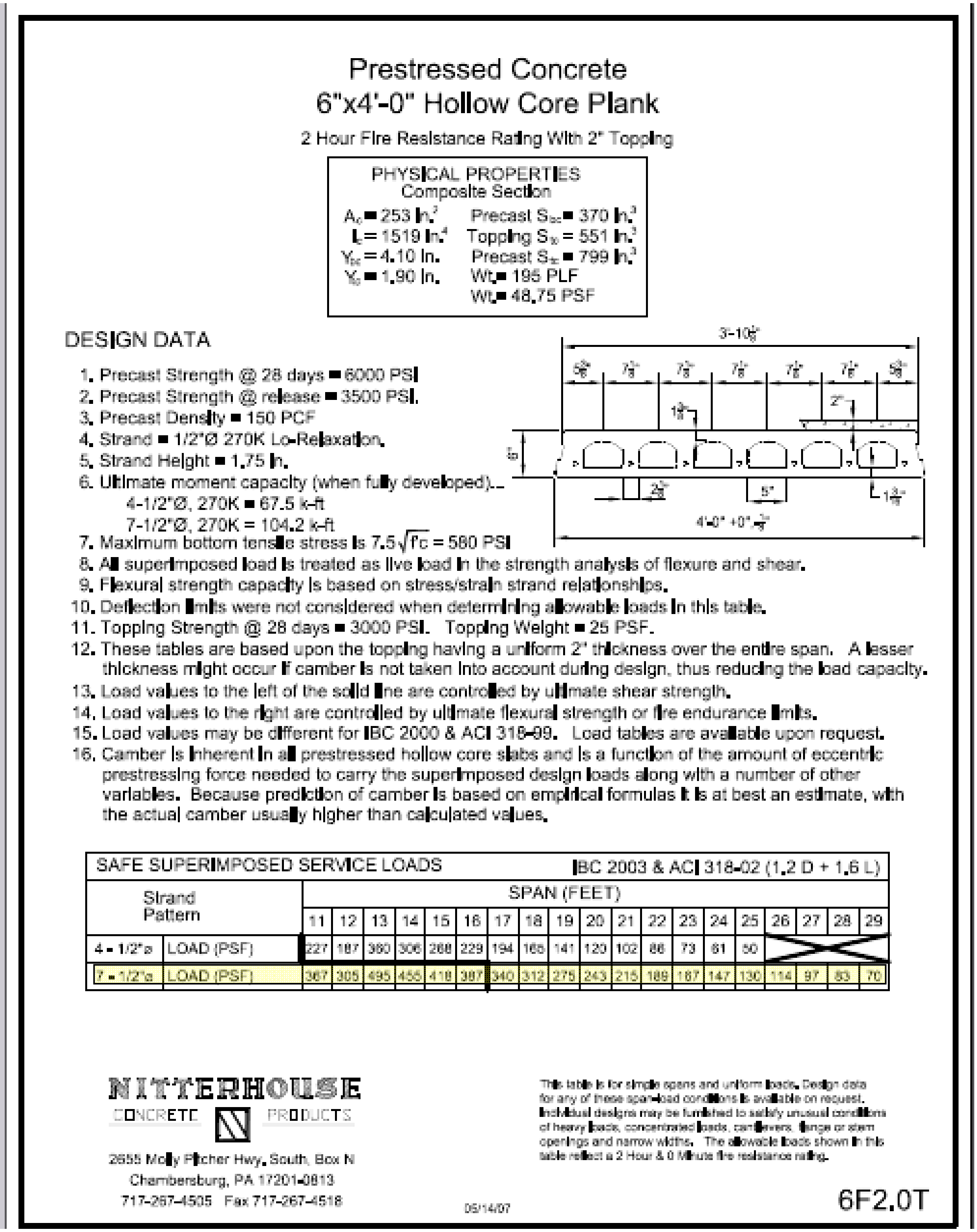
PRECAST HOLLOWCORE CONCRETE PLANK
SPAN: 24'-5"
LOADS:
W_{LL} = 100 PSF
6"X4'-0" HOLLOW CORE CONCRETE PLANK WITH 2" TOPPING AND 2 HOUR FIRE RESISTANCE RATING WITH 7-1/2" DIAMETER STRANDS
SERVICE LIVE LOAD = 140 PSF > 100 PSF ✓OK
6"X4'-0" HOLLOW CORE CONCRETE PLANK WITH 2" TOPPING AND 2 HOUR FIRE RESISTANCE RATING REINFORCED WITH 7-1/2" DIAMETER STRANDS
W_{DL} = 10 PSF + 48.75 PSF + 25 PSF = 83.15 PSF
W_{LL} = 100 PSF
$W_{TL} = 1.2W_{DL} + 1.6W_{LL} = 1.2(83.75\text{ PSF}) + 1.6(100\text{ PSF}) = 261\text{ PSF}$

$$\Delta_L = \frac{5w_Ll^4}{384EI} = \frac{5(100\text{PSF})(4')^4(1728)}{384(33(145\text{PCF})^{1.5}\sqrt{3000\text{PSI}})(1519\text{ IN}^4)} = 0.0001" < \frac{l}{360} = \frac{(4')(12)}{360} = 0.133" \text{ ✓OK}$$

$$\Delta_T = \frac{5w_{TL}l^4}{384EI} = \frac{5(261\text{ PSF})(4')^4(1728)}{384(33(145\text{PCF})^{1.5}\sqrt{3000\text{PSI}})(1519\text{ IN}^4)} = 0.0003" < \frac{l}{240} = \frac{(4')(12)}{360} = 0.200" \text{ ✓OK}$$

MOMENT FRAME STEEL
RAM STRUCTURAL SYSTEM - LRFD 3rd EDITION

1/1



Prestressed Concrete
6"x4'-0" Hollow Core Plank

2 Hour Fire Resistance Rating With 2" Topping

PHYSICAL PROPERTIES
Composite Section

A_c = 253 in.^{2}
I_c = 1519 in.^{4}
Y_{bc} = 4.10 in.
Y_{tc} = 1.90 in.
Precast S_{bc} = 370 in.^{3}
Topping S_{tc} = 551 in.^{3}
Precast S_{tc} = 799 in.^{3}
Wt. = 195 PLF
Wt. = 48.75 PSF

DESIGN DATA

1. Precast Strength @ 28 days = 6000 PSI
2. Precast Strength @ release = 3500 PSI.
3. Precast Density = 150 PCF
4. Strand = 1/2"Ø 270K Lo-Relaxation.
5. Strand Height = 1.75 in.
6. Ultimate moment capacity (when fully developed)...
   4-1/2"Ø, 270K = 67.5 k-ft
   7-1/2"Ø, 270K = 104.2 k-ft
7. Maximum bottom tensile stress is $7.5\sqrt{f'c}$ = 580 PSI
8. All superimposed load is treated as live load in the strength analysis of flexure and shear.
9. Flexural strength capacity is based on stress/strain strand relationships.
10. Deflection limits were not considered when determining allowable loads in this table.
11. Topping Strength @ 28 days = 3000 PSI. Topping Weight = 25 PSF.
12. These tables are based upon the topping having a uniform 2" thickness over the entire span. A lesser thickness might occur if camber is not taken into account during design, thus reducing the load capacity.
13. Load values to the left of the solid line are controlled by ultimate shear strength.
14. Load values to the right are controlled by ultimate flexural strength or fire endurance limits.
15. Load values may be different for IBC 2000 & ACI 318-99. Load tables are available upon request.
16. Camber is inherent in all prestressed hollow core slabs and is a function of the amount of eccentric prestressing force needed to carry the superimposed design loads along with a number of other variables. Because prediction of camber is based on empirical formulas it is at best an estimate, with the actual camber usually higher than calculated values.

SAFE SUPERIMPOSED SERVICE LOADS		IBC 2003 & ACI 318-02 (1.2 D + 1.6 L)																		
Strand Pattern		SPAN (FEET)																		
		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
4 - 1/2"ø	LOAD (PSF)	227	187	360	306	268	229	194	165	141	120	102	86	73	61	50				
7 - 1/2"ø	LOAD (PSF)	367	305	495	455	418	387	340	312	275	243	215	189	167	147	130	114	97	83	70

NITTERHOUSE
CONCRETE PRODUCTS

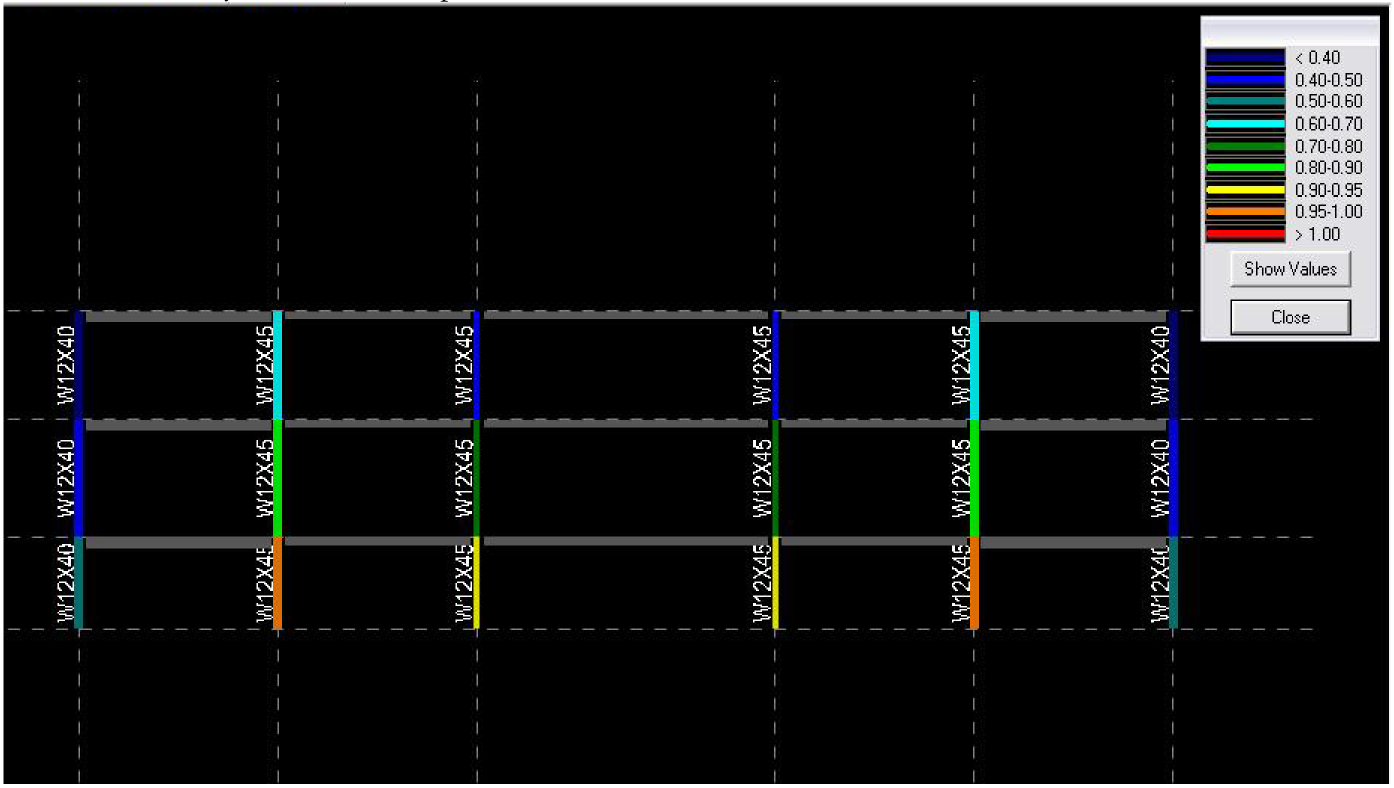
2655 Molly Pitcher Hwy. South, Box N
Chambersburg, PA 17201-0813
717-267-4505 Fax 717-267-4518

This table is for simple spans and uniform loads. Design data for any of these span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, flange or stem openings and narrow widths. The allowable loads shown in this table reflect a 2 Hour & 0 Minute fire resistance rating.

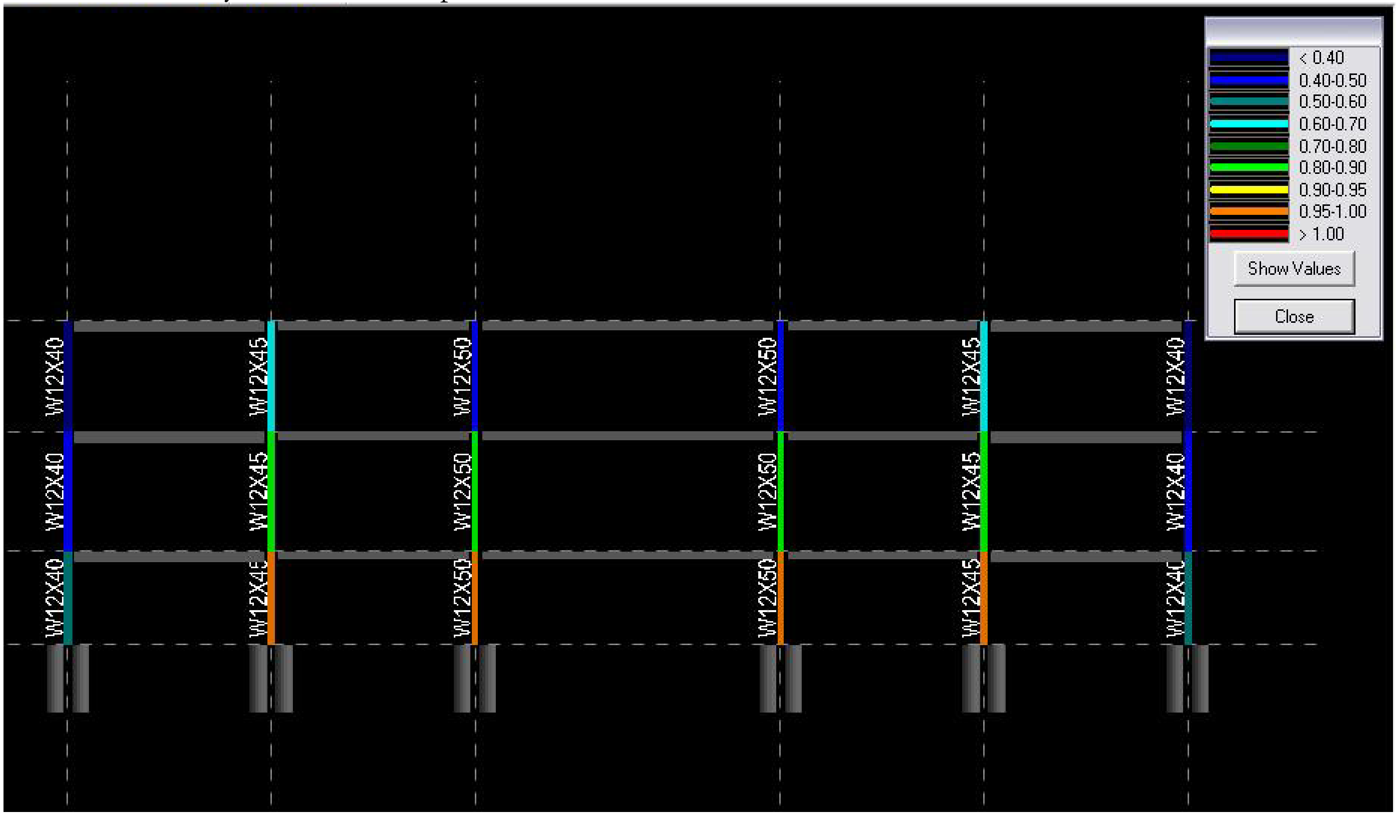
05/14/07

6F2.0T

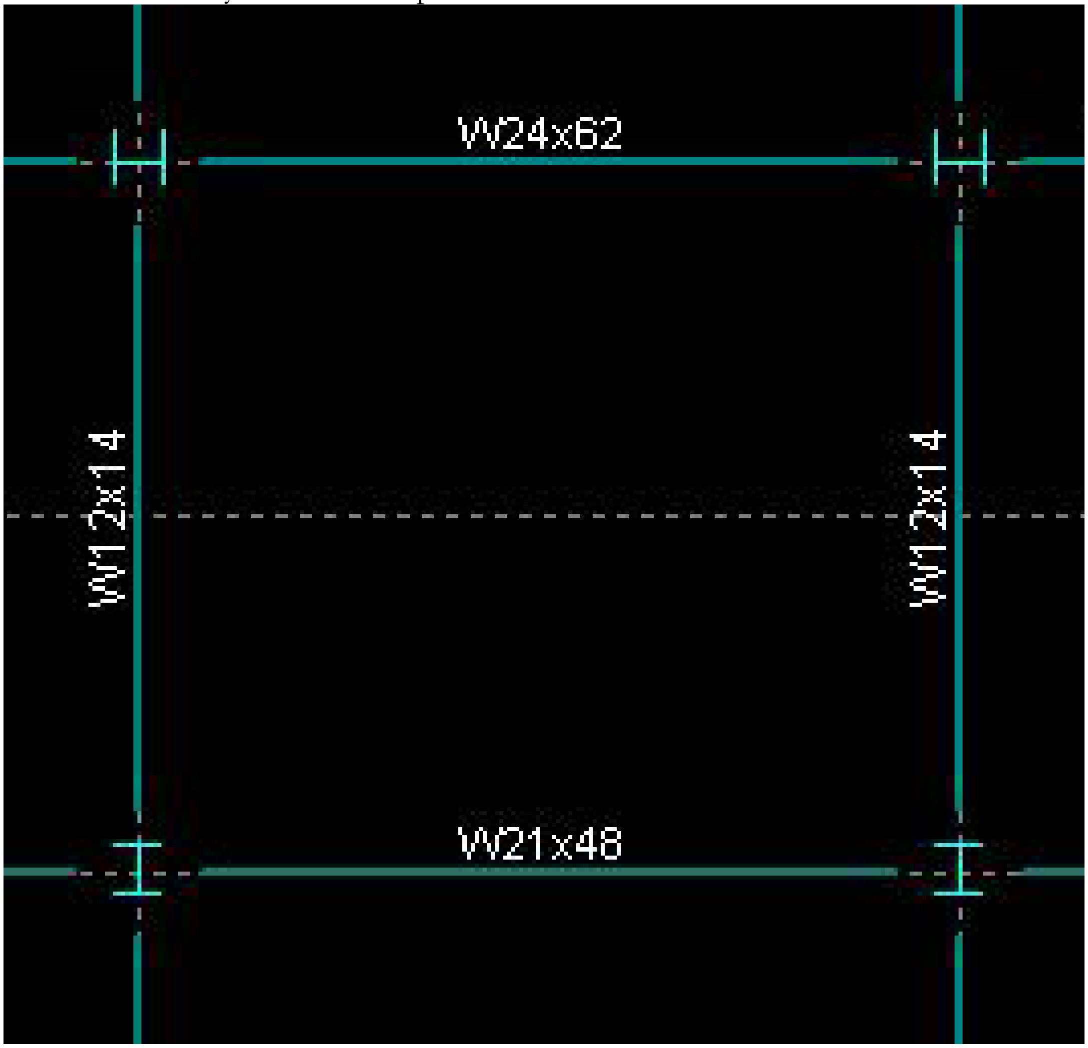
RAM Structural System Line 4 Output



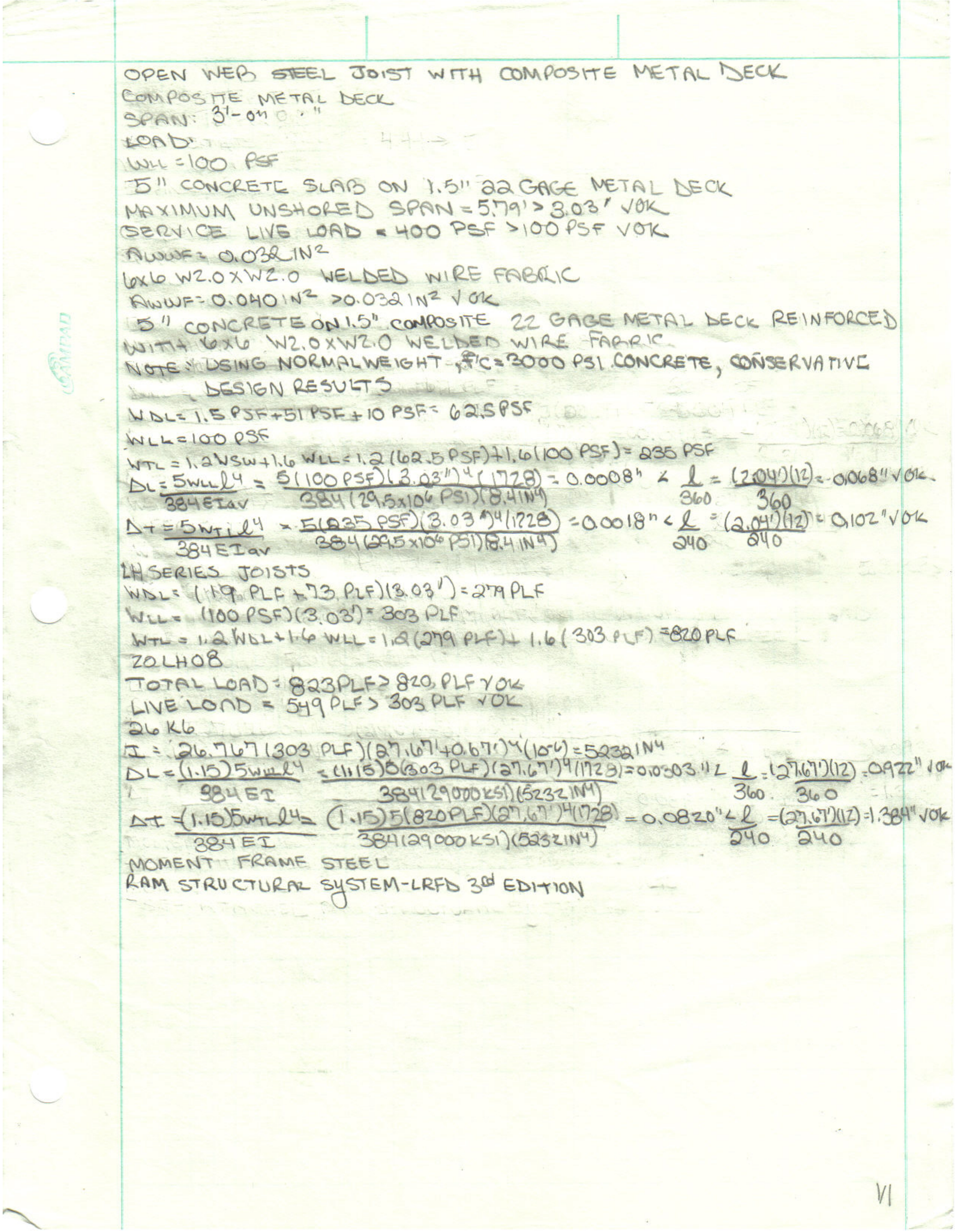
RAM Structural System Line 5 Output



RAM Structural System Plan Output



Open Web Steel Joist with Composite Metal Deck Floor System



OPEN WEB STEEL JOIST WITH COMPOSITE METAL DECK

COMPOSITE METAL DECK

SPAN: 3'-0"

LOAD:

W_{LL} = 100 PSF

5" CONCRETE SLAB ON 1.5" 22 GAGE METAL DECK

MAXIMUM UNSHORED SPAN = 5.79' > 3.03' ✓OK

SERVICE LIVE LOAD = 400 PSF > 100 PSF ✓OK

A_{WWF} = 0.032 IN^2

6x6 W2.0xW2.0 WELDED WIRE FABRIC

A_{WWF} = 0.040 IN^2 > 0.032 IN^2 ✓OK

5" CONCRETE ON 1.5" COMPOSITE 22 GAGE METAL DECK REINFORCED WITH 6x6 W2.0xW2.0 WELDED WIRE FABRIC

NOTE: USING NORMALWEIGHT f'_c = 3000 PSI CONCRETE, CONSERVATIVE DESIGN RESULTS

W_{DL} = 1.5 PSF + 51 PSF + 10 PSF = 62.5 PSF

W_{LL} = 100 PSF

$W_{TL} = 1.2W_{SW} + 1.6W_{LL} = 1.2(62.5\text{ PSF}) + 1.6(100\text{ PSF}) = 235\text{ PSF}$

$$\Delta_L = \frac{5w_{LL}l^4}{384EI_{av}} = \frac{5(100\text{ PSF})(3.03')^4(1728)}{384(29.5\times10^6\text{ PSI})(8.41\text{N}^4)} = 0.0008" < \frac{l}{360} = \frac{(2.04')(12)}{360} = 0.068"\ \checkmark\text{OK}$$

$$\Delta_T = \frac{5w_{TL}l^4}{384EI_{av}} = \frac{5(235\text{ PSF})(3.03')^4(1728)}{384(29.5\times10^6\text{ PSI})(8.4\text{ IN}^4)} = 0.0018" < \frac{l}{240} = \frac{(2.04')(12)}{240} = 0.102"\ \checkmark\text{OK}$$

LH SERIES JOISTS

W_{DL} = (19 PLF + 73 PLF)(3.03') = 279 PLF

W_{LL} = (100 PSF)(3.03') = 303 PLF

$W_{TL} = 1.2W_{DL} + 1.6W_{LL} = 1.2(279\text{ PLF}) + 1.6(303\text{ PLF}) = 820\text{ PLF}$

20LH08

TOTAL LOAD = 823 PLF > 820 PLF ✓OK

LIVE LOAD = 549 PLF > 303 PLF ✓OK

26K6

$I = 26.767(303\text{ PLF})(27.67' + 0.67')^4(10^{-6}) = 5232\text{ IN}^4$

$$\Delta_L = \frac{(1.15)5w_{LL}l^4}{384EI} = \frac{(1.15)5(303\text{ PLF})(27.67')^4(1728)}{384(29000\text{ KSI})(5232\text{ IN}^4)} = 0.0303" < \frac{l}{360} = \frac{(27.67')(12)}{360} = 0.922"\ \checkmark\text{OK}$$

$$\Delta_T = \frac{(1.15)5w_{TL}l^4}{384EI} = \frac{(1.15)5(820\text{ PLF})(27.67')^4(1728)}{384(29000\text{ KSI})(5232\text{ IN}^4)} = 0.0820" < \frac{l}{240} = \frac{(27.67')(12)}{240} = 1.384"\ \checkmark\text{OK}$$

MOMENT FRAME STEEL

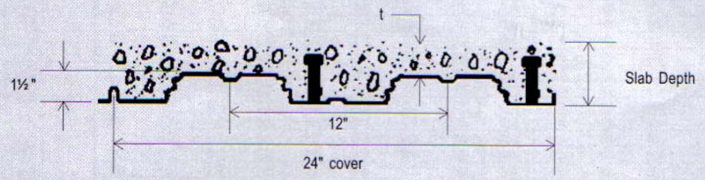
RAM STRUCTURAL SYSTEM-LRFD 3rd EDITION

VI

USD United Steel Deck, Inc.

LRFD

1.5" LOK-FLOOR



The **Deck Section Properties** are per foot of width. The **I** value is for positive bending (in.^{4}); **t** is the gage thickness in inches; **w** is the weight in pounds per square foot; $\mathbf{S_p}$ and $\mathbf{S_n}$ are the section moduli for positive and negative bending (in.^{3}); $\mathbf{R_b}$ and $\phi\mathbf{V_n}$. are the interior reaction and the shear in pounds (per foot of width); studs is the number of studs required per foot in order to obtain the full resisting moment, $\phi\mathbf{M_{nf}}$.

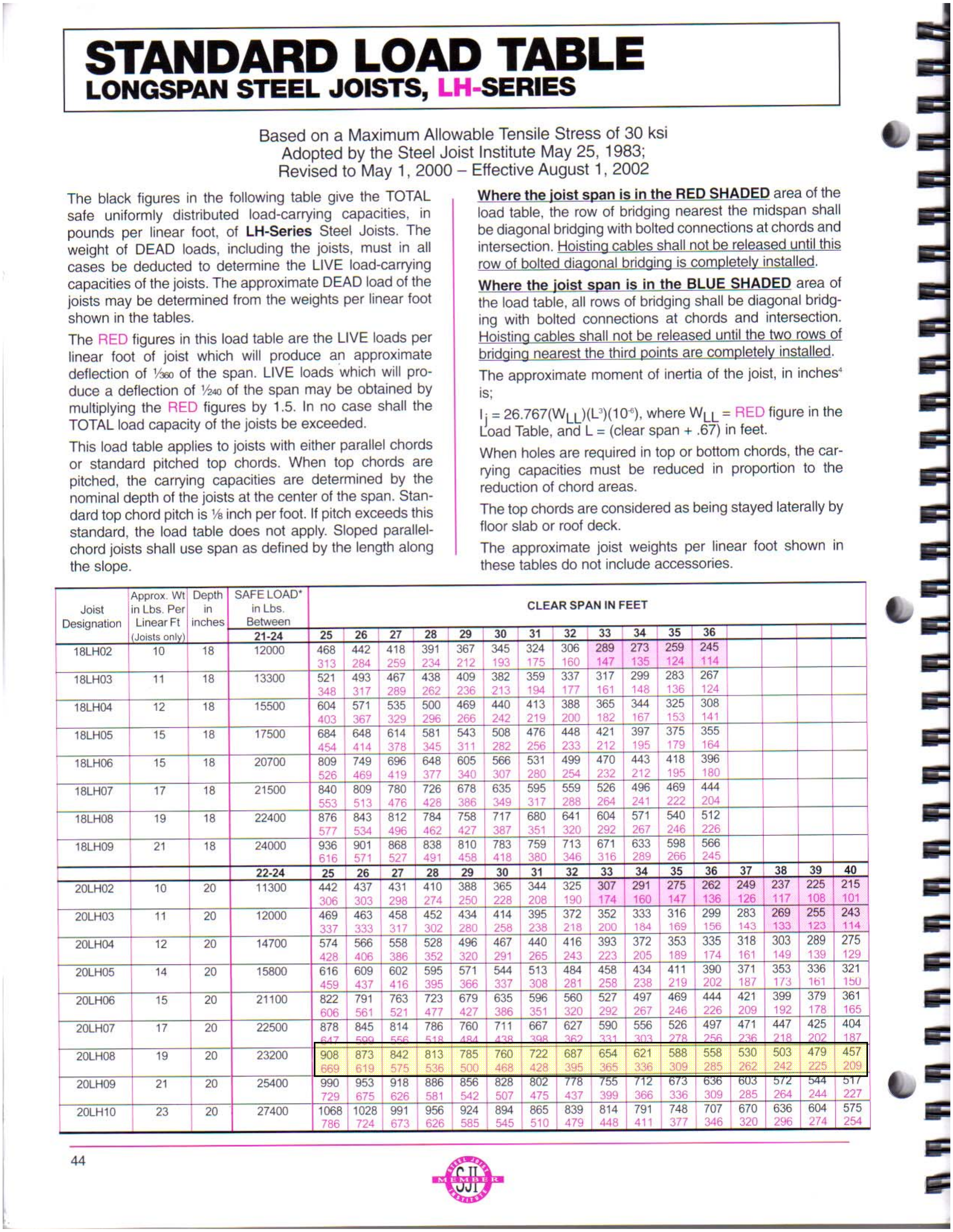
The **Composite Properties** are a list of values for the composite slab. The **slab depth** is the distance from the bottom of the steel deck to the top of the slab in inches as shown on the sketch. U.L. ratings generally refer to the cover over the top of the deck so it is important to be aware of the difference in names. $\phi\mathbf{M_{nf}}$ is the factored resisting moment provided by the composite slab when the "full" number of studs as shown in the upper table are in place; inch kips (per foot of width). $\mathbf{A_c}$ is the area of concrete available to resist shear, in.^{2} per foot of width. **Vol.** is the volume of concrete in ft.^{3} per ft.^{2} needed to make up the slab; no allowance for frame or deck deflection is included. **W** is the concrete weight in pounds per ft.^{2}. $\mathbf{S_c}$ is the section modulus of the "cracked" concrete composite slab; in.^{3} per foot of width. $\mathbf{I_{av}}$ is the average of the "cracked" and "uncracked" moments of inertia of the transformed composite slab; in.^{4} per foot of width. The $\mathbf{I_{av}}$ transformed section analysis is based on steel; therefore, to calculate deflections the appropriate modulus of elasticity to use is 29.5 **x** 10^6 psi. $\phi\mathbf{M_{no}}$ is the factored resisting moment of the composite slab if there are no studs on the beams (the deck is attached to the beams or walls on which it is resting) inch kips (per foot of width). $\phi\mathbf{V_{nt}}$ is the factored vertical shear resistance of the composite system; it is the sum of the shear resistances of the steel deck and the concrete but is not allowed to exceed $\phi\,4(f'_c)^{1/2}A_c$; pounds (per foot of width). The next three columns list the **maximum unshored spans** in feet; these values are obtained by using the construction loading requirements of the SDI; combined bending and shear, deflection, and interior reactions are considered in calculating these values. $\mathbf{A_{wwf}}$ is the minimum area of welded wire fabric recommended for temperature reinforcing in the composite slab; square inches per foot.

DECK PROPERTIES

Gage	t	w	As	I	S_p	S_n	R_b	ϕV_n	studs
22	0.0295	1.5	0.430	0.189	0.206	0.207	692	1560	0.36
20	0.0358	1.8	0.520	0.237	0.267	0.270	972	1890	0.43
19	0.0418	2.1	0.610	0.276	0.327	0.330	1280	2200	0.51
18	0.0474	2.3	0.690	0.313	0.378	0.376	1610	2490	0.57
16	0.0598	3.0	0.870	0.395	0.474	0.474	2370	3130	0.72

COMPOSITE PROPERTIES

	Slab Depth	ϕM_{nf} in.k	A_c in^2	Vol. ft^3/ft^2	W psf	S_c in^3	I_{av} in^4	ϕM_{no} in.k	ϕV_{nt} lbs.	Max. unshored spans, ft. 1span	2span	3span	A_{wwf}
22 gage	4.00	36.40	30.7	0.271	39	0.97	4.4	27.28	4420	4.86	6.49	6.57	0.023
	4.50	42.43	36.0	0.313	45	1.16	6.2	32.47	4910	4.62	6.20	6.27	0.027
	4.75	45.45	38.8	0.333	48	1.25	7.3	35.12	5170	4.52	6.07	6.14	0.029
	5.00	48.46	41.7	0.354	51	1.35	8.4	37.79	5440	4.42	5.95	6.02	0.032
	5.50	54.50	47.0	0.396	57	1.54	11.1	43.20	5940	4.25	5.72	5.79	0.036
	5.75	57.51	49.4	0.417	60	1.64	12.7	45.94	6160	4.17	5.62	5.69	0.038
	6.00	60.53	51.8	0.438	63	1.74	14.3	48.68	6380	4.12	5.53	5.59	0.041
	6.50	66.56	56.5	0.479	69	1.93	18.1	54.22	6820	4.03	5.35	5.41	0.045
	6.75	69.57	58.9	0.500	73	2.03	20.2	57.00	7040	3.98	5.27	5.33	0.047
	7.00	72.59	61.3	0.521	76	2.13	22.4	59.79	7260	3.94	5.19	5.25	0.050
20 gage	4.00	43.31	30.7	0.271	39	1.16	4.8	32.48	4750	5.74	7.68	7.79	0.023
	4.50	50.61	36.0	0.313	45	1.38	6.7	38.69	5240	5.45	7.30	7.42	0.027
	4.75	54.25	38.8	0.333	48	1.49	7.8	41.86	5500	5.32	7.13	7.25	0.029
	5.00	57.90	41.7	0.354	51	1.61	9.0	45.06	5770	5.20	6.97	7.10	0.032
	5.50	65.19	47.0	0.396	57	1.84	11.8	51.55	6270	4.99	6.68	6.82	0.036
	5.75	68.84	49.4	0.417	60	1.95	13.5	54.83	6490	4.90	6.54	6.70	0.038
	6.00	72.49	51.8	0.438	63	2.07	15.2	58.13	6710	4.84	6.42	6.58	0.041
	6.50	79.78	56.5	0.479	69	2.31	19.2	64.78	7150	4.72	6.18	6.36	0.045
	6.75	83.43	58.9	0.500	73	2.43	21.4	68.12	7370	4.67	6.08	6.26	0.047
	7.00	87.07	61.3	0.521	76	2.55	23.7	71.48	7590	4.62	5.97	6.16	0.050
19 gage	4.00	49.98	30.7	0.271	39	1.34	5.1	37.46	5060	6.51	8.49	8.77	0.023
	4.50	58.54	36.0	0.313	45	1.59	7.1	44.68	5550	6.17	8.07	8.33	0.027
	4.75	62.81	38.8	0.333	48	1.72	8.2	48.37	5810	6.03	7.88	8.14	0.029
	5.00	67.09	41.7	0.354	51	1.86	9.5	52.10	6080	5.89	7.70	7.96	0.032
	5.50	75.65	47.0	0.396	57	2.13	12.5	59.67	6580	5.64	7.38	7.63	0.036
	5.75	79.92	49.4	0.417	60	2.26	14.2	63.49	6800	5.54	7.24	7.47	0.038
	6.00	84.20	51.8	0.438	63	2.40	16.1	67.34	7020	5.46	7.10	7.33	0.041
	6.50	92.76	56.5	0.479	69	2.68	20.2	75.10	7460	5.33	6.84	7.07	0.045
	6.75	97.03	58.9	0.500	73	2.82	22.5	79.00	7680	5.27	6.72	6.94	0.047
	7.00	101.31	61.3	0.521	76	2.96	25.0	82.92	7900	5.21	6.61	6.83	0.050
18 gage	4.00	55.70	30.7	0.271	39	1.49	5.3	41.82	5350	7.11	9.05	9.36	0.023
	4.50	65.38	36.0	0.313	45	1.78	7.4	49.93	5840	6.74	8.61	8.90	0.027
	4.75	70.22	38.8	0.333	48	1.93	8.6	54.07	6100	6.58	8.41	8.69	0.029
	5.00	75.06	41.7	0.354	51	2.08	10.0	58.27	6370	6.42	8.22	8.50	0.032
	5.50	84.73	47.0	0.396	57	2.38	13.1	66.77	6870	6.15	7.88	8.15	0.036
	5.75	89.57	49.4	0.417	60	2.53	14.9	71.08	7090	6.03	7.73	7.98	0.038
	6.00	94.41	51.8	0.438	63	2.69	16.8	75.41	7310	5.95	7.58	7.83	0.041
	6.50	104.09	56.5	0.479	69	3.00	21.1	84.14	7750	5.81	7.31	7.55	0.045
	6.75	108.93	58.9	0.500	73	3.16	23.5	88.54	7970	5.74	7.18	7.42	0.047
	7.00	113.76	61.3	0.521	76	3.31	26.1	92.95	8190	5.67	7.06	7.30	0.050
16 gage	4.00	55.70	30.7	0.271	39	1.83	5.8	41.82	5710	8.14	10.15	10.49	0.023
	4.50	65.38	36.0	0.313	45	2.19	8.1	49.93	6480	7.71	9.66	9.98	0.027
	4.75	70.22	38.8	0.333	48	2.37	9.5	54.07	6740	7.51	9.44	9.75	0.029
	5.00	75.06	41.7	0.354	51	2.56	10.9	58.27	7010	7.34	9.23	9.54	0.032
	5.50	84.73	47.0	0.396	57	2.94	14.3	66.77	7510	7.02	8.85	9.15	0.036
	5.75	89.57	49.4	0.417	60	3.13	16.3	71.08	7730	6.88	8.68	8.97	0.038
	6.00	94.41	51.8	0.438	63	3.32	18.3	75.41	7950	6.79	8.52	8.80	0.041
	6.50	104.09	56.5	0.479	69	3.71	23.0	84.14	8390	6.62	8.21	8.49	0.045
	6.75	108.93	58.9	0.500	73	3.91	25.6	88.54	8610	6.54	8.08	8.34	0.047
	7.00	113.76	61.3	0.521	76	4.10	28.3	92.95	8830	6.46	7.94	8.21	0.050



STANDARD LOAD TABLE
LONGSPAN STEEL JOISTS, LH-SERIES

Based on a Maximum Allowable Tensile Stress of 30 ksi
Adopted by the Steel Joist Institute May 25, 1983;
Revised to May 1, 2000 – Effective August 1, 2002

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of **LH-Series** Steel Joists. The weight of DEAD loads, including the joists, must in all cases be deducted to determine the LIVE load-carrying capacities of the joists. The approximate DEAD load of the joists may be determined from the weights per linear foot shown in the tables.

The RED figures in this load table are the LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be obtained by multiplying the RED figures by 1.5. In no case shall the TOTAL load capacity of the joists be exceeded.

This load table applies to joists with either parallel chords or standard pitched top chords. When top chords are pitched, the carrying capacities are determined by the nominal depth of the joists at the center of the span. Standard top chord pitch is ⅛ inch per foot. If pitch exceeds this standard, the load table does not apply. Sloped parallel-chord joists shall use span as defined by the length along the slope.

Where the joist span is in the RED SHADED area of the load table, the row of bridging nearest the midspan shall be diagonal bridging with bolted connections at chords and intersection. Hoisting cables shall not be released until this row of bolted diagonal bridging is completely installed.

Where the joist span is in the BLUE SHADED area of the load table, all rows of bridging shall be diagonal bridging with bolted connections at chords and intersection. Hoisting cables shall not be released until the two rows of bridging nearest the third points are completely installed.

The approximate moment of inertia of the joist, in inches^4 is;

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$, where W_{LL} = RED figure in the Load Table, and L = (clear span + .67) in feet.

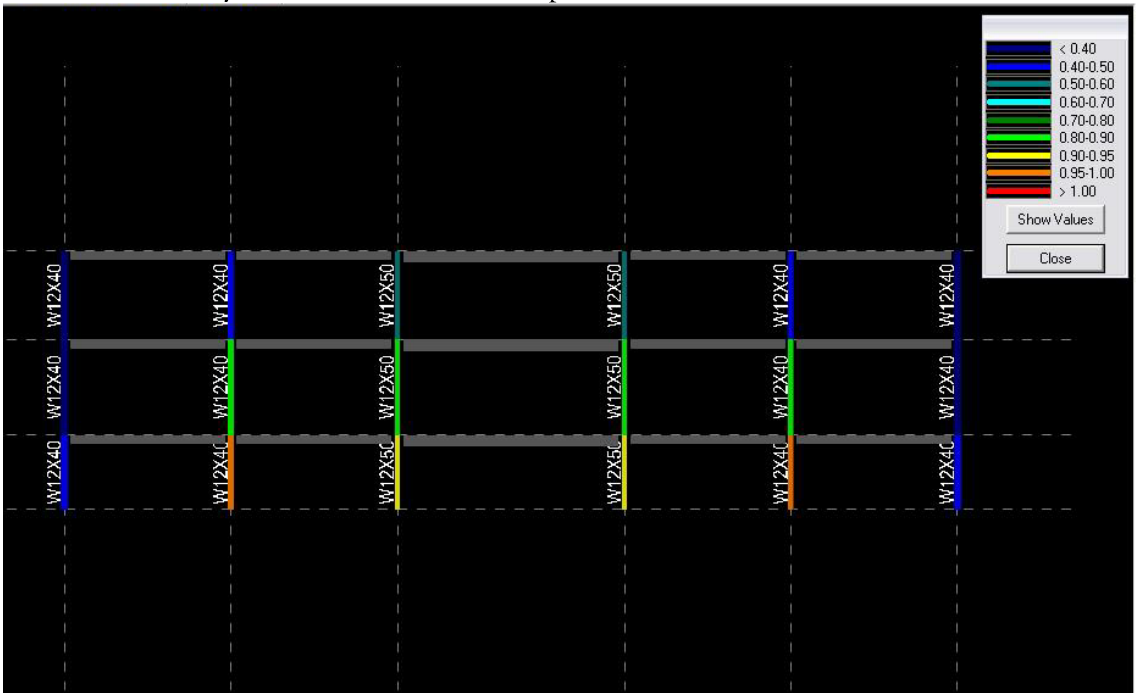
When holes are required in top or bottom chords, the carrying capacities must be reduced in proportion to the reduction of chord areas.

The top chords are considered as being stayed laterally by floor slab or roof deck.

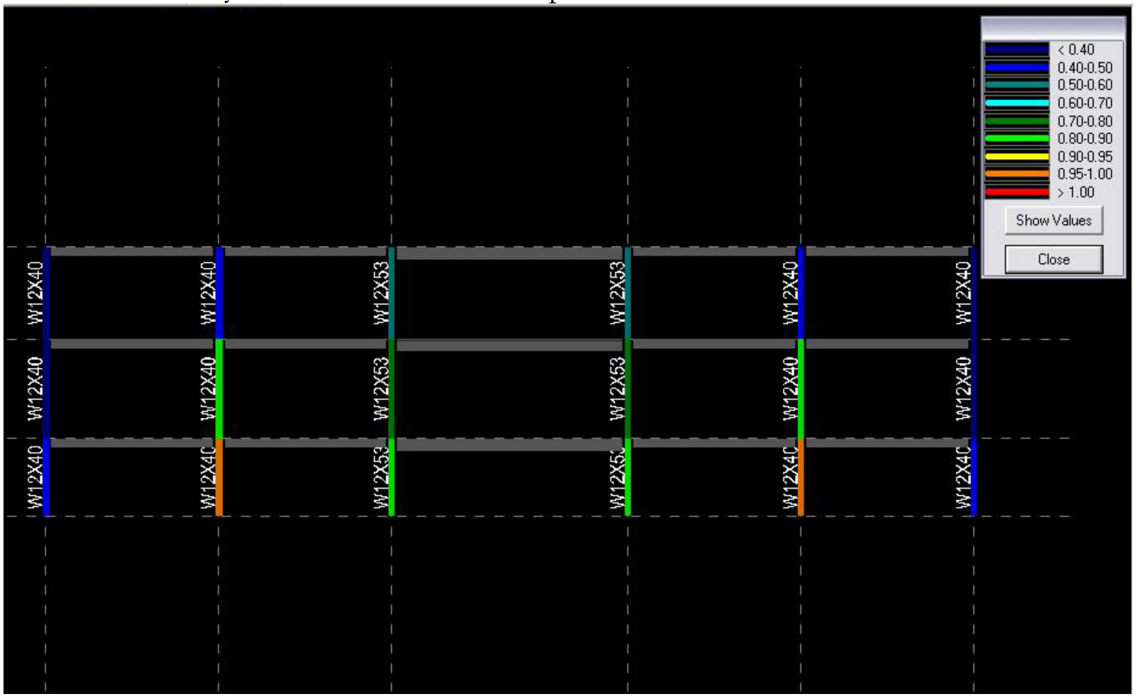
The approximate joist weights per linear foot shown in these tables do not include accessories.

Joist Designation	Approx. Wt in Lbs. Per Linear Ft (Joists only)	Depth in inches	SAFE LOAD* in Lbs. Between	CLEAR SPAN IN FEET															
			21-24	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**				
18LH02	10	18	12000	468 313	442 284	418 259	391 234	367 212	345 193	324 175	306 160	289 147	273 135	259 124	245 114				
18LH03	11	18	13300	521 348	493 317	467 289	438 262	409 236	382 213	359 194	337 177	317 161	299 148	283 136	267 124				
18LH04	12	18	15500	604 403	571 367	535 329	500 296	469 266	440 242	413 219	388 200	365 182	344 167	325 153	308 141				
18LH05	15	18	17500	684 454	648 414	614 378	581 345	543 311	508 282	476 256	448 233	421 212	397 195	375 179	355 164				
18LH06	15	18	20700	809 526	749 469	696 419	648 377	605 340	566 307	531 280	499 254	470 232	443 212	418 195	396 180				
18LH07	17	18	21500	840 553	809 513	780 476	726 428	678 386	635 349	595 317	559 288	526 264	496 241	469 222	444 204				
18LH08	19	18	22400	876 577	843 534	812 496	784 462	758 427	717 387	680 351	641 320	604 292	571 267	540 246	512 226				
18LH09	21	18	24000	936 616	901 571	868 527	838 491	810 458	783 418	759 380	713 346	671 316	633 289	598 266	566 245				
			22-24	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
20LH02	10	20	11300	442 306	437 303	431 298	410 274	388 250	365 228	344 208	325 190	307 174	291 160	275 147	262 136	249 126	237 117	225 108	215 101
20LH03	11	20	12000	469 337	463 333	458 317	452 302	434 280	414 258	395 238	372 218	352 200	333 184	316 169	299 156	283 143	269 133	255 123	243 114
20LH04	12	20	14700	574 428	566 406	558 386	528 352	496 320	467 291	440 265	416 243	393 223	372 205	353 189	335 174	318 161	303 149	289 139	275 129
20LH05	14	20	15800	616 459	609 437	602 416	595 395	571 366	544 337	513 308	484 281	458 258	434 238	411 219	390 202	371 187	353 173	336 161	321 150
20LH06	15	20	21100	822 606	791 561	763 521	723 477	679 427	635 386	596 351	560 320	527 292	497 267	469 246	444 226	421 209	399 192	379 178	361 165
20LH07	17	20	22500	878 647	845 599	814 556	786 518	760 484	711 438	667 398	627 362	590 331	556 303	526 278	497 256	471 236	447 218	425 202	404 187
20LH08	19	20	23200	908 669	873 619	842 575	813 536	785 500	760 468	722 428	687 395	654 365	621 336	588 309	558 285	530 262	503 242	479 225	457 209
20LH09	21	20	25400	990 729	953 675	918 626	886 581	856 542	828 507	802 475	778 437	755 399	712 366	673 336	636 309	603 285	572 264	544 244	517 227
20LH10	23	20	27400	1068 786	1028 724	991 673	956 626	924 585	894 545	865 510	839 479	814 448	791 411	748 377	707 346	670 320	636 296	604 274	575 254

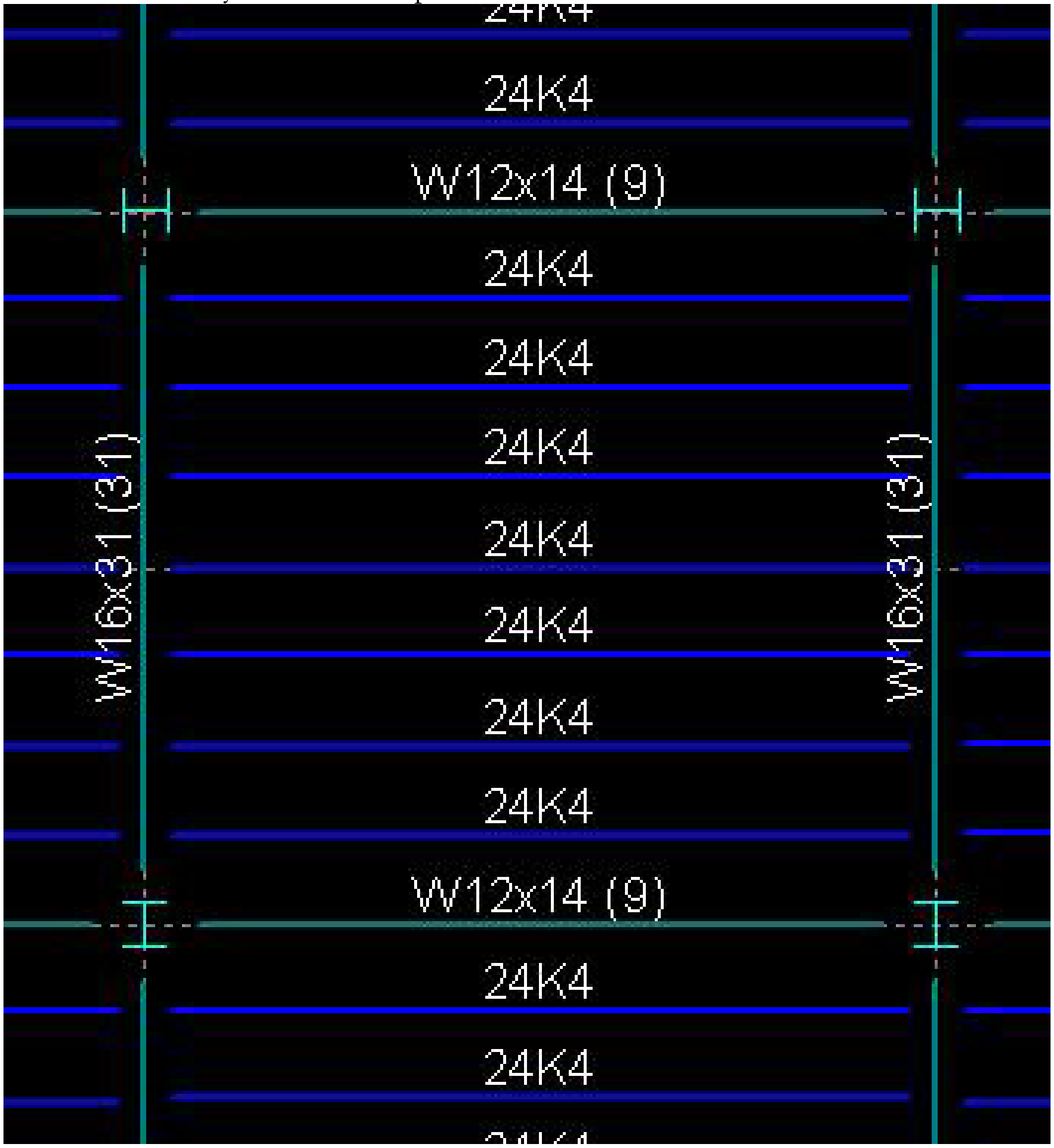
RAM Structural System Column Line 4 Output



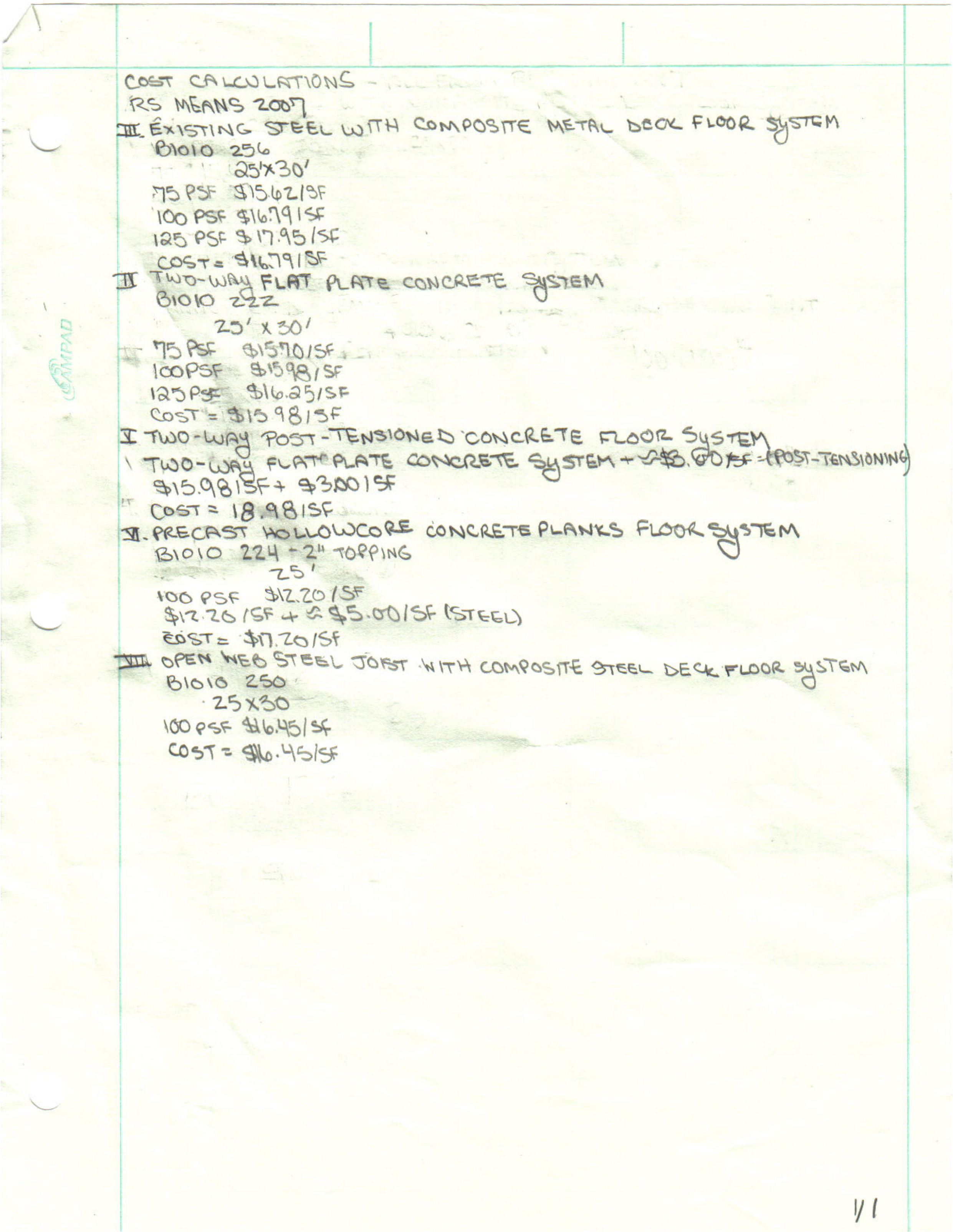
RAM Structural System Column Line 5 Output



RAM Structural System Plan Output



Cost Calculations



COST CALCULATIONS -
RS MEANS 2007
III. EXISTING STEEL WITH COMPOSITE METAL DECK FLOOR SYSTEM
B1010 256
25'×30'
75 PSF $15.62/SF
100 PSF $16.79/SF
125 PSF $17.95/SF
COST = $16.79/SF
II TWO-WAY FLAT PLATE CONCRETE SYSTEM
B1010 222
25' × 30'
75 PSF $15.70/SF
100PSF $15.98/SF
125PSF $16.25/SF
COST = $15.98/SF
I TWO-WAY POST-TENSIONED CONCRETE FLOOR SYSTEM
TWO-WAY FLAT PLATE CONCRETE SYSTEM + ≈ $3.00/SF = (POST-TENSIONING)
$15.98/SF + $3.00/SF
COST = 18.98/SF
VI. PRECAST HOLLOWCORE CONCRETE PLANKS FLOOR SYSTEM
B1010 224 + 2" TOPPING
25'
100 PSF $12.20/SF
$12.20/SF + ≈ $5.00/SF (STEEL)
COST = $17.20/SF
VIII OPEN WEB STEEL JOIST WITH COMPOSITE STEEL DECK FLOOR SYSTEM
B1010 250
25×30
100 PSF $16.45/SF
COST = $16.45/SF

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