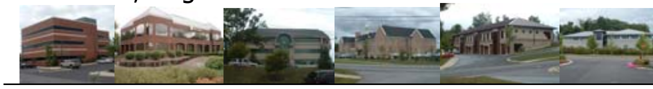


EXECUTIVE SUMMARY

Like most suburban office building in Northern Virginia, the Signal Hill Professional Center, a four-story office structure in Manassas features composite steel construction for both the office building and its corresponding underground parking garage structure.

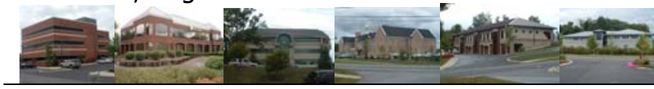
In order to assess the competence of this composite system, it was compared to various design alternatives, including:

- Non-composite Steel Beams
- Precast Concrete Floor Planks
- Steel Joists
- One-Way Concrete Slab
- Concrete Pan Joists
- Two-Way Concrete Slab
- Trus-Joist Manufactured Wood Joists and Girders

A standard 20'-0"x 30'-0" bay was analyzed for both office loads and parking structure loads, using specifications from various manufacturers, the Concrete Reinforcing Steel Institute Handbook, and the Precast Concrete Institute Handbook to simplify alternative structure design processes.

Considering that building weight and architectural layout are not major considerations, economy from easy and fast construction, material availability, and an overall shorter building height from narrower floor section depths shows that:

- The simplest redesign would be a steel composite system where infill beams span in the longer 30'-0" east-west span. Though the longer beams are much larger to primarily account for deflection, this creates a significantly narrower floor section depth in both the office building and parking structure at the expense of less space under the floor slab for additional engineered systems.
- Steel Joists produced a narrow floor section depth and light bay weights; however, fireproofing and mechanical placement must be explored further.
- The most viable concrete system would be Pan Joists spanning in both directions. This creates one of the thinnest floor section depths and is one of the lightest concrete systems, at the expense of slightly more complicated construction and less space for additional engineered systems.
- Precast Concrete Floor Planks resting on a non-composite steel structure would be a good way to improve quality through prefabrication and produces a relatively light and thin floor system.
- TrusJoist Manufactured Wood Joists and Parallam Girders, though featuring one of the largest floor section depths and closest beam spacing, could add an element of architectural interest to the interior architecture and are 60% lighter than the current system. Further analysis with respect to serviceability would be necessary before implementing this unconventional system.
- A one-way concrete slab is a possibility though it is heavier and does not significantly reduce floor section depth.
- A two-way slab would be possible only if the column layout were redesigned to feature smaller bays.



CURRENT STRUCTURAL SYSTEM AND REDESIGN GOALS

The Signal Hill Professional Center, designed to be an addition to the Manassas Town Center in Northern Virginia, is a 68,000 square foot, four story office building. The building is made up of two sections: a 75′ x 165′ office structure, with appropriate open office loads, resting on a 110′ x 200′ parking structure, which must support relatively large 250 psf fire-engine live loads.

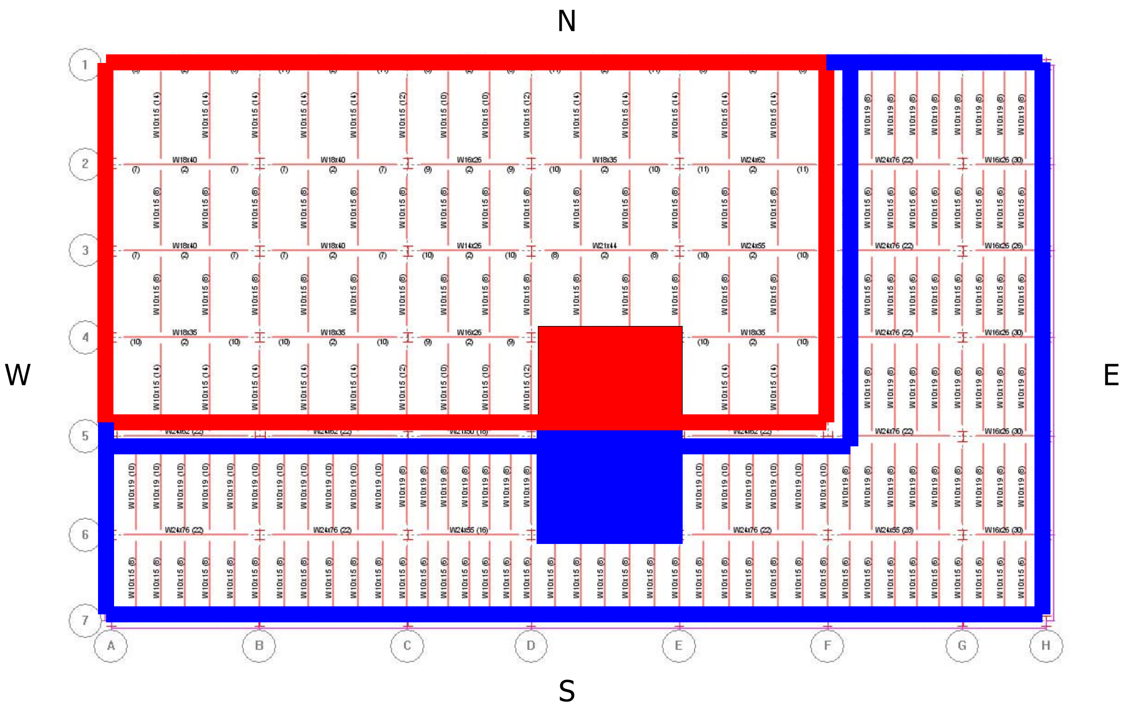
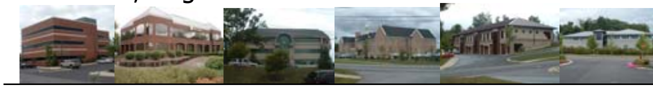


Figure. Structural Layout, Building Highlighted in Red, Parking Highlighted in Blue
Typical Bays Highlighted in Center

The current structure features:

- Bays ranging in width from 17′-6″ to 30′-0″ and in height from 17′-6″ to 20′-0″,
- An office building structure employing typically W10 beams resting on W18 and W21 girders with a 3.5″ thick, 4000 psi concrete slab on a 3″ deck.
- A parking structure employing typically W10 beams resting on W16 and W24 girders with a 4.5″ thick, 4000 psi concrete slab on a 2″ deck.
- An overall floor to ceiling height of 13′-4″, and finished ceiling height of 8′-8″,
- Generally a 27.5″ thick maximum floor section depth in the office area and a 30.5″ thick maximum floor section depth in the parking structure.
- 2-hour fire rating between the parking structure and office building and in the central corridor bays.

This is a relatively typical structure for suburban Washington DC buildings; there are no stringent soil support conditions or lateral loadings. However, this building's 53′-4″ height, which only slightly undercuts the maximum 55′-0″ building height prescribed in Manassas building codes no doubt played a role in overall design.



OUTLINE OF PROPOSED ALTERNATIVES

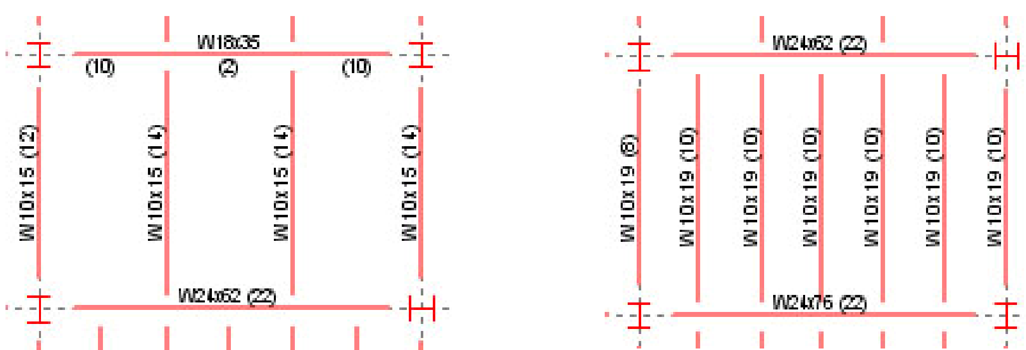
Considering the flexibility of the given floor plan, with only an explicitly designed central corridor, stairwell and bathroom area, many redesigns are possible, with an effort to:

- Maximize efficient use of building materials.
- Minimize floor thickness to shorten the building to more easily conform to Manassas height standards, or to more easily provide for additional engineered services throughout the building.
- Maintain a 2-hour fire rating surrounding the corridor area and a 1-hour fire rating throughout the rest of the building.
- Provide for stable, serviceable, and comfortable working conditions.

Therefore, in an effort to improve the current structural floor system, the following materials were considered separately under both Office and Parking Structure loads:

- **Composite Steel Beams**, spanning in the east-west direction, using output from a RAMSteel model,
- **Non-Composite Steel Beams**, spanning in the north-south and east-west directions, using output from a RAMSteel model,
- **Precast Concrete Floor Planks**, using estimates from the Precast Concrete Institute Manual,
- **Steel Joists** using the New Columbia Joist Company suggested sizes,
- **One-Way Concrete Slab**, using estimates from the CRSI Manual,
- **Concrete Pan-Joists**, spanning in the north-south and east-west directions, using estimates from the CRSI Manual,
- **Manufactured Wood Joists and Girders,** using TrusJoist Specifications, and
- **Two-Way Concrete Slab**, using estimates from the CRSI Manual.

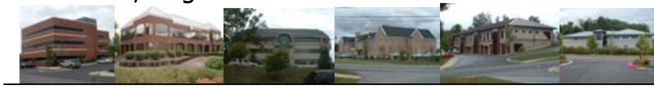
Since loadings are drastically different between the office structure and the underground parking structure and driveway, it is assumed that the two can have different structures; therefore, for most alternatives, separate designs for office (O) and parking structure (P) conditions are considered. For both the office and parking structure, a typical 20'-0"x30'-0" bay is analyzed, which is the largest in both. Assuming that it is an exterior bay, designs found here could be applied throughout both structures.



Office Loads

Parking Loads

Figure. Representative Bays under differing loads showing current composite steel design.



COMPOSITE STEEL BEAMS

Though the current structure already benefits from a composite structural beam system, girders as large as W21 are necessary to support these beams across a maximum 30'-0" east-west span. Therefore, this alteration seeks to reduce girder size and take advantage of the long-span strength of composite steel framing by spanning the beams, not the girders, in the longer 30'-0" east-west span. The same RAMSteel model used for the original building frame analysis was altered and used for this analysis.

Loads for the office building redesign include: *(see Appendix A)*

- 100 psf Live Load (open office)
- 10 psf superimposed Dead Load (MEP, finishes)
- 60 psf Dead Load from 3" Composite Steel Deck and 3.5" lightweight concrete slab
- Controlling 1.2D + 1.6L load combination

Loads for the parking structure redesign include:

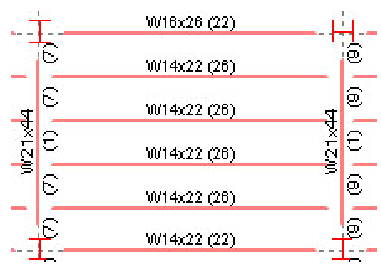
- 250 psf Live Load (fire engine loads)
- 93 psf Dead Load from 2" deck with additional 4.5" normal weight concrete slab and additional 4" asphalt topping
- 30 psf snow load
- Controlling 1.2D + 1.6L + 0.5S load combination

Office Building Design Results:

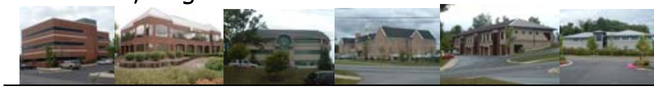
- W12 and W10 beams spaced on average 6'-8" O.C.
- W14 and W12 girders
- 20.5" estimated floor thickness
- 46.3k average bay weight

Parking Structure Design Results:

- W14 and W12 beams spaced on average 4'-0" O.C.
- W21, W18 and W16 girders
- 31.5" estimated floor thickness
- 63.7k average bay weight



The RAM modeler designed the most efficient beams possible; while beams and girders in the office area were fully composite, beams and girders in the parking area were only partially composite. See Appendix A for calculations. The composite system most effectively responds to the longer spans necessary in the rectangular beams. This system proves to be among the lightest, and with only two infill beams per bay, there are plenty of spaces within the floor structure to place additional engineered systems. When the infill beams are spanned in the longer east-west direction, girder depth is reduced by 3", providing more open spaces for additional engineered systems or inhabitable space. However, composite steel construction requires slightly more skilled labor than non-composite systems, and cementitious fireproofing would need to be applied to the beams and girders to obtain the needed two-hour fire rating. In addition, expensive moment frames would be the most logical lateral load resisting system.



NON-COMPOSITE STEEL BEAMS

When considering non-composite steel framing, three conditions were considered:

1. Non-composite steel in an identical layout as the composite system;
2. A similar layout, with closer beam spacing; and
3. Spanning the beams in the 30’-0” east-west direction.

The same RAMSteel model from the composite design was altered for this analysis.

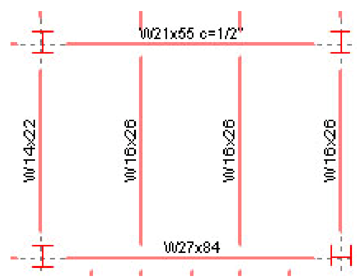
Loads for the office building redesign include:

- 100 psf Live Load (open office)
- 10 psf superimposed Dead Load (MEP, finishes)
- 60 psf Dead Load from 3” Composite Steel Deck and 3.5” lightweight concrete slab
- Controlling 1.2D + 1.6L load combination

Loads for the parking structure redesign include:

- 250 psf Live Load (fire engine loads)
- 93 psf Dead Load from 2” deck with additional 4.5” normal weight concrete slab and additional 4” asphalt topping
- 30 psf snow load
- Controlling 1.2D + 1.6L + 0.5S load combination

Same Basic Layout. The current structure was able to reduce overall floor thickness despite 20’-0” spans and 10’-0” spacing through its composite system; this system however uses labor intensive and structurally heavy shear studs. This redesign investigates the differences between using composite and non-composite beams and girders.

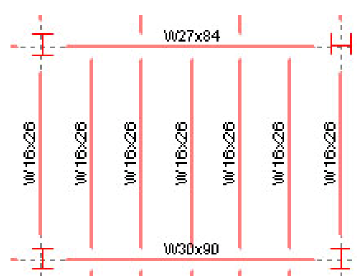


Office Building Design Results: *(see Appendix B)*

- W16 and W14 beams spaced on average 10’-0” O.C.
- W27 and W24 girders
- 30.5” estimated floor thickness
- 48.2k average bay weight

Parking Structure Design Results:

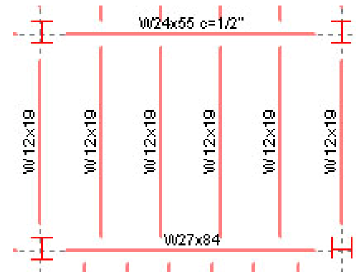
- W16 and W14 beams spaced on average 5’-0” O.C.
- W30 and W27 girders
- 40.5” estimated floor thickness
- 64.7k average bay weight

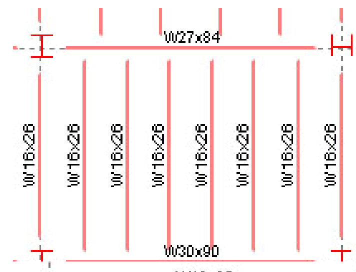


Narrower Beam Spacing. In order to provide suitable room for additional engineered services within the floor section, narrower beam spacing was investigated in an effort to reduce beam sizes.

Office Building Design Results:
- W12 beams spaced on average 6'-0" O.C.
- W27 and W24 girders
- 30.5" estimated floor thickness
- 48.5k average bay weight

Parking Structure Design Results:
- W16 and W14 beams spaced on average 4'-3" O.C.
- W30 and W27 girders
- 40.5" estimated floor thickness
- 65.2k average bay weight

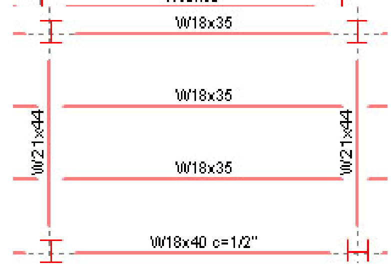


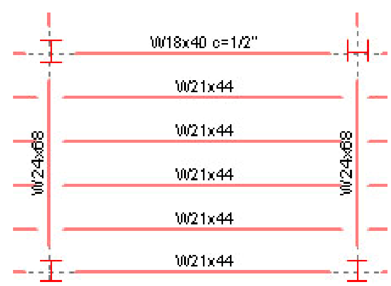


Spanning Beams in the East-West Direction. Since the girder sizes found in both non-composite steel designs featuring north-south beam spacing were significantly larger than those used in the non-composite design, this alteration seeks to span the beams in the larger 30'-0" east-west direction to shorten the girder span and perhaps girder depth.

Office Building Design Results:
- W18 and W16 beams spaced on average 6'-4" O.C.
- W21 and W18 girders
- 27.5" estimated floor thickness
- 49.1k average bay weight

Parking Structure Design Results:
- W21 and W18 beams spaced on average 4'-0" O.C.
- W27 and W24 girders
- 37.5" estimated floor thickness
- 66.3k average bay weight





Like composite steel construction, non-composite steel construction is lightweight, with easy, fast, and therefore less expensive construction. However, without strength from a composite system, non-composite systems require deeper beams or narrower spacing, which either expands the floor thickness into inhabited spaces or makes it more difficult to incorporate other engineered systems. Regardless, girders as large as 24" and 30" deep are necessary to support loads for the office building and parking structures, unless they span in the shorter 20'-0" north-south direction, which reduces depth by about 3". Also like composite construction, cementitious fireproofing would be necessary on the steel members and costly moment frames would be most likely used to resist lateral forces. In addition, like in the composite steel designs, the RAM modeler presented beam designs just barely strong enough for the given loads.

PRECAST CONCRETE PLANK FLOOR SYSTEM

In order to reduce system weight and floor thickness, precast structural floor planks were considered for two conditions:

1. Double-T Planks
2. Hollowcore Concrete Planks

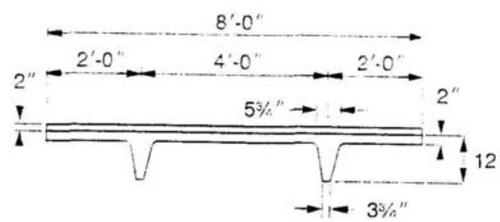
The Prestressed Concrete Institute Manual was used for member sizing. Since planks capable of supporting heavier parking loads are designed for long spans, more analysis and possibly a new layout would be necessary to size members in the parking structure.

Loads for the office building redesign include:

- 100 psf Live Load (open office)
- 15 psf superimposed Dead Load (MEP, finishes)
- Controlling D + L service load combination

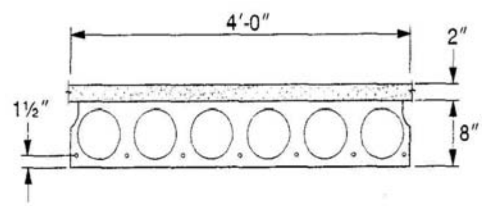
Double-T Planks. Office Building Design Results: *(see Appendix C)*

- 8′-0″ wide by 12″ deep Double-T lightweight concrete Planks, untopped, number 48-S, spanning in the north-south 20′-0″ direction
- 12″ wide by 28″ deep precast concrete beam or W24x55 steel girder spanning in the east-west 30′-0″ direction
- 28″-32″ estimated floor thickness
- 29.4k-47.4k average bay weight



Hollowcore Concrete Planks. Office Building Design Results:

- 4′-0″ wide by 8″ deep Hollowcore lightweight concrete Planks, number 66-S, spanning in the north-south 20′-0″ direction
- 12″ wide by 32″ deep precast rectangular girder, 12″ wide, 28″ deep inverted T-beam, or W21x62 steel girder spanning in the east-west 30′-0″ direction
- 29″-40″ estimated floor thickness
- 40.3k-69.6k average bay weight



Precast concrete planks proved to provide among the narrowest floor section depths and one of the lightest average bays. Since they are prefabricated, initial quality is expected to be superior, quick and easy construction offsets the more expensive initial costs, and, unlike steel systems, a two-hour fire rating is already achieved through the planks. Ample room would be provided for additional engineered systems between girders for both systems. However, since this system is prefabricated, longer lead times would be necessary to procure the necessary planks, and the benefits of thin precast planks are overshadowed by deep precast concrete beams or non-composite steel girders.

STEEL JOIST FRAMING

When considering the larger loads in the open office building and parking structure, prefabricated steel joists were analyzed due to their light weight and longer span capabilities. Two conditions were considered:

1. Joists spanning the shorter 20'-0" north-south direction, and
2. Joists spanning the longer 30'-0" east-west direction.

Specification guides provided by the New Columbia Joist Company were used to size the individual joists while hand calculations were used to determine appropriate supporting girder sizes.

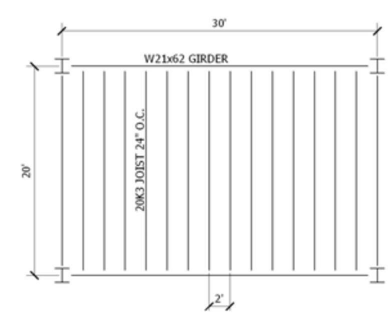
Loads for the office building redesign include:

- 100 psf Live Load (open office)
- 10 psf superimposed Dead Load (MEP, finishes)
- 60 psf Dead Load from 3" Composite Steel Deck and 3.5" lightweight concrete slab
- Controlling D + L service load combination

Loads for the parking structure redesign include:

- 250 psf Live Load (fire engine loads)
- 93 psf Dead Load from 2" deck with additional 4.5" normal weight concrete slab and additional 4" asphalt topping
- 30 psf snow load
- Controlling D + L + S service load combination

North-South Span. This alteration seeks to minimize joist depth by spanning them in the shorter direction.

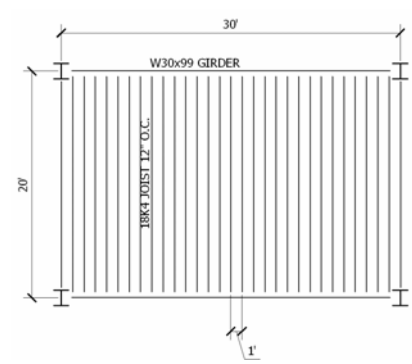


Office Building Design Results: *(see Appendix D)*

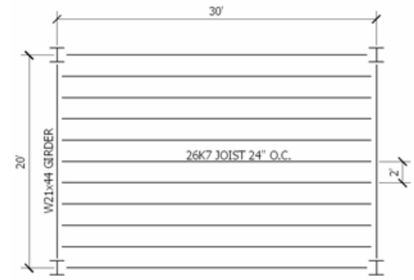
- 16K2 Joists spaced 2'-0" O.C.
- W21 Girders
- 27.5" estimated floor thickness
- 47.5k average bay weight

Parking Structure Design Results:

- 16K3 Joists spaced 12" O.C.
- W30 girders
- 40.5" estimated floor thickness
- 65.7k average bay weight

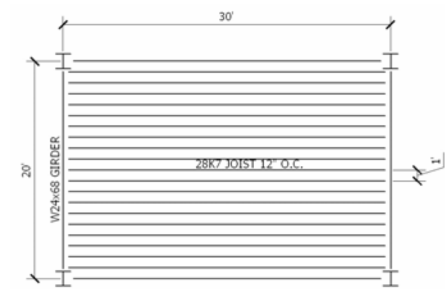


East-West Span. This alteration seeks to minimize overall floor thickness through minimizing girder depth by taking advantage of the long-span capabilities of Steel Joists.



Office Building Design Results:

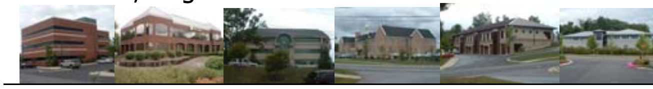
- 22K5 Joists spaced 2'-0" O.C.
- W21 Girders
- 27.5" estimated floor thickness
- 46.8k average bay weight



Parking Structure Design Results:

- 24K5 Joists spaced 12" O.C.
- W24 girders
- 34.5" estimated floor thickness
- 65.1k average bay weight

The steel joist system provided a very light building weight and surprisingly an equal or slightly smaller floor section thickness than in traditional steel framing, especially under the large parking structure loads. While the joists were closely spaced, open areas in the webs would provide spaces for narrow mechanical ductwork and systems. In addition, open web steel joist construction is much simpler than composite steel beams. However, complicated fireproofing and long procurement times could affect the viability of this solution.



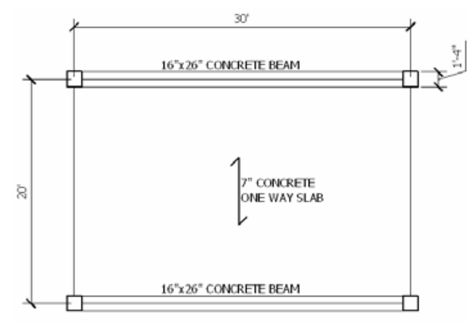
ONE WAY CONCRETE SLAB

In an effort to reduce overall floor thickness, increase structural rigidity, and improve fire resistance, concrete slabs and beams were considered. Due to the rectangular (20'-0"x30'-0") spans, two-way slabs would not be possible without a significant column redesign. The CRSI was used for this analysis, assuming normal strength concrete and standard concrete forms.

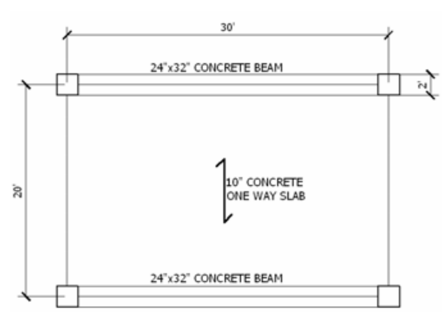
Loads for the office building redesign include:
- 100 psf Live Load (open office)
- 15 psf superimposed Dead Load (MEP, finishes)
- Controlling 1.4D + 1.7L load combination

Loads for the parking structure redesign include:
- 250 psf Live Load (fire engine loads)
- 50 psf Dead Load from 4" asphalt topping (conc. self-weight only for beams)
- 30 psf snow load
- Controlling 1.4D + 1.7L + S load combination

Office Building Design Results: *(see Appendix E)*
- 7" thick concrete slab, spanning in the 20'-0" north-south direction, with #6@10" top reinforcement and #6@11 bottom reinforcement
- 26" deep by 16" wide concrete beams, spanning in the 30'-0" east-west direction, poured integrally with the slab, using 3-#10 top reinforcement and 2-#10 bottom reinforcement.
- 26" estimated floor thickness
- 72.5k average bay weight



Parking Structure Design Results:
- 10" thick concrete slab, spanning in the 20'-0" north-south direction, with #8@12" top reinforcement and #8@13 bottom reinforcement
- 32" deep by 24" wide concrete beams, spanning in the 30'-0" east-west direction, poured integrally with the slab, using 6-#14 top reinforcement and 3-#14 bottom reinforcement.
- 36" estimated floor thickness
- 123.0k average bay weight



The key benefit to the one-way slab was the reduction in floor thickness. Besides being on average 1.5" narrower than all but one steel floor construction, the lack of joists produces large areas below the slab for additional engineered systems. Unlike steel framing, fireproofing is not a concern with a 7" thick slab; like traditional steel framing, a one-way slab is relatively easy to construct. Since a concrete floor is capable of acting as an effective diaphragm for lateral force resistance, shear walls would be the key lateral structural system, requiring some architectural redesign around the corridor area.

PAN JOISTS

While using a concrete floor structure, Pan Joists were considered to reduce the overall floor thickness and more efficiently use concrete materials. For this alternative, two conditions were considered:

1. Pan Joists spanning the shorter 20'-0" north-south direction, and
2. Pan Joists spanning the longer 30'-0" east-west direction.

The CRSI was used for this analysis, assuming normal strength concrete and standard concrete forms.

Loads for the office building redesign include:

- 100 psf Live Load (open office)
- 15 psf superimposed Dead Load (MEP, finishes)
- Controlling 1.4D + 1.7L load combination

Loads for the parking structure redesign include:

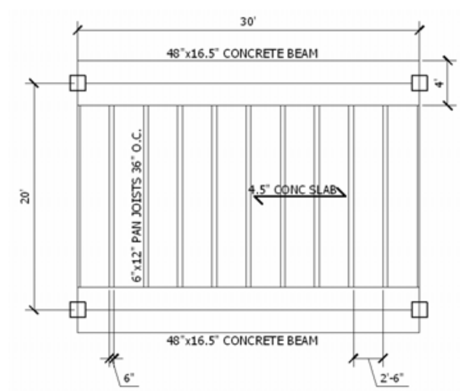
- 250 psf Live Load (fire engine loads)
- 50 psf Dead Load from 4" asphalt topping
- 30 psf snow load
- Controlling 1.4D + 1.7L + S load combination

Per the CRSI, self-weight of concrete was only considered for beam sizing.

North-South Span. This alteration seeks to mimic most closely the existing system.

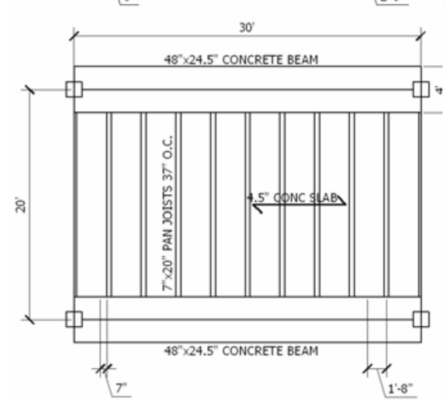
Office Building Design Results: *(see Appendix F)*

- 6" wide, 16" deep ribs spaced 36" O.C., spanning in the 20'-0" direction
- 4.5" thick concrete slab, poured monolithically with the joists, with #4@8" top reinforcement and 1-#5/1-#6 bottom reinforcement
- 20.5" deep by 24" wide girder, poured monolithically with the joists, spanning in the east-west 30'-0" direction.
- 20.5" estimated floor thickness
- 80.95k average bay weight



Parking Structure Design Results:

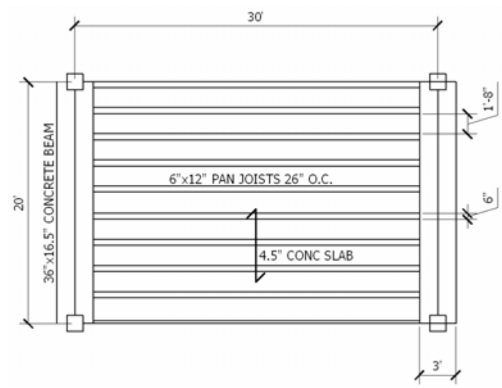
- 7" wide, 20" deep ribs spaced 37" O.C., spanning in the 20'-0" direction
- 4.5" thick concrete slab, poured monolithically with the joists
- 24.5" deep by 48" wide girder, poured monolithically with the joists, spanning in the east-west 30'-0" direction.
- 24.5" estimated floor thickness
- 116.0k average bay weight



East-West Span. In order to reduce the total concrete used, this alteration seeks to minimize the girder size through spanning joists in the longer 30’-0” east-west span.

Office Building Design Results:

- 6” wide, 12” deep ribs spaced 26” O.C., spanning in the 30’-0” direction
- 4.5” thick concrete slab, poured monolithically with the joists, with #4@11.5” top reinforcement and 1-#4/1-#5 bottom reinforcement
- 16.5” deep by 36” wide girder, poured monolithically with the joists, spanning in the north-south 20’-0” direction.
- 16.5” estimated floor thickness
- 67.0k average bay weight



For the east-west span under office loads and north-south span under parking loads, Pan Joists were determined to be a very good possibility for redesign. Besides being the narrowest, with floor section depths 4” and 7” less than composite steel designs in the office and parking structure, respectively, it is also the lightest concrete system. Though a little more complicated for construction than a one-way slab system, standard pan sizes can be reused throughout the building. Unlike the one-way slab system, a thin (4.5”) slab means that complex fireproofing would have to be addressed or the slab would need to be thicker and heavier; like all other concrete systems, shear walls would be most likely the best lateral force resisting system, which would require a redesign around the central stairwell and corridor area.

MANUFACTURED WOOD FRAMING

Though not typical for commercial office buildings, TrusJoist manufactured wood joists and girders were investigated due to their high quality, light weight, and possible benefits. For this alteration, two conditions are considered:

1. Wood Joists spanning the shorter 20'-0" north-south direction, and
2. Wood Joists spanning the longer 30'-0" east-west direction.

For this analysis, specifications provided by TrusJoist literature were used to size joists and girders based on service loads.

Loads for the office building redesign include:

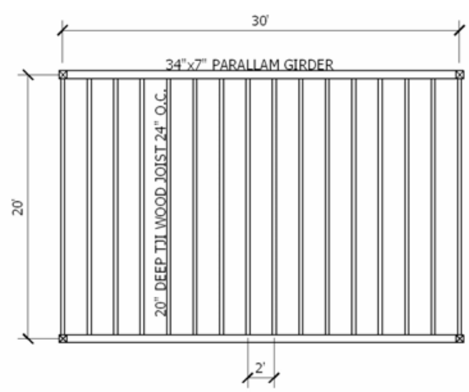
- 100 psf Live Load (open office)
- 20 psf superimposed Dead Load (MEP, finishes, wood floor panels)
- Service Loading

Per the specifications, self-weight of wood was not considered.

North-South Span. This alteration seeks to mimic most closely the existing system and serve as a comparison for steel and concrete pan joists.

Office Building Design Results: *(see Appendix G)*

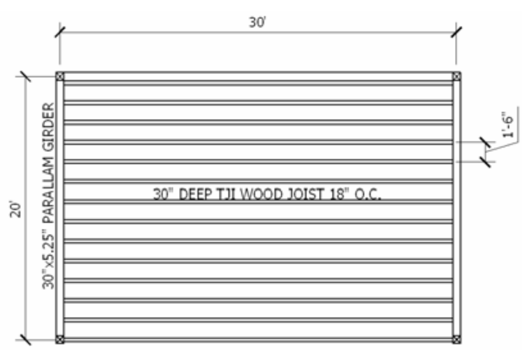
- 22" deep by 3.5" wide TJI H90 wood joists spaced 24" O.C., spanning in the 20'-0" direction
- Traditional Plywood flooring
- 34" deep by 7" Parallam commercial girders spanning in the 30'-0" direction
- 34.5" estimated floor thickness
- 18.4k average bay weight



East-West Span. In order to reduce the total floor thickness via thinner girders, wood joists spanning in the larger 30'-0" east-west direction were considered.

Office Building Design Results:

- 30" deep by 3.5" wide TJI H90 wood joists spaced 18" O.C., spanning in the 30'-0" direction
- Traditional Plywood flooring
- 30" deep by 7" Parallam commercial girders spanning in the 30'-0" direction
- 30.5" estimated floor thickness
- 17.44k average bay weight



Due to the relatively large loading and flexibility of wood members, wood joist framing was not considered for the parking garage.

Though unconventional for suburban office buildings, wood framing could be a viable alternative for the office structure, and could serve as a distinct architectural addition to its interior appearance. Especially with wood joists spanning in the larger east-west direction, the floor depth is only 4" greater than a non-composite steel system, and the average bay weight is about 60% less. Due to the nature of its unconventional construction, issues of floor flexibility and vibration isolation, fire resistance in combustible members, and overall performance characteristics would need to be analyzed, and, like the concrete structures, shear walls, perhaps using another material, would need to be designed around the central stairwell/corridor area as the lateral force resisting system.

TWO WAY SLAB

Two-way slabs can have smaller floor section depths and simpler construction. Since a two-way slab is impractical with rectangular bays, this redesign would only be possible if the 165′ x 75′ building footprint were arranged into bays ranging from 20′ x 25′ to 25′ x 25′. *(see Appendix H)*

Loads for the office building redesign include:

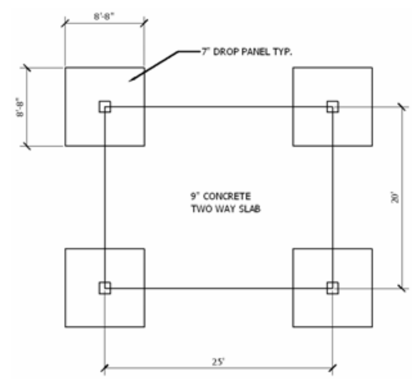
- 100 psf Live Load (open office)
- 15 psf superimposed Dead Load (MEP, finishes)
- Controlling 1.4D + 1.7L load combination

Loads for the parking structure redesign include:

- 250 psf Live Load (fire engine loads)
- 50 psf Dead Load from 4″ asphalt topping (conc. self-weight only for beams)
- 30 psf Snow Load
- Controlling 1.4D + 1.7L + S load combination

With Drop Panels. A potential design using this system included:

- 9″ flat slab with 7″ deep, 9′-0″ square drop panels for the office building,
- 11″ flat slab with 9″ deep, 9′-0″ square drop panels for the parking structure.



Flat Slab. A potential design using this system included:

- 8″ flat slab throughout office building.

This system would work most effectively with bay sizes approaching 20′-0″ square.

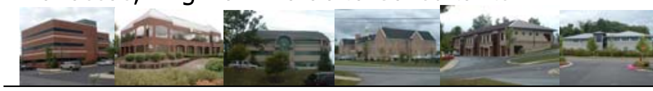
Since the building features an open floor plan, with only corridors, bathrooms and stairwells explicitly laid out in the building center, it would be easier to design the building for three 25′-0″ wide north-south bays and two 20′-0″ and five 25′-0″ wide east-west bays. As the bays would approach a 20′-0″ square spacing, a two-way slab would become more practical.

CONCLUSIONS

A cursory analysis of varying structural systems designed to resist gravity loads for both a four story office building and its supporting parking garage showed that:

- When beams are spanned in the longer East-West direction, deflection tends to control over flexural capacity, producing much larger beams. However, girder size is significantly reduced.
- Concrete systems are significantly heavier than all other systems. Though soil bearing capacities aren't a major factor in this particular building design, larger building weights would cause larger footings and foundation elements.
- Composite Steel systems are the lightest and provide ample room in the floor section for additional engineered systems. However, these systems are slightly more complicated to construct than non-composite systems, and moment frames become necessary for lateral force resistance.
- Non-Composite Steel systems are simpler to construct than composite systems, though large floor section depths are necessary.
- Prefabricated Concrete Plank systems are most easy to install and maintain high quality and can provide significantly lighter average bays and relatively thinner floor section depths. Precast Planks resting on non-composite steel beams is the most viable system.
- Steel Joists provide ample room for additional engineered systems and actually feature floor section depths similar to traditional steel framing systems. Easy installation would be offset by long procurement times, while complicated fireproofing would need to be addressed.
- One-Way Concrete slabs, though heavy, provide a sturdy floor diaphragm to resist lateral forces when in combination with shear walls, and provide spaces for additional engineered systems.
- Pan Joists are the most viable concrete alternative with very small section depths and relatively light weight. Joists every 20" or 30" however may inhibit additional engineered system placement.
- TrusJoist manufactured Wood Joists and Parallam beams provide a super-lightweight structure which has only a slightly larger depth than non-composite steel systems. However, further research is necessary into performance characteristics of wood structures before it is applied to an office building.

See the following comparison table for a summary.



STRUCTURAL FLOOR SYSTEM COMPARISON TABLE

Floor System	Depth (in)	Bay Wt. (kips)	Pros	Cons	Further Analysis?
Composite Steel, N/S Span	27.5 (O) 34.5 (P)	46.0 (O) 63.2 (P)	• Lightweight • Fast Construction • Narrow Floor Section Depth	• Additional Fireproofing required • Moment Frame most possible lateral system	N/A
Composite Steel, E/W Span	20.5 (O) 31.5 (P)	46.3 (O) 63.7 (P)	• Lightweight • Fast Construction • Narrow Floor Section Depth	• Additional Fireproofing required • Moment Frame most possible lateral system	Yes
Non-Composite Steel, Given Layout	30.5 (O) 40.5 (P)	48.2 (O) 64.7 (P)	• Lightweight • Traditional Construction	• Additional Fireproofing required • Moment Frame most possible lateral system • Large Floor Section Depth	No
Non-Composite Steel, Narrower N/S Span	30.5 (O) 40.5 (P)	48.5 (O) 65.2 (P)	• Lightweight • Traditional Construction	• Additional Fireproofing required • Moment Frame most possible lateral system • Large Floor Section Depth • Multiple Joists inhibit MEP system placement	No
Non-Composite Steel E/W Span	27.5 (O) 37.5 (P)	49.1 (O) 66.3 (P)	• Lightweight • Traditional Construction • Reduced Floor Section Depth	• Additional Fireproofing required • Moment Frame most possible lateral system • Enlarged beams for deflection due to long 30'-0" span	Yes
Prefabricated Concrete Double-T Plank	28.0-32.0 (O)	29.4-47.4 (O)	• Good Fire Rating • High Initial Quality from prefabrication • Easy, Fast Construction	• Can have larger floor section depths • Long Procurement needed for planks	Yes
Prefabricated Concrete Hollowcore Plank	28.0-40.0 (O)	40.3-69.6 (O)	• Good Fire Rating • High Initial Quality from prefabrication Easy Construction	• Can have larger floor section depths • Long Procurement needed for planks	Yes

STRUCTURAL FLOOR SYSTEM COMPARISON TABLE, CONTINUED

Floor System	Depth (in)	Bay Wt. (kips)	Pros	Cons	Further Analysis?
Steel Joists, N/S Span	27.5 (O) 40.5 (P)	47.5 (O) 65.6 (P)	• Lightweight • Fast Construction • Open Web Joists provide spaces for MEP placement	• Complicated Fireproofing required • Moment Frame most possible lateral system • Very Large Floor Section Depth	No
Steel Joists, E/W Span	27.5 (O) 34.5 (P)	46.8 (O) 65.1 (P)	• Lightweight • Fast Construction • Open Web Joists provide spaces for MEP placement	• Complicated Fireproofing required • Moment Frame lateral system • Very Large Floor Section Depth	No
One-Way Concrete Slab	26.0 (O) 36.0 (P)	72.5 (O) 123.0 (P)	• Easy, Simple Construction • Narrow Floor provides space for MEP systems • Good Fire Rating • Floor Diaphragm capable of resisting lateral forces	• Very Heavy Weight • Shear Walls most likely needed for lateral system • Possible foundation redesign for weight	Yes
Concrete Pan Joists, N/S Span	20.5 (O) 24.5 (P)	81.0 (O) 116.0 (P)	• Very narrow floor section depth • Lightest Concrete Construction • Standard Pan Sizes • Easy Construction	• Complicated Fireproofing required • Shear Walls most likely needed for lateral system • Possible foundation redesign for weight	Yes
Concrete Pan Joists, E/W Span	16.5 (O)	67.0 (O)	• Very narrow floor section depth • Lightest Concrete Construction • Standard Pan Sizes • Easy Construction	• Complicated Fireproofing required • Shear Walls most likely needed for lateral system • Possible foundation redesign for weight	No
Wood Framing, N/S Span	34.5 (O)	18.4 (O)	• Most Lightweight • Easy Joist/Hanger Construction • Generates Visual Interest • Average Floor Depth • High quality prefabrication w	• Complicated Fireproofing required • Shear Walls most likely needed for lateral system • Flexible Floor Diaphragm subject to vibrations and creaking • Close Joists inhibit MEP placement	Yes

STRUCTURAL FLOOR SYSTEM COMPARISON TABLE, CONTINUED

Floor System	Depth (in)	Bay Wt. (kips)	Pros	Cons	Further Analysis?
Wood Framing, E/W Span	30.5 (O)	17.5 (O)	• Most Lightweight • Easy Joist/Hanger Construction • Generates Visual Interest • Average Floor Depth • High quality, prefabricated	• Complicated Fireproofing required • Shear Walls most likely needed for lateral system • Flexible Floor Diaphragm subject to vibrations and creaking • Close Joists inhibit MEP placement	Yes
Two-Way Concrete Slab with Drop Panels	15.0 (O) 20.0 (P)	83.8 (O) 126.0 (P)	• Good Fire Rating • Small Floor Section Depth	• Complicated Construction around Drop Panels • Requires New Layout • Very Heavy – possible foundation redesign required	No
Two-Way Flat Slab	8.0 (O)	69.0 (O)	• Good Fire Rating • Very Narrow Floor Section Depth • Lighter than One-Way Slab • Very Easy to Construct	• Requires New Layout • Very Heavy – possible foundation redesign required	Yes

APPENDIX A: COMPOSITE STEEL DESIGN CALCULATIONS/REFERENCES

COMPOSITE STEEL WEIGHT CALCULATIONS

STANDARD SYSTEM

OFFICE BUILDING WEIGHT: [redacted], 70 PSF DL

([redacted] + 70)(20)(30) = [redacted] 42^K
4(W10x12)(20') = 0.960^K
2(W16x31)(30') = 1.860^K
ASSUME 10lb/SHEAR STUD (134) = 1.340^K
Σ [redacted] 46.16 K

PARKING STRUCTURE WEIGHT:

[redacted], 93 PSF D, [redacted]
(93)(20)(30) = 55.8^K
6[redacted](W12x14)(20') = 1.680^K
1(W10x12)(20') = 0.240^K
1(W21x48)(30') = 1.440^K
1(W24x55)(30') = 1.650^K
228 V STUDS (10) = 2.280^K
Σ 63.09 K

DIFFERING SPANS

OFFICE BUILDING WT: 70 PSF DL

(70)(20)(30) = 42^K
3(W12x16)(30') = 1.440
1(W12x14)(30') = 0.420
2(W14x22)(20') = 0.880
154 STUDS (10lb) = 1.540
Σ 46.28^K

PARKING STRUCTURE WT: 93 PSF DL

(93)(20)(30) = 55.8^K
6(W14x22)(30) = 3.960
2(W21x44)(20) = 1.760
214 STUDS (10lb) = 2.140
Σ 63.66^K

SAMPLE COMPOSITE BEAM CALCULATIONS

CHECKING W12x16 (24 SHEAR STUDS) OFFICE BEAM

100 PSF L (1.6) + 70 PSF D (1.2) = 244 PSF (6'-8" TRIB) = 1626 PLF

$M_{MAX} = \frac{1}{8}wL^2 = \frac{1}{8}(1.626)(30^2) = 189$ FT-K

FROM SPECS

$\Sigma Q_N = 24(19.6^K/\text{STUD}) = 470.4^K/2 = 235.2^K$ → FULLY COMPOSITE

ASSUME $Y1 = 0$

$a = \frac{235.2}{0.85(4)(45)} = 1.54''$ $Y2 = 6.5 - \frac{1}{2}a = 5.73$

$b_{eff} = \frac{1}{8}(30') = 45''$

$\phi_b M_p = 192$ FT-K > 189 ✓ OK

CHECKING W14x22 (26 SHEAR STUDS) PARKING BEAM

250 PSF L(1.6) + 93 PSF D(1.2) + 30 PSF S(0.5) = 526.6 PSF (4' TRIB) 2.107 KLF

$M_{MAX} = \frac{1}{8}wL^2 = 237$ FT-K

$\Sigma Q_N = 26(19.6^K/\text{STUD}) = 509.6^K/2 = 255^K$ → NOT FULLY COMPOSITE

$b_{eff} = 45''$

$a = \frac{255}{0.85(4)(45)} = 1.54''$ $Y2 = 6.5 - \frac{1}{2}a = 5.73$

ASSUME $\Sigma Q_N = 241^K$ → $\phi_b M_p = 251$ FT-K > 237 ✓ OK

CHECKING W14x22 (25 SHEAR STUDS) OFFICE GIRDER

[illegible] $\Sigma Q_N = 25(19.6^K/\text{STUD}) = 255^K$

USING REDUCED LIVE LOADS, $M = [1.2(7.24 + 5.98) + 1.6(8.04 + 6.70)]6.667 = 260$ FT-K

$a = \frac{255}{0.85(4)(60)} = 1.25$ $Y2 = 6.5 - \frac{1}{2}a = 5.875$

$\phi_b M_p = 267$ FT-K > 260 ✓

APPENDIX B: NON-COMPOSITE STEEL DESIGN CALCULATIONS/REFERENCES

NON COMPOSITE STEEL WEIGHT CALCULATIONS

SAME BASIC LAYOUT

OFFICE BUILDING WEIGHT: 70 PSF DL

(70)(20)(30) = 42K
3(W16x26)(20') = 1.560
1(W14x22)(20') = 0.440
1(W21x55)(30') = 1.650
1(W27x84)(30') = 2.520
Σ 48.17K

PARKING STRUCTURE WEIGHT: 93 PSF DL

(93)(20)(30) = 55.8K
7(W16x26)(20') = 3.640K
1(W27x84)(30') = 2.520K
1(W30x90)(30') = 2.700K
Σ 64.66K

NARROWER BEAM SPACING

OFFICE BUILDING WEIGHT: 70 PSF DL

(70)(20)(30) = 42.0K
6(W12x19)(20') = 2.280K
1(W24x55)(30') = 1.650
1(W27x84)(30') = 2.520
Σ 48.45K

PARKING STRUCTURE WEIGHT: 93 PSF DL

(93)(20)(30) = 55.8K
8(W16x26)(20') = 4.160
1(W27x84)(30') = 2.520
1(W30x90)(30') = 2.700
Σ 65.18K K

EAST-WEST BEAM SPACING

OFFICE BUILDING WEIGHT: 70 PSF DL = 1

(70)(20)(30) = 42.0K
3(W18x35)(30') = 3.150
1(W18x40)(30') = 1.20
2(W24x68)(20') = 2.72
Σ 49.07K

PARKING STRUCTURE WEIGHT: 93 PSF DL =

(93)(20)(30) = 55.8K
5(W21x44)(30') = 6.6K
1(W18x40)(30') = 1.2K
2(W24x68)(20') = 2.720K
Σ 66.32K

SAMPLE NON-COMPOSITE BEAM CALCULATIONS

CHECKING W16x26 BEAM (NORMAL OFFICE CONFIGURATION)

244 PSF (10'-0" TRIB) = 2.444 [redacted]
M = ⅛wL² = 122.2 FT-K
FULLY BRACED → ϕbMp = 166 FT-K ✓ [TBL 5-4 LRFD SPEC]

CHECKING W30x90 GIRDER (NORMAL PARKING CONFIGURATION)

527 PSF ([redacted] 18.75 TRIB) = [redacted] 9.8 KLF
M = ⅛wL² = [redacted] = 1102 K-FT
↳ ϕbMp = 1060 K-FT OK POINT LOADS FROM BEAMS LESS THAN THIS DISTRIBUTED LOAD
MU = 920 FT-K ✓ OK

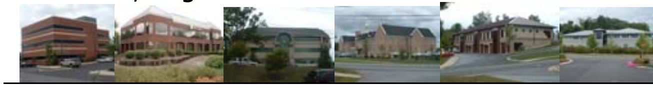
CHECKING W18x35 BEAM (EW CONFIGURATION)

[redacted] 244 PSF (8.3' TRIB) = 2.03 KLF M = 228 FT-K
FULLY BRACED ϕbMp = 249 FT-K ✓

CHECKING W21x44 BEAM (EW CONFIGURATION)

527 PSF (4' TRIB) = 2.108 KLF M = 237.2 FT-K
ϕbMp = 359 FT-K ✓ OK → (250+93+30) 4' = 1.492 K

$$\Delta = \frac{5wL^4}{384EI} = \frac{5([redacted])(30^4)(1728)}{384(29000)(843)} = 1.01'' \sim \frac{L}{360} = 1''$$



APPENDIX C: PCI PRECAST CONCRETE PLANK DESIGN CALCULATIONS/REFERENCES

PRECAST PLANK FLOORS

LOADING (SERVICE)

OFFICE. 100 PSF L + 15 PSF D = 115 PSF
PARKING. 250 PSF L + 50 PSF D + 30 PSF S = 330 PSF

MEMBER SELECTION

OFFICE. USE 8'-0" x 12" DOUBLE-T UNTOPPED 48-S
CAPABLE OF 120 PSF WT = 29 PSF
GIRDER. (115 + 29)(20' TRIB) = 2880 PLF
USE 12" WIDE BY 28" DEEP PRECAST BEAM
CAPABLE OF 3197 PLF WT. = 350 PLF

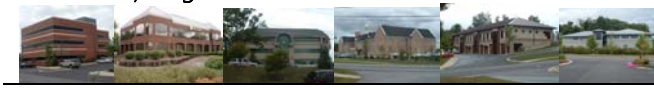
STEEL. Mu = 478.8 FT-K
$Z_{MIN} \geq 127.7$ IN³
USE

OFFICE ALTERNATE. USE 4'-0" x 8" LW CONC. HOLLOWCORE 66-S
CAPABLE OF 152 PSF WT = 46 PSF
GIRDER. (115 + 46)(20' TRIB) = 3220 PLF
USE 12" WIDE BY 32" DEEP BM
CAPABLE OF 4268 PLF WT = 400 PLF
ALTERNATIVE GIRDER: USE 28" DEEP, 1'-0" WIDE INVERTED TEE BEAM
: (HOLLOWCORE PLANK SITS ON T)

ALTERNATIVE STEEL GIRDER. [(61)(1.2) + 100(1.6)] 20' = 4.664 KLF
$M_{MAX} = \frac{1}{8} wL^2 =$ = 524.7 FT-K
$Z_{MIN} \geq 140$ IN³
USE

WEIGHT

DOUBLE T, PRECAST GIRDER	(15 + 29)(20)(30)	= 26.4 K
	(350)(2)(30)	= 21.0 K
		Σ 47.4 K
DOUBLE T, STEEL GIRDER	(15 + 29)(20)(30)	= 26.4 K
	( )(2)(30)	=
		Σ
HOLLOW CORE, PRECAST SQUARE GIRDER	(15 + 46)(20)(30)	= 36.6 K
	(400)(2)(30)	= 24.0 K
		Σ 60.4 K
HOLLOWCORE, INVERTED T	(15 + 46)(20)(30)	= 36.6
	(550)(2)(30)	= 33.0
		Σ 69.6 K
HOLLOWCORE, STEEL GIRDER	(15 + 46)(20)(30)	= 36.6 K
	( )(2)(30)	=
		Σ



Strand Pattern Designation

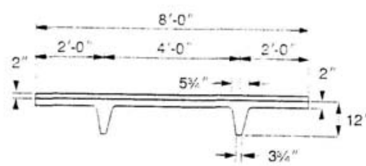
68-D1
- No. of strand (6)
- S = straight D = depressed
- No. of depression points
- Diameter of strand in 16ths

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Key
186 — Safe superimposed service load, psf
0.2 — Estimated camber at erection, in.
0.3 — Estimated long-time camber, in.

DOUBLE TEE

8′-0″ x 12″
Lightweight Concrete



f'_c = 5,000 psi
f_{pu} = 270,000 psi

Section Properties

		Untopped	Topped
A	=	287 in²	—
I	=	2,872 in⁴	4,819 in⁴
y_b	=	9.13 in.	10.82 in.
y_t	=	2.87 in.	3.18 in.
S_b	=	315 in³	445 in³
S_t	=	1,001 in³	1,515 in³
wt	=	229 plf	429 plf
		29 psf	54 psf
V/S	=	1.22 in.	

8LDT12

Table of safe superimposed service load (psf) and cambers (in.) — **No Topping**

Strand Pattern	e_e, in. / e_c, in.	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
28-S	7.13 / 7.13	186	144	116	89	68	53	41	31								
		0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.6								
		0.3	0.4	0.5	0.6	0.6	0.7	0.7	0.6								
48-S	5.13 / 5.13			195	153	120	95	77	62	50	41	33					
				0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.3	1.3					
				0.8	0.9	1.1	1.2	1.3	1.3	1.4	1.3	1.2					
68-S	3.13 / 3.13				169	133	106	86	70	57	47	39	32				
					0.6	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.0				
					0.8	1.0	1.1	1.1	1.1	1.1	1.0	0.8	0.5				
68-D1	3.13 / 6.63											72	61	52	45	38	33
												2.6	2.8	3.0	3.1	3.2	3.2
												2.9	2.9	2.9	2.7	2.4	2.1

Strand Pattern Designation

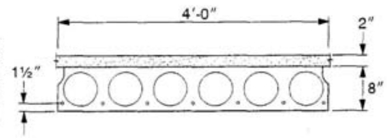
76-S
- S = straight
- Diameter of strand in 16ths
- No. of strand (7)

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load. Check availability of lightweight sections.

Capacity of sections of other configurations are similar. For precise values, see local hollow-core manufacturer.

HOLLOW-CORE

4′-0″ x 8″
Lightweight Concrete



f'_c = 5,000 psi
f'_{ci} = 3,500 psi

Section Properties

		Untopped	Topped
A	=	215 in²	—
I	=	1,666 in⁴	3,529 in⁴
y_b	=	4.00 in.	5.70 in.
y_t	=	4.00 in.	4.30 in.
S_b	=	416 in³	619 in³
S_t	=	416 in³	821 in³
b_w	=	12.00 in.	12.00 in.
wt	=	184 plf	272 plf
		46 psf	68 psf
V/S	=	1.92 in.	

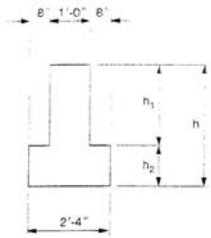
Key
346 — Safe superimposed service load, psf
0.3 — Estimated camber at erection, in.
0.4 — Estimated long-time camber, in.

4LHC8

Table of safe superimposed service load (psf) and cambers (in.) — **No Topping**

Strand Designation Code	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
66-S	346	297	257	224	196	172	152	135	120	107	95	85	76	68	61	55	49	44	39	35			
	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.0			
	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.2	0.0	−0.1	−0.3	−0.5	−0.8			
76-S		348	302	263	231	204	181	161	144	129	115	104	93	84	76	68	62	56	50	45	41	36	
		0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.0	
		0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.3	0.1	−0.1	−0.3	−0.6	−0.9	
58-S		350	325	304	286	265	236	211	189	170	154	139	126	114	104	95	86	79	72	66	60	55	50
		0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.8	0.7
		0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	0.9	0.8	0.7	0.5	0.2	0.0
68-S			334	313	292	274	258	243	229	206	187	169	154	140	128	117	107	98	90	83	76	70	64
			0.7	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.4
			1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.3	1.1	0.9
78-S			343	319	301	283	267	249	237	225	212	197	181	165	151	139	127	117	108	100	92	85	78
			0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.0	2.1	2.1	2.1	2.2	2.2	2.1	2.1
			1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3	2.3	2.3	2.2	2.2	2.1	2.0	1.8

INVERTED TEE BEAMS



f'_c = 5,000 psi
f_{pu} = 270,000 psi

½ in. diameter
low-relaxation strand

Key
6,929 — Safe superimposed service load, plf
0.3 — Estimated camber at erection, in.
0.1 — Estimated long-time camber, in.

Normal Weight Concrete

Section Properties

Designation	h in.	h_1/h_2 in.	A in²	I in⁴	y_b in.	S_b in³	S_t in³	wt plf
28IT20	20	12/8	368	11,688	7.91	1,478	967	383
28IT24	24	12/12	480	20,275	9.60	2,112	1,408	500
28IT28	28	16/12	528	32,076	11.09	2,892	1,897	550
28IT32	32	20/12	576	47,872	12.67	3,778	2,477	600
28IT36	36	24/12	624	68,101	14.31	4,759	3,140	650
28IT40	40	24/16	736	93,503	15.83	5,907	3,869	767
28IT44	44	28/16	784	124,437	17.43	7,139	4,683	817
28IT48	48	32/16	832	161,424	19.08	8,460	5,582	867
28IT52	52	36/16	880	204,884	20.76	9,869	6,558	917
28IT56	56	40/16	928	255,229	22.48	11,354	7,614	967
28IT60	60	44/16	976	312,866	24.23	12,912	8,747	1,017

1. Check local area for availability of other sizes.

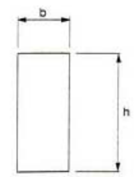
2. Safe loads shown include 50% superimposed dead load and 50% live load. 800 psi top tension has been allowed, therefore additional top reinforcement is required.

3. Safe loads can be significantly increased by use of structural composite topping.

Table of safe superimposed service load (plf) and cambers

Designation	No. Strand	e	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
28IT20	9	5.82	6929 0.3 0.1	5402 0.3 0.1	4310 0.4 0.1	3502 0.4 0.1	2887 0.5 0.1	2409 0.6 0.1	2029 0.6 0.0	1723 0.7 0.0	1473 0.7 0.0	1265 0.8 −0.1	1091 0.8 −0.1							
28IT24	11	6.77	9714 0.2 0.1	7580 0.3 0.1	6054 0.3 0.1	4925 0.4 0.1	4066 0.4 0.1	3398 0.5 0.1	2868 0.6 0.1	2440 0.6 0.1	2090 0.7 0.1	1799 0.7 0.0	1556 0.7 0.0	1351 0.8 0.0	1175 0.8 −0.1	1024 0.8 −0.2				
28IT28	13	8.44			8505 0.3 0.1	6951 0.4 0.1	5768 0.5 0.1	4848 0.5 0.2	4118 0.6 0.2	3529 0.7 0.2	3047 0.7 0.2	2648 0.8 0.2	2313 0.9 0.2	2030 0.9 0.2	1788 1.0 0.2	1579 1.0 0.1	1399 1.1 0.1	1242 1.1 0.1	1103 1.1 0.0	981 1.1 −0.1
28IT32	15	9.17				9202 0.3 0.1	7646 0.4 0.1	6435 0.4 0.1	5474 0.5 0.1	4698 0.5 0.1	4064 0.6 0.1	3538 0.6 0.1	3097 0.7 0.1	2724 0.7 0.1	2406 0.8 0.1	2132 0.8 0.1	1894 0.9 0.0	1687 0.9 0.0	1505 0.9 0.0	1345 0.9 −0.1
28IT36	16	10.81						8485 0.4 0.1	7236 0.4 0.1	6227 0.5 0.1	5402 0.5 0.1	4718 0.6 0.1	4145 0.6 0.1	3660 0.7 0.1	3246 0.7 0.1	2890 0.8 0.1	2581 0.8 0.0	2311 0.9 0.0	2075 0.9 0.0	1866 0.9 −0.1
28IT40	19	11.28							8615 0.4 0.1	7415 0.4 0.1	6433 0.5 0.1	5620 0.5 0.1	4938 0.6 0.1	4361 0.6 0.1	3868 0.7 0.1	3444 0.7 0.1	3077 0.8 0.1	2756 0.8 0.1	2475 0.8 0.1	2226 0.9 0.0
28IT44	20	12.89								9308 0.4 0.1	8092 0.5 0.1	7083 0.5 0.1	6239 0.5 0.1	5624 0.6 0.1	4913 0.6 0.1	4388 0.7 0.1	3932 0.7 0.1	3535 0.8 0.1	3186 0.8 0.1	2879 0.8 0.0
28IT48	22	14.16									9741 0.4 0.1	8539 0.5 0.1	7532 0.5 0.1	6680 0.6 0.1	5952 0.6 0.1	5326 0.7 0.1	4783 0.7 0.1	4310 0.8 0.1	3894 0.8 0.1	3528 0.8 0.1
28IT52	24	15.44											8935 0.5 0.1	7934 0.5 0.1	7080 0.6 0.1	6345 0.6 0.1	5707 0.7 0.1	5151 0.7 0.1	4664 0.8 0.1	4233 0.8 0.1
28IT56	26	16.74												9284 0.5 0.1	8294 0.6 0.1	7442 0.6 0.1	6703 0.7 0.1	6059 0.7 0.1	5493 0.8 0.1	4994 0.8 0.1
[illegible]	[illegible]	[illegible]													9590	8613	7766	7027	6379	5807

RECTANGULAR BEAMS



f'_c = 5,000 psi
f_{pu} = 270,000 psi

½ in. diameter
low-relaxation strand

Key
3,344 — Safe superimposed service load, plf
0.4 — Estimated camber at erection, in.
0.1 — Estimated long-time camber, in.

Normal Weight Concrete

Section Properties

Designation	b in.	h in.	A in²	I in⁴	y_b in.	S in³	wt plf
12RB16	12	16	192	4,096	8.00	512	200
12RB20	12	20	240	8,000	10.00	800	250
12RB24	12	24	288	13,824	12.00	1,152	300
12RB28	12	28	336	21,952	14.00	1,568	350
12RB32	12	32	384	32,768	16.00	2,048	400
12RB36	12	36	432	46,656	18.00	2,592	450
16RB24	16	24	384	18,432	12.00	1,536	400
16RB28	16	28	448	29,269	14.00	2,091	467
16RB32	16	32	512	43,691	16.00	2,731	533
16RB36	16	36	576	62,208	18.00	3,456	600
16RB40	16	40	640	85,333	20.00	4,267	667

1. Check local area for availability of other sizes.

2. Safe loads shown include 50% superimposed dead load and 50% live load. 800 psi top tension has been allowed, therefore additional top reinforcement is required.

3. Safe loads can be significantly increased by use of structural composite topping.

Table of safe superimposed service load (plf) and cambers

Designation	No. Strand	e	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
12RB16	5	5.67	3344 0.4 0.1	2605 0.5 0.2	2075 0.6 0.2	1684 0.7 0.2	1386 0.8 0.2	1154 0.9 0.2	970 1.0 0.2											
12RB20	8	6.60	6101 0.4 0.1	4773 0.5 0.2	3823 0.6 0.2	3121 0.7 0.2	2585 0.8 0.3	2166 0.9 0.3	1833 1.0 0.3	1565 1.1 0.3	1345 1.2 0.3	1163 1.3 0.3	1010 1.4 0.3							
12RB24	10	7.76	8884 0.3 0.1	6957 0.4 0.1	5578 0.5 0.2	4558 0.6 0.2	3782 0.7 0.2	3178 0.8 0.3	2699 0.9 0.3	2312 1.0 0.3	1996 1.1 0.3	1734 1.2 0.4	1514 1.3 0.4	1328 1.4 0.4	1170 1.5 0.4	1033 1.6 0.4				
12RB28	12	8.89		9502 0.3 0.1	7630 0.4 0.2	6245 0.5 0.2	5192 0.6 0.2	4372 0.7 0.2	3721 0.8 0.3	3197 0.9 0.3	2767 1.0 0.3	2411 1.1 0.4	2113 1.2 0.4	1861 1.3 0.4	1645 1.4 0.4	1460 1.5 0.4	1299 1.5 0.4	1159 1.6 0.4	1035 1.7 0.4	
12RB32	13	10.48				8238 0.4 0.2	6859 0.5 0.2	5785 0.6 0.2	4933 0.7 0.2	4246 0.8 0.3	3683 0.9 0.3	3217 0.9 0.3	2826 1.0 0.3	2495 1.1 0.3	2213 1.2 0.3	1970 1.3 0.4	1760 1.4 0.4	1576 1.5 0.4	1415 1.5 0.3	1272 1.6 0.3
12RB36	15	11.64					8734 0.5 0.2	7376 0.5 0.2	6298 0.6 0.2	5428 0.7 0.2	4716 0.8 0.3	4126 0.9 0.3	3632 1.0 0.3	3214 1.0 0.3	2856 1.1 0.4	2549 1.2 0.4	2283 1.3 0.4	2050 1.4 0.4	1846 1.5 0.4	1666 1.5 0.4
16RB24	13	7.86		9278 0.4 0.1	7439 0.5 0.2	6079 0.6 0.2	5044 0.7 0.2	4239 0.8 0.3	3600 0.9 0.3	3084 1.0 0.3	2662 1.1 0.3	2313 1.2 0.3	2020 1.3 0.4	1772 1.4 0.4	1560 1.5 0.4	1378 1.6 0.3	1220 1.6 0.3	1082 1.7 0.3	961 1.8 0.2	
16RB28	13	8.89			9022 0.4 0.1	7383 0.4 0.1	6137 0.5 0.1	5167 0.6 0.2	4397 0.6 0.2	3776 0.7 0.2	3267 0.8 0.2	2846 0.9 0.2	2493 1.0 0.2	2194 1.0 0.2	1939 1.1 0.2	1720 1.2 0.2	1530 1.2 0.1	1364 1.3 0.1	1218 1.3 0.0	1089 1.3 0.0
16RB32	18	10.29					9145 0.5 0.2	7713 0.6 0.2	6577 0.7 0.2	5661 0.8 0.3	4911 0.9 0.3	4289 1.0 0.3	3768 1.1 0.3	3327 1.1 0.4	2951 1.2 0.4	2627 1.3 0.4	2346 1.4 0.4	2101 1.5 0.4	1886 1.6 0.4	1697 1.7 0.4
16RB36	20	11.64						9834 0.5	8397 0.6	7237 0.7	6288 0.8	5502 0.9	4843 1.0	4285 1.0	3809 1.1	3399 1.2	3043 1.3	2733 1.4	2461 1.5	2221 1.5

APPENDIX D: STEEL JOIST FRAMING DESIGN

STEEL JOIST FRAMING

NORTH-SOUTH SPAN

LOADING

OFFICE BLDG: (100) + (70) = 170 PSF (2'-0 O.C.) = 340 PLF
PARKING STRUCTURE: (250) + (93) + (30) = 373 PSF (1'-0) = 373 PLF

MEMBER SELECTION

SEE SPEC ATTACHED

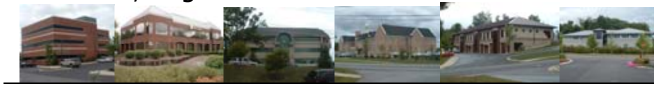
OFFICE GIRDER: 16K2: 5.5 PLF / 2'-0 O.C. = 2.75 PSF
(1.6(100) + 1.2(70) + 1.2(2.75))(18.75' TRIB) = 4.636 KLF
$M_{MAX} = \frac{1}{8}wL^2 = 521.6$ FT-K = 0.9(50) Zx
ZMIN = 139 IN³ → W21x62
$V_{MAX} = \frac{1}{2}wL = 69.6^K < \phi_v V_N = 227^K$ ✓

PARKING GIRDER: 16K3 : 6.3 PLF / 1'-0 = 6.3
(1.6(250) + 1.2(99.3) + 0.5(30))(18.75) = 10.02 KLF
$M_{MAX} = \frac{1}{8}wL^2 = 1128$ FT-K (12) = 45 Zx
ZMIN = 300.8 → W30x99
$V_{MAX} = \frac{1}{2}wL = 150.3^K < \phi_v V_N = 417^K$ ✓

WEIGHT CALCULATION

OFFICE BLDG WT: 70 PSF DL
(30)(20)(70) = 42.0ᴷ
16(16K2)(20') = 1.76ᴷ
2(W21x62)(30') = 3.72ᴷ
Σ 47.48ᴷ

PARKING STRUCTURE WT: 93 PSF DL
(30)(20)(93) = 55.8
31(16K3)(20) = 3.906
2(W30x99)(30') = 5.940
Σ 65.646ᴷ



STEEL JOIST FRAMING

EAST-WEST SPAN

LOADING

OFFICE BLDG : 340 PLF
PARKING STRUCTURE : 373 PLF

MEMBER SELECTION

SEE SPEC ATTACHED

OFFICE GIRDER: 22K5 : 8.8 PLF / 2' = 4.4 PSF

$(1.6(100) + 1.2(70) + 1.2(4.4))(30') = 7.48$ KLF

$M_{MAX} = \frac{1}{8} wL^2 = 374$ FT-K $= 45Z$

$Z_{MIN} = 100 IN^3 \rightarrow$ W21x48

$V_{MAX} = \frac{1}{2} wL = 74.8 < \phi V_N = 231^K$ ✓

PARKING GIRDER: 24K5 : 9.3 / 1' = 9.3 PSF

$(1.6(250) + 1.2(93) + 1.2(9.3))(30') = 15.68$ KLF

$M_{MAX} = (1/8)wL^2 = 784.140$ FT-K $= (45)Z$

$Z_{MIN} = 209 IN^3 \rightarrow$ W24x84

$V_{MAX} = (1/2)wL = 156.8^K < 306^K$ ✓

WEIGHT CALCULATION

OFFICE BLDG WT: 70 PSF DL

(70)(30)(20)	42.0
11(8.8)(30)	2.904
2(W21x48)(20')	1.920
	Σ 46.824^K

PARKING STRUCTURE WT: 93 PSF DL

(93)(30)(20)	55.8
2(24K5)(30)	5.859
2(W24x84)(20)	3.360
	Σ 65.019^K

K-SERIES ECONOMY TABLE

Joist Designation	10K1	12K1	8K1	14K1	16K2	12K3	14K3	16K3	18K3	14K4	20K3	16K4	12K5	18K4	16K5	20K4
Depth (In.)	10	12	8	14	16	12	14	16	18	14	20	16	12	18	16	20
Approx. Wt. (lbs./ft.)	5	5	5.1	5.2	5.5	5.7	6	6.3	6.6	6.7	6.7	7	7.1	7.2	7.5	7.6
Span (ft.) ↓																
8			550 550													
9			550 550													
10	550 550		550 480													
11	550 542		532 377													
12	550 455	550 550	444 288			550 550							550 550			
13	479 363	550 510	377 225			550 510							550 510			
14	412 289	500 425	324 179	550 550		550 463	550 550			550 550			550 463			
15	358 234	434 344	281 145	511 475		543 428	550 507			550 507			550 434			
16	313 192	380 282	246 119	448 390	550 550	476 351	550 467	550 550		550 467		550 550	550 396		550 550	
17	277 159	336 234		395 324	512 488	420 291	495 404	550 526		550 443		550 526	550 366		550 526	
18	246 134	299 197		352 272	456 409	374 245	441 339	508 456	550 550	530 397		550 490	507 317	550 550	550 490	
19	221 113	268 167		315 230	408 347	335 207	395 287	455 386	514 494	475 336		547 452	454 269	550 523	550 455	
20	199 97	241 142		284 197	368 297	302 177	356 246	410 330	463 423	428 287	517 517	493 386	409 230	550 490	550 426	550 550
21		218 123		257 170	333 255	273 153	322 212	371 285	420 364	388 248	468 453	447 333	370 198	506 426	503 373	550 520
22		199 106		234 147	303 222	249 132	293 184	337 247	382 316	353 215	426 393	406 289	337 172	460 370	458 323	514 461
23		[illegible]		214 128	277 194	227 116	268 160	308 216	349 276	322 188	389 344	371 252	308 150	420 323	418 282	469 402
24		[illegible]		196 113	254 170	208 101	245 141	283 189	320 242	295 165	357 302	340 221	282 132	385 284	384 248	430 353
25				180 100	234 150		226 124	260 167	294 214	272 145	329 266	313 195		355 250	353 219	396 312
26				166 88	216 133		209 110	240 148	272 190	251 129	304 236	289 173		328 222	326 194	366 277
27				[illegible]	200 119		193 98	223 132	252 169	233 115	281 211	268 155		303 198	302 173	339 247
28				[illegible]	186 106		180 88	207 118	234 151	216 103	261 189	249 138		282 177	281 155	315 221
29					[illegible]			193 106	218 136		243 170	232 124		263 159	261 139	293 199
30					[illegible]			[illegible]	203 123		227 153	216 112		245 144	244 126	274 179
31					[illegible]			[illegible]	[illegible]		212 138	203 101		229 130	228 114	256 162
32					[illegible]			[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	240 147
33									[illegible]		[illegible]			[illegible]		226 134
34									[illegible]		[illegible]			[illegible]		[illegible]
35									[illegible]		[illegible]			[illegible]		[illegible]
36									[illegible]		[illegible]			[illegible]		[illegible]
37											[illegible]					[illegible]
38											[illegible]					[illegible]
39											[illegible]					[illegible]
40											[illegible]					[illegible]

48

K-SERIES ECONOMY TABLE

Joist Designation	14K6	18K5	22K4	16K6	20K5	24K4	18K6	16K7	22K5	20K6	18K7	22K6	20K7	24K5	22K7	24K6
Depth (In.)	14	18	22	16	20	24	18	16	22	20	18	22	20	24	22	24
Approx. Wt. (lbs./ft.)	7.7	7.7	8	8.1	8.2	8.4	8.5	8.6	8.8	8.9	9	9.2	9.3	9.3	9.7	9.7
Span (ft.) ↓																
14	550 550															
15	550 507															
16	550 467			550 550				550 550								
17	550 443			550 526				550 526								
18	550 408	550 550		550 490			550 550	550 490			550 550					
19	550 383	550 523		550 455			550 523	550 455			550 523					
20	525 347	550 490		550 426	550 550		550 490	550 426		550 550	550 490		550 550			
21	475 299	550 460		548 405	550 520		550 460	550 406		550 520	550 460		550 520			
22	432 259	518 414	550 548	498 351	550 490		550 438	550 385	550 548	550 490	550 438	550 548	550 490		550 548	
23	395 226	473 362	518 491	455 307	529 451		516 393	507 339	550 518	550 468	550 418	550 518	550 468		550 518	
24	362 199	434 318	475 431	418 269	485 396	520 516	473 345	465 298	536 483	528 430	526 382	550 495	550 448	550 544	550 495	550 544
25	334 175	400 281	438 381	384 238	446 350	479 456	435 305	428 263	493 427	486 380	485 337	537 464	541 421	540 511	550 474	550 520
26	308 156	369 249	404 338	355 211	412 310	442 405	402 271	395 233	455 379	449 337	448 299	496 411	500 373	499 453	550 454	543 493
27	285 139	342 222	374 301	329 188	382 277	410 361	372 241	366 208	422 337	416 301	415 267	459 367	463 333	462 404	512 406	503 439
28	265 124	318 199	348 270	306 168	355 248	381 323	346 216	340 186	392 302	386 269	385 239	427 328	430 298	429 362	475 364	467 393
29		296 179	324 242	285 151	330 223	354 290	322 194	317 167	365 272	360 242	359 215	398 295	401 268	400 325	443 327	435 354
30		276 161	302 219	266 137	308 201	331 262	301 175	296 151	341 245	336 218	335 194	371 266	374 242	373 293	413 295	406 319
31		258 146	283 198	249 124	289 182	310 237	281 158	277 137	319 222	314 198	313 175	347 241	350 219	349 266	387 267	380 289
32		242 132	265 180	233 112	271 165	290 215	264 144	259 124	299 201	295 179	294 159	326 219	328 199	327 241	363 242	357 262
33		228 121	249 164		254 150	273 196	248 131		281 183	277 163	276 145	306 199	309 181	308 220	341 221	335 239
34		214 110	235 149		239 137	257 179	233 120		265 167	261 149	260 132	288 182	290 165	290 201	321 202	315 218
35		202 101	221 137		226 126	242 164	228 110		249 153	246 137	245 121	272 167	274 151	273 184	303 185	297 200
36		191 92	209 126		213 115	229 150	208 101		236 141	232 125	232 111	257 153	259 139	258 169	286 169	281 183
37			198 116		202 106	216 138			223 130	220 115		243 141	245 128	244 155	271 156	266 169
38			187 107		191 98	205 128			211 119	208 109		230 130	232 118	231 143	256 144	252 156
39			178 98		181 90	195 118			200 110	198 98		218 120	220 109	219 132	243 133	239 144
40			169 91		172 84	185 109			190 102	188 91		207 111	209 101	208 122	231 123	227 133
41			161 85			176 101			181 95			197 103		198 114	220 114	216 124
42			153 79			168 94			173 88			188 96		189 106	209 108	206 115
43			146 73			160 88			165 82			179 89		180 98	200 99	198 107
44			139 68			153 82			157 76			171 83		172 92	191 92	187 100
45						146 76								164 86		179 93
46						139 71								157 80		171 87
47						133 67								150 75		164 82
48						128 63								144 70		157 77

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APPENDIX E: ONE-WAY SLAB DESIGN CALCULATIONS/REFERENCES

ONE WAY CONCRETE SLAB

LOADING

OFFICE BLDG : 1.4(15) + 1.7(100) = 191 PSF
PARKING : 1.4(50) + 1.7(250) + (30) = 525 PSF

MEMBER SELECTION SEE CRSI TABLES ATTACHED

OFFICE (20' ~ CLEAR SPAN) USE MAX. REINFORCEMENT
7" THICK 88 PSF

PARKING (20' ~ CLEAR SPAN) USE MAX REINFORCEMENT
10" THICK 125 PSF
[COULD PROBABLY USE 9.5" (-C SPAN < 20'-0")

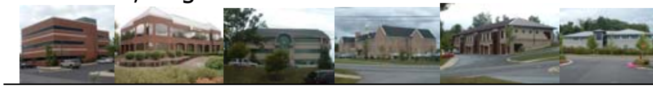
SUPPORTING BEAM OFFICE : l_N = 30'-0"
LOAD: 191 + 1.4(88) = (314.2 PSF)(20' TRIB) = 6.284 KLF
USE 26" DEEP, 18" WIDE BEAM

SUPPORTING BEAM PARKING : l_N = 30'-0"
LOAD: 525 + 1.4(125) = (700 PSF)(20' TRIB) = 14.0 KLF
USE 34" DEEP, 24" WIDE
[COULD POSSIBLY USE A NARROWER BM, SIZED FOR l_N = 32'-0"]

WEIGHT CALCULATION

OFFICE : [88 + 15] = 103 PSF DL (20')(30') = 61.8^K
(19)(18)(1/144)(30)(150 PCF) = 10.7
Σ 72.5^K

PARKING : [50 + 125] = 175 PSF DL (20')(30') = 105^K
(24)(24)(1/144)(30)(150 PCF) = 18
Σ 123.0^K



SOLID ONE-WAY SLABS—END SPAN Top Steel for $-M_u$

$f'_c = 3{,}000$ psi Grade 60 Bars $\rho \approx 0.0075$

Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Top Bars Spacing (in.)	#4 10	#4 9	#5 11	#5 9	#5 8	#6 11	#6 10	#7 12	#7 12	#7 11	#7 11	#7 10	#8 12
Bottom Bars Spacing (in.)	#4 9	#4 8	#5 10	#5 10	#5 9	#6 12	#6 11	#6 10	#6 10	#7 12	#7 11	#7 10	#7 10
Top Bars Free End Spacing (in.)	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 11	#4 10	#4 10
T-S Bars Spacing (in.)	#3 15	#3 13	#3 12	#3 11	#4 18	#4 17	#4 15	#4 14	#4 13	#4 13	#4 12	#5 18	#5 17
Areas of Steel (in.^{2}/ft) Top Interior Bottom	.240 .267	.267 .300	.338 .372	.413 .372	.465 .413	.480 .440	.528 .480	.600 .554	.600 .528	.655 .528	.655 .655	.720 .655	.790 .720
Slab Wt. (psf)	50	56	63	69	75	81	88	94	100	106	113	119	125
CLEAR SPAN	**FACTORED USABLE SUPERIMPOSED LOAD (psf)**												
6′-0″	924												
6′-6″	777												
7′-0″	660	873											
7′-6″	566	750											
8′-0″	489	650	939										
8′-6″	425	566	822	941									
9′-0″	372	497	723	829									
9′-6″	326	438	640	734	922								
10′-0″	288	387	555*	653	822	963							
10′-6″	200	273	409	583	735	847							
11′-0″	176	242	365	523	661	761	928						
11′-6″	155	215	326	470	596	687	839						
12′-0″	137	191	292	424	538	622	760	931					
12′-6″	121	170	262	384	488	564	691	847	923				
13′-0″	106	151	236	347	443	513	629	774	842				
13′-6″	93	134	212	314	403	467	575	708	771	929			
14′-0″	82	119	191	285	368	426	526	649	707	853	919		
14′-6″	71	106	172	257*	335	390	482	596	650	785	846		
15′-0″	62	94	155	232*	301*	357	442	548	598	724	780		
15′-6″	54	83	140	210*	275*	327	406	505	551	669	720	859	
16′-0″	46	73	126	189*	250*	300	373	466	508	619	666	795	932
16′-6″		64	113	173*	228*	275	344	430	470	573	617	738	866
17′-0″		56	101	157*	208*	253	317	398	434	531	572	686	805
17′-6″		48	90	143*	190*	232	292	368	402	493	531	638	750
18′-0″		41	81	130*	174*	213	269	340	372	457	493	593	699
18′-6″			72	119*	159*	196	248	315	345	425	458	553	653
19′-0″			63	109*	145*	179	229	290*	320	395	426	516	610
19′-6″			56	100	134*	165	211	268*	296	368	397	481	570
20′-0″			48	90	123*	151	194	248*	275	342	369	449	533

Note: See Fig. 7-1 for reinforcing bar details.
*Service loads corresponding to 1/1.7 tabulated superimposed load result in calculated immediate deflection of 1/360 span.

CONCRETE REINFORCING STEEL INSTITUTE

7-13

f'_c = 4,000 psi
f_y = 60,000 psi

RECTANGULAR BEAMS, END SPANS

STEM		BARS[1]				TOTAL CAPACITY $U = 1.4D + 1.7L$[3]																				$+\phi M_n$ / $-\phi M_n$	DEFL. (C)
h	b	BOTTOM		Layers	TOP	SPAN, ℓ_n = 24 ft					SPAN, ℓ_n = 26 ft					SPAN, ℓ_n = 28 ft					SPAN, ℓ_n = 30 ft					(6)	(7) 10
in.	in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	ft-kip	in.
26		2# 9		1	3# 8	3.8	113I	9	-	348	3.2	123I	9	-	376	2.8	123I	8	-	399	2.4	123I	8	-	122	199	501
				1			184F	35	1.3	507		204F	34	1.2	553		214F	34	1.2	588		234F	33	1.2	633	231	
		2#11		1	3# 9	5.0	134I	9	-	543	4.3	133I	9	-	523	3.7	143I	8	-	561	3.2	143I	8	-	594	299	459
				1			185F	35	1.2	772		205F	34	1.2	843		214F	34	1.2	741		234F	33	1.2	797	290	
	14	2#11	1#11	1	3#11	7.4	135I	9	-	823	6.3	145I	9	-	885	5.5	154I	8	-	873	4.8	164I	8	-	930	128	390
				1			295C	35	1.2	1193		205F	34	1.2	1074		215F	34	1.2	1141		235F	33	1.2	1228	129	
		2#11	1#11	1	4#11	8.2	135I	9	-	913	7.0	145I	9	-	981	6.0	165I	8	-	1063	5.2	165I	8	-	1119	429	352
				2			295C	35	1.2	1283		315C	34	1.2	1376		215F	34	1.2	1244		235F	33	1.2	1336	501	
		2#10		1	3# 8	4.1	113I	11	-	395	3.5	113I	11	-	421	3.0	123I	10	-	452	2.6	123I	10	-	479	251	421
				1			165G	43	1.4	657		184G	42	1.4	587		214F	42	1.4	650		234F	42	1.4	700	236	
		2#11		1	3#10	5.8	134I	11	-	593	4.9	134I	11	-	629	4.2	143I	10	-	616	3.7	143I	10	-	652	302	406
				1			165G	43	1.4	793		185G	42	1.4	868		195G	42	1.4	924		205G	42	1.3	979	361	
	16	2#11	1#11	1	3#11	7.6	135I	11	-	827	6.5	145I	11	-	890	5.6	154I	10	-	876	4.8	164I	10	-	931	136	313
				1			245D	43	1.4	1116		265D	42	1.4	1204		195G	42	1.3	1117		205G	42	1.3	1186	436	
		6# 6	6# 6	2	3#14	9.0	145FdI	11	-	1007	7.7	145I	11	-	1068	6.6	165I	10	-	1156	5.8	165I	10	-	1217	471	301
				1			245D	43	1.4	1282		265D	42	1.4	1382		285D	42	1.3	1481		305D	41	1.3	1581	600	
		2# 8	1# 8	1	3# 9	4.5	113I	13	-	410	3.9	113I	13	-	437	3.3	113I	13	-	464	2.9	123I	13	-	496	238	377
				1			165G	52	1.5	682		184G	51	1.5	609		194G	51	1.5	649		264E	50	1.5	763	296	
		2#10	1#10	1	3#10	6.4	134I	13	-	638	5.5	134I	13	-	678	4.7	143I	13	-	667	4.1	143I	13	-	707	368	393
				1			165G	52	1.5	846		185G	51	1.5	926		195G	51	1.5	986		205G	50	1.5	1016	368	
	18	2#11	1#11	1	3#14	8.4	135I	13	-	959	7.2	145I	13	-	1030	6.2	154I	13	-	1023	5.4	164I	13	-	1089	442	292
				1			245D	52	1.5	1260		265D	51	1.5	1358		285D	51	1.5	1455		305D	50	1.5	1553	602	
		2#11	2#11	1	3#14	10.5	155FeI	13	-	1101	8.9	165FdI	13	-	1182	7.7	165I	13	-	1249	6.7	165I	13	-	1315	568	269
				1			295C	52	1.5	1475		265D	51	1.5	1481		285D	51	1.5	1588		305D	50	1.5	1695	607	
		2# 9	1# 9	1	3# 9	5.2	113I	15	-	463	4.4	113I	15	-	495	3.8	123I	15	-	531	3.3	123I	15	-	562	298	315
				1			155H	61	1.7	724		165H	61	1.7	777		175H	60	1.7	829		185H	59	1.6	891	298	
		2#10	1#10	1	3#11	7.1	134I	15	-	694	6.0	134I	15	-	738	5.2	143I	15	-	729	4.5	143I	15	-	773	371	278
				1			215E	61	1.7	1015		225E	61	1.7	1079		175H	60	1.6	1018		185H	59	1.6	1092	447	
	20	2#11	2#11	1	3#14	10.6	145FdI	15	-	1092	9.1	155FcI	15	-	1173	7.8	155I	15	-	1240	6.8	165I	15	-	1321	576	259
				1			295C	61	1.7	1495		265D	61	1.7	1499		285D	60	1.6	1607		265E	59	1.6	1632	612	
		3#11	2#11	1	4#14	13.3	295C	15	-	1573	11.3	175EhI	15	-	1486	9.8	175FfI	15	-	1573	8.5	185FfI	15	-	1673	696	219
				1			485A	61	1.7	2156		315C	61	1.7	1888		345C	60	1.6	2037		365C	59	1.6	2161	776	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of ℓ_n/360 are designated thus: * — $\ell_n/360$ < deflection < $\ell_n/240$
X — $\ell_n/240$ < deflection < $\ell_n/180$
Y — deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation: N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b x h.
(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft), ℓ_n in ft.
"Average service load" is taken as w/1.6.

f'_c = 4,000 psi
f_y = 60,000 psi

RECTANGULAR BEAMS, END SPANS

TOTAL CAPACITY $U = 1.4D + 1.7L$ (3)

STEM h in.	STEM b in.	BARS (1) BOTTOM ℓ_n + 12 in.	BARS BOTTOM 0.875 ℓ_n	Layers (2)	TOP	SPAN, ℓ_n = 32 ft LOAD (4) k/ft	32 ft STIR. TIES (5)	32 ft ϕT_n ft-kips	32 ft Aℓ sq. in.	32 ft STEEL WGT lb.	SPAN, ℓ_n = 34 ft LOAD (4) k/ft	34 ft STIR. TIES (5)	34 ft ϕT_n ft-kips	34 ft Aℓ sq. in.	34 ft STEEL WGT lb.	SPAN, ℓ_n = 36 ft LOAD (4) k/ft	36 ft STIR. TIES (5)	36 ft ϕT_n ft-kips	36 ft Aℓ sq. in.	36 ft STEEL WGT lb.	SPAN, ℓ_n = 38 ft LOAD (4) k/ft	38 ft STIR. TIES (5)	38 ft ϕT_n ft-kips	38 ft Aℓ sq. in.	38 ft STEEL WGT lb.	$+\phi M_n$ / $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\cdot 10^{-3}$ in.
		2#11		1	3#10	4.5	113N	15	-	686	4.0	123N	15	-	728	3.5	123N	15	-	764	3.2	123N	15	-	801	415	190
				1			185I	62	1.8	1027		195I	61	1.8	1085		205I	61	1.8	1144		215I	60	1.8	1203	501	
		2#14		1	3#11	5.9	124N	15	-	974	5.2	134N	15	-	1033	4.7	134N	15	-	1082	4.2	144N	15	-	1112	592	173
				1			245F	62	1.8	1382		265F	61	1.8	1476		275F	61	1.8	1547		215I	60	1.7	1463	601	
	16	2#14	1#14	1	4#14	9.0	155IfN	15	-	1642	7.9	155JeN	15	-	1721	7.1	165JdN	15	-	1817	6.3	165JcN	15	-	1897	833	133
				2			325D	62	1.8	2106		345D	61	1.8	2230		315E	61	1.8	2243		335E	60	1.7	2367	992	
		4#9	4#9	2	4#14	9.7	175GiN	15	-	1788	8.6	175HhN	15	-	1875	7.7	165IIN	15	-	1945	6.9	175IIN	15	-	2018	932	[illegible]
				2			385C	61	1.8	2353		345D	61	1.8	2350		365D	60	1.8	2482		385D	60	1.7	2613	992	
		2#10	1#10	1	3#10	4.9	114N	19	-	800	4.4	114N	19	-	839	3.9	124N	18	-	890	3.5	124N	18	-	930	805	169
				1			185I	75	2.0	1095		195I	74	2.0	1158		205I	74	2.0	1221		215I	73	2.0	1284	505	
		2#11	1#11	1	3#14	6.6	125N	19	-	1208	5.8	134N	19	-	1201	5.2	134N	18	-	1259	4.7	144N	18	-	1327	610	111
				1			245F	75	2.0	1556		265F	74	2.0	1659		275F	74	2.0	1739		295F	73	1.9	1813	815	
	18	2#14	2#14	1	4#14	10.6	175GiN	19	-	1898	9.4	175GhN	19	-	1992	8.4	175HgN	18	-	2085	7.5	175IIN	18	-	2178	1083	109
				1			385C	75	2.0	2484		415C	74	2.0	2646		365D	74	2.0	2624		385D	73	1.9	2763	1083	
		2#14	2#14	1	5#14	11.6	285E	19	-	2252	10.3	195FkN	19	-	2202	9.2	195GjN	18	-	2304	8.3	195GiN	18	-	2406	1093	106
34				2			485B	75	2.0	2881		415C	74	2.0	2822		435C	74	2.0	2970		385D	73	1.9	2957	[illegible]	
		2#10	1#10	1	3#11	5.5	114N	22	-	870	4.8	114N	22	-	913	4.3	124N	22	-	967	3.9	124N	22	-	1011	598	152
				1			225G	89	2.2	1270		235G	89	2.2	1337		185J	88	2.1	1262		195J	87	2.1	1329	615	
		2#11	1#11	1	3#14	6.6	124N	22	-	1136	5.9	124N	22	-	1193	5.2	134N	22	-	1261	4.7	134N	22	-	1319	615	137
				1			225G	89	2.2	1525		235G	89	2.2	1606		245G	88	2.1	1687		265G	87	2.1	1792	865	
	20	2#14	2#14	1	4#14	10.8	165GhN	22	-	1887	9.5	165HgN	22	-	1980	8.5	165IfN	22	-	2073	7.6	165JeN	22	-	2166	1100	105
				1			385C	89	2.2	2510		415C	88	2.2	2674		365D	88	2.1	2619		385D	87	2.1	2799	1100	
		3#14	2#14	1	5#14	12.9	285E	22	-	2514	11.5	215EnN	22	-	2511	10.2	205FlN	22	-	2611	9.2	215FkN	22	-	2715	1325	90
				1			485B	89	2.2	3167		515B	88	2.2	3355		435C	88	2.1	3283		465C	87	2.1	3171	1325	
		2#11	1#11	1	4#10	6.6	113N	30	-	991	5.8	113N	30	-	1042	5.2	123N	29	-	1103	4.7	123N	29	-	1151	622	130
				1			225G	120	2.6	1761		235G	119	2.6	1852		245G	118	2.5	1943		195J	117	2.5	1791	671	
		2#14	1#14	1	4#14	9.4	134N	30	-	1668	8.3	134N	30	-	1748	7.4	144N	29	-	1849	6.6	144N	29	-	1928	870	107
				1			245F	120	2.6	2366		235G	119	2.6	2405		245G	118	2.5	2525		265G	117	2.5	2686	1127	
	24	3#14	2#14	1	5#14	13.4	135N	30	-	2466	11.8	145N	30	-	2617	10.6	155N	29	-	2767	9.5	155N	29	-	2805	1367	95
				1			325D	120	2.6	3328		295E	119	2.6	3324		315E	118	2.5	3522		335E	117	2.5	3720	1367	
		3#14	3#14	1	6#14	15.5	284E	30	-	3008	13.8	155JdN	30	-	3058	12.3	165JdN	29	-	3231	11.0	165JcN	29	-	3371	1591	75
				1			485B	120	2.6	4362		345D	119	2.6	3934		365D	118	2.5	4155		385D	117	2.5	4376	1591	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * — $\ell_n/360$ < deflection < $\ell_n/240$; X — $\ell_n/240$ < deflection < $\ell_n/180$; Y — deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation:
N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft), ℓ_n in ft. "Average service load" is taken as ÷ 1.6

APPENDIX F: PAN-JOIST DESIGN CALCULATIONS/REFERENCES

PAN JOISTS

LOADING

OFFICE BLDG: 1.4(15) + 1.7(100) = 191 PSF
PARKING: 1.4(50) + 1.7(250) + (30) = 525 PSF

MEMBER SELECTION

NORTH-SOUTH SPAN (l_N = 20'-0)

OFFICE: 30" FORMS, 16" DEEP, 6" WIDE RIBS W/4.5" SLAB
(SUITABLE FOR LONGER SPAN) WT. 78 PSF

PARKING: 20" FORMS, 20" DEEP, 7" WIDE RIBS W/4.5" SLAB WT. 115 PSF

OFFICE GIRDER: (191 + 1.4(78)) = 300.2 PSF (20') = 6.0 KLF
USE 20.5" DEEP x 24" WIDE GIRDER

PARKING: (525 + 1.4(115)) = 686 PSF (20') = 13.7 KLF
USE 24.5" DEEP x 48" WIDE GIRDER

OFFICE BLDG WT. (20'-2')(30')(93) 30.22
(20.5)(24)(1/144)(30)(150PCF) 30.75
Σ 80.95 K

PARKING WT. (20-4)(30)(165) 79.2
(24.5)(48)(1/144)(30)(150) = 36.750
= 116.0 K

EAST-WEST SPAN (l_N = 30'-0")

OFFICE: 20" FORMS, 12" DEEP, 6" WIDE RIBS W/4.5" SLAB WT 92 PSF

OFFICE GIRDER: (191 + 1.4(92)) = 319.8 PSF (20') = 6.4 KLF
USE 16.5" DEEP x 36" WIDE GIRDER

WEIGHT: (20 - 3)(30)(107) 54.6
(16.5)(36)(1/144)(20')(150PCF) = 12.4
Σ 67.0 K

f'_c = 4,000 psi
f_y = 60,000 psi

JOIST-BAND BEAMS, END SPANS

TOTAL CAPACITY $U = 1.4D + 1.7L$[3]

STEM h in.	STEM b in.	BARS[1] BOTTOM ℓ_n 12 in.	BARS[1] BOTTOM 0.875 ℓ_n	Layers (2)	TOP	28 ft LOAD (4) k/ft	28 ft STIR. TIES (5)	28 ft φTn ft-kips	28 ft Aℓ sq. in.	28 ft STEEL WGT lb.	30 ft LOAD (4) k/ft	30 ft STIR. TIES (5)	30 ft φTn ft-kips	30 ft Aℓ sq. in.	30 ft STEEL WGT lb.	32 ft LOAD (4) k/ft	32 ft STIR. TIES (5)	32 ft φTn ft-kips	32 ft Aℓ sq. in.	32 ft STEEL WGT lb.	34 ft LOAD (4) k/ft	34 ft STIR. TIES (5)	34 ft φTn ft-kips	34 ft Aℓ sq. in.	34 ft STEEL WGT lb.	+φMn −φMn (6) ft-kip	DEFL (C) (7) ×10⁻⁹ in.
[illegible]	21	[illegible]	1#10	1	4#9	4.7	133H	18	-	726	4.1	143H	18	-	775	3.6	143H	18	-	816	3.2	143H	18	-	856	350	353
				1			175H	72	1.8	1190		185H	71	1.8	1264		195H	71	1.8	1339		215H	70	1.8	1447	368	
		[illegible]	1#11	1	4#11	5.9	153H	18	-	979	5.2	153H	18	-	1034	4.5	163H	18	-	1098	4.0	163H	18	-	1154	422	309
				1			175H	72	1.8	1426		185H	71	1.8	1515		195H	71	1.8	1604		215H	70	1.8	1727	547	
		[illegible]	1#14	1	4#14	8.2	171H	18	-	1519	[illegible]	174H	18	-	1599	6.3	183H	18	-	1549	5.5*	193H	18	-	1638	582	252
				1			245E	72	1.8	2048		265E	71	1.8	2195		285E	71	1.8	2343		215H	70	1.8	2185	742	
		[illegible]	[illegible]	1	5#14	10.4	175H	18	-	2031	9.1	184H	18	-	1979	8.0*	194H	18	-	2098	7.1*	204H	18	-	2216	742	214
				1			245E	72	1.8	2389		265E	71	1.8	2559		285E	71	1.8	2729		295E	70	1.8	2865	886	
	36	[illegible]	2#10	1	5#10	6.6	133H	32	-	1000	5.8	133H	32	-	1057	5.1	133H	32	-	1114	4.5	133H	32	-	1172	471	231
				1			563A	130	2.7	1572		603A	129	2.7	1680		643A	128	2.7	1767		683A	127	2.7	1894	580	
		[illegible]	2#11	1	5#11	8.0	143H	32	-	1219	7.0	153H	32	-	1300	6.1	153H	32	-	1371	5.4	153H	32	-	1441	569	222
				1			175H	130	2.7	1743		185H	129	2.7	1853		643A	128	2.7	2024		683A	127	2.7	2145	697	
		[illegible]	2#14	1	5#14	12.2	165H	32	-	2270	10.6	174H	32	-	2230	9.3	184H	32	-	2366	8.3*	194H	32	-	2502	956	173
				1			285D	130	2.7	2883		265E	129	2.7	2923		285E	128	2.6	3117		295E	127	2.6	3273	956	
		[illegible]	3#14	1	7#14	15.6	165EdH	32	-	2820	13.6*	185H	32	-	2969	12.0*	195H	32	-	3147	10.6*	205H	32	-	3325	1114	146
				1			345C	130	2.7	3606		365C	129	2.7	3832		325D	128	2.6	3826		345D	127	2.6	4052	1261	
	46	[illegible]	3#10	1	6#10	9.0	133H	48	-	1327	7.8	133H	48	-	1405	6.9	133H	47	-	1484	6.1	143H	47	-	1573	701	175
				1			**	193	3.8	1188		**	191	3.7	1267		**	190	3.7	1345		**	188	0.0	1424	701	
		[illegible]	3#11	1	6#11	10.8	143H	48	-	1622	9.4	153H	48	-	1730	8.3	153H	47	-	1827	7.3	163H	47	-	1935	845	167
				1			344C	193	3.6	2405		364C	191	3.6	2557		**	190	3.7	1667		**	188	3.6	1764	845	
		[illegible]	3#14	1	7#14	16.3	175H	48	-	2838	14.2	175H	48	-	2987	12.5*	185H	47	-	3167	11.1*	194H	47	-	3122	1164	132
				1			425B	192	3.6	4121		455B	191	3.5	4400		485B	189	3.5	4680		515B	188	3.5	4959	1329	
		[illegible]	[illegible]	1	9#14	20.8	195FgH	48	-	3616	18.2*	205EfH	48	-	3843	16.0*	215EaH	47	-	4070	14.1*	215EdH	47	-	4265	1485	111
				1			425B	192	3.6	4831		455B	191	3.5	5160		485B	189	3.5	5486		515B	188	3.5	5812	1633	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column first line is number of layers for bottom bars; second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * — $\ell_n/360$ < deflection < $\ell_n/240$; X — $\ell_n/240$ < deflection < $\ell_n/180$; Y — deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation:
N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft. "Average service load" is taken as w/1.6.

CONCRETE REINFORCING STEEL INSTITUTE

8-30

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS		30" Forms + 6" Rib @ 36" c.-c. (2) FACTORED USABLE SUPERIMPOSED LOAD (PSF)											f'_c = 4,000 psi f_y = 60,000 psi
		16" Deep Rib + 4.5" Top Slab = 20.5" Total Depth											
TOP BARS	Size @	# 4 10	# 4 8	# 5 10.5	# 5 9	# 6 10.5	End Span Defl. Coeff. (3)	# 4 9	# 5 11	# 5 9	# 6 11	# 6 9	Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	# 7 # 7		# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	
Steel (psf)		.85	1.04	1.24	1.44	1.71		.93	1.18	1.42	1.70	2.01	
CLEAR SPAN		END SPAN						INTERIOR SPAN					
27'-0"		131 / 0	185 / 0	240 / 0	305* / 306	314* / 373	6.398	184 / 0	252 / 0	331 / 0	359* / 412	368* / 454*	3.938
28'-0"		112 / 0	163 / 0	214 / 0	275 / 0	293* / 338	7.400	161 / 0	225 / 0	299 / 0	338* / 373	346* / 423*	4.554
29'-0"		95 / 0	142 / 0	190 / 0	247 / 0	274* / 306	8.516	141 / 0	201 / 0	269 / 0	318* / 339	325* / 395*	5.240
30'-0"		80 / 0	124 / 0	169 / 0	222 / 0	256* / 277	9.752	123 / 0	178 / 0	243 / 0	300* / 307	306* / 370*	6.001
31'-0"		66 / 0	108 / 0	149 / 0	200 / 0	240* / 250	11.119	106 / 0	158 / 0	218 / 0	279 / 0	289* / 347*	6.842
32'-0"		54 / 0	93 / 0	132 / 0	179 / 0	226* / 227	12.625	92 / 0	140 / 0	197 / 0	254 / 0	273* / 322	7.769
33'-0"		43 / 0	79 / 0	116 / 0	160 / 0	205 / 0	14.278	78 / 0	124 / 0	177 / 0	230 / 0	258* / 295	8.787
34'-0"			66 / 0	101 / 0	143 / 0	185 / 0	16.089	66 / 0	109 / 0	159 / 0	209 / 0	244* / 270	9.901
35'-0"			55 / 0	88 / 0	127 / 0	167 / 0	18.067	54 / 0	95 / 0	142 / 0	190 / 0	231* / 247	11.118
36'-0"			45 / 0	76 / 0	113 / 0	150 / 0	20.222	44 / 0	82 / 0	127 / 0	172 / 0	219* / 226	12.445
37'-0"				64 / 0	99 / 0	135 / 0	22.565		71 / 0	113 / 0	155 / 0	207 / 0	13.886
38'-0"				54 / 0	87 / 0	121 / 0	25.105		60 / 0	100 / 0	140 / 0	189 / 0	15.449
39'-0"				44 / 0	76 / 0	108 / 0	27.853		50 / 0	88 / 0	126 / 0	172 / 0	17.141
40'-0"					65 / 0	96 / 0	30.822		41 / 0	77 / 0	113 / 0	157 / 0	18.967

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .65 CF/SF) (4)

NEGATIVE MOMENT											
STEEL AREA (SQ. IN.)	.72	.90	1.06	1.24	1.51		.80	1.01	1.24	1.44	1.76
STEEL % (UNIFORM)	.49	.61	.73	.85	1.04		.55	.70	.85	.99	1.21
(TAPERED)	.30	.37	.44	.51	.63		.33	.42	.51	.60	.73
EFF. DEPTH, IN.	19.3	19.3	19.2	19.2	19.1		19.3	19.2	19.2	19.1	19.1
−ICR/IGR	.154	.184	.208	.234	.269		.168	.201	.234	.260	.300
POSITIVE MOMENT											
STEEL AREA (SQ. IN.)	.62	.75	.88	1.04	1.20		.51	.62	.75	.88	1.04
STEEL %	.09	.11	.13	.15	.17		.07	.09	.11	.13	.15
EFF. DEPTH, IN.	19.2	19.1	19.1	19.1	19.1		19.2	19.2	19.1	19.1	19.1
+ICR/IGR	.168	.199	.230	.265	.302		.140	.168	.199	.230	.265

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS		30" Forms + 7" Rib @ 37" c.-c. (2) FACTORED USABLE SUPERIMPOSED LOAD (PSF)											f'_c = 4,000 psi f_y = 60,000 psi
		16" Deep Rib + 4.5" Top Slab = 20.5" Total Depth											
TOP BARS	Size @	# 4 10	# 4 8.5	# 5 11	# 5 9	# 5 8	End Span Defl. Coeff. (3)	# 4 9	# 5 11	# 5 9.5	# 5 8	# 6 9.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	# 7 # 7		# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	
Steel (psf)		.83	1.00	1.20	1.41	1.63		.92	1.16	1.36	1.63	[illegible]	
CLEAR SPAN		END SPAN						INTERIOR SPAN					
27'-0"		[redacted]			0	354	6.576	170 / 0	236 / 0	313 / 0	391 / 0	[illegible]	[illegible]
28'-0"		100 / 0	149 / 0	199 / 0	259 / 0	319 / 0	7.606	148 / 0	210 / 0	281 / 0	354 / 0	292 / 111	4.691
29'-0"		83 / 0	129 / 0	176 / 0	232 / 0	288 / 0	8.752	128 / 0	186 / 0	253 / 0	320 / 0	[illegible] / 401	5.386
30'-0"		69 / 0	112 / 0	155 / 0	207 / 0	260 / 0	10.023	110 / 0	164 / 0	227 / 0	290 / 0	[illegible] / 300	6.169
31'-0"		55 / 0	95 / 0	136 / 0	185 / 0	235 / 0	11.428	94 / 0	145 / 0	203 / 0	263 / 0	321 / 331	7.033
32'-0"		43 / 0	81 / 0	119 / 0	165 / 0	211 / 0	12.975	80 / 0	127 / 0	182 / 0	238 / 0	304 / 0	7.995
33'-0"			68 / 0	103 / 0	147 / 0	190 / 0	14.675	67 / 0	111 / 0	163 / 0	215 / 0	279 / 0	9.031
34'-0"			55 / 0	89 / 0	130 / 0	171 / 0	16.536	55 / 0	97 / 0	145 / 0	194 / 0	253 / 0	10.170
35'-0"			44 / 0	76 / 0	115 / 0	153 / 0	18.569	43 / 0	83 / 0	129 / 0	175 / 0	231 / 0	[illegible]
36'-0"				64 / 0	100 / 0	137 / 0	20.784		71 / 0	114 / 0	158 / 0	211 / 0	[illegible]
37'-0"				53 / 0	88 / 0	122 / 0	23.191		59 / 0	100 / 0	142 / 0	192 / 0	[illegible]
38'-0"				43 / 0	76 / 0	109 / 0	25.802		49 / 0	89 / 0	127 / 0	175 / 0	[illegible]
39'-0"					65 / 0	96 / 0	28.627			76 / 0	114 / 0	159 / 0	[illegible]
40'-0"					54 / 0	84 / 0	31.678			65 / 0	101 / 0	141 / 0	[illegible]

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .68 CF/SF) (4)

NEGATIVE MOMENT											
STEEL AREA (SQ. IN.)	.74	.87	1.04	1.27	1.43		.82	1.01	1.21	1.43	1.71
STEEL % (UNIFORM)	.45	.53	.63	.77	.87		.50	.63	.73	.87	1.01
(TAPERED)	.28	.33	.40	.49	.55		.31	.40	.46	.55	.63
EFF. DEPTH, IN.	19.3	19.3	19.2	19.2	19.2		19.3	19.2	19.2	19.2	19.1
−ICR/IGR	.146	.166	.191	.223	.244		.159	.191	.214	.244	.277
POSITIVE MOMENT											
STEEL AREA (SQ. IN.)	.62	.75	.88	1.04	1.20		.51	.62	.75	.88	1.01
STEEL %	.09	.11	.12	.15	.17		.07	.09	.11	.12	.15
EFF. DEPTH, IN.	19.2	19.1	19.1	19.1	19.1		19.2	19.2	19.1	19.1	19.1
+ICR/IGR	.152	.180	.208	.240	.273		.127	.152	.180	.208	[illegible]

CONCRETE REINFORCING STEEL INSTITUTE

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS — 30" Forms + 6" Rib @ 36" c.-c. (2) — FACTORED USABLE SUPERIMPOSED LOAD (PSF) — f'_c = 4,000 psi, f_y = 60,000 psi

20" Deep Rib + 4.5" Top Slab = 24.5" Total Depth

TOP BARS Size @ / BOTTOM BARS	#5 12 / #5 #6	#5 10.5 / #6 #6	#5 9 / #6 #7	#6 11 / #7 #7	#6 9 / #7 #8	End Span Defl. Coeff.	#5 11 / #5 #5	#5 9.5 / #5 #6	#5 8 / #6 #6	#6 9.5 / #6 #7	#7 11 / #7 #7	Int. Span Defl. Coeff.
Steel (psf)	1.05	1.24	1.44	1.69	1.96	(3)	1.18	1.38	1.66	1.96	2.31	(3)
CLEAR SPAN	END SPAN						INTERIOR SPAN					
32'-0"	124	172	229	287	325*	12.625	182	250	319	374*	379*	7.769
	0	0	0	0	354		0	0	0	403	433*	
33'-0"	108	152	206	261	306*	14.278	162	226	291	354*	359*	8.787
	0	0	0	0	324		0	0	0	370	408*	
34'-0"	92	135	185	237	288*	16.089	143	204	265	336*	340*	9.901
	0	0	0	0	296		0	0	0	339	386*	
35'-0"	79	118	166	215	271	18.067	127	184	242	312	323*	11.118
	0	0	0	0	0		0	0	0	0	365*	
36'-0"	66	104	149	195	248	20.222	111	166	220	286	307*	12.445
	0	0	0	0	0		0	0	0	0	346*	
37'-0"	54	90	133	176	227	22.565	97	149	200	263	292*	13.886
	0	0	0	0	0		0	0	0	0	326	
38'-0"	44	77	118	159	207	25.105	84	133	182	241	278*	15.449
	0	0	0	0	0		0	0	0	0	301	
39'-0"		66	104	143	189	27.853	72	118	165	221	265*	17.141
		0	0	0	0		0	0	0	0	278	
40'-0"		55	92	129	172	30.822	61	105	149	203	252*	18.967
		0	0	0	0		0	0	0	0	257	
41'-0"		45	80	115	156	34.022	51	93	135	186	237	20.936
		0	0	0	0			0	0	0	0	0
42'-0"			69	102	142	37.464	41	81	121	170	219	23.055
			0	0	0		0	0	0	0	0	
43'-0"			59	91	128	41.162		70	109	155	202	25.330
			0	0	0			0	0	0	0	
44'-0"			49	80	115	45.127		60	97	141	186	27.770
			0	0	0			0	0	0	0	
45'-0"			40	70	104	49.371		51	86	128	171	30.382
			0	0	0			0	0	0	0	

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ ℓ_n/18.5 for end spans, ℓ_n/21 for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = ℓ_n/360.

PROPERTIES FOR DESIGN (CONCRETE .73 CF/SF) (4)

NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	93	1.06	1.24	1.44	1.76		1.01	1.17	1.39	1.67	1.96	
STEEL % (UNIFORM)	51	.58	67	.79	.96		.55	.64	.76	.91	1.07	
(TAPERED)	.31	.35	.41	.48	.59		.34	.39	.47	.56	.66	
EFF. DEPTH, IN.	23.2	23.2	23.2	23.1	23.1		23.2	23.2	23.2	23.1	23.1	
−ICR/IGR	167	.186	.210	.234	.272		.179	.201	.230	.261	.293	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.75	.88	1.04	1.20	1.39		.62	.75	.88	1.04	1.20	
STEEL %	.09	.11	.13	.14	.17		.07	.09	.11	.13	.14	
EFF. DEPTH, IN.	23.1	23.1	23.1	23.1	23.0		23.2	23.1	23.1	23.1	23.1	
+ICR/IGR	.173	.200	232	.264	.299		.146	.173	.200	.232	.264	

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS — 30" Forms + 7" Rib @ 37" c.-c. (2) — FACTORED USABLE SUPERIMPOSED LOAD (PSF) — f'_c = 4,000 psi, f_y = 60,000 psi

20" Deep Rib + 4.5" Top Slab = 24.5" Total Depth

TOP BARS Size @ / BOTTOM BARS	#5 12 / #5 #6	#5 11 / #6 #6	#5 9.5 / #6 #7	#5 8 / #7 #7	#5 7 / #7 #8	End Span Defl. Coeff.	#5 12 / #5 #5	#5 9.5 / #5 #6	#5 8 / #6 #6	#5 7 / #6 #7	#5 6 / #7 #7	Int. Span Defl. Coeff.
Steel (psf)	1.03	1.20	1.40	1.63	1.87	(3)	1.11	1.36	1.63	1.88	2.20	(3)
CLEAR SPAN	END SPAN						INTERIOR SPAN					
32'-0"	108	155	210	267	332	12.975	164	231	298	380	419*	7.985
	0	0	0	0	0		0	0	0	0	462	
33'-0"	92	136	188	241	303	14.675	145	208	271	347	397*	9.031
	0	0	0	0	0		0	0	0	0	425	
34'-0"	77	119	168	218	276	16.536	127	186	246	318	377*	10.176
	0	0	0	0	0		0	0	0	0	391	
35'-0"	64	103	149	197	251	18.569	111	167	223	291	359*	11.427
	0	0	0	0	0		0	0	0	0	360	
36'-0"	52	88	132	177	229	20.784	96	149	202	266	331	12.790
	0	0	0	0	0		0	0	0	0	0	
37'-0"	40	75	117	159	208	23.191	82	132	182	243	305	14.272
	0	0	0	0	0		0	0	0	0	0	
38'-0"		63	102	142	189	25.802	70	117	165	222	280	15.878
		0	0	0	0		0	0	0	0	0	
39'-0"		51	89	127	171	28.627	58	103	148	203	258	17.617
		0	0	0	0		0	0	0	0	0	
40'-0"		41	77	113	155	31.678	47	90	133	185	237	19.494
		0	0	0	0		0	0	0	0	0	
41'-0"			65	100	139	34.967		78	119	168	218	21.518
			0	0	0			0	0	0	0	
42'-0"			54	87	125	38.505		66	105	153	200	23.695
			0	0	0			0	0	0	0	
43'-0"			45	76	112	42.305		56	93	138	184	26.034
			0	0	0			0	0	0	0	
44'-0"				65	100	46.380		46	82	125	168	28.542
				0	0			0	0	0	0	
45'-0"				55	88	50.742			71	112	154	31.226
				0	0				0	0	0	

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ ℓ_n/18.5 for end spans, ℓ_n/21 for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = ℓ_n/360.

PROPERTIES FOR DESIGN (CONCRETE .77 CF/SF) (4)

NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.96	1.04	1.21	1.43	1.64		.96	1.21	1.43	1.64	1.91	
STEEL % (UNIFORM)	.46	.50	.58	.69	.79		.46	.58	.69	.79	.92	
(TAPERED)	.30	.32	.37	.44	.51		.30	.37	.44	.51	.59	
EFF. DEPTH, IN.	23.2	23.2	23.2	23.2	23.2		23.2	23.2	23.2	23.2	23.2	
−ICR/IGR	.159	.170	.192	.219	.243		.159	.192	.219	.243	.273	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.75	.88	1.04	1.20	1.39		.62	.75	.88	1.04	1.20	
STEEL %	.09	.10	.12	.14	.16		.07	.09	.10	.12	.14	
EFF. DEPTH, IN.	23.1	23.1	23.1	23.1	23.0		23.2	23.1	23.1	23.1	23.1	
+ICR/IGR	.157	.181	.210	.239	.272		.132	.157	.181	.210	.239	

f'_c = 4,000 psi
f_y = 60,000 psi

JOIST-BAND BEAMS, END SPANS

STEM		BARS[1]				TOTAL CAPACITY $U = 1.4D + 1.7L$[3]																				$\pm\phi M_n$	DEFL. (C)
h	b	BOTTOM		Layers	TOP	SPAN, ℓ_n = 20 ft					SPAN, ℓ_n = 22 ft					SPAN, ℓ_n = 24 ft					SPAN, ℓ_n = 26 ft						
in.	in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	Aℓ sq. in.	STEEL WGT lb.	(6) ft-kip	(7) 10 in.
20.5	24	2#9	1#9	1	4#8	6.0	133F	14	-	453	4.9	133F	14	-	485	4.2	143F	14	-	525	3.5	143F	14	-	557	227	617
				1			154F	56	1.6	641		264C	55	1.6	883		293C	55	1.6	699		313C	54	1.5	751	239	
		2#10	1#10	1	4#10	7.8	143F	14	-	612	6.4	153F	14	-	665	5.4	163F	14	-	717	4.6	163F	14	-	762	282	555
				1			155F	56	1.6	972		175F	55	1.6	1079		185F	55	1.5	1155		204F	54	1.5	1023	365	
		3#10	2#10	1	4#11	10.9	154F	14	-	959	9.0	164F	14	-	1039	7.6	173F	14	-	996	6.4	183F	14	-	1070	413	458
				1			155F	56	1.6	1202		175F	55	1.6	1330		185F	55	1.5	1427		205F	54	1.5	1551	135	
		8#6	8#6	2	4#14	12.8	154F	14	-	1149	10.6	174F	14	-	1259	8.9	184F	14	-	1355	7.6*	194F	13	-	1451	461	111
				1			245C	56	1.6	1672		265C	55	1.5	1815		185F	54	1.5	1647		205F	54	1.5	1790	580	
	36	2#9	2#9	1	5#9	8.4	123F	25	-	610	6.9	133F	24	-	664	5.8	133F	24	-	709	5.0	133F	24	-	755	305	390
				1			403A	99	2.4	965		443A	98	2.3	1056		483A	97	2.3	1147		523A	96	2.3	1239	375	
		2#10	2#10	1	5#10	10.4	143F	25	-	766	8.6	143F	24	-	823	7.3	153F	24	-	889	6.2	153F	24	-	916	370	395
				1			204D	99	2.3	1092		224D	98	2.3	1194		483A	97	2.3	1310		523A	96	2.3	1113	466	
		4#10	3#10	1	5#14	17.3	155F	25	-	1566	14.3	174F	24	-	1551	12.0	184F	24	-	1669	10.2*	194F	24	-	1788	627	297
				1			245C	99	2.3	2028		265C	98	2.3	2202		295C	97	2.3	2411		315C	96	2.3	2585	751	
		4#10	4#10	1	5#14	18.9	155F	25	-	1644	15.6	175F	24	-	1806	13.1	185F	24	-	1942	11.2*	194F	24	-	1888	702	285
				1			245C	99	2.3	2106		265C	98	2.3	2287		295C	97	2.3	2504		315C	96	2.3	2685	751	
	48	3#9	3#9	1	6#9	11.4	123F	36	-	803	9.4	133F	36	-	874	7.9	133F	36	-	936	6.7	N/A	35	-	873	451	302
				1			**	146	0.0	687		**	144	0.0	749		**	142	0.0	811		**	141	0.0	973	451	
		3#10	3#10	1	6#11	15.5	144F	36	-	1227	12.8	154F	36	-	1331	10.8	163F	35	-	1293	9.2	163F	35	-	1378	561	297
				1			175E	145	3.1	1662		264C	144	3.1	1718		294C	142	3.0	1880		**	141	5.3	1221	677	
		5#10	4#10	1	6#14	22.3	155F	36	-	1890	18.4	165F	36	-	2046	15.5	175F	35	-	2202	13.2*	184F	35	-	2161	810	233
				1			305B	145	3.1	2672		335B	144	3.1	2921		365B	142	3.0	3171		395B	141	3.0	3120	921	
		6#10	5#10	1	7#14	26.1	175CfF	36	-	2231	21.6	195CeF	36	-	2442	18.2	185F	35	-	2564	15.5*	195F	35	-	2715	961	208
				1			305B	145	3.1	2954		335B	144	3.1	3228		365B	142	3.0	3503		395B	141	3.0	3777	1015	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * — $\ell_n/360$ < deflection < $\ell_n/240$
X — $\ell_n/240$ < deflection < $\ell_n/180$
Y — deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation:
N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C × (w/1.6) × ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft.
Average service load is taken as w/1.6

12-88 CONCRETE REINFORCING STEEL INSTITUTE

STANDARD ONE WAY JOISTS (1) MULTIPLE SPANS		20" Forms + 5" Rib @ 25" c.-c. (2) FACTORED USABLE SUPERIMPOSED LOAD (PSF)											f'_c = 4,000 psi f_y = 60,000 psi
12" Deep Rib + 4.5" Top Slab = 16.5" Total Depth													
TOP BARS	Size @	# 5 12	# 5 10.5	# 5 8.5	# 6 10	# 7 11	End Span Defl. Coeff. (3)	# 5 12	# 5 9.5	# 6 10.5	# 7 11	# 7 9.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7		# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	
Steel (psf)		1.02	1.24	1.50	1.81	2.14		1.08	1.35	1.73	2.16	2.55	
CLEAR SPAN		END SPAN						INTERIOR SPAN					
22'-0"		246	326	383*	393*		1.959	302	417	443*			1.205
		0	0	418	511			0	0	533			
23'-0"		214	288	354*	363*	376*	2.340	266	371	412*	422*	431*	1.440
		0	0	371	456	517*		0	0	477	575*	591*	
24'-0"		186	254	329*	336*	348*	2.774	233	330	385*	394*	402*	1.707
		0	0	330	408	483*		0	0	428	527*	542*	
25'-0"		162	224	294	313*	323*	3.266	205	294	360*	368*	376*	2.010
		0	0	0	366	452		0	0	384	486*	499*	
26'-0"		140	197	262	291*	300*	3.821	180	262	338*	345*	352*	2.351
		0	0	0	329	408		0	0	345	440	461*	
27'-0"		120	173	234	272*	280*	4.443	157	234	311	324*	330*	2.734
		0	0	0	296	369		0	0	0	399	428*	
28'-0"		103	152	208	254*	262*	5.139	137	208	280	305*	310*	3.163
		0	0	0	266	334		0	0	0	362	398*	
29'-0"		87	133	186	238*	245*	5.914	119	185	252	287*	292*	3.639
		0	0	0	239	302		0	0	0	329	372*	
30'-0"		73	116	165	215	230*	6.772	103	165	227	271*	275*	4.168
		0	0	0	0	274		0	0	0	299	348*	
31'-0"		60	100	146	193	215*	7.722	88	146	204	255*	260*	4.752
		0	0	0	0	249		0	0	0	272	326*	
32'-0"		48	86	129	173	202*	8.767	75	129	184	241*	245*	5.395
		0	0	0	0	225		0	0	0	247	306*	
33'-0"			73	114	155	190*	9.915	62	114	165	224	232*	6.102
			0	0	0	204		0	0	0	0	284	
34'-0"			61	100	139	179*	11.173	51	100	148	204	220*	6.876
			0	0	0	185		0	0	0	0	260	
35'-0"			51	87	124	167	12.547	41	87	133	185	208*	7.721
			0	0	0	0		0	0	0	0	238	

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .62 CF/SF) (4)												
NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.65	.74	.91	1.10	1.36		.65	.82	1.05	1.36	1.58	
STEEL % (UNIFORM)	.68	.78	.96	1.16	1.45		.68	.86	1.11	1.45	1.68	
(TAPERED)	.41	.47	.58	.71	.88		.41	.52	.68	.88	1.02	
EFF. DEPTH, IN.	15.2	15.2	15.2	15.1	15.1		15.2	15.2	15.1	15.1	15.1	
−ICR/IGR	.196	.217	.255	.290	.334		.196	.235	.280	.334	.370	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.51	.62	.75	.88	1.04		.40	.51	.62	.75	.88	
STEEL %	.13	.16	.20	.23	.28		.10	.13	.16	.20	.23	
EFF. DEPTH, IN.	15.2	15.2	15.1	15.1	15.1		15.3	15.2	15.2	15.1	15.1	
+ICR/IGR	.203	.242	.285	.326	.376		.164	.203	.242	.285	.328	

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS		20" Forms + 6" Rib @ 26" c.-c. (2) FACTORED USABLE SUPERIMPOSED LOAD (PSF)											f'_c = 4,000 psi f_y = 60,000 psi
12" Deep Rib + 34.5" Top Slab = 16.5" Total Depth													
TOP BARS	Size @	# 5 12	# 5 11	# 5 9	# 6 10.5	# 6 9	End Span Defl. Coeff. (3)	# 5 12	# 5 10	# 5 8	# 6 9	# 7 10.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7		# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	
Steel (psf)		.99	1.19	1.44	1.73	2.02		1.06	1.30	1.68	2.00	2.38	
CLEAR SPAN		END SPAN						INTERIOR SPAN					
22'-0"		225	302	390	434*	445*	2.037	279	389	496*	504*		1.254
		0	0	0	480	586		0	0	501	629		
23'-0"		194	265	345	402*	412*	2.433	243	345	447	470*	475*	1.497
		0	0	0	427	524		0	0	0	564	641*	
24'-0"		167	232	306	374*	383*	2.885	212	305	399	439*	444*	1.775
		0	0	0	381	470		0	0	0	507	590*	
25'-0"		144	203	271	341	356*	3.397	185	271	357	412*	416*	2.090
		0	0	0	0	423		0	0	0	457	545*	
26'-0"		122	178	241	305	333*	3.974	161	240	320	386*	390*	2.445
		0	0	0	0	381		0	0	0	412	505*	
27'-0"		104	155	213	273	311*	4.621	139	213	287	363*	367*	2.844
		0	0	0	0	343		0	0	0	372	458	
28'-0"		87	134	189	244	291*	5.345	120	188	257	336	345*	3.289
		0	0	0	0	309		0	0	0	0	417	
29'-0"		72	116	167	218	273*	6.150	103	166	231	304	326*	3.785
		0	0	0	0	279		0	0	0	0	379	
30'-0"		58	99	147	195	252	7.043	87	146	207	275	308*	4.334
		0	0	0	0	0		0	0	0	0	345	
31'-0"		46	84	129	174	227	8.030	73	128	185	249	291*	4.942
		0	0	0	0	0		0	0	0	0	315	
32'-0"			71	113	155	205	9.118	60	112	165	226	275*	5.611
			0	0	0	0		0	0	0	0	287	
33'-0"			59	98	137	185	10.312	48	97	147	204	261*	6.346
			0	0	0	0		0	0	0	0	262	
34'-0"			47	84	122	166	11.620		84	131	184	239	7.151
			0	0	0	0			0	0	0	0	
35'-0"				72	107	149	13.049		71	116	166	218	8.030
				0	0	0			0	0	0	0	

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .64 CF/SF) (4)												
NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.67	.73	.90	1.09	1.27		.67	.81	1.01	1.27	1.49	
STEEL % (UNIFORM)	.61	.66	.81	.99	1.16		.61	.73	.91	1.16	1.36	
(TAPERED)	.39	.43	.52	.64	.75		.39	.47	.59	.75	.88	
EFF. DEPTH, IN.	15.2	15.2	15.2	15.1	15.1		15.2	15.2	15.2	15.1	15.1	
−ICR/IGR	.185	.199	.232	.266	.298		.185	.214	.254	.298	.330	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.51	.62	.75	.88	1.04		.40	.51	.62	.75	.88	
STEEL %	.13	.16	.19	.22	.27		.10	.13	.16	.19	.22	
EFF. DEPTH, IN.	15.2	15.2	15.1	15.1	15.1		15.3	15.2	15.2	15.1	15.1	
+ICR/IGR	.180	.215	.253	.291	.334		.146	.180	.215	.253	.291	

CONCRETE REINFORCING STEEL INSTITUTE

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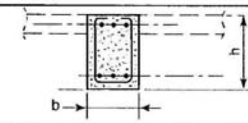
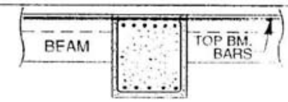
f'_c = 4,000 psi
f_y = 60,000 psi

JOIST-BAND BEAMS, END SPANS





STEM h in.	STEM b in.	BARS(1) BOTTOM ℓ_n + 12 in.	BARS(1) BOTTOM 0.875 ℓ_n	Layers (2)	TOP	SPAN, ℓ_n = 16 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN, ℓ_n = 18 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN, ℓ_n = 20 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN, ℓ_n = 22 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	$+\phi M_n$ / $-\phi M_n$ (6) ft-kip	DEFL. (7) in.
		2# 8	1# 8	1	4# 7	5.6	113E	10	-	297	4.4	123E	10	-	328	3.6	123E	10	-	353	2.9	123E	10	-	[illegible]	[illegible]	[illegible]
				1			193C	40	1.3	389		223C	39	1.3	440		243C	39	1.3	482		263C	38	1.3	525	112	
		2# 8	1# 8	1	4# 9	6.0	123E	10	-	370	4.8	123E	10	-	401	3.9	133E	10	-	439	3.2	133E	10	-	470	[illegible]	[illegible]
				1			194C	40	1.3	619		223C	39	1.3	513		243C	39	1.3	562		263C	38	1.3	611	221	
	24	7# 5	7# 5	2	4#10	9.9	163D	10	-	543	7.8	173D	10	-	597	6.3	193D	10	-	658	5.2*	203D	10	-	712	[illegible]	[illegible]
				1			165D	39	1.3	890		184D	39	1.3	796		204D	38	1.3	878		264C	38	1.3	1030	[illegible]	
		9# 5	8# 5	2	4#11	11.7	164D	10	-	749	9.2	184D	10	-	834	7.5*	203D	10	-	789	6.2*	213D	10	-	854	[illegible]	[illegible]
				1			165D	39	1.3	993		185D	39	1.3	1108		205D	38	1.3	1223		224D	38	1.2	[illegible]	[illegible]	
		2# 8	2# 8	1	5# 8	8.1	113E	17	-	408	6.4	123E	17	-	451	5.2	N/A	17	-	395	4.3	N/A	17	-	431	[illegible]	[illegible]
				1			323A	69	1.9	659		363A	68	1.9	736		403A	67	1.9	814		413A	66	1.9	891	231	
		3# 8	2# 8	1	5# 9	10.0	123E	17	-	507	7.9	133E	17	-	559	6.4	143E	17	-	612	5.3	143E	17	-	657	231	[illegible]
				1			164D	69	1.9	743		363A	68	1.9	837		403A	67	1.9	924		443A	66	1.9	1011	[illegible]	
16.5	36	4# 8	4# 8	1	5#11	15.2	144E	17	-	870	12.0	154E	17	-	956	9.7	164E	17	-	1041	8.0*	173E	17	-	1004	351	[illegible]
				1			145E	69	1.9	1126		165E	68	1.9	1263		205D	67	1.9	1467		224D	66	1.9	1326	117	
		13# 5	13# 5	2	6#11	17.8	165D	17	-	1200	14.0	184D	17	-	1173	11.4*	204D	17	-	1291	9.4*	214D	17	-	1391	113	[illegible]
				1			325A	69	1.9	1879		185D	67	1.9	1502		205D	67	1.9	1657		225D	66	1.9	1811	[illegible]	
		3# 8	3# 8	1	6# 8	10.9	113E	25	-	534	8.6	123E	25	-	592	7.0	123E	24	-	640	5.8	N/A	21	-	595	[illegible]	[illegible]
				1			**	100	0.0	439		**	98	0.0	488		**	97	0.0	537		**	96	0.0	595	[illegible]	
		3# 8	3# 8	1	6#10	12.0	123E	25	-	667	9.5	123E	25	-	727	7.7	133E	24	-	796	6.4	133E	24	-	856	[illegible]	[illegible]
				1			**	100	5.4	563		**	98	5.4	623		**	97	5.3	683		**	96	5.3	743	127	
	48	6# 8	5# 8	1	6#11	19.9	145E	25	-	1230	15.7	154E	25	-	1199	12.7	164E	24	-	1308	10.5*	174E	21	-	1118	[illegible]	[illegible]
				1			245B	100	2.6	1769		275B	98	2.5	1976		175E	97	2.5	1688		261C	96	2.5	1750	[illegible]	
		17# 5	17# 5	2	6#14	23.3	165D	25	-	1565	18.4	185D	24	-	1738	14.9*	204D	24	-	1711	12.3*	214D	24	-	1318	[illegible]	[illegible]
				1			325A	99	2.5	2355		365A	98	2.5	2627		405A	96	2.5	2899		225D	96	2.5	[illegible]	678	

TOTAL CAPACITY $U = 1.4D + 1.7L$[3]

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * — $\ell_n/360$ < deflection < $\ell_n/240$; X — $\ell_n/240$ < deflection < $\ell_n/180$; Y — deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation: N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C × (w/1.6) × ℓ_n^2, where w = tabulated load (k/ft.), ℓ_n in ft. "Average service load" is taken as w/1.6

APPENDIX G: TRUSJOIST MANUFACTURED WOOD PRODUCTS DESIGN CALCULATIONS/REFERENCES

MANUFACTURED WOOD FRAMING

NORTH-SOUTH SPAN

LOADING

OFFICE BLDG: (100) + 20 = 120 PSF (2'-0" O.C.) = 240 PLF

MEMBER SELECTION

SEE SPEC ATTACHED

GIRDER: 6.0 PLF 12'-0 = 3 PSF
(120 + 3)(18.75' TRIB) = 2306 PLF

WEIGHT CALCULATION

OFFICE: 20 PSF D
(20)(30)(20) = 12.0 K
16(TJI)(20') = 1.920 K
2 (PARALLAM)(30') = 2(34)(7)(1/144)(45)(30) = 4.463 K
Σ 18.383 K

EAST-WEST SPAN

LOADING

(100 + 20)(1.5' O.C) = 180 PLF

MEMBER SELECTION

SEE SPEC ATTACHED

GIRDER 7.1 PLF / 1.5' = 4.8 PSF
(120 + 4.8)(30' TRIB) = 3744 PLF

WEIGHT CALCULATION

20 PSF D
(20)(30)(20) = 12.0 K
14(TJI)(30') = 2.982 K
2(28)(7)(1/144)(45)(20) = 2.450 K
Σ 17.432 K

TJI® H90 • Allowable Uniform Load (PLF)

Depth	11⅞"		14"		16"		18"		20"		22"		24"		26"		28"		30"	
Span	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL	100% TL	115% TL
	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL	100% LL	125% TL
14'	275	316	297	341	320	368	320	368	342	393	365	419	365	419	387	445	410	471	410	471
	230	343	*	371	*	400	*	400	*	427	*	456	*	456	*	483	*	512	*	512
16'	240	276	260	299	280	322	280	322	299	344	319	367	319	367	338	389	358	412	358	412
	163	300	229	325	*	350	*	350	*	374	*	399	*	399	*	423	*	448	*	448
18'	213	245	231	265	248	286	248	286	266	306	283	326	283	326	301	346	318	366	318	366
	106	267	150	288	197	311	*	311	*	332	*	354	*	354	*	376	*	398	*	398
20'	166	221	208	239	224	257	224	257	239	275	255	293	255	293	271	311	287	330	287	330
	72	221	102	260	135	280	172	280	212	299	*	319	*	319	*	338	*	358	*	358
22'	127	170	183	217	203	234	203	234	217	250	232	267	232	267	246	283	260	300	260	300
	55	170	79	236	105	254	134	254	166	272	201	290	*	290	*	307	*	326	*	326
24'	100	133	144	192	186	214	186	214	199	229	212	244	212	244	225	259	239	275	239	275
	43	133	62	192	83	233	106	233	132	249	161	266	191	266	*	282	*	298	*	298
26'	79	106	115	154	155	198	172	198	184	211	196	226	196	226	208	239	220	253	220	253
	34	106	50	154	66	207	86	215	107	230	130	245	156	245	183	260	212	275	*	275
28'		86	93	125	126	168	160	184	171	196	182	209	182	209	193	222	205	235	205	235
		86	40	125	54	168	70	200	87	213	107	228	128	228	151	241	175	256	202	256
30'		70	77	102	104	138	134	171	159	183	170	195	170	195	180	207	191	220	191	220
		70	33	102	44	138	58	179	72	199	88	212	106	212	126	225	146	239	169	239
32'		58		85	86	115	112	150	141	170	159	183	159	183	169	194	179	206	179	206
		58		85	37	115	48	150	60	185	74	199	89	199	105	211	123	224	142	224
34'		49		71	72	97	94	126	119	150	144	165	150	172	159	183	168	194	168	194
		49		71	31	97	40	126	51	159	63	180	75	187	89	199	105	211	121	211
36'		41		60		82	80	107	101	134	125	148	140	161	150	173	159	183	159	183
		41		60		82	34	107	43	135	53	160	64	175	76	188	89	199	103	199
38'		35		52		70	69	92	87	116	107	132	126	144	136	157	146	168	151	173
		35		52		70	29	92	37	116	46	143	55	157	66	170	77	183	89	188
40'		30		44		60		79	75	100	93	119	112	130	123	141	132	152	141	163
		30		44		60		79	32	100	39	124	48	142	57	154	67	165	77	177
42'				38		52		69	65	87	80	107	98	118	111	128	120	138	128	148
				38		52		69	28	87	34	107	42	128	49	139	58	150	68	160

*Indicates total load value controls.

See instructions and notes on page 6

Joist Depth	Basic Properties						Reaction Properties[4][5]							
							End Reaction (lbs)				Intermediate Reaction (lbs)			
							Bearing Length				Bearing Length			
	Joist Weight (lbs/ft)	Resistive Moment[1] (ft-lbs)	Vertical Shear[2] (lbs)	EI x 10^6 (in.²-lbs)	EI[3] x 10^6 TJI® Joist with Nailed Floor Sheathing (in.²-lbs)	EI[3] x 10^6 TJI® Joist with Glue-Nailed Floor Sheathing (in.²-lbs)	1¾"		3½"		3½"		5¼"	
							Web Stiffeners[6]		Web Stiffeners[6]		Web Stiffeners[6]		Web Stiffeners[6]	
							No	Yes	No	Yes	No	Yes	No	Yes
TJI® L65 Joist														
11⅞"	3.3	6,750	1,925	450	512	561	1,375	1,745	1,885	1,925	2,745	3,120	3,365	3,735
14"	3.6	8,030	2,125	666	752	821	1,375	1,750	1,885	2,125	2,745	3,365	3,365	3,985
16"	3.9	9,210	2,330	913	1,025	1,116	1,375	1,750	1,885	2,330	2,745	3,490	3,365	4,105
18"	4.2	10,380	2,535	1,205	1,348	1,462	1,375	1,750	1,885	2,535	2,745	3,615	3,365	4,230
20"	4.4	11,540	2,740	1,545	1,722	1,864	N.A.	1,750	N.A.	2,740	N.A.	3,740	N.A.	4,355
22"	4.7	12,690	2,935	1,934	2,149	2,322	N.A.	1,750	N.A.	2,935	N.A.	3,860	N.A.	4,480
24"	5.0	13,830	3,060	2,374	2,632	2,838	N.A.	1,750	N.A.	3,060	N.A.	3,875	N.A.	4,605
26"	5.3	14,960	2,900	2,868	3,172	3,416	N.A.	1,750	N.A.	2,900	N.A.	4,725[7]	N.A.	5,345[8]
28"	5.5	16,085	2,900	3,417	3,772	4,056	N.A.	1,750	N.A.	2,900	N.A.	4,850[7]	N.A.	5,470[8]
30"	5.8	17,205	2,900	4,025	4,434	4,762	N.A.	1,750	N.A.	2,900	N.A.	4,975[7]	N.A.	5,590[8]
TJI® L90 Joist														
11⅞"	4.2	9,605	1,925	621	687	741	1,400	1,715	1,885	1,925	3,350	3,665	3,965	4,285
14"	4.5	11,430	2,125	913	1,005	1,079	1,400	1,875	1,885	2,125	3,350	3,825	3,965	4,440
16"	4.7	13,115	2,330	1,246	1,366	1,462	1,400	2,030	1,885	2,330	3,350	3,980	3,965	4,600
18"	5.0	14,785	2,535	1,635	1,786	1,908	1,400	2,030	1,885	2,515	3,350	3,980	3,965	4,600
20"	5.3	16,435	2,740	2,085	2,272	2,422	N.A.	2,190	N.A.	2,675	N.A.	4,140	N.A.	4,755
22"	5.6	18,075	2,935	2,597	2,824	3,006	N.A.	2,345	N.A.	2,830	N.A.	5,090	N.A.	5,705
24"	5.8	19,700	3,060	3,172	3,442	3,659	N.A.	2,345	N.A.	2,830	N.A.	5,405	N.A.	6,020
26"	6.1	21,315	2,900	3,814	4,132	4,387	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]
28"	6.4	22,915	2,900	4,525	4,895	5,191	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]
30"	6.6	24,510	2,900	5,306	5,732	6,073	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]
TJI® H90 Joist														
11⅞"	4.6	10,960	1,925	687	755	810	1,400	1,715	1,885	1,925	3,495	3,810	4,100	4,420
14"	4.9	13,090	2,125	1,015	1,109	1,185	1,400	1,875	1,885	2,125	3,495	3,970	4,100	4,575
16"	5.2	15,065	2,330	1,389	1,512	1,610	1,400	2,030	1,885	2,330	3,495	4,130	4,100	4,735
18"	5.4	17,010	2,535	1,827	1,982	2,106	1,400	2,030	1,885	2,515	3,495	4,130	4,100	4,735
20"	5.7	18,945	2,740	2,331	2,522	2,676	N.A.	2,190	N.A.	2,675	N.A.	4,285	N.A.	4,890
22"	6.0	20,855	2,935	2,904	3,136	3,321	N.A.	2,345	N.A.	2,830	N.A.	5,235	N.A.	5,840
24"	6.3	22,755	3,060	3,549	3,825	4,046	N.A.	2,345	N.A.	2,830	N.A.	5,425	N.A.	6,155
26"	6.5	24,645	2,900	4,266	4,590	4,850	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]
28"	6.8	26,520	2,900	5,059	5,436	5,737	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]
30"	7.1	28,380	2,900	5,930	6,363	6,710	N.A.	2,450	N.A.	2,900	N.A.	5,800[7]	N.A.	5,800[8]

APPENDIX H: TWO-WAY SLAB DESIGN CALCULATIONS/REFERENCES

TWO WAY SLAB

WITH DROP PANELS

LOADING

OFFICE BLDG: 1.4(15) + 1.7(100) = 191 PSF
PARKING : 1.4(50) + 1.7(250) + 1.0(30) = 525 PSF

SLAB SELECTION

OFFICE l_N = 25'-0 9" FLAT SLAB, 7" DROPS, 8'-4" SQUARE, 15" SQ. COL

PARKING: l_N = 25'-0" 11" FLAT SLAB, 9" DROP PANELS, 10'-0 SQUARE

OFFICE WT: (0.75')(150) + 15 = 127.5 PSF (20)(30) = 76.5^K
(8.33)(8.33)(7/12)(150)(30/25) = 7.3
Σ 83.8^K

PARKING WT: (11/12)(150) + 50 = 187.5 PSF (20)(30) = 112.5^K
(10)(10)(0.75)(150)(30/25) = 13.5^K
Σ 126.0^K

FLAT PLATE

OFFICE: l_N = 25'-0" 8" SLAB

WT. (0.67)(150) + 15 = 115 PSF (20)(30) = 69.0^K

FLAT PLATE SYSTEM (WITHOUT SHEARHEADS)

f'_c = 4,000 psi
Grade 60 Bars

SQUARE EDGE PANEL

8 in. = TOTAL THICKNESS OF SLAB — 0.667 c.f./s.f.

SPAN c.-c. Cols. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	(1) Min. Square Column (in.)	γ_f	Total Panel Moments −M Ext. (ft-kip)	+M Int. (ft-kip)	−M 1st. int. (ft-kip)	Each Column Strip Top Ext. +	Each Column Strip Bottom	Each Column Strip Top Int.	Each Middle Strip Bottom	Each Middle Strip Top Int.	End Panel Steel (psf) E	EC	C
21	50	15	0.779	52	103	139	11-#4 5	11-#4	12-#5	10-#4	11-#4	2.08	2.09	2.01
21	100	19	0.699	63	126	170	11-#4 5	13-#4	11-#6	10-#4	11-#4	2.26	2.29	2.24
21	150	22	0.671	74	148	199	13-#4 4	10-#5	13-#6	10-#4	11-#4	2.52	2.54	2.60
21	200	25	0.693	84	168	227	15-#4 6	12-#5	20-#5	8-#5	11-#4	2.90	2.91	2.97
21	250	29	0.623	93	186	251	16-#4 5	13-#5	12-#7	13-#4	11-#4	3.09	3.11	3.20
21	300	34	0.610	100	199	268	12-#5 2	10-#6	13-#7	9-#5	8-#5	3.43	3.46	3.56
21	350	39	0.609	105	210	282	12-#5 2	8-#7	11-#8	10-#5	8-#5	3.71	3.75	3.85
22	50	17	0.733	59	118	159	11-#4 5	12-#4	14-#5	10-#4	11-#4	2.07	2.09	2.06
22	100	21	0.672	72	144	193	13-#4 4	10-#5	12-#6	10-#4	11-#4	2.35	2.36	2.37
22	150	24	0.699	84	169	227	15-#4 6	12-#5	20-#5	12-#4	11-#4	2.74	2.73	2.79
22	200	28	0.612	95	190	256	11-#5 2	13-#5	13-#7	13-#4	11-#4	3.03	3.08	3.17
22	250	33	0.610	104	208	281	12-#5 2	11-#6	11-#8	10-#5	12-#4	3.47	3.50	3.54
22	300	39	0.609	111	221	298	19-#4 4	23-#4	11-#8	10-#5	13-#4	3.55	3.58	3.71
22	350	45	0.608	116	231	311	20-#4 3	16-#5	12-#8	16-#4	9-#5	3.79	3.84	4.02
23	50	18	0.738	67	134	180	12-#4 5	9-#5	16-#5	10-#4	12-#4	2.16	2.17	2.14
23	100	23	0.696	81	163	219	14-#4 7	11-#5	14-#6	11-#4	12-#4	2.49	2.50	2.51
23	150	27	0.629	95	190	255	17-#4 4	13-#5	12-#7	13-#4	12-#4	2.84	2.86	2.92
23	200	32	0.640	107	214	288	19-#4 6	11-#6	14-#7	10-#5	13-#4	3.32	3.36	3.39
23	250	38	0.609	115	230	310	13-#5 4	16-#5	12-#8	16-#4	9-#5	3.55	3.58	3.71
23	300	44	0.608	122	244	328	14-#5 3	9-#7	13-#8	11-#5	14-#4	3.85	3.90	4.02
23	350	51	0.607	127	254	342	22-#4 2	10-#7	13-#8	12-#5	10-#5	4.11	4.18	4.31
24	50	20	0.748	76	151	203	13-#4 8	16-#4	13-#6	11-#4	13-#4	2.30	2.32	2.33
24	100	25	0.658	92	183	247	16-#4 5	9-#6	12-#7	13-#4	13-#4	2.71	2.75	2.75
24	150	30	0.663	107	213	287	12-#5 5	11-#6	14-#7	10-#5	13-#4	3.16	3.20	3.25
24	200	36	0.619	118	236	317	14-#5 3	9-#7	12-#8	11-#5	9-#5	3.53	3.56	3.68
24	250	43	0.608	127	254	341	22-#4 4	10-#7	13-#8	12-#5	10-#5	3.83	3.93	4.05
24	300	50	0.607	133	267	359	23-#4 4	10-#7	14-#8	12-#5	16-#4	4.09	4.16	4.33
24	350	57	0.606	139	277	373	16-#5 0	14-#6	14-#8	9-#6	16-#4	4.35	4.37	4.53
25	50	22	0.707	85	169	228	15-#4 6	12-#5	20-#5	12-#4	13-#4	2.45	2.45	2.40
25	100	27	0.677	103	206	277	18-#4 7	10-#6	13-#7	14-#4	13-#4	2.88	2.89	2.97
25	150	34	0.617	118	236	318	14-#5 3	12-#6	13-#8	11-#5	14-#4	3.35	3.41	3.52
25	200	41	0.608	130	259	349	15-#5 3	10-#7	13-#8	12-#5	10-#5	3.75	3.82	3.98
25	250	49	0.607	138	276	372	16-#5 2	14-#6	14-#8	19-#4	16-#4	4.03	4.10	4.28
25	300	56	0.606	145	291	391	17-#5 2	11-#7	15-#8	20-#4	11-#5	4.36	4.36	4.42
25	350	63	0.606	151	303	408	13-#6 1	21-#5	16-#8	10-#6	12-#5	4.55	4.63	4.85

SQUARE INTERIOR PANEL

8 in. = TOTAL THICKNESS OF SLAB — 0.667 c.f./s.f.

(2) Span c.-c. (ft)	(3) Load (psf)	(1) Min. Sq. Col. (in.)	Column Strip Top	Column Strip Bottom	Middle Strip Top	Middle Strip Bottom	Steel (psf) Location of Panel I	IE	IC
21	50	10	17-#4	10-#4	11-#4	10-#4	2.09	2.10	2.12
21	100	14	14-#5	9-#4	11-#4	10-#4	2.21	2.27	2.30
21	150	18	12-#6	11-#4	11-#4	10-#4	2.57	2.60	2.62
21	200	22	11-#7	8-#5	11-#4	10-#4	2.91	2.91	2.98
21	250	26	15-#6	13-#4	11-#4	10-#4	2.99	3.02	3.05
21	300	33	12-#7	14-#4	11-#4	10-#4	3.20	3.21	3.29
21	350	40	13-#7	10-#5	8-#5	10-#4	3.51	3.55	3.59
22	50	11	13-#5	10-#4	11-#4	10-#4	2.12	2.13	2.14
22	100	16	16-#5	10-#4	11-#4	10-#4	2.31	2.33	2.35
22	150	20	11-#7	12-#4	11-#4	10-#4	2.76	2.74	2.71
22	200	25	21-#5	9-#5	11-#4	10-#4	2.87	2.91	3.00
22	250	31	13-#7	10-#5	12-#4	10-#4	3.27	3.31	3.35
22	300	39	11-#8	10-#5	12-#4	11-#4	3.51	3.55	3.56
22	350	47	11-#8	16-#4	13-#4	11-#4	3.64	3.69	3.71
23	50	13	15-#5	10-#4	12-#4	10-#4	2.17	2.18	2.19
23	100	18	13-#6	12-#4	12-#4	10-#4	2.50	2.52	2.54
23	150	23	21-#5	9-#5	12-#4	10-#4	2.76	2.80	2.83
23	200	28	13-#7	10-#5	12-#4	10-#4	3.11	3.14	3.18
23	250	37	14-#7	16-#4	13-#4	11-#4	3.38	3.43	3.49
23	300	46	12-#8	11-#5	13-#4	11-#4	3.69	3.74	3.79
23	350	54	12-#8	12-#5	9-#5	12-#4	3.88	3.93	3.99
24	50	14	12-#6	11-#4	13-#4	11-#4	2.34	2.36	2.38
24	100	20	15-#6	13-#4	13-#4	11-#4	2.69	2.72	2.74
24	150	25	13-#7	10-#5	13-#4	11-#4	3.05	3.07	3.10
24	200	34	19-#6	11-#5	13-#4	11-#4	3.28	3.33	3.39
24	250	43	12-#8	12-#5	9-#5	12-#4	3.65	3.70	3.74
24	300	53	13-#8	12-#5	14-#4	12-#4	3.85	3.90	3.96
24	350	62	13-#8	19-#4	10-#5	13-#4	4.02	4.07	4.11
25	50	16	14-#6	12-#4	13-#4	11-#4	2.41	2.41	2.43
25	100	22	13-#7	10-#5	13-#4	11-#4	2.91	2.91	2.90
25	150	29	19-#6	11-#5	13-#4	11-#4	3.12	3.20	3.29
25	200	39	13-#8	12-#5	14-#4	12-#4	3.61	3.62	3.63
25	250	50	13-#8	19-#4	10-#5	13-#4	3.79	3.83	3.86
25	300	60	14-#8	13-#5	10-#5	13-#4	4.05	4.10	4.15
25	350	69	14-#8	10-#6	16-#4	14-#4	4.21	4.31	4.43

(1) Columns same above and below plate.
(2) Center-to-center of columns; $\ell_1 = \ell_2$.
(3) Superimposed factored load (factored dead load has been deducted).

9-22 CONCRETE REINFORCING STEEL INSTITUTE

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM

SQUARE EDGE PANEL — With Drop Panels — No Beams

h = 9 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS

SPAN c-c $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	Square Drop Panel Depth (in.)	Square Drop Panel Width (ft)	(3) Square Column Size (in.)	Square Column γ_f	Column Strip (1) Top Ext.	+	Column Strip (1) Bottom	Column Strip (1) Top Int.	Middle Strip Bottom	Middle Strip Top Int.	Total Steel (psf)	Moments Edge (−) (ft-k)	Moments Bot. (+) (ft-k)	Moments Int. (−) (ft-k)
23	100	4.00	7.67	12	0.771	12-#4	4	17-#4	19-#4	8-#5	8-#5	2.16	93.9	187.9	252.9
23	200	5.50	7.67	15	0.631	12-#4	1	11-#6	22-#4	10-#5	13-#4	2.61	125.9	251.8	339.0
23	300	7.00	7.67	17	0.631	13-#4	1	8-#8	25-#4	9-#6	16-#4	3.19	158.6	317.2	427.0
23	400	7.00	7.67	19	0.664	15-#4	3	17-#6	14-#6	11-#6	13-#5	3.89	190.0	380.0	511.5
23	500	8.50	9.20	21	0.629	16-#4	2	16-#7	11-#7	19-#5	8-#7	4.59	222.6	467.3	599.3
24	100	5.50	8.00	12	0.689	13-#4	2	13-#5	19-#4	13-#4	8-#5	2.20	107.5	215.0	289.4
24	200	5.50	8.00	15	0.746	13-#4	5	18-#5	12-#6	12-#5	10-#5	2.86	143.8	287.7	387.3
24	300	7.00	8.00	17	0.684	14-#4	4	12-#7	14-#6	8-#7	12-#5	3.58	181.3	362.6	488.2
24	400	8.50	8.00	19	0.631	16-#4	2	15-#7	11-#7	8-#8	8-#7	4.39	217.6	435.2	585.9
24	500	8.50	9.60	21	0.684	18-#4	3	14-#8	13-#7	11-#7	8-#8	5.08	253.8	507.6	683.4
25	100	5.50	8.33	12	0.735	13-#4	3	15-#5	14-#5	10-#5	13-#4	2.36	121.9	243.8	328.2
25	200	7.00	8.33	15	0.666	13-#4	4	20-#5	12-#6	13-#5	11-#5	2.95	163.7	327.5	440.8
25	300	8.50	8.33	17	0.633	15-#4	3	11-#8	14-#6	9-#7	10-#6	3.92	205.7	411.3	553.7
25	400	8.50	10.00	20	0.702	18-#4	5	13-#8	13-#7	20-#5	9-#7	4.55	247.2	494.5	665.6
25	500	8.50	10.00	24	0.669	13-#5	2	20-#7	19-#6	10-#8	14-#6	5.49	285.7	571.4	769.2
26	100	7.00	8.67	12	0.646	13-#4	2	9-#7	14-#5	11-#5	9-#5	2.47	138.0	276.0	371.6
26	200	7.00	8.67	15	0.720	15-#4	4	23-#5	14-#6	15-#5	19-#4	3.27	185.0	370.0	498.1
26	300	8.50	8.67	17	0.715	17-#4	5	12-#8	12-#7	10-#7	16-#5	4.13	232.6	465.2	626.2
26	400	8.50	10.40	22	0.687	13-#5	2	15-#8	26-#5	23-#5	10-#7	5.02	277.8	555.7	748.0
27	100	7.00	9.00	12	0.716	14-#4	3	19-#5	16-#5	19-#4	16-#4	2.61	155.0	310.1	417.4
27	200	8.50	9.00	15	0.658	15-#4	3	11-#8	14-#6	9-#7	10-#6	3.62	208.5	417.0	561.4
27	300	8.50	9.00	19	0.701	12-#5	3	14-#8	13-#7	15-#6	10-#7	4.52	260.0	520.0	700.0
27	400	8.50	10.80	24	0.717	22-#4	6	17-#8	12-#8	11-#8	9-#8	5.62	310.9	621.7	836.9

SQUARE INTERIOR PANEL — With Drop Panels(2) — No Beams

h = 9 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS

SPAN (ft)	Factored Superimposed Load (psf)	(3) Square Column Size (in.)	Column Strip Top	Column Strip Bottom	Middle Strip Top	Middle Strip Bottom	Total Steel (psf)	Concrete (cu. ft / sq. ft)
23	100	12	12-#5	12-#4	8-#5	8-#5	2.09	0.787
23	200	18	14-#5	15-#4	8-#5	8-#5	2.34	0.801
23	300	20	15-#5	19-#4	10-#5	13-#4	2.71	0.815
23	400	22	18-#5	11-#6	12-#5	10-#5	3.38	0.815
23	500	23	14-#6	19-#5	10-#6	19-#4	3.93	0.863
24	100	12	12-#5	13-#4	8-#5	8-#5	2.04	0.801
24	200	18	11-#6	18-#4	9-#5	8-#5	2.51	0.801
24	300	20	17-#5	15-#5	8-#6	10-#5	3.07	0.815
24	400	22	14-#6	18-#5	10-#6	12-#5	3.70	0.829
24	500	24	12-#7	11-#7	16-#5	10-#6	4.32	0.863
25	100	12	13-#5	15-#4	13-#4	13-#4	2.13	0.801
25	200	18	16-#5	13-#5	10-#5	13-#4	2.58	0.815
25	300	21	18-#5	9-#7	19-#4	11-#5	3.32	0.829
25	400	23	15-#6	20-#5	11-#6	13-#5	3.87	0.863
25	500	24	13-#7	10-#8	10-#7	11-#6	4.80	0.863
26	100	12	13-#5	11-#5	13-#4	13-#4	2.15	0.815
26	200	18	18-#5	15-#5	12-#5	10-#5	2.87	0.815
26	300	21	14-#6	19-#5	22-#4	19-#4	3.46	0.829
26	400	23	13-#7	23-#5	10-#7	15-#5	4.36	0.863
27	100	12	15-#5	19-#4	10-#5	9-#5	2.31	0.815
27	200	18	18-#5	9-#7	13-#5	11-#5	3.07	0.829
27	300	21	12-#7	21-#5	16-#5	10-#6	3.79	0.829
27	400	23	12-#8	11-#8	14-#6	9-#7	4.91	0.863

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.

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM

SQUARE EDGE PANEL With Drop Panels No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	Square Drop Panel Depth (in.)	Square Drop Panel Width (ft)	(3) Square Column Size (in.)	γ_f	Reinforcing Bars (E. W.) Column Strip (1) Top Ext. +	Column Strip Bottom	Column Strip Top Int.	Middle Strip Bottom	Middle Strip Top Int.	Total Steel (psf)	Moments Edge (−) (ft-k)	Moments Bot. (+) (ft-k)	Moments Int. (−) (ft-k)
						h = 11 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS								
22	100	3.00	7.33	12	0.718	10-#5 0	9-#5	11-#5	9-#5	9-#5	2.38	92.7	185.5	249.7
22	200	3.00	7.33	15	0.757	10-#5 2	8-#6	15-#5	9-#5	9-#5	2.64	120.3	240.6	323.9
22	300	3.00	7.33	18	0.767	10-#5 3	10-#6	18-#5	9-#5	9-#5	2.86	146.6	293.2	394.7
22	400	5.00	7.33	19	0.629	10-#5 0	9-#7	18-#5	8-#6	10-#5	3.23	175.1	357.2	471.4
22	500	5.00	7.33	20	0.756	11-#5 3	9-#8	15-#6	10-#6	8-#6	3.93	203.7	444.0	548.4
22	600	7.00	7.33	22	0.629	11-#5 0	11-#8	11-#7	9-#7	9-#6	4.58	231.3	535.0	622.8
22	700	7.00	8.80	22	0.741	12-#5 3	13-#8	10-#8	11-#7	10-#6	5.33	261.2	635.1	703.3
23	100	3.00	7.67	12	0.770	11-#5 0	10-#5	13-#5	9-#5	9-#5	2.37	106.4	212.8	286.5
23	200	5.00	7.67	15	0.633	11-#5 0	13-#5	15-#5	9-#5	9-#5	2.56	138.1	276.1	371.7
23	300	5.00	7.67	18	0.647	11-#5 1	16-#5	18-#5	8-#6	9-#5	2.97	169.0	338.0	455.0
23	400	5.00	7.67	19	0.753	11-#5 3	8-#8	11-#7	9-#6	8-#6	3.54	200.8	401.5	540.5
23	500	7.00	7.67	21	0.629	11-#5 2	8-#9	15-#6	16-#5	9-#6	4.13	233.0	496.7	627.2
23	600	7.00	9.20	22	0.723	12-#5 3	16-#7	13-#7	8-#8	10-#6	4.88	266.3	610.2	717.0
23	700	9.00	9.20	23	0.630	12-#5 0	12-#9	13-#7	8-#9	16-#5	5.84	299.0	718.2	805.1
24	100	3.00	8.00	12	0.813	11-#5 1	8-#6	15-#5	10-#5	10-#5	2.54	121.4	242.7	326.7
24	200	5.00	8.00	15	0.699	11-#5 1	15-#5	12-#6	10-#5	10-#5	2.73	157.7	315.4	424.6
24	300	5.00	8.00	18	0.739	11-#5 3	13-#6	20-#5	12-#5	10-#5	3.16	193.2	386.5	520.3
24	400	7.00	8.00	20	0.630	11-#5 2	9-#8	11-#7	8-#7	12-#5	3.71	229.2	458.3	617.0
24	500	7.00	8.00	21	0.708	12-#5 3	11-#8	13-#7	9-#7	10-#6	4.37	265.6	539.0	715.1
24	600	9.00	9.60	23	0.630	12-#5 2	11-#9	13-#7	9-#8	16-#5	5.22	303.2	683.9	816.3
24	700	9.00	9.60	24	0.655	14-#5 1	13-#9	11-#8	9-#9	8-#8	6.19	339.8	792.9	914.8
25	100	5.00	8.33	12	0.774	12-#5 2	13-#5	15-#5	10-#5	10-#5	2.47	138.2	276.3	372.0
25	200	5.00	8.33	15	0.755	12-#5 1	9-#7	14-#6	11-#5	10-#5	2.90	179.1	358.3	482.3
25	300	7.00	8.33	18	0.632	12-#5 1	15-#6	20-#5	10-#6	12-#5	3.34	220.1	440.3	592.7
25	400	7.00	8.33	20	0.677	12-#5 2	18-#6	13-#7	9-#7	10-#6	4.06	260.7	521.4	701.9
25	500	9.00	8.33	21	0.632	12-#5 2	12-#8	13-#7	14-#6	16-#5	4.56	301.6	603.1	811.9
25	600	9.00	10.00	23	0.688	14-#5 2	13-#9	12-#8	10-#8	10-#7	5.64	343.9	746.6	925.9
26	100	5.00	8.67	12	0.809	12-#5 3	15-#5	16-#5	10-#5	10-#5	2.49	155.9	311.9	419.8
26	200	7.00	8.67	15	0.637	12-#5 0	14-#6	13-#6	9-#6	11-#5	3.00	203.0	405.9	546.4
26	300	7.00	8.67	18	0.691	12-#5 2	17-#6	12-#7	16-#5	13-#5	3.60	249.0	497.9	670.3
26	400	9.00	8.67	20	0.632	12-#5 2	12-#8	13-#7	10-#7	11-#6	4.34	294.5	588.9	792.8
26	500	9.00	10.40	22	0.664	14-#5 1	11-#9	12-#8	9-#8	10-#7	4.97	340.8	681.6	917.6
26	600	11.00	10.40	23	0.632	14-#5 1	17-#8	12-#8	9-#9	11-#7	5.79	388.9	824.0	1047.1
27	100	7.00	9.00	12	0.721	12-#5 2	9-#7	16-#5	11-#5	11-#5	2.63	175.8	351.6	473.3
27	200	7.00	9.00	15	0.725	12-#5 2	9-#8	15-#6	15-#5	12-#5	3.28	228.2	456.5	614.5
27	300	9.00	9.00	18	0.635	12-#5 2	11-#8	12-#7	10-#7	15-#5	3.89	279.8	559.7	753.4
27	400	9.00	9.00	20	0.660	13-#5 2	11-#9	14-#7	15-#6	10-#7	4.68	331.7	663.3	892.9
27	500	11.00	10.80	22	0.633	14-#5 1	13-#9	12-#8	10-#8	11-#7	5.26	383.7	767.4	1033.1
27	600	11.00	10.80	23	0.704	16-#5 3	18-#8	13-#8	12-#8	10-#8	6.08	436.9	881.7	1176.2

SQUARE INTERIOR PANEL With Drop Panels(2) No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	(3) Square Column Size (in.)	Reinforcing Bars (E. W.) Column Strip Top	Column Strip Bottom	Middle Strip Top	Middle Strip Bottom	Total Steel (psf)	Concrete (cu. ft / sq. ft)
			h = 11 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS					
22	100	12	11-#5	9-#5	9-#5	9-#5	2.40	0.911
22	200	17	10-#6	9-#5	9-#5	9-#5	2.59	0.911
22	300	21	16-#5	9-#5	9-#5	9-#5	2.69	0.911
22	400	22	12-#6	11-#5	9-#5	9-#5	2.91	0.963
22	500	22	14-#6	14-#5	10-#5	10-#5	3.40	0.963
22	600	22	14-#6	9-#7	8-#6	8-#6	3.94	0.981
22	700	22	12-#7	11-#7	13-#5	10-#6	4.60	1.010
23	100	12	12-#5	9-#5	9-#5	9-#5	2.33	0.944
23	200	18	13-#5	9-#5	9-#5	9-#5	2.41	0.963
23	300	21	16-#5	11-#5	9-#5	9-#5	2.71	0.963
23	400	23	14-#6	9-#6	10-#5	9-#5	3.14	0.963
23	500	23	14-#6	16-#5	8-#6	8-#6	3.57	0.981
23	600	23	12-#7	8-#8	13-#5	13-#5	4.25	1.010
23	700	23	12-#7	8-#9	8-#7	8-#7	5.01	1.037
24	100	12	14-#5	10-#5	10-#5	10-#5	2.49	0.944
24	200	18	15-#5	10-#5	10-#5	10-#5	2.57	0.963
24	300	21	13-#6	12-#5	10-#5	10-#5	2.90	0.963
24	400	23	14-#6	15-#5	8-#6	10-#5	3.23	0.981
24	500	24	12-#7	9-#7	13-#5	8-#6	3.82	0.981
24	600	24	12-#7	9-#8	8-#7	8-#7	4.53	1.037
24	700	24	26-#5	11-#8	9-#7	9-#7	5.26	1.037
25	100	12	13-#5	10-#5	10-#5	10-#5	2.35	0.963
25	200	18	12-#6	11-#5	10-#5	10-#5	2.62	0.963
25	300	21	13-#6	14-#5	11-#5	10-#5	2.95	0.981
25	400	23	12-#7	9-#7	9-#6	11-#5	3.62	0.981
25	500	25	12-#7	10-#7	15-#5	9-#6	3.99	1.000
25	600	25	26-#5	10-#8	9-#7	16-#5	4.72	1.037
26	100	12	15-#5	10-#5	10-#5	10-#5	2.34	0.953
26	200	18	12-#6	9-#6	10-#5	10-#5	2.65	0.981
26	300	21	15-#6	16-#5	12-#5	11-#5	3.20	0.981
26	400	24	12-#7	10-#7	10-#6	9-#6	3.80	1.000
26	500	26	18-#6	9-#8	9-#7	10-#6	4.26	1.037
26	600	26	26-#5	11-#8	10-#7	18-#5	4.90	1.063
27	100	12	15-#5	11-#5	11-#5	11-#5	2.42	0.981
27	200	18	14-#6	15-#5	11-#5	11-#5	2.89	0.981
27	300	22	15-#6	18-#5	10-#6	12-#5	3.34	1.000
27	400	24	13-#7	11-#7	16-#5	10-#6	4.01	1.000
27	500	27	18-#6	10-#8	10-#7	16-#5	4.42	1.063
27	600	27	12-#8	12-#8	9-#8	10-#7	5.30	1.063

(Continued on next Page)

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.