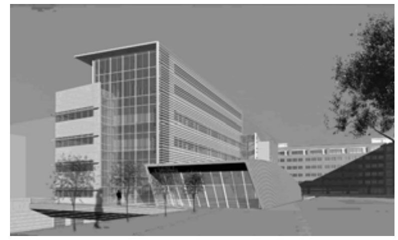
Timothy Mueller
Structural Option
Walter Schneider



FDA CDRH Laboratory

Silver, Spring Maryland

Executive Summary:

For this technical report I looked at 5 alternatives to the current structural system of the typical bays and then compared the pros and cons of each of the alternative systems to the original system. The current system is a concrete one-way system which spans in the east-west direction for each of the 3 bays that make up this cross-section of the building. The 5 alternatives that I reviewed were: composite steel girders, beams and decking; non-composite steel girders, beams, and concrete slab; steel girders, joists, and concrete slab; two-way concrete slab with drop panels, and a one-way concrete system. Through my analysis I found that all of these alternatives could be viable solutions for my building's structural system. Each alternative resulted in a lighter system, that normally had a smaller structural floor depth than the current system as well. This system allowed for no additional weight on the foundation system, and due to the upward stability of the ground the foundation, could actually be made smaller. I found that a main concern that developed due to the lighter systems was an increased susceptibility to vibration. However, when looking at the girder design of the one-way slab systems, it was noticed that this susceptibility may not be as great as originally thought. Due to a very low deflection, which in turn results in a high stiffness, the vibrations are decreased. This assumption may not be the case for all the structural systems, especially the steel framed systems. This assumption does, however, give an even more persuasive option with the alternatives looked at compared to the current system, due to very little drawbacks and possible money savings because of less time or material spent. The time savings is from the quick erection process of steel as compared to that of concrete for the steel structures, and the decrease in the amount of material (based on weight) of the concrete structures.

After comparing all of the alternatives to the current system, I found that although all the systems made for viable alternatives, at this time, the concrete alternatives were better suited for this structure. This is mainly due to the high amount of labor available for concrete work in the DC area as compared to the less common steel contractor. Also, no additional fireproofing is needed as compared to the spay on fireproofing that is needed for the steel components. Additional lateral support is also not needed in these concrete systems, due to the stout profile as the CDRH laboratory, the monolithic construction causing all joints to be fixed is all the lateral support that is needed, as compared to the necessity to have bracing or moment connections in the steel frames. Of the concrete systems, one system seemed to stand out. The one-way system, which had its supporting members turned perpendicular to the current system (spanning the shorter direction) in the controlling bay seemed to be the best alternative of them all. This system allowed for a great reduction in weight as well as depth, as compared to the current system, however, due to the low deflection, should have good stability against vibration. The only downfall of this system is that it does cause a change in the direction of the final bay as compared to the other two bays found in this system. This can be resolved by making the other bays span the long direction, which would result in a larger system, however, also allow for continuity of the building. Another resolution would be to leave the system with two different span directions, which may cause for a lack of continuity of the structural system, but a more economic building overall.

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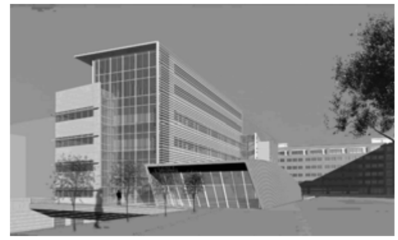

FDA CDRH Laboratory
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The FDA CDRH Laboratory is currently being built on the FDA consolidation campus in Silver Spring, Maryland. It is made up of a main four story laboratory topped with a 5th floor penthouse suite. There is also a one story high-bay laboratory space found on the west side of the main laboratory and office space. The building, with only the exception of the penthouse and high-bay laboratory, is made of cast-in-place concrete.

Loading:

Loading for the bays to be studied in this report will be found using the typical laboratory sections of the building.

Dead load values derived from ASCE 7-02, Section 3
Concrete: 150pcf
Superimposed: 25psf (assumed)

Ceiling:	Acoustical Fiber board	1psf
Floor:	VCT	1psf
Mechanical/Electrical:		10psf
Partitions:		13psf
Total:		25psf

All live load values come from ASCE 7-20, Section 4
Light Manufacturing (Most Laboratory Spaces): 125psf
Light Storage (Supplementary Laboratory Spaces): 125psf

Live loads are reducible (See Appendices D and E)

The Current System:

The typical floor system throughout the building is made of 4.5" thick one way slabs, spanning in the north to south direction. There are two typical joist layouts, both of which are pan-joist systems due to the monolithic pour of the slab and joist. The first typical plan is made of 10" wide by 16" deep joists, spaced 5'-3" on center. These joists span either 18' or 15'–5" and are designed with the same requirements as beams due to their large size and spacing. They are reinforced with #3 top reinforcement, #6 bottom reinforcement. The shear forces are resisted with #3 rebar. The second typical bay is also a pan-joist system with the joist dimension of 16"X16". They are spaced 3' on center and span a distance of 30'-9". They too must be designed like a beam due to their large size and spacing. The top and shear reinforcement is #3 rebar, with the bottom #8 reinforcement. These bays feed into a system of beams also poured monolithically.

The typical beam is 19.7" wide by 20.5" deep and spans 21'. The reinforcement at the midspan is comprised of 3 - #9 rebar with endspan reinforcement of 6 - #9 rebar. The shear forces are resisted with #3 rebar at 6" and then R rebar at 9". All concrete used in the pan-joist system, as well as the beams have a strength of 4000psi. The beams then feed into the typical 24"X18" columns, which are made of 5000psi concrete and 6-#8 rebar. This is a fixed connection causing for resistance against moments, which make up the entire lateral resistive system. The total weight of the current system is quite large, at 163.83K per controlling (30'-9" span) bay, with a total depth of 20.5".

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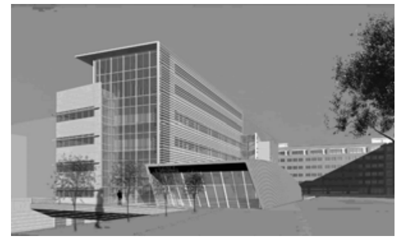

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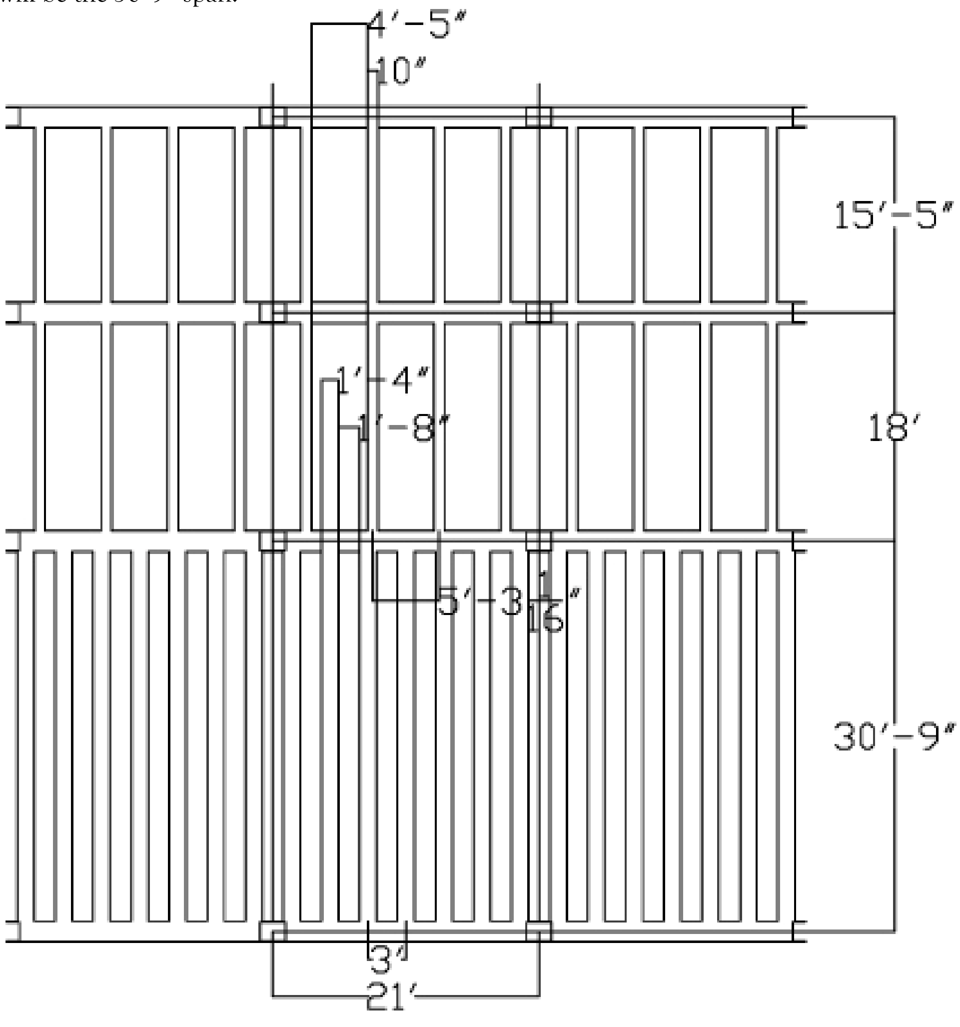
The following image is a representation of a building section of the 3 repeated panels found in the CDRH laboratory. For all calculations found in the appendix, the entire 3 panel system was looked at to account for load carry-over. However, for the purpose of this report only the controlling span will be discussed in depth. This span in most circumstances will be the 30'-9" span.



In the greater Washington D.C. metro area one will find a great deal of concrete construction. This is due to the height restriction found in the District itself, and the ability to increase the number of floors because of thinner structural sandwich than typical steel construction. Although, the Silver Spring area is not under this same height restriction, the location does play a part in the local skilled labor and customary design in the area, utilizing the high demand of concrete. The high density of concrete is also very advantageous to control vibration, which is a major concern in a laboratory situation. There is also no need for fireproofing. However, the very large joist system used does cause for large loads on the supporting members and foundation.

For Additional information and supporting calculations see appendix F

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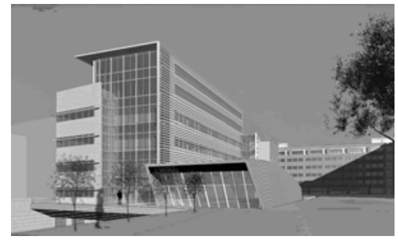

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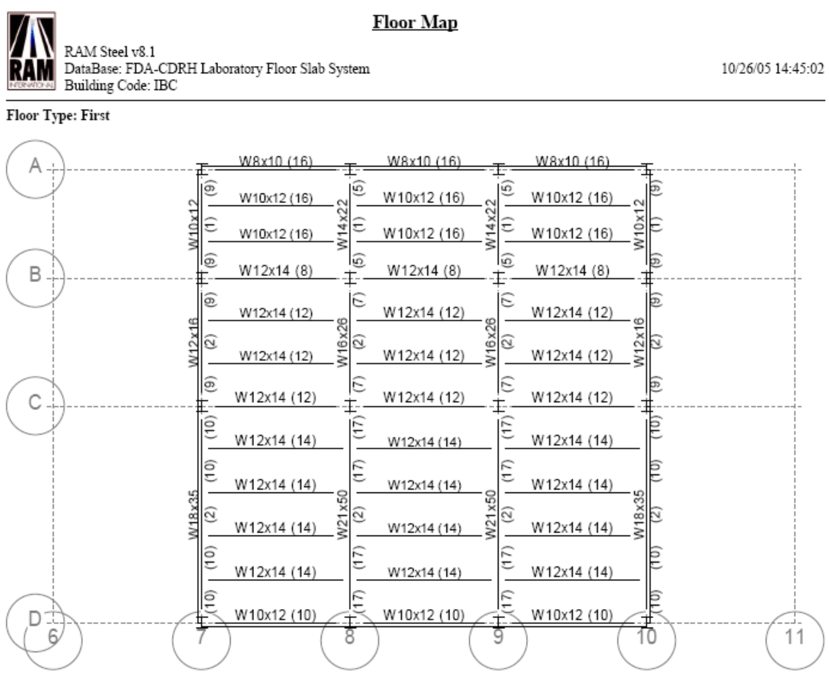
Alternative Systems:

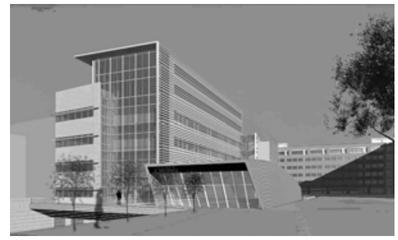
I chose to look at two types of building materials for the alternative systems: concrete and steel. The concrete was used as an exact material comparison in different layouts and spacing. Steel was compared based on a change in constructability, weight, and structural system depth.

Alternative System 1: Composite Steel Beams with Composite Decking

A steel composite system with composite decking was the first system that I analyzed. For the decking I used the 2001 United Steel Decking manual to find that for the loading condition I have chosen, I would need a 4.5" slab over a 2" lok-floor decking system made of 22 gage steel. To allow for composite action between the steel decking and the concrete slab, I will use 3/4" studs. There is no need for welded wire fabric in this system do to the extremely large loading capability. I then entered the required weights and design criteria into RAM Structural System, 2003. RAM calculated the needed steel beam sizes, as well as the number of shear studs needed. The end result is shown below:



The final result of using this system is an overall floor depth of 25.1" at a weight of only 30.234K. This system is lighter in weight than the concrete system that is currently in place, due to the use of steel members and a thin slab. Because of this, there is no concern of not having an adequate foundation to support the new structure. However, there is a concern about the susceptibility to vibration, which is an important consideration for a structure with such valuable and precise instruments in the laboratory spaces. This system, although having a similar total cost to the steel system, will need additional preconstruction planning to allow for delivery of appropriate materials as well as

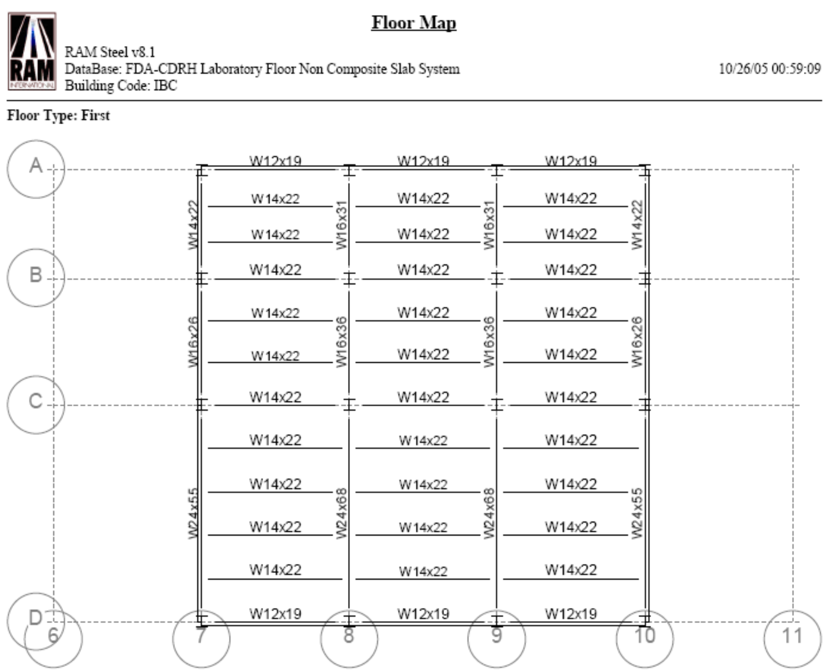


additional staging areas, however, it will not require the expensive formwork or lengthy curing time needed for concrete. There will also be a need for additional lateral bracing or moment connections to support the lateral loads that are currently being resisted by the monolithic concrete construction. This system does cause for a local dilemma due to the extraordinary amount of concrete work found in the area. Steel construction as well as steel contractors and construction companies are not nearly as prevalent as concrete contractors and construction. In addition, this structure will need to have spay-on fireproofing, while the current system does not need any additional fireproofing due to its thick slabs and concrete construction. Although this systems does have some drawbacks, the loss of space and weight are very important. Therefore, it is an okay alternative and can be further explored in the future to find how extensive the drawbacks such as vibration truly are.

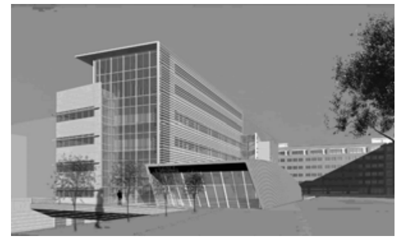
For Additional information and supporting calculations see appendix A

Alternative System 2: Non-Composite Steel Beams with Form Deck

A steel non-composite system with form deck was the second system that I analyzed. For the decking I used the 2001 United Steel Decking manual to find that for the loading condition that I have chosen, I would need a 5" slab over a UF2X form deck made of 22 gage steel. This system will use 44-W2.9XW2.9 welded wire fabric. I then entered the required weights and design criteria into RAM Structural System, 2003. The systems was able to calculate the needed steel beam sizes needed. This is the end result:



The non-composite design produced larger members with a total structural sandwich depth of 28.7" and a total weight of 35.565K per 30'-9" bay. This result is due to the lack of "shared" strength between composite members.

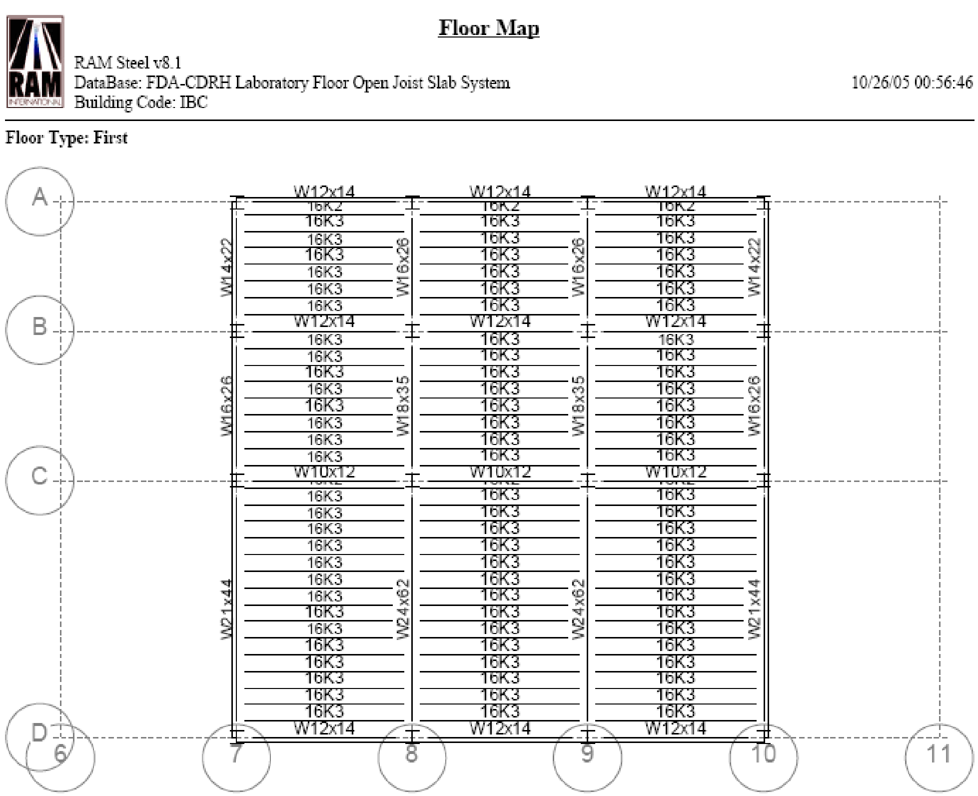


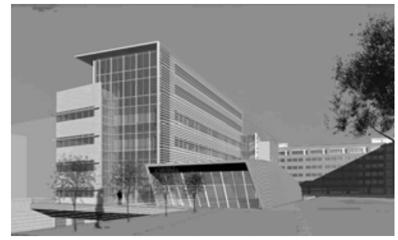
Other than the slightly larger size and weight then the first alternative system, most of the similarities and differences between the current and alternative 2 are the same as those in alternative 1. The only advantage this system may have over the composite system, is that the additional mass may help to reduce vibration, however, due to the non-composite construction, this may not be a significant benefit. Again, this system is an okay alternative, having both drawbacks and advantages, and can continue to be analyzed in the future to see if the benefits truly outweigh those found in the current system.

For Additional information and supporting calculations see appendix B

Alternative System 3: Steel Joist System

A steel joist spaced at 2' on center was the third system that I analyzed. For the decking I used the 2001 United Steel Decking manual to find that for the loading condition that I have chosen, I would need a 2.5" slab over a UFS form deck made of 28 gage steel. This system will use 66-W1.4XW1.4 welded wire fabric. I also used the New Columbia Joist Company Steel Joist and Joist Girder manual, 2002 to find that a 16K3 joist would be adequate to support the loading conditions. I then entered the required weights and design criteria into RAM Structural System, 2003. The systems was able to calculate the needed steel beam as well as confirming they joist type chosen. This is the end result:



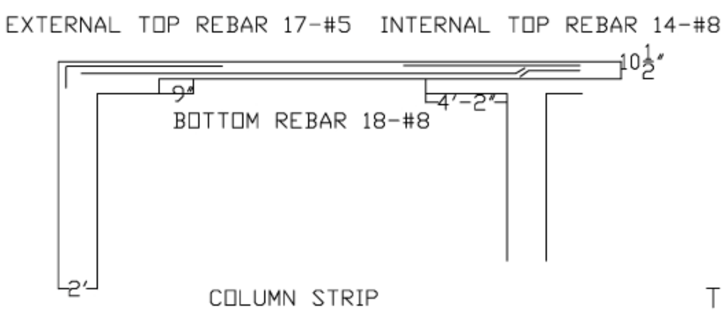


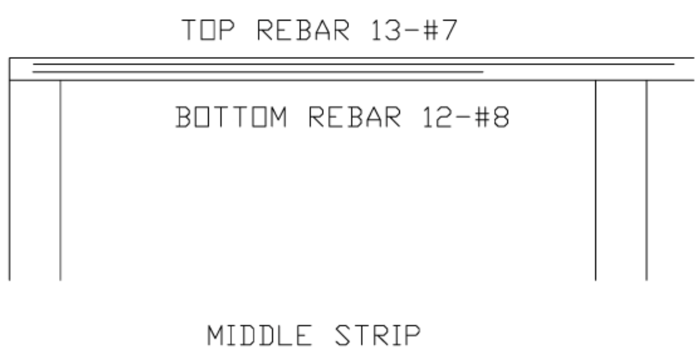
The joist design produced an intermediate design depth of 26.2", however, due to the use of many smaller members with a much smaller floor slab, the total weight went down a great deal, totaling only 21.7959K per controlling bay. The additional members cause for a large addition to construction time because of the increased number of connections, as compared to alternatives 1 and 2. Also, because of the much lighter weight, vibration becomes a greatly increased concern. There is also a need for a greater amount of fireproofing on the deck due to the less then 3" slab. Other than the greatly reduced weight and large number of small members, most of the similarities and differences between the current and alternative 3 are the same as those in alternatives 1 and 2. Although there is no great advantage, due to the problems that are associated with the greatly reduced weight, this system can still be considered an okay alternative, due to the fact that the drawbacks can be further analyzed to find how great of a concern they truly are.

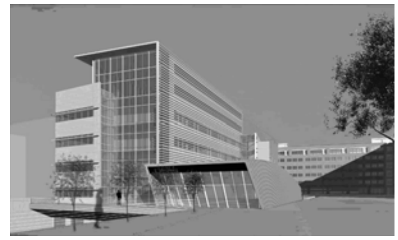
For Additional information and supporting calculations see appendix C

Alternative System 4: Two-Way Slab System

The fourth system that I looked at used the same material as the original system, concrete. Instead of the current one-way joist system, I used a two-way system with drop panels around the columns. To find the required sizes and reinforcement, I used the 2002 CRSI Design Manual. I assumed the concrete to have a strength of 4ksi with 60ksi steel reinforcement. I found that the controlling span of 30'-9", would need square drop panels with a 10.33' width and a 9" depth. The columns to support this slab would need to be 24" square. The column strip would need 17#5 top external reinforcement, 18#8 bottom reinforcement, and 14#8 top internal reinforcement. The middle strips would need bottom reinforcement of 12#8 and top internal reinforcement of 13#7. The following are diagrams of the size of the drop panels as well as the size and placement of the required reinforcement for both the column and middle strip.





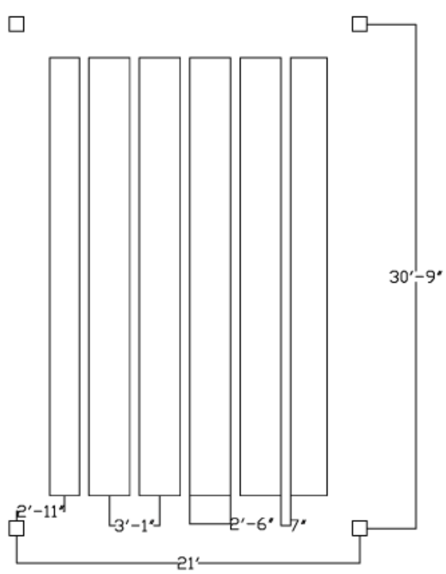


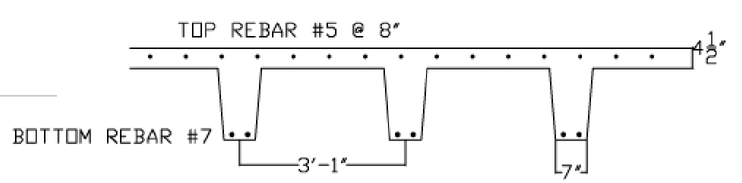
With a total depth of 19.5" and a total weight of 96.75K per controlling bay, this systems give a large reduction to the weight while keeping a similar structural sandwich depth. Due to the lighter weight, the impact on the foundation of this system was not a concern. Cost was not a concern either, due to the similar construction method found in the current system. This system may have a slight advantage over the current system, in the fact that there is a less complicated formwork required for each bay. As with the current system, no additional fireproofing is needed, and the erection time will be about the same, with a slight possibility of time savings with the actual laying out of the formwork. There is also possible financial savings due to the reduced amount of concrete used. The monolithic construction does not require a changed lateral support system because of the fixed ends on all members. Also, by using the local "norm" of concrete, there is a large skilled workforce to choose from. The only possible disadvantage to this system is that because of the lighter weight and lack of central bay spanning members, there could be an increase in vibration susceptibility. Due to few disadvantages, this system is a viable alternative. Further study of the vibrations will reveal if this system is truly provides a great advantage over the current system.

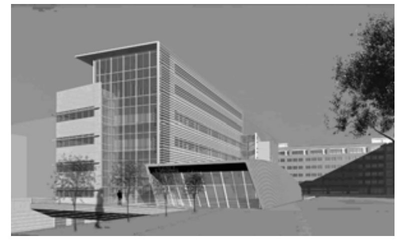
For Additional information and supporting calculations see appendix D

Alternative System 5a: One-Way Slab System in the 30'-9" Direction

The fifth system I analyzed was a redesign of the current system. I changed the sizes and spacing of the current system by using the 2002 CRSI Design Manual. I assumed the concrete to have a strength of 4ksi with 60ksi steel reinforcement. By looking up the current loading conditions in the CRSI, I was able to find that a system made up of 30" forms with 7" wide ribs and a 16" depth. A 4.5" slab is needed, which would bring the total depth to 20.5". The reinforcement would include, #5 bars spaced 8" apart on the top and 2#7 bars in the bottom of each rib. There would also be 4X12-W3.5XW2 welded wire mesh to guard against temperature and shrinkage. After the necessary slab and joist system was found, a girder needed to be designed to carry the load to the columns. I found that a girder that had the same depth equal to the total depth of 20.5" would need to have a width of 48.5". The girders would also require 6#14 reinforcing bars. These girders were also checked for deflection and were found to have practically no deflection under the required loading. Below are two diagrams of the proposed system. One is a floor plan that shows the layout of the beam spanning the 30'-9" direction with the large girders surrounding the main area, while the other diagram is a representation of the placement of the rebar in the joists and slab.





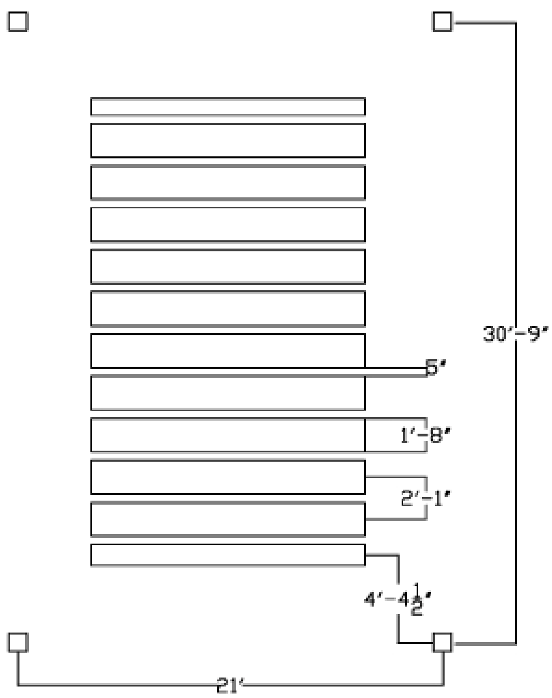


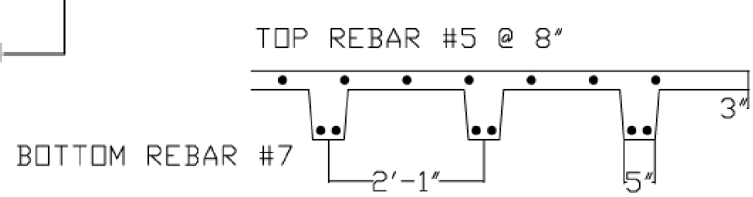
Having a total depth of 20.5" and a total weight of 116.72K, I found that the one-way span using new spacing would have the same depth as the current system, however, there is a weight reduction of almost 50K. This does not cause impact on the foundation and only reduces cost because of the reduced amount of concrete needed. However, as with all the other alternatives, the reduced weight may cause and increase in vibration susceptibility. Despite this fact, because of the very low decrease in weight, this will not be as great of an increase in susceptibility, and because of the extremely low deflection under normal loading, one can assume that there will be very little susceptibility to vibration. Because of the extreme similarity to construction as the current system, there are also many similarities in to the current system, from the time it takes to erect, the work force number and availability, the lateral loading resistance from the fixed monolithic connections, and the fact that there is no need for fireproofing. Due to the cost savings from using less concrete, while still having low increase in susceptibility to vibration, this system seems to be a very good alternative, and can be looked at in more detail to see if the assumptions about the vibration are correct.

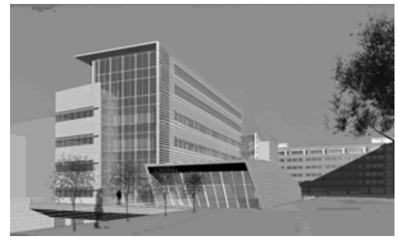
For Additional information and supporting calculations see appendix E

Alternative System 5b: One-Way Slab System in the 21' Direction

The last alternative that I reviewed was the same one-way system that was used in the previous alternative, however, in this alternative, instead of just changing the spacing of the current system, I also changed the spanning direction. Because the non-controlling bays had their smaller span in the east-west direction, the controlling span also had an east-west spanning direction, which, although caused for an increased spanning condition, also gave continuity to the total building span direction. I, however, wanted to see what savings and advantages could come from spanning this bay in the non-controlling span (the 21' direction). I found using the CRSI, 2002, that if you use a one-way span in the 21' direction, using the predetermined loading, you will require, 20" forms with 5" rid width and 8' rib depth. There would also be a slab depth of 3" making a total depth of 11". The reinforcement requirements are #5 bars at 10" for the top in the slab and 2#5 bars in the bottom of each rib. 4X12-W2.1XW1.4 welded wire fabric is also used for reinforcement the slab. I then designed the girder system for this bay, using the depth of the ribs and slab my girders are 11" deep by 92.2" wide. The entire structural system per bay weighs 91.64K. The girders are reinforced with 6#9 reinforcing bars. Below are diagrams of the plan of the slab system with its very wide girders as well as an elevation showing the joist sizes and the placement of the rebar.







Having a total depth of only 11" and a total weight of 91.645K, I found that the one-way span using the new spacing and direction on the critical bay allows for an extreme reduction in both weight and depth of the structural system. The huge reduction in concrete also allows for financial savings. This, as with all the other systems, does not cause impact on the foundation. As with the one-way alternative, spanning the 30'-9" direction, the girders were found to work extremely well in deflection and, although this system is much lighter then the current system, it should not have much increase in vibration susceptibility. Just as with the other one-way alternative, because of the extreme similarity to the current construction, there are also many similarities in to the current system, from the time it takes to erect, the work force number and availability, the lateral loading resistance from the fixed monolithic connections, and the fact that there is no need for fireproofing. Due to the cost savings from using less concrete as well as the decrease in slab depth, while still having low increase in susceptibility to vibration, this system seems to be the best alternative, however, further analysis will have to be done to give solidity to this conclusion..

For Additional information and supporting calculations see appendix E

The next two pages have a summary of the previously discussed pros and cons to the alternative systems as compared to the current system in tabular form.

	WEIGHT	IMPACT ON FOUNDATION	DEPTH	LATERAL SUPPORT	COST	SUSCEPTABILTY TO VIBRATION
CURRENT SYSTEM	163.83k	no change	20.5"	no change (no additional support needed due to monolithic pour)	no change (expensive formwork)	no change (not very susceptable)
ALTERNATIVE 1: COMPOSITE CONSTUCTION	30.234K	much lighter	25.3"	needs cross bracing or moment connections	shear studs large steel members decking	lighter frame (more susceptable)
ALTERNATIVE 2: NON-COMPOSITE CONSTUCTION	35.565K	much lighter	28.7"	needs cross bracing or moment connections	large steel members decking	lighter frame (more susceptable)
ALTERNATIVE 3: STEEL JOIST	21.7959K	much lighter	26.2"	needs cross bracing or moment connections	many small steel members decking	lighter frame (more susceptable)
ALTERNATIVE 4: TWO-WAY SLAB SYSTEM	96.75k	lighter	19.5"	no need for additional moment resistance due to monolithic pour	lower cost due to less concrete expensive formwork	lighter mass (more susceptable)
ALTERNATIVE 5a: ONE-WAY SLAB SYSTEM IN 30'-9" DIRECTION	116.72K	lighter	20.5"	no need for additional moment resistance due to monolithic pour	lower cost due to less concrete expensive formwork	lighter mass (more susceptable)
ALTERNATIVE 5b: ONE-WAY SLAB SYSTEM IN 21' DIRECTION	91.645K	lighter	11"	no need for additional moment resistance due to monolithic pour	lower cost due to less concrete expensive formwork	lighter mass (more susceptable)

	FIRE PROOFING	CONSTUCTION ISSUES	ERECTION TIME	LOCAL ABILITY	CONCLUSION
CURRENT SYSTEM	no change (not nessessary)	no change (forming takes great deal of time)	no change (low amount of planning great deal on site)	no change (area very involved in concrete construction)	**NO CHANGE**
ALTERNATIVE 1: COMPOSITE CONSTUCTION	spray on beams and decking	labor for framework and studs	more preliminary order time less on site time	availble but not as prevelent	**Okay Alternavtive** more vibration and fireproofing
ALTERNATIVE 2: NON-COMPOSITE CONSTUCTION	spray on beams and decking	labor for framework	more preliminary order time less on site time	availble but not as prevelent	**Okay Alternavtive** more vibration and fireproofing
ALTERNATIVE 3: STEEL OPEN WEB JOIST	spray on beams and decking	labor for framework (many connections)	more preliminary order time less on site time	availble but not as prevelent	**Okay Alternavtive** more vibration and fireproofing
ALTERNATIVE 4: TWO-WAY SLAB SYSTEM	not nessessary	similar to current (forming takes great deal of time)	similar to current (low amount of planning great deal on site)	similar to current (area very involved in concrete construction)	**Good Alternative** more vibration less material
ALTERNATIVE 5a: ONE-WAY SLAB SYSTEM IN 30'-9" DIRECTION	not nessessary	similar to current (forming takes great deal of time)	similar to current (low amount of planning great deal on site)	similar to current (area very involved in concrete construction)	**Good Alternative** more vibration less material
ALTERNATIVE 5b: ONE-WAY SLAB SYSTEM IN 21' DIRECTION	not nessessary	similar to current with change in direction of spans	similar to current (low amount of planning great deal on site)	similar to current (area very involved in concrete construction)	**Good Alternative** more vibration less material

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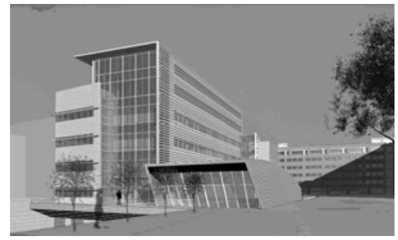

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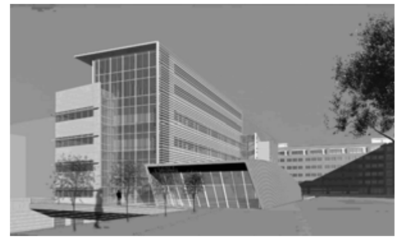
Silver, Spring Maryland

Conclusion:

By looking at alternatives to the current bay systems, I found that a concern with the new systems was the vibration. All of my alternatives reduced the weight by a great deal and most reduced the total depth of the structural system. This reduction of weight in all the systems also caused for no problems with the foundations systems support. The steel systems also allow for faster erection time on the project site, saving money ,however, depending on the additional lateral resistance system used, it may have additional time needed for the connections. The steel systems, because of their extreme light weight, need for fireproofing and lateral resistance, and lack of local availability of a skilled work force makes for a useable alternative, however, not likely to be as viable of a solution as the concrete alternatives. The concrete alternatives allowed for a the same constructability situations as the current system, however, they too allowed for a much lighter system and at times a much smaller structural depth. The ability to construct with a locally popular construction method and with less material you have the ability to save money. The fact that the concrete systems in general weigh more than steel structures the fact that additional mass will reduce the vibrations is very useful in a situation in which vibrations must be kept to a minimum, because of the precise scientific use of this laboratory. Another positive about the use of concrete when concerning vibrations is the very low level of deflection found in the systems in which girders were used (the one-way systems), the extreme stiffness, allowing for little deflections also allows for very little vibration. Concrete construction on such a stout building takes away the need for additional lateral support because of the monolithic pour causing all connections to be fixed. This system also allow takes away the need for fireproofing. The best alternative at this point seems to be the one-way system that is very similar to the original design, however, by changing the spanning direction, one saves a great deal of space and weight, which also allows for a great financial savings. This coupled with the low additional susceptibility to vibration, and the positives mentioned earlier about concrete construction allows for anticipation of a viable and possibly superior alternative to the current structural system.



Appendix A
Alternative 1

Composite Steel System

The first alternative bay system I chose to use was a steel composite system. I chose to evaluate this system by using RAM Structural System, 2003. I laid out the columns in the same configuration as were used by the current system to keep continuity between the new systems and the current architectural features and open spaces found in the building. I then placed intermediate beams between each of the girders which are found spanning the column lines. These beams were spaced so that there were 2 beams spaced equally in both the 15'-5" and the 18' span. There were 4 beams spaced equally in the 30'-9" span. Using the 30'-9" span, the largest span for the decking was found to be 6'-2". I then used the United Steel Deck manual from 2001 to find the appropriate total surface weight on my structure. The loading from the concrete and decking can be found on page 28 (Appendix A.4). The appropriate slab depth and steel decking can be found on page 29 of the USD manual (Appendix A.5). No live load reductions were used due to the fact that they could not be used on the smaller spans ($K_{LL}A_T$ is small then 400 sq ft).

At first I had to assume a weight of concrete and decking to see what depth of concrete would be needed to support my load. After comparing the decking strength to the depth of the concrete I found that a 4.5" concrete slab on 22 gage deck, could be used with a total slab and decking weight of 42psf.

Loading was found by using the following values:

Live load:		125psf
Dead Load:		
	Superimposed	25psf
	4.5" Slab	<u>42psf</u>
		67psf

Total Load: 1.2 Dead + 1.6 Live
Total Load: 1.2(67psf) + 1.6 (125psf) = 280.4psf

For loading of decking you are to use service live load which equals: 125psf

After all calculations were completed I found that the following values and products to be appropriate for my decking to span 6.5' (the minimum manual distance that is greater then the distance between beams) that could still support a loading of 125psf to be:

2" Lok-floor system
22 gauge steel
Slab depth of 4.5"

This will support a load of 365psf

Due to the fact that there is a great deal of additional support, to reduce cost welded wire fabric can be removed from the slab. The amount of load that the slab can support is then reduced to:

365psf - 365psf(.10) = 328.5psf

This value is still sufficient to carry a load of 125psf..

The total surface load is then taken to be (not including self weight of the beams and girders):
328.5psf.

RAM accounts for all factors on loading and deflection limitations

I used 3/4" studs with a 3.5" height to allow for a 1" cover in the 4.5" slab.

I then added an additional line load along the top and bottom of the RAM model to account for exterior wall loads of:160.33plf

This was using the assumptions of the average exterior of the building being represented by:

60% insulated aluminum sheet siding with gypsum wall board interior weighing 12psf
40% glass weighing 8psf

Total exterior wall load:

0.60(12psf) + 0.40(8psf) = 10.4psf
10.4psf (15'-5" tributary story height)=160.33plf

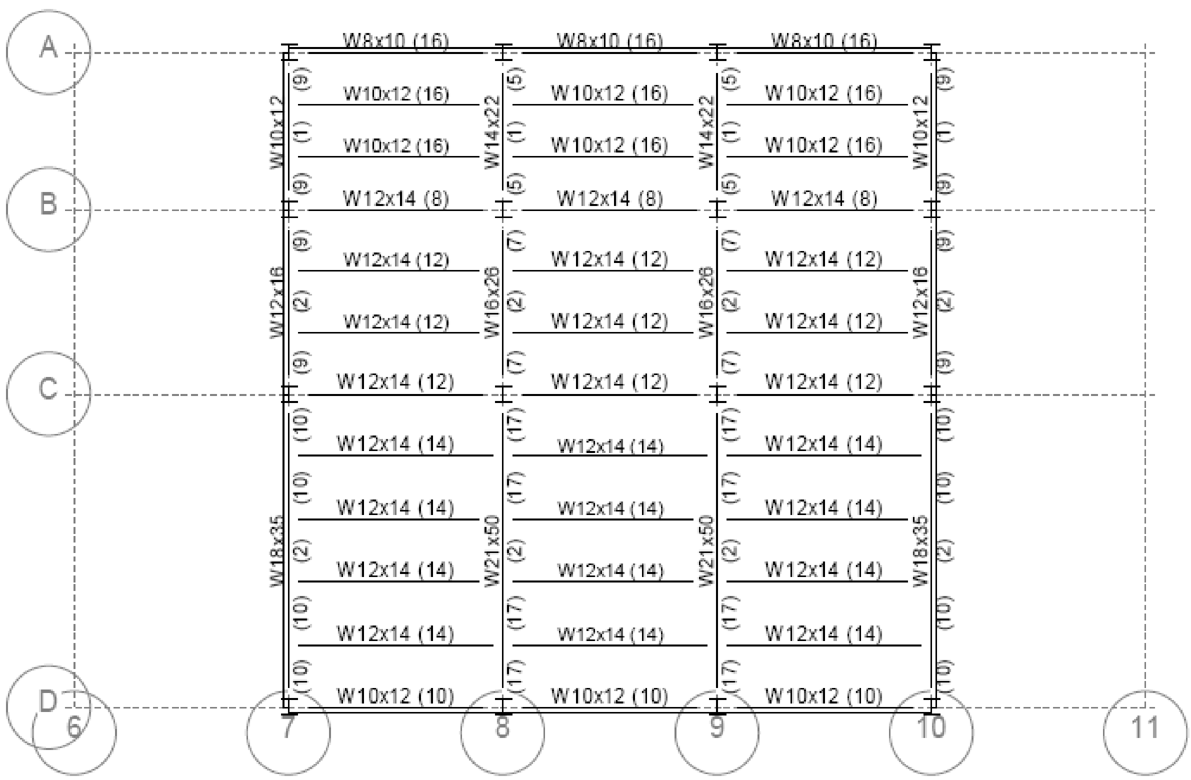
After applying a 6" overhang the following steel beam and girder types were found to be:

Floor Map

RAM Steel v8.1
DataBase: FDA-CDRH Laboratory Floor Slab System
Building Code: IBC

10/26/05 14:45:02

Floor Type: First



The largest beam being a 21X50 gave a total depth of:20.8"

This added to the slab depth of 4.5" gave a total floor depth for the structural components to be:
4.5"+20.8"=25.3"

Total depth for the 30'-9" bay: 25.3"

Total depth for the 18' bay:
Depth of a W16X26: 15.7"
Total depth = 15.7"+4.5"=20.2"

Total depth for the 15'-5" bay:
Depth of a W14X22: 13.7"
Total depth = 13.7"+4.5"=18.2"

Total Weight for the 30'9" bay:

Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((4.5)(14)+(1)(12))(21')+(1)(50)(30'-9") = 3112.5lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (42psf)(30'9")(21')=27121.5lbs
Total Weight=3112.5lbs+27121.5lbs=30234lbs=30.234k

Total Weight for the 18' bay:

Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((3)(14))(21')+(1)(26)(18) = 1350lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (42psf)(18')(21')=15876lbs
Total Weight=1350lbs+15876lbs=17229lbs=17.229k

Total Wight for the 15' bay:

Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((2)(12)+(0.5)(14)+(1)(10))(21')+(1)(31)(15'-5") = 1339lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (42psf)(15'5")(21')=13597.5lbs
Total Weight=1339lbs+13597.5lbs=14936.5lbs=14.9365k

The longest span does have the largest depth and load, therefore it is the critical beam and will be the beam used for comparison in the main report. However, one can also see that by splitting the span in 2 parts the depth of the structural sandwich can be reduced by over a half foot and the weight can be reduced by almost half.

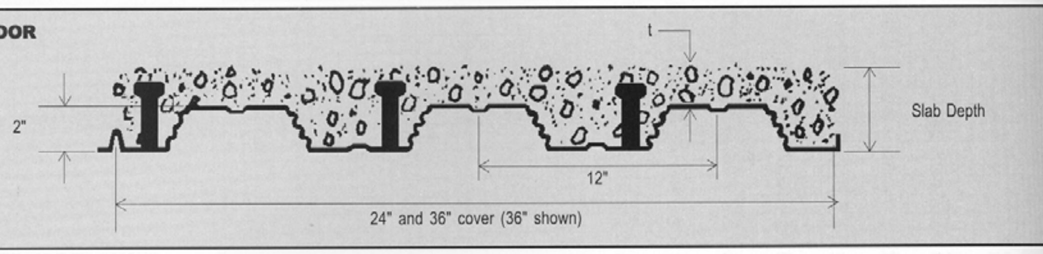
Table from United Steel Deck manual from 2002, Page 28
For a 6'-6" deck span

2 x 12" DECK F_y = 33ksi f'_c = 3 ksi   145 pcf concrete

United Steel Deck, Inc.

LRFD

2" LOK-FLOOR



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

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

DECK PROPERTIES

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

COMPOSITE PROPERTIES

	Slab Depth	ϕM_{nf} in.k	A_c in²	Vol. ft³/ft²	W psf	S_c in³	I_{av} in⁴	ϕM_{no} in.k	ϕV_{nt} lbs.	Max. unshored spans, ft. 1span	2span	3span	A_{wwf}
22 gage	4.50	40.27	32.6	0.292	42	1.05	5.9	29.40	5030	5.82	7.83	7.92	0.023
	5.00	46.44	37.5	0.333	48	1.23	8.0	34.53	5480	5.54	7.47	7.56	0.027
	5.25	49.53	40.0	0.354	51	1.32	9.2	37.16	5720	5.41	7.31	7.39	0.029
	5.50	52.61	42.6	0.375	54	1.42	10.5	39.81	5960	5.30	7.16	7.24	0.032
	6.00	58.78	48.0	0.417	60	1.61	13.5	45.21	6460	5.09	6.89	6.97	0.036
	6.25	61.87	50.8	0.438	63	1.71	15.3	47.95	6720	5.03	6.76	6.84	0.038
	6.50	64.95	53.6	0.458	66	1.81	17.1	50.70	6980	4.97	6.65	6.72	0.041
	7.00	71.12	59.5	0.500	73	2.01	21.2	56.26	7530	4.85	6.43	6.51	0.045
	7.25	74.21	61.9	0.521	76	2.11	23.5	59.07	7750	4.79	6.32	6.41	0.047
	7.50	77.29	64.3	0.542	79	2.21	26.0	61.88	7970	4.74	6.22	6.31	0.050
20 gage	4.50	48.60	32.6	0.292	42	1.26	6.3	35.43	5450	6.81	8.97	9.27	0.023
	5.00	56.18	37.5	0.333	48	1.48	8.6	41.65	5900	6.47	8.55	8.83	0.027
	5.25	59.96	40.0	0.354	51	1.60	9.8	44.84	6140	6.32	8.36	8.63	0.029
	5.50	63.75	42.6	0.375	54	1.71	11.3	48.07	6380	6.18	8.18	8.45	0.032
	6.00	71.32	48.0	0.417	60	1.95	14.5	54.63	6880	5.94	7.85	8.11	0.036
	6.25	75.11	50.8	0.438	63	2.07	16.3	57.96	7140	5.86	7.70	7.95	0.038
	6.50	78.90	53.6	0.458	66	2.19	18.2	61.31	7400	5.79	7.56	7.80	0.041
	7.00	86.47	59.5	0.500	73	2.43	22.6	68.09	7950	5.65	7.29	7.53	0.045
	7.25	90.26	61.9	0.521	76	2.55	25.0	71.50	8170	5.58	7.17	7.41	0.047
	7.50	94.05	64.3	0.542	79	2.67	27.6	74.93	8390	5.52	7.05	7.28	0.050
19 gage	4.50	55.85	32.6	0.292	42	1.45	6.7	40.69	5850	7.65	9.76	10.08	0.023
	5.00	64.68	37.5	0.333	48	1.71	9.0	47.87	6300	7.26	9.30	9.61	0.027
	5.25	69.10	40.0	0.354	51	1.84	10.4	51.56	6540	7.09	9.09	9.39	0.029
	5.50	73.52	42.6	0.375	54	1.97	11.9	55.30	6780	6.93	8.90	9.19	0.032
	6.00	82.35	48.0	0.417	60	2.24	15.2	62.90	7280	6.65	8.54	8.83	0.036
	6.25	86.77	50.8	0.438	63	2.38	17.1	66.76	7540	6.56	8.38	8.66	0.038
	6.50	91.19	53.6	0.458	66	2.52	19.2	70.65	7800	6.48	8.23	8.50	0.041
	7.00	100.03	59.5	0.500	73	2.80	23.8	78.50	8350	6.32	7.94	8.20	0.045
	7.25	104.44	61.9	0.521	76	2.94	26.3	82.46	8570	6.24	7.81	8.07	0.047
	7.50	108.86	64.3	0.542	79	3.08	29.0	86.45	8790	6.17	7.68	7.94	0.050
18 gage	4.50	62.08	32.6	0.292	42	1.62	7.0	45.34	6080	8.42	10.48	10.83	0.023
	5.00	72.04	37.5	0.333	48	1.90	9.5	53.36	6670	7.98	9.99	10.32	0.027
	5.25	77.02	40.0	0.354	51	2.05	10.9	57.48	6910	7.79	9.77	10.10	0.029
	5.50	82.00	42.6	0.375	54	2.20	12.4	61.66	7150	7.61	9.56	9.88	0.032
	6.00	91.95	48.0	0.417	60	2.50	15.9	70.18	7650	7.30	9.18	9.49	0.036
	6.25	96.93	50.8	0.438	63	2.66	17.9	74.50	7910	7.20	9.01	9.31	0.038
	6.50	101.91	53.6	0.458	66	2.81	20.0	78.85	8170	7.11	8.85	9.14	0.041
	7.00	111.87	59.5	0.500	73	3.13	24.8	87.66	8720	6.93	8.54	8.82	0.045
	7.25	116.85	61.9	0.521	76	3.28	27.4	92.10	8940	6.85	8.40	8.68	0.047
	7.50	121.83	64.3	0.542	79	3.44	30.2	96.57	9160	6.77	8.26	8.54	0.050
16 gage	4.50	62.08	32.6	0.292	42	1.99	7.7	45.34	6080	9.58	11.63	12.02	0.023
	5.00	72.04	37.5	0.333	48	2.35	10.4	53.36	6980	9.08	11.10	11.47	0.027
	5.25	77.02	40.0	0.354	51	2.53	11.9	57.48	7450	8.85	10.85	11.22	0.029
	5.50	82.00	42.6	0.375	54	2.72	13.6	61.66	7940	8.65	10.63	10.98	0.032
	6.00	91.95	48.0	0.417	60	3.10	17.4	70.18	8460	8.29	10.21	10.55	0.036
	6.25	96.93	50.8	0.438	63	3.29	19.5	74.50	8720	8.17	10.02	10.35	0.038
	6.50	101.91	53.6	0.458	66	3.48	21.8	78.85	8980	8.07	9.84	10.17	0.041
	7.00	111.87	59.5	0.500	73	3.88	27.0	87.66	9530	7.86	9.50	9.82	0.045
	7.25	116.85	61.9	0.521	76	4.08	29.8	92.10	9750	7.77	9.35	9.66	0.047
	7.50	121.83	64.3	0.542	79	4.28	32.8	96.57	9970	7.67	9.20	9.50	0.050

2" LOK-FLOOR

Table from United Steel Deck manual from 2002, Page 29
For a 6'-6" deck span

2 x 12" DECK F_y = 33ksi f'_c = 3 ksi 145 pcf concrete

LRFD

	Slab Depth	φMn in.k	L, Uniform Live Service Loads, psf * 6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00
22 gage	4.50	40.27	400	365	310	265	230	200	175	155	135	120	105	95	85
	5.00	46.44	400	400	360	305	265	230	200	175	155	140	125	110	95
	5.50	52.61	400	400	400	350	300	260	230	200	175	155	140	125	110
	6.00	58.78	400	400	400	390	335	295	255	225	200	175	155	140	125
	6.50	64.95	400	400	400	400	370	325	285	250	220	195	175	155	135
	7.00	71.12	400	400	400	400	400	365	310	275	240	215	190	170	150
	7.25	74.21	400	400	400	400	400	370	325	285	250	225	200	175	155
	7.50	77.29	400	400	400	400	400	385	340	295	260	230	205	185	165
20 gage	4.50	48.60	400	400	380	325	285	245	215	190	170	150	135	120	110
	5.00	56.18	400	400	400	380	330	285	250	220	195	175	155	140	125
	5.50	63.75	400	400	400	400	375	325	285	250	225	200	175	160	140
	6.00	71.32	400	400	400	400	400	365	320	285	250	225	200	180	160
	6.50	78.90	400	400	400	400	400	400	355	315	280	245	220	195	175
	7.00	86.47	400	400	400	400	400	400	390	345	305	270	240	215	195
	7.25	90.26	400	400	400	400	400	400	400	360	320	285	255	225	205
	7.50	94.05	400	400	400	400	400	400	400	375	330	295	265	235	210
19 gage	4.50	55.85	400	400	400	380	330	290	255	225	200	180	160	145	130
	5.00	64.68	400	400	400	400	385	335	295	260	230	205	185	165	150
	5.50	73.52	400	400	400	400	400	380	335	295	265	235	210	190	170
	6.00	82.35	400	400	400	400	400	400	375	335	295	265	235	215	190
	6.50	91.19	400	400	400	400	400	400	400	370	330	295	265	235	210
	7.00	100.03	400	400	400	400	400	400	400	400	360	320	290	260	235
	7.25	104.44	400	400	400	400	400	400	400	400	375	335	300	270	245
	7.50	108.86	400	400	400	400	400	400	400	400	395	350	315	280	255
18 gage	4.50	62.08	400	400	400	400	370	325	285	255	225	200	180	160	145
	5.00	72.04	400	400	400	400	400	375	335	295	260	235	210	190	170
	5.50	82.00	400	400	400	400	400	400	380	335	300	265	240	215	195
	6.00	91.95	400	400	400	400	400	400	400	375	335	300	270	245	220
	6.50	101.91	400	400	400	400	400	400	400	400	375	335	300	270	245
	7.00	111.87	400	400	400	400	400	400	400	400	400	365	330	295	270
	7.25	116.85	400	400	400	400	400	400	400	400	400	385	345	310	280
	7.50	121.83	400	400	400	400	400	400	400	400	400	400	360	325	290
16 gage	4.50	62.08	400	400	400	400	370	325	285	255	225	200	180	160	145
	5.00	72.04	400	400	400	400	400	375	335	295	260	235	210	190	170
	5.50	82.00	400	400	400	400	400	400	380	335	300	265	240	215	195
	6.00	91.95	400	400	400	400	400	400	400	375	335	300	270	245	220
	6.50	101.91	400	400	400	400	400	400	400	400	375	335	300	270	245
	7.00	111.87	400	400	400	400	400	400	400	400	400	365	330	295	270
	7.25	116.85	400	400	400	400	400	400	400	400	400	385	345	310	280
	7.50	121.83	400	400	400	400	400	400	400	400	400	400	360	325	290
	4.50	29.40	305	255	215	185	160	135	120	105	90	80	70	60	50
	5.00	34.53	360	305	255	220	185	160	140	120	105	95	80	70	65
	5.50	39.61	400	350	295	255	215	190	165	140	125	110	95	85	75
	6.00	45.21	400	400	340	290	250	215	185	160	140	125	110	95	85
	6.50	50.70	400	400	380	325	280	240	210	185	160	140	125	110	95
	7.00	56.26	400	400	400	360	310	270	235	205	180	155	140	120	105
	7.25	59.07	400	400	400	380	325	285	245	215	190	165	145	130	115
	7.50	61.88	400	400	400	400	345	295	260	225	200	175	155	135	120
	4.50	35.43	375	315	270	230	200	170	150	130	115	100	90	80	70
	5.00	41.65	400	375	315	270	235	205	175	155	135	120	105	95	85
	5.50	48.07	400	400	365	315	270	235	205	180	160	140	125	110	95
	6.00	54.63	400	400	400	360	310	270	235	205	180	160	140	125	110
	6.50	61.31	400	400	400	400	350	300	265	230	205	180	160	140	125
	7.00	68.09	400	400	400	400	390	335	295	260	230	200	180	160	140
	7.25	71.50	400	400	400	400	400	355	310	270	240	210	190	165	150
	7.50	74.93	400	400	400	400	400	370	325	285	250	225	200	175	155
	4.50	40.69	400	370	315	270	230	200	175	155	135	120	105	95	85
	5.00	47.87	400	400	370	315	275	240	210	185	160	145	125	115	100
	5.50	55.30	400	400	400	365	320	275	240	215	190	165	150	130	120
	6.00	62.90	400	400	400	400	365	315	275	245	215	190	170	150	135
	6.50	70.65	400	400	400	400	400	355	310	275	245	215	190	170	155
	7.00	78.50	400	400	400	400	400	395	350	305	270	240	215	190	170
	7.25	82.46	400	400	400	400	400	400	365	320	285	255	225	200	180
	7.50	86.45	400	400	400	400	400	400	385	340	300	265	235	210	190
	4.50	45.34	400	400	350	300	260	230	200	175	155	140	125	110	100
	5.00	53.38	400	400	400	355	310	270	235	210	185	165	145	130	115
	5.50	61.68	400	400	400	400	360	315	275	240	215	190	170	150	135
	6.00	70.18	400	400	400	400	400	360	315	275	245	220	195	175	155
	6.50	78.85	400	400	400	400	400	400	355	310	275	245	220	195	175
	7.00	87.66	400	400	400	400	400	400	395	350	310	275	245	220	195
	7.25	92.10	400	400	400	400	400	400	400	365	325	290	260	230	210
	7.50	96.57	400	400	400	400	400	400	400	385	340	305	270	245	220
	4.50	45.34	400	400	350	300	260	230	230	175	155	140	125	110	100
	5.00	53.38	400	400	400	355	310	270	235	210	185	165	145	130	115
	5.50	61.68	400	400	400	400	360	315	275	240	215	190	170	150	135
	6.00	70.18	400	400	400	400	400	360	315	275	245	220	195	175	155
	6.50	78.85	400	400	400	400	400	400	355	310	275	245	220	195	175
	7.00	87.66	400	400	400	400	400	400	395	350	310	275	245	220	195
	7.25	92.10	400	400	400	400	400	400	400	365	325	290	260	230	210
	7.50	96.57	400	400	400	400	400	400	400	385	340	305	270	245	220

1 STUD/FT.

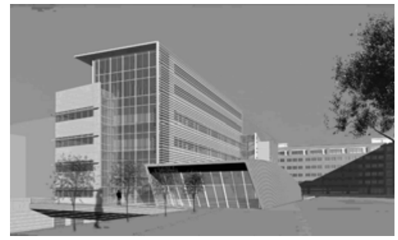
NO STUDS

* 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_{nf} is used to calculate the uniform load when the full required number of studs is present; ϕM_{no} 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 400 psf 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 servicibility 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.



Appendix B
Alternative 2

Non-Composite Steel System

The second alternative bay system I chose to use was a steel non-composite system. I chose to evaluate this system by using RAM Structural System, 2003 as well. I laid out the columns, girders, and beams in the same fashion as the first alternative in order to keep constancy with both the current system, as well as the alternative systems for more accurate comparisons. Once again the largest spacing for the deck to span was found to be 6'-2". I then used the United Steel Deck manual from 2001 to find the appropriate total surface weight on my structure. The loading from the concrete can be found on page57 (Appendix B.5). The appropriate slab depth and steel decking can be found on page 55 of the USD manual (Appendix B.4). I then needed to check to find the appropriate welded wire mesh to confirm slab depth as well as carrying capacity from page 59 in the USD manual (Appendix B.6). No live load reductions were used do to the fact that they could not be used on the smaller spans ($K_{LL}A_T$ is small then 400 sq ft).

At first I had to assume a weight of concrete and decking to see what depth of concrete would be needed to support my load but after comparing the decking strength and the welded wire mesh to the depth of the concrete I found that a 5.0" concrete slab could be used with a total slab and decking weight of 48psf.

Loading was found by using the following values:

Live load:		125psf
Dead Load:		
	Superimposed	25psf
	5.0" Slab	<u>48psf</u>
		73psf

Total Load: 1.2 Dead + 1.6 Live

Total Load: 1.2(73psf) + 1.6(125psf) = 287.6psf

The welded wire mesh was what actually controlled the depth of the concrete in which a 5" slab over a 6.5' span would need to have 44-W2.9 X 2.9 welded wire mesh to support the load or 287.6psf

After all calculations were completed I found that the following values and products to be appropriate for my decking to span 6.5' (the minimum manual distance that is greater then the distance between beams) that could still support a loading of 287.6psf, in the three span condition, with the LRFD reduction factors to be:

UF2X floor system
22 gauge steel
Slab depth of 5.0"
44– W2.9 X 2.9 welded wire mesh

This will support a load of 332psf

The total surface load is then taken to be (not including self weight of the beams and girders):
287.6psf

RAM accounts for all factors on loading and deflection limitations

I then added an additional line load along the top and bottom of the RAM model to account for exterior wall loads of: 160.33plf

This was using the assumptions of the average exterior of the building being represented by:

60% insulated aluminum sheet siding with gypsum wall board interior weighing 12psf

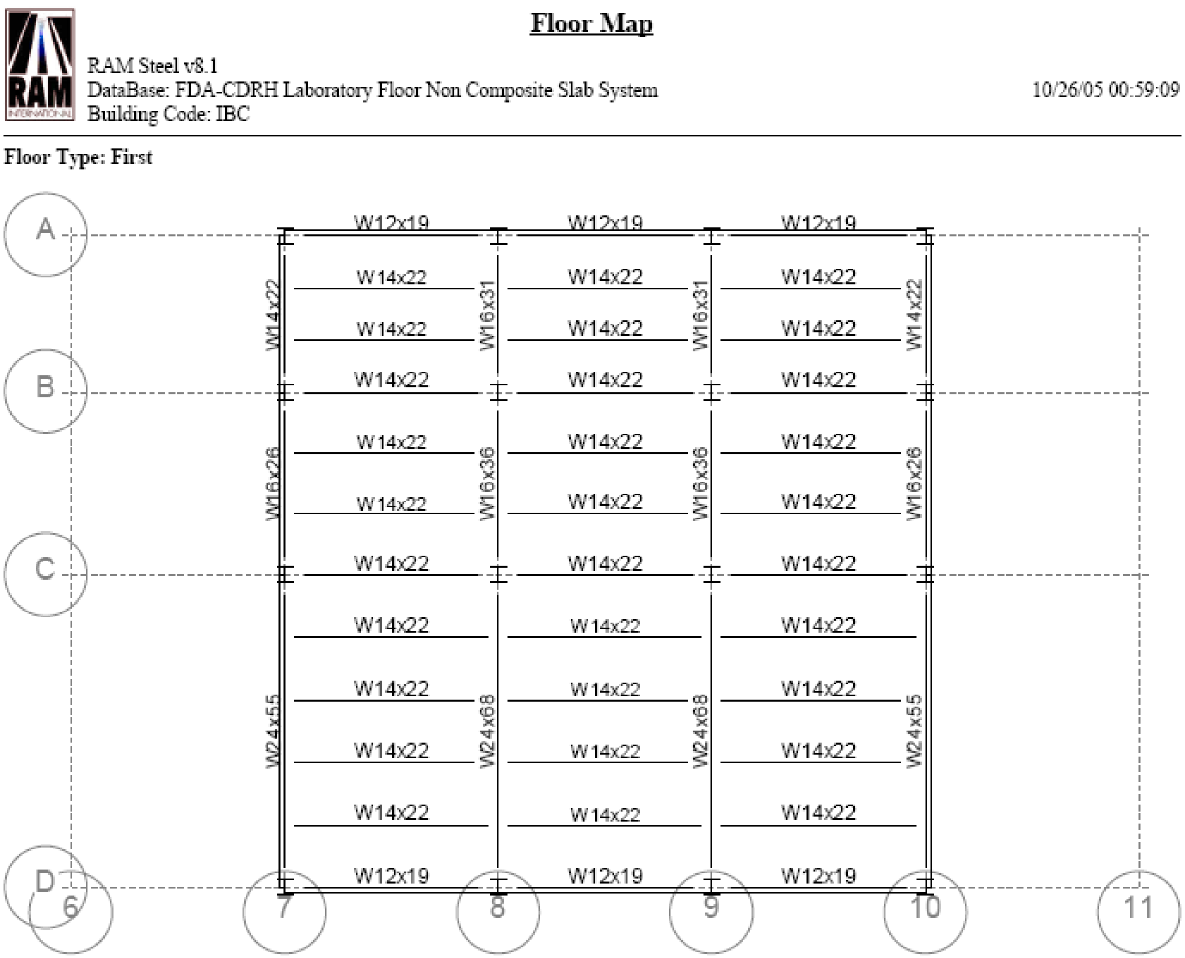
40% glass weighing 8psf

Total Exterior load:

0.60(12psf) + 0.40(8psf) = 10.4psf

10.4psf (15'-5" tributary story height)=160.33plf

After applying a 6" overhang the following steel beam types were.



The largest beam being a 24X68 gave a total depth of:

This added to the slab depth of 5" gave a total floor depth for the structural components to be:
5"+23.7"=28.7"

Total depth for the 30’-9“ bay: 28.7”

Total depth for the 18’ bay:
Depth of a W16X36: 15.9”
Total depth = 15.9”+4.5”=20.4”

Total depth for the 15’-5” bay:
Depth of a W16X31: 15.9”
Total depth = 15.9”+4.5”=20.4”

Total Weight for the 30’9” bay:

Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((4.5)(22)+(1)(19))(21’)+(1)(68)(30’-9”) = 4569lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (48psf)(30’9”)(21’)=30996lbs
Total Weight=4569lbs+30996lbs=35565lbs=35.565k

Total Weight for the 18’ bay:

Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((3)(22))(21’)+(1)(36)(18) = 2034lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (48psf)(18’)(21’)=18144lbs
Total Weight=2034lbs+18144lbs=20178lbs=20.178k

Total Wight for the 15’ bay:

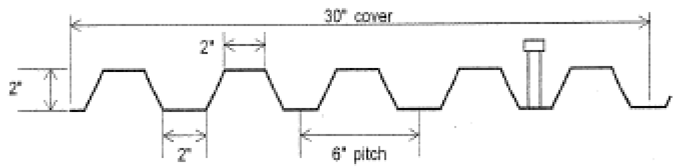
Total Weight= (Weight of steel)+(weight of decking)
Weight of steel= ∑(weight of each piece)(length of each piece)
= ((2.5)(22)+(1)(19))(21’)+(1)(31)(15’-5”) = 2032lbs
Weight of decking = (weight of slab and decking)(area of decking)
= (48psf)(15’5”)(21’)=15540lbs
Total Weight=2032lbs+15540lbs=17572lbs=17.572k

The longest span does have the largest depth and load, therefore it is the critical beam and will be the beam used for comparison in the main report. However, one can also see that by splitting the span in 2 parts the depth of the structural sandwich can be reduced by almost 3/4 of a foot and the weight can be greatly reduced.

Table from United Steel Deck manual from 2002, Page 55
For a 6'-6" deck span

SECTION PROPERTIES							ASD		LRFD		
Metal Thickness Gage	Inches	Wt. (psf)	I_p (in.^{4})	S_p (in.^{3})	S_n (in.3)	V (lbs)	R_1 (lbs)	R_2 (lbs)	ϕV (lbs)	ϕR_1 (lbs)	ϕR_2 (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"

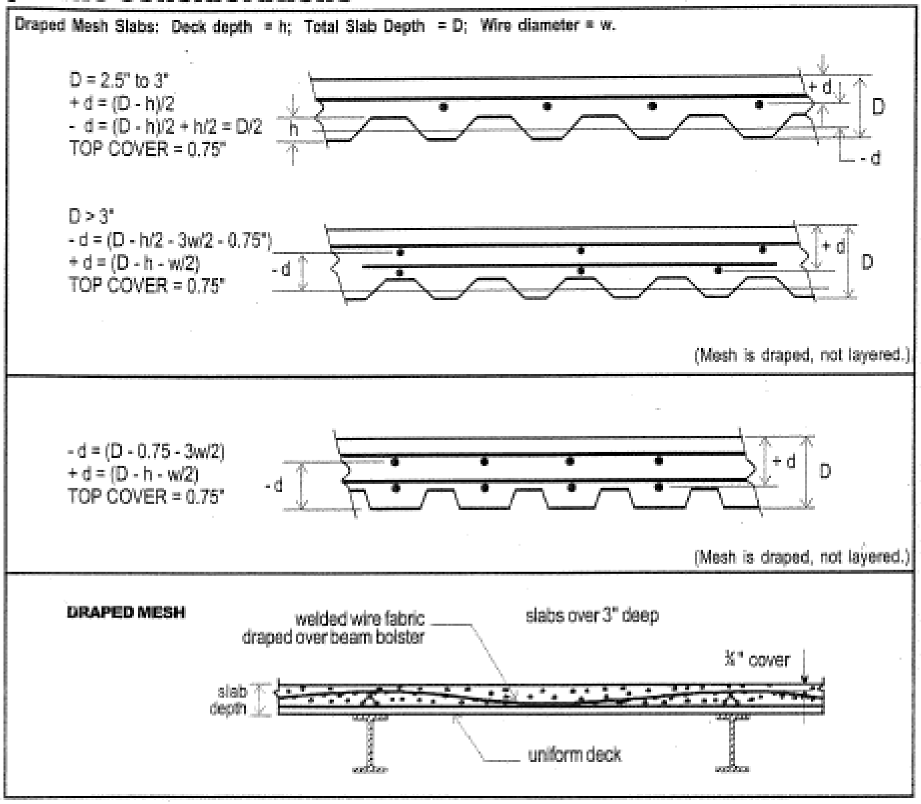
UNIFORM TOTAL LOAD / Load that Produces l/180 Deflection, psf

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

Table from United Steel Deck manual from 2002, Page 57
For a 6'-6" deck span

profile considerations



UFS, UF1X and UFX-36 have a b width of 12" for both positive and negative bending. For D < 3" place the mesh in the center of the concrete that is above the ribs. For D > 3", mesh is draped, not layered.

Inverted B and UF2X have a b width of 12" for positive bending. For negative bending the b width for Inverted B deck is 7.5"; for UF2X the negative bending b width is 6". For D > 3" mesh is draped, not layered.

FORM DECKS weights and volumes

Total Slab Depth		UFS C_v = .0234	UF1X C_v = .0417	UFX C_v = .0547	INV. B C_v = .0781	UF2X C_v = .0833
2.5"	Wt	27				
	Vol.	0.185				
3.0"	Wt	33	30	28		
	Vol.	0.226	0.208	0.195		
3.5"	Wt	39	36	34	36	
	Vol.	0.268	0.250	0.237	0.245	
4.0"	Wt	45	42	40	41	36
	Vol.	0.310	0.292	0.279	0.286	0.250
4.5"	Wt	51	48	46	48	42
	Vol.	0.352	0.333	0.320	0.328	0.292
5.0"	Wt	57	54	52	54	48
	Vol.	0.393	0.375	0.362	0.370	0.333
5.5"	Wt	63	60	59	60	54
	Vol.	0.435	0.417	0.404	0.411	0.375
6.0"	Wt	69	66	65	66	60
	Vol.	0.476	0.458	0.445	0.453	0.417
6.5"	Wt	75	73	71	72	67
	Vol.	0.518	0.500	0.487	0.495	0.459
7.0"	Wt	81	79	77	78	73
	Vol.	0.560	0.542	0.528	0.536	0.500

The weights are shown in pounds per square foot and are based on 145 pcf concrete. Volumes are in ft.³ per ft.². C_v is the volume of concrete required to fill the ribs. Multiply the volume shown in the table by 144 to find the gross area of concrete in in²/ft.

Table from United Steel Deck manual from 2002, Page 59
For a 6'-6" deck span

LRFD

concrete slabs on UF2X form deck - UNIFORM LOADS, PSF

Slab	Mesh	+d	-d	+M	-M	Spans, feet 4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"
4.0"	66 - W2.0 x 2.0* 66 - W2.9 x 2.9	1.919 1.904	3.007 2.962	4.060 5.785	6.326 8.921	157 224	127 181	105 150	88 126	75 107	65 93	57 81	50 71	44 63	 56
4.5"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.387 2.404 2.387	3.412 3.462 3.412	9.975 10.893 14.708	14.062 15.463 20.585	386 ### ###	313 342 ###	259 282 381	217 237 320	185 202 273	160 174 235	139 152 205	122 133 180	108 118 160	97 105 142
5.0"	66 - W4.0 x 4.0* 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.887 2.904 2.887	3.912 3.962 3.912	12.135 13.242 17.948	16.222 17.812 23.825	### ### ###	381 ### ###	315 343 ###	264 289 389	225 246 332	194 212 286	169 185 249	149 162 219	132 144 194	117 128 173
5.5"	44 - W2.9 x 2.9* 44 - W4.0 x 4.0	3.404 3.387	4.462 4.412	15.591 21.188	20.161 27.065	### ###	### ###	392 ###	329 ###	281 377	242 325	211 283	185 249	164 220	146 197
6.0"	44 - W4.0 x 4.0	3.887	4.912	24.428	30.305	###	###	###	###	###	364	317	279	247	220
6.5"	44 - W4.0 x 4.0	4.387	5.412	27.668	33.545	###	###	###	###	###	###	351	308	273	244
7.0"	44 - W4.0 x 4.0	4.887	5.912	30.908	36.785	###	###	###	###	###	###	385	338	299	267

24 gage (4'6"–7'0") — 22 gage (7'6"–8'0") — 20 gage (8'6"–9'0")

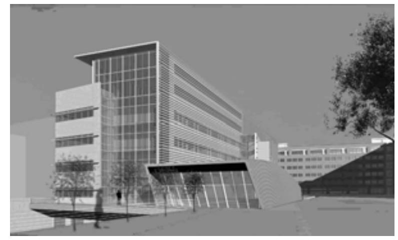
concrete slabs on B-INV form deck - UNIFORM LOADS, PSF

Slab	Mesh	+d	-d	+M	-M	Spans, feet 4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"
3.5"	66 - W2.0 x 2.0* 66 - W2.9 x 2.9*	1.919 1.904	2.507 2.462	4.060 5.785	5.274 7.414	194 273	153 215	124 174	103 144	86 121	73 103	63 89	55 78	48 68	
4.0"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.387 2.404 2.387	2.912 2.962 2.912	9.975 10.893 14.708	12.015 13.248 17.599	### ### ###	349 385 ###	283 312 ###	234 258 342	196 216 288	167 184 245	144 159 211	126 139 184	110 122 162	98 108 143
4.5"	66 - W4.0 x 4.0* 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.887 2.904 2.887	3.412 3.462 3.412	12.135 13.242 17.948	14.175 15.597 20.839	### ### ###	### ### ###	334 367 ###	276 303 ###	232 255 341	197 217 290	170 187 250	148 163 218	130 143 192	115 127 170
5.0"	44 - W2.9 x 2.9* 44 - W4.0 x 4.0	3.404 3.387	3.962 3.912	15.591 21.188	17.946 24.079	### ###	### ###	### ###	349 ###	293 393	250 335	215 289	188 252	165 221	146 196
5.5"	44 - W4.0 x 4.0	3.887	4.412	24.428	27.319	###	###	###	###	###	380	328	286	251	222
6.0"	44 - W4.0 x 4.0	4.387	4.912	27.668	30.559	###	###	###	###	###	###	367	320	281	
6.5"	44 - W4.0 x 4.0*	4.887	5.412	30.908	33.799	###	###	###	###	###	###	###	353	311	

22 gage (5'0"–5'6") — 20 gage (6'0"–6'6") — 18 gage (7'0"–7'6") — 16 gage (8'0")

Slab, +d, and -d are in inches.
+M and -M are in kip inches. (per foot of width).
* A_s does not meet ACI criterion. (.0018 A_c for temperature steel.)
Heavy lines are based on three span conditions.
means the calculated live loads exceed 400 psf.

DRAPED MESH CONSTRUCTION



Appendix C
Alternative 3

Steel Joist System

The third alternative bay system I chose to use was a open web steel joist system. I also chose to evaluate this system by using the RAM Structural System, 2003. I laid out the columns, girders, and beams in the same fashion as the first and second alternative in order to keep constancy with both the current system, as well as the other alternative systems for more accurate comparisons. I chose to space joist 2' apart, and they will run parallel to the 21' girders. The 21' direction was chose due to the large span of 30'-9" controlling the spanning direction for the entire floor system. The constancy with spanning direction is preferred due to necessity to order differing lengths of joist as well as confusion on the job site if changing of joist direction is implemented. I then used the United Steel Deck manual from 2001 to find the appropriate total surface weight on my structure. The loading from the concrete can be found on page57 (Appendix C.5). The appropriate slab depth and steel decking can be found on page 52 of the USD manual (Appendix C.4). The appropriate welded wire mesh can be found on USD page 58 (Appendix C.6). No live load reductions were used do to the fact that they could not be used on the smaller spans ($K_{LL}A_T$ is less then 400 sq ft).

At first I had to assume a weight of concrete and decking to see what depth of concrete would be needed to support my load but after comparing the decking strength and the welded wire mesh to the depth of the concrete I found that a 2.5" concrete slab could be used with a total slab and decking weight of 27psf.

I found the joist weight by first estimating a weight and using RAM to find a good estimate of the joists to be used. I then used this value to find the exact joist that would hold the total weight of the slab, decking, and self-weight from page 23 of the New Columbia Joist Company Steel Joist and Joist Girders manual from 2002 (Appendix C.7). I continued to work between RAM and the manual until both the manual and RAM values for the joist matched. The self-weight of the 16K3 joists was found to be 6.3plf which when divided by the tributary width of 2' was found to be 3.15psf.

Loading was found by using the following values:

Live load:		125psf
Dead Load:		
	Superimposed	25psf
	2.5" Slab	27psf
	16K3 Joist	3.15 psf
		55.15psf

Total Load: 1.2 Dead + 1.6 Live

Total Load: 1.2(55.15psf) + 1.6(125psf) = 266.18psf

The welded wire mesh to support this load over the depth of the concrete in which a 2.5" slab over a 2' span would need to have 66-W 1.4 X 1.4 to support the load of 272psf.

I found that this system needed:
2.5" slab
16K3 Joist
28 gage UFS Form deck
66-W 1.4 X 1.4

The total surface load is then taken to be (including the self-weight of the joists and not including self-weight of the girders):266.18psf.

RAM accounts for all factors on loading and deflection limitations

I then added an additional line load along the top and bottom of the RAM model to account for exterior wall loads of: 160.33plf

This was using the assumptions of the average exterior of the building being represented by:

60% insulated aluminum sheet siding with gypsum wall board interior weighing 12psf
40% glass weighing 8psf

Total Exterior load:

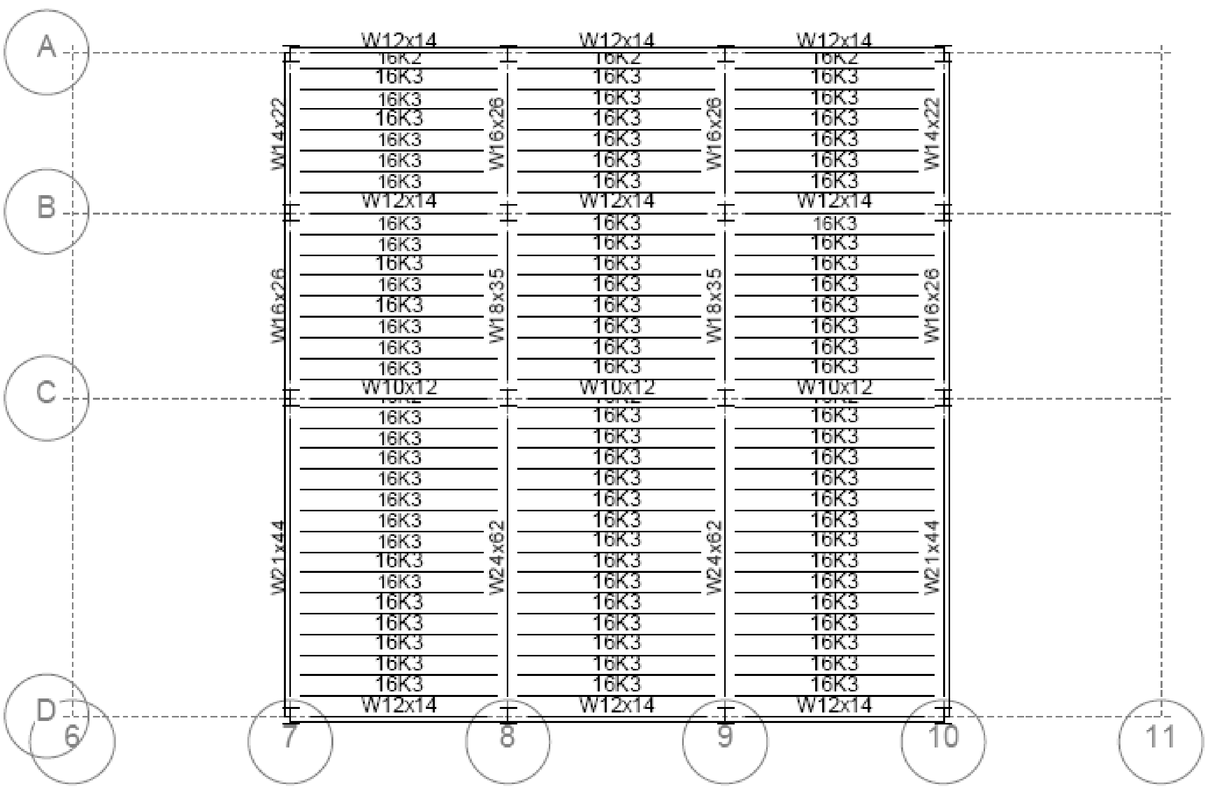
0.60(12psf) + 0.40(8psf) = 10.4psf
10.4psf (15'-5" tributary story height)=160.33plf

After applying a 6" overhang the following steel beam types were .

Floor Map

RAM Steel v8.1
DataBase: FDA-CDRH Laboratory Floor Open Joist Slab System — 10/26/05 00:56:46
Building Code: IBC

Floor Type: First



The largest beam being a 24X62 gave a total depth of:

This added to the slab depth of 2.5" gave a total floor depth for the structural component to be:
2.5"+ 23.7"=26.2"

Total depth for the 30'-9" bay: 26.2"

Total depth for the 18' bay:

Depth of a W18X35: 17.7"

Total depth = 15.7"+4.5"=22.2"

Total depth for the 15'-5" bay:

Depth of a W16X26: 15.7"

Total depth = 13.7"+4.5"=20.2"

Total Weight for the 30'9" bay:

Total Weight= (Weight of steel)+(weight of decking)+(weight of joists)

Weight of steel= ∑(weight of each piece)(length of each piece)

= ((0.5)(12)+(1)(14))(21')+(1)(62)(30'-9") = 2326.5lbs

Weight of decking = (weight of slab and decking)(area of decking)

= (27psf)(30'9")(21')=17435.25lbs

Weight of Joists=(weight of joist)(area joist support)

=(3.15psf)(30'9")(21')=2034.1125lbs

Total Weight=2326.5lbs+17435.25lbs+2034.1125lbs=21795.9lbs=21.7959k

Total Weight for the 18' bay:

Total Weight= (Weight of steel)+(weight of decking)+(weight of joists)

Weight of steel= ∑(weight of each piece)(length of each piece)

= ((0.5)(12)+(0.5)(14))(21')+(1)(35)(18') = 903lbs

Weight of decking = (weight of slab and decking)(area of decking)

= (27psf)(18')(21')=10206lbs

Weight of Joists=(weight of joist)(area joist support)

=(3.15psf)(18')(21')=1190.7lbs

Total Weight=903lbs+10206lbs+1190.7lbs=12299.7lbs=12.2997k

Total Wight for the 15' bay:

Total Weight= (Weight of steel)+(weight of decking)+(weight of joists)

Weight of steel= ∑(weight of each piece)(length of each piece)

= ((1.5)(14))(21')+(1)(26)(15'-5") = 841.83lbs

Weight of decking = (weight of slab and decking)(area of decking)

= (27psf)(15'5")(21')=8741.25lbs

Weight of Joists=(weight of joist)(area joist support)

=(3.15psf)(15'5")(21')=1019.8125lbs

Total Weight=841.83lbs+8741.25lbs+1019.8125lbs=10602.9lbs=10.6029k

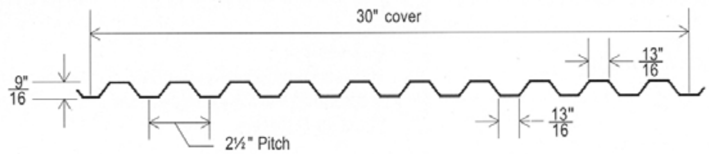
The longest span does have the largest depth and load, therefore it is the critical beam and will be the beam used for comparison in the main report. However, one can also see that by splitting the span in 2 parts the depth of the structural sandwich can be reduced by almost half foot and the weight can be reduced by almost half.

Table from United Steel Deck manual from 2002, Page 52
For a 21’ span

USD United Steel Deck, Inc.

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)
28	0.0149	1.00	0.012	0.036	0.037	1634	413	432	1944	643	643
26	0.0179	1.00	0.015	0.046	0.047	1956	547	797	2327	826	1104
24	0.0239	1.00	0.020	0.065	0.064	2595	864	1670	3087	1238	2323
22	0.0295	1.50	0.025	0.080	0.079	3224	1248	2803	3787	1690	3773

UFS



approx. scale: 1½" = 1'0"

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

	Gage	Span Condition	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"
ASD	28	Single	216 / 131	138 / 67	96 / 39	71 / 25	54 / 16	43 / 12	35 / 8	29 / 6	24 / 5
		Double	219 / 316	141 / 162	98 / 94	72 / 59	55 / 40	44 / 28	35 / 20	29 / 15	25 / 12
		Triple	272 / 247	175 / 127	122 / 73	90 / 46	69 / 31	55 / 22	44 / 16	37 / 12	31 / 9
	26	Single	276 / 164	177 / 84	123 / 49	90 / 31	69 / 21	55 / 14	44 / 11	36 / 8	31 / 6
		Double	278 / 395	179 / 202	124 / 117	92 / 74	70 / 49	56 / 35	45 / 25	37 / 19	31 / 15
		Triple	345 / 309	222 / 158	155 / 92	114 / 58	88 / 39	69 / 27	56 / 20	46 / 15	39 / 11
	24	Single	390 / 219	250 / 112	173 / 65	127 / 41	98 / 27	77 / 19	62 / 14	52 / 11	43 / 8
		Double	378 / 527	243 / 270	169 / 156	125 / 98	96 / 66	76 / 46	61 / 34	51 / 25	43 / 20
		Triple	469 / 412	302 / 211	211 / 122	155 / 77	119 / 52	94 / 36	76 / 26	63 / 20	53 / 15
	22	Single	480 / 274	307 / 140	213 / 81	157 / 51	120 / 34	95 / 24	77 / 18	63 / 13	53 / 10
		Double	466 / 659	300 / 337	209 / 195	154 / 123	118 / 82	93 / 58	76 / 42	63 / 32	53 / 24
		Triple	579 / 515	373 / 264	261 / 153	192 / 96	147 / 64	116 / 45	94 / 33	78 / 25	66 / 19
LRFD	28	Single	342 / 131	219 / 67	152 / 39	112 / 25	85 / 16	68 / 12	55 / 8	45 / 6	38 / 5
		Double	257 / 316	206 / 162	154 / 94	114 / 59	87 / 40	69 / 28	56 / 20	46 / 15	39 / 12
		Triple	292 / 247	234 / 127	192 / 73	142 / 46	109 / 31	86 / 22	70 / 16	58 / 12	49 / 9
	26	Single	437 / 164	280 / 84	194 / 49	143 / 31	109 / 21	86 / 14	70 / 11	58 / 8	49 / 6
		Double	434 / 395	281 / 202	196 / 117	144 / 74	111 / 49	88 / 35	71 / 25	59 / 19	49 / 15
		Triple	502 / 309	348 / 158	244 / 92	180 / 58	138 / 39	109 / 27	89 / 20	73 / 15	62 / 11
	24	Single	617 / 219	395 / 112	274 / 65	202 / 41	154 / 27	122 / 19	99 / 14	82 / 11	69 / 8
		Double	590 / 527	382 / 270	267 / 156	197 / 98	151 / 66	119 / 46	97 / 34	80 / 25	67 / 20
		Triple	729 / 412	473 / 211	331 / 122	245 / 77	188 / 52	149 / 36	121 / 26	100 / 20	84 / 15
	22	Single	760 / 274	486 / 140	338 / 81	248 / 51	190 / 34	150 / 24	122 / 18	100 / 13	84 / 10
		Double	728 / 659	471 / 337	329 / 195	243 / 123	186 / 82	147 / 58	119 / 42	99 / 32	83 / 24
		Triple	899 / 515	584 / 264	409 / 153	302 / 96	232 / 64	184 / 45	149 / 33	123 / 25	104 / 19

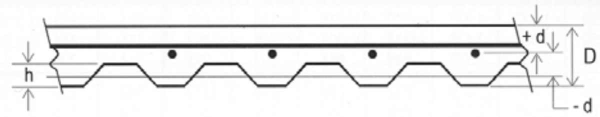
NOTES:
R_1 is the bearing capacity at an **exterior** condition. R_2 is the bearing capacity at an **interior** condition.

Table from United Steel Deck manual from 2002, Page 57
For a 21' span

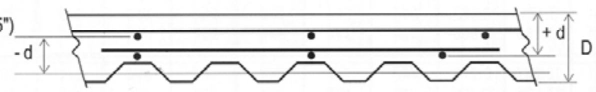
profile considerations

Draped Mesh Slabs: Deck depth = h; Total Slab Depth = D; Wire diameter = w.

D = 2.5" to 3"
+ d = (D - h)/2
- d = (D - h)/2 + h/2 = D/2
TOP COVER = 0.75"



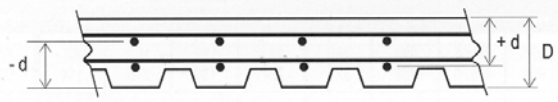
D > 3"
- d = (D - h/2 - 3w/2 - 0.75")
+ d = (D - h - w/2)
TOP COVER = 0.75"



(Mesh is draped, not layered.)

UFS, UF1X and UFX-36 have a b width of 12" for both positive and negative bending. For D < 3" place the mesh in the center of the concrete that is above the ribs. For D > 3", mesh is draped, not layered.

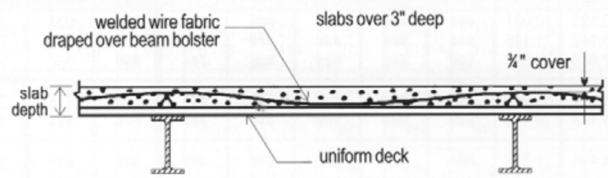
- d = (D - 0.75 - 3w/2)
+ d = (D - h - w/2)
TOP COVER = 0.75"



(Mesh is draped, not layered.)

Inverted B and UF2X have a b width of 12" for positive bending. For negative bending the b width for Inverted B deck is 7.5"; for UF2X the negative bending b width is 6". For D > 3" mesh is draped, not layered.

DRAPED MESH



FORM DECKS weights and volumes

Total Slab Depth		UFS C_v = .0234	UF1X C_v = .0417	UFX C_v = .0547	INV. B C_v = .0781	UF2X C_v = .0833
2.5"	Wt	27				
	Vol.	0.185				
3.0"	Wt	33	30	28		
	Vol.	0.226	0.208	0.195		
3.5"	Wt	39	36	34	36	
	Vol.	0.268	0.250	0.237	0.245	
4.0"	Wt	45	42	40	41	36
	Vol.	0.310	0.292	0.279	0.286	0.250
4.5"	Wt	51	48	46	48	42
	Vol.	0.352	0.333	0.320	0.328	0.292
5.0"	Wt	57	54	52	54	48
	Vol.	0.393	0.375	0.362	0.370	0.333
5.5"	Wt	63	60	59	60	54
	Vol.	0.435	0.417	0.404	0.411	0.375
6.0"	Wt	69	66	65	66	60
	Vol.	0.476	0.458	0.445	0.453	0.417
6.5"	Wt	75	73	71	72	67
	Vol.	0.518	0.500	0.487	0.495	0.459
7.0"	Wt	81	79	77	78	73
	Vol.	0.560	0.542	0.528	0.536	0.500

The weights are shown in pounds per square foot and are based on 145 pcf concrete. Volumes are in ft.^{3} per ft.^{2}. C_v is the volume of concrete required to fill the ribs. Multiply the volume shown in the table by 144 to find the gross area of concrete in in^2/ft.

Table from United Steel Deck manual from 2002, Page 58
For a 21' span

USD United Steel Deck, Inc.

LRFD

concrete slabs on UFS form deck - UNIFORM LOADS, PSF

Slab	Mesh	+d	-d	+M	-M	Spans, feet 2'0"	2'3"	2'6"	2'9"	3'0"	3'3"	3'6"
2.5"	66 - W1.4 x 1.4* 66 - W2.0 x 2.0* 66 - W2.9 x 2.9*	0.969 0.969 0.969	1.250 1.250 1.250	1.423 2.008 2.856	1.848 2.615 3.737	272 385 ###	215 304 ###	174 246 352	144 203 291	121 171 244	103 146 208	89 126 179
3.0"	66 - W1.4 x 1.4* 66 - W2.0 x 2.0* 66 - W2.9 x 2.9*	1.219 1.219 1.219	1.500 1.500 1.500	1.801 2.548 3.639	2.226 3.155 4.520	327 ### ###	259 367 ###	210 297 ###	173 245 352	146 206 295	124 176 252	107 152 217
3.5"	66 - W2.9 x 2.9* 66 - W4.0 x 4.0*	2.842 2.825	2.181 2.131	8.721 11.865	6.652 8.866	### ###	### ###	### ###	### ###	### ###	370 ###	319 ###
4.0"	66 - W2.9 x 2.9* 66 - W4.0 x 4.0*	3.342 3.325	2.681 2.631	10.287 14.025	8.218 11.026	### ###	### ###	### ###	### ###	### ###	### ###	395 ###

28 gage — 26 gage — 24 gage

concrete slabs on UF1X form deck - UNIFORM LOADS, PSF

Slab	Mesh	+d	-d	+M	-M	Spans, feet 2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'0"
3.0"	66 - W2.0 x 2.0* 66 - W2.9 x 2.9	1.000 1.000	1.500 1.500	2.075 2.954	3.155 4.520	### ###	260 371	181 257	133 189	102 145	80 114	65 93	54 77	45 64	
3.5"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.387 2.404 2.387	1.912 1.962 1.912	9.975 10.893 14.708	7.921 8.817 11.628	### ### ###	### ### ###	### ### ###	380 ### ###	291 324 ###	230 256 338	186 207 274	154 171 226	129 144 190	110 123 162
4.0"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.887 2.904 2.887	2.412 2.462 2.412	12.135 13.242 17.948	10.081 11.166 14.868	### ### ###	### ### ###	### ### ###	### ### ###	371 ### ###	293 324 ###	237 263 350	196 217 289	165 182 243	140 155 207
4.5"	44 - W2.9 x 2.9 44 - W4.0 x 4.0	3.404 3.387	2.962 2.912	15.591 21.188	13.515 18.108	### ###	### ###	### ###	### ###	### ###	393 ###	318 ###	263 352	221 296	188 252
5.0"	44 - W4.0 x 4.0	3.887	3.412	24.428	21.348	###	###	###	###	###	###	###	###	349	297
5.5"	44 - W4.0 x 4.0	4.387	3.912	27.688	24.588	###	###	###	###	###	###	###	###	###	342
6.0"	44 - W4.0 x 4.0	4.887	4.412	30.908	27.828	###	###	###	###	###	###	###	###	###	

26 gage — 24 gage — 22 gage — 20 gage

concrete slabs on UFX-36 form deck - UNIFORM LOADS, PSF

Slab	Mesh	+d	-d	+M	-M	Spans, feet 3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
3.0"	66 - W2.0 x 2.0* 66 - W2.9 x 2.9	0.844 0.844	1.500 1.500	1.738 2.465	3.155 4.520	111 158	85 121	67 95	55 77	45 64	 54	 40			
3.5"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.075 2.092 2.075	1.756 1.806 1.756	8.625 9.425 12.683	7.246 8.083 10.615	348 388 ###	266 297 390	210 235 308	170 190 250	141 157 206	118 132 173	101 113 148	86 97 127	75 84 111	66 74 97
4.0"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.575 2.592 2.575	2.256 2.306 2.256	10.785 11.774 15.923	9.406 10.432 13.855	### ### ###	346 384 ###	273 303 ###	221 245 326	183 203 269	154 170 226	131 145 193	112 125 166	98 109 144	86 95 127
4.5"	44 - W2.9 x 2.9 44 - W4.0 x 4.0	3.092 3.075	2.806 2.756	14.123 19.163	12.781 17.095	### ###	### ###	371 ###	301 ###	249 332	209 279	178 238	153 205	133 178	117 157
5.0"	44 - W4.0 x 4.0	3.575	3.256	22.403	20.335	###	###	###	###	395	332	283	244	212	186
5.5"	44 - W4.0 x 4.0	4.075	3.756	25.643	23.575	###	###	###	###	###	385	328	283	246	216
6.0"	44 - W4.0 x 4.0	4.575	4.256	28.883	26.815	###	###	###	###	###	###	373	321	280	

26 gage — 24 gage — 22 gage — 20 gage

C.6

Table from New Columbia Joist Company Steel Joist and Joist Girders manual 2002, Page 23
For a 21' span

STANDARD LOAD TABLE
FOR OPEN WEB STEEL JOISTS, K-SERIES

Based on a Maximum Allowable Tensile Stress of 30 ksi
Adopted by the Steel Joist Institute November 4, 1985;
Revised to May 1, 2000 – Effective August 1, 2002

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of K-Series Steel Joists. The weight of DEAD loads, including the joists, must be deducted to determine the LIVE load-carrying capacities of the joists. Sloped parallel-chord joists shall use span as defined by the length along the slope.

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

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

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

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$, where W_{LL} = RED figure in the Load Table and L = (Span - .33) in feet.

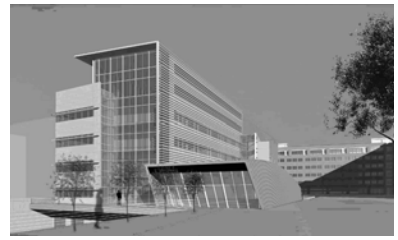
For the proper handling of concentrated and/or varying loads, see Section 5.5 in the Recommended Code of Standard Practice for Steel Joists and Joist Girders.

Where the joist span exceeds the unshaded area of the load table, the row of bridging nearest the mid-span shall be diagonal bridging with bolted connections at the chords and intersections.

STANDARD LOAD TABLE/OPEN WEB STEEL JOISTS, K-SERIES
Based on a Maximum Allowable Tensile Stress of 30 ksi

Joist Designation	8K1	10K1	12K1	12K3	12K5	14K1	14K3	14K4	14K6	16K2	16K3	16K4	16K5	16K6	16K7	16K9
Depth (in.)	8	10	12	12	12	14	14	14	14	16	16	16	16	16	16	16
Approx. Wt (lbs./ft.)	5.1	5.0	5.0	5.7	7.1	5.2	6.0	6.7	7.7	5.5	6.3	7.0	7.5	8.1	8.6	10.0
Span (ft.) ↓																
8	550 550															
9	550 550															
10	550 480	550 550														
11	532 377	550 542														
12	444 288	550 455	550 550	550 550	550 550											
13	377 225	479 363	550 510	550 510	550 510											
14	324 179	412 289	500 425	550 463	550 463	550 550	550 550	550 550	550 550							
15	281 145	358 234	434 344	543 428	550 434	511 475	550 507	550 507	550 507							
16	246 119	313 192	380 282	476 351	550 396	448 390	550 467	550 467	550 467	550 550	550 550	550 550	550 550	550 550	550 550	550 550
17		277 159	336 234	420 291	550 366	395 324	495 404	550 443	550 443	512 488	550 526	550 526	550 526	550 526	550 526	550 526
18		246 134	299 197	374 245	507 317	352 272	441 339	530 397	550 408	456 409	508 456	550 490	550 490	550 490	550 490	550 490
19		221 113	268 167	335 207	454 269	315 230	395 287	475 336	550 383	408 347	455 386	547 452	550 455	550 455	550 455	550 455
20		199 97	241 142	302 177	409 230	284 197	356 246	428 287	525 347	368 297	410 330	493 386	550 426	550 426	550 426	550 426
21			218 123	273 153	370 198	257 170	322 212	388 248	475 299	333 255	371 285	447 333	503 373	548 405	550 406	550 406
22			199 106	249 132	337 172	234 147	293 184	353 215	432 259	303 222	337 247	406 289	458 323	498 351	550 385	550 385
23			181 93	227 116	308 150	214 128	268 160	322 188	395 226	277 194	308 216	371 252	418 282	455 307	507 339	550 363
24			166 81	208 101	282 132	196 113	245 141	295 165	362 199	254 170	283 189	340 221	384 248	418 269	465 298	550 346
25						180 100	226 124	272 145	334 175	234 150	260 167	313 195	353 219	384 238	428 263	514 311
26						166 88	209 110	251 129	308 156	216 133	240 148	289 173	326 194	355 211	395 233	474 276
27						154 79	193 98	233 115	285 139	200 119	223 132	268 155	302 173	329 188	366 208	439 246
28						143 70	180 88	216 103	265 124	186 106	207 118	249 138	281 155	306 168	340 186	408 220
29										173 95	193 106	232 124	261 139	285 151	317 167	380 198
30										161 86	180 96	216 112	244 126	266 137	296 151	355 178
31										151 78	168 87	203 101	228 114	249 124	277 137	332 161
32										142 71	158 79	190 92	214 103	233 112	259 124	311 147

Timothy Mueller
Structural Option
Walter Schneider



FDA CDRH Laboratory
Silver, Spring Maryland

Appendix D
Alternative 4

Two-Way Concrete System

For my fourth alternative I chose to use the material of the current structure (concrete), however, I am going to try an alternative 2-way system. I used the CRSI 2002 edition to find the slab information needed.

Each bay was designed separately due to the different sizes using chapter 10 (two-way systems) of the CRSI manual. Each span may also have different loading conditions depending on the allowed live load reduction.

Each slab had to be looked at as if were square due to the 2-way system being used for equal widths and depths. I will go over the each bay by it largest length to ensure that they system will hold the required loading.

For the 30'-9" span

The bay is considered 31' X 31' external

Live load reduction (from ASCE7-02 equation 4-1)

$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

$K_{LL} = 1$ (from ASCE7-02 table 4-2)

$A_T = 30.75 \times 21 = 645.75$ sq ft

$K_{LL}A_T$ is greater then 400 sq ft therefore live load reduction can be used

$L=(125psf)(0.25 + 15/\sqrt{(1 \times 645.75)}) = 105psf$

Live load with reduction 105psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(105psf) = 213.5psf

Using page 10-25 (Appendix D.6) of the CRSI I found the following characteristics needed to support this span with a load of 213.5psf:

Drop panels with a 9.00" depth by 10.33' width.
Columns that are 24" square
Column Strip Reinforcement:

Top External:	17-#5
Bottom:	18-#8
Top Internal:	14-#8

Middle Strip Reinforcement:

Bottom:	12-#8
Top Internal:	13-#7

The load limit of 300psf greatly exceeds the required strength of 213.5psf.

Total Depth: 19.5"
Slab Depth: 10.5"
Drop Panel Depth: 9"

Weight per bay = (Area of concrete structure)(150pcf)
Area slab = (10.5")(30'-9")(21')=565cf
Area drop panels = (9")(10.33')(10.33')=80cf
Total Area = 565cf+80cf=645cf
Weight per bay
=(645pcf)(150pcf)=96750lbs=96.75k

For the 18' span

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

K_{LL} = 1 (from ASCE7-02 table 4-2)

A_T = 15.4167 × 21 = 323.75 sq ft

$K_{LL}A_T$ is less then 400 sq ft therefore live load reduction can not be used

Live load is 125psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(125psf) = 247.5psf

The bay size is considered 21' X 21' external (Due to the depth being shorter then the width of 21')

Using page 10-11 (Appendix D.4) of the CRSI I found the following characteristics needed to support this span with a load of 247.5psf:

Drop panels with a 6.00" depth by 7.00' width.
Columns that are 19" square
Column Strip Reinforcement:

Top:	14-#5
Bottom:	19-#4

Middle Strip Reinforcement:

Top:	14-#4
Bottom:	12-#4

The load limit of 300psf greatly exceeds the required strength of 247.5psf.

The total depth of this slab system is :

Total Depth: 13"

Slab Depth: 7"

Drop Panel Depth: 6"

Weight per bay = (Area of concrete structure)(150pcf)

Area slab = (7")(18')(21')=220.5cf

Area drop panels = (6")(7')(7')=24.5cf

Total Area = 220.5cf+24.5cf=245cf

Weight per bay
=(245pcf)(150pcf)=36750lbs=36.75k

For the 15'-5" span

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

K_{LL} = 1 (from ASCE7-02 table 4-2)

A_T = 18 × 21 = 378 sq ft

$K_{LL}A_T$ is less then 400 sq ft therefore live load reduction can not be used

Live load is 125psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(125psf) = 247.5psf

The bay size is considered 21' X 21' internal (Due to the depth being shorter then the width of 21')

Using page 10-11 (Appendix D.5) of the CRSI I found the following characteristics needed to support this span with a load of 247.5psf:

Drop panels with a 6.00" depth by 7.00' width.
Columns that are 16" square
Column Strip Reinforcement:
Top External: 12-#4
Bottom: 19-#5
Top Internal: 22-#4
Middle Strip Reinforcement:
Bottom: 19-#4
Top Internal: 16-#4

The load limit of 300psf exceeds the required strength of 247.5psf.

Total Depth: 13"
Slab Depth: 7"
Drop Panel Depth: 6"

Weight per bay = (Area of concrete structure)(150pcf)
Area slab = (7")(15'-5")(21')=189cf
Area drop panels = (6")(7')(7')=24.5cf
Total Area = 189cf+24.5cf=213.5cf
Weight per bay
=(213.5pcf)(150pcf)=32025lbs=32.025cf

As one can guess the worst case is the largest span with a total depth of 19.5" and total weight of 96.75k. Both the other bays were over a half foot shallower with a depth of only 13" as well as almost one third the weight (averaging around 35k). Although the smaller spans will not be looked at further in this design, they can be used to compare how making a bay contain smaller spans can allow for a lower total floor sandwich depth and a much lower weight.

Table from CRSI 2002, Page 10-11
For the 18' span

f'_c = 4,000 psi, Grade 60 Bars

FLAT SLAB SYSTEM — SQUARE EDGE PANEL With Drop Panels, No Beams / SQUARE INTERIOR PANEL With Drop Panels(2), No Beams

Square Edge Panel — h = 7 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.)	γ_f	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)
19	100	3.00	6.33	12	0.697	11-#4	0	11-#4	12-#4	13-#3	10-#4	1.73	44.8	89.6	120.7
19	200	4.00	6.33	14	0.638	11-#4	0	16-#4	16-#4	11-#4	10-#4	2.21	63.1	126.2	169.9
19	300	5.00	6.33	15	0.650	11-#4	1	21-#4	12-#5	9-#5	12-#4	2.74	81.5	163.0	219.4
19	400	6.00	7.60	17	0.636	11-#4	2	19-#5	13-#5	12-#5	14-#4	3.42	99.8	214.0	268.6
20	100	3.00	6.67	12	0.791	12-#4	2	13-#4	14-#4	15-#3	10-#4	1.84	52.6	105.1	141.5
20	200	4.00	6.67	14	0.777	12-#4	3	19-#4	12-#5	12-#4	11-#4	2.39	74.1	148.3	199.6
20	300	5.00	6.67	16	0.711	12-#4	2	16-#5	14-#5	16-#4	13-#4	2.97	94.9	189.9	255.6
20	400	6.00	8.00	18	0.673	12-#4	2	11-#7	16-#5	13-#5	11-#5	3.68	116.3	233.6	313.2
21	100	4.00	7.00	12	0.754	12-#4	2	10-#5	15-#4	10-#4	11-#4	1.96	61.3	122.6	165.1
21	200	5.00	7.00	14	0.761	12-#4	4	22-#4	19-#4	10-#5	12-#4	2.60	86.5	173.0	232.9
21	300	6.00	7.00	16	0.675	12-#4	2	19-#5	22-#4	19-#4	16-#4	3.24	110.9	221.7	298.4
21	400	6.00	8.40	20	0.666	13-#4	2	17-#6	18-#5	15-#5	19-#4	4.01	134.0	268.0	360.8

Square Interior Panel — h = 7 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)
19	100	12	11-#4	13-#3	10-#4	14-#3	1.64	0.611
19	200	16	14-#4	11-#4	10-#4	14-#3	1.97	0.620
19	300	18	11-#5	9-#5	11-#4	9-#4	2.42	0.630
19	400	19	12-#5	12-#5	13-#4	12-#4	2.91	0.663
20	100	12	13-#4	9-#4	10-#4	14-#3	1.72	0.611
20	200	16	17-#4	13-#4	10-#4	15-#3	2.12	0.620
20	300	19	19-#4	16-#4	12-#4	11-#4	2.58	0.630
20	400	20	14-#5	13-#5	10-#5	13-#4	3.12	0.663
21	100	12	14-#4	10-#4	11-#4	15-#3	1.77	0.620
21	200	16	12-#5	15-#4	11-#4	10-#4	2.28	0.630
21	300	19	14-#5	19-#4	14-#4	12-#4	2.79	0.639
21	400	21	25-#4	15-#5	12-#5	10-#5	3.47	0.663

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

Table from CRSI 2002, Page 10-11
For the 15'-5" span

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)	Square Column (3) Size (in.)	Square Column (3) γ_f	Reinforcing Bars (E. W.) Column Strip (1) Top Ext.	Column Strip (1) +	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)
						h = 7 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS									
19	100	3.00	6.33	12	0.697	11-#4	0	11-#4	12-#4	13-#3	10-#4	1.73	44.8	89.6	120.7
19	200	4.00	6.33	14	0.638	11-#4	0	16-#4	16-#4	11-#4	10-#4	2.21	63.1	126.2	169.9
19	300	5.00	6.33	15	0.650	11-#4	1	21-#4	12-#5	9-#5	12-#4	2.74	81.5	163.0	219.4
19	400	6.00	7.60	17	0.636	11-#4	2	19-#5	13-#5	12-#5	14-#4	3.42	99.8	214.0	268.6
20	100	3.00	6.67	12	0.791	12-#4	2	13-#4	14-#4	15-#3	10-#4	1.84	52.6	105.1	141.5
20	200	4.00	6.67	14	0.777	12-#4	3	19-#4	12-#5	12-#4	11-#4	2.39	74.1	148.3	199.6
20	300	5.00	6.67	16	0.711	12-#4	2	16-#5	14-#5	16-#4	13-#4	2.97	94.9	189.9	255.6
20	400	6.00	8.00	18	0.673	12-#4	2	11-#7	16-#5	13-#5	11-#5	3.68	116.3	233.6	313.2
21	100	4.00	7.00	12	0.754	12-#4	2	10-#5	15-#4	10-#4	11-#4	1.96	61.3	122.6	165.1
21	200	5.00	7.00	14	0.761	12-#4	4	22-#4	19-#4	10-#5	12-#4	2.60	86.5	173.0	232.9
21	300	6.00	7.00	16	0.675	12-#4	2	19-#5	22-#4	19-#4	16-#4	3.24	110.9	221.7	298.4
21	400	6.00	8.40	20	0.666	13-#4	2	17-#6	18-#5	15-#5	19-#4	4.01	134.0	268.0	360.8

SQUARE INTERIOR PANEL

With Drop Panels(2) — No Beams

SPAN (ft)	Factored Superimposed Load (psf)	Square Column (3) 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 = 7 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS						
19	100	12	11-#4	13-#3	10-#4	14-#3	1.64	0.611
19	200	16	14-#4	11-#4	10-#4	14-#3	1.97	0.620
19	300	18	11-#5	9-#5	11-#4	9-#4	2.42	0.630
19	400	19	12-#5	12-#5	13-#4	12-#4	2.91	0.663
20	100	12	13-#4	9-#4	10-#4	14-#3	1.72	0.611
20	200	16	17-#4	13-#4	10-#4	15-#3	2.12	0.620
20	300	19	19-#4	16-#4	12-#4	11-#4	2.58	0.630
20	400	20	14-#5	13-#5	10-#5	13-#4	3.12	0.663
21	100	12	14-#4	10-#4	11-#4	15-#3	1.77	0.620
21	200	16	12-#5	15-#4	11-#4	10-#4	2.28	0.630
21	300	19	14-#5	19-#4	14-#4	12-#4	2.79	0.639
21	400	21	25-#4	15-#5	12-#5	10-#5	3.47	0.663

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

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM

SQUARE EDGE PANEL With Drop Panels
No Beams

h = 10.5 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.)	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)
26	100	6.00	8.67	12	0.760	12-#5 2	15-#5	15-#5	10-#5	10-#5	2.46	151.6	303.2	408.1
26	200	6.00	8.67	15	0.798	12-#5 4	11-#7	14-#6	13-#5	11-#5	3.08	198.2	396.4	533.6
26	300	7.50	8.67	18	0.679	12-#5 2	18-#6	12-#7	9-#7	10-#6	3.83	244.7	489.4	658.8
26	400	9.00	8.67	20	0.632	12-#5 2	16-#7	13-#7	14-#6	9-#7	4.39	291.2	582.3	783.9
26	500	9.00	10.40	22	0.707	14-#5 2	12-#9	12-#8	12-#7	10-#7	5.17	336.6	673.1	906.1
26	600	9.00	10.40	26	0.701	16-#5 3	17-#8	13-#8	9-#9	9-#8	6.00	379.8	772.7	1022.5
27	100	6.00	9.00	12	0.797	12-#5 3	9-#7	12-#6	12-#5	10-#5	2.66	170.3	340.6	458.5
27	200	7.50	9.00	16	0.651	12-#5 1	12-#7	20-#5	15-#5	9-#6	3.25	222.6	445.2	599.3
27	300	9.00	9.00	18	0.634	12-#5 2	15-#7	12-#7	10-#7	11-#6	3.96	274.9	549.8	740.1
27	400	9.00	9.00	20	0.741	14-#5 4	14-#8	12-#8	9-#8	10-#7	4.88	327.9	655.8	882.8
27	500	9.00	10.80	25	0.694	16-#5 3	13-#9	13-#8	9-#9	15-#6	5.70	375.4	750.8	1010.7
28	100	7.50	9.33	12	0.750	13-#5 2	19-#5	18-#5	13-#5	11-#5	2.74	191.0	382.0	514.2
28	200	7.50	9.33	16	0.767	13-#5 4	18-#6	16-#6	12-#6	10-#6	3.50	249.3	498.5	671.1
28	300	9.00	9.33	18	0.745	13-#5 5	13-#8	26-#5	11-#7	17-#5	4.32	308.1	616.1	829.4
28	400	9.00	11.20	23	0.722	15-#5 4	13-#9	16-#7	10-#8	11-#7	5.20	365.1	730.3	983.1
28	500	9.00	11.20	28	0.644	17-#5 2	18-#8	14-#8	12-#8	10-#8	5.95	415.8	831.6	1119.4
29	100	7.50	9.67	12	0.787	13-#5 3	22-#5	14-#6	10-#6	12-#5	2.88	212.8	425.5	572.8
29	200	9.00	9.67	16	0.702	13-#5 3	15-#7	23-#5	10-#7	11-#6	3.67	277.7	555.4	747.6
29	300	9.00	9.67	19	0.763	14-#5 5	12-#9	15-#7	10-#8	19-#5	4.75	342.7	685.5	922.7
29	400	9.00	11.60	25	0.702	17-#5 3	14-#9	14-#8	12-#8	10-#8	5.68	405.3	810.5	1091.1
30	100	9.00	10.00	12	0.722	14-#5 1	17-#6	14-#6	16-#5	13-#5	3.00	236.8	473.6	637.6
30	200	9.00	10.00	16	0.763	14-#5 4	13-#8	18-#6	11-#7	17-#5	3.99	308.5	617.1	830.7
30	300	9.00	10.00	22	0.691	16-#5 3	13-#9	17-#7	18-#6	15-#6	5.07	377.6	755.2	1016.6
30	400	9.00	12.00	28	0.700	18-#5 5	16-#9	15-#8	10-#9	18-#6	5.96	444.1	888.3	1195.7
31	100	9.00	10.33	12	0.777	14-#5 3	11-#8	16-#6	13-#6	15-#5	3.29	261.9	523.8	705.1
31	200	9.00	10.33	18	0.749	14-#5 5	12-#9	15-#7	12-#7	19-#5	4.29	339.6	679.2	914.3
31	300	9.00	10.33	24	0.731	17-#5 6	18-#8	14-#8	12-#8	13-#7	5.38	416.0	832.0	1120.0
31	400	9.00	12.40	31	0.697	14-#6 4	17-#9	14-#9	11-#9	12-#8	6.43	483.9	967.9	1302.9

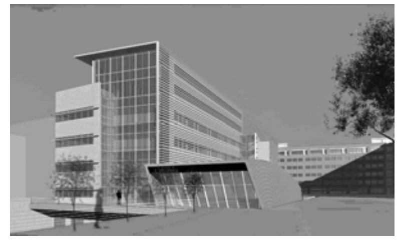
SQUARE INTERIOR PANEL

With Drop Panels[2]
No Beams

h = 10.5 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS

SPAN (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 $\left(\frac{\text{cu. ft}}{\text{sq. ft}}\right)$
26	100	12	14-#5	10-#5	10-#5	10-#5	2.29	0.931
26	200	18	18-#5	13-#5	10-#5	10-#5	2.67	0.931
26	300	21	15-#6	9-#7	9-#6	11-#5	3.39	0.944
26	400	23	12-#7	14-#6	15-#5	13-#5	3.82	0.958
26	500	26	26-#5	12-#7	10-#7	15-#5	4.41	0.995
26	600	26	12-#8	11-#8	11-#7	18-#5	5.19	0.995
27	100	12	16-#5	12-#5	10-#5	10-#5	2.40	0.931
27	200	18	14-#6	15-#5	12-#5	10-#5	2.85	0.944
27	300	22	15-#6	13-#6	10-#6	12-#5	3.40	0.958
27	400	23	18-#6	9-#8	9-#7	15-#5	4.24	0.958
27	500	26	12-#8	11-#8	14-#6	9-#7	4.93	0.995
28	100	12	16-#5	13-#5	11-#5	11-#5	2.48	0.944
28	200	18	15-#6	12-#6	13-#5	11-#5	3.07	0.944
28	300	22	13-#7	21-#5	16-#5	10-#6	3.75	0.958
28	400	24	15-#7	18-#6	10-#7	12-#6	4.51	0.995
28	500	27	13-#8	12-#8	12-#7	10-#7	5.25	0.995
29	100	12	18-#5	14-#5	11-#5	11-#5	2.52	0.944
29	200	19	15-#6	19-#5	10-#6	12-#5	3.13	0.958
29	300	22	26-#5	17-#6	10-#7	15-#5	4.01	0.958
29	400	24	13-#8	12-#8	12-#7	18-#5	4.95	0.995
30	100	12	18-#5	16-#5	12-#5	11-#5	2.57	0.958
30	200	19	17-#6	21-#5	16-#5	10-#6	3.43	0.958
30	300	22	16-#7	11-#8	14-#6	12-#6	4.48	0.958
30	400	26	14-#8	10-#9	10-#8	20-#5	5.16	0.995
31	100	12	20-#5	18-#5	14-#5	12-#5	2.77	0.958
31	200	19	26-#5	23-#5	13-#6	15-#5	3.60	0.958
31	300	22	17-#7	21-#6	12-#7	19-#5	4.68	0.958
31	400	29	16-#8	11-#9	11-#8	12-#7	5.65	0.995

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.



Appendix E
Alternative 5

One-Way Concrete System

The fifth comparison that I did was a comparison using my current floor system (one-way slab) with a new spacing. I used the CRSI 2002 to find the slab requirements. Each bay was designed separately due to the different sizes using chapter 8 (one-way systems) of the CRSI manual. Each span may also have different loading conditions depending on the allowed live load reduction.

Each slab will have a l_n of 1' less then the length of the actual span due an assumed square column of 12" (6" from each column supporting the beam).

For the 30'-9" span

The bay is considered 30' exterior clear span

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$
$K_{LL} = 1$ (from ASCE7-02 table 4-2)
$A_T = 30.75 \times 21 = 645.75$ sq ft
$K_{LL}A_T$ is greater then 400 sq ft therefore live load reduction can be used
$L=(125psf)(0.25 + 15/\sqrt{(1 \times 645.75)}) = 105psf$

Live load with reduction 105psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(105psf) = 213.5psf

Using page 8-30 (Appendix E.10) of the CRSI, I found the following characteristics needed to support this span with a load of 213.5psf:

30" forms
7" ribs width
16" rib depth
37" center to center distance
4.5" slab depth
Reinforcement:
Top bars: #5 @ 8"
Bottom bars: 2-#7

Using page 8-2 (Appendix E.9) of the CRSI, the following welded wire fabric should be placed with the larger diameter wires placed normal to the span of the joints.
4X12-W3.5XW2

The load limit of 260psf exceeds the required strength of 213.5psf.

There is no need for deflection limitation calculations due to the chosen values being above the deflection line on the table.

Total Depth: 20.5"
Slab Depth: 4.5"
Rib Depth: 16"

Total Weight of slab and joists= (Square area of slab)(weight from CRSI page 8-13) (Appendix E.14).
=(30.75')(21')(101psf)=6522075lbs=65.22k

For the 18' span

The bay is considered 17' interior clear span

Live load reduction (from ASCE7-02 equation 4-1)
$L = L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$
K_{LL} = 1 (from ASCE7-02 table 4-2)
A_T = 18 × 21 = 378 sq ft
$K_{LL}A_T$ is less then 400 sq ft therefore live load reduction can not be used

Live load is 125psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(125psf) = 247.5psf

Using page 8-14 (Appendix E.11) of the CRSI, I found the following characteristics needed to support this span with a load of 247.5psf:

20" forms
5" ribs width
8" rib depth
25" center to center distance
3" slab depth
Reinforcement:
Top bars: #4 @ 10"
Bottom bars: 1-#3, 1-#4

Using page 8-2 (Appendix E.9) of the CRSI, the following welded wire fabric should be placed with the larger diameter wires placed normal to the span of the joints.
4X12-W2.1XW1.4

The load limit of 273psf exceeds the required strength of 247.5psf.

There is no need for deflection limitation calculations due to the chosen values being above the deflection line on the table.

Slab Depth: 3"
Rib Depth: 8"

Total Depth: 11"

Total Weight of slab and joists= (Square area of slab)(weight from CRSI page 8-13) (Appendix E.15)
=(18')(21')(60psf)=22680lbs=22.68k

For the 15'-5" span

The bay is considered 15' exterior clear span

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

K_{LL} = 1 (from ASCE7-02 table 4-2)

A_T = 15.4167 × 21 = 323.75 sq ft

$K_{LL}A_T$ is less then 400 sq ft therefore live load reduction can not be used

Live load is 125psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(125psf) = 247.5psf

Using page 8-14 (Appendix E.12) of the CRSI, I found the following characteristics needed to support this span with a load of 247.5psf:

20" forms
5" ribs width
8" rib depth
25" center to center distance
3" slab depth
Reinforcement:

Top bars:	#4 @ 8"
Bottom bars:	2-#4

Using page 8-2 (Appendix E.9) of the CRSI, the following welded wire fabric should be placed with the larger diameter wires placed normal to the span of the joints.
4X12-W2.1XW1.4

The load limit of 321psf exceeds the required strength of 247.5psf.

There is no need for deflection limitation calculations due to the chosen values being above the deflection line on the table.

Slab Depth: 3"
Rib Depth: 8"

Total Depth: 11"

Total Weight of slab and joists= (Square area of slab)(weight from CRSI page 8-13) (Appendix E.16)
=(15'-5")(21')(60psf)=19425lbs=19.425k

I also made a comparison using my current floor system (one-way slab) with a new spacing and a new direction for the 30'-9" bay. By making the floor span in the 21' direction, I will be able to reduce the depth of the concrete, however, this will cause for discontinuity between each spans direction of span. I used the CRSI 2002 to find the slab requirements.

Each slab will have a l_n of 1' less then the length of the actual span due an assumed square column of 12" (6" from each column supporting the beam).

For the 21’ span

The bay is considered 20’ exterior clear span

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

$K_{LL} = 1$ (from ASCE7-02 table 4-2)

$A_T = 30.75 \times 21 = 645.75$ sq ft

$K_{LL}A_T$ is greater then 400 sq ft therefore live load reduction can be used

$L=(125psf)(0.25 + 15/\sqrt{(1 \times 645.75)}) = 105psf$

Live load with reduction 105psf

Dead load = superimposed dead load = 25psf

Total Load = 1.4 Dead + 1.7 Live (due to the use of 2002 CRSI manual)
= 1.4 (25psf) + 1.7(105psf) = 213.5psf

Using page 8-30 (Appendix E.10) of the CRSI, I found the following characteristics needed to support this span with a load of 213.5psf:

20” forms
5” ribs width
8” rib depth
25” center to center distance
3” slab depth
Reinforcement:
Top bars: #5 @ 10”
Bottom bars: 2-#5

Using page 8-2 (Appendix E.9) of the CRSI, the following welded wire fabric should be placed with the larger diameter wires placed normal to the span of the joints.
4X12-W2.1XW1.4

The load limit of 233psf exceeds the required strength of 213.5psf.

Due to the chosen values location below the deflection limitation line, a deflection limitation calculation did have to be performed using the following equation:

Thickness $\geq l_n/18.5$

l_n=20’
$3 \geq (20/18.5)=1.081$
This is true, therefore deflection is satisfactory

Slab Depth: 3”
Rib Depth: 8”

Total Depth: 11”

Total Weight of slab and joists= (Square area of slab)(weight from CRSI page 8-13) (Appendix E.17)
=(30.75’)(21’)(60psf)=38745lbs=38.745k

The longest span does have the largest depth and load, therefore it is the critical beam and will be the beam used for comparison in the main report, however, it will be compared in both spanning directions due to the fact that by changing the spanning direction the weight of the slab and joists, as well as the depth was reduced by about one half. Although the two smaller spans are not being compared, the 21' spanning direction does allow for a good understanding of how these shorter spans will reduce weight as well as depth a great deal compared to the larger span.

The next element that needed to be designed was the girders. By looking at the two worst cases (both span directions of the 30'-9" bay) a good picture of how changing the span direction will greatly effect the girder size and weight. Also this smaller span will give a good example of what the girders for the smaller bays will be.

Girder Designs (for the 2 worst cases—30'9" X 21' and 21' X 30'9")

Long span design (30'-9" X 21')

The girder has a 30'-9" X 21' tributary width

Live load reduction (from ASCE7-02 equation 4-1)

$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$

$K_{LL} = 1$ (from ASCE7-02 table 4-2)

$A_T = 30.75 \times 21 = 645.75$ sq ft

$K_{LL}A_T$ is greater then 400 sq ft therefore live load reduction can be used

$L=(125psf)(0.25 + 15/\sqrt{(1 \times 645.75)}) = 105psf$

Live load with reduction 105psf

$w_u = 1.2\ (62.55psf+25psf) + (1.6)(105psf) = 314.1psf$

$W_u = (314.1psf)(21') = 6596.1plf = 6.6klf$

Girder is spanning 30'-9"-(2(6")=29'-9"

$$M_u = \frac{W_u L^2}{8} = \frac{(6.6klf)(30'\text{-}9")^2}{8} = 780.1'k$$

$f'_C = 4ksi$

$f_y = 60ksi$

$\rho=0.6\rho_{max} = 0.6(0.0206) = 0.0124$ (for tension controlled section)

$d= 20.5"-2.5"=18"$

$M_u \leq \Phi M_n = \Phi\rho bd^2 f_y(1\text{-}059\rho(f_y/f'_C))$

$780.1'k=0.9(0.0124)(bd^2)(60ksi)(1\text{-}0.59(0.0124)(60ksi/4ksi))(1'/12")$

$bd^2=15703.6$

$d=18"$

$b= 48.5"$

$h= 20.5"$

$W_{u\ beam}= (1.2)(48.5")(20.5")(150pcf)/(144in^2/1ft^2)= 1242.8plf = 1.24klf$

$$M_{u\ beam}= 780.1'k + \frac{(1.24klf)(30'9")^2}{8} = 926.66'k$$

Steel Design

$M_u \leq \Phi A_s d f_y(1\text{-}059\rho(f_y/f'_C))$
926.66'k=0.9A_s(18")(60ksi)(1-0.59(0.0124)(60ksi/4ksi))(1'/12")
A_s=12.85in^2
Use 6#14 (A_s=13.5in^2)

Deflection Check

I= (1/12)(bh^3) = (1/12)(48.5")$(20.5")^3$ = 34819.46in^4

W_u = 6.6klf+1.24klf=7.84klf (1'/12")=0.653k/in=653lb/in

E=3.6 X 10^6psi
Δ≤L/240
Δ≤(30.75')(12"/1')/240=1.5"

$\Delta = \frac{5W_u L^4}{384EI}$ = ((5)(653lb/in)(30.75')^4)/((384)(3.6 X 10^6psi)(5102in^4))=0.000000014"

0.000000014"≤1.5"
Beam is more then adiquite for deflection

Assume each column is 12" then beams are spanning length-1'

Weight of beam:
Weight of beam=(area of beam)(150pcf)
=(29'-9")(20.5")(48.5")(150pcf)=30811.4lbs=30.8k (long span)
=(20')(20.5")(48.5")(150pcf)=20713.54lbs=20.7k (short span)

Total Weight of bay (assuming 1/2 of a beam on each side)
=(weight of 2(1/2) beams) + (weight of 2(1/2) beams) + (wieght of slab and joists)
=30.8k + 20.7k + 65.22k=116.72k

Short span design (21' X 30'-9")

The girder has a 24'-4.5" X 21' tributary width
Tributary width was found by: ((30'-9"+18")/2) X 21'

Live load reduction (from ASCE7-02 equation 4-1)
$L=L_o(0.25 + 15/\sqrt{(K_{LL}A_T)})$
K_{LL} = 1 (from ASCE7-02 table 4-2)
A_T = 24.375 × 21 = 511.875 sq ft
$K_{LL}A_T$ is greater then 400 sq ft therefore live load reduction can be used
L=(125psf)(0.25 + 15/√(1 × 511.875)) = 114psf

Live load with reduction 114psf

w_u = 1.2 (38.745psf+25psf) + (1.6)(105psf) = 244.494psf

W_u = (244.494psf)(24'-4.5") = 5959.5plf = 6.0klf

$M_u = \frac{W_u L^2}{8} = \frac{(6.0klf)(21')^2}{8}$ = 330.75'k

f'_C= 4ksi
f_y= 60ksi
ρ=0.6ρ_{max} = 0.6(0.0206) = 0.0124 (for tension controlled section)
d= 11"-2.5"=8.5"

$M_u \leq \Phi M_n$ $^{=}$ $\Phi \rho bd^2 f_y(1\text{-}059\rho(f_y/f'_C))$

330.75'k=0.9(0.0124)(bd^2)(60ksi)(1-0.59(0.0124)(60ksi/4ksi))(1'/12")
bd^2=6658
d=8.5"
b= 92.2"
h= 11"

$W_{u\ beam}$= (1.2)(92.2")(11")(150pcf)/(144in^2/1ft^2)=1267.75plf=1.27klf

$M_{u\ beam}$= 330.75'k + $\underline{(1.27klf)(21')^2}$ = 400.76'k

Steel Design

$M_u \leq \Phi A_s d f_y(1\text{-}059\rho(f_y/f'_C))$
400.76'k=0.9A_s(18")(60ksi)(1-0.59(0.0124)(60ksi/4ksi))(1'/12")
A_s=5.56in^2
Use 6#9 (A_s=6in^2)

Deflection Check

I= (1/12)(bh^3) = (1/12)(99.2")(11")^3 = 11002.93in^4

W_u = 6.0klf+1.27klf=7.27klf (1'/12")=0.605k/in=605lb/in

E=3.6 X 10^{6}psi
$\Delta \leq$L/240
$\Delta \leq$(21')(12"/1')/240=1.05"

$\Delta = \frac{5W_u L^4}{384EI}$ = ((5)(605lb/in)(21')^4)/((384)(3.6 X 10^{6}psi)(11002.93in^4))=0.00003868"

0.00003868"$\leq$1.05"
Beam is more then adiquite for deflection.3

Assume each column is 12" then beams are spanning length-1'

Weight of beam:
Weight of beam=(area of beam)(150pcf)
=(20')(11")(92.2")(150pcf)=21129.167lbs=21.1k (short span)
=(29.9')(11")(92.9")(150pcf)=31827.93lbs=31.8k (Long span)

Total Weight of bay (assuming 1/2 of a beam on each side)
=(weight of 2(1/2) beams) + (weight of 2(1/2) beams) + (wieght of slab and joists)
=21.1k+ 31.8k + 38.745k =91.645k

Tables from CRSI 2002, Page 8-2
For all spans

Top Slab Thickness (In.)	Bars Grade 60	Welded Wire Fabric***	
		One Way**	Square
2½	#3@12*	4 X 12-W2.1 X W1.4	6 X 6-W2.9 X W2.9
3	#3@15*	4 X 12-W2.1 X W1.4	6 X 6-W4 X W4
3½	#3@17	4 X 12-W2.5 X W1.4	6 X 6-W4 X W4
4	#3@15	4 X 12-W3 X W2	4 X 4-W2.9 X W2.9
4½	#3@12	4 X 12-W3.5 X W2	4 X 4-W3.5 X W3.5

* Maximum spacing permitted by ACI 7.12.2.2 (5 times slab thickness ≤ 18 in.)
** Larger diameter wires are to be placed *normal* to span of the joists.
*** Commonly available wire sizes.

For the 30'-9" span

Top Slab Thickness (In.)	Bars Grade 60	Welded Wire Fabric***	
		One Way**	Square
2½	#3@12*	4 X 12-W2.1 X W1.4	6 X 6-W2.9 X W2.9
3	#3@15*	4 X 12-W2.1 X W1.4	6 X 6-W4 X W4
3½	#3@17	4 X 12-W2.5 X W1.4	6 X 6-W4 X W4
4	#3@15	4 X 12-W3 X W2	4 X 4-W2.9 X W2.9
4½	#3@12	4 X 12-W3.5 X W2	4 X 4-W3.5 X W3.5

* Maximum spacing permitted by ACI 7.12.2.2 (5 times slab thickness ≤ 18 in.)
** Larger diameter wires are to be placed *normal* to span of the joists.
*** Commonly available wire sizes.

Top Slab Thickness (In.)	Bars Grade 60	Welded Wire Fabric***	
		One Way**	Square
2½	#3@12*	4 X 12-W2.1 X W1.4	6 X 6-W2.9 X W2.9
3	#3@15*	4 X 12-W2.1 X W1.4	6 X 6-W4 X W4
3½	#3@17	4 X 12-W2.5 X W1.4	6 X 6-W4 X W4
4	#3@15	4 X 12-W3 X W2	4 X 4-W2.9 X W2.9
4½	#3@12	4 X 12-W3.5 X W2	4 X 4-W3.5 X W3.5

* Maximum spacing permitted by ACI 7.12.2.2 (5 times slab thickness ≤ 18 in.)
** Larger diameter wires are to be placed *normal* to span of the joists.
*** Commonly available wire sizes.

For the 18' span

For the 15'-5" span

Top Slab Thickness (In.)	Bars Grade 60	Welded Wire Fabric***	
		One Way**	Square
2½	#3@12*	4 X 12-W2.1 X W1.4	6 X 6-W2.9 X W2.9
3	#3@15*	4 X 12-W2.1 X W1.4	6 X 6-W4 X W4
3½	#3@17	4 X 12-W2.5 X W1.4	6 X 6-W4 X W4
4	#3@15	4 X 12-W3 X W2	4 X 4-W2.9 X W2.9
4½	#3@12	4 X 12-W3.5 X W2	4 X 4-W3.5 X W3.5

* Maximum spacing permitted by ACI 7.12.2.2 (5 times slab thickness ≤ 18 in.)
** Larger diameter wires are to be placed *normal* to span of the joists.
*** Commonly available wire sizes.

For the 21' direction of the 30'-9" span

Table from CRSI 2002, Page 8-30
For the 30'-9" span

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	1.93	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
27'-0"	118 0	171 0	225 0	289 0	346* 354	6.576	170 0	236 0	313 0	391 0	406* 485	4.047
28'-0"	100 0	149 0	199 0	259 0	319 0	7.606	148 0	210 0	281 0	354 0	382* 441	4.681
29'-0"	83 0	129 0	176 0	232 0	288 0	8.752	128 0	186 0	253 0	320 0	360* 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	340* 366	6.168
31'-0"	55 0	95 0	136 0	185 0	235 0	11.428	94 0	145 0	203 0	263 0	321* 334	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	7.985
33'-0"		68 0	103 0	147 0	190 0	14.675	67 0	111 0	163 0	215 0	278 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	10.176
35'-0"		44 0	76 0	115 0	153 0	18.569	43 0	83 0	129 0	175 0	231 0	11.427
36'-0"			64 0	100 0	137 0	20.784		71 0	114 0	158 0	211 0	12.790
37'-0"			53 0	88 0	122 0	23.191		59 0	100 0	142 0	192 0	14.272
38'-0"			43 0	76 0	109 0	25.802		49 0	88 0	127 0	175 0	15.878
39'-0"				65 0	96 0	28.627			76 0	114 0	159 0	17.617
40'-0"				54 0	84 0	31.678			65 0	101 0	144 0	19.494

(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	1.04	1.21	1.43	1.71	
STEEL % (UNIFORM)	.45	.53	.63	.77	.87		.50	.63	.73	.87	1.04	
(TAPERED)	.28	.33	.40	.49	.55		.31	.40	.46	.55	.66	
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	1.04	
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	.240	

Table from CRSI 2002, Page 8-14
For the 18' span

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

TOP BARS Size @	# 4 12	# 4 10.5	# 4 8	# 5 10	# 6 11	End Span Defl. Coeff. (3)	# 4 12	# 4 10	# 5 11.5	# 5 9		Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5		
Steel (psf)	.63	.79	1.01	1.25	1.54		.65	.82	1.11	1.39		
CLEAR SPAN	END SPAN						INTERIOR SPAN					
11'-0"	502 / 0	567* / 670	597* / 868	623* / 900*		.122						
12'-0"	409 / 0	496* / 550	521* / 716	540* / 791*	570* / 820*	.173						
13'-0"	336 / 0	437* / 456	456* / 597	471* / 700*	495* / 723*	.239						
14'-0"	278 / 0	381 / 0	405* / 503	417* / 627	436* / 646*	.321	293 / 0	442 / 0	454* / 593	468* / 715*		.198
15'-0"	231 / 0	321 / 0	363* / 428	372* / 535	388* / 583*	.423	244 / 0	375 / 0	410* / 506	422* / 650*		.260
16'-0"	193 / 0	272 / 0	327* / 368	335* / 460	348* / 529*	.548	205 / 0	319 / 0	373* / 434	383* / 570		.337
17'-0"	161 / 0	231 / 0	297* / 314	304* / 398	315* / 484*	.698	172 / 0	273 / 0	341* / 375	349* / 495		.430
18'-0"	135 / 0	197 / 0	271 / 0	277* / 346	286* / 430	.878	144 / 0	234 / 0	313* / 325	320* / 433		.540
19'-0"	112 / 0	168 / 0	235 / 0	253* / 302	261* / 378	1.090	121 / 0	202 / 0	283 / 0	295* / 380		.671
20'-0"	93 / 0	144 / 0	204 / 0	233* / 264	240* / 333	1.338	101 / 0	174 / 0	248 / 0	273* / 334		.823
21'-0"	77 / 0	123 / 0	177 / 0	214* / 232	221* / 294	1.626	83 / 0	150 / 0	217 / 0	253* / 295		1.001
22'-0"	62 / 0	104 / 0	154 / 0	198* / 204	204* / 260	1.959	68 / 0	129 / 0	190 / 0	235* / 262		1.205
23'-0"	50 / 0	88 / 0	133 / 0	179 / 0	189* / 231	2.340	55 / 0	111 / 0	167 / 0	219* / 232		1.440
24'-0"		74 / 0	116 / 0	158 / 0	175* / 205	2.774	44 / 0	95 / 0	146 / 0	205* / 206		1.707

(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 .40 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.42	.48	.63	.77	1.00		.42	.50	.67	.86		
STEEL % (UNIFORM)	.74	.84	1.10	1.38	1.79		.74	.88	1.20	1.53		
(TAPERED)	.44	.50	.65	.82	1.06		.44	.52	.71	.91		
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.7	9.7		
-ICR/IGR	.179	.198	.243	.279	.328		.179	.205	.253	.300		
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51		
STEEL %	.13	.16	.21	.26	.31		.09	.13	.16	.21		
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7		
+ICR/IGR	.176	.222	.271	.322	.374		.130	.176	.222	.271		

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

TOP BARS Size @	# 4 12	# 4 11	# 4 8.5	# 5 10.5	# 6 12	End Span Defl. Coeff. (3)	# 4 12	# 4 10.5	# 4 8	# 5 9.5	# 6 10.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	
Steel (psf)	.61	.76	.97	1.20	1.46		.64	.79	1.04	1.33	1.70	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
14'-0"	260 / 0	360 / 0	450* / 477	462* / 596	476* / 678*	.334	275 / 0	418 / 0	514* / 563	523* / 734	534* / 770*	.206
15'-0"	215 / 0	302 / 0	404 / 0	414* / 508	426* / 613*	.440	228 / 0	353 / 0	465* / 479	472* / 628	482* / 700*	.271
16'-0"	178 / 0	255 / 0	344 / 0	374* / 436	384* / 538	.570	189 / 0	299 / 0	411 / 0	430* / 541	438* / 641*	.351
17'-0"	148 / 0	215 / 0	295 / 0	340* / 376	348* / 467	.726	158 / 0	255 / 0	353 / 0	393* / 469	400* / 587	.447
18'-0"	122 / 0	182 / 0	253 / 0	311* / 326	317* / 407	.913	131 / 0	218 / 0	306 / 0	362* / 409	367* / 514	.562
19'-0"	101 / 0	155 / 0	218 / 0	283 / 0	291* / 356	1.133	109 / 0	187 / 0	265 / 0	334* / 358	339* / 452	.697
20'-0"	82 / 0	131 / 0	188 / 0	247 / 0	268* / 313	1.391	89 / 0	160 / 0	231 / 0	309* / 314	313* / 399	.856
21'-0"	66 / 0	111 / 0	163 / 0	216 / 0	247* / 275	1.691	73 / 0	137 / 0	201 / 0	277 / 0	291* / 354	1.041
22'-0"	52 / 0	93 / 0	140 / 0	189 / 0	229* / 243	2.037	58 / 0	117 / 0	175 / 0	244 / 0	271* / 315	1.254
23'-0"	40 / 0	77 / 0	121 / 0	165 / 0	213* / 215	2.433	46 / 0	99 / 0	153 / 0	216 / 0	253* / 280	1.497
24'-0"		64 / 0	104 / 0	144 / 0	190 / 0	2.885		84 / 0	133 / 0	191 / 0	236* / 250	1.775
25'-0"		52 / 0	89 / 0	126 / 0	168 / 0	3.397		70 / 0	116 / 0	169 / 0	222* / 224	2.090
26'-0"		41 / 0	75 / 0	110 / 0	149 / 0	3.974		58 / 0	100 / 0	150 / 0	200 / 0	2.445
27'-0"			63 / 0	95 / 0	132 / 0	4.621		48 / 0	87 / 0	132 / 0	179 / 0	2.844

(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 .42 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.43	.47	.61	.77	.95		.43	.50	.65	.85	1.09	
STEEL % (UNIFORM)	.65	.71	.92	1.16	1.46		.65	.75	.98	1.29	1.66	
(TAPERED)	.41	.45	.58	.73	.92		.41	.47	.62	.81	1.05	
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.8	9.7	9.6	
-ICR/IGR	.169	.180	.220	.257	.295		.169	.187	.230	.276	.324	
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51	.62	
STEEL %	.12	.16	.20	.25	.30		.09	.12	.16	.20	.25	
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7	9.7	
+ICR/IGR	.156	.196	.240	.285	.331		.115	.156	.196	.240	.285	

Table from CRSI 2002, Page 8-14
For the 15'-5" span

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

		END SPAN						INTERIOR SPAN					
TOP BARS	Size @	# 4 12	# 4 10.5	# 4 8	# 5 10	# 6 11	End Span Defl. Coeff. (3)	# 4 12	# 4 10	# 5 11.5	# 5 9		Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5		
Steel (psf)		.63	.79	1.01	1.25	1.54		.65	.82	1.11	1.39		
CLEAR SPAN													
11'-0"		502	567*	597*	623*		.122						
		0	670	868	900*								
12'-0"		409	496*	521*	540*	570*	.173						
		0	550	718	791*	820*							
13'-0"		336	437*	456*	471*	495*	.239						
		0	456	597	700*	723*							
14'-0"		278	381	405*	417*	436*	.321	293	442	454*	468*		.198
		0	0	503	627	646*		0	0	593	715*		
15'-0"		231	321	363*	372*	388*	.423	244	375	410*	422*		.260
		0	0	428	535	583*		0	0	506	650*		
16'-0"		193	272	327*	335*	348*	.548	205	319	373*	383*		.337
		0	0	366	460	529*		0	0	434	570		
17'-0"		161	231	297*	304*	315*	.698	172	273	341*	349*		.430
		0	0	314	398	484*		0	0	375	495		
18'-0"		135	197	271	277*	286*	.878	144	234	313*	320*		.540
		0	0	0	346	430		0	0	325	433		
19'-0"		112	168	235	253*	261*	1.090	121	202	283	295*		.671
		0	0	0	302	378		0	0	0	380		
20'-0"		93	144	204	233*	240*	1.338	101	174	248	273*		.823
		0	0	0	264	333		0	0	0	334		
21'-0"		77	123	177	214*	221*	1.626	83	150	217	253*		1.001
		0	0	0	232	294		0	0	0	295		
22'-0"		62	104	154	198*	204*	1.959	68	129	190	235*		1.205
		0	0	0	204	260		0	0	0	262		
23'-0"		50	88	133	179	189*	2.340	55	111	167	219*		1.440
		0	0	0	0	231		0	0	0	232		
24'-0"			74	116	158	175*	2.774	44	95	146	205*		1.707
			0	0	0	205		0	0	0	206		

(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 .40 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.42	.48	.63	.77	1.00		.42	.50	.67	.86	
STEEL % (UNIFORM)	.74	.84	1.10	1.38	1.79		.74	.88	1.20	1.53	
(TAPERED)	.44	.50	.65	.82	1.06		.44	.52	.71	.91	
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.7	9.7	
-ICR/IGR	.179	.198	.243	.279	.328		.179	.205	.253	.300	
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51	
STEEL %	.13	.16	.21	.26	.31		.09	.13	.16	.21	
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7	
+ICR/IGR	.176	.222	.271	.322	.374		.130	.176	.222	.271	

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

		END SPAN						INTERIOR SPAN					
TOP BARS	Size @	# 4 12	# 4 11	# 4 8.5	# 5 10.5	# 6 12	End Span Defl. Coeff. (3)	# 4 12	# 4 10.5	# 4 8	# 5 9.5	# 6 10.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS	# #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	
Steel (psf)		.61	.76	.97	1.20	1.46		.64	.79	1.04	1.33	1.70	
CLEAR SPAN													
14'-0"		260	360	450*	462*	476*	.334	275	418	514*	523*	534*	.206
		0	0	477	596	678*		0	0	563	734	770*	
15'-0"		215	302	404	414*	426*	.440	228	353	465*	472*	482*	.271
		0	0	0	508	613*		0	0	479	628	700*	
16'-0"		178	255	344	374*	384*	.570	189	299	411	430*	438*	.351
		0	0	0	436	538		0	0	0	541	641*	
17'-0"		148	215	295	340*	348*	.726	158	255	353	393*	400*	.447
		0	0	0	376	467		0	0	0	469	587	
18'-0"		122	182	253	311*	317*	.913	131	218	306	362*	367*	.562
		0	0	0	326	407		0	0	0	409	514	
19'-0"		101	155	218	283	291*	1.133	109	187	265	334*	339*	.697
		0	0	0	0	356		0	0	0	358	452	
20'-0"		82	131	188	247	268*	1.391	89	160	231	309*	313*	.856
		0	0	0	0	313		0	0	0	314	399	
21'-0"		66	111	163	216	247*	1.691	73	137	201	277	291*	1.041
		0	0	0	0	275		0	0	0	0	354	
22'-0"		52	93	140	189	229*	2.037	58	117	175	244	271*	1.254
		0	0	0	0	243		0	0	0	0	315	
23'-0"		40	77	121	165	213*	2.433	46	99	153	216	253*	1.497
		0	0	0	0	215		0	0	0	0	280	
24'-0"			64	104	144	190	2.885		84	133	191	236*	1.775
			0	0	0	0			0	0	0	250	
25'-0"			52	89	126	168	3.397		70	116	169	222*	2.090
			0	0	0	0			0	0	0	224	
26'-0"			41	75	110	149	3.974		58	100	150	200	2.445
			0	0	0	0			0	0	0	0	
27'-0"				63	95	132	4.621		48	87	132	179	2.844
				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 .42 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.43	.47	.61	.77	.95		.43	.50	.65	.85	1.09
STEEL % (UNIFORM)	.65	.71	.92	1.16	1.46		.65	.75	.98	1.29	1.66
(TAPERED)	.41	.45	.58	.73	.92		.41	.47	.62	.81	1.05
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.8	9.7	9.6
-ICR/IGR	.169	.180	.220	.257	.295		.169	.187	.230	.276	.324
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51	.62
STEEL %	.12	.16	.20	.25	.30		.09	.12	.16	.20	.25
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7	9.7
+ICR/IGR	.156	.196	.240	.285	.331		.115	.156	.196	.240	.285

CONCRETE REINFORCING STEEL INSTITUTE

Table from CRSI 2002, Page 8-14
For the 21' span of the 30'-9" bay

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

TOP BARS Size @	# 4 @ 12	# 4 @ 10.5	# 4 @ 8	# 5 @ 10	# 6 @ 11	End Span Defl. Coeff. (3)	# 4 @ 12	# 4 @ 10	# 5 @ 11.5	# 5 @ 9	Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5	
Steel (psf)	.63	.79	1.01	1.25	1.54		.65	.82	1.11	1.39	
CLEAR SPAN	END SPAN						INTERIOR SPAN				
11'-0"	502 / 0	567* / 670	597* / 868	623* / 900*		.122					
12'-0"	409 / 0	496* / 550	521* / 718	540* / 791*	570* / 820*	.173					
13'-0"	336 / 0	437* / 456	456* / 597	471* / 700*	495* / 723*	.239					
14'-0"	278 / 0	381 / 0	405* / 503	417* / 627	436* / 646*	.321	293 / 0	442 / 0	454* / 593	468* / 715*	.198
15'-0"	231 / 0	321 / 0	363* / 428	372* / 535	388* / 583*	.423	244 / 0	375 / 0	410* / 506	422* / 650*	.260
16'-0"	193 / 0	272 / 0	327* / 366	335* / 460	346* / 529*	.548	205 / 0	319 / 0	373* / 434	383* / 570	.337
17'-0"	161 / 0	231 / 0	297* / 314	304* / 398	315* / 484*	.698	172 / 0	273 / 0	341* / 375	349* / 495	.430
18'-0"	135 / 0	197 / 0	271 / 0	277* / 346	286* / 430	.878	144 / 0	234 / 0	313* / 325	320* / 433	.540
19'-0"	112 / 0	168 / 0	235 / 0	253* / 302	261* / 378	1.090	121 / 0	202 / 0	283 / 0	295* / 380	.671
20'-0"	93 / 0	144 / 0	204 / 0	233* / 264	240* / 333	1.338	101 / 0	174 / 0	248 / 0	273* / 334	.823
21'-0"	77 / 0	123 / 0	177 / 0	214* / 232	221* / 294	1.626	83 / 0	150 / 0	217 / 0	253* / 295	1.001
22'-0"	62 / 0	104 / 0	154 / 0	198* / 204	204* / 260	1.959	68 / 0	129 / 0	190 / 0	235* / 262	1.205
23'-0"	50 / 0	88 / 0	133 / 0	179 / 0	189* / 231	2.340	55 / 0	111 / 0	167 / 0	219* / 232	1.440
24'-0"		74 / 0	116 / 0	158 / 0	175* / 205	2.774	44 / 0	95 / 0	146 / 0	205* / 206	1.707

(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 .40 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.42	.48	.63	.77	1.00		.42	.50	.67	.86
STEEL % (UNIFORM)	.74	.84	1.10	1.38	1.79		.74	.88	1.20	1.53
(TAPERED)	.44	.50	.65	.82	1.06		.44	.52	.71	.91
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.7	9.7
-ICR/IGR	.179	.198	.243	.279	.328		.179	.205	.253	.300
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51
STEEL %	.13	.16	.21	.26	.31		.09	.13	.16	.21
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7
+ICR/IGR	.176	.222	.271	.322	.374		.130	.176	.222	.271

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

8" Deep Rib + 3.0" Top Slab = 11.0" Total Depth

TOP BARS Size @	# 4 @ 12	# 4 @ 11	# 4 @ 8.5	# 5 @ 10.5	# 6 @ 12	End Span Defl. Coeff. (3)	# 4 @ 12	# 4 @ 10.5	# 4 @ 8	# 5 @ 9.5	# 6 @ 10.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6		# 3 # 3	# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5	
Steel (psf)	.61	.76	.97	1.20	1.46		.64	.79	1.04	1.33	1.70	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
14'-0"	260 / 0	360 / 0	450* / 477	462* / 596	476* / 678*	.334	275 / 0	418 / 0	514* / 563	523* / 734	534* / 770*	.206
15'-0"	215 / 0	302 / 0	404 / 0	414* / 508	426* / 613*	.440	228 / 0	353 / 0	465* / 479	472* / 628	482* / 700*	.271
16'-0"	178 / 0	255 / 0	344 / 0	374* / 436	384* / 538	.570	189 / 0	299 / 0	411 / 0	430* / 541	438* / 641*	.351
17'-0"	148 / 0	215 / 0	295 / 0	340* / 376	348* / 467	.726	158 / 0	255 / 0	353 / 0	393* / 469	400* / 587	.447
18'-0"	122 / 0	182 / 0	253 / 0	311* / 326	317* / 407	.913	131 / 0	218 / 0	306 / 0	362* / 409	367* / 514	.562
19'-0"	101 / 0	155 / 0	218 / 0	283 / 0	291* / 356	1.133	109 / 0	187 / 0	265 / 0	334* / 358	339* / 452	.697
20'-0"	82 / 0	131 / 0	188 / 0	247 / 0	268* / 313	1.391	89 / 0	160 / 0	231 / 0	309* / 314	313* / 399	.856
21'-0"	66 / 0	111 / 0	163 / 0	216 / 0	247* / 275	1.691	73 / 0	137 / 0	201 / 0	277 / 0	291* / 354	1.041
22'-0"	52 / 0	93 / 0	140 / 0	189 / 0	229* / 243	2.037	58 / 0	117 / 0	175 / 0	244 / 0	271* / 315	1.254
23'-0"	40 / 0	77 / 0	121 / 0	165 / 0	213* / 215	2.433	46 / 0	99 / 0	153 / 0	216 / 0	253* / 280	1.497
24'-0"		64 / 0	104 / 0	144 / 0	190 / 0	2.885		84 / 0	133 / 0	191 / 0	236* / 250	1.775
25'-0"		52 / 0	89 / 0	126 / 0	168 / 0	3.397		70 / 0	116 / 0	169 / 0	222* / 224	2.090
26'-0"		41 / 0	75 / 0	110 / 0	149 / 0	3.974		58 / 0	100 / 0	150 / 0	200 / 0	2.445
27'-0"			63 / 0	95 / 0	132 / 0	4.621		48 / 0	87 / 0	132 / 0	179 / 0	2.844

(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 .42 CF/SF) [4]

NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.43	.47	.61	.77	.95		.43	.50	.65	.85	1.09
STEEL % (UNIFORM)	.65	.71	.92	1.16	1.46		.65	.75	.98	1.29	1.66
(TAPERED)	.41	.45	.58	.73	.92		.41	.47	.62	.81	1.05
EFF. DEPTH, IN.	9.8	9.8	9.8	9.7	9.6		9.8	9.8	9.8	9.7	9.6
-ICR/IGR	.169	.180	.220	.257	.295		.169	.187	.230	.276	.324
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.31	.40	.51	.62	.75		.22	.31	.40	.51	.62
STEEL %	.12	.16	.20	.25	.30		.09	.12	.16	.20	.25
EFF. DEPTH, IN.	9.8	9.8	9.7	9.7	9.6		9.8	9.8	9.8	9.7	9.7
+ICR/IGR	.156	.196	.240	.285	.331		.115	.156	.196	.240	.285

Table from CRSI 2002, Page 8-13
For the 30'-9" span

TABLE 8-1 CROSS SECTION PROPERTIES — STANDARD JOIST CONSTRUCTION (1)

Joist (2)	3-Inch Top Slab						4.5-Inch Top Slab					
	Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)	Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)
8 + 5 + 20	120.3	60	7.49	1,104	5.8	12.4	157.8	79	8.50	1,630	7.6	16.1
	152.3		6.75	1,582		14.7	189.8		7.74	2,340		19.4
8 + 6 + 20	131.3	63	7.32	1,254	6.8	13.5	170.3	82	8.33	1,852	8.8	17.6
	163.3		6.67	1,709		15.6	202.3		7.65	2,528		20.6
10 + 5 + 20	133.3	67	8.76	1,826	8.2	17.0	170.8	85	9.86	2,561	10.3	21.8
	173.3		7.89	2,594		20.1	210.8		8.93	3,659		26.0
10 + 6 + 20	146.3	70	8.56	2,069	9.6	18.4	185.3	89	9.65	2,906	11.9	23.7
	186.3		7.80	2,801		21.3	225.3		8.83	3,951		27.5
12 + 5 + 20	147.0	74	9.99	2,799	11.1	22.1	184.5	92	11.16	3,797	13.4	28.1
	195.0		9.01	3,951		26.1	232.5		10.10	5,388		33.3
12 + 6 + 20	162.0	78	9.76	3,165	12.8	23.9	201.0	97	10.92	4,300	15.6	30.5
	210.0		8.90	4,264		27.6	249.0		9.97	5,815		35.2
8 + 5 + 30	150.3	54	7.89	1,223	6.1	15.5	202.8	72	8.89	1,813	8.1	19.8
	190.3		7.07	1,914		19.3	242.8		8.08	2,825		25.3
8 + 6 + 30	161.3	56	7.73	1,393	7.1	16.8	215.3	75	8.74	2,058	9.3	21.6
	201.3		6.99	2,051		20.2	255.3		7.99	3,028		26.6
10 + 5 + 30	163.3	58	9.26	2,032	8.7	21.5	215.8	77	10.35	2,841	10.8	27.1
	213.3		8.26	3,145		26.2	265.8		9.35	4,422		33.9
10 + 6 + 30	176.3	61	9.06	2,307	10.1	23.1	230.3	80	10.16	3,227	12.6	29.4
	226.3		8.16	3,366		27.5	280.3		9.24	4,737		35.6
12 + 5 + 30	177.0	63	10.58	3,128	11.7	28.0	229.5	82	11.77	4,219	14.2	35.2
	237.0		9.42	4,790		34.0	289.5		10.57	6,520		43.5
12 + 6 + 30	192.0	67	10.34	3,541	13.5	30.1	246.0	85	11.53	4,783	16.4	38.0
	252.0		9.31	5,124		35.6	306.0		10.45	6,979		45.6
14 + 5 + 30	191.3	68	11.86	4,549	15.2	35.0	243.8	87	13.13	5,986	18.0	44.1
	261.3		10.56	6,905		42.4	313.8		11.76	9,174		53.8
14 + 6 + 30	208.3	72	11.59	5,135	17.5	37.5	262.3	91	12.86	6,773	20.8	47.4
	278.3		10.44	7,382		44.4	332.3		11.62	9,812		56.4
16 + 6 + 30	225.3	78	12.81	7,127	22.0	45.5	279.3	97	14.15	9,238	25.8	57.5
	305.3		11.55	10,197		54.1	359.3		12.78	13,295		68.1
16 + 7 + 30	244.3	83	12.55	7,890	24.9	48.3	299.8	101	13.88	10,246	29.2	61.2
	324.3		11.43	10,844		56.6	379.8		12.64	14,137		71.1
20 + 6 + 30	261.3	91	15.18	12,469	32.5	63.0	315.3	109	16.65	15,768	37.4	79.4
	361.3		13.74	17,741		75.8	415.3		15.05	22,454		93.9
20 + 7 + 30	284.3	96	14.88	13,769	36.6	67.0	339.8	115	16.33	17,433	42.2	84.3
	384.3		13.61	18,864		79.4	439.8		14.89	23,861		98.1

(1) f'_c = 4,000 psi, rib side slope = 1 to 12.
(2) First value is the pan depth, second value is the rib width, and the third value is the pan width (in.)
(3) First value is for a standard section; second value is at a tapered end.
(4) For normal-weight concrete, w = 150 pcf (added weight of tapers is neglected.)

Table from CRSI 2002, Page 8-13
For the 18' span

TABLE 8-1 CROSS SECTION PROPERTIES — STANDARD JOIST CONSTRUCTION (1)

	3-Inch Top Slab						4.5-Inch Top Slab					
(2) Joist	Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)	Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)
8 + 5 + 20	120.3	60	7.49	1,104	5.8	12.4	157.8	79	8.50	1,630	7.6	16.1
	152.3		6.75	1,582		14.7	189.8		7.74	2,340		19.4
8 + 6 + 20	131.3	63	7.32	1,254	6.8	13.5	170.3	82	8.33	1,852	8.8	17.6
	163.3		6.67	1,709		15.6	202.3		7.65	2,528		20.6
10 + 5 + 20	133.3	67	8.76	1,826	8.2	17.0	170.8	85	9.86	2,561	10.3	21.8
	173.3		7.89	2,594		20.1	210.8		8.93	3,659		26.0
10 + 6 + 20	146.3	70	8.56	2,069	9.6	18.4	185.3	89	9.65	2,906	11.9	23.7
	186.3		7.80	2,801		21.3	225.3		8.83	3,951		27.5
12 + 5 + 20	147.0	74	9.99	2,799	11.1	22.1	184.5	92	11.16	3,797	13.4	28.1
	195.0		9.01	3,951		26.1	232.5		10.10	5,388		33.3
12 + 6 + 20	162.0	78	9.76	3,165	12.8	23.9	201.0	97	10.92	4,300	15.6	30.5
	210.0		8.90	4,264		27.6	249.0		9.97	5,815		35.2
8 + 5 + 30	150.3	54	7.89	1,223	6.1	15.5	202.8	72	8.89	1,813	8.1	19.8
	190.3		7.07	1,914		19.3	242.8		8.08	2,825		25.3
8 + 6 + 30	161.3	56	7.73	1,393	7.1	16.8	215.3	75	8.74	2,058	9.3	21.6
	201.3		6.99	2,051		20.2	255.3		7.99	3,028		26.6
10 + 5 + 30	163.3	58	9.26	2,032	8.7	21.5	215.8	77	10.35	2,841	10.8	27.1
	213.3		8.26	3,145		26.2	265.8		9.35	4,422		33.9
10 + 6 + 30	176.3	61	9.06	2,307	10.1	23.1	230.3	80	10.16	3,227	12.6	29.4
	226.3		8.16	3,366		27.5	280.3		9.24	4,737		35.6
12 + 5 + 30	177.0	63	10.58	3,128	11.7	28.0	229.5	82	11.77	4,219	14.2	35.2
	237.0		9.42	4,790		34.0	289.5		10.57	6,520		43.5
12 + 6 + 30	192.0	67	10.34	3,541	13.5	30.1	246.0	85	11.53	4,783	16.4	38.0
	252.0		9.31	5,124		35.6	306.0		10.45	6,979		45.6
14 + 5 + 30	191.3	68	11.86	4,549	15.2	35.0	243.8	87	13.13	5,986	18.0	44.1
	261.3		10.56	6,905		42.4	313.8		11.76	9,174		53.8
14 + 6 + 30	208.3	72	11.59	5,135	17.5	37.5	262.3	91	12.86	6,773	20.8	47.4
	278.3		10.44	7,382		44.4	332.3		11.62	9,812		56.4
16 + 6 + 30	225.3	78	12.81	7,127	22.0	45.5	279.3	97	14.15	9,238	25.8	57.5
	305.3		11.55	10,197		54.1	359.3		12.78	13,295		68.1
16 + 7 + 30	244.3	83	12.55	7,890	24.9	48.3	299.8	101	13.88	10,246	29.2	61.2
	324.3		11.43	10,844		56.6	379.8		12.64	14,137		71.1
20 + 6 + 30	261.3	91	15.18	12,469	32.5	63.0	315.3	109	16.65	15,768	37.4	79.4
	361.3		13.74	17,741		75.8	415.3		15.05	22,454		93.9
20 + 7 + 30	284.3	96	14.88	13,769	36.6	67.0	339.8	115	16.33	17,433	42.2	84.3
	384.3		13.61	18,864		79.4	439.8		14.89	23,861		98.1

(1) f'_c = 4,000 psi, rib side slope = 1 to 12.
(2) First value is the pan depth, second value is the rib width, and the third value is the pan width (in.)
(3) First value is for a standard section; second value is at a tapered end.
(4) For normal-weight concrete, w = 150 pcf (added weight of tapers is neglected.)

Table from CRSI 2002, Page 8-13
For the 15'-5" span

TABLE 8-1 CROSS SECTION PROPERTIES — STANDARD JOIST CONSTRUCTION (1)

Joist (2)	3-Inch Top Slab						4.5-Inch Top Slab					
	Gross Area(3) (in.2)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.4)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)	Gross Area(3) (in.2)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.4)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)
8 + 5 + 20	120.3	60	7.49	1,104	5.8	12.4	157.8	79	8.50	1,630	7.6	16.1
	152.3		6.75	1,582		14.7	189.8		7.74	2,340		19.4
8 + 6 + 20	131.3	63	7.32	1,254	6.8	13.5	170.3	82	8.33	1,852	8.8	17.6
	163.3		6.67	1,709		15.6	202.3		7.65	2,528		20.6
10 + 5 + 20	133.3	67	8.76	1,826	8.2	17.0	170.8	85	9.86	2,561	10.3	21.8
	173.3		7.89	2,594		20.1	210.8		8.93	3,659		26.0
10 + 6 + 20	146.3	70	8.56	2,069	9.6	18.4	185.3	89	9.65	2,906	11.9	23.7
	186.3		7.80	2,801		21.3	225.3		8.83	3,951		27.5
12 + 5 + 20	147.0	74	9.99	2,799	11.1	22.1	184.5	92	11.16	3,797	13.4	28.1
	195.0		9.01	3,951		26.1	232.5		10.10	5,388		33.3
12 + 6 + 20	162.0	78	9.76	3,165	12.8	23.9	201.0	97	10.92	4,300	15.6	30.5
	210.0		8.90	4,264		27.6	249.0		9.97	5,815		35.2
8 + 5 + 30	150.3	54	7.89	1,223	6.1	15.5	202.8	72	8.89	1,813	8.1	19.8
	190.3		7.07	1,914		19.3	242.8		8.08	2,825		25.3
8 + 6 + 30	161.3	56	7.73	1,393	7.1	16.8	215.3	75	8.74	2,058	9.3	21.6
	201.3		6.99	2,051		20.2	255.3		7.99	3,028		26.6
10 + 5 + 30	163.3	58	9.26	2,032	8.7	21.5	215.8	77	10.35	2,841	10.8	27.1
	213.3		8.26	3,145		26.2	265.8		9.35	4,422		33.9
10 + 6 + 30	176.3	61	9.06	2,307	10.1	23.1	230.3	80	10.16	3,227	12.6	29.4
	226.3		8.16	3,366		27.5	280.3		9.24	4,737		35.6
12 + 5 + 30	177.0	63	10.58	3,128	11.7	28.0	229.5	82	11.77	4,219	14.2	35.2
	237.0		9.42	4,790		34.0	289.5		10.57	6,520		43.5
12 + 6 + 30	192.0	67	10.34	3,541	13.5	30.1	246.0	85	11.53	4,783	16.4	38.0
	252.0		9.31	5,124		35.6	306.0		10.45	6,979		45.6
14 + 5 + 30	191.3	68	11.86	4,549	15.2	35.0	243.8	87	13.13	5,986	18.0	44.1
	261.3		10.56	6,905		42.4	313.8		11.76	9,174		53.8
14 + 6 + 30	208.3	72	11.59	5,135	17.5	37.5	262.3	91	12.86	6,773	20.8	47.4
	278.3		10.44	7,382		44.4	332.3		11.62	9,812		56.4
16 + 6 + 30	225.3	78	12.81	7,127	22.0	45.5	279.3	97	14.15	9,238	25.8	57.5
	305.3		11.55	10,197		54.1	359.3		12.78	13,295		68.1
16 + 7 + 30	244.3	83	12.55	7,890	24.9	48.3	299.8	101	13.88	10,246	29.2	61.2
	324.3		11.43	10,844		56.6	379.8		12.64	14,137		71.1
20 + 6 + 30	261.3	91	15.18	12,469	32.5	63.0	315.3	109	16.65	15,768	37.4	79.4
	361.3		13.74	17,741		75.8	415.3		15.05	22,454		93.9
20 + 7 + 30	284.3	96	14.88	13,769	36.6	67.0	339.8	115	16.33	17,433	42.2	84.3
	384.3		13.61	18,864		79.4	439.8		14.89	23,861		98.1

(1) f'_c = 4,000 psi, rib side slope = 1 to 12.
(2) First value is the pan depth, second value is the rib width, and the third value is the pan width (in.)
(3) First value is for a standard section; second value is at a tapered end.
(4) For normal-weight concrete, w = 150 pcf (added weight of tapers is neglected.)

Table from CRSI 2002, Page 8-13
For the 21' span of the 30'-9" bay

TABLE 8-1 CROSS SECTION PROPERTIES — STANDARD JOIST CONSTRUCTION (1)

Joist (2)	3-Inch Top Slab Gross Area (3) (in.²)	Wt. (4) (psf)	Y_{cg} (3) (in.)	I_g (3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$ (3) (ft-k)	4.5-Inch Top Slab Gross Area (3) (in.²)	Wt. (4) (psf)	Y_{cg} (3) (in.)	I_g (3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$ (3) (ft-k)
8 + 5 + 20	120.3	60	7.49	1,104	5.8	12.4	157.8	79	8.50	1,630	7.6	16.1
	152.3		6.75	1,582		14.7	189.8		7.74	2,340		19.4
8 + 6 + 20	131.3	63	7.32	1,254	6.8	13.5	170.3	82	8.33	1,852	8.8	17.6
	163.3		6.67	1,709		15.6	202.3		7.65	2,528		20.6
10 + 5 + 20	133.3	67	8.76	1,826	8.2	17.0	170.8	85	9.86	2,561	10.3	21.8
	173.3		7.89	2,594		20.1	210.8		8.93	3,659		26.0
10 + 6 + 20	146.3	70	8.56	2,069	9.6	18.4	185.3	89	9.65	2,906	11.9	23.7
	186.3		7.80	2,801		21.3	225.3		8.83	3,951		27.5
12 + 5 + 20	147.0	74	9.99	2,799	11.1	22.1	184.5	92	11.16	3,797	13.4	28.1
	195.0		9.01	3,951		26.1	232.5		10.10	5,388		33.3
12 + 6 + 20	162.0	78	9.76	3,165	12.8	23.9	201.0	97	10.92	4,300	15.6	30.5
	210.0		8.90	4,264		27.6	249.0		9.97	5,815		35.2
8 + 5 + 30	150.3	54	7.89	1,223	6.1	15.5	202.8	72	8.89	1,813	8.1	19.8
	190.3		7.07	1,914		19.3	242.8		8.08	2,825		25.3
8 + 6 + 30	161.3	56	7.73	1,393	7.1	16.8	215.3	75	8.74	2,058	9.3	21.6
	201.3		6.99	2,051		20.2	255.3		7.99	3,028		26.6
10 + 5 + 30	163.3	58	9.26	2,032	8.7	21.5	215.8	77	10.35	2,841	10.8	27.1
	213.3		8.26	3,145		26.2	265.8		9.35	4,422		33.9
10 + 6 + 30	176.3	61	9.06	2,307	10.1	23.1	230.3	80	10.16	3,227	12.6	29.4
	226.3		8.16	3,366		27.5	280.3		9.24	4,737		35.6
12 + 5 + 30	177.0	63	10.58	3,128	11.7	28.0	229.5	82	11.77	4,219	14.2	35.2
	237.0		9.42	4,790		34.0	289.5		10.57	6,520		43.5
12 + 6 + 30	192.0	67	10.34	3,541	13.5	30.1	246.0	85	11.53	4,783	16.4	38.0
	252.0		9.31	5,124		35.6	306.0		10.45	6,979		45.6
14 + 5 + 30	191.3	68	11.86	4,549	15.2	35.0	243.8	87	13.13	5,986	18.0	44.1
	261.3		10.56	6,905		42.4	313.8		11.76	9,174		53.8
14 + 6 + 30	208.3	72	11.59	5,135	17.5	37.5	262.3	91	12.86	6,773	20.8	47.4
	278.3		10.44	7,382		44.4	332.3		11.62	9,812		56.4
16 + 6 + 30	225.3	78	12.81	7,127	22.0	45.5	279.3	97	14.15	9,238	25.8	57.5
	305.3		11.55	10,197		54.1	359.3		12.78	13,295		68.1
16 + 7 + 30	244.3	83	12.55	7,890	24.9	48.3	299.8	101	13.88	10,246	29.2	61.2
	324.3		11.43	10,844		56.6	379.8		12.64	14,137		71.1
20 + 6 + 30	261.3	91	15.18	12,469	32.5	63.0	315.3	109	16.65	15,768	37.4	79.4
	361.3		13.74	17,741		75.8	415.3		15.05	22,454		93.9
20 + 7 + 30	284.3	96	14.88	13,769	36.6	67.0	339.8	115	16.33	17,433	42.2	84.3
	384.3		13.61	18,864		79.4	439.8		14.89	23,861		98.1

(1) f'_c = 4,000 psi, rib side slope = 1 to 12.
(2) First value is the pan depth, second value is the rib width, and the third value is the pan width (in.)
(3) First value is for a standard section; second value is at a tapered end.
(4) For normal-weight concrete, w = 150 pcf (added weight of tapers is neglected.)

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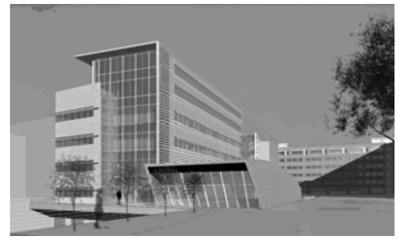

Appendix F
Current System

Depth and Weight

Slab: 4.5”
Joist: 16”X16”.
Center to Center Distance: 3’
Joists Span: 30’-9”.
Bay Dimension: 30’-9”X21’

Total Number of joists per bay:
30’9”=369”/30” =12.3 = 13 Joists/bay

Total Depth = Joist Depth + Slab Depth
= 16”+4.5”=20.5”

Total Weight of joist and slab=(area of joist)(number of joists)(150pcf)+(Area of Slab)(150pcf)
=(16”)(16”)(30’-9”)(13)(150pcf)+(30’-9”)(21’)(4.5”)(150pcf)=142923.4375lbs=142.92k

Typical beam is 19.7” wide by 20.5”

Assume each column is 12” then beams are spanning length-1’

Weight of beam:
Weight of beam=(area of beam)(150pcf)
=(20’)(19.7”)(20.5”)(150pcf)=8413.54lbs=8.41k (short span)
=(29.9’)(19.7”)(20.5”)(150pcf)=12515.14lbs=12.5k (Long span)

Total Weight of bay (assuming 1/2 of a beam on each side)
=(weight of 2(1/2) beams) + (weight of 2(1/2) beams) + (wieght of slab and joists)
=8.41k+ 12.5k + 142.92k =163.83k