Technical Report #2

Administration Building

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Pennsylvania

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Administration Building is an office building in Pennsylvania which is 87' tall, but only 67' are above grade. It has five floors with the first floor being 20' floor to floor height and the rest being 13.33' floor to floor height. It is a rather long building with 560' in the long direction and 203' in the short direction.

The purpose of this report is to evaluate four different floor framing options and compare them to the existing composite metal deck system. Non-composite, Open web steel joists, 1 way slab and wood joists supported by steel girders were the four systems chosen to compare. To compare, we analyzed cost, fire protection, lead time, constructability, weight, vibration, depth, durability, column grid, lateral system, and deflections.

The non-composite system cost $6.8 Million with a lead time of less than 6 months. It is the 2nd heaviest system analyzed with a 30" depth and received a deflection of 1.9". It would require no column grid change as everything would be the same, minus the composite action. In the end, it was dismissed as a possible solution simply because you can do the same thing but better with a composite system.

The only other steel system analyzed is open web steel joists. It came in at $6.65 Million which is the cheapest solution and it has the least depth required of 24". Spray-on fireproofing is going to be tough since there is nothing to catch the fireproofing. To fix this, you will have to put a steel mesh between the flanges for the fire proofing to adhere to. In the long run, this system was regarded as a possible solution due to its cost, depth and deflection.

Another joist system was analyzed but this time it is wood I-joists supported by steel girders. This system is not very common in a commercial building like the Administration Building. This system came in at $6.8 Million but it requires a special detail to adhere to the 2-hour fire rating. This detail is described in detail in the fire protection section. A positive to this system is there is barley any lead time, it is extremely light and has a joist deflection of 0.3". On the negative side, it will not be the easiest to construct because the contractor will not be familiar with this type of construction. Also a negative, is it has a depth of 45", which has a huge architectural impact on the building. In the end, this system was not chosen as a possible solution.

Finally the last system is a 1-way slab. The 1-way slab came in at $7.9 Million which requires extensive formwork and is labor intensive. This is the only system that has a lateral system change and this would change from a braced frame to a shear wall. This was the heaviest system analyzed which will make the footings significantly larger. Overall, this system was picked as a possible solution.

STRUCTURAL SYSTEM OVERVIEW:

BUIDING INFORMATION:

This is an administration building for a confidential client in Pennsylvania that was constructed in July 2003. It offers offices and specialty amenity spaces as the architectural layout of 311,905 S.F. of usable floor area. There are five floors, four of which are above grade with a cost ranging between $70-75 million.

FOUNDATION:

The foundation system will consist of reinforced concrete spread footings that are sized utilizing bearing capacities ranging from 4,000 psf at soil bearing footings and 15,000 psf at rock-bearing footings. Total building settlements will be less than 1" with differential settlements not exceeding ½" or 1/300, based on a 20' bay. Typical perimeter frost walls are supported on continuous reinforced concrete strip footings. Foundation walls at basement or below grade levels are reinforced concrete basement walls designed for soil lateral loads and appropriate surcharge loads and supported by continuous reinforced concrete strip footings. These walls are drained on the soil side to minimize lateral surcharge loads on the walls and buildings. The slab on grade varies between a 5", 6" and 8" thickness, typically with 6x6-W4.0xW4.0 W.W.F.

FLOOR SYSTEM:

The structural floor system is 3¼" concrete slab on a 3", 20 gauge composite metal deck, totaling 6¼". The metal deck utilizes ¾" steel studs, supported by wide-flange beams and wide-flange columns. The typical sizes of the beams range from W18x40 to W30x116. The girders range from W21x50 to W27x146. The columns range from W10x43 to W14x211. The concrete is lightweight weight (115 pcf), cast-in-place concrete and will have a 28 day strength of 4,000 psi. The concrete slab is reinforced with 6x6-W2.9xW2.9 W.W.F. to minimize plastic shrinkage cracking. The thickness of the concrete is established based on the required 2 hour fire rating for the floor construction without spray fireproofing applied to the underside of the metal deck. Structural steel shall comply with ASTM A572, Grade 50. Steel stud shear connectors shall conform to ASTM A108.

To maintain the 5'-0" building module within the typical bay sizes of 20'-0" and 40'-0", the typical beams supporting the composite slab are spaced at 10'-0" on center. These beams supporting the composite slab for the typical bays span to girders oriented across the width of the building. The wide flange steel girders in the long direction or the building support the wide flange steel beams that span the 3 bay width of the building consisting of (1) 20'-0" and (2) 40'-0" bays. Spanning the beams across the width of the building works best in combination with a braced frame lateral load resisting system.

ROOF SYSTEM:

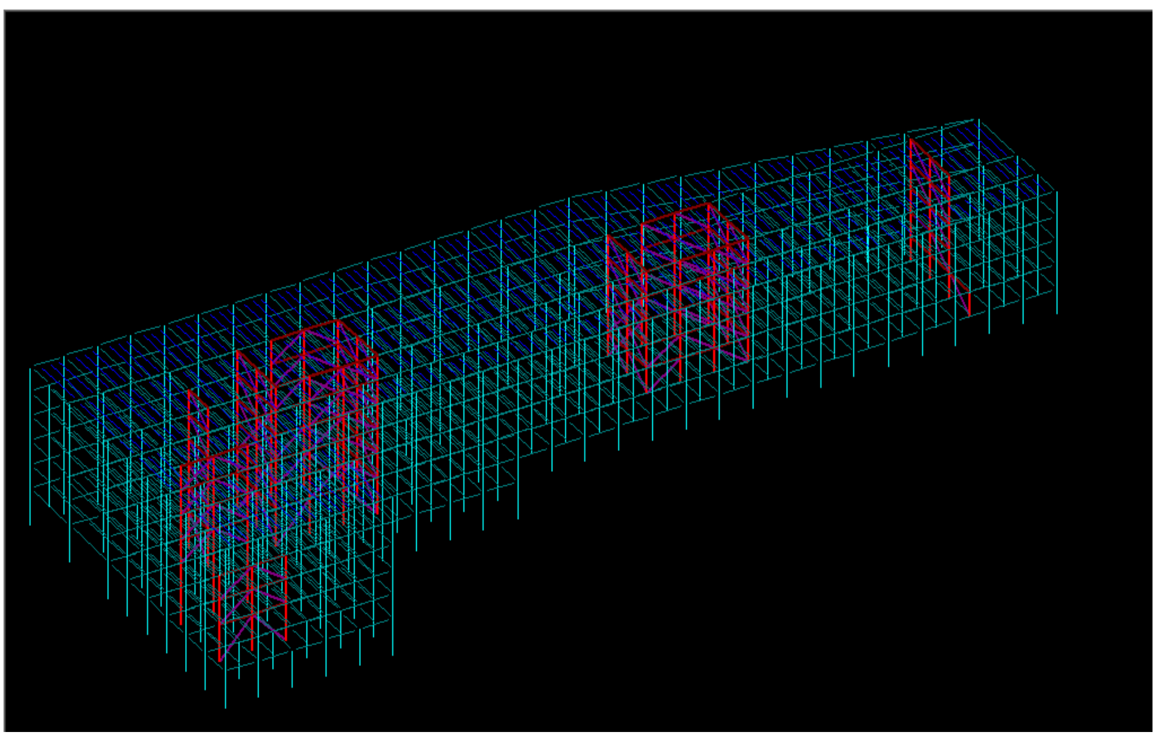
The structural roof system consists of a 1½", 20 gauge, Type B, galvanized metal roof deck with spray fireproofing. Below mechanical equipment a concrete slab on composite metal deck is used instead of the standard roof deck and the concrete slab is reinforced with 6x6-W2.9xW2.9 W.W.F. to minimize shrinkage cracking. The framing members supporting the metal deck are either open-web joists or wide flange steel beams at 4'-0" and 5'-0" centers. The beams supporting the composite slab are wide flange steel beams at 10'-0" centers that span the width of the building.

LATERAL SYSTEM:

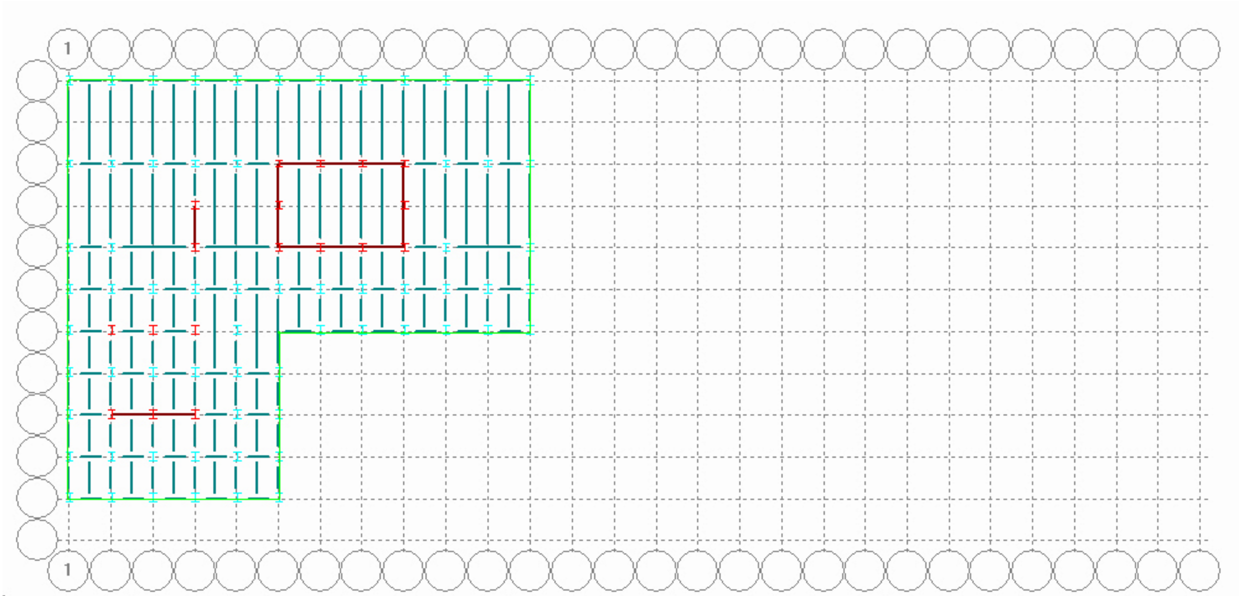
The typical composite steel-framed building utilizes a braced frame lateral load resisting system. The braced frames have been coordinated, located and configured to integrate with the architectural layout and mechanical distribution. These frames consist of wide flange columns, wide flange beams at each story and one HSS (hollow structural section) diagonal braces between each story. Typically the HSS braces will be HSS8x6x1/2.

EXTERIOR WALL SYSTEM:

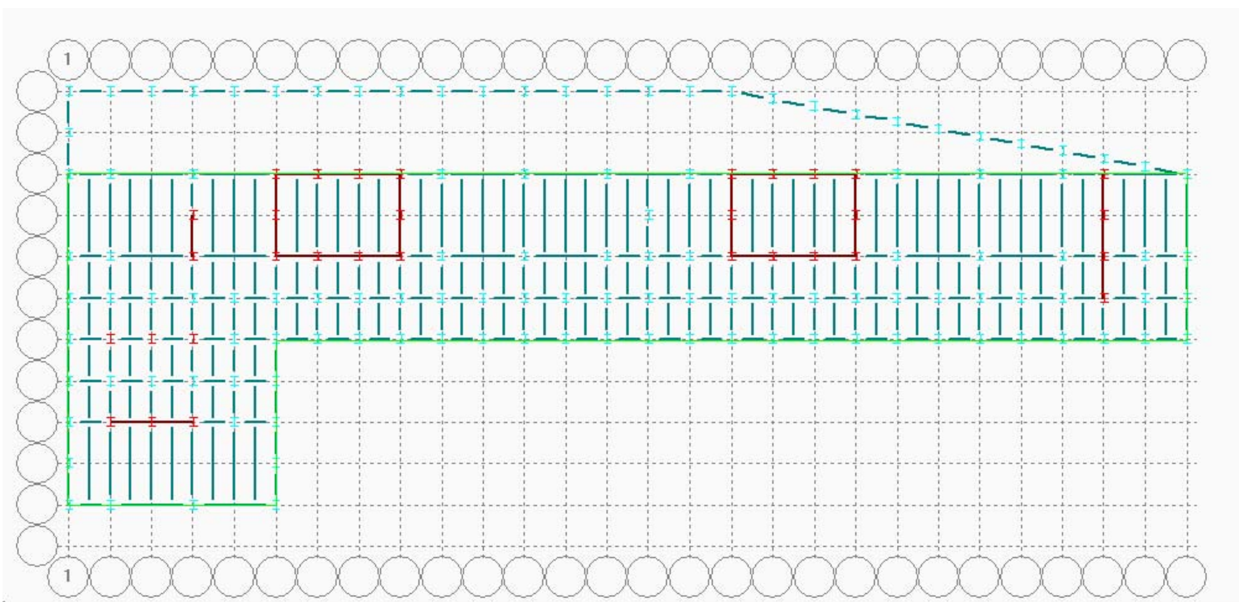
Pre-fabricated brick truss panel assemblies comprised of structural tube and stud infill, steel relieving lintels, and shop-applied exterior brick face. There was a nine-month lead-time for brick materials. This system is independent of the floor and roof framing thus enabling smaller spandrel beam sizes.



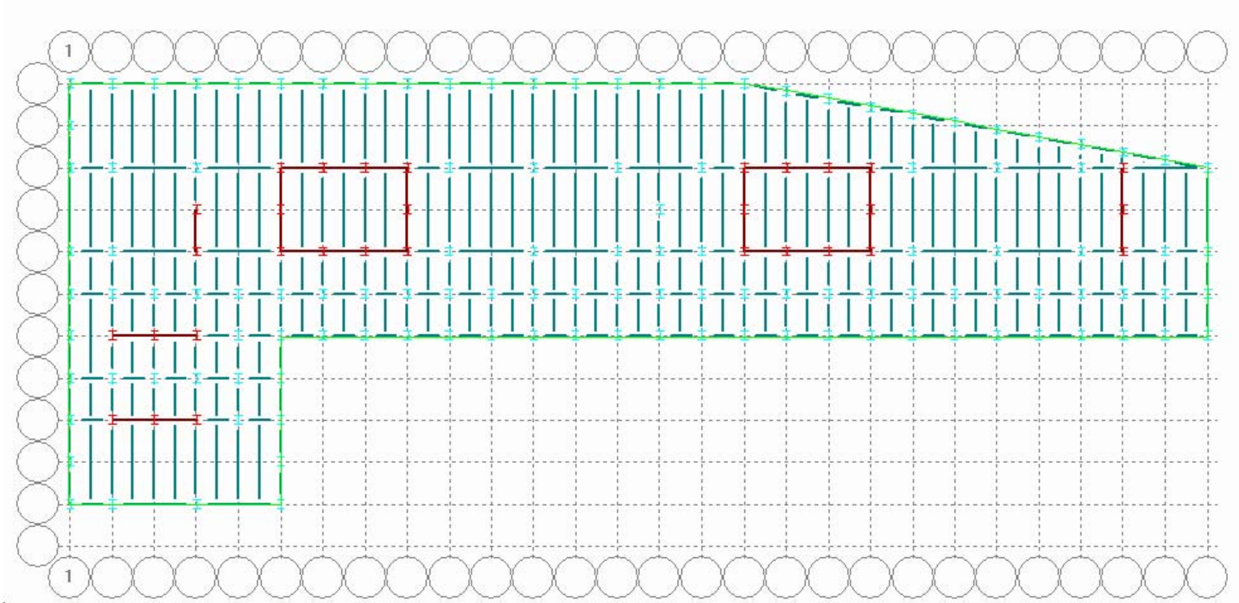
FIRST FLOOR FRAMING PLAN:



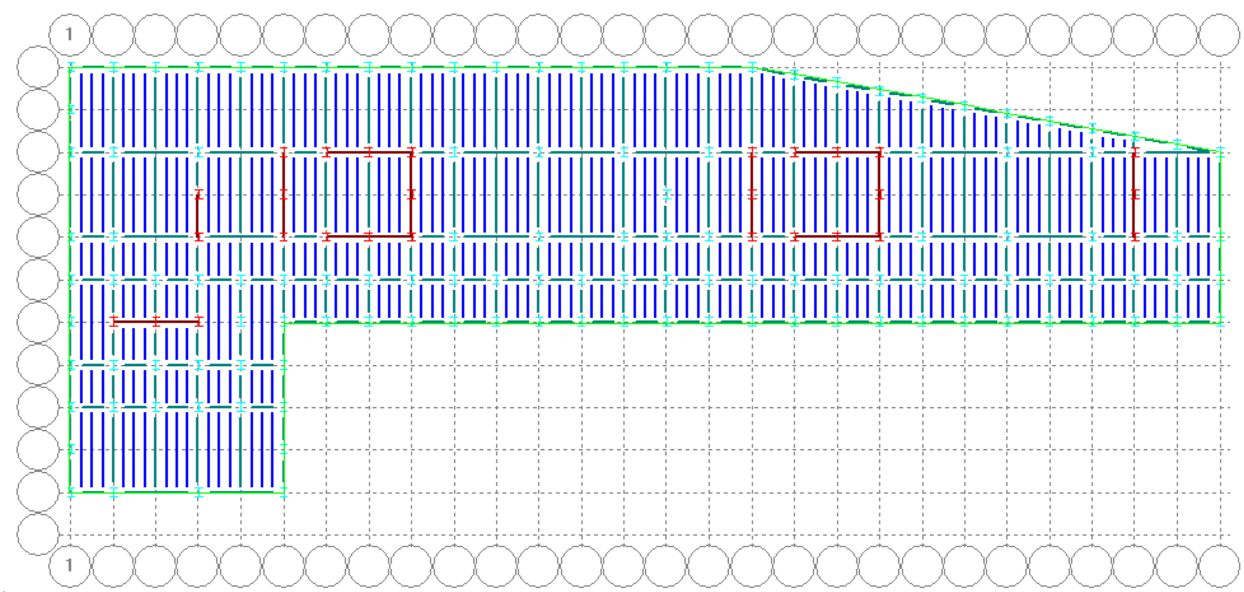
SECOND FLOOR FRAMING PLAN:



THIRD-FIFTH FLOOR FRAMING PLAN:



ROOF FRAMING PLAN:



Red indicates braced frame
Blue indicates open-web joists
Dark green indicates composite beams
Light green indicates columns

LOADS

The administration building's gravity loads are shown below based on live load, dead load and snow load. The live load lists all the applicable areas inside the building and using 100 PSF as the standard floor live load. The floor dead load is found by the concrete slab, superimposed dead load, steel structure/deck and the façade which only applies to the edge beams. The design snow loads are given for easy reference. All these loads were used to design the building.

FLOOR LIVE LOAD:

ROOM	MIN DESIGN LOAD (PSF) ASCE7-05	DESIGN LOAD
Fitness Center	100	100
Lobbies	100	100
Stairs and Exits	100	100
Offices	50	100
Dining Room	100	100
Mechanical Rooms	N/A	150
Corridors	100-FIRST FLOOR 80-ALL OTHER FLOORS	100
Roof	20	30

FLOOR DEAD LOAD:

ITEM	DESIGN VALUE
CONCRETE SLAB	35 PSF
SUPERIMPOSED DEAD LOAD	30 PSF
STEEL STRUCTURE	15 PSF
EXTERIOR BRICK TRUSS PANEL	40 PSF

ROOF SNOW LOAD:

ITEM	DESIGN VALUE	CODE BASIS
ROOF LIVE LOAD	30 PSF	ASCE7-05
GROUND SNOW LOAD (Pg)	30 PSF	ASCE7-05
FLAT ROOF SNOW LOAD (Pf)	24 PSF	ASCE7-05
SNOW EXPOSURE FACTOR (Ce)	0.9	ASCE7-05
SNOW IMPORTANCE FACTOR (I)	1.2	ASCE7-05

SYSTEM ANALYSIS OVERVIEW

The existing framing is currently what the building is designed for, but it is not the only system that will work for a specific type of application. An analysis of four alternative floor framing systems was performed, where one floor framing system has to be a different framing material. A system analysis is a brief system by system description of the four alternative floor framing systems that were chosen for analysis. Preliminary sizes of the framing members and slabs are introduced in this section.

STEEL COMPOSITE FLOOR (EXISTING):

This is the existing condition which is already constructed in the Administration Building in Pennsylvania. The floor system is a 3¼" light-weight concrete slab on a 3" composite metal deck. Refer to page 38 for specifications of the 3" composite metal deck. The metal deck is typically supported by W18x35 beams and W18x35 girders. The concrete is light weight, cast-in-place concrete and will have a 28 day strength of 4,000 psi. The thickness of the concrete is established based on the required 2 hour fire rating for the floor construction without spray fireproofing applied to the underside of the metal deck. Refer to page 24 for a typical bay framing plan. The existing system was designed using the existing typical floor and RAM Structural System. This is the base design that the four alternative systems will be compared to.

Using the gravity loads on page 8 in RAM Structural System, gave the same exact sizes as the construction documents. So, this leads one to believe that the estimated assumptions of live and dead load are almost exactly the same as the designer's loads. The designer's used Load Resistance Factor Design (LRFD) in the design of the composite system. So, for easy comparison, LRFD was also used in RAM Structural System as the base steel code.

STEEL NONCOMPOSITE FLOOR:

Using the existing floor framing, existing column grid, and RAM Structural System was how this floor system was designed. The floor system is a 3¼" light-weight concrete slab on a 3" non-composite metal deck. Refer to page 38 for specifications of the 3" metal deck. The metal deck is typically supported by W24x68 beams and W24x55 girders. The concrete is light weight, cast-in-place concrete and will have a 28 day strength of 4,000 psi. The thickness of the concrete is established based on the required 2 hour fire rating for the floor construction without spray fireproofing applied to the underside of the metal deck. Refer to page 25 for a typical bay framing plan. This is the existing framing system, just without composite action. Just as expected, bigger beams and girders were increased to make up for the non-composite action. Just like the existing system, LRFD design was used as the model steel code.

OPEN-WEB STEEL JOISTS:

Using the existing column grid with girders framing in the opposite 40' direction. The joists run perpendicular to the girders, spanning in the 20' direction. The floor system is a 4” light-weight concrete slab on a 2” form deck. Refer to page 39 for specifications of the 2” form deck. The metal deck is typically supported by 18LH06 open-web steel joists spaced 4’ on center and W24x76 girders. The concrete is light weight, cast-in-place concrete and will have a 28 day strength of 4,000 psi. The thickness of the concrete is established based on the required 2 hour fire rating for the floor construction with cementitious sprayed fireproofing. The fireproofing is applied to the underside of the metal deck and applied to the web of the steel joists. A wire-mesh must be applied to the web of the joists for the cementitious sprayed fireproofing to adhere to. Refer to page 26 for a typical bay framing plan. This system was designed using the existing RAM Structural System, LRFD as the model steel code, and the SJI Standard Specification.

WOOD FLOOR JOISTS:

Using the existing column grid with steel girders framing in the opposite 40’ direction. The joists run perpendicular to the girders, spanning in the 20’ direction. The floor system is a 48/24 tongue and groove span rated sheathing (exposure 1). The wood deck is typically supported by TJI H90 open-web steel joists spaced at 16” on center and wide-flanged girders. This is a commercial grade I-joist with a depth of 20” and a commercial floor deflection limit of L/600. The sheathing is established based on the required 2 hour fire rating for the floor construction. Refer to page 12 for a more detailed description of the fire protection. This system was designed using existing beams and the I-Level design catalogs.

ONE WAY SLAB:

The existing column grid was used in conjunction with the beams framing in the 40’ direction, supported by the girders framing in the 20’ direction. Using the CRSI handbook load combination of 1.4D + 1.7L, a 10” slab was found using 3,000 PSI concrete strength. The beams were 16” x 28” and a 20” x 26” girder was found to carry the load using 4,000 PSI concrete strength. The CRSI handbook calculated the slab being 10” thick based on the live and dead loads. Using a 10” slab is more than sufficient to acquire the 2-hour fire rating.

FLOOR SYSTEM COMPARISONS

To compare the four alternative floor framing systems, eleven factors were chosen for the analysis between each system. The eleven items include cost, fire protection, lead time, constructability, weight, vibrations, depth of system, durability issues, column grid changes, lateral system changes, and deflection. Some criteria are more important than others, but all factors play a role in the decision of which systems are viable and which are not an option.

COST:

Using the R.S. Means Assemblies Cost Data Book, the cost per square foot was obtained for each framing system. The following represents an estimated cost for the framing systems on a 450,000 square foot building. Refer to page 33 for the R.S. Means Assemblies Cost Data that was used.

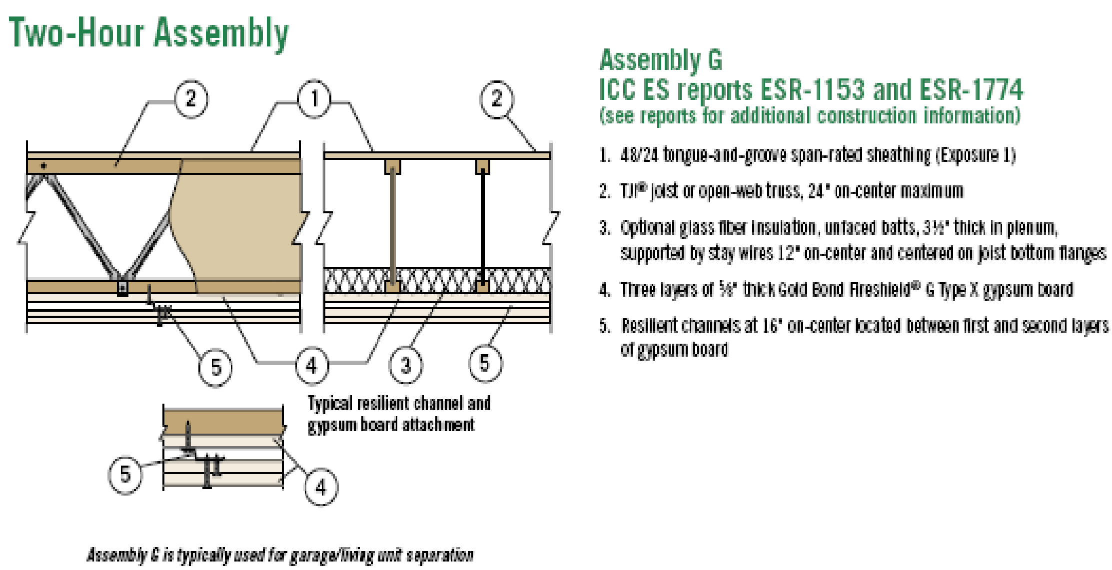
SYSTEM	MATERIAL/ S.F.	INSTALLATION/ S.F.	TOTAL/ S.F.	TOTAL
COMPOSITE	14.2	6.5	20.70	**$9.31 Million**
1 WAY SLAB	6.45	11.1	17.55	**$7.90 Million**
NONCOMPOSITE	11.55	3.65	15.2	**$6.8 Million**
WOOD JOISTS	10.55	4.38	15.14	**$6.8 Million**
OPEN WEB JOISTS	9.9	4.88	14.78	**$6.65 Million**

The cost per system is listed by the most expensive at the top to the least expensive at the bottom. For the wood joists, the cost of the steel beams was added, as they were not included. The non-composite, wood and steel joists were really close in the cost comparison of each other. The composite action is almost $2 Million more than the 1 way slab, which is surprising.

FIREPROTECTION:

The metal deck and thickness of the concrete is established based on the required 2-hour fire rating for the floor construction without spray fireproofing applied to the underside of the metal deck. The 2 hour fire rating is satisfied with the concrete depth and metal deck for composite and non-composite systems. The steel beams, girders and open web joists must be sprayed with spray-on-fireproofing. The open web joists utilize a 2” USD form deck and the required slab thickness is 3-7/8” for lightweight concrete.

3-7/8” slab is an odd thickness, so a 4” slab was chosen. Refer to 40 for the fire protection rating. It is harder to spray-proof open-web joists, so a wire mesh must be applied to the joists, so the spray-on fireproofing has something to adhere to. While this is a viable solution to meet the 2 hour fire rating, it will add to the cost of the open web joists. The one-way slab meets the 2 hour fire rating and nothing additional has to be done to it. Finally, the wood joists will cause a problem to meet the 2 hour fire rating. To obtain this fire rating, you must add certain materials to the joists. It requires 48/24 tongue and groove span rated sheathing (exposure 1), 3 layers of 5/8” thick Gold Bond Fireshield G Type X gypsum board and resilient channels at 16” on center located between first and second layers of gypsum board. Refer to the diagram below.



LEAD TIME:

Lead time should not be an issue for the Administration Building. This project is a Design-Bid-Build, so the design is done before it goes under construction. There will be fabrication lead time for the joists and steel shapes but you can order them in the early stages and have them sit on the site as it is a fairly large open site. On average, the lead time for steel can be 1 week all the way up to 6 months. There is no lead time for concrete, so that can be done at anytime. There is a 1 month lead time for the fabrication of the wood joists.

CONSTRUCTABILITY:

All of these systems can be constructed by a skilled and experienced contractor. The one-way slab would be cast in place which takes a lot of time to prepare and set-up the formwork. A one-way slab is also a lot more labor intensive which can increase the cost. The composite and non-composite would be the easiest and simplest to construct. While the open web joists are no harder to construct than the composite and non-composite systems, but it is harder to adhere to the 2 hour fire rating and spray fireproofing on them. The wood joist system is an odd system, so it might take some time to get used to as it is not common at all. With that in mind, it might add some difficulty to constructing it.

WEIGHT:

The weight of the structure was assumed not to be a problem for the preliminary analysis. Weight will affect the seismic loads but wind governs for this building anyway. Weight will also affect the footings, but the only system that has any significance causing the footings to increase would be the one-way slab. The one-way slab is significantly higher than the other floor systems. Below is an estimated weight of the floor systems for a 60’ x 100’ floor area. Refer to page 21 for the calculation of the weights.

FLOOR SYSTEM	WEIGHT (#)
1-WAY SLAB	1,272,000
NONCOMPOSITE	299,852
OPEN-WEB JOISTS	295,462
COMPOSITE	292,525
WOOD JOISTS	55,234

VIBRATION:

Vibrations have a lot to do with the depth, weight, and stiffness of the system. With that in mind, 1-way slab, Composite, Non-composite, and open web joists should have no problem with vibrations. The wood joists would have more of a problem because they are not very deep and the joists themselves do not weigh very much. Floor vibration was a concern but it was checked in the RAM models and assuming for the wood joists with a deflection criteria of L/600, that would be somewhat of a stiff member and would be ignored. An in-depth analysis must be preformed to accurately access vibrations in the floor systems.

DEPTH:

SYSTEM	DEPTH
WOOD JOISTS	45.2” (TJI H90 + 1.5” SHEATHING + W24x62)
1 WAY SLAB	38” (28” BEAM + 10” SLAB)
NONCOMPOSITE	30” (W24x62 + 6.5” SLAB)
COMPOSITE	27” (W21x44-EXISTING + 6.5” SLAB)
OPEN WEB JOISTS	23.75” (18LHO6 + 6” SLAB)

From the depth analysis above, wood joists came in last due to TJI joists have to sit on top of the girder which radically increases the total depth. It gets progressively better with each system but open web joists take the gold with the least depth. Depth of the floor is very important deciding factor of a floor system. A majority of buildings are height controlled in certain areas of the world, especially areas like Washington D.C., so it is very important to minimize the floor depth to maximize the usable floor to floor height. The administration building is not height controlled, so floor depth is not an issue, but should not be taken lightly.

DURABILITY:

The concrete may crack, flake or spall because of freeze and thawing. It can also crack, flake or spall because of too much water in the mix and it was finished before the excess bleed water had a chance to evaporate. The wood may endure creep over time. Durability should not be an issue and the framing systems should be fine.

COLUMN GRID CHANGES:

The framing systems chosen for analysis all work with the existing column grid. This makes it easy to compare different framing solutions without too much trouble. With the ability to work with the existing column grid, no changes were needed or executed to the existing grid.

LATERAL SYSTEM:

There are no changes that are required to the HSS braced frame for the Composite, non-composite, Open Web Steel Joists and the Wood Joist systems. For the 1 way slab, the lateral system will have to change to a shear wall.

DEFLECTIONS:

The framing systems have been designed for L/360 for live load and L/240 for total load except the wood joists. The wood joists have been designed for L/600 for live load.

SYSTEM	DEFLECTION(TOTAL)
COMPOSITE	2”
NON-COMPOSITE	1.9”
1 WAY SLAB	1.77”
OPEN WEB JOISTS	0.85”
WOOD JOISTS	0.3”

The composite, non-composite, and 1 way slab beams are 40’ long which leads to the higher deflection compared to the joist systems. The joist systems are 20’ long which explains the lower deflection. The wood joists system is lower than the open web joists due to the live load deflection limit set to L/600 and because they are spaced much closer to each other which will minimize the load one individual joist will see. Refer to page 20 and 27 for deflection calculations.

COMPARISON SPREADSHEET

After all eleven factors were considered and analyzed; a spreadsheet was created to clearly list the factors for each system. An actual value is inputted into the spreadsheet for easy comparison between the systems. The last two rows include further investigation and possible solution of the five floor framing systems. Further investigation would be necessary for an in-depth analysis of the system if more information is needed to accurately describe the system. The very last column indicates whether the system is a feasible based on the eleven factors.

ITEM	COMPOSITE	NONCOMPOSITE	1 WAY SLAB	OPEN WEB JOISTS	WOOD JOISTS
COST	$9.31 Million	$6.8 Million	$7.9 Million	$6.65 Million	$6.8 Million
FIRE PROTECTION	None	None	None	Spray-On	Special Detail
LEAD TIME	<6 Months	<6 Months	None	<6 Months	<1 Month
CONSTRUCTIBILITY	Easy	Easy	Extensive Formwork	Easy	Moderate
WEIGHT	292,525#	299,852#	1,272,000#	295,462#	55,234#
VIBRATION PROBLEM	No	No	No	Maybe	Maybe
DEPTH	27”	30”	38”	23.75”	45.2”
DURABILITY ISSUES	None	None	Crack, Flake, or Spall	None	Creep
COLUMN GRID CHANGES	No	No	No	No	No
LATERAL SYSTEM CHANGES	None	None	Shear Wall	None	None
DEFLECTIONS	2”	1.9”	1.77”	0.85”	0.3”
FURTHER INVESTIGATION	No	No	No	No	Yes
POSSIBLE SOLUTION	**Yes**	**No**	**Yes**	**Yes**	**No**

SYSTEM EVALUATION

The purpose of this report is to evaluate four different floor framing options and compare them to the existing composite metal deck system. Non-composite, Open web steel joists, 1 way slab and wood joists supported by steel girders were the four systems chosen to compare. To compare, we analyzed cost, fire protection, lead time, constructability, weight, vibration, depth, durability, column grid, lateral system, and deflections.

COMPOSITE:

Advantages:

- No additional fire protection needed
- Can be easily constructed
- Weight of structure being 292,525 pounds
- No vibration problem
- Small depth of structural floor which is 27"
- No durability problems
- No changes in the column grid
- No lateral system changes

Disadvantages:

- Most expensive system at $9.31 million
- Lead time up to 6 months
- Highest deflection at 2"

NON-COMPOSITE:

Advantages:

- Fairly cheap at $6.8 million
- No additional fire protection needed
- Can be easily constructed
- No vibration problem
- Average depth of structural floor being 30"
- No durability issues
- No changes in the column grid
- No changes to the lateral system

Disadvantages:

- Long lead time of up to 6 months
- Fairly heavy system coming in at almost 300,000 pounds
- High deflection of 1.9"

1 WAY SLAB:

Advantages:

- No additional fire protection needed
- No vibration problem
- No column grid changes
- Change lateral system to shear walls

Disadvantages:

- $7.9 million price tag
- Extensive formwork
- System weighing the most at 1,272,000 pounds
- No vibration problem
- Large depth of structural floor at 38”
- Concrete can crack, flake or spall if installed wrong
- Deflection of 1.77”

OPEN WEB JOISTS:

Advantages:

- Cheapest system of $6.65 million
- Easy constructability
- Light structure weighing in at 295,462 pounds
- Smallest structural floor of 23.75”
- No fatigue problems
- No lateral system changes
- Deflection of 0.85”

Disadvantages:

- Spray-on fireproofing and wire mess added to the web
- Lead time up to 6 months

WOOD JOISTS:

Advantages:

- Cost of $6.8 million
- Short lead time of less than 1 month
- Lightest system of 55,234 pounds
- No column grid changes
- No lateral system changes
- Deflection of 0.3”

Disadvantages:

- Special fire protection design needed
- Moderately hard to construct
- Vibration problems may exist
- Highest depth of structural floor of 45.2”
- Creep will be an issue over time

The existing framing which consists of a composite metal deck is currently what is designed for the building. It is the most sensible choice for the floor framing and is why the design professional chose the composite system. It is the most expensive system at $9.31 million with a long lead time for the steel; however it has many benefits that make it the best choice. No additional fire protection is needed; it can be constructed fairly easily because it is a standard system, which both will help keep the cost down. It is one of the lighter systems, weighing in at 292,525 pounds and it maximizes the floor to ceiling height by keeping the depth of the floor minimal.

The non-composite system is almost the same thing as the composite system; it just does not have the composite action. Without the composite action, it will significantly keep the cost down because placing the studs is very expensive in the composite system. It might keep the cost down, but without composite action, the beams and girders will increase a couple sizes to make up for the strength composite action gives. With bigger beams and girders, the structure will increase in weight and it comes in as the second heaviest system at almost 300,000 pounds. With these factors in mind, non-composite was not chosen as a possible solution simply because you can do the same thing but better with a composite system.

The next system analyzed was the 1-way concrete slab system. It is cheaper than the composite system by a little over $1 million, but with changing over to an entirely concrete structure will significantly increase the weight of the building. This system is not even close to the other system in terms of weight, weighing in at 1,272,000 pounds. With all that extra weight, the foundation will have to drastically increase in size and will in turn drive the cost of the building up. With a 10" concrete slab, fire protection is not an issue. Being this system being cheaper and no lead time for concrete is why this was chosen as a possible solution.

Open web joists was another system analyzed for comparison against the composite system. This system has a lot of advantages with only a few disadvantages. It is the cheapest framing system analyzed at $6.65 million, which is almost $3 million cheaper than composite. It is almost the same weight of the composite system, so foundation change will not be an issue. It has the smallest structural floor depth of 23.75", which maximizes the floor to ceiling height. However, fire protection is an issue where additional measure must be taken. Wire mess must be added to the web for the required spray-on fire proofing to be applied to maintain the 2-hour fire rating. Just like the composite system, this system has a lead time of up to 6 months. With all these factors considered, open web joists were chosen as a possible solution.

The last and final system chosen for analysis is the wood joists system on steel girders. It is a fairly cheap system of $6.8 million and a short lead time for the wood joists. It is incredibly lighter than the composite system, but it has many downfalls. Too many extras have to be added to this system to maintain the 2-hour fire rating. It will be moderately hard to construct because it is not common at all and vibration problems can arise with this light of a system. Wood joists have the biggest depth of all systems of 45.2". This system has too many significant disadvantages, so this was not chosen as a possible solution.

Overall, two systems were chosen and two systems were not chosen. 1-way slab and open web joists were honorable systems in comparison to the composite system, so they were chosen. Non-composite and wood joists were not very good systems in comparison to the composite system, so they were disregarded as possible solutions.

DEFLECTIONS

DEFLECTIONS : $\Delta = \frac{5WL^4}{384EI}$

1 WAY SLAB :

• BEAM : $I = \frac{bh^3}{12} = \frac{16"(28")^3}{12} = 29,269 \text{ in}^4$

$$\Delta = \frac{5(3.3\text{ KLF})(40')^4 \cdot 1728}{384\ (3674)\ 29,269} = 1.77"$$

$$E = w^{1.5}\sqrt{f'c}$$
$$= 150^{1.5}\sqrt{4} = 3674$$

• GIRDER :

$$I = \frac{20(26)^3}{12} = 29,293 \text{ in}^4$$

$$\Delta = \frac{5(14.5\text{ KLF})(20')^4 \cdot 1728}{384(29,293)(3674)} = 0.49"$$

WOOD JOISTS :

$$EI = 2,331\text{ E6}$$

$$\Delta = \frac{5(0.193\text{ KLF})(20')^2 \cdot 1728 \cdot 1000}{384\ (2,331\text{ E6})} = 0.3"$$

$$\frac{L}{600} = \frac{20'(12)}{600} = 0.4"$$

WEIGHT

WEIGHT : (60' × 100') = 6,000 FT²

OPEN WEB JOISTS : 15,300 # JOISTS
22,242 # GIRDERS
572 STUDS (10 #) = 5,720 #
252,200 # SLAB
295,462 #

COMPOSITE : 32,885 # BEAMS / GIRDERS
744 STUDS (10 #) = 7440 #
252,200 # SLAB
292,525 #

NONCOMPOSITE : 47,657 # BEAMS / GIRDERS
252,200 # SLAB
299,857 #

WOOD JOISTS : ≈ 22,242 # GIRDERS
3.7 PSF (60' × 100') = 22,200 # SHEATHING
7.1 PLF (20') 76 = 10,792 # JOISTS
55,234 #

1 WAY SLAB : $\frac{10''}{12}$ (150) · 60' · 100' = 750,000 #
$\frac{16 \cdot 28}{144}$ (150) · 21 · 40' = 392,000 #
$\frac{20 \cdot 26}{144}$ (150) · 20' · 12 = 130,000 #
1,272,000 #

WOOD JOIST

- WOOD JOISTS W/ STEEL BEAMS + GIRDERS

LL = 100 PSF
DL : SDL = 30 PSF
STEEL STRUCTURE + WOOD = 15 PSF
45 PSF

W_u = 145 PSF (1.33') = 193 PLF

- 20' SPAN
- 100 % LL
- TJI H90 – MAX PLF = 212 PLF → 20'' DEPTH
  - COMMERCIAL FLOOR DEFLECTION LIMIT → L/600
- REFER TO I-LEVEL COMMERCIAL CATALOG

1 WAY SLAB

1 WAY SLAB

LL = 100 PSF
SDL = 30 PSF

SPACING: 10'
L_n = 40'

$W_u = 1.4(30) + 1.7(100) = 212$ PSF

1.4 + 1.7 → 2002 CRSI VALUES

h = 7" → $\rho = 0.0018bh$ → TABLE 7.4 CRSI
$f'_c = 3,000$

$W_{SLAB} = \frac{7}{12}(150\ PCF)(10') = 875$ PLF

BEAMS

ASSUME 18"× 24" BM $W_{BM} = \frac{18"(24")150}{144} = 450$ PLF

$W_u = 1.4(30\ PSF \cdot 10' + 875\ PLF + 450\ PLF)$
$+ 1.7(100\ PSF \cdot 10') = 3.3$ KLF

↗ $W_u = 3.4$ KLF

USE 16"×28" → $W_u = 4.5$ KLF TABLE 12-67 – CRSI

BOTTOM	TOP	TRANSVERSE REINF.
2 #14	3 #14	(16) #4 @ 12"

GIRDERS L_n = 20'

$P_u = \frac{3.4\ KLF\ (40')}{2} = 68^k$

TRY 20×28 → $W = \frac{20 \cdot 28\ (150)}{144} = 584\ (1.4) = 818$ PLF

$M_u = P_u \cdot a = 68^k \cdot (10') = 680^{k\text{-}ft}$

$M_u = \frac{W_u L^2}{8} \Rightarrow 680^{k\text{-}ft} = \frac{W_u \cdot (20')^2}{8} \rightarrow W_u = 13.6$ KLF

$W_u = 13.6 + 0.818 = 14.5$ KLF

USE 20"×26" → $W_u = 14.8$ KLF, LN = 24' → TABLE 12-64 – CRSI

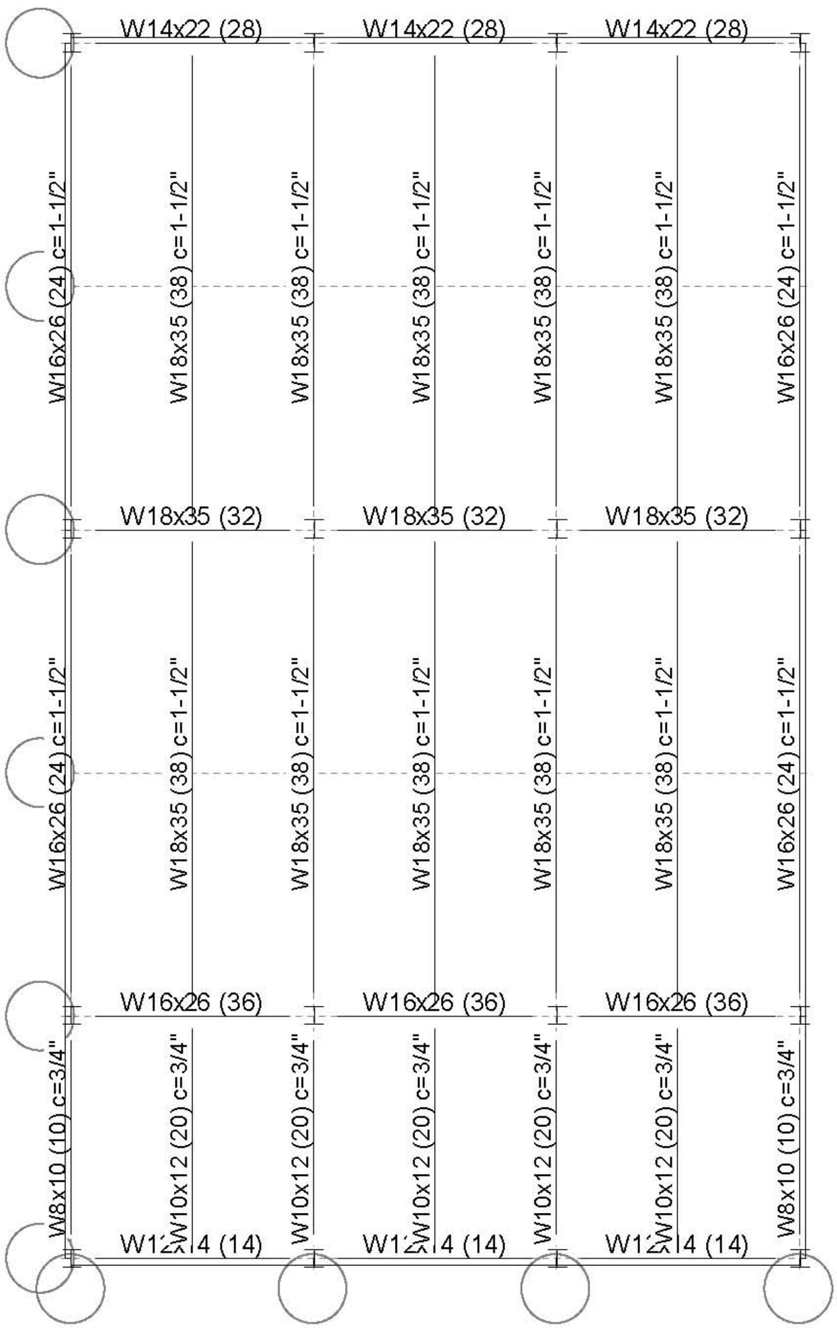
BOTTOM	TOP	T.R.
2 #14	4 #14	26 #5 @ 5"

COMPOSITE FRAMING PLAN

Floor Map

RAM Steel v11.0
DataBase: STEEL
Building Code: IBC

Floor Type: EXISTING

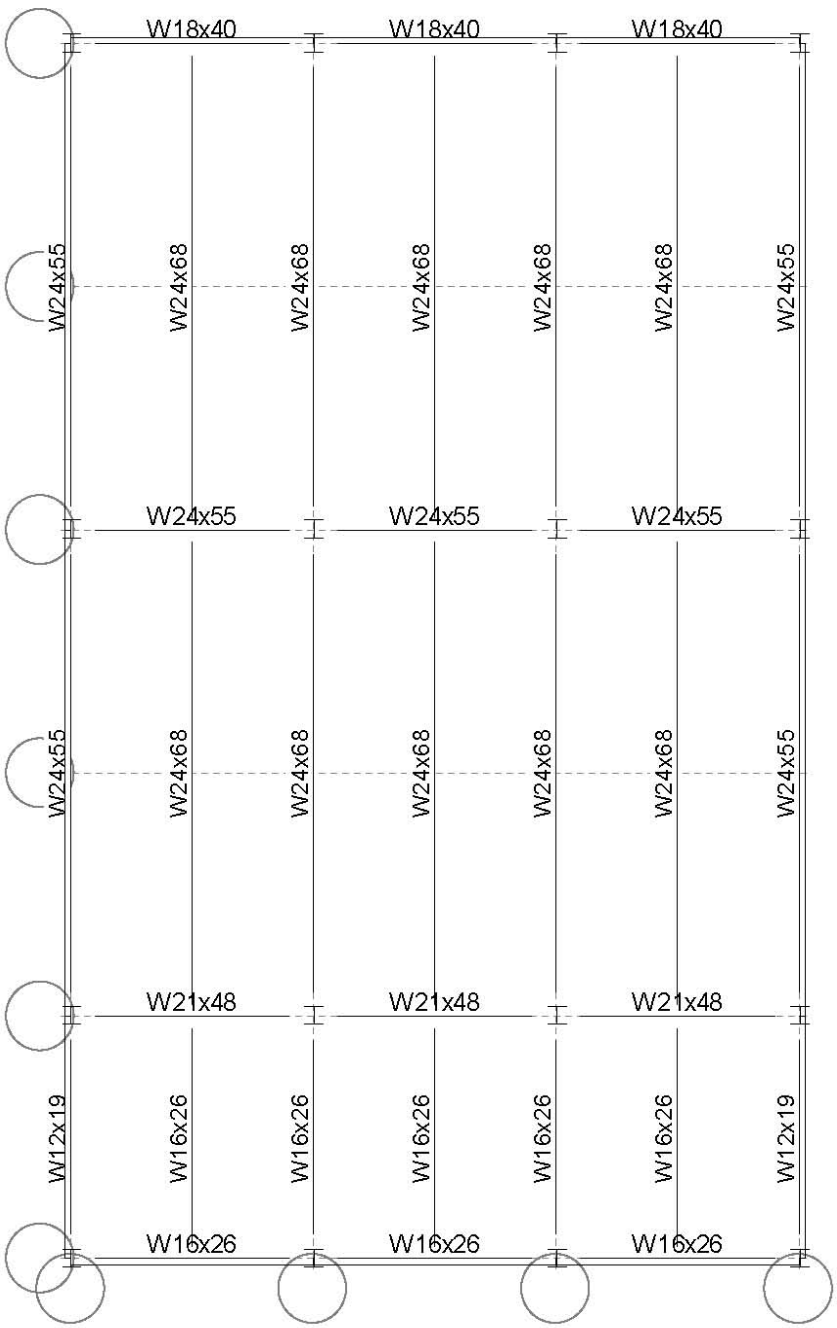


NON-COMPOSITE FRAMING PLAN

Floor Map

RAM Steel v11.0
DataBase: STEEL
Building Code: IBC

Floor Type: NON COMPOSITE

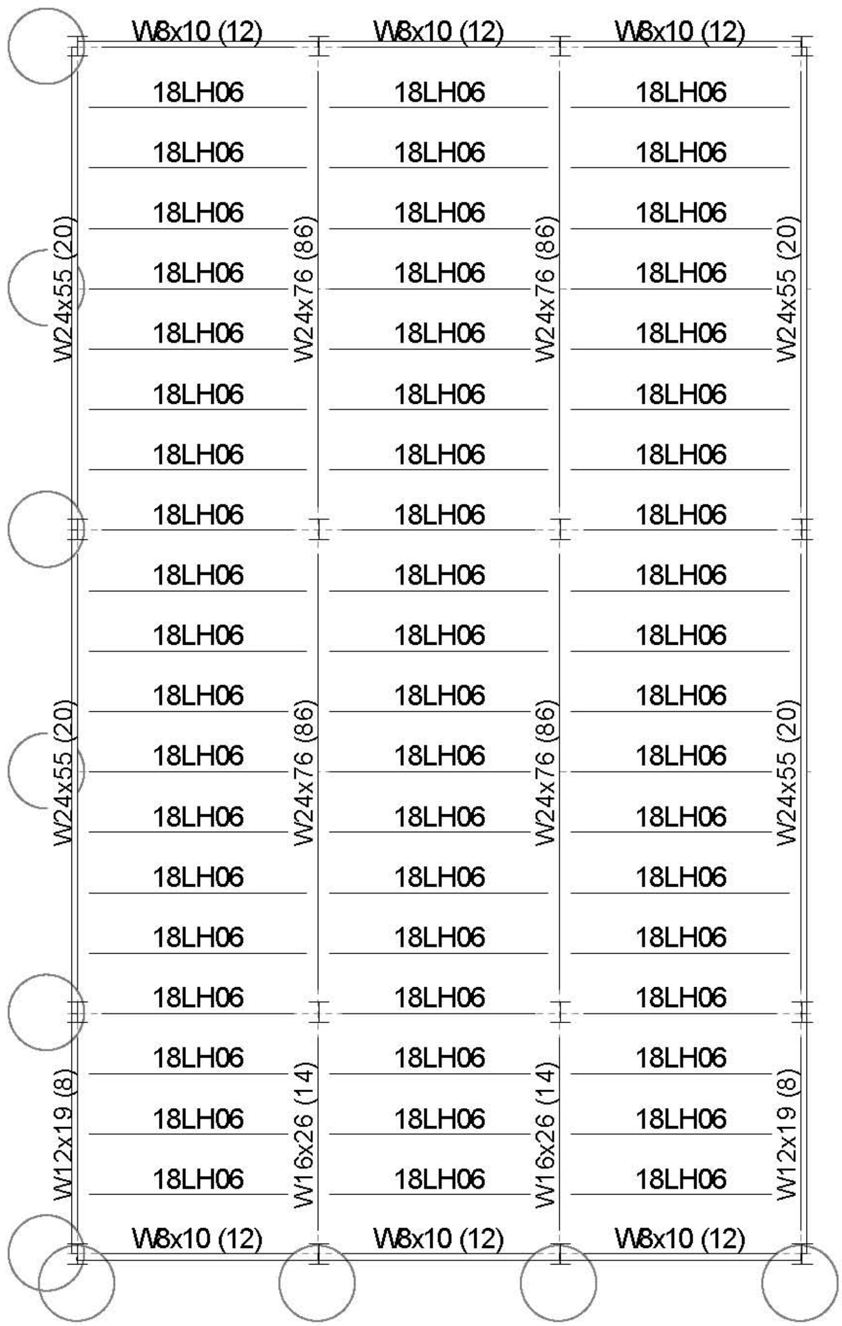


OPEN WEB JOISTS FRAMING PLAN

Floor Map

RAM Steel v11.0
DataBase: OPEN WEB JOISTS
Building Code: IBC

Floor Type: OPEN WEB JOISTS



COMPOSITE AND NON-COMPOSITE DEFLECTIONS

Beam Deflection Summary

RAM Steel v11.0
DataBase: STEEL
Building Code: IBC

STEEL BEAM DEFLECTION SUMMARY:

Floor Type: EXISTING

Composite / Unshored

Bm #	Beam Size	Initial in	PostLive in	PostTotal in	NetTotal in	Camber in
10	W12X14	0.459	0.235	0.306	0.765	
24	W12X16	0.621	0.276	0.358	0.980	
9	W18X40	1.148	0.646	0.846	1.994	
19	W16X31	0.495	0.202	0.272	0.766	
8	W18X40	1.148	0.646	0.846	1.994	
18	W18X35	0.491	0.179	0.248	0.740	
1	W16X26	0.432	0.234	0.306	0.738	
31	W12X19	0.562	0.295	0.383	0.946	
28	W21X50	1.252	0.535	0.740	1.992	
25	W21X50	1.252	0.535	0.740	1.992	
11	W12X19	0.562	0.295	0.383	0.946	
23	W12X16	0.621	0.276	0.358	0.980	
12	W21X50	1.252	0.535	0.740	1.992	
20	W16X31	0.495	0.202	0.272	0.766	
7	W21X50	1.252	0.535	0.740	1.992	
17	W18X35	0.491	0.179	0.248	0.740	
2	W16X26	0.432	0.234	0.306	0.738	
32	W12X19	0.562	0.295	0.383	0.946	
29	W21X50	1.252	0.535	0.740	1.992	
26	W21X50	1.252	0.535	0.740	1.992	
14	W12X19	0.562	0.295	0.383	0.946	
22	W12X16	0.621	0.276	0.358	0.980	
13	W21X50	1.252	0.535	0.740	1.992	
21	W16X31	0.495	0.202	0.272	0.766	
6	W21X50	1.252	0.535	0.740	1.992	
5	W18X35	0.491	0.179	0.248	0.740	
3	W16X26	0.432	0.234	0.306	0.738	
33	W12X19	0.562	0.295	0.383	0.946	
30	W21X50	1.252	0.535	0.740	1.992	
27	W21X50	1.252	0.535	0.740	1.992	
15	W12X14	0.459	0.235	0.306	0.765	
16	W18X40	1.148	0.646	0.846	1.994	
4	W18X40	1.148	0.646	0.846	1.994	

Floor Type: NON COMPOSITE

Noncomposite

Bm #	Beam Size	Dead in	Live in	NetTotal in	Camber in
10	W14X22	0.312	0.343	0.655	

Beam Deflection Summary

RAM Steel v11.0
DataBase: STEEL
Building Code: IBC

Bm #	Beam Size	Dead	Live	NetTotal	Camber
24	W16X26	0.324	0.351	0.675	
9	W24X55	0.780	0.775	1.555	
19	W21X48	0.293	0.268	0.561	
8	W24X55	0.780	0.775	1.555	
18	W24X55	0.279	0.228	0.507	
1	W18X40	0.322	0.329	0.650	
31	W16X26	0.370	0.412	0.782	
28	W24X68	1.018	0.847	1.865	
25	W24X68	1.018	0.847	1.865	
11	W16X26	0.370	0.412	0.782	
23	W16X26	0.324	0.351	0.675	
12	W24X68	1.018	0.847	1.865	
20	W21X48	0.293	0.268	0.561	
7	W24X68	1.018	0.847	1.865	
17	W24X55	0.279	0.228	0.507	
2	W18X40	0.322	0.329	0.650	
32	W16X26	0.370	0.412	0.782	
29	W24X68	1.018	0.847	1.865	
26	W24X68	1.018	0.847	1.865	
14	W16X26	0.370	0.412	0.782	
22	W16X26	0.324	0.351	0.675	
13	W24X68	1.018	0.847	1.865	
21	W21X48	0.293	0.268	0.561	
6	W24X68	1.018	0.847	1.865	
5	W24X55	0.279	0.228	0.507	
3	W18X40	0.322	0.329	0.650	
33	W16X26	0.370	0.412	0.782	
30	W24X68	1.018	0.847	1.865	
27	W24X68	1.018	0.847	1.865	
15	W14X22	0.312	0.343	0.655	
16	W24X55	0.780	0.775	1.555	
4	W24X55	0.780	0.775	1.555	

OPEN WEB JOISTS DEFLECTIONS

Beam Deflection Summary

RAM Steel v11.0
DataBase: OPEN WEB JOISTS

STEEL JOIST DEFLECTION SUMMARY:

Floor Type: OPEN WEB JOISTS

Standard Joists

Bm #	Beam Size	Dead in	Live in	Total in
41	18LH06	0.393	0.452	0.845
40	18LH06	0.393	0.452	0.845
39	18LH06	0.393	0.452	0.845
79	18LH06	0.393	0.452	0.845
38	18LH06	0.393	0.452	0.845
37	18LH06	0.393	0.452	0.845
36	18LH06	0.393	0.452	0.845
35	18LH06	0.393	0.452	0.845
34	18LH06	0.393	0.452	0.845
33	18LH06	0.393	0.452	0.845
32	18LH06	0.393	0.452	0.845
76	18LH06	0.393	0.452	0.845
31	18LH06	0.393	0.452	0.845
30	18LH06	0.393	0.452	0.845
29	18LH06	0.393	0.452	0.845
28	18LH06	0.393	0.452	0.845
27	18LH06	0.393	0.452	0.845
26	18LH06	0.393	0.452	0.845
25	18LH06	0.393	0.452	0.845
58	18LH06	0.393	0.452	0.845
57	18LH06	0.393	0.452	0.845
56	18LH06	0.393	0.452	0.845
80	18LH06	0.393	0.452	0.845
55	18LH06	0.393	0.452	0.845
54	18LH06	0.393	0.452	0.845
53	18LH06	0.393	0.452	0.845
52	18LH06	0.393	0.452	0.845
51	18LH06	0.393	0.452	0.845
50	18LH06	0.393	0.452	0.845
49	18LH06	0.393	0.452	0.845
77	18LH06	0.393	0.452	0.845
48	18LH06	0.393	0.452	0.845
47	18LH06	0.393	0.452	0.845
46	18LH06	0.393	0.452	0.845
45	18LH06	0.393	0.452	0.845
44	18LH06	0.393	0.452	0.845
43	18LH06	0.393	0.452	0.845
42	18LH06	0.393	0.452	0.845
75	18LH06	0.393	0.452	0.845

1 WAY SLAB DESIGN

SOLID ONE-WAY SLABS—SINGLE SPAN — Recommended Minimum Reinforcement

f'_c = 3,000 psi — Grade 60 Bars — $\rho \geq 0.0018bh$

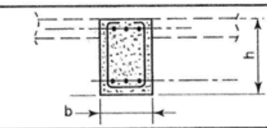
Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Bottom Bars	#3	#3	#3	#3	#3	#3	#3	#3	#4	#4	#4	#4	#4
Spacing (in.)	12	12	12	11	10	9	8	8	12	12	12	11	11
Top Bars	#3	#3	#3	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
Spacing (in.)	12	12	12	12	12	12	12	12	12	12	12	12	12
T-S Bars	#3	#3	#3	#3	#4	#4	#4	#4	#4	#4	#4	#5	#5
Spacing (in.)	15	13	12	11	18	17	15	14	13	13	12	18	17
Areas of Steel (in.²/ft) Bottom	.110	.110	.110	.120	.132	.147	.165	.165	.200	.200	.200	.218	.218
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″	254	301	346	436	545	680	849	923					
6′-6″	206	245	282	357	449	563	705	767					
7′-0″	168	200	231	294	373	470	591	643	859	924	987		
7′-6″	137	164	189	244	311	394	499	543	730	786	840	989	
8′-0″	112	135	156	203	261	333	424	462	625	672	719	849	902
8′-6″	91	110	128	168	219	282	361	394	537	579	619	733	779
9′-0″	74	90	104	140	184	239	309	337	464	500	535	636	676
9′-6″	59	73	85	115	154	203	264	289	402	434	464	554	589
10′-0″	46	58	68	95	129	172	227	248	349	377	403	483	514
10′-6″		45	53	77	107	145	194	213	304	328	351	423	450
11′-0″			41	61	88	122	166	182	264	285	305	371	395
11′-6″				48	72	102	141	155	230	249	266	325	346
12′-0″					57	85	120	132	200	216	231	285	304
12′-6″					44	69	100	111	173	187	201	249	266
13′-0″						55	84	93	149	162	174	218	233
13′-6″						43	69	76	128	140	149	190	203
14′-0″							55	62	109	119	128	165	176
14′-6″							43	49	92	101	108	142	153
15′-0″									77	85	91	122	131
15′-6″									63	70	75	104	112
16′-0″									51	56	61	87	94
16′-6″										44	48	72	78
17′-0″												59	63
17′-6″												45	50
18′-0″													
18′-6″													
19′-0″													
19′-6″													
20′-0″													

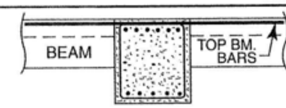
Note: CRSI recommendations for minimum reinforcement are based on practical considerations of rigidity against displacement under normal construction traffic. In all cases, these minimums satisfy minimum prescribed in ACI 10.5. See Fig. 7-1 for reinforcing bar details.

7-4 CONCRETE REINFORCING STEEL INSTITUTE

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

RECTANGULAR BEAMS, INTERIOR SPANS





STEM		BARS[1]				TOTAL CAPACITY $U = 1.4D + 1.7L$[3]																				$+\phi M_n$ $-\phi M_n$	DEFL (C)
h	b	BOTTOM		Lay-ers	TOP	SPAN, ℓ_n = 34 ft					SPAN, ℓ_n = 36 ft					SPAN, ℓ_n = 38 ft					SPAN, ℓ_n = 40 ft					(6)	(7) $\times 10^{-9}$
in.	in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	ft-kip	in.
28	14	2#9		1 1	3#9	3.0	123J 234G	9 37	- 1.3	524 743	2.7	123J 244G	9 37	- 1.3	551 783	2.4	123J 254G	9 37	- 1.3	578 822	2.2	133J 264G	9 37	- 1.3	610 861	217 317	227
		2#10		1 1	3#10	3.7	133J 235G	9 37	- 1.3	653 1042	3.3	143J 245G	9 37	- 1.3	692 1096	3.0	143J 255G	9 37	- 1.3	727 1149	2.7	143J 264G	9 37	- 1.3	761 1007	271 393	221
		2#10	1#10	1 1	3#14	5.4	154J 235G	9 37	- 1.3	1064 1379	4.9	154J 245G	9 37	- 1.3	1118 1453	4.4	164J 255G	9 37	- 1.3	1181 1526	3.9	164J 265G	9 37	- 1.3	1235 1600	393 634	170
		2#14		1 1	3#14	6.0	155J 345D	9 37	- 1.3	1267 1718	5.4	165J 365D	9 37	- 1.3	1342 1818	4.8	165J 255G	9 37	- 1.3	1403 1665	4.4	174J 265G	9 37	- 1.3	1389 1746	451 634	164
	16	2#9		1 1	3#9	3.0	113J 264F	12 47	- 1.5	521 791	2.7	113J 274F	12 46	- 1.5	548 831	2.4	113J 294F	12 46	- 1.5	575 883	2.2	113J 304F	11 46	- 1.4	603 922	218 321	189
		2#11		1 1	3#11	4.6	144J 235G	12 47	- 1.5	860 1197	4.1	143J 245G	12 46	- 1.5	841 1260	3.6	143J 265G	11 46	- 1.4	884 1342	3.3	153J 275G	11 46	- 1.4	931 1405	330 478	189
		2#14		1 1	3#14	6.2	155J 345D	12 47	- 1.5	1272 1741	5.5	155J 365D	12 46	- 1.4	1333 1843	5.0	164J 265G	11 46	- 1.4	1323 1702	4.5	164J 275G	11 46	- 1.4	1384 1784	459 650	156
		2#10	2#10	1 2	4#14	7.1	155J 345D	12 47	- 1.5	1431 1900	6.4	165J 365D	12 46	- 1.4	1516 2011	5.7	175J 385D	11 46	- 1.4	1601 2122	5.2	175J 395D	11 46	- 1.4	1672 2213	515 749	148
	18	2#8	1#8	1 1	3#10	3.6	113J 215H	14 57	- 1.6	601 986	3.2	123J 225H	14 56	- 1.6	637 1038	2.9	123J 234H	14 56	- 1.6	669 907	2.6	123J 244H	14 55	- 1.6	701 952	259 402	170
		2#10	1#10	1 1	3#11	4.6	133J 215H	14 57	- 1.6	835 1210	4.1	133J 225H	14 56	- 1.6	880 1276	3.7	143J 235H	14 56	- 1.6	930 1342	3.3	143J 245H	14 55	- 1.6	975 1408	402 484	165
		2#11	1#11	1 1	3#14	6.3	145J 295E	14 56	- 1.6	1234 1633	5.6	154J 315E	14 56	- 1.6	1227 1734	5.1	154J 335E	14 56	- 1.6	1287 1836	4.6	164J 345E	14 55	- 1.6	1356 1916	484 663	147
		2#11	2#11	1 1	4#14	8.0	165GdJ 345D	14 56	- 1.6	1573 2046	7.1	165J 365D	14 56	- 1.6	1651 2165	6.4	175J 335E	14 56	- 1.6	1744 2181	5.8	175J 345E	14 55	- 1.6	1822 2280	624 840	123
	20	2#9	1#9	1 1	3#11	4.5	123J 215H	17 67	- 1.8	745 1139	4.0	133J 225H	17 66	- 1.8	790 1200	3.6	133J 235H	16 66	- 1.8	830 1262	3.3	133J 245H	16 65	- 1.7	870 1323	325 489	158
		2#10	1#10	1 1	3#11	4.7	123J 215H	17 67	- 1.8	832 1225	4.2	133J 225H	17 66	- 1.8	881 1291	3.7	133J 235H	16 66	- 1.8	926 1358	3.4	133J 245H	16 65	- 1.7	971 1424	406 489	152
		2#11	2#11	1 1	4#14	8.2	165GcJ 345D	17 67	- 1.8	1578 2069	7.3	165J 315E	17 66	- 1.8	1656 2083	6.5	165J 335E	16 66	- 1.7	1734 2204	5.9	175J 345E	16 65	- 1.7	1828 2303	632 857	118
		2#14	1#14	1 1	5#14	9.3	175GfJ 415C	17 67	- 1.8	1855 2481	8.3	175GeJ 365D	17 66	- 1.8	1948 2467	7.5	185GdJ 385D	16 66	- 1.7	2056 2603	6.7	185GcJ 405D	16 65	- 1.7	2149 2739	673 1022	107

(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 > $\ell_n/180$

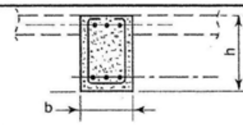
(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

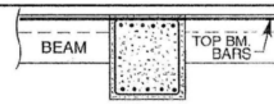
Other notation: N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(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.

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

RECTANGULAR BEAMS, INTERIOR SPANS





STEM		BARS[1]				TOTAL CAPACITY $U = 1.4D + 1.7L$[3]																				+φMn −φMn	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)
in.	in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	ft-kip	$\times 10^{-9}$ in.
26	14	2# 9		1	3# 9	5.5	113I	9	-	381	4.7	113I	9	-	408	4.1	123I	9	-	439	3.5	123I	9	-	467	199	287
				1			185F	35	1.3	671		204F	35	1.3	590		214F	34	1.2	628		234F	34	1.2	679	290	
		2#10		1	3#10	6.9	124I	9	-	522	5.8	124I	9	-	557	5.0	134I	9	-	599	4.4	133I	9	-	581	248	272
				1			185F	35	1.3	760		205F	35	1.3	832		215F	34	1.2	885		235F	34	1.2	957	359	
		2#10	1#10	1	4#10	8.8	125I	9	-	729	7.5	135I	9	-	789	6.5	144I	9	-	778	5.6	144I	9	-	825	359	226
				1			295C	35	1.3	1112		205F	35	1.2	990		215F	34	1.2	1055		235F	34	1.2	1140	460	
		2#14		1	3#14	11.0	264C	9	-	967	9.3	145FcI	9	-	998	8.1	145I	9	-	1059	7.0	155I	9	-	1134	411	200
				1			295C	35	1.3	1294		315C	35	1.2	1393		345C	34	1.2	1510		365C	34	1.2	1609	574	
	16	2# 9		1	3# 9	5.6	103I	11	-	378	4.8	113I	11	-	409	4.1	113I	11	-	437	3.6	123I	11	-	468	200	245
				1			165G	44	1.4	645		185G	43	1.4	711		195G	43	1.4	758		204G	42	1.4	653	294	
		2#11		1	3#11	8.3	125I	11	-	685	7.1	124I	11	-	666	6.1	134I	11	-	717	5.3	144I	11	-	769	302	232
				1			245D	44	1.4	988		265D	43	1.4	1069		195G	43	1.4	976		205G	42	1.4	1038	436	
		2#14		1	3#14	11.3	145FdI	11	-	942	9.6	135I	11	-	989	8.3	145I	11	-	1064	7.2	155I	11	-	1139	418	190
				1			245D	44	1.4	1217		265D	43	1.4	1317		285D	43	1.4	1417		305D	42	1.4	1517	590	
		2#14		1	5#11	11.6	145FeI	11	-	1000	9.9	145FdI	11	-	1066	8.5	145I	11	-	1132	7.4	155I	11	-	1212	418	191
				2			245D	44	1.4	1275		265D	43	1.4	1380		285D	43	1.4	1485		305D	42	1.4	1590	627	
	18	2# 8	1# 8	1	3#10	6.6	113I	13	-	438	5.6	113I	13	-	470	4.9	113I	13	-	502	4.2	123I	13	-	539	238	218
				1			165G	53	1.6	711		185G	53	1.6	783		195G	52	1.5	835		205G	51	1.5	887	368	
		2# 9	1# 9	1	3#11	8.2	114I	13	-	583	7.0	124I	13	-	632	6.1	134I	13	-	681	5.3	133I	13	-	666	296	216
				1			245D	53	1.6	970		185G	52	1.5	889		195G	52	1.5	949		205G	51	1.5	1009	442	
		2#11	1#11	1	3#14	11.5	135FdI	13	-	912	9.8	135I	13	-	971	8.5	145I	13	-	1045	7.4	145I	13	-	1105	442	179
				1			245D	53	1.6	1212		265D	52	1.5	1313		285D	52	1.5	1413		305D	51	1.5	1513	602	
		2#10	2#10	1	4#14	13.3	145FfI	13	-	1057	11.3	155FeI	13	-	1142	9.7	155FdI	13	-	1213	8.5	155I	13	-	1284	477	157
				1			295C	53	1.6	1444		315C	52	1.5	1556		285D	52	1.5	1566		305D	51	1.5	1677	759	
	20	2# 8	1# 8	1	3#10	6.7	103I	16	-	435	5.7	113I	16	-	472	4.9	113I	15	-	504	4.3	113I	15	-	535	239	189
				1			155H	63	1.7	701		165H	62	1.7	754		175H	61	1.7	807		185H	61	1.7	859	371	
		2#10	1#10	1	3#11	8.5	114I	16	-	647	7.3	124I	15	-	701	6.3	124I	15	-	746	5.5	133I	15	-	743	371	190
				1			215E	63	1.7	986		225E	62	1.7	1051		175H	61	1.7	992		185H	61	1.7	1058	447	
		2#11	1#11	1	4#14	12.4	135FdI	16	-	1038	10.6	135I	15	-	1108	9.1	145I	15	-	1193	7.9	145I	15	-	1263	447	154
				1			295C	63	1.7	1456		265D	62	1.7	1463		285D	61	1.7	1575		265E	60	1.7	1603	776	
		2#14	1#14	1	4#14	14.8	265C	16	-	1385	12.6	155FfI	15	-	1309	10.9	155FeI	15	-	1392	9.5	165FdI	15	-	1489	612	141
				1			485A	63	1.7	2011		315C	62	1.7	1739		345C	61	1.7	1885		305D	60	1.7	1884	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: * — ℓ_n/360 < deflection < ℓ_n/240
X — ℓ_n/240 < deflection < ℓ_n/180
Y — deflection > ℓ_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.

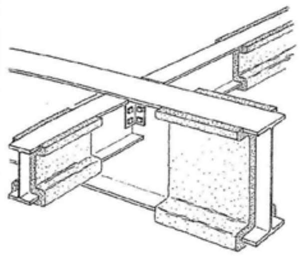
Other notation: N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS EXCEEDS ALLOWABLE

(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.

R.S. MEANS

B10 Superstructure

B1010 Floor Construction



General: The following table is based upon structural W shape beam and girder framing. Non-composite action is assumed between beams and decking. Deck costs not included.

The deck spans the short direction. The steel beams and girders are fireproofed with sprayed fiber fireproofing.

Design and Pricing Assumptions:
Structural steel is A36, with high strength A325 bolts.

Fireproofing is sprayed fiber (non-asbestos).

Total load includes steel, deck & live load.

Spandrels are assumed the same as interior beams and girders to allow for exterior wall loads and bracing or moment connections. No columns included in price.

See Tables B1010 528 and B1020 128 for metal deck costs.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 241 1350 **15'X20' BAY,40 P.S.F. L.L.,12"DEPTH, .535P.S.F. FIREPROOF, 50 PSF T.LOAD**					
Structural steel	3.200	Lb.	3.68	1.19	4.87
Spray mineral fiber/cement for fire proof., 1" thick on beams	.535	S.F.	.26	.45	.71
TOTAL			3.94	1.64	5.58

B1010 241 W Shape Beams & Girders

	BAY SIZE (FT.) BEAM X GIRD	SUPERIMPOSED LOAD (P.S.F.)	STEEL FRAMING DEPTH (IN.)	FIREPROOFING (S.F. PER S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1350	15x20	40	12	.535	50	3.94	1.63	5.57
1400		40	16	.65	90	5.15	2.10	7.25
1450		75	18	.694	125	6.80	2.65	9.45
1500		125	24	.796	175	9.35	3.71	13.06
1550		200	24	.89	263	10.60	3.35	13.95
1600	20x15	40	14	.659	50	4	1.73	5.73
1650		40	14	.69	90	5.40	2.20	7.60
1700		75	14	.806	125	6.60	2.67	9.27
1800		125	16	.86	175	7.80	3.21	11.01
1900		200	18	1.00	250	9.25	2.96	12.21
2000	20x20	40	12	.55	50	4.41	1.79	6.20
2050		40	14	.579	90	6.05	2.33	8.38
2100		75	16	.672	125	7.25	2.78	10.03
2150		125	16	.714	175	8.65	3.40	12.05
2200		200	24	.841	263	10.80	3.37	14.17
2300	20x20	40	14	.67	50	4.47	1.88	6.35
2400		40	14	.718	90	6.10	2.44	8.54
2500		75	18	.751	125	7.05	2.77	9.82
2550		125	21	.879	175	9.65	3.85	13.50
2600		200	21	.976	250	11.55	3.65	15.20
2650	20x20	40	14	.746	50	4.51	1.95	6.46
2700		40	14	.839	90	6.15	2.55	8.70
2750		75	18	.894	125	7.80	3.11	10.91
2800		125	21	.959	175	10.35	4.15	14.50
2850		200	21	1.10	250	12.75	4.05	16.80
2900	20x25	40	16	.53	50	4.86	1.92	6.78
2950		40	18	.621	96	7.65	2.88	10.53
3000		75	18	.651	131	8.85	3.27	12.12
3050		125	24	.77	200	11.65	4.47	16.12
3100		200	27	.855	275	13.30	4.02	17.32

31

B10 Superstructure

B1010 Floor Construction

Description: Table below lists the S.F. costs for wood joists and a minimum thickness plywood subfloor.

Design Assumptions: 10% allowance has been added to framing quantities for overlaps, waste, double joists at openings or under partitions, etc. 5% added to subfloor for waste.

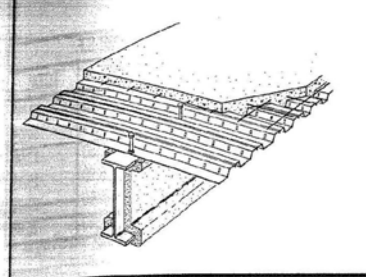
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 261 2500 WOOD JOISTS 2"X6", 12" O.C.					
Framing joists, fir, 2"x6"	1.100	B.F.	.70	.80	1.50
Subfloor plywood CDX 1/2"	1.050	S.F.	.55	.64	1.19
TOTAL			1.25	1.44	2.69

B1010 261	Wood Joist	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
2500	Wood joists, 2"x6", 12" O.C.	1.24	1.44	2.68
2550	16" O.C.	1.07	1.25	2.32
2600	24" O.C.	1.17	1.17	2.34
2900	2"x8", 12" O.C.	1.56	1.55	3.11
2950	16" O.C.	1.31	1.33	2.64
3000	24" O.C.	1.33	1.23	2.56
3300	2"x10", 12" O.C.	1.99	1.77	3.76
3350	16" O.C.	1.63	1.49	3.12
3400	24" O.C.	1.53	1.33	2.86
3700	2"x12", 12" O.C.	2.27	1.80	4.07
3750	16" O.C.	1.84	1.51	3.35
3800	24" O.C.	1.68	1.34	3.02
4100	2"x14", 12" O.C.	3.17	1.95	5.12
4150	16" O.C.	2.52	1.62	4.14
4200	24" O.C.	2.14	1.42	3.56
4500	3"x6", 12" O.C.	2.86	1.73	4.59
4550	16" O.C.	2.28	1.46	3.74
4600	24" O.C.	1.98	1.31	3.29
4900	3"x8", 12" O.C.	3.68	1.70	5.38
4950	16" O.C.	2.90	1.43	4.33
5000	24" O.C.	2.39	1.29	3.68
5300	3"x10", 12" O.C.	4.46	1.93	6.39
5350	16" O.C.	3.50	1.61	5.11
5400	24" O.C.	2.79	1.42	4.21
5700	3"x12", 12" O.C.	4.79	1.68	6.47
5750	16" O.C.	4.14	1.91	6.05
5800	24" O.C.	3.21	1.61	4.82
6100	4"x6", 12" O.C.	3.74	1.76	5.50
6150	16" O.C.	2.94	1.48	4.42
6200	24" O.C.	2.41	1.33	3.74

101

B10 Superstructure

B1010 Floor Construction



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

Design and Pricing Assumptions:
Structural steel is A36, high strength bolted.
Composite steel deck varies from 22 gauge to 16 gauge, galvanized.
Shear Studs are 3/4".
W.W.F., 6 x 6 – W1.4 x W1.4 (10 x 10)
Concrete f'c = 3 KSI, lightweight.
Steel trowel finish and cure.
Fireproofing is sprayed fiber (non-asbestos).

Spandrels are assumed the same as interior beams and girders to allow for exterior wall loads and bracing or moment connections.

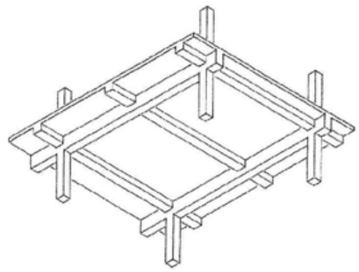
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 256 2400					
20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS					
Structural steel	4.320	Lb.	4.97	1.60	6.57
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.10	.28	.38
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	1.85	.84	2.69
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.045	L.F.	.16	.10	.26
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.14	.31	.45
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	2.41		2.41
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.43	.43
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.76	.76
Curing with sprayed membrane curing compound	.010	C.S.F.	.05	.08	.13
Shores, erect and strip vertical to 10' high	.020	Ea.		.35	.35
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.24	.40	.64
TOTAL			9.92	5.15	15.07

B1010 256	Composite Beams, Deck & Slab							
	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2400	20x25	40	5-1/2	1 - 5-1/2	80	9.90	5.15	15.05
2500	RB1010 -100	75	5-1/2	1 - 9-1/2	115	10.30	5.15	15.45
2750		125	5-1/2	1 - 9-1/2	167	12.55	6.05	18.60
2900		200	6-1/4	1 - 11-1/2	251	14.20	6.50	20.70
3000	25x25	40	5-1/2	1 - 9-1/2	82	9.75	4.89	14.64
3100		75	5-1/2	1 - 11-1/2	118	10.85	4.97	15.82
3200		125	5-1/2	2 - 2-1/2	169	11.30	5.40	16.70
3300		200	6-1/4	2 - 6-1/4	252	15.25	6.30	21.55
3400	25x30	40	5-1/2	1 - 11-1/2	83	9.95	4.87	14.82
3600		75	5-1/2	1 - 11-1/2	119	10.70	4.92	15.62
3900		125	5-1/2	1 - 11-1/2	170	12.40	5.55	17.95
4000		200	6-1/4	2 - 6-1/4	252	15.35	6.30	21.65
4200	30x30	40	5-1/2	1 - 11-1/2	81	10	5	15
4400		75	5-1/2	2 - 2-1/2	116	10.80	5.25	16.05
4500		125	5-1/2	2 - 5-1/2	168	13.05	5.90	18.95
4700		200	6-1/4	2 - 9-1/4	252	15.65	6.80	22.45
4900	30x35	40	5-1/2	2 - 2-1/2	82	10.50	5.20	15.70
5100		75	5-1/2	2 - 5-1/2	117	11.45	5.30	16.75
5300		125	5-1/2	2 - 5-1/2	169	13.45	6	19.45
5500		200	6-1/4	2 - 9-1/4	254	15.80	6.85	22.65
5750	35x35	40	5-1/2	2 - 5-1/2	84	11.15	5.20	16.35
6000		75	5-1/2	2 - 5-1/2	121	12.70	5.60	18.30

97

B10 Superstructure

B1010 Floor Construction



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

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

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 219 3000					
BM. & SLAB ONE WAY 15'X15'BAY, 40 PSF S.LOAD,12" MIN. COL.					
Forms in place, flat plate to 15' high, 4 uses	.858	S.F.	1.35	4.09	5.44
Forms in place, exterior spandrel, 12" wide, 4 uses	.142	SFCA	.19	1.22	1.41
Forms in place, interior beam. 12" wide, 4 uses	.306	SFCA	.47	2.17	2.64
Reinforcing in place, elevated slabs #4 to #7	1.600	Lb.	.82	.59	1.41
Concrete ready mix, regular weight, 3000 psi	.410	C.F.	1.74		1.74
Place and vibrate concrete, elevated slab less than 6", pump	.410	C.F.		.53	.53
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.76	.76
Cure with sprayed membrane curing compound	.010	C.S.F.	.05	.08	.13
TOTAL			4.62	9.44	14.06

B1010 219 Cast in Place Beam & Slab, One Way

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
3000	15x15	40	12	4	120	4.60	9.45	14.05
3100	RB1010 -010	75	12	4	138	4.69	9.50	14.19
3200		125	12	4	188	4.79	9.55	14.34
3300		200	14	4	266	5.10	9.90	15
3600	15x20	40	12	4	102	4.71	9.35	14.06
3700	RB1010 -100	75	12	4	140	4.90	9.65	14.55
3800		125	14	4	192	5.15	10	15.15
3900		200	16	4	272	5.70	10.65	16.35
4200	20x20	40	12	5	115	5.10	9.15	14.25
4300		75	14	5	154	5.50	9.85	15.35
4400		125	16	5	206	5.75	10.35	16.10
4500		200	18	5	287	6.45	11.10	17.55
5000	20x25	40	12	5-1/2	121	5.30	9.15	14.45
5100		75	14	5-1/2	160	5.80	9.95	15.75
5200		125	16	5-1/2	215	6.25	10.50	16.75
5300		200	18	5-1/2	294	6.75	11.30	18.05
5500	25x25	40	12	6	129	5.60	9	14.60
5600		75	16	6	171	6.10	9.65	15.75
5700		125	18	6	227	7.05	11.05	18.10
5800		200	2	6	300	7.80	11.85	19.65
6500	25x30	40	14	6-1/2	132	5.70	9.15	14.85
6600		75	16	6-1/2	172	6.20	9.75	15.95
6700		125	18	6-1/2	231	7.25	11	18.25
6800		200	20	6-1/2	312	7.85	12	19.85

61

B10 Superstructure

B1010 Floor Construction

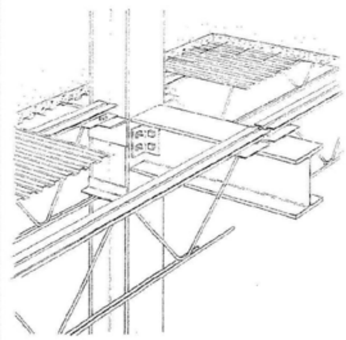


Table below lists costs for a floor system on steel columns and beams using open web steel joists, galvanized steel slab form, and 2-1/2" concrete slab reinforced with welded wire fabric.

Design and Pricing Assumptions:
Structural Steel is A36.
Concrete f'c = 3 KSI placed by pump.
WWF 6 x 6 – W1.4 x W1.4 (10 x 10)
Columns are 12' high.
Building is 4 bays long by 4 bays wide.
Joists are 2' O.C. ± and span the long direction of the bay.

Joists at columns have bottom chords extended and are connected to columns.

Slab form is 28 gauge galvanized.
Column costs in table are for columns to support 1 floor plus roof loading in a 2-story building; however, column costs are from ground floor to 2nd floor only. Joist costs include appropriate bridging.
Deflection is limited to 1/360 of the span.
Screeds and steel trowel finish.

Design Loads	Min.	Max.
S.S. & Joists	6.3 PSF	15.3 PSF
Slab Form	1.0	1.0
2-1/2" Concrete	27.0	27.0
Ceiling	3.0	3.0
Misc.	5.7	1.7
	43.0 PSF	48.0 PSF

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 250 2350					
15'X20'BAY 40 PSF S. LOAD, 17" DEPTH, 83 PSF TOTAL LOAD					
Structural steel	1.974	Lb.	2.23	.73	2.96
Open web joists	3.140	Lb.	2.45	1	3.45
Slab form, galvanized steel 9/16" deep, 28 gauge	1.020	S.F.	1.02	.65	1.67
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.14	.31	.45
Concrete ready mix, regular weight, 3000 psi	.210	C.F.	.89		.89
Place and vibrate concrete, elevated slab less than 6", pumped	.210	C.F.		.28	.28
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.76	.76
Curing with sprayed membrane curing compound	.010	S.F.	.05	.08	.13
TOTAL			6.78	3.81	10.59

B1010 250 Steel Joists, Beams & Slab on Columns

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	DEPTH (IN.)	TOTAL LOAD (P.S.F.)	COLUMN ADD	COST PER S.F. MAT.	INST.	TOTAL
2350	15x20 RB1010 -100	40	17	83		6.80	3.81	10.61
2400					column	1.07	.35	1.42
2450	15x20	65	19	108		7.50	4.04	11.54
2500					column	1.07	.35	1.42
2550	15x20	75	19	119		7.80	4.18	11.98
2600					column	1.17	.38	1.55
2650	15x20	100	19	144		8.30	4.35	12.65
2700					column	1.17	.38	1.55
2750	15x20	125	19	170		9.30	4.90	14.20
2800					column	1.55	.51	2.06
2850	20x20	40	19	83		7.35	3.98	11.33
2900					column	.87	.29	1.16
2950	20x20	65	23	109		8.10	4.26	12.36
3000					column	1.17	.38	1.55
3100	20x20	75	26	119		8.55	4.40	12.95
3200					column	1.17	.38	1.55
3400	20x20	100	23	144		8.90	4.52	13.42
3450					column	1.17	.38	1.55
3500	20x20	125	23	170		9.90	4.88	14.78
3600					column	1.40	.46	1.86

90

METAL DECK

3 x 12" DECK F_y = 33ksi f'_c = 3 ksi 115 pcf concrete

LRFD

Gage	Studs	Slab Depth	φMn in.k	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00
				L, Uniform Live Loads, psf *												
22 gage	1 stud/ft	5.50	52.80	240	215	190	170	150	135	125	110	100	90	80	75	70
22 gage	1 stud/ft	6.00	58.89	275	245	215	195	175	155	140	125	115	105	95	85	75
22 gage	1 stud/ft	6.25	62.43	290	255	230	205	185	165	150	135	120	110	100	90	80
22 gage	1 stud/ft	6.50	65.97	305	270	240	215	195	175	155	140	130	115	105	95	85
22 gage	1 stud/ft	7.00	74.05	340	300	270	240	215	190	175	155	140	130	115	105	95
22 gage	1 stud/ft	7.25	77.59	355	315	280	250	225	200	180	165	150	135	120	110	100
22 gage	1 stud/ft	7.50	81.13	375	330	295	260	235	210	190	170	155	140	130	115	105
22 gage	1 stud/ft	8.00	88.22	400	360	320	285	255	230	205	185	170	155	140	125	115
20 gage	1 stud/ft	5.50	62.81	285	250	230	205	185	170	150	135	125	115	105	95	85
20 gage	1 stud/ft	6.00	71.37	335	295	265	235	210	190	175	155	140	130	120	110	100
20 gage	1 stud/ft	6.25	75.65	355	315	280	250	225	205	185	165	150	135	125	115	105
20 gage	1 stud/ft	6.50	79.92	375	330	295	265	240	215	195	175	160	145	130	120	110
20 gage	1 stud/ft	7.00	88.48	400	365	330	295	265	240	215	195	175	160	145	135	125
20 gage	1 stud/ft	7.25	92.76	400	385	345	310	275	250	225	205	185	170	155	140	130
20 gage	1 stud/ft	7.50	97.03	400	400	360	320	290	260	235	215	195	175	160	150	135
20 gage	1 stud/ft	8.00	105.59	400	400	390	350	315	285	255	235	210	195	175	160	145
19 gage	1 stud/ft	5.50	72.04	340	300	270	240	220	195	180	160	145	135	125	110	105
19 gage	1 stud/ft	6.00	82.00	390	345	305	275	250	225	205	185	170	155	140	130	120
19 gage	1 stud/ft	6.25	86.97	400	365	325	295	265	240	215	195	180	165	150	135	125
19 gage	1 stud/ft	6.50	91.95	400	385	345	310	280	250	230	205	190	170	160	145	135
19 gage	1 stud/ft	7.00	101.91	400	400	385	345	310	280	255	230	210	190	175	160	145
19 gage	1 stud/ft	7.25	106.89	400	400	400	360	325	295	265	240	220	200	185	170	155
19 gage	1 stud/ft	7.50	111.87	400	400	400	380	340	310	280	255	230	210	195	175	160
19 gage	1 stud/ft	8.00	121.83	400	400	400	400	370	335	305	275	250	230	210	195	175
18 gage	1 stud/ft	5.50	80.36	385	345	305	275	250	225	205	185	170	155	140	130	120
18 gage	1 stud/ft	6.00	92.32	400	390	350	315	285	255	235	210	195	175	160	150	135
18 gage	1 stud/ft	6.25	98.00	400	400	370	335	300	275	245	225	205	190	170	160	145
18 gage	1 stud/ft	6.50	103.68	400	400	395	355	320	290	260	240	220	200	180	165	155
18 gage	1 stud/ft	7.00	115.04	400	400	400	395	355	320	290	265	240	220	205	185	170
18 gage	1 stud/ft	7.25	120.72	400	400	400	400	370	335	305	280	255	235	215	195	180
18 gage	1 stud/ft	7.50	126.40	400	400	400	400	390	355	320	290	265	245	225	205	190
18 gage	1 stud/ft	8.00	137.76	400	400	400	400	400	385	350	320	290	265	245	225	205
16 gage	1 stud/ft	5.50	80.36	385	345	305	275	250	225	205	185	170	155	140	130	120
16 gage	1 stud/ft	6.00	92.32	400	390	350	315	285	255	235	210	195	175	160	150	135
16 gage	1 stud/ft	6.25	98.00	400	400	370	335	300	275	245	225	205	190	170	160	145
16 gage	1 stud/ft	6.50	103.68	400	400	395	355	320	290	260	240	220	200	180	165	155
16 gage	1 stud/ft	7.00	115.04	400	400	400	395	355	320	290	265	240	220	205	185	170
16 gage	1 stud/ft	7.25	120.72	400	400	400	400	370	335	305	280	255	235	215	195	180
16 gage	1 stud/ft	7.50	126.40	400	400	400	400	390	355	320	290	265	245	225	205	190
16 gage	1 stud/ft	8.00	137.76	400	400	400	400	400	385	350	320	290	265	245	225	205
22 gage	No studs	5.50	36.57	155	135	120	105	90	80	75	65	60	50	45	40	35
22 gage	No studs	6.00	40.32	175	155	135	120	105	95	85	75	65	60	55	45	40
22 gage	No studs	6.25	42.63	190	165	145	130	115	100	90	80	70	65	55	50	45
22 gage	No studs	6.50	45.49	200	175	155	140	125	110	95	85	75	70	60	55	50
22 gage	No studs	7.00	52.24	230	200	175	155	140	125	110	100	90	80	70	65	55
22 gage	No studs	7.25	55.17	240	210	185	165	145	130	115	105	95	85	75	65	60
22 gage	No studs	7.50	58.14	255	225	200	175	155	140	125	110	100	90	80	70	65
22 gage	No studs	8.00	64.15	280	250	220	195	175	155	140	125	110	100	90	80	70
20 gage	No studs	5.50	42.29	185	165	145	130	115	105	90	80	75	65	60	55	50
20 gage	No studs	6.00	48.61	215	190	170	150	135	120	105	95	85	75	70	60	55
20 gage	No studs	6.25	51.83	230	205	180	160	145	130	115	105	90	85	75	65	60
20 gage	No studs	6.50	55.23	245	215	195	170	155	135	120	110	100	90	80	70	65
20 gage	No studs	7.00	62.07	280	245	220	195	175	155	140	125	110	100	90	80	75
20 gage	No studs	7.25	65.57	295	260	230	205	185	165	145	130	120	105	95	85	80
20 gage	No studs	7.50	69.10	310	275	245	215	195	175	155	140	125	115	100	90	85
20 gage	No studs	8.00	76.28	345	305	270	240	215	190	170	155	140	125	115	105	95
19 gage	No studs	5.50	48.35	220	195	170	150	135	120	110	100	90	80	70	65	60
19 gage	No studs	6.00	55.60	250	225	200	175	155	140	125	115	105	95	85	75	70
19 gage	No studs	6.25	59.35	270	240	210	190	170	150	135	120	110	100	90	80	75
19 gage	No studs	6.50	62.20	285	255	225	200	180	160	145	130	120	105	95	90	80
19 gage	No studs	7.00	71.08	325	285	255	225	205	185	165	150	135	120	110	100	90
19 gage	No studs	7.25	75.10	345	305	270	240	215	195	175	155	140	130	115	105	95
19 gage	No studs	7.50	79.17	360	320	285	255	230	205	185	165	150	135	125	110	100
19 gage	No studs	8.00	87.46	400	355	315	280	255	225	205	185	165	150	135	125	115
18 gage	No studs	5.50	54.28	250	220	195	175	155	140	125	115	105	95	85	75	70
18 gage	No studs	6.00	62.43	285	255	225	200	180	160	145	130	120	110	100	90	80
18 gage	No studs	6.25	66.67	305	270	240	215	195	175	155	140	130	115	105	95	85
18 gage	No studs	6.50	70.39	325	290	260	230	205	185	165	150	135	125	115	105	95
18 gage	No studs	7.00	78.88	370	325	290	260	235	210	190	170	155	140	130	115	105
18 gage	No studs	7.25	84.42	390	345	310	275	245	225	200	180	165	150	135	125	115
18 gage	No studs	7.50	88.03	400	365	325	290	260	235	210	190	175	160	145	130	120
18 gage	No studs	8.00	96.33	400	400	360	325	290	260	235	215	195	175	160	145	135
16 gage	No studs	5.50	54.28	250	220	195	175	155	140	125	115	105	95	85	75	70
16 gage	No studs	6.00	62.43	285	255	225	200	180	160	145	130	120	110	100	90	80
16 gage	No studs	6.25	66.67	305	270	240	215	195	175	155	140	130	115	105	95	85
16 gage	No studs	6.50	70.39	325	290	260	230	205	185	165	150	135	125	115	105	95
16 gage	No studs	7.00	78.88	370	325	290	260	235	210	190	170	155	140	130	115	105
16 gage	No studs	7.25	84.42	390	345	310	275	245	225	200	180	165	150	135	125	115
16 gage	No studs	7.50	88.03	400	365	325	290	260	235	210	190	175	160	145	130	120
16 gage	No studs	8.00	96.33	400	400	360	325	290	260	235	215	195	175	160	145	135

Light Weight

1 STUD/FT.

NO STUDS

* The Uniform Live Loads are based on the LRFD equation $\phi M_n = (1.6L + 1.2D)l^2/8$. Although there are other load combinations that may require investigation, this will control most of the time. The equation assumes there is no negative bending reinforcement over the beams and therefore each composite slab is a single span. Two sets of values are shown; ϕM_n is used to calculate the uniform load when the full required number of studs is present; ϕM_{nf} is used to calculate the load when no studs are present. A straight line interpolation can be done if the average number of studs is between zero and the required number needed to develop the "full" factored moment. The tabulated loads are checked for shear controlling (it seldom does), and also limited to a live load deflection of 1/360 of the span.

An upper limit of 400psf has been applied to the tabulated loads. This has been done to guard against equating large concentrated to uniform loads. Concentrated loads may require special analysis and design to take care of serviceability requirements not covered by simply using a uniform load value. On the other hand, for any load combination the values provided by the composite properties can be used in the calculations.

Welded wire fabric in the required amount is assumed for the table values. If welded wire fabric is not present, deduct 10% from the listed loads.

Refer to the example problems for the use of the tables.

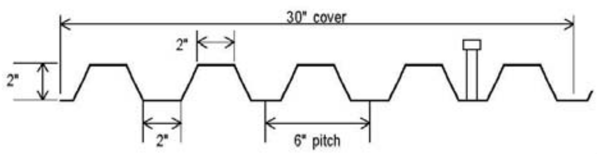
3" LOK-FLOOR

41

STEEL JOIST DECK

SECTION PROPERTIES						ASD			LRFD		
Metal Thickness		Wt.	I_p	S_p	S_n	V	R_1	R_2	ϕV	ϕR_1	ϕR_2
Gage	Inches	(psf)	(in.^{4})	(in.^{3})	(in.3)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
24	0.0239	1.50	0.232	0.192	0.200	2360	360	836	3223	532	1156
22	0.0295	2.00	0.300	0.252	0.263	4205	528	1484	5477	736	1992
20	0.0358	2.00	0.379	0.325	0.339	6062	728	2224	8067	1004	3064
18	0.0474	3.00	0.523	0.468	0.485	8796	1204	3948	11182	1648	5388

UF2X



The bottom flange can accept a ¾" shear stud.

approx. scale: 1½" = 1'0"

UNIFORM TOTAL LOAD / Load that Produces l/180 Deflection, psf

	Gage	Span Condition	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"	9'6"	10'0"
ASD	24	Single	128 / 94	109 / 74	94 / 59	82 / 48	72 / 40	64 / 33	57 / 28	51 / 24	46 / 20
ASD	24	Double	130 / 226	111 / 178	96 / 143	84 / 116	74 / 96	66 / 80	59 / 67	53 / 57	48 / 49
ASD	24	Triple	162 / 177	138 / 139	120 / 112	105 / 91	92 / 75	82 / 62	73 / 52	66 / 45	59 / 38
ASD	22	Single	168 / 122	143 / 96	123 / 77	108 / 62	94 / 51	84 / 43	75 / 36	67 / 31	60 / 26
ASD	22	Double	173 / 293	148 / 230	128 / 184	111 / 150	98 / 123	87 / 103	78 / 87	70 / 74	63 / 63
ASD	22	Triple	215 / 229	184 / 180	159 / 144	139 / 117	122 / 97	108 / 81	97 / 68	87 / 58	78 / 49
ASD	20	Single	217 / 154	185 / 121	159 / 97	139 / 79	122 / 65	108 / 54	96 / 46	86 / 39	78 / 33
ASD	20	Double	224 / 370	191 / 291	165 / 233	144 / 189	126 / 156	112 / 130	100 / 110	90 / 93	81 / 80
ASD	20	Triple	279 / 289	238 / 228	205 / 182	179 / 148	158 / 122	140 / 102	125 / 86	112 / 73	101 / 63
ASD	18	Single	312 / 212	266 / 167	229 / 133	200 / 109	176 / 89	155 / 75	139 / 63	124 / 53	112 / 46
ASD	18	Double	320 / 510	273 / 401	236 / 321	206 / 261	181 / 215	160 / 179	143 / 151	128 / 129	116 / 110
ASD	18	Triple	399 / 399	340 / 314	294 / 252	256 / 204	226 / 168	200 / 140	179 / 118	160 / 101	145 / 86
LRFD	24	Single	177 / 94	164 / 74	149 / 59	130 / 48	114 / 40	101 / 33	90 / 28	81 / 24	73 / 20
LRFD	24	Double	154 / 226	142 / 178	132 / 143	123 / 116	116 / 96	104 / 80	93 / 67	83 / 57	75 / 49
LRFD	24	Triple	175 / 177	162 / 139	150 / 112	140 / 91	131 / 75	124 / 62	115 / 52	103 / 45	94 / 38
LRFD	22	Single	245 / 122	226 / 96	195 / 77	170 / 62	150 / 51	133 / 43	118 / 36	106 / 31	96 / 26
LRFD	22	Double	266 / 293	233 / 230	201 / 184	176 / 150	155 / 123	137 / 103	122 / 87	110 / 74	99 / 63
LRFD	22	Triple	302 / 229	279 / 180	250 / 144	218 / 117	192 / 97	171 / 81	152 / 68	137 / 58	124 / 49
LRFD	20	Single	335 / 154	292 / 121	252 / 97	220 / 79	193 / 65	171 / 54	152 / 46	137 / 39	124 / 33
LRFD	20	Double	353 / 370	301 / 291	260 / 233	227 / 189	200 / 156	177 / 130	158 / 110	142 / 93	128 / 80
LRFD	20	Triple	418 / 289	375 / 228	324 / 182	283 / 148	249 / 122	221 / 102	197 / 86	177 / 73	160 / 63
LRFD	18	Single	494 / 212	421 / 167	363 / 133	316 / 109	278 / 89	246 / 75	220 / 63	197 / 53	178 / 46
LRFD	18	Double	505 / 510	431 / 401	372 / 321	325 / 261	286 / 215	253 / 179	226 / 151	203 / 129	183 / 110
LRFD	18	Triple	627 / 399	536 / 314	463 / 252	404 / 204	356 / 168	316 / 140	282 / 118	253 / 101	229 / 86

NOTES:

Vented deck with 1.5% open area is available for use with insulating fills. Insulating fill manufacturers have determined load capacities of various combinations of fill and deck both with and without foamed plastic insulation boards. Refer to the fill manufacturer's literature for loading limitations.

R_1 is the bearing capacity at an **exterior** condition. R_2 is the bearing capacity at an **interior** condition.

UF2X AND UF2XV

55

STEEL JOIST FIRE PROTECTION

RESTRAINED ASSEMBLY RATINGS (HOURLY)	U.L. DESIGN NO.	CONCRETE COVER AND TYPE	USD FORM PRODUCT
1	G039	2"NW	UFS (26 ga. min.)
1	G208	2½"NW	UFS
1	G211	2½"NW	UFS (24 ga. min.)
1	G255	2½"NW	UFS
1	G256	2½"NW	UFS (24 ga. min)
1	G262	2½"NW	UFS
1	G501	2"NW	UFS
1	G531	2½"LW	UF1X
1	G534	1½"LW (MIN.)	UFS
1	G701	2½"NW, LW	UFS
1	G703	3⅛"NW, 2⅜"LW	UFS
1	G705	2½"NW, LW	UFS
1	G706	3¾", 4½"NW; 3", 4½"LW	UFS, B
1	G707	3⅛"NW, 2⅜"LW	UFX
1	G708	2½"NW, LW	UFS
1	G801	2¾"NW, LW	UFS
1	G802	3¾", 4½"NW; 3", 4½"LW	UFS, B
1	G803	3¾", 4½"NW; 3", 4½"LW	UFS, B
1	G804	2½"NW, LW	UFS
1	G805	3⅛"NW, 2⅜"LW	UFX
1½	G204	2½"NW	UFS
1½	G211	2½"NW	UFS
1½	G213	2½"NW	UFS, B
1½	G228	2½"NW	UFS
1½	G229	3¼"NW	UFS
1½	G231	2½"NW	UFS
1½	G236	2½"NW	UFS
1½	G243	2½"NW	UFS
1½	G244	3"NW	UFS
1½	G256	2½"NW	UFS
1½	G262	2½"NW	UFS (24 ga. min.)
1½	G264	2½"NW	UFS (24 ga. min.)
1½	G502	2"NW	UFS
1½	G508	2"NW	UFS
1½	G509	2"NW	UFS
1½	G530	2"NW	UF1X (24 ga. min.)
1½	G531	2½"NW	UFS, UFX
1½	G701	2½"NW, LW	UFS
1½	G703	3⅛"NW, 2⅛"LW	UFX, B
1½	G705	2½"NW, LW	UFS
1½	G706	4½"NW, 3½"LW	UFS, B
1½	G707	3⅜"NW, LW	UFX
1½	G708	2½"NW, LW	UFS
1½	G801	2½"NW, LW	UFS
1½	G802	4½"NW, LW	UFS, B
1½	G803	4½"NW, LW	UFS, B
1½	G804	2½"NW, LW	UFS
1½	G805	3⅛"NW, LW	UFX
2	G023	2¼"NW	UFS
2	G028	2½"NW	UFS
2	G031	2½"NW	UFS, UF1X, UFX
2	G036	2½"NW	UFS
2	G037	2¼"NW	UFS
2	G038	3"NW	UFS
2	G204	2½"NW	UFS
2	G208	2½"NW	UFS
2	G209	3"NW	UFS
2	G211	2½"NW	UFS
2	G212	3"NW	UFS
2	G213	2½"NW	UFS, B
2	G227	2½"NW	UFS
2	G228	2½"NW	UFS
2	G229	2½"NW	UFS
2	G231	2½"NW	UFS
2	G236	2½"NW	UFS
2	G243	2½"NW	UFS
2	G244	3"NW	UFS
2	G250	2½"NW	UFS
2	G255	2½"NW	UFS
2	G256	2½"NW	UFS
2	G258	2½"NW	UFS
2 cont'd	G503	2½"NW	UFS
2 cont'd	G504	2½"NW	UFS
2 cont'd	G505	2"NW	UFS
2 cont'd	G510	2½"NW	UFS
2 cont'd	G514	2½"NW	UFS
2 cont'd	G515	2¾"NW	UFS
2 cont'd	G521	2½"NW	UFS
2 cont'd	G523	2½"NW	UFS
2 cont'd	G529	2½"NW, LW	UFS
2 cont'd	G530	2½"NW, LW	UF1X, (24ga. min.)
2 cont'd	G531	3¼"NW, 2¾"LW	UFS, UFX
2 cont'd	G533	3" LW	UFS
2 cont'd	G538	2½"NW	UFS
2 cont'd	G701	2½"NW, LW	UFS
2 cont'd	G703	4⅝"NW, 3⅞"LW	UFX, B
2 cont'd	G705	2½"NW, LW	UFS
2 cont'd	G706	5¼"NW, 4½"LW	UFS, B
2 cont'd	G707	4⅝"NW, 3⅞"LW	UFX
2 cont'd	G708	2½"NW, LW	UFS
2 cont'd	G801	2¾"NW, LW	UFS
2 cont'd	G802	5¼"NW, 4½"LW	UFS, B
2 cont'd	G803	5¼"NW, 4½"LW	UFS, B
2 cont'd	G804	2½"NW, LW	UFS
2 cont'd	G805	4⅝"NW, 3⅞"LW	UFS
3	G033	3½"NW	UFS
3	G036	3¼"NW	UFS
3	G211	3"NW	UFS
3	G213	3½"NW	UFS, B
3	G229	3¼"NW	UFS
3	G256	3½"NW	UFS
3	G512	2½"NW	UFS
3	G523	3"NW	UFS
3	G529	2¾"NW, LW	UFS
3	G701	2¾"NW, LW	UFS
3	G703	2⅝", 3⅞"NW, LW	UFX, B
3	G705	2¾"NW, LW	UFS
3	G707	2⅝", 3⅞"NW, LW	B
3	G708	2¾"NW, LW	UFS
3	G801	2¾"NW, LW	UFS
3	G805	2⅝", 3⅞"NW,LW	B
4	G401	2½"NW	UFS

The table shows constructions that are normally used for floors. For roofs see U.L. Numbers Pxxx and page 14 of this manual. In general, heavier and deeper form members may be used without compromising the fire rating; however, concrete cover must remain and any beam and joist spacing restrictions still apply. In all cases the U.L. Fire Resistance Directory should be consulted for concrete densities, fastening requirements, and all details of construction. Some ratings have the concrete cover vary with the span - particulary the 700 numbers. This table was prepared using the 1996 U.L. Fire Resistance Directory.

FIRE PROTECTION CODE	
U.L. #	
000-099	Concealed Grid
200-299	Exposed Grid
400-499	Suspended Plaster
500-599	Suspended Gypsum Board
700-799	Cementitious Sprayed
800-899	Sprayed Fibrous

FORM DECK SLAB FIRE RATINGS

61