Dulles Town Center
Building One

Dulles, Virginia

Technical Report II

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Executive Summary

Within this second technical report you will find a study of alternate floor framing systems for Dulles Town Center Building One. Four different floor systems were designed, analyzed and then compared using certain criteria. Some factors used for comparison were total depth, cost, fire rating, constructability, and effect on building. Building One currently utilizes a post-tension beam and non-post-tension one-way slab system because it was originally designed as a 'spec' building. The post-tension beams are able to span large distances providing large open areas for office space. The beams are heavily loaded, though, which make the beams very wide and moderately deep. This gave reason to investigate other floor framing possibilities. The following are the alternative systems that were analyzed in this report:

1. Composite Metal Deck Floor System on Steel Beams
2. Flat Slab System with Drop Panels
3. Precast Hollow-Core Plank System

After reviewing these systems, the post-tension beam and one-way slab (existing) system and the composite metal deck system appear to be the most adequate framing options. They are both able to handle the long spans and loads the building requires, while keeping the total floor depth reasonable. They each have their own, additional advantages, which will be discussed later in this report. Changing the building from concrete to steel could have significant effects on the architecture and cost of the building. The lateral system will most likely remain moment frames, but with the lighter system the overturning moment will become a factor that will affect the foundation. These issues will be addressed in technical report three.

Introduction

The Dulles Town Center Building One project consists of seven stories of office space above grade and one story below grade that includes rentable space, storage, mechanical rooms, a loading area, a trash room, building service offices, and a workout space. It is located in Dulles, Virginia; five minutes north of Dulles International Airport and 25 miles outside of Washington, D.C. The building's architectural use of precast concrete and glass curtain-wall have helped set the tone for the modernist themes conveyed along the Route 28 corridor. At night, this building is one of the most recognizable buildings along Route 28 with its linear neon focal points.

The building is approximately 202,000 square feet and reaches a height of 118 feet above grade. The building has an open floor plan and an average floor-to-floor height of 12'-6" making it ideal for office space. A typical bay is 20 feet by 40 feet, and consists of a post-tension concrete beam and non-post-tension one-way slab system.

The post-tension concrete beams allow for long spans and an open floor area, making it flexible for any tenant. The large bays, however, place large loads on the beams and in effect, post-tensioning is needed. They leave little room for a lateral system, as well.

This report will analyze and compare three alternative floor systems for Dulles Town Center Building One. Each system's effectiveness will be evaluated using criteria regarding safety, construction, serviceability, and cost. The purpose of this analysis is to become more knowledgeable of the alternative framing options, as well as the existing, and decide which are practical for a more detailed study. Please recognize that all calculations and designs are preliminary and will be adjusted if deemed necessary to progress further in investigation.

Existing Structural System Overview

Floor Systems

The typical floor is a post-tensioned beam and non-post-tensioned one-way slab system. The 7″ thick slab is of normal weight with continuous edge drops that are 3′ wide and 5 ½″ deep along the east face to help support the precast concrete and ribbon window façade. The typical bay, as seen in Figure 1, is 20′ x 40′ with a typical beam length of 40′. Slab reinforcement consists of #4 top bars spaced at 6″ on center and #4 bottom bars at 12″ on center. Reinforced concrete beams are located at stairwells and elevator shafts. This system will be used as a standard for comparison for the possible alternatives.

Typical Floor – Typical Frame

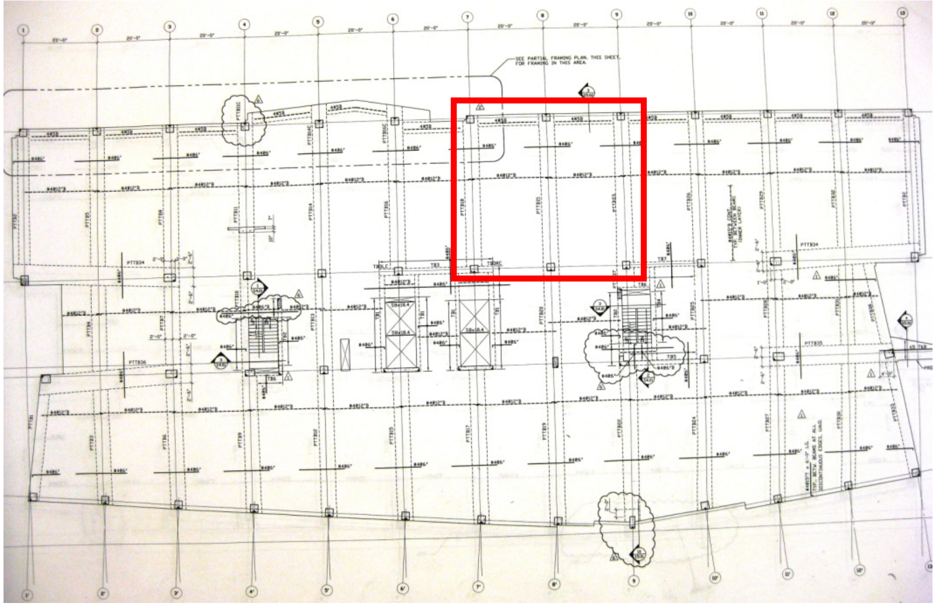


Figure 1

Foundation

The foundation system consists of a slab on grade with strap beams and caissons. The slab is 5″ thick and reinforced with 6x6 – W2.0xW2.0 welded wire fabric. It sits on a 6 mil. polyethylene vapor barrier over 6″ of washed, crushed stone. Strap beams ranging from 24″x 36″ to 48″x 48″ rest on a 2′-0″ thick foundation wall to help support the slab at grade changes. The cast-in-place caissons are capped with reinforced concrete and have shaft diameters that range from 30″ to 75″.

Lateral System

The lateral resistance system is comprised predominantly of concrete moment frames with typical columns being 24″ x 24″. In addition, there is an eccentrically braced steel frame, or K-Brace, located on the roof within the architectural fin. This consists mostly of galvanized steel HSS members connected by fillet welds. The K-Brace is fillet welded to a 12″ x 1′-0″ x ½″ steel plate tied into the concrete roof with (4) ¾″ dia. x 12″ galvanized lightgage studs.

Typical Floor - Concrete Moment Frame

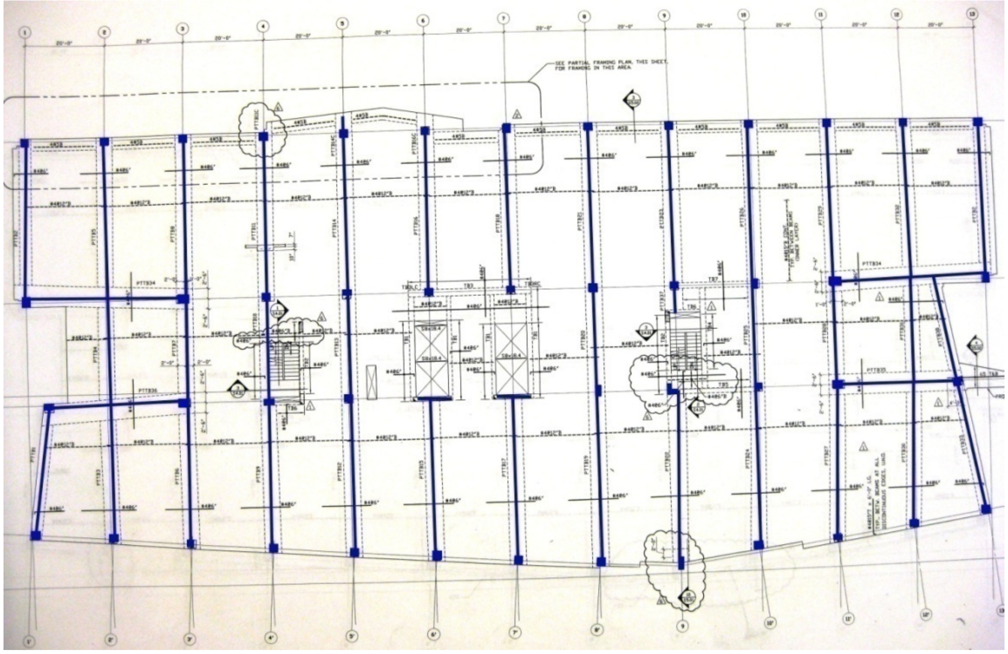


Figure 2

Codes and References

These are the codes and references used to assist in the preliminary design and evaluation of the existing and alternative floor systems.

- *Codes*

  Building Code Requirements for Structural Concrete (ACI 318-08),
  American Concrete Institute (ACI)
  International Building Code 2006
  Minimum Design Loads for Buildings and Other Structures (ASCE 7-05),
  American Society of Civil Engineers (ASCE)
  Steel Construction Manual, 13th Edition,
  American Institute of Steel Construction (AISC)

- *References*

  CRSI Design Handbook 2002,
  Concrete Reinforcing Steel Institute
  Design of Concrete Structures, 13th Edition,
  Nilson, Darwin, and Dolan
  PCI Design Handbook, 6th Edition,
  Precast/Prestressed Concrete Institute (PCI)
  RS Means – Assemblies Cost Data 2009,
  RS Means Company
  RS Means – Building Construction Cost Data 2009,
  RS Means Company
  Steel Roof and Floor Deck,
  Vulcraft Company

Pro-Con Analysis of Existing Structural System

The post-tension beam and one-way slab system is more than ample to carry out the structural requirements of Dulles Town Center Building One. Its ability to handle the required loads while keeping its lengthy spans makes it ideal for any 'spec' building. With this system open floor plans and typical 12'-6" floor-to-floor heights were achieved. The large post-tension beams help minimize deflection on each floor while, along with the thick slab, also provide the stiffness and damping needed to keep vibrations to a minimum.

Typical Post-Tension Beam

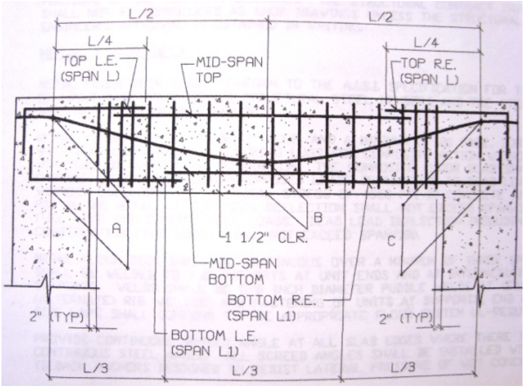


Figure 3

The first floor framing is made up of a flat slab system and cuts the typical bay size down to 20' x 20', easily distributing the building's loads over a caisson system which is adequate to muscle the weight. The construction of this system, although not the most efficient, is relatively cheap (approximately $21.00 per ft^2) and fairly easy to construct, being as Building One is located in Northern Virginia where concrete is the preferred building material.

The beams, while keeping the total floor depth to 24", have tendons that drape to within 1 ¾" of the bottom of the beam, providing the floor system with only a 1-hour fire rating. This requires that additional fire protection be added to reach the 2-hour minimum. Construction time is also slow due to forming and curing times.

Overall, the post-tension beam and one-way slab system is an excellent option for this project, not only because it achieves the open office plan which is attractive to prospective tenants, but also meets the brutal structural requirements set forth by this seven-story architectural masterpiece.

Alternate Floor System Discussion

System 1: Composite Metal Deck with Steel Beams

Framing Layout for Composite Steel System

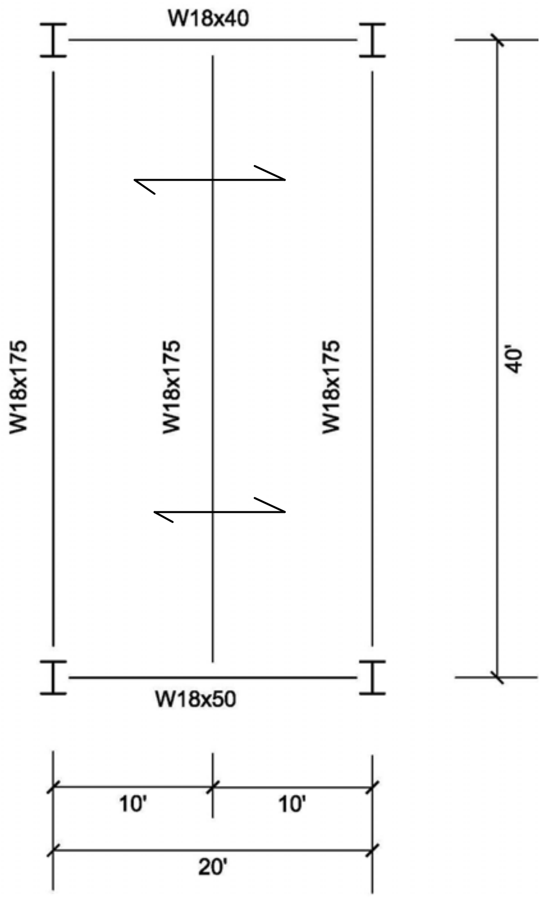


Figure 4

Loads:

Dead load (superimposed) = 15 psf
Live load = 78 psf
(Live load reduction was used)

Material Properties:

f'_c = 4000 psi
f_y = 40 ksi (metal deck)
= 50 ksi (beams/girders)
= 60 ksi (shear studs)

3”, 19 gage metal deck
Normal weight concrete (145 pcf)
Total Slab Depth = 5”
Total weight = 44 psf
¾” diameter shear studs
Refer to Appendix A for design

Evaluation:

This system allows concrete and steel to work together in order to achieve long spans while still being able to carry large loads. To preserve a smaller floor depth, which ended up being 25”, only W18 shapes were considered in the design process. This unfortunately resulted in very large steel members, which in the long run will be costly. The approximate cost is already one of the higher ones at $23.57 per ft^2 according to RS Means. While a 2-hour fire rating was reached with the 5” thickness of the slab and metal deck, these large steel members will be required to get spray-on fireproofing. With minimal concrete used in this system, vibration control due to lack of stiffness for dampening and lateral load resistance due to weight change, they could become problems down the road.

In order to keep the 20′ x 40′ bays, not only were large steel members required to span the 40′, but additional beams were needed to shorten the span at which the deck was to run. The floor depth was maintained to within an inch of the current one by only using W18 shapes. This will allow the floor-to-ceiling height to remain at approximately 9′-6″.

Construction time will also quicken due to the erection of steel being much faster than that of concrete. This is owed to the absence of curing set backs. In addition, the floor slab is not required to be cut as much and therefore minimizes time between pours.

Typical Composite Steel Floor System

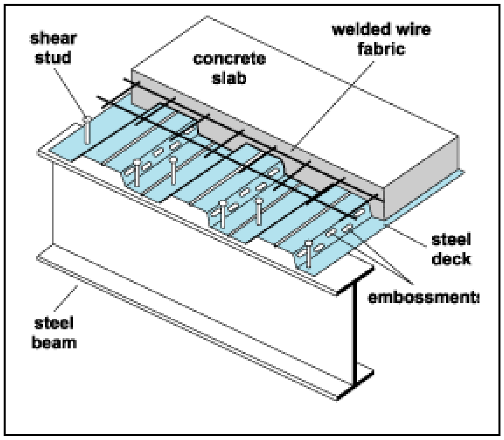


Figure 5

In conclusion, because this system can maintain the bay area and total floor depth while also having the proper fire rating and cutting down on construction time, it is a viable alternative to Dulles Town Center Building One's structural system.

System 2: Two-Way Flat Slab System with Drop Panels

Loads:

Dead load (superimposed) = 15 psf
Live load = 100 psf

Material Properties:

f'_c = 4000 psi
f_y = 60 ksi (reinforcement)

Normal weight concrete (145 pcf)
Slab depth = 7 in.

Refer to Appendix A for design

Framing Layout for Flat Slab System

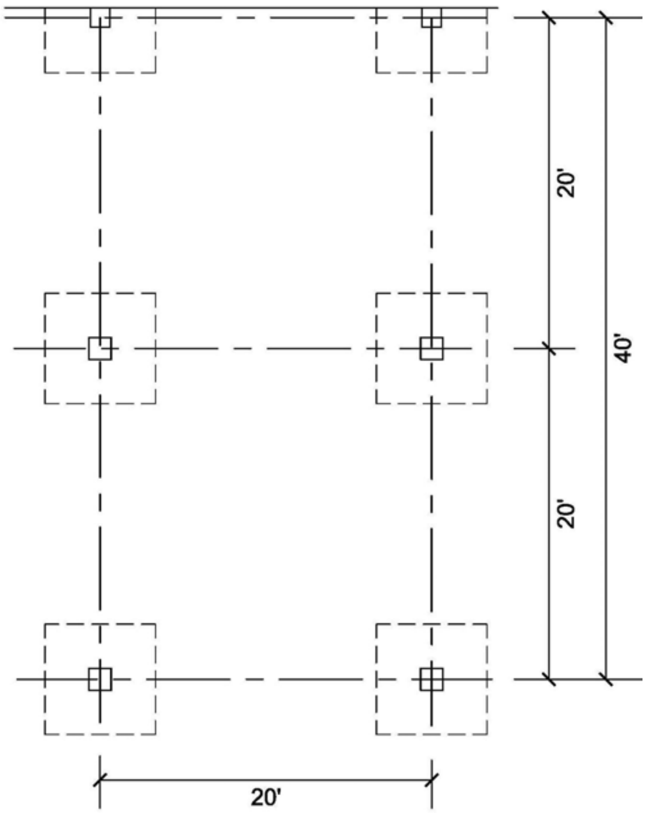


Figure 6

Evaluation:

Two-way flat slab floor systems are very useful in that they are durable and absorb vibrations very well, while also achieving the necessary fire ratings. Two-way flat slab systemsare optimal when dealing with square bays. Dulles Town Center Building One's typical bay is 20′x40′ making it easy to turn it into two 20′x20′ bays (40′x40′ was unavailable). Deciding on a maximum slab depth of 7″ and using the 1.4D + 1.7L combination, the CRSI Handbook was used to design the drop panels, reinforcement, and column size. The first floor framing is already a flat slab system, so the foundation plan would not change except for pile sizes. Since there are no beams in this system, the total depth, including the drop panels, is 11″; much lower than that of any other system.

Due to the addition of columns at the current floor system's mid-span, the open office floor plan has diminished, taking away a huge selling point for the owner. The total floor depth has been reduced dramatically, though, improving the floor-to-ceiling height.

Typical Flat Slab System

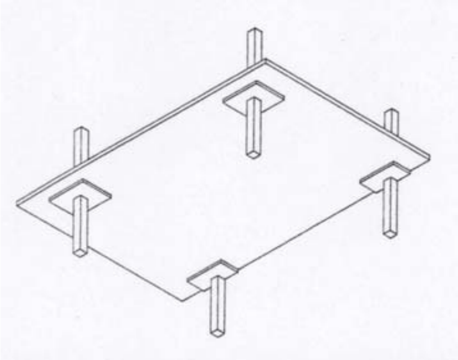


Figure 7

Construction will be much like that of the post-tension beam one-way slab system; lots of forming and curing time. It won't however, have beams or post-tensioning to worry about. Each level will be almost exactly the same, therefore formwork could be used multiple times.

Overall, this system is really neither better nor worse than the current one. It introduces new columns to the floor plan, obliterating the open office space, but at the same time significantly lowers the total floor depth. The fire rating and vibration control are good and the foundation is minimally effected. This system seems enticing with its 11″ total floor depth, but is unusable due to its interruption to the open floor plan, a major selling point to future tenants.

System 3: Precast Hollow-Core Plank System

Framing Layout for Plank System

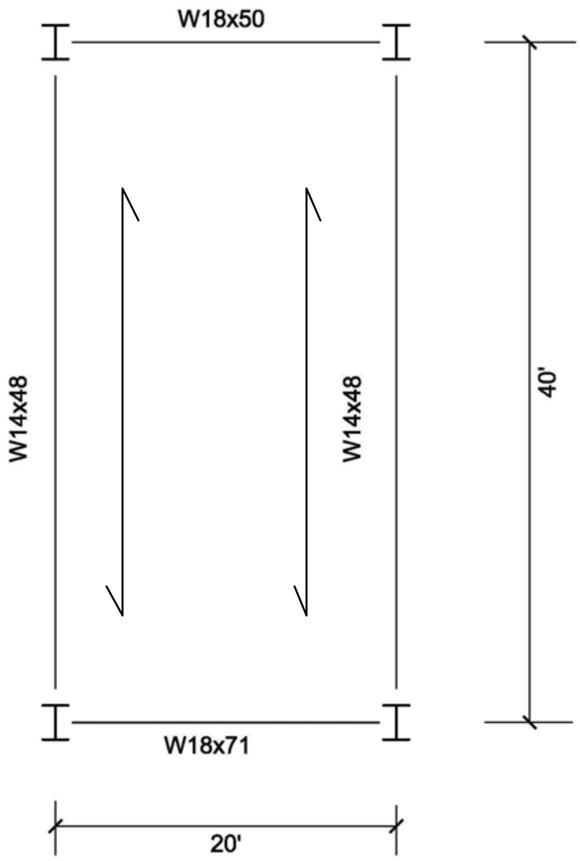


Figure 8

Loads:

Dead load (superimposed) = 15 psf
Live load = 100 psf

Material Properties:

f'_c = 9000 psi
f'_{ci} = 3500 psi
f'_{ct} = 3000 psi
f_{pu} = 270 ksi (prestressed tendons)

Total weight = 117 psf
Slab depth = 12 in.
Structural topping = 2 in.

Refer to Appendix A for design

Evaluation:

The last system analyzed was the precast hollow-core plank system. This system is beneficial in that it can cover large spans while also keeping the total floor depth reasonable. It is able to achieve this with the use of pretensioning, which make intermittent beams unnecessary. W14x48 beams were placed every 20′, though, because it's assumed they will be needed to help support lateral loads. This will be investigated further in technical report three if deemed necessary. The planks come 4′ wide making it a perfect fit in either direction of the 20′x40′ typical bay. Both directions were analyzed using tables found on the Molin Concrete Products Company website, but having the planks run the 40′ seemed more reasonable due to the massive steel shapes that were necessary if ran the other way.

With this system the large spans were maintained and the column grid was untouched. A W14x48 was assumed as a necessary evil to help with lateral loads in the east-west direction and unfortunately increased the typical total floor depth to 28″. The floor depth is 32.5″ in just a few places where loads from the planks are picked up.

Typical Hollow-Core Plank

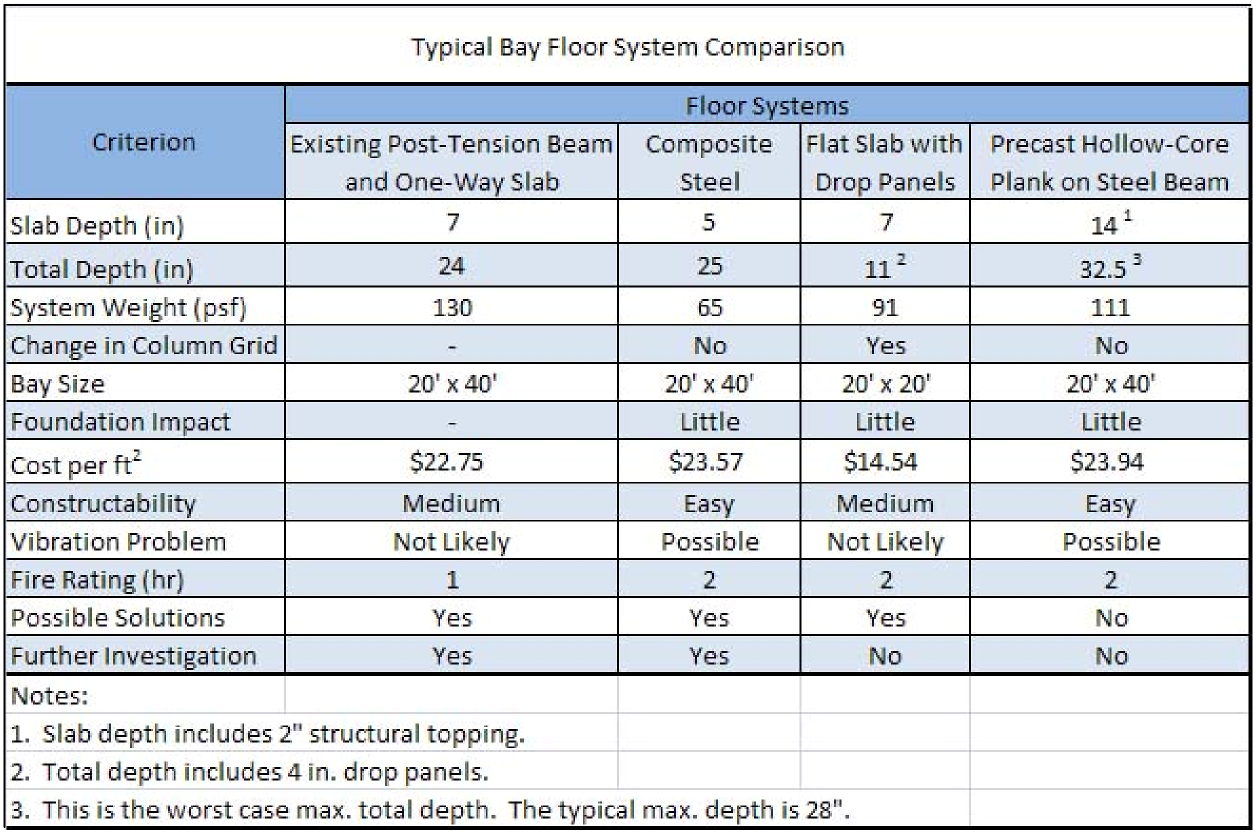
Figure 9

The planks are precast concrete which means they are cast off-site and brought to the site when needed. Although this requires a large lead time, when they arrive they only need to be set into place. This speeds up erection time and helps cut back on labor requirements in the field. The planks also have voids that span their entire length, reducing weight and allowing for MEP equipment to run through it. The reduction in weight helps save in material costs. This system is still the most expensive out of the four systems costing approximately \$23.94 per ft^2.

As a result, the hollow plank system seems like it would work, but steel erection would have to stop at every level in order to install the precast planks, leaving the contractor with a lot of lag time. The typical total floor depth is good, but at those certain areas it increases to a whopping 32.5" deep, reducing the floor-to-ceiling height enormously. The weight is close to that of the current system, which would have left the foundation almost as-is, but the cost and large lead time make it unattractive to investigate further.

System Comparison

The results found within this alternative floor system study and preliminary design for Dulles Town Center Building One are shown below in the form of a comparison chart.



Typical Bay Floor System Comparison

Criterion	Floor Systems			
	Existing Post-Tension Beam and One-Way Slab	Composite Steel	Flat Slab with Drop Panels	Precast Hollow-Core Plank on Steel Beam
Slab Depth (in)	7	5	7	14[1]
Total Depth (in)	24	25	11[2]	32.5[3]
System Weight (psf)	130	65	91	111
Change in Column Grid	-	No	Yes	No
Bay Size	20' x 40'	20' x 40'	20' x 20'	20' x 40'
Foundation Impact	-	Little	Little	Little
Cost per ft^2	$22.75	$23.57	$14.54	$23.94
Constructability	Medium	Easy	Medium	Easy
Vibration Problem	Not Likely	Possible	Not Likely	Possible
Fire Rating (hr)	1	2	2	2
Possible Solutions	Yes	Yes	Yes	No
Further Investigation	Yes	Yes	No	No

Notes:

1. Slab depth includes 2" structural topping.
2. Total depth includes 4 in. drop panels.
3. This is the worst case max. total depth. The typical max. depth is 28".

Conclusions

In closing, the existing system achieves large, open spaces while maintaining a reasonable total floor depth. Although additional fire protection is needed due to the 1-hour fire rating, the concrete is able to dampen most vibrations found in an office building. Constructability is medium, but the approximate cost of \$22.75 per ft^2 makes it a candidate for further investigation.

The composite metal deck system, although not as good with handling vibration, is able to keep the span of the original system, maintain a reasonable total floor depth, and decrease the building weight. The approximate cost of \$23.57 per ft^2 is not much higher when compared to the others, but when considering changing an all-concrete building to a composite system there could be some hidden, non-monetary costs, especially when considering Northern, VA, is predominantly concrete structures. This floor system will be investigated further.

Due to the column grid and need for large spans, the flat slab system is not the best choice as an alternative floor system. The system's approximate cost of \$14.54, its outstanding vibration control and 2-hour fire rating, along with its unbeatable total floor depth of 11" should put it as a major front-runner for further investigation. Unfortunately, without being able to maintain the large open area for office space the flat slab system with drop panels is just not feasible. If it comes down to it, this system could be re-evaluated and possibly investigated further.

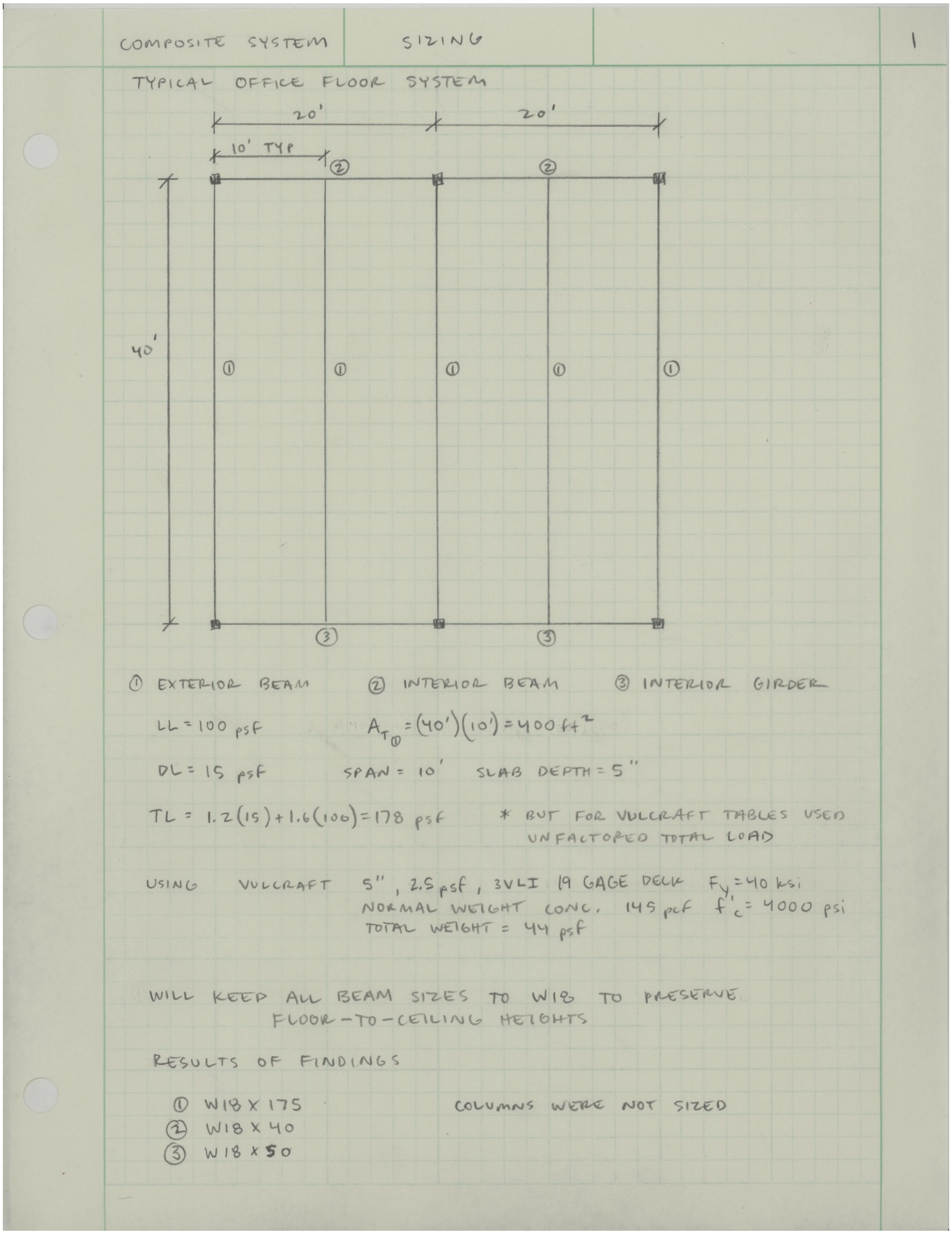
In regards to the precast hollow-core plank system; although vibration control was ample and only some additional fire protection on the steel members would have been needed, total construction time could increase. This system did, however, keep the 20'x40' unobstructed bays, but with large, long-spanning concrete planks, beams became too big and increased the total floor thickness. Floor-to-ceiling height is too important for office buildings, which unfortunately means this floor system will not be investigated further.

This leaves the post-tension beam and one-way slab system (existing) as one of the ideal floor systems for Dulles Town Center Building One. The alternative, a composite metal deck system. And even though changing an all-concrete building to an almost-all-steel building is drastic, they are both considered for further investigation.

Appendix A

Calculations

Composite System Calculations



COMPOSITE SYSTEM SIZING 1

TYPICAL OFFICE FLOOR SYSTEM

① EXTERIOR BEAM ② INTERIOR BEAM ③ INTERIOR GIRDER

LL = 100 psf $A_{T_①} = (40')(10') = 400 ft^2$

DL = 15 psf SPAN = 10' SLAB DEPTH = 5"

TL = 1.2(15) + 1.6(100) = 178 psf

* BUT FOR VULCRAFT TABLES USED UNFACTORED TOTAL LOAD

USING VULCRAFT 5", 2.5 psf, 3VLI 19 GAGE DECK $F_y = 40$ ksi
NORMAL WEIGHT CONC. 145 pcf $f'_c = 4000$ psi
TOTAL WEIGHT = 44 psf

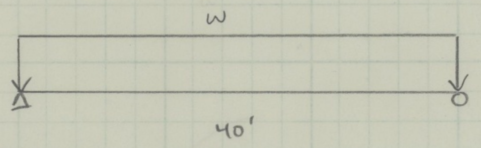
WILL KEEP ALL BEAM SIZES TO W18 TO PRESERVE FLOOR-TO-CEILING HEIGHTS

RESULTS OF FINDINGS

① W18 X 175
② W18 X 40
③ W18 X 50

COLUMNS WERE NOT SIZED

① INTERIOR BEAM (LONG SPAN)



LL REDUCTION (IBC 2006)

$$L = L_0\left(.25 + \frac{15}{\sqrt{K_{LL}A_T}}\right) = 100\,\text{psf}\left(.25 + \frac{15}{\sqrt{2(400\,ft^2)}}\right) = 78\,\text{psf}$$

LL = 78 psf DL = 15 + 44 = 59 psf

TL = 1.2(59) + 1.6(78) = 196 psf

w = (196 psf)(10') = 1.96 k/ft w/ BM WT

$V = \frac{(1.96\,k/ft)(40')}{2} = 39.2\,k$ V = 42.7 k

$M = \frac{(1.96\,k/ft)(40')^2}{8} = 392\,k\text{-}ft$ M = 427 k-ft

$\Delta_{MAX} = \frac{l}{360} = \frac{40'(12)}{360} = 1.33''$

$1.33'' = \frac{5(1.96\,k/ft)(40')^4(1728)}{384(29000)(I_{MIN})}$ $\Delta = 1.23'' < 1.33''$ ∴ ok

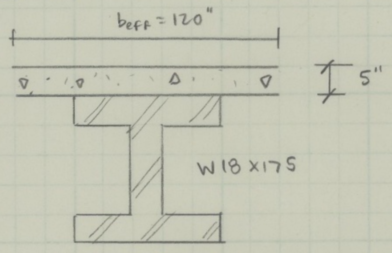
$I_{MIN} = 2927\,in^4$

USING TABLE 3-2 (AISC STEEL MANUAL)

$\phi M_p = 420\,k\text{-}ft$ FOR W18x55 BUT $I = 890\,in^4 < 2927\,in^4$ ∴ NO GOOD

NEED A W18x175 TO SATISFY $l/360$ AND $\phi M_p > M$

① CONT'D



$b_{eff} = \frac{1}{4}(40')(12) = 120''$

OR

$(10'+10')(12).5 = 120''$

* DECKING NOT SHOWN

$A_s = 51.3 \text{ in}^2$ $d = 20 \text{ in}$ $b_f = 11.4 \text{ in}$ $t_f = 1.59 \text{ in}$

$V'_c = .85(4 \text{ ksi})(120')(5'') = 2040 \text{ k}$ ← CONTROLS ∴ PNA IN STEEL

$V'_s = (51.3 \text{ in}^2)(50 \text{ ksi}) = 2565 \text{ k}$

ASSUMING FULL COMPOSITE ACTION, SHEAR CONNECTORS MUST CARRY SMALLEST OF V'_c AND V'_s

$T_f = (50)(11.4)(1.59) = 906.3 \text{ k}$

$T_w = 2565 - 2(906.3) = 752.4 \text{ k}$

THUS $C_c = 2040 > T_f + T_w = 906.3 + 752.4 = 1658.7 \text{ k}$

∴ PNA IS IN FLANGE

$$A_{s-c} = \frac{T_s - C_c}{2F_y} = \frac{2565 - 2040}{2(50)} = 5.25 \text{ in}^2$$

$$x = \frac{A_{s-c}}{b_f} = \frac{5.25}{11.4} = .46''$$

$$M_n = (2565)\left(\frac{20''}{2}\right) + (2040)\left(5''/2\right) - 2(5.25'')(50 \text{ ksi})\left(\frac{.46''}{2}\right) = 30630 \text{ k-in}$$
$$= 2553 \text{ k-ft}$$

$\phi M_n = .9(2553 \text{ k-ft}) = 2297 \text{ k-ft}$

SHEAR STUDS

$V'_q = 2040 \text{ k} = \Sigma Q_n$

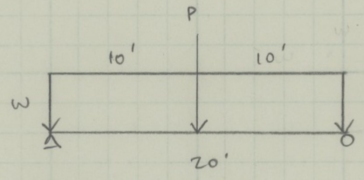
USING 3/4" STUDS ⇒ $Q_n = 26.1 \text{ k/STUD}$

$$\# \text{ STUDS} = \frac{\Sigma Q_n}{Q_n} = \frac{2040}{26.1} = 78.2 \approx 79$$

* PLACE 79 SHEAR STUDS ON EACH SIDE OF THE BEAM BETWEEN THE MAX. MOMENT OF THE BEAM AND ZERO MOMENT

COMPOSITE

② EXTERIOR BEAM



$LL = (100\ psf)(1') = 100\ ^{lb}/ft$

$DL = (15\ ^{lb}/_{ft^2})(1') + \left[\left(\left(^{7.5"}/_{12}\right)(7')(150\ pcf)\right) + \left((8\ ^{lb}/_{ft^2})(6')\right)\right] = 15 + 657 + 48 = 720\ ^{lb}/ft$

FACADE

PRECAST PANELS ↑ ↑ GLASS

$P = 42.7\ k$

$w = 1.2(720) + 1.6(100) = 1.02\ ^{k}/ft$

$V = \frac{42.7k}{2} + \frac{1.02\ ^{k}/ft\ (20')}{2}$

$= 21.4 + 10.2 = 31.6\ k$

WITH BM. WT.

$V = 32\ k$

$M = \frac{(42.7\ k)(20')}{4} + \frac{(1.02\ ^{k}/ft)(20')^2}{8}$

$= 213.5 + 51 = 264.5\ k\text{-}ft$

$M = 266.5\ k\text{-}ft < 294\ k\text{-}ft$

$\therefore$ ok

$\Delta = \frac{l}{360} = \frac{(20')(12)}{360} = .67"$

$\Delta = .31 + .215 = .53" < .67"$

$\therefore$ ok

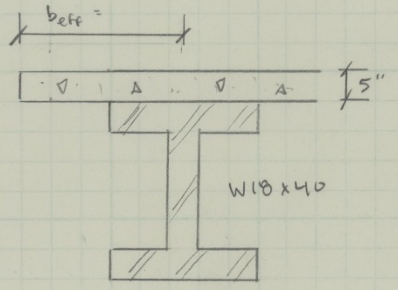
$$.67" = \frac{.00932(42.7)(20)^3(1728)}{29000\ (I_{MIN})} + \frac{5(1.02)(20)^4(1728)}{384(29000)(I_{MIN})}$$

$I_{MIN} = 283.1 + 189 = 472\ in^4$

TABLE 3.2 $\Rightarrow$ $\phi M_p = 294\ k\text{-}ft$ FOR A W18×40

$I = 612\ in^4 > 472 in^4$ $\therefore$ ok

② CONT'D



$b_{eff} = \frac{SPAN}{8} = \frac{20'(12)}{8} = 30''$

OR

DIST. TO EDGE OF SLAB = 3" + 7.5" = 10.5"

↑ $\frac{1}{2}$ FLANGE ↑ FACADE THK.

$A_s = 11.8 in^2$
$d = 17.9''$
$b_f = 6.02''$
$t_f = .525''$ $t_w = .315''$

$V'_c = .85(4)(10.5'')(5'') = 178.5 k$

* DECKING NOT SHOWN

$V'_s = (11.8 in^2)(50 ksi) = 590 k$

ASSUMING FULL COMPOSITE ACTION, SHEAR CONNECTORS MUST CARRY SMALLEST OF V'_c AND V'_s

$T_f = (50)(6.02)(.525) = 158 k$

$T_w = 590 - 2(158) = 274 k$

THUS $C_c = 178.5 k < T_f + T_w = 158 + 274 = 432 k$
$\therefore$ PNA IN WEB

$A_{s-c} = \frac{590 - 178.5}{2(50)} = 4.1 in^2$

$x = \frac{A_{s-c} - b_f t_f}{t_w} + t_f = \frac{4.1 in^2 - (6.02'')(.525'')}{.315''} + .525'' = 3.51''$

$$M_n = (590)\left(\frac{17.9''}{2}\right) + (178.5)\left(\frac{5''}{2}\right) - 2(50 ksi)\left[(6.02)(.525)\left(\frac{.525}{2}\right) + \left((4.1 - (6.02)(.525)\right)\left(\left(\frac{3.51 - .525}{2} + .525\right)\right)\right]$$

$= 5280.5 + 446.3 - 100(.83 + 1.9) = 5453.8 k\text{-}in$
$= 454.5 k\text{-}ft$

$\phi M_n = .9(454.5) = 409 k\text{-}ft$

SHEAR STUDS

$V'_q = 179 k$

USING 3/4" STUDS ⇒ $Q_n = 26.1 k/STUD$

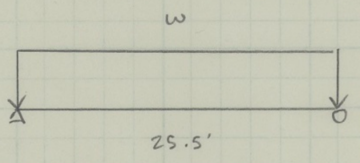
$\# STUDS = \frac{179}{26.1} = 6.85 \approx 7$

* PLACE 7 SHEAR STUDS ON EACH SIDE OF THE BEAM BETWEEN THE MAX. MOMENT OF THE BEAM AND ZERO MOMENT

③ INTERIOR BEAM (SHORT SPAN)

$LL = 100$ psf
$DL = 15 + 44 = 59$ psf
$TL = 1.2(59) + 1.6(100) = 230.8$ psf

SOLVE FOR POINT LOAD COMING FROM PLAN SOUTH



$w = 230.8 \text{ psf} (10') = 2.31 \text{ k/ft}$

w/ BM. WT.

$V = \frac{(2.31 \text{ k/ft})(25.5')}{2} = 29.5 \text{ k}$

$V = 30.2 \text{ k}$

$M = \frac{(2.31)(25.5)^2}{8} = 187.8 \text{ k-ft}$

$M = 193 \text{ k-ft}$

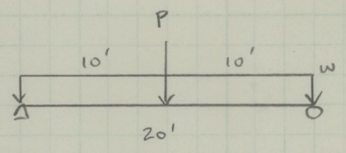
$\Delta = \frac{l}{360} = \frac{25.5(12)}{360} = .85''$

$.85'' = \frac{5(2.31)(25.5)^4(1728)}{384(29000)(I_{MIN})}$

$\Delta = .79'' < .85'' \therefore \text{ok}$

$I_{MIN} = 892 \text{ in}^4$

USING TABLE 13-2 ⇒ $\phi M_p = 203$ k-ft FOR A W16×31
NEED A W18×60 TO SATISFY $l/360$
$I = 984 > 892 \text{ in}^4 \therefore \text{ok}$



$P = 42.7 \text{ k} + 30.2 \text{ k} = 72.9 \text{ k}$

$w = 178 \text{ lb/ft}$ (CONSERVATIVE)

w/ BM WT.

$V = \frac{72.9 \text{ k}}{2} + \frac{(.178)(20')}{2} = 36.5 + 1.78 = 38.3 \text{ k}$

$V = 38.8 \text{ k}$

$M = \frac{(72.9)(20)}{4} + \frac{(.178)(20)^2}{8} = 364.5 + 8.9 = 373.4 \text{ k-ft}$

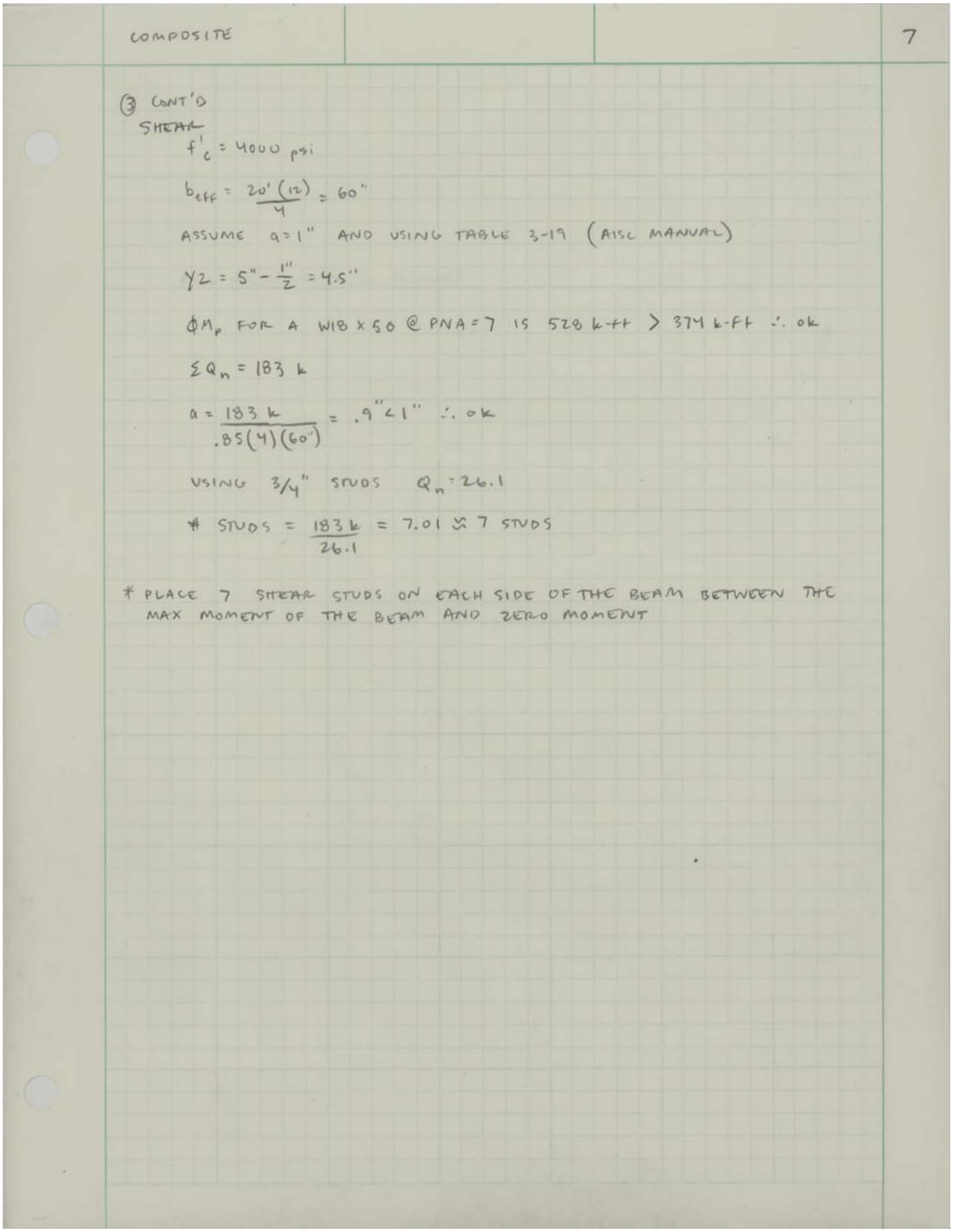
$M = 374 \text{ k-ft}$

$\Delta = .67'' = \frac{.00932(72.9)(20)^3(1728)}{29000(I_{MIN})} + \frac{5(.178)(20)^4(1728)}{384(29000)(I_{MIN})}$

$\Delta =$ OK BY INPECTION

$I_{MIN} = 483.4 + 33 = 517 \text{ in}^4$

TABLE 3-2 ⇒ NEED A W18×50 $\phi M_p = 379 \text{ k-ft} > 374 \text{ k-ft} \therefore \text{ok}$
$I = 800 > 517 \text{ in}^4 \therefore \text{ok}$



COMPOSITE

7

③ CONT'D

SHEAR

$f'_c = 4000$ psi

$b_{eff} = \frac{20'(12)}{4} = 60''$

ASSUME $a = 1''$ AND USING TABLE 3-19 (AISC MANUAL)

$Y2 = 5'' - \frac{1''}{2} = 4.5''$

ϕM_p FOR A W18 × 50 @ PNA = 7 IS 528 k-ft > 374 k-ft ∴ ok

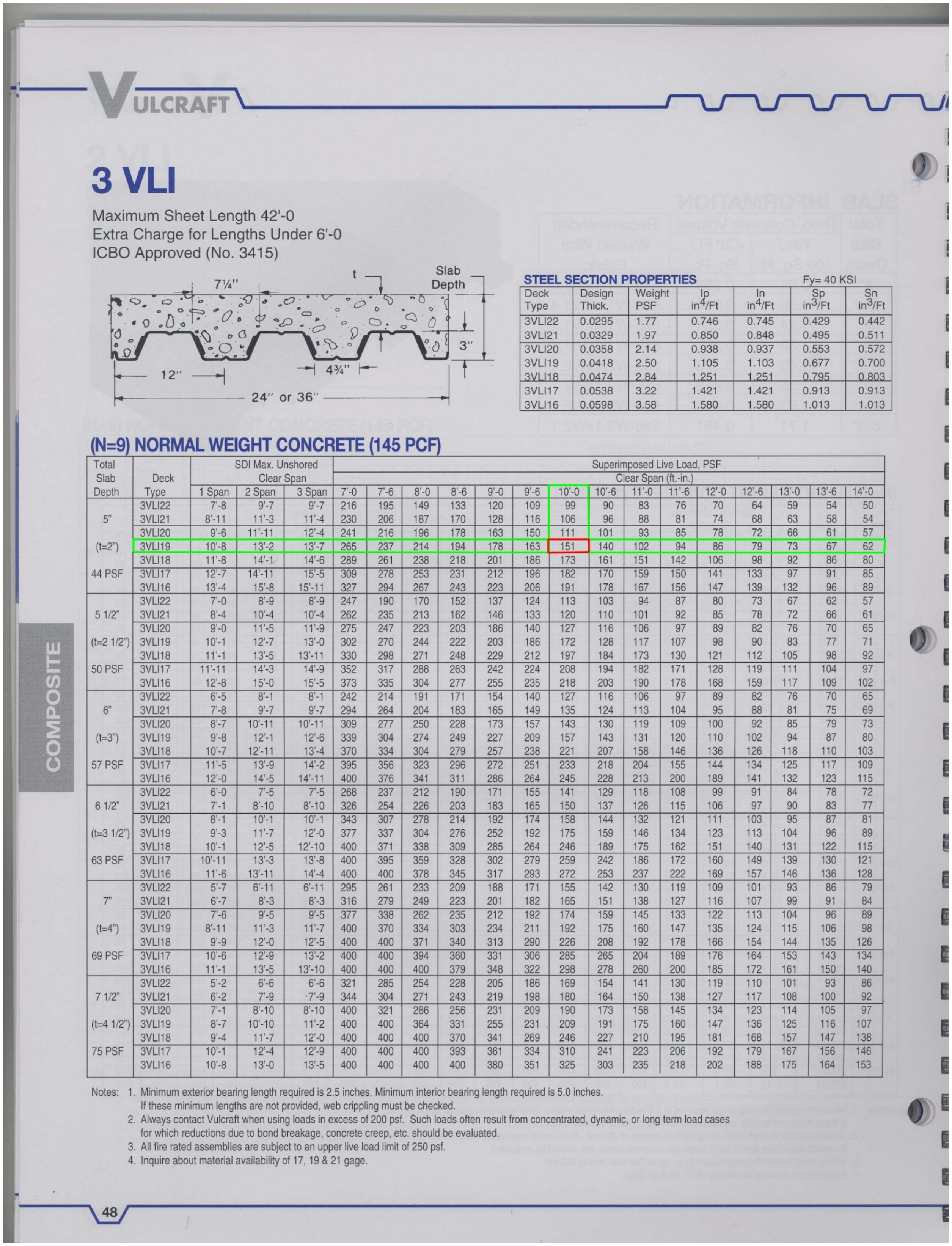
$\Sigma Q_n = 183$ k

$a = \frac{183 \text{ k}}{.85(4)(60'')} = .9'' < 1''$ ∴ ok

USING 3/4" STUDS $Q_n = 26.1$

\# STUDS $= \frac{183 \text{ k}}{26.1} = 7.01 \approx 7$ STUDS

* PLACE 7 SHEAR STUDS ON EACH SIDE OF THE BEAM BETWEEN THE MAX MOMENT OF THE BEAM AND ZERO MOMENT



3 VLI

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0
ICBO Approved (No. 3415)

STEEL SECTION PROPERTIES

Fy= 40 KSI

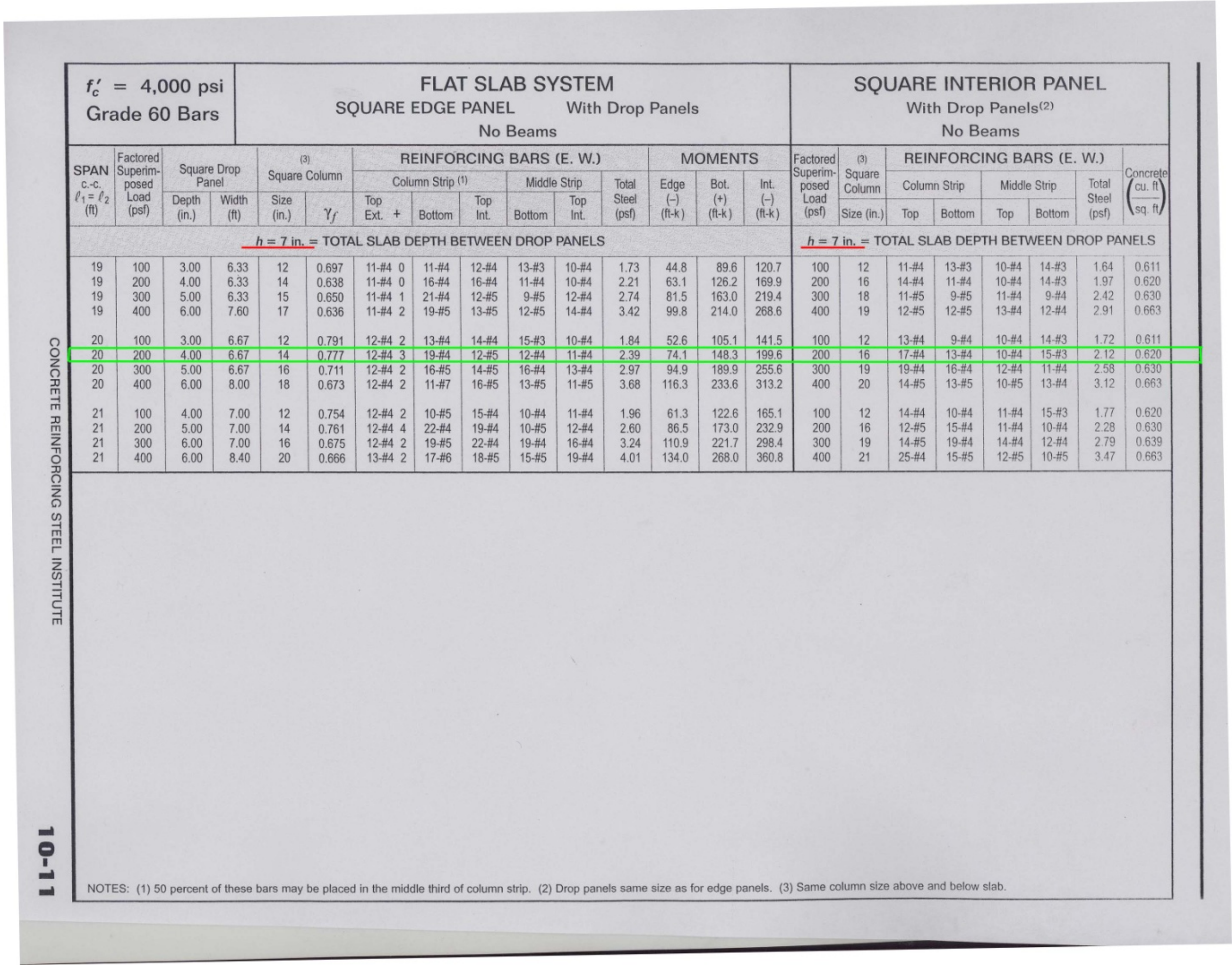
Deck Type	Design Thick.	Weight PSF	Ip in^4/Ft	In in^4/Ft	Sp in^3/Ft	Sn in^3/Ft
3VLI22	0.0295	1.77	0.746	0.745	0.429	0.442
3VLI21	0.0329	1.97	0.850	0.848	0.495	0.511
3VLI20	0.0358	2.14	0.938	0.937	0.553	0.572
3VLI19	0.0418	2.50	1.105	1.103	0.677	0.700
3VLI18	0.0474	2.84	1.251	1.251	0.795	0.803
3VLI17	0.0538	3.22	1.421	1.421	0.913	0.913
3VLI16	0.0598	3.58	1.580	1.580	1.013	1.013

(N=9) NORMAL WEIGHT CONCRETE (145 PCF)

Total Slab Depth	Deck Type	SDI Max. Unshored Clear Span			Superimposed Live Load, PSF														
					Clear Span (ft.-in.)														
		1 Span	2 Span	3 Span	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0	12'-6	13'-0	13'-6	14'-0
	3VLI22	7'-8	9'-7	9'-7	216	195	149	133	120	109	99	90	83	76	70	64	59	54	50
5"	3VLI21	8'-11	11'-3	11'-4	230	206	187	170	128	116	106	96	88	81	74	68	63	58	54
	3VLI20	9'-6	11'-11	12'-4	241	216	196	178	163	150	111	101	93	85	78	72	66	61	57
(t=2")	3VLI19	10'-8	13'-2	13'-7	265	237	214	194	178	163	151	140	102	94	86	79	73	67	62
	3VLI18	11'-8	14'-1	14'-6	289	261	238	218	201	186	173	161	151	142	106	98	92	86	80
44 PSF	3VLI17	12'-7	14'-11	15'-5	309	278	253	231	212	196	182	170	159	150	141	133	97	91	85
	3VLI16	13'-4	15'-8	15'-11	327	294	267	243	223	206	191	178	167	156	147	139	132	96	89
	3VLI22	7'-0	8'-9	8'-9	247	190	170	152	137	124	113	103	94	87	80	73	67	62	57
5 1/2"	3VLI21	8'-4	10'-4	10'-4	262	235	213	162	146	133	120	110	101	92	85	78	72	66	61
	3VLI20	9'-0	11'-5	11'-9	275	247	223	203	186	140	127	116	106	97	89	82	76	70	65
(t=2 1/2")	3VLI19	10'-1	12'-7	13'-0	302	270	244	222	203	186	172	128	117	107	98	90	83	77	71
	3VLI18	11'-1	13'-5	13'-11	330	298	271	248	229	212	197	184	173	130	121	112	105	98	92
50 PSF	3VLI17	11'-11	14'-3	14'-9	352	317	288	263	242	224	208	194	182	171	128	119	111	104	97
	3VLI16	12'-8	15'-0	15'-5	373	335	304	277	255	235	218	203	190	178	168	159	117	109	102
	3VLI22	6'-5	8'-1	8'-1	242	214	191	171	154	140	127	116	106	97	89	82	76	70	65
6"	3VLI21	7'-8	9'-7	9'-7	294	264	204	183	165	149	135	124	113	104	95	88	81	75	69
	3VLI20	8'-7	10'-11	10'-11	309	277	250	228	173	157	143	130	119	109	100	92	85	79	73
(t=3")	3VLI19	9'-8	12'-1	12'-6	339	304	274	249	227	209	157	143	131	120	110	102	94	87	80
	3VLI18	10'-7	12'-11	13'-4	370	334	304	279	257	238	221	207	158	146	136	126	118	110	103
57 PSF	3VLI17	11'-5	13'-9	14'-2	395	356	323	296	272	251	233	218	204	155	144	134	125	117	109
	3VLI16	12'-0	14'-5	14'-11	400	376	341	311	286	264	245	228	213	200	189	141	132	123	115
	3VLI22	6'-0	7'-5	7'-5	268	237	212	190	171	155	141	129	118	108	99	91	84	78	72
6 1/2"	3VLI21	7'-1	8'-10	8'-10	326	254	226	203	183	165	150	137	126	115	106	97	90	83	77
	3VLI20	8'-1	10'-1	10'-1	343	307	278	214	192	174	158	144	132	121	111	103	95	87	81
(t=3 1/2")	3VLI19	9'-3	11'-7	12'-0	377	337	304	276	252	192	175	159	146	134	123	113	104	96	89
	3VLI18	10'-1	12'-5	12'-10	400	371	338	309	285	264	246	189	175	162	151	140	131	122	115
63 PSF	3VLI17	10'-11	13'-3	13'-8	400	395	359	328	302	279	259	242	186	172	160	149	139	130	121
	3VLI16	11'-6	13'-11	14'-4	400	400	378	345	317	293	272	253	237	222	169	157	146	136	128
	3VLI22	5'-7	6'-11	6'-11	295	261	233	209	188	171	155	142	130	119	109	101	93	86	79
7"	3VLI21	6'-7	8'-3	8'-3	316	279	249	223	201	182	165	151	138	127	116	107	99	91	84
	3VLI20	7'-6	9'-5	9'-5	377	338	262	235	212	192	174	159	145	133	122	113	104	96	89
(t=4")	3VLI19	8'-11	11'-3	11'-7	400	370	334	303	234	211	192	175	160	147	135	124	115	106	98
	3VLI18	9'-9	12'-0	12'-5	400	400	371	340	313	290	226	208	192	178	166	154	144	135	126
69 PSF	3VLI17	10'-6	12'-9	13'-2	400	400	394	360	331	306	285	265	204	189	176	164	153	143	134
	3VLI16	11'-1	13'-5	13'-10	400	400	400	379	348	322	298	278	260	200	185	172	161	150	140
	3VLI22	5'-2	6'-6	6'-6	321	285	254	228	205	186	169	154	141	130	119	110	101	93	86
7 1/2"	3VLI21	6'-2	7'-9	7'-9	344	304	271	243	219	198	180	164	150	138	127	117	108	100	92
	3VLI20	7'-1	8'-10	8'-10	400	321	286	256	231	209	190	173	158	145	134	123	114	105	97
(t=4 1/2")	3VLI19	8'-7	10'-10	11'-2	400	400	364	331	255	231	209	191	175	160	147	136	125	116	107
	3VLI18	9'-4	11'-7	12'-0	400	400	400	370	341	269	246	227	210	195	181	168	157	147	138
75 PSF	3VLI17	10'-1	12'-4	12'-9	400	400	400	393	361	334	310	241	223	206	192	179	167	156	146
	3VLI16	10'-8	13'-0	13'-5	400	400	400	400	380	351	325	303	235	218	202	188	175	164	153

Notes:
1. Minimum exterior bearing length required is 2.5 inches. Minimum interior bearing length required is 5.0 inches. If these minimum lengths are not provided, web crippling must be checked.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic, or long term load cases for which reductions due to bond breakage, concrete creep, etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.
4. Inquire about material availability of 17, 19 & 21 gage.

Two-Way Flat Slab with Drop Panels



f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM
SQUARE EDGE PANEL With Drop Panels
No Beams

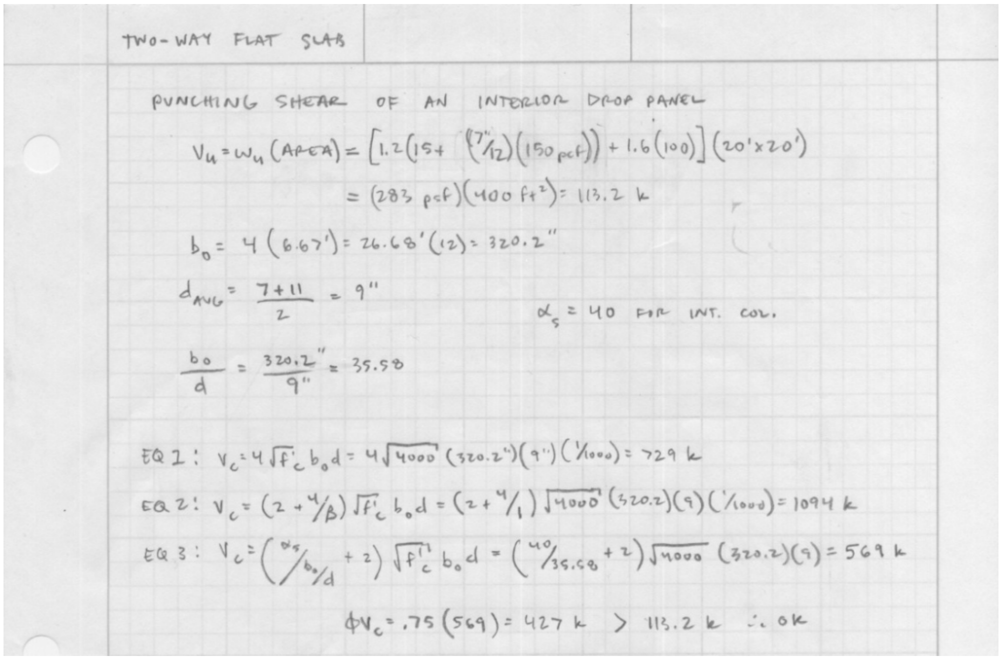
SQUARE INTERIOR PANEL
With Drop Panels(2)
No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superim-posed Load (psf)	Square Drop Panel		(3) Square Column		REINFORCING BARS (E. W.)						MOMENTS			Factored Superim-posed Load (psf)	(3) Square Column	REINFORCING BARS (E. W.)					Concrete $\left(\frac{\text{cu. ft}}{\text{sq. ft}}\right)$
						Column Strip (1)			Middle Strip		Total Steel (psf)	Edge (–) (ft-k)	Bot. (+) (ft-k)	Int. (–) (ft-k)			Column Strip		Middle Strip		Total Steel (psf)	
		Depth (in.)	Width (ft)	Size (in.)	γ_f	Top Ext. +	Bottom	Top Int.	Bottom	Top Int.						Size (in.)	Top	Bottom	Top	Bottom		
						h = 7 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS									h = 7 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS							
19	100	3.00	6.33	12	0.697	11-#4 0	11-#4	12-#4	13-#3	10-#4	1.73	44.8	89.6	120.7	100	12	11-#4	13-#3	10-#4	14-#3	1.64	0.611
19	200	4.00	6.33	14	0.638	11-#4 0	16-#4	16-#4	11-#4	10-#4	2.21	63.1	126.2	169.9	200	16	14-#4	11-#4	10-#4	14-#3	1.97	0.620
19	300	5.00	6.33	15	0.650	11-#4 1	21-#4	12-#5	9-#5	12-#4	2.74	81.5	163.0	219.4	300	18	11-#5	9-#5	11-#4	9-#4	2.42	0.630
19	400	6.00	7.60	17	0.636	11-#4 2	19-#5	13-#5	12-#5	14-#4	3.42	99.8	214.0	268.6	400	19	12-#5	12-#5	13-#4	12-#4	2.91	0.663
20	100	3.00	6.67	12	0.791	12-#4 2	13-#4	14-#4	15-#3	10-#4	1.84	52.6	105.1	141.5	100	12	13-#4	9-#4	10-#4	14-#3	1.72	0.611
20	200	4.00	6.67	14	0.777	12-#4 3	19-#4	12-#5	12-#4	11-#4	2.39	74.1	148.3	199.6	200	16	17-#4	13-#4	10-#4	15-#3	2.12	0.620
20	300	5.00	6.67	16	0.711	12-#4 2	16-#5	14-#5	16-#4	13-#4	2.97	94.9	189.9	255.6	300	19	19-#4	16-#4	12-#4	11-#4	2.58	0.630
20	400	6.00	8.00	18	0.673	12-#4 2	11-#7	16-#5	13-#5	11-#5	3.68	116.3	233.6	313.2	400	20	14-#5	13-#5	10-#5	13-#4	3.12	0.663
21	100	4.00	7.00	12	0.754	12-#4 2	10-#5	15-#4	10-#4	11-#4	1.96	61.3	122.6	165.1	100	12	14-#4	10-#4	11-#4	15-#3	1.77	0.620
21	200	5.00	7.00	14	0.761	12-#4 4	22-#4	19-#4	10-#5	12-#4	2.60	86.5	173.0	232.9	200	16	12-#5	15-#4	11-#4	10-#4	2.28	0.630
21	300	6.00	7.00	16	0.675	12-#4 2	19-#5	22-#4	19-#4	16-#4	3.24	110.9	221.7	298.4	300	19	14-#5	19-#4	14-#4	12-#4	2.79	0.639
21	400	6.00	8.40	20	0.666	13-#4 2	17-#6	18-#5	15-#5	19-#4	4.01	134.0	268.0	360.8	400	21	25-#4	15-#5	12-#5	10-#5	3.47	0.663

NOTES: (1) 50 percent of these bars may be placed in the middle third of column strip. (2) Drop panels same size as for edge panels. (3) Same column size above and below slab.

CONCRETE REINFORCING STEEL INSTITUTE

10-11



TWO-WAY FLAT SLAB

PUNCHING SHEAR OF AN INTERIOR DROP PANEL

$$V_u = w_u\,(\text{AREA}) = \left[1.2\left(15 + \left(\tfrac{7''}{12}\right)(150_{\text{pcf}})\right) + 1.6(100)\right](20'\times 20')$$

$$= (283\ \text{psf})(400\ \text{ft}^2) = 113.2\ \text{k}$$

$$b_o = 4\,(6.67') = 26.68'(12) = 320.2''$$

$$d_{AVG} = \frac{7+11}{2} = 9''$$

$\alpha_s = 40$ FOR INT. COL.

$$\frac{b_o}{d} = \frac{320.2''}{9''} = 35.58$$

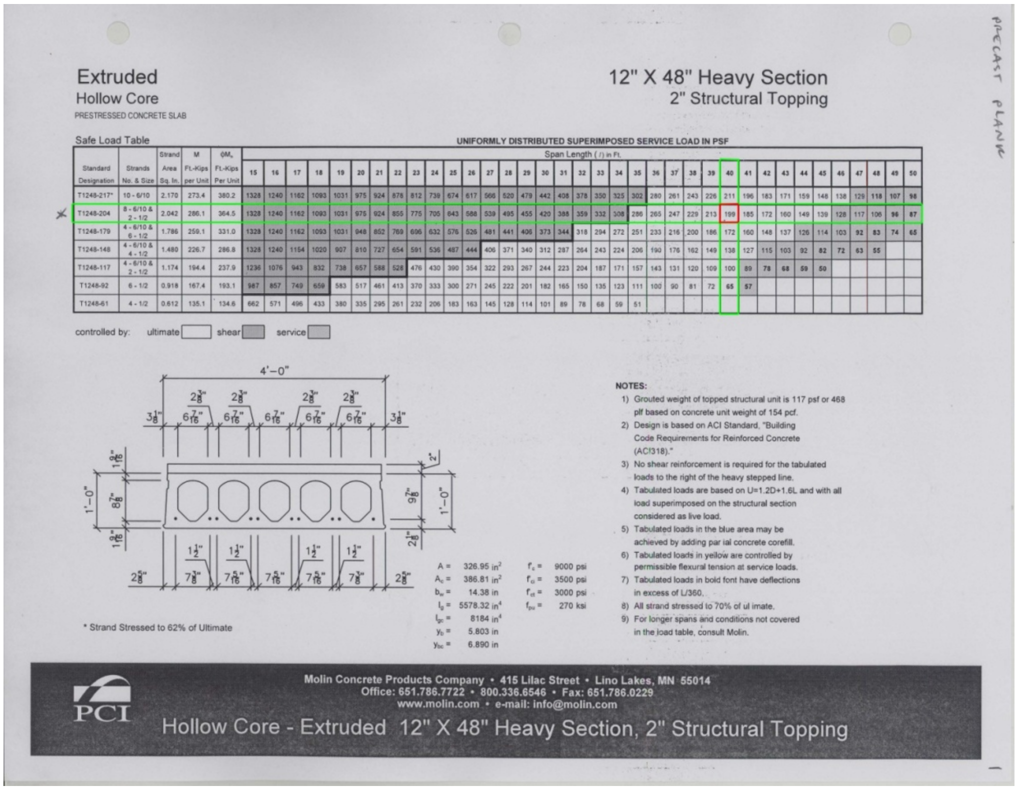
EQ 1: $V_c = 4\sqrt{f'_c}\,b_o d = 4\sqrt{4000}\,(320.2'')(9'')(1/1000) = 729\ \text{k}$

EQ 2: $V_c = (2 + 4/\beta)\sqrt{f'_c}\,b_o d = (2 + 4/1)\sqrt{4000}\,(320.2)(9)(1/1000) = 1094\ \text{k}$

EQ 3: $V_c = \left(\dfrac{\alpha_s}{b_o/d} + 2\right)\sqrt{f'_c}\,b_o d = \left(40/35.58 + 2\right)\sqrt{4000}\,(320.2)(9) = 569\ \text{k}$

$$\phi V_c = .75\,(569) = 427\ \text{k} > 113.2\ \text{k} \quad \therefore \text{OK}$$

Precast Hollow-Core Plank on Steel Beam



PRECAST PLANK

Extruded
Hollow Core
PRESTRESSED CONCRETE SLAB

12" X 48" Heavy Section
2" Structural Topping

Safe Load Table

UNIFORMLY DISTRIBUTED SUPERIMPOSED SERVICE LOAD IN PSF

	Standard Designation	Strands No. & Size	Strand Area Sq. In.	M Ft.-Kips per Unit	ϕM_n Ft.-Kips Per Unit	Span Length (l) in Ft.																																			
						15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
	T1248-217*	10 - 6/10	2.170	273.4	380.2	1328	1240	1162	1093	1031	975	924	878	812	739	674	617	566	520	479	442	408	378	350	325	302	280	261	243	226	211	196	183	171	159	148	138	129	118	107	98
*	T1248-204	8 - 6/10 & 2 - 1/2	2.042	286.1	364.5	1328	1240	1162	1093	1031	975	924	855	775	705	643	588	539	495	455	420	388	359	332	308	286	265	247	229	213	199	185	172	160	149	139	128	117	106	96	87
	T1248-179	4 - 6/10 & 6 - 1/2	1.786	259.1	331.0	1328	1240	1162	1093	1031	948	852	769	696	632	576	526	481	441	406	373	344	318	294	272	251	233	216	200	186	172	160	148	137	126	114	103	92	83	74	65
	T1248-148	4 - 6/10 & 4 - 1/2	1.480	226.7	286.8	1328	1240	1154	1020	907	810	727	654	591	536	487	444	406	371	340	312	287	264	243	224	206	190	176	162	149	138	127	115	103	92	82	72	63	55		
	T1248-117	4 - 6/10 & 2 - 1/2	1.174	194.4	237.9	1236	1076	943	832	738	657	588	528	476	430	390	354	322	293	267	244	223	204	187	171	157	143	131	120	109	100	89	78	68	59	50					
	T1248-92	6 - 1/2	0.918	167.4	193.1	987	857	749	659	583	517	461	413	370	333	300	271	245	222	201	182	165	150	135	123	111	100	90	81	72	65	57									
	T1248-61	4 - 1/2	0.612	135.1	134.6	662	571	496	433	380	335	295	261	232	206	183	163	145	128	114	101	89	78	68	59	51															

controlled by: ultimate ☐ shear ▨ service ▨

* Strand Stressed to 62% of Ultimate

A = 326.95 in^2
A_c = 386.81 in^2
b_w = 14.38 in
I_g = 5578.32 in^4
I_{gc} = 8184 in^4
y_b = 5.803 in
y_{bc} = 6.890 in

f'_c = 9000 psi
f'_{ci} = 3500 psi
f'_{ct} = 3000 psi
f_{pu} = 270 ksi

NOTES:

1) Grouted weight of topped structural unit is 117 psf or 468 plf based on concrete unit weight of 154 pcf.
2) Design is based on ACI Standard, "Building Code Requirements for Reinforced Concrete (ACI318)."
3) No shear reinforcement is required for the tabulated loads to the right of the heavy stepped line.
4) Tabulated loads are based on U=1.2D+1.6L and with all load superimposed on the structural section considered as live load.
5) Tabulated loads in the blue area may be achieved by adding par ial concrete corefill.
6) Tabulated loads in yellow are controlled by permissible flexural tension at service loads.
7) Tabulated loads in bold font have deflections in excess of L/360.
8) All strand stressed to 70% of ul imate.
9) For longer spans and conditions not covered in the load table, consult Molin.

PCI

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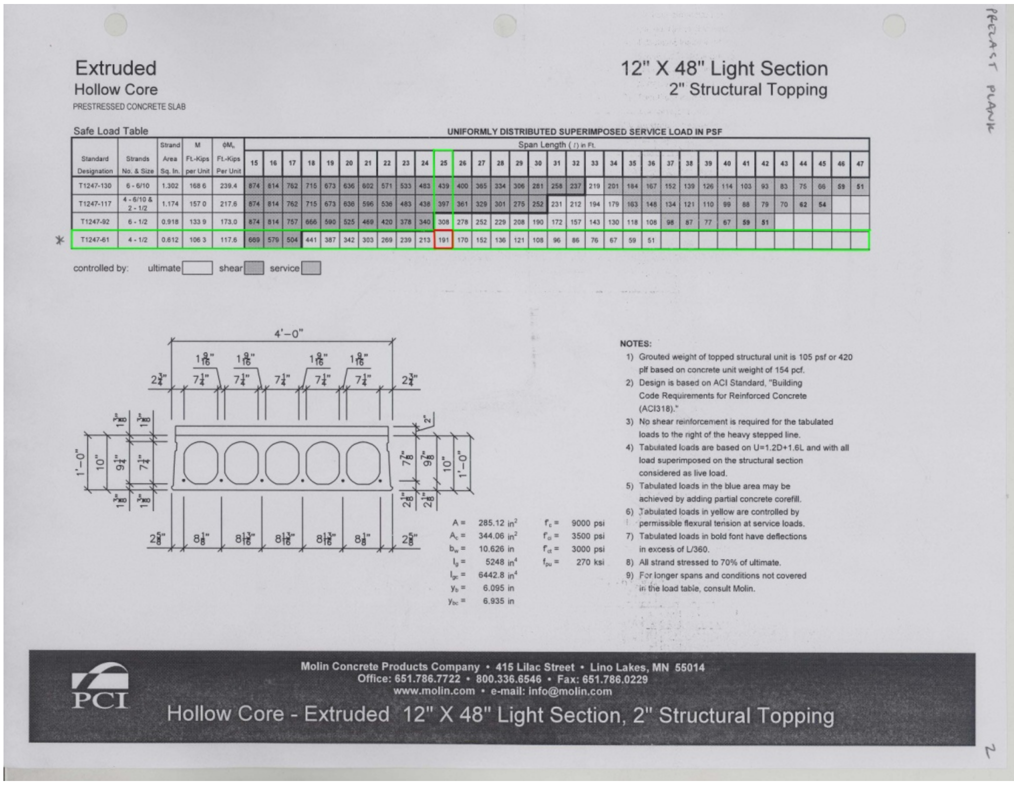
Hollow Core - Extruded 12" X 48" Heavy Section, 2" Structural Topping

1



PRECAST PLANK

Extruded
Hollow Core
PRESTRESSED CONCRETE SLAB

12" X 48" Light Section
2" Structural Topping

Safe Load Table

UNIFORMLY DISTRIBUTED SUPERIMPOSED SERVICE LOAD IN PSF

	Standard Designation	Strands No. & Size	Strand Area Sq. In.	M Ft.-Kips per Unit	ϕM_n Ft.-Kips Per Unit	Span Length (l) in Ft.																																
						15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
	T1247-130	6 - 6/10	1.302	168 6	239.4	874	814	762	715	673	636	602	571	533	483	439	400	365	334	306	281	258	237	219	201	184	167	152	139	126	114	103	93	83	75	66	59	51
	T1247-117	4 - 6/10 & 2 - 1/2	1.174	157 0	217.6	874	814	762	715	673	636	596	536	483	438	397	361	329	301	275	252	231	212	194	179	163	148	134	121	110	99	88	79	70	62	54		
	T1247-92	6 - 1/2	0.918	133 9	173.0	874	814	757	666	590	525	469	420	378	340	308	278	252	229	208	190	172	157	143	130	118	108	98	87	77	67	59	51					
*	T1247-61	4 - 1/2	0.612	106 3	117.6	669	579	504	441	387	342	303	269	239	213	191	170	152	136	121	108	96	86	76	67	59	51											

controlled by: ultimate ☐ shear ▨ service ▨

A = 285.12 in^2
A_c = 344.06 in^2
b_w = 10.626 in
I_g = 5248 in^4
I_{gc} = 6442.8 in^4
y_b = 6.095 in
y_{bc} = 6.935 in

f'_c = 9000 psi
f'_{ci} = 3500 psi
f'_{ct} = 3000 psi
f_{pu} = 270 ksi

NOTES:

1) Grouted weight of topped structural unit is 105 psf or 420 plf based on concrete unit weight of 154 pcf.
2) Design is based on ACI Standard, "Building Code Requirements for Reinforced Concrete (ACI318)."
3) No shear reinforcement is required for the tabulated loads to the right of the heavy stepped line.
4) Tabulated loads are based on U=1.2D+1.6L and with all load superimposed on the structural section considered as live load.
5) Tabulated loads in the blue area may be achieved by adding partial concrete corefill.
6) Tabulated loads in yellow are controlled by permissible flexural tension at service loads.
7) Tabulated loads in bold font have deflections in excess of L/360.
8) All strand stressed to 70% of ultimate.
9) For longer spans and conditions not covered in the load table, consult Molin.

PCI

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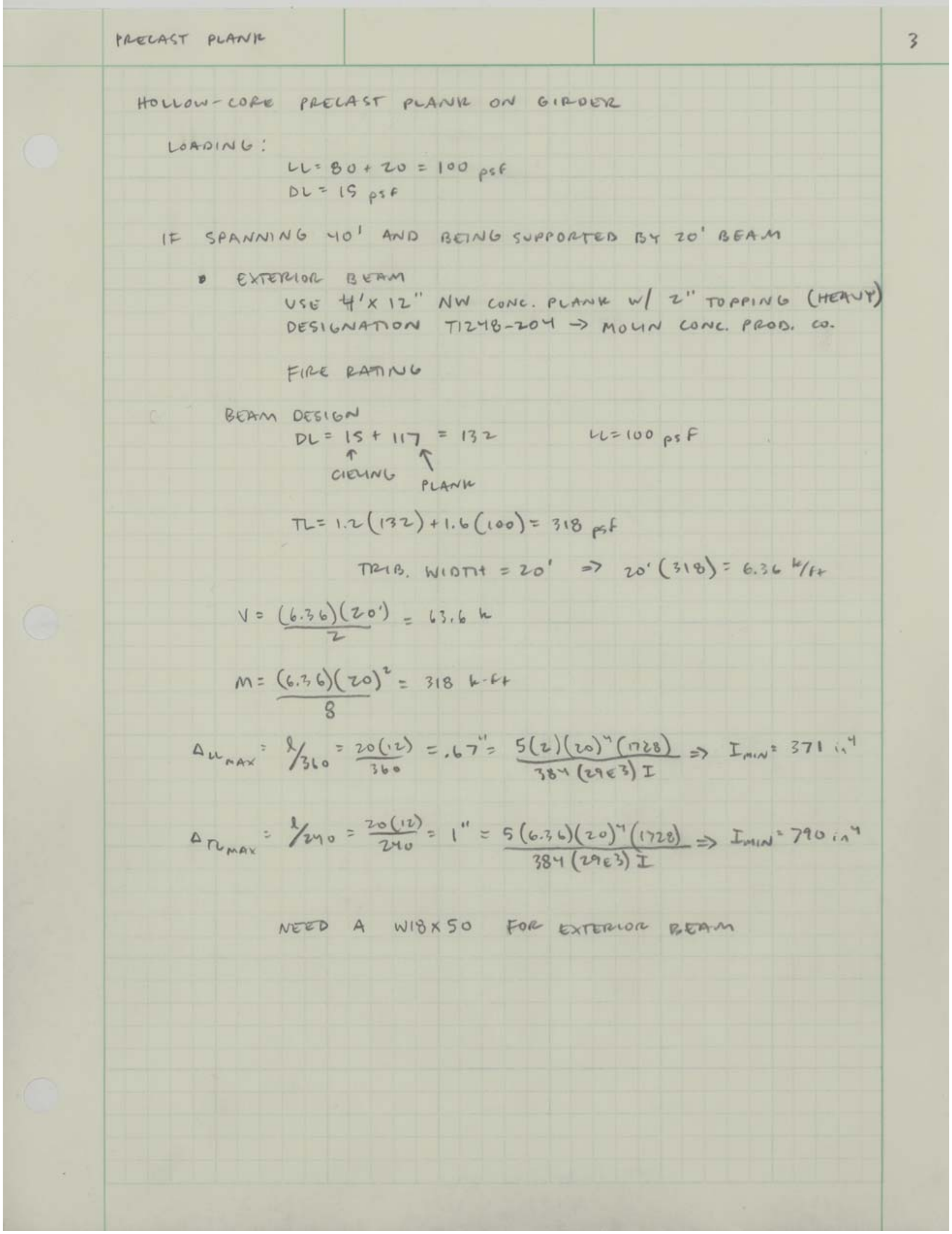
Hollow Core - Extruded 12" X 48" Light Section, 2" Structural Topping

2



PRECAST PLANK 3

HOLLOW-CORE PRECAST PLANK ON GIRDER

LOADING:

LL = 80 + 20 = 100 psf

DL = 15 psf

IF SPANNING 40' AND BEING SUPPORTED BY 20' BEAM

- EXTERIOR BEAM

USE 4'x 12" NW CONC. PLANK w/ 2" TOPPING (HEAVY)

DESIGNATION T1248-204 → MOLIN CONC. PROD. CO.

FIRE RATING

BEAM DESIGN

$$DL = \underset{\uparrow \text{ CIELING}}{15} + \underset{\uparrow \text{ PLANK}}{117} = 132 \qquad LL = 100 \text{ psf}$$

$$TL = 1.2(132) + 1.6(100) = 318 \text{ psf}$$

TRIB. WIDTH = 20' ⇒ 20'(318) = 6.36 k/ft

$$V = \frac{(6.36)(20')}{2} = 63.6 \text{ k}$$

$$M = \frac{(6.36)(20)^2}{8} = 318 \text{ k-ft}$$

$$\Delta_{LL_{MAX}} = l/360 = \frac{20(12)}{360} = .67'' = \frac{5(2)(20)^4(1728)}{384(29E3)I} \Rightarrow I_{MIN} = 371 \text{ in}^4$$

$$\Delta_{TL_{MAX}} = l/240 = \frac{20(12)}{240} = 1'' = \frac{5(6.36)(20)^4(1728)}{384(29E3)I} \Rightarrow I_{MIN} = 790 \text{ in}^4$$

NEED A W18x50 FOR EXTERIOR BEAM

PRECAST PLANK

- INTERIOR BEAM (WORST CASE)

SOLVING LOADS FOR 25.5' SPAN TO ADD TO PREVIOUS CALCS.

IF SPANNING 25.5' AND BEING SUPPORTED BY 20' BEAM
USE 4' x 12" NW CONC. PLANK w/ 2" TOPPING (LIGHT)
DESIGNATION T1247-61 → MOLIN CONC. PROD. CO.

FIRE RATING

BEAM DESIGN [JUST LIGHT SECTION, HEAVY WILL BE ADDED LATER]

DL = 15 + 105 = 120   LL = 100

TL = 1.2(120) + 1.6(100) = 304 psf

$$\text{TRIB. WIDTH} = \frac{25.5'}{2} = 12.75' \Rightarrow 12.75'(304) = 3.88\ ^{k}/_{ft}$$

w/ 40' SPAN LOADS ADDED

LL = 100 (12.75 + 20) = 3.28 k/ft

TL = 3.88 + 6.36 = 10.24 k/ft

$$V = \frac{(10.24)(20)}{2} = 102.4\ k$$

$$M = \frac{(10.24)(20')^2}{8} = 512\ k\text{-}ft \rightarrow W18 \times 71$$

$$\Delta_{LL_{MAX}} = 1.33'' = \frac{5(3.28)(20)^4(1728)}{384(29E3)I} \Rightarrow I_{MIN} = 307\ in^4$$

$$\Delta_{TL_{MAX}} = 2'' = \frac{5(10.24\ ^k/_{ft})(20)^4(1728)}{384(29E3)I} \Rightarrow I_{MIN} = 636\ in^4$$

NEED A W18 x 71

PRECAST PLANK

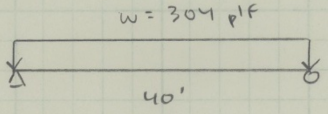
5

- INTERIOR BEAM NEEDED FOR LATERAL LOAD IN E-W DIRECTION
  BUT ONLY SIZED FOR DEAD LOAD NOW

$LL = 100$ psf $\quad DL = 15 + 105$ psf

$TL = 1'\left[(1.2)(120) + 1.6(100)\right] = 304$ plf

SPAN = 40'



$$V = \frac{(304\ ^{lb}/_{ft})(40')}{2} = 6.1\ k$$

$$M = \frac{(304\ ^{lb}/_{ft})(40')^2}{8} = 60.8\ k\text{-}ft$$

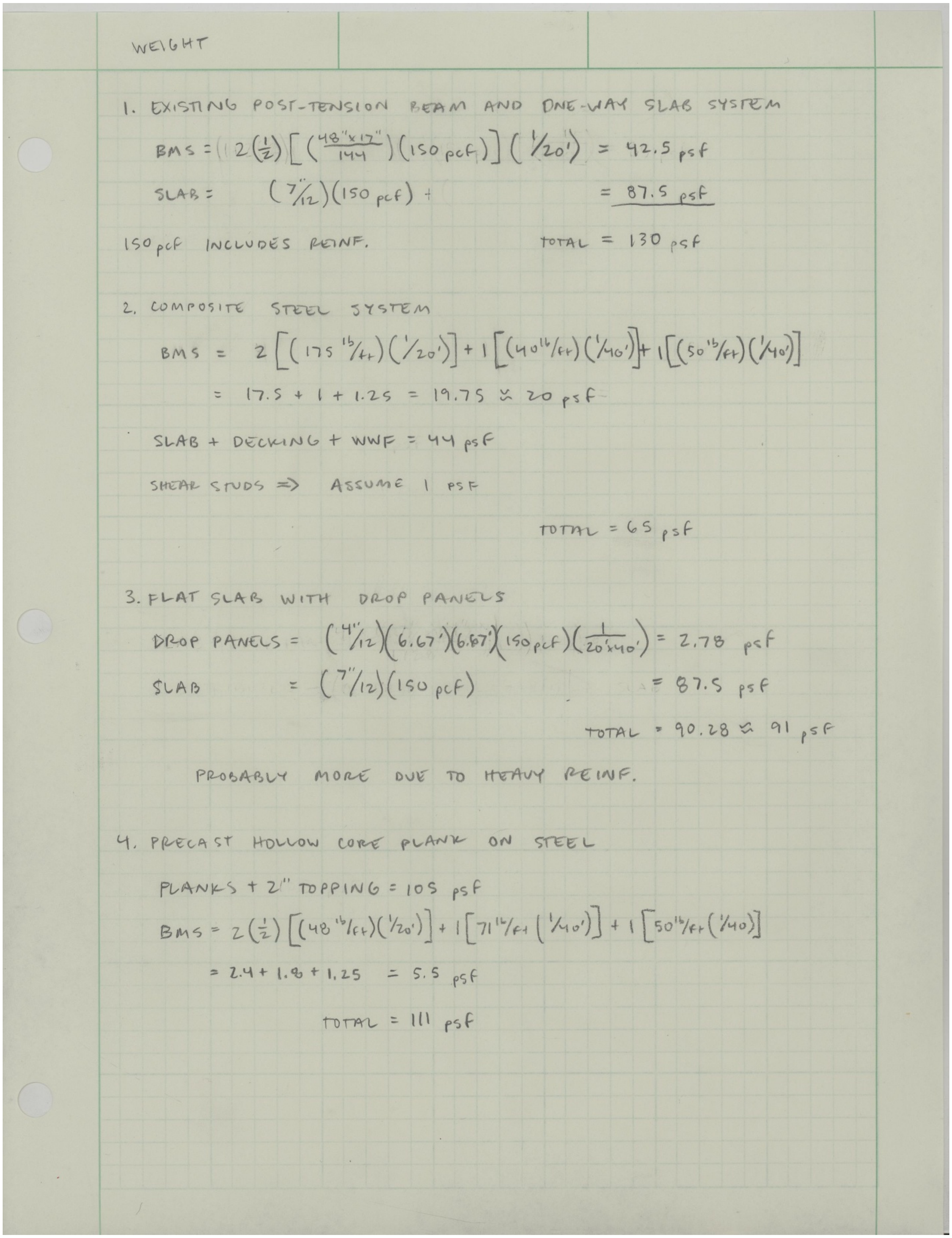
$$\Delta = \frac{l}{360} = 1.33'' = \frac{5(.304)(40')^2(1728)}{384(29000)\,I_{MIN}}$$

$$I_{MIN} = 454\ in^4$$

TABLE 3-2

USE A W14x48 WITH $\phi M_p = 294$ k-ft > 60.8 k-ft ∴ ok
NEEDED TO SATISFY $l/360$

THIS WILL CHANGE TYPICAL TOTAL DEPTH TO 28.1"
INSTEAD OF 32.5"



WEIGHT

1. EXISTING POST-TENSION BEAM AND ONE-WAY SLAB SYSTEM

$BMS = 2\left(\frac{1}{2}\right)\left[\left(\frac{48'' \times 17''}{144}\right)(150\ pcf)\right]\left(\frac{1}{20'}\right) = 42.5\ psf$

$SLAB = \left(\frac{7''}{12}\right)(150\ pcf) + \qquad = \underline{87.5\ psf}$

150 pcf INCLUDES REINF.

TOTAL = 130 psf

2. COMPOSITE STEEL SYSTEM

$BMS = 2\left[\left(175\ ^{lb}/_{ft}\right)\left(\frac{1}{20'}\right)\right] + 1\left[\left(40\ ^{lb}/_{ft}\right)\left(\frac{1}{40'}\right)\right] + 1\left[\left(50\ ^{lb}/_{ft}\right)\left(\frac{1}{40'}\right)\right]$

$= 17.5 + 1 + 1.25 = 19.75 \approx 20\ psf$

SLAB + DECKING + WWF = 44 psf

SHEAR STUDS ⇒ ASSUME 1 PSF

TOTAL = 65 psf

3. FLAT SLAB WITH DROP PANELS

$DROP\ PANELS = \left(\frac{4''}{12}\right)(6.67')(6.67')(150\ pcf)\left(\frac{1}{20' \times 40'}\right) = 2.78\ psf$

$SLAB = \left(\frac{7''}{12}\right)(150\ pcf) = 87.5\ psf$

TOTAL = 90.28 ≈ 91 psf

PROBABLY MORE DUE TO HEAVY REINF.

4. PRECAST HOLLOW CORE PLANK ON STEEL

PLANKS + 2" TOPPING = 105 psf

$BMS = 2\left(\frac{1}{2}\right)\left[\left(48\ ^{lb}/_{ft}\right)\left(\frac{1}{20'}\right)\right] + 1\left[71\ ^{lb}/_{ft}\left(\frac{1}{40'}\right)\right] + 1\left[50\ ^{lb}/_{ft}\left(\frac{1}{40}\right)\right]$

$= 2.4 + 1.8 + 1.25 = 5.5\ psf$

TOTAL = 111 psf

Appendix B

Costs

COST

1. EXISTING POST-TENSION BEAM AND ONE-WAY SLAB SYSTEM

FLOOR CONSTRUCTION = \$20.60 (.926) = \$19.08

↑ LOCATION

ASSUME 1 lb OF POST TENSIONING PER FT² = \$2.06 (.926) = \$1.91

TOTAL = \$21.00 PER SQ. FT.

* PROBABLY MORE DUE TO LARGE BEAM SIZES, HIGHER-STRESS CONCRETE

2. COMPOSITE STEEL SYSTEM

FLOOR CONSTRUCTION = \$25.45 (.926) = \$23.57

* PROBABLY MORE DUE TO LARGER BEAM SIZES, HIGHER-STRESS CONCRETE

3. FLAT SLAB WITH DROP PANELS

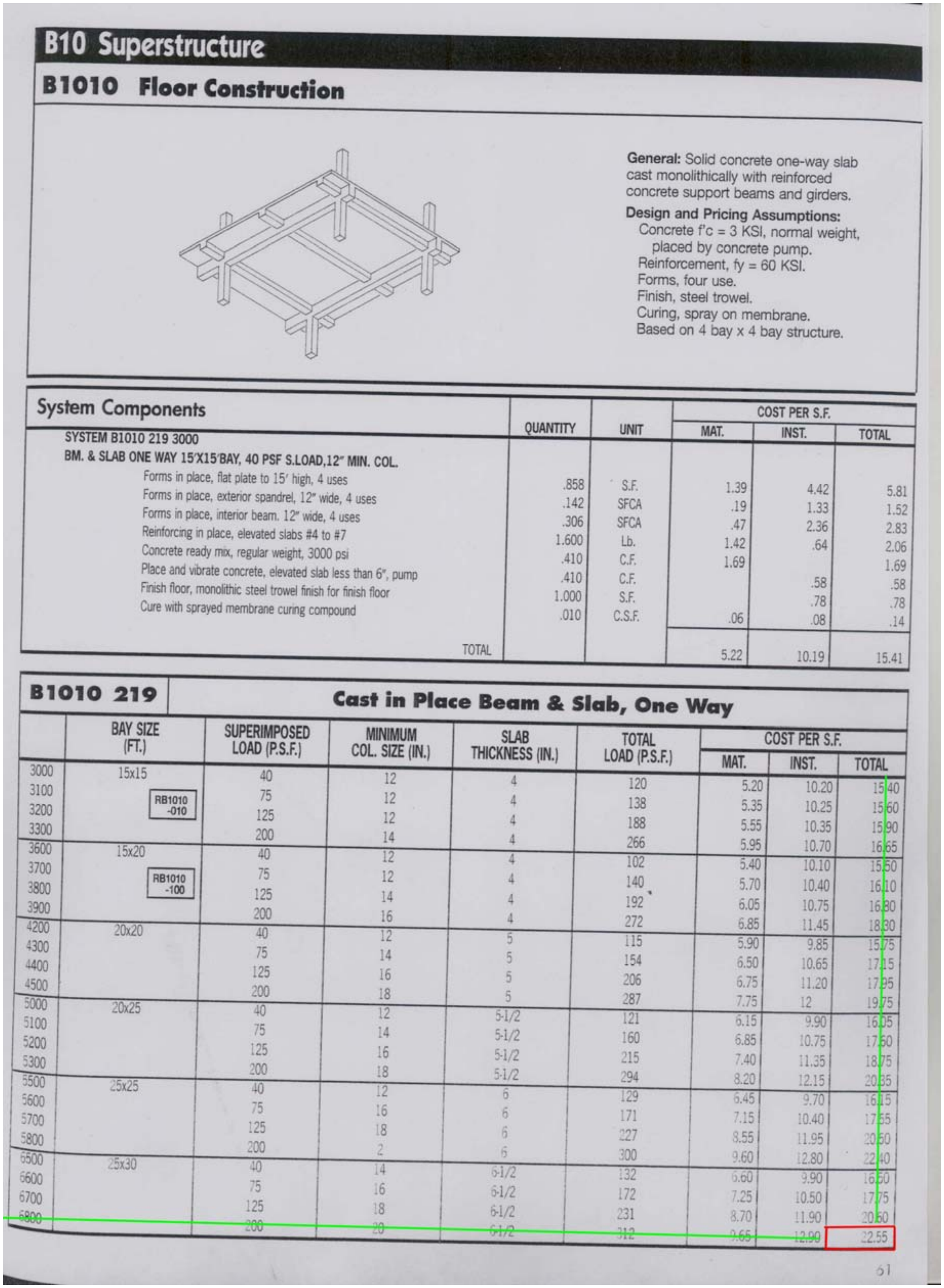
FLOOR CONSTRUCTION = \$15.70 (.926) = \$14.54

4. PRECAST HOLLOW CORE PLANK ON STEEL BEAM

FLOOR CONSTRUCTION = \$25.85 (.926) = \$23.94

* PICKED A LARGER AREA TO OFFSET SMALLER PLANK THICKNESS AND LACK OF STEEL BEAMS

Post-Tension Beam and One-Way Slab System



B10 Superstructure

B1010 Floor Construction

General: Solid concrete one-way slab cast monolithically with reinforced concrete support beams and girders.

Design and Pricing Assumptions:
Concrete f'c = 3 KSI, normal weight, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F.		
			MAT.	INST.	TOTAL
SYSTEM B1010 219 3000 BM. & SLAB ONE WAY 15'X15'BAY, 40 PSF S.LOAD,12" MIN. COL.					
Forms in place, flat plate to 15' high, 4 uses	.858	S.F.	1.39	4.42	5.81
Forms in place, exterior spandrel, 12" wide, 4 uses	.142	SFCA	.19	1.33	1.52
Forms in place, interior beam. 12" wide, 4 uses	.306	SFCA	.47	2.36	2.83
Reinforcing in place, elevated slabs #4 to #7	1.600	Lb.	1.42	.64	2.06
Concrete ready mix, regular weight, 3000 psi	.410	C.F.	1.69		1.69
Place and vibrate concrete, elevated slab less than 6", pump	.410	C.F.		.58	.58
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.78	.78
Cure with sprayed membrane curing compound	.010	C.S.F.	.06	.08	.14
TOTAL			5.22	10.19	15.41

B1010 219 Cast in Place Beam & Slab, One Way

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
3000	15x15	40	12	4	120	5.20	10.20	15.40
3100	RB1010 -010	75	12	4	138	5.35	10.25	15.60
3200		125	12	4	188	5.55	10.35	15.90
3300		200	14	4	266	5.95	10.70	16.65
3600	15x20	40	12	4	102	5.40	10.10	15.50
3700	RB1010 -100	75	12	4	140	5.70	10.40	16.10
3800		125	14	4	192	6.05	10.75	16.80
3900		200	16	4	272	6.85	11.45	18.30
4200	20x20	40	12	5	115	5.90	9.85	15.75
4300		75	14	5	154	6.50	10.65	17.15
4400		125	16	5	206	6.75	11.20	17.95
4500		200	18	5	287	7.75	12	19.75
5000	20x25	40	12	5-1/2	121	6.15	9.90	16.05
5100		75	14	5-1/2	160	6.85	10.75	17.60
5200		125	16	5-1/2	215	7.40	11.35	18.75
5300		200	18	5-1/2	294	8.20	12.15	20.35
5500	25x25	40	12	6	129	6.45	9.70	16.15
5600		75	16	6	171	7.15	10.40	17.55
5700		125	18	6	227	8.55	11.95	20.50
5800		200	2	6	300	9.60	12.80	22.40
6500	25x30	40	14	6-1/2	132	6.60	9.90	16.50
6600		75	16	6-1/2	172	7.25	10.50	17.75
6700		125	18	6-1/2	231	8.70	11.90	20.60
6800		200	20	6-1/2	312	9.65	12.90	22.55

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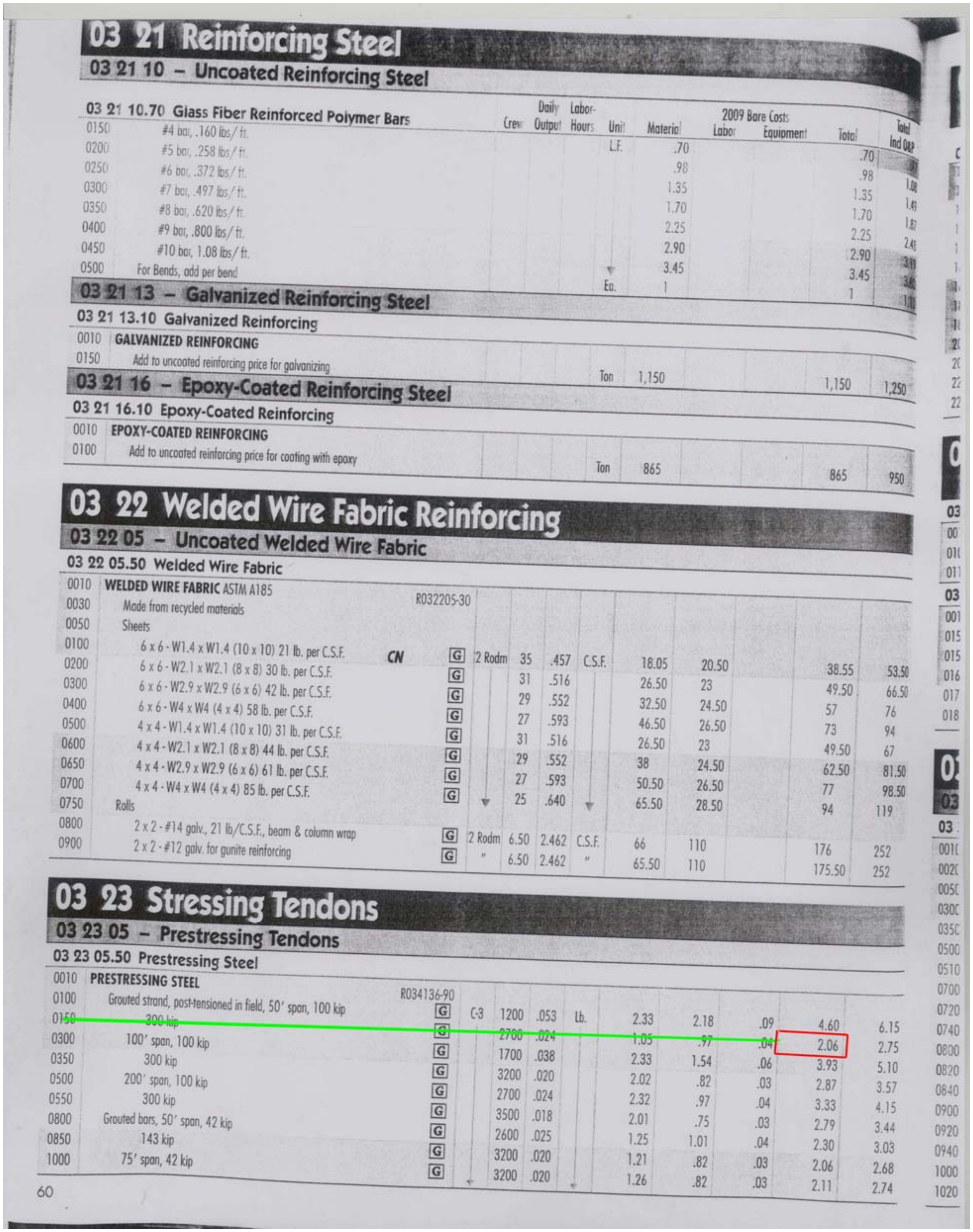

03 21 Reinforcing Steel

03 21 10 – Uncoated Reinforcing Steel

	03 21 10.70 Glass Fiber Reinforced Polymer Bars	Crew	Daily Output	Labor-Hours	Unit	2009 Bare Costs				Total Incl O&P
						Material	Labor	Equipment	Total	
0150	#4 bar, .160 lbs/ft.				L.F.	.70			.70	[illegible]
0200	#5 bar, .258 lbs/ft.					.98			.98	1.08
0250	#6 bar, .372 lbs/ft.					1.35			1.35	1.49
0300	#7 bar, .497 lbs/ft.					1.70			1.70	1.87
0350	#8 bar, .620 lbs/ft.					2.25			2.25	2.48
0400	#9 bar, .800 lbs/ft.					2.90			2.90	3.19
0450	#10 bar, 1.08 lbs/ft.				▼	3.45			3.45	3.80
0500	For Bends, add per bend				Ea.	1			1	1.10

03 21 13 – Galvanized Reinforcing Steel

	03 21 13.10 Galvanized Reinforcing	Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**GALVANIZED REINFORCING**									
0150	Add to uncoated reinforcing price for galvanizing				Ton	1,150			1,150	1,250

03 21 16 – Epoxy-Coated Reinforcing Steel

	03 21 16.10 Epoxy-Coated Reinforcing	Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**EPOXY-COATED REINFORCING**									
0100	Add to uncoated reinforcing price for coating with epoxy				Ton	865			865	950

03 22 Welded Wire Fabric Reinforcing

03 22 05 – Uncoated Welded Wire Fabric

	03 22 05.50 Welded Wire Fabric		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**WELDED WIRE FABRIC** ASTM A185										
0030	Made from recycled materials	R032205-30									
0050	Sheets										
0100	6 x 6 - W1.4 x W1.4 (10 x 10) 21 lb. per C.S.F.	**CN** G	2 Rodm	35	.457	C.S.F.	18.05	20.50		38.55	53.50
0200	6 x 6 - W2.1 x W2.1 (8 x 8) 30 lb. per C.S.F.	G		31	.516		26.50	23		49.50	66.50
0300	6 x 6 - W2.9 x W2.9 (6 x 6) 42 lb. per C.S.F.	G		29	.552		32.50	24.50		57	76
0400	6 x 6 - W4 x W4 (4 x 4) 58 lb. per C.S.F.	G		27	.593		46.50	26.50		73	94
0500	4 x 4 - W1.4 x W1.4 (10 x 10) 31 lb. per C.S.F.	G		31	.516		26.50	23		49.50	67
0600	4 x 4 - W2.1 x W2.1 (8 x 8) 44 lb. per C.S.F.	G		29	.552		38	24.50		62.50	81.50
0650	4 x 4 - W2.9 x W2.9 (6 x 6) 61 lb. per C.S.F.	G		27	.593		50.50	26.50		77	98.50
0700	4 x 4 - W4 x W4 (4 x 4) 85 lb. per C.S.F.	G	▼	25	.640	▼	65.50	28.50		94	119
0750	Rolls										
0800	2 x 2 - #14 galv., 21 lb/C.S.F., beam & column wrap	G	2 Rodm	6.50	2.462	C.S.F.	66	110		176	252
0900	2 x 2 - #12 galv. for gunite reinforcing	G	"	6.50	2.462	"	65.50	110		175.50	252

03 23 Stressing Tendons

03 23 05 – Prestressing Tendons

	03 23 05.50 Prestressing Steel		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**PRESTRESSING STEEL**										
0100	Grouted strand, post-tensioned in field, 50′ span, 100 kip	R034136-90 G	C-3	1200	.053	Lb.	2.33	2.18	.09	4.60	6.15
~~0150~~	~~300 kip~~	~~G~~		~~2700~~	~~.024~~		~~1.05~~	~~.97~~	~~.04~~	2.06	2.75
0300	100′ span, 100 kip	G		1700	.038		2.33	1.54	.06	3.93	5.10
0350	300 kip	G		3200	.020		2.02	.82	.03	2.87	3.57
0500	200′ span, 100 kip	G		2700	.024		2.32	.97	.04	3.33	4.15
0550	300 kip	G		3500	.018		2.01	.75	.03	2.79	3.44
0800	Grouted bars, 50′ span, 42 kip	G		2600	.025		1.25	1.01	.04	2.30	3.03
0850	143 kip	G		3200	.020		1.21	.82	.03	2.06	2.68
1000	75′ span, 42 kip	G	▼	3200	.020	▼	1.26	.82	.03	2.11	2.74

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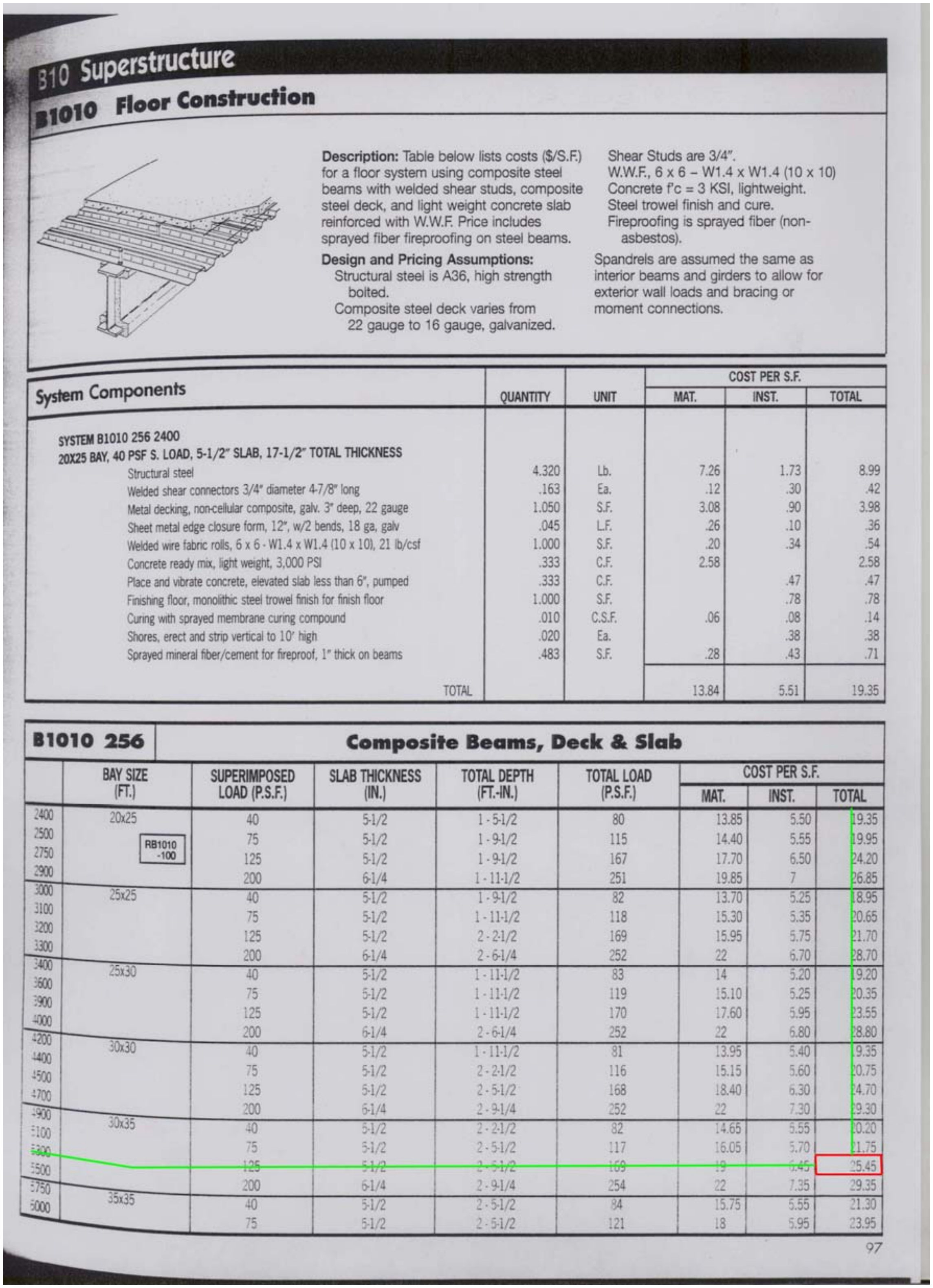
Composite Metal Deck System on Steel Beam



B10 Superstructure

B1010 Floor Construction

Description: Table below lists costs ($/S.F.) for a floor system using composite steel beams with welded shear studs, composite steel deck, and light weight concrete slab reinforced with W.W.F. Price includes sprayed fiber fireproofing on steel beams.

Design and Pricing Assumptions:
Structural steel is A36, high strength bolted.
Composite steel deck varies from 22 gauge to 16 gauge, galvanized.
Shear Studs are 3/4".
W.W.F., 6 x 6 – W1.4 x W1.4 (10 x 10)
Concrete f'c = 3 KSI, lightweight.
Steel trowel finish and cure.
Fireproofing is sprayed fiber (non-asbestos).
Spandrels are assumed the same as interior beams and girders to allow for exterior wall loads and bracing or moment connections.

System Components	QUANTITY	UNIT	COST PER S.F.		
			MAT.	INST.	TOTAL
SYSTEM B1010 256 2400 **20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS**					
Structural steel	4.320	Lb.	7.26	1.73	8.99
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.12	.30	.42
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	3.08	.90	3.98
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.045	L.F.	.26	.10	.36
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.20	.34	.54
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	2.58		2.58
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.47	.47
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.78	.78
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.08	.14
Shores, erect and strip vertical to 10' high	.020	Ea.		.38	.38
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.28	.43	.71
TOTAL			13.84	5.51	19.35

B1010 256 Composite Beams, Deck & Slab

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
2400	20x25	40	5-1/2	1 - 5-1/2	80	13.85	5.50	19.35
2500	RB1010 -100	75	5-1/2	1 - 9-1/2	115	14.40	5.55	19.95
2750		125	5-1/2	1 - 9-1/2	167	17.70	6.50	24.20
2900		200	6-1/4	1 - 11-1/2	251	19.85	7	26.85
3000	25x25	40	5-1/2	1 - 9-1/2	82	13.70	5.25	18.95
3100		75	5-1/2	1 - 11-1/2	118	15.30	5.35	20.65
3200		125	5-1/2	2 - 2-1/2	169	15.95	5.75	21.70
3300		200	6-1/4	2 - 6-1/4	252	22	6.70	28.70
3400	25x30	40	5-1/2	1 - 11-1/2	83	14	5.20	19.20
3600		75	5-1/2	1 - 11-1/2	119	15.10	5.25	20.35
3900		125	5-1/2	1 - 11-1/2	170	17.60	5.95	23.55
4000		200	6-1/4	2 - 6-1/4	252	22	6.80	28.80
4200	30x30	40	5-1/2	1 - 11-1/2	81	13.95	5.40	19.35
4400		75	5-1/2	2 - 2-1/2	116	15.15	5.60	20.75
4500		125	5-1/2	2 - 5-1/2	168	18.40	6.30	24.70
4700		200	6-1/4	2 - 9-1/4	252	22	7.30	29.30
4900	30x35	40	5-1/2	2 - 2-1/2	82	14.65	5.55	20.20
5100		75	5-1/2	2 - 5-1/2	117	16.05	5.70	21.75
5300		125	5-1/2	2 - 5-1/2	169	19	6.45	25.45
5500		200	6-1/4	2 - 9-1/4	254	22	7.35	29.35
5750	35x35	40	5-1/2	2 - 5-1/2	84	15.75	5.55	21.30
6000		75	5-1/2	2 - 5-1/2	121	18	5.95	23.95

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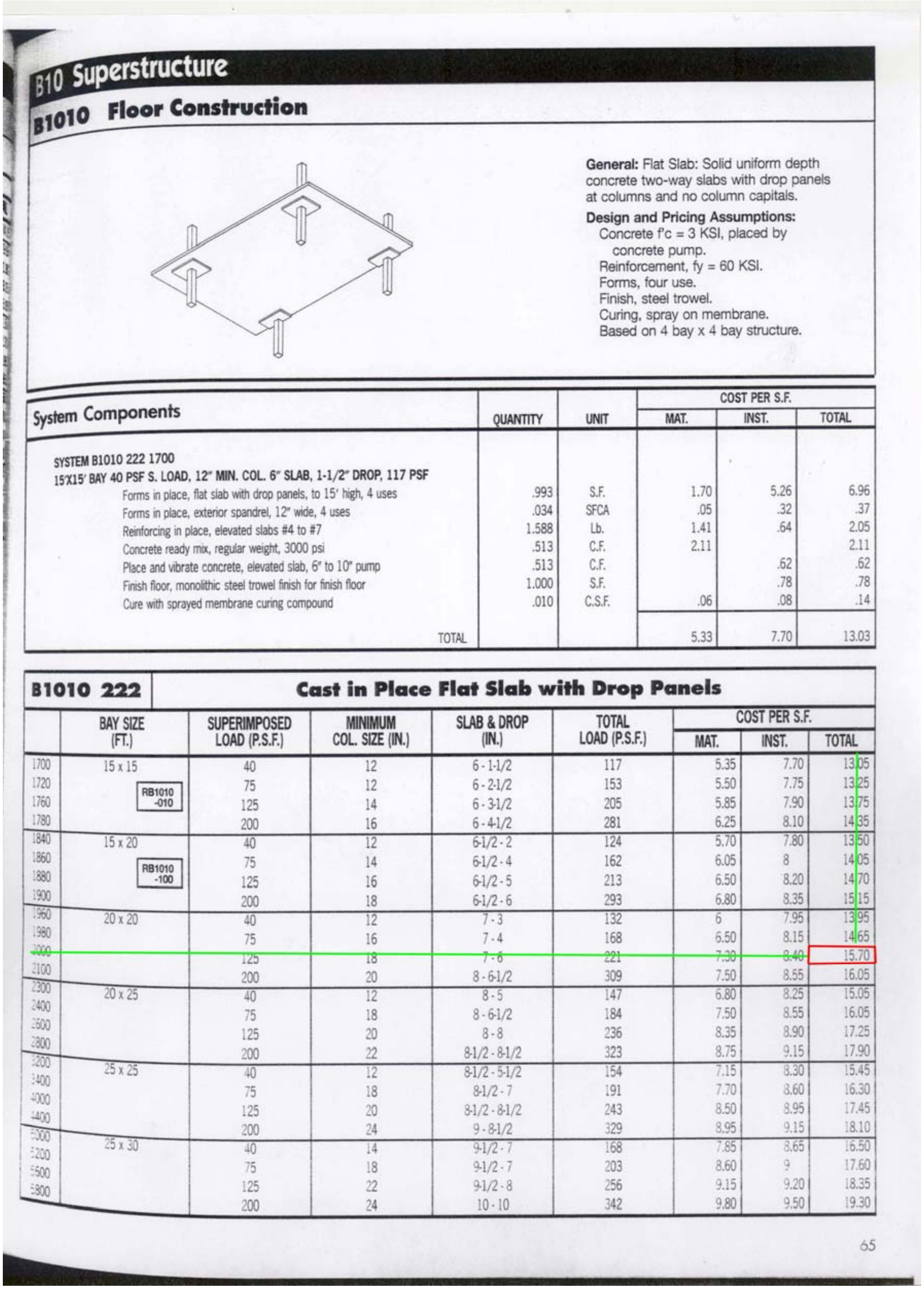
Two-Way Flat Slab System with Drop Panels



B10 Superstructure

B1010 Floor Construction

General: Flat Slab: Solid uniform depth concrete two-way slabs with drop panels at columns and no column capitals.

Design and Pricing Assumptions:
Concrete f'c = 3 KSI, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 222 1700 **15'X15' BAY 40 PSF S. LOAD, 12" MIN. COL. 6" SLAB, 1-1/2" DROP, 117 PSF**					
Forms in place, flat slab with drop panels, to 15' high, 4 uses	.993	S.F.	1.70	5.26	6.96
Forms in place, exterior spandrel, 12" wide, 4 uses	.034	SFCA	.05	.32	.37
Reinforcing in place, elevated slabs #4 to #7	1.588	Lb.	1.41	.64	2.05
Concrete ready mix, regular weight, 3000 psi	.513	C.F.	2.11		2.11
Place and vibrate concrete, elevated slab, 6" to 10" pump	.513	C.F.		.62	.62
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.78	.78
Cure with sprayed membrane curing compound	.010	C.S.F.	.06	.08	.14
TOTAL			5.33	7.70	13.03

B1010 222 Cast in Place Flat Slab with Drop Panels

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB & DROP (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1700	15 x 15	40	12	6 - 1-1/2	117	5.35	7.70	13.05
1720	RB1010 -010	75	12	6 - 2-1/2	153	5.50	7.75	13.25
1760		125	14	6 - 3-1/2	205	5.85	7.90	13.75
1780		200	16	6 - 4-1/2	281	6.25	8.10	14.35
1840	15 x 20	40	12	6-1/2 - 2	124	5.70	7.80	13.50
1860	RB1010 -100	75	14	6-1/2 - 4	162	6.05	8	14.05
1880		125	16	6-1/2 - 5	213	6.50	8.20	14.70
1900		200	18	6-1/2 - 6	293	6.80	8.35	15.15
1960	20 x 20	40	12	7 - 3	132	6	7.95	13.95
1980		75	16	7 - 4	168	6.50	8.15	14.65
2000		125	18	7 - 6	221	7.30	8.40	15.70
2100		200	20	8 - 6-1/2	309	7.50	8.55	16.05
2300	20 x 25	40	12	8 - 5	147	6.80	8.25	15.05
2400		75	18	8 - 6-1/2	184	7.50	8.55	16.05
2600		125	20	8 - 8	236	8.35	8.90	17.25
2800		200	22	8-1/2 - 8-1/2	323	8.75	9.15	17.90
3200	25 x 25	40	12	8-1/2 - 5-1/2	154	7.15	8.30	15.45
3400		75	18	8-1/2 - 7	191	7.70	8.60	16.30
4000		125	20	8-1/2 - 8-1/2	243	8.50	8.95	17.45
4400		200	24	9 - 8-1/2	329	8.95	9.15	18.10
5000	25 x 30	40	14	9-1/2 - 7	168	7.85	8.65	16.50
5200		75	18	9-1/2 - 7	203	8.60	9	17.60
5500		125	22	9-1/2 - 8	256	9.15	9.20	18.35
5800		200	24	10 - 10	342	9.80	9.50	19.30

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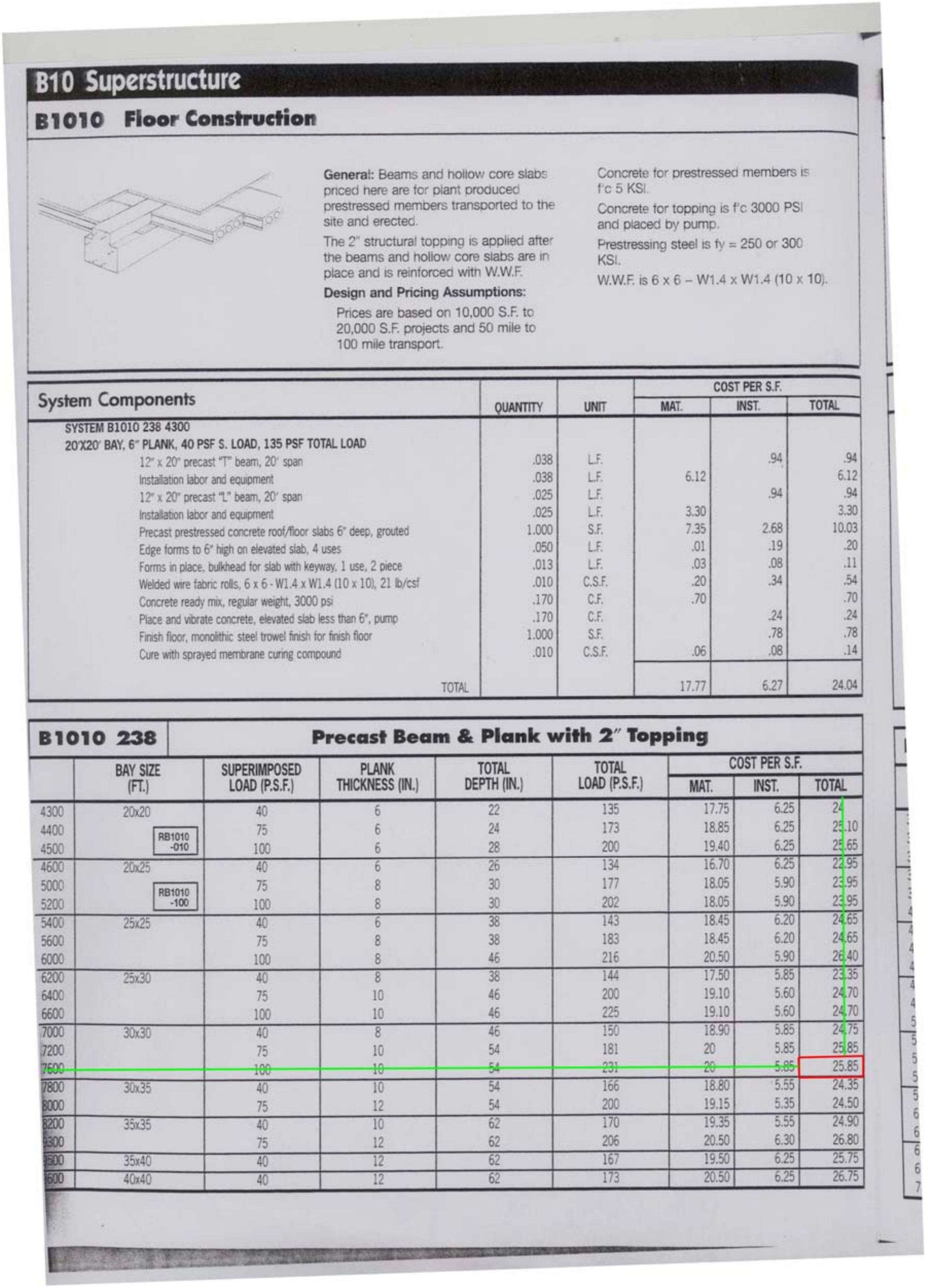
Precast Hollow-Core Plank System on Steel Girder



B10 Superstructure

B1010 Floor Construction

General: Beams and hollow core slabs priced here are for plant produced prestressed members transported to the site and erected.

The 2" structural topping is applied after the beams and hollow core slabs are in place and is reinforced with W.W.F.

Design and Pricing Assumptions:

Prices are based on 10,000 S.F. to 20,000 S.F. projects and 50 mile to 100 mile transport.

Concrete for prestressed members is f'c 5 KSI.

Concrete for topping is f'c 3000 PSI and placed by pump.

Prestressing steel is fy = 250 or 300 KSI.

W.W.F. is 6 x 6 – W1.4 x W1.4 (10 x 10).

System Components	QUANTITY	UNIT	COST PER S.F.		
			MAT.	INST.	TOTAL
SYSTEM B1010 238 4300					
20'X20' BAY, 6" PLANK, 40 PSF S. LOAD, 135 PSF TOTAL LOAD					
12" x 20" precast "T" beam, 20' span	.038	L.F.		.94	.94
Installation labor and equipment	.038	L.F.	6.12		6.12
12" x 20" precast "L" beam, 20' span	.025	L.F.		.94	.94
Installation labor and equipment	.025	L.F.	3.30		3.30
Precast prestressed concrete roof/floor slabs 6" deep, grouted	1.000	S.F.	7.35	2.68	10.03
Edge forms to 6" high on elevated slab, 4 uses	.050	L.F.	.01	.19	.20
Forms in place, bulkhead for slab with keyway, 1 use, 2 piece	.013	L.F.	.03	.08	.11
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	.010	C.S.F.	.20	.34	.54
Concrete ready mix, regular weight, 3000 psi	.170	C.F.	.70		.70
Place and vibrate concrete, elevated slab less than 6", pump	.170	C.F.		.24	.24
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.78	.78
Cure with sprayed membrane curing compound	.010	C.S.F.	.06	.08	.14
TOTAL			17.77	6.27	24.04

B1010 238 Precast Beam & Plank with 2″ Topping

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	PLANK THICKNESS (IN.)	TOTAL DEPTH (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
4300	20x20	40	6	22	135	17.75	6.25	24
4400	RB1010 -010	75	6	24	173	18.85	6.25	25.10
4500		100	6	28	200	19.40	6.25	25.65
4600	20x25	40	6	26	134	16.70	6.25	22.95
5000	RB1010 -100	75	8	30	177	18.05	5.90	23.95
5200		100	8	30	202	18.05	5.90	23.95
5400	25x25	40	6	38	143	18.45	6.20	24.65
5600		75	8	38	183	18.45	6.20	24.65
6000		100	8	46	216	20.50	5.90	26.40
6200	25x30	40	8	38	144	17.50	5.85	23.35
6400		75	10	46	200	19.10	5.60	24.70
6600		100	10	46	225	19.10	5.60	24.70
7000	30x30	40	8	46	150	18.90	5.85	24.75
7200		75	10	54	181	20	5.85	25.85
7600		100	10	54	231	20	5.85	25.85
7800	30x35	40	10	54	166	18.80	5.55	24.35
8000		75	12	54	200	19.15	5.35	24.50
8200	35x35	40	10	62	170	19.35	5.55	24.90
9300		75	12	62	206	20.50	6.30	26.80
9500	35x40	40	12	62	167	19.50	6.25	25.75
9600	40x40	40	12	62	173	20.50	6.25	26.75