Kelly M. Sadusky
Structural Option
The Food Science Building –University Park, PA
Primary Faculty Consultant: MKP

Technical Assignment #2
October 27, 2004
Pro-Con Structural Study of Alternate Floor Systems

Executive Summary

This report investigates four structural design alternatives for The Food Science Building. The existing system, composite beams and composite floor decking, is the basis for comparison with the alternatives. The alternative systems are as follows:

1. Non-Composite Steel
2. Composite Steel with Alternative Spacing
3. Two-Way Solid Flat Slabs-Square Panels with Drops
4. Waffle Flat Slabs-Square Panels

Although it seems that all of these systems would work, the Non-Composite steel system is the least favorable. Following that design would result in a cost increase due to required larger beam sizes. The larger beams are also unfavorable for the simple reason that a heavier system should not be placed on an already poor foundation.

Both of the concrete systems explored, the waffle flat slab and the two-way solid flat slab, are favorable. Neither of them require fireproofing, they provide the shallowest depth, and the labor involved is relatively simple when compared to the steel systems.

In the future, I hope to explore the alternative spacing option along with the two-way flat slab option. I am anticipating a deeper cost-examination of the alternative spacing versus the existing composite steel floor. Although I expect the two-way flat slab to be a better solution than the waffle flat slab, a deeper investigation must also to take place to prove this theory.

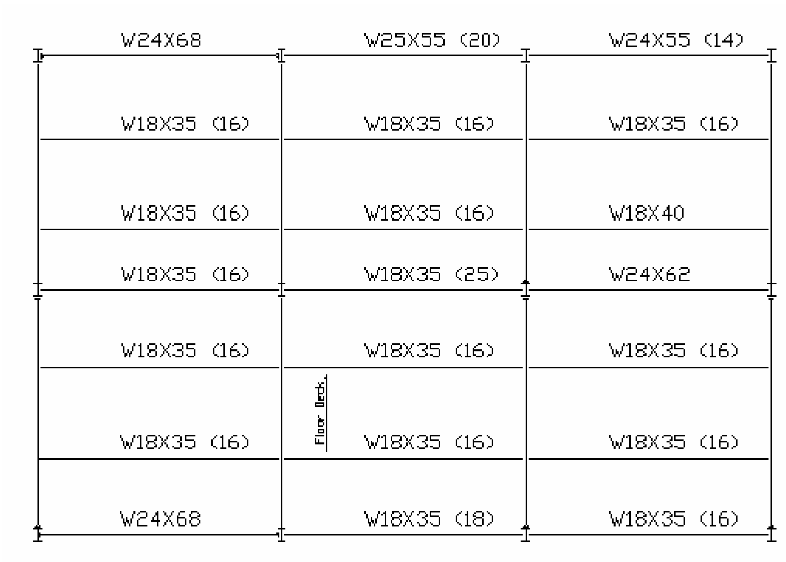
Introduction of the Existing Floor System

Loads:
- Live: 100 psf*
- Dead: 15psf

Material Strengths:
- Steel: 36ksi
- Concrete: fc'= 3ksi

*(It is possible that the designers used 70psf office load for this particular bay. I used the 100 psf laboratory load. This may be the reason for the slightly different beam sizes I got when I ran the calculations on RAM)

The existing floor plan for The Food Science Building is composed of composite beams and composite floor decking. The framing is partially restrained and semi rigid. The lateral system of this building is moment frames in both directions. The basic framing plan to be analyzed consists of 32'4" X 29'4" interior bays. A typical bay consists of a W24X62 girder and a W18X40 girder supporting W18X35 beams (shown below.) Two more W18X35 beams connect directly into the columns, completing a full bay.



For this bay configuration, a 3-1/4" thick lightweight concrete slab with 6X6 W2.1XW2.1 welded wire fabric on 3"-18 gage galvanized composite steel deck with three continuous spans minimum (6-1/4" total slab thickness) creates the floor system. The lightweight concrete strength is 3ksi with a density of 110pcf. The concrete reinforcing is 60 ksi steel.

The deepest part of this system is the 24" deep girder with 6-1/4" thick deck and concrete slab on top of it, making a total depth of 30'-1/4". The deepest beam would reach 24'-1/4".

Spray-on fibrous fireproofing provides the 2hr fire rating necessary for this floor system.

Advantages of the Existing Composite System:

- Fast erection time
- Allows for long spans
- Light system
- Normally more economical than concrete, especially for long spans
- Provides large office spaces because it allows longer beam spans, which will cut down on columns
- Shallower than non-composite system

Disadvantages of the Existing Composite System:

- Deeper floor depth than concrete systems
- Needs fireproofing
- Highest vibration of systems investigated in this report
- Long lead time for steel design, fabrication, and delivery

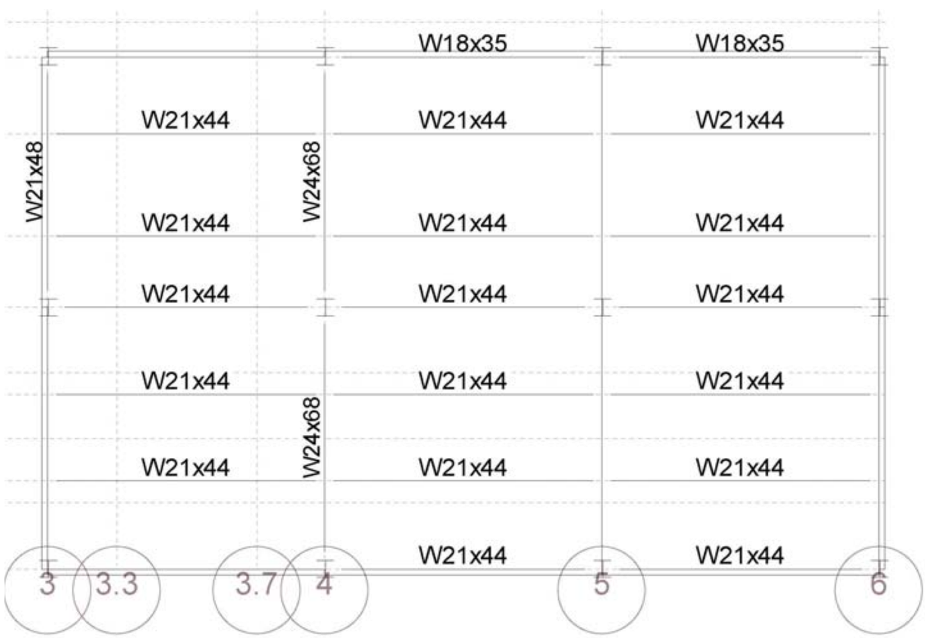
System 1: Non-Composite Steel System with 50ksi Steel

Loads:
- Live: 100 psf
- Dead: 15psf

Material Strengths:
- Steel: 50ksi
- Concrete: fc'= 3ksi

Using the same floor layout as the original design, RAM was used to analyze a non-composite floor beam system. The slab was designed as composite steel deck and the beams as non-composite.

The composite slab consists of a 3-1/4" thick lightweight concrete slab with 6X6 W2.1XW2.1 welded wire fabric on 3"-18 gage galvanized composite steel deck with three continuous spans minimum (6-1/4" total slab thickness.) This system meets the 2hr fire rating requirement with fibrous spray-on fireproofing.



In comparison with the existing flooring design, the non-composite design requires larger beam members. A typical beam of W21X44 is required as opposed to the composite beam's W18X35.

Advantages of the Non-Composite Beam Design:

- Lightweight steel framing system
- Easy to erect
- Allows for long spans
- No shear connectors needed
- One size beam throughout design = cost cuts
- Heavier beams than composite system = less vibrations

Disadvantages of the Non-Composite Beam Design:

- Increase in beam sizes = cost increase
- Needs fireproofing
- Depth increased to 27-1/4" (up from previous 24-1/4")
- Larger beams = heavier than the composite system
- The lack of shear studs will require a camber in the beams to compensate for deflection

System 2: Composite Floor System with Alternative Spacing

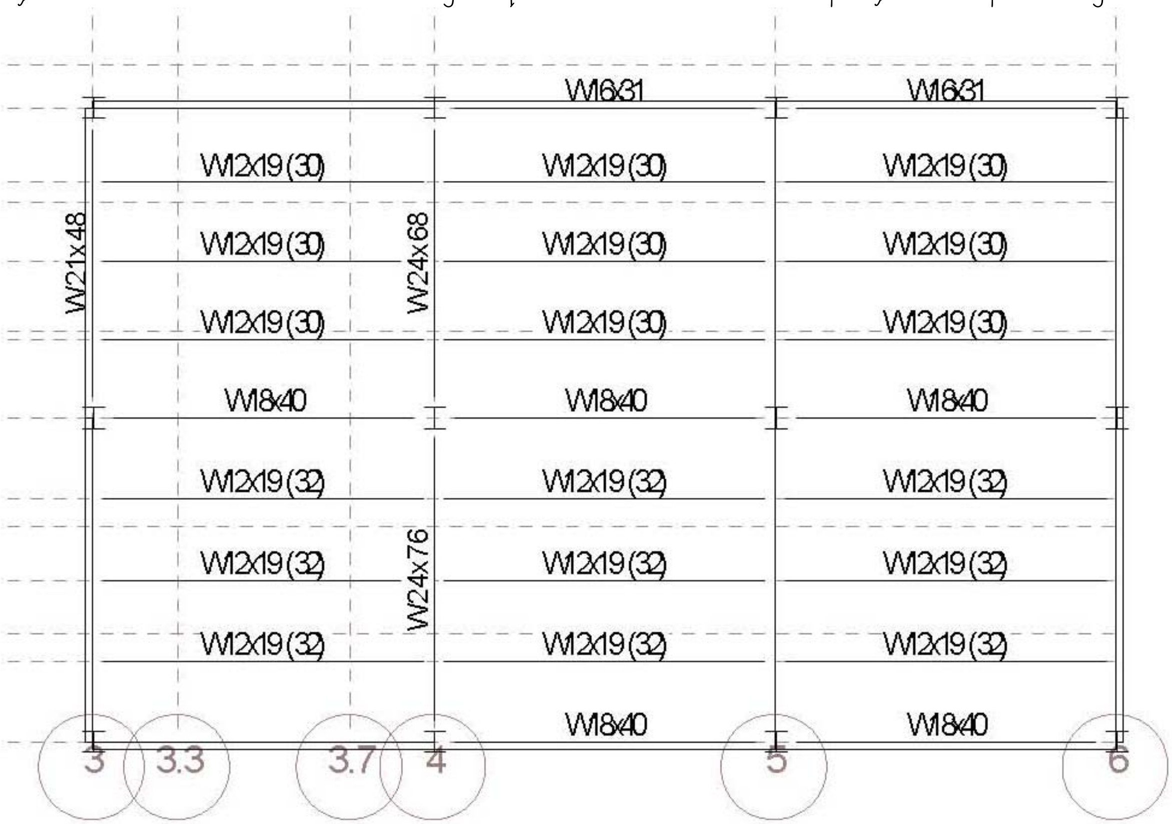
Loads:
Live: 100 psf
Dead: 15psf

Material Strengths:
Steel: 50ksi
Concrete: fc'= 3ksi

A composite floor was used in the computation of the beam designs for the alternative spacing system. Using the same bay size as the original design, another interior beam was added. The spacing between the beams is almost equal. The spacing is 10'-3", 10'-2", 10'-3". The slab was designed as composite steel deck.

It was found that this system reduced the total weight only slightly. The new spacing lets us use the same interior beam throughout the bay. This may save us money in the long run, though the cost of constructing the extra beams might even out that cost cut.

The composite slab consists of a 3-1/4" thick lightweight concrete slab with 6X6 W2.1XW2.1 welded wire fabric on 3"-18 gage galvanized composite steel deck with four continuous spans minimum (6-1/4" total slab thickness.) This system meets the 2hr fire rating requirement with fibrous spray-on fireproofing.



Advantages of Alternate Spacing:

- Ability to use same beam size for interior beams
- Lightest system found
- Allows long spans
- Fast erection time
- Shallower than non-composite floor

Disadvantages of Alternate Spacing:

- Extra beams in the configuration
- More construction time and cost
- Long lead time for steel design, fabrication, and delivery
- Needs fireproofing

System 3: Two-Way Solid Flat Slabs-Square Panels with Drops

Loads:
Live: 100 psf
Dead: 15psf

Material Strengths:
Steel: Grade 60 Reinforcement
Concrete: fc'= 4ski

Using the CRSI Handbook for a Flat Slab-Square Panels, the 29'X32'-4" bay was approximated as a 33' square bay, which is conservative. The combined factored load resulted in a total factored load of 172psf, which calls for the following system:

Given Information: h=11in.= Total Slab Depth Between Drop Panels
Span: 33ft f'c: 4,000 psi
Factored Superimposed Load: 200psf

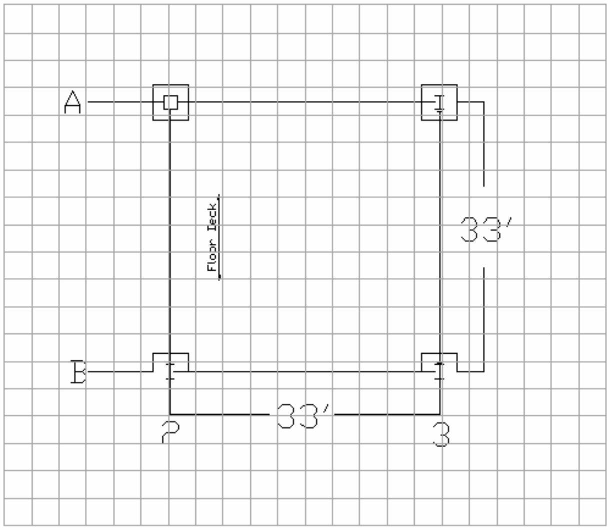
Information Obtained from CRSI:
1. Flat Slab System
- Square Drop Panel Depth: 11.00in
- Square Drop Panel Width: 11.00in
- Square Column Size: 16in

Reinforcing Bars (E.W.)
- Top Exterior (column strip): 15-#5
- Bottom (column strip): 17-#8
- Top Interior (column strip): 22-#6
- Bottom (middle strip): 11-#8
- Top Interior (middle strip): 12-#7
- Total Steel: 4.68 psf

Moments
- Edge (-): 425.1 (ft-k)
- Bottom (+): 850.1 (ft-k)
- Interior (-): 1144.4 (ft-k)

2. Square Interior Panel
- Square Column: 19in
- Concrete: 1.019 (cf/sf)

Reinforcing Bars (E.W.)
- Column Strip (Top): 15-#7
- Column Strip (Bottom): 11-#8
- Middle Strip (Top): 11-#17
- Middle Strip (Bottom): 18-#5
- Total Steel: 4.06 psf



Advantages of the Two-Way Solid Flat Slab:

- Requires no fire protection with proper cover
- Requires less skilled labor to erect than steel
- Somewhat small column sizes
- Heaviest system = least vibrations
- Shallow depth
- One of the most economical concrete systems

Disadvantages of the Two-Way Solid Flat Slab:

- Large amount of dead weight; heaviest system
- Thick slabs
- Punching shear around columns
- Increased foundation size

System 4: Waffle Flat Slabs-Square Panels

The fourth and last system that was explored is an entirely concrete system. A two-way waffle slab was chosen because of the thin floor system depth and for its ability to span long distances. The system is built using reusable pan forms with typical sizes being 30"X30" or 19"X19". The 19"X19" dome size is typical for spans less than 25 feet. A 30"X30" pan form was used in this design.

Using the CRSI Handbook for a Waffle Flat Slab-Square Panels, the 29'X32'-4" bay was approximated as a 33' square bay. The combined factored load resulted in a total factored load of 172psf, which calls for the following system:

Given Information: Total Depth=15in; Rib Depth=12in; Total Slab Depth=3in
f'c=4,000psi;
Span= 33ft; D=12.500; Rib on column line;
0.687 CF/SF
Factored Superimposed Load: 200 psf

Information Obtained from CRSI:

1. Square Edge Panels
- Steel: 3.76 psf

Square Edge Column
- C1=C2: 18in
- Stirrups: 4 S 6 1

Reinforcing Bars –Each Direction
- Top Edge, Column Strip (No.-Size): 25-#5+ 2
- Bottom, Column Strip
  - -No. Ribs: 5
  - -Bars per Rib: 1-#8 and 1-#9
- Top Interior, Column Strip (No.-Size): 28-#6
- Middle Strip
  - -Bottom
    - *No. Ribs: 6
    - *Long Bars: #6
    - *Short Bars: #7
  - -Top Interior (No.-Size): 13-#5

Moments

- -M Edge: 355 (ft-k)
- +M Bottom: 827 (ft-k)
- -M Interior: 956 (ft-k)

2. Square Interior Panels

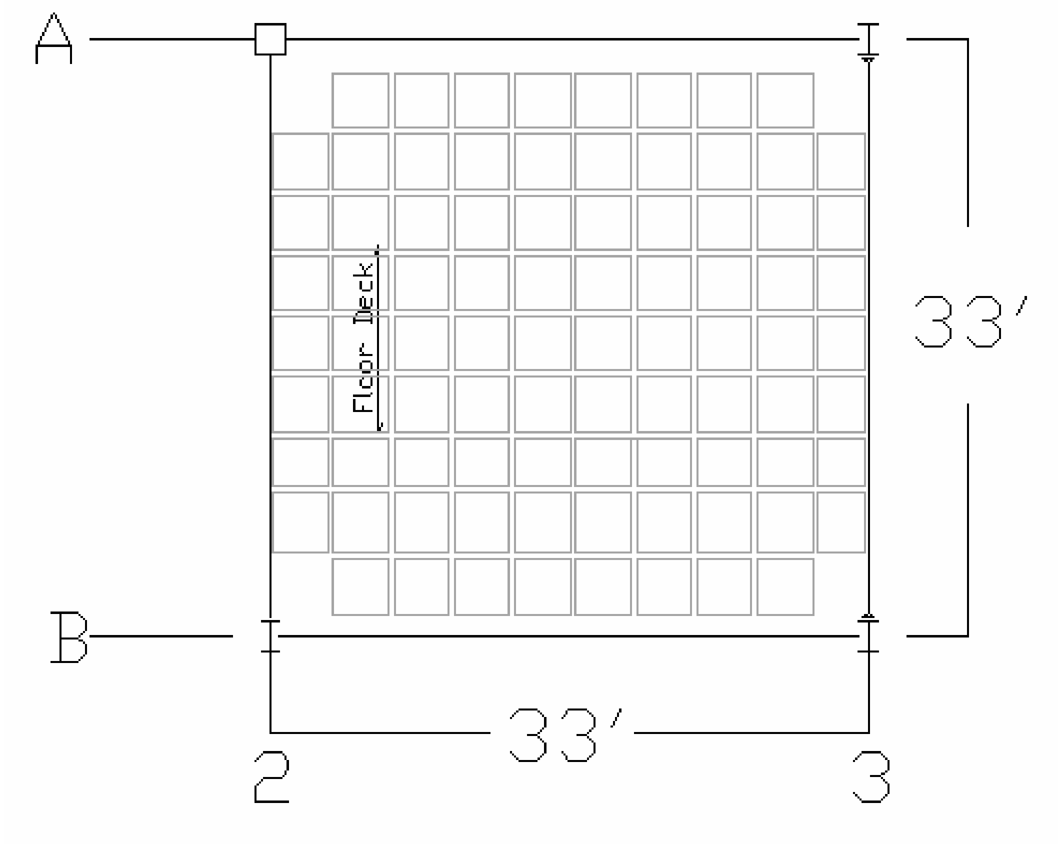
- Steel: 3.35 psf

Square Interior Column

- C1=C2: 16in
- Stirrups: 4 S 6 1

Reinforcing Bars –Each Direction

- Bottom, Column Strip
  - -No. Ribs: 5
  - -Bars per Rib: 2-#7
- Top Interior No.-Sizes: 26-#6
- Bottom, Middle Strip
  - -No. Ribs: 6
  - -Long Bars: #5
  - -Short Bars: #6
- Top Interior, Middle Strip (No.-size): 12-#5



Advantages of Waffle Flat Slabs-Square Panels:

- When compared with the conventional solid flat slab construction, waffle flat slab construction allows a considerable reduction in dead load.
- Shortest system depth
- Meets fireproofing requirements
- Improved Vibration Control
- Can support greater loads

Disadvantages of Waffle Flat Slabs-Square Panels:

- Requires forming and reinforcing on site
- Must use concrete columns
- Shoring required
- Solid heads are required around the columns to provide for shear

System Comparison

System	Pros	Cons	Viable for Proposal
Existing – Composite System	• Fast erection time • Allows for long spans • Light system • more economical than concrete • allows longer beam spans, which will cut down on columns • Shallower than non-composite system	• Deeper floor depth than concrete systems • Needs fireproofing • Highest vibration of systems investigated in this report • Long lead time for steel design, fabrication, and delivery	Existing
Non-Composite Steel	• Lightweight steel framing system • Easy to erect • Allows for long spans • No shear connectors needed • One size beam throughout design = cost cuts • Heavier beams than composite system = less vibrations	• Increase in beam sizes = cost increase • Needs fireproofing • Depth increased to 27-1/4" (up from previous 24-1/4") • Larger beams = heavier than the composite system • The lack of studs will require a camber in the beams in the beams to compensate for deflection	No
Alternative Spacing	• Ability to use same beam size for interior beams • Lightest system found • Allows long spans • Fast erection time • Shallower than non-composite floor	• Extra beams in the configuration • More construction time and cost • Long lead time for steel design, fabrication, and delivery • Needs fireproofing	Yes

Two-Way Flat Slab	• Requires no fire protection • Requires less skilled labor • small column sizes compared to flat plate • least vibrations • Shallow depth • most economical concrete systems	• Large amount of dead weight; heaviest system • Thick slabs • Punching shear around columns • Increased foundation size	Yes
Waffle Flat Slabs	• Shortest system depth • Meets fireproofing requirements • Improved Vibration Control • Can support greater loads	• Requires forming and reinforcing on site • Must use concrete columns • Shoring required • Solid heads are required around the columns to provide for shear	Yes

Appendix

Contents:

Non-Composite Design (Page 1 of 2)

Beam Design Criteria

RAM Steel v8.1
DataBase: tech2-non
Building Code: IBC

10/26/04 13:16:28
Steel Code: AISC LRFD

TABLES SELECTED:

Master Steel Table: ramaisc
Default Steel Table: ramaisc
Alternate Steel Table: ramaisc

UNBRACED LENGTH:

Check Unbraced Length
Do Not Consider Point of Inflection as Brace Point
Noncomposite Beam Design:
  Deck Perpendicular to Beam Braces flange
  Deck Parallel to Beam does not Brace flange
Calculate Cb for all Simple Span Beams
Use Cb=1 for all Cantilevers

SPAN/DEPTH CRITERIA:

Maximum Span/Depth Ratio (ft/ft): 0.00

DEFLECTION CRITERIA:

Default Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	360.0	0.0
Total Superimposed:	240.0	0.0
Total (Init+Superimp-Camber):	240.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0

Alternate Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	0.0	0.0
Total Superimposed:	0.0	0.0
Total (Init+Superimp-Camber):	0.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0
Total Load:	0.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0

Non-Composite Design (Page 2 of 2)

Beam Design Criteria

RAM Steel v8.1
DataBase: tech2-non
Building Code: IBC

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10/26/04 13:16:28
Steel Code: AISC LRFD

Total Load:	0.0	0.0

Note: 0.0 indicates No Limit

CAMBER CRITERIA FOR COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
(For Unshored Composite the specified % of Construction DL is used)
Camber Increment (in): 0.250
Minimum Camber (in): 0.750
Maximum Camber (in): 4.000

CAMBER CRITERIA FOR NON-COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
Camber Increment (in): 0.250
Minimum Camber (in): 0.500
Maximum Camber (in): 4.000

STUD CRITERIA:

Stud Distribution: Use Optimum
Maximum % of Full Composite Allowed: 100.00
Minimum % of Full Composite Allowed: 25.00
Maximum Rows of Studs Allowed: 3
Minimum Flange Width for 2 Rows of Studs (in): 5.500
Minimum Flange Width for 3 Rows of Studs (in): 8.500
Maximum Stud Spacing: Per Code

Non Composite Beam Deflection Summary

Beam Deflection Summary

RAM Steel v8.1
DataBase: tech2-non
Building Code: IBC

10/26/04 13:28:53
Steel Code: AISC LRFD

STEEL BEAM DEFLECTION SUMMARY:

Floor Type: typical floor

Noncomposite

Bm #	Beam Size	Dead in	Live in	NetTotal in	Camber in
40	W21X44	0.199	0.856	1.055	
37	W21X44	0.199	0.856	1.055	
22	W21X48	0.199	0.727	0.926	
23	W21X44	0.184	0.803	0.987	
30	W21X44	0.198	0.854	1.052	
33	W21X44	0.204	0.874	1.078	
43	W24X68	0.239	0.731	0.969	
29	W21X44	0.735	0.583	0.818	1/2
41	W21X44	0.199	0.856	1.055	
38	W21X44	0.199	0.856	1.055	
24	W24X68	0.194	0.590	0.784	
36	W21X44	0.184	0.803	0.987	
31	W21X44	0.198	0.854	1.052	
34	W21X44	0.204	0.874	1.078	
25	W18X35	0.187	0.859	1.046	
28	W21X44	0.735	0.583	0.818	1/2
42	W21X44	0.199	0.856	1.055	
39	W21X44	0.199	0.856	1.055	
27	W21X44	0.184	0.803	0.987	
32	W21X44	0.198	0.854	1.052	
35	W21X44	0.204	0.874	1.078	
26	W18X35	0.187	0.859	1.046	

Percent of Dead Load Used for Camber Calculation = 80.00%
Camber Increment (in) = 0.250
Minimum Camber (in) = 0.750

Non Composite Beam Summary

Beam Summary

RAM Steel v8.1
DataBase: tech2-non
Building Code: IBC

10/26/04 13:28:53
Steel Code: AISC LRFD

STEEL BEAM DESIGN SUMMARY:

Floor Type: typical floor

Bm #	Length ft	+Mu kip-ft	-Mu kip-ft	Mn kip-ft	Fy ksi	Beam Size	Studs
40	32.33	208.9	0.0	286.2	36.0	W21X44	
37	32.33	208.9	0.0	286.2	36.0	W21X44	
22	29.33	241.0	0.0	321.0	36.0	W21X48	
23	32.33	195.7	0.0	286.2	36.0	W21X44	
30	32.33	208.3	0.0	286.2	36.0	W21X44	
33	32.33	213.5	0.0	286.2	36.0	W21X44	
43	30.67	446.9	0.0	531.0	36.0	W24X68	
29	32.33	235.8	0.0	286.2	36.0	W21X44	
41	32.33	208.9	0.0	286.2	36.0	W21X44	
38	32.33	208.9	0.0	286.2	36.0	W21X44	
24	29.33	388.2	0.0	531.0	36.0	W24X68	
36	32.33	195.7	0.0	286.2	36.0	W21X44	
31	32.33	208.4	0.0	286.2	36.0	W21X44	
34	32.33	213.5	0.0	286.2	36.0	W21X44	
25	32.33	125.7	0.0	199.5	36.0	W18X35	
28	32.33	235.7	0.0	286.2	36.0	W21X44	
42	32.33	208.9	0.0	286.2	36.0	W21X44	
39	32.33	208.9	0.0	286.2	36.0	W21X44	
27	32.33	195.7	0.0	286.2	36.0	W21X44	
32	32.33	208.3	0.0	286.2	36.0	W21X44	
35	32.33	213.5	0.0	286.2	36.0	W21X44	
26	32.33	125.7	0.0	199.5	36.0	W18X35	

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

Non Composite Floor Map

Floor Map

RAM Steel v8.1
DataBase: tech2-non
Building Code: IBC

10/26/04 14:05:23

Floor Type: typical floor

Composite Beam Design Criteria (page 1 of 2)

Beam Design Criteria

RAM Steel v8.1
DataBase: tech2 — 10/26/04 13:24:07
Building Code: IBC — Steel Code: AISC LRFD

TABLES SELECTED:

Master Steel Table:	ramaisc
Default Steel Table:	ramaisc
Alternate Steel Table:	ramaisc

UNBRACED LENGTH:

Check Unbraced Length
Do Not Consider Point of Inflection as Brace Point
Noncomposite Beam Design:
  Deck Perpendicular to Beam Braces flange
  Deck Parallel to Beam does not Brace flange
Calculate Cb for all Simple Span Beams
Use Cb=1 for all Cantilevers

SPAN/DEPTH CRITERIA:

Maximum Span/Depth Ratio (ft/ft): 0.00

DEFLECTION CRITERIA:

Default Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	360.0	0.0
Total Superimposed:	240.0	0.0
Total (Init+Superimp-Camber):	240.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0

Alternate Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	0.0	0.0
Total Superimposed:	0.0	0.0
Total (Init+Superimp-Camber):	0.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0
Total Load:	0.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0

Composite Beam Design Criteria (page 2 of 2)

Beam Design Criteria

RAM Steel v8.1
DataBase: tech2
Building Code: IBC

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10/26/04 13:24:07
Steel Code: AISC LRFD

Total Load:	0.0	0.0

Note: 0.0 indicates No Limit

CAMBER CRITERIA FOR COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
(For Unshored Composite the specified % of Construction DL is used)
Camber Increment (in): 0.250
Minimum Camber (in): 0.750
Maximum Camber (in): 4.000

CAMBER CRITERIA FOR NON-COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
Camber Increment (in): 0.250
Minimum Camber (in): 0.500
Maximum Camber (in): 4.000

STUD CRITERIA:

Stud Distribution: Use Optimum
Maximum % of Full Composite Allowed: 100.00
Minimum % of Full Composite Allowed: 25.00
Maximum Rows of Studs Allowed: 3
Minimum Flange Width for 2 Rows of Studs (in): 5.500
Minimum Flange Width for 3 Rows of Studs (in): 8.500
Maximum Stud Spacing: Per Code

Composite Beam Deflection Summary

Beam Deflection Summary

RAM Steel v8.1
DataBase: tech2 10/26/04 13:43:35
Building Code: IBC Steel Code: AISC LRFD

STEEL BEAM DEFLECTION SUMMARY:

Floor Type: typical floor

Composite / Unshored

Bm #	Beam Size	Initial in	PostLive in	PostTotal in	NetTotal in	Camber in
40	W12X19	0.124	0.819	1.029	1.153	
37	W12X19	0.124	0.819	1.029	1.153	
22	W14X22	0.139	0.739	0.934	1.073	
23	W12X16	0.132	0.847	1.058	1.190	
30	W12X19	0.124	0.816	1.026	1.150	
33	W12X19	0.124	0.836	1.053	1.177	
43	W18X35	0.121	0.593	0.785	0.906	
29	W16X26	0.074	0.431	1.163	1.236	
41	W12X19	0.124	0.819	1.029	1.153	
38	W12X19	0.124	0.819	1.029	1.153	
24	W16X31	0.127	0.593	0.786	0.913	
36	W12X16	0.132	0.847	1.058	1.190	
31	W12X19	0.124	0.816	1.026	1.150	
34	W12X19	0.124	0.836	1.053	1.177	
25	W10X12	0.190	0.997	1.210	1.400	
28	W16X26	0.074	0.431	1.162	1.236	
42	W12X19	0.124	0.819	1.029	1.153	
39	W12X19	0.124	0.819	1.029	1.153	
27	W12X16	0.132	0.847	1.058	1.190	
32	W12X19	0.124	0.816	1.026	1.150	
35	W12X19	0.124	0.836	1.053	1.177	
26	W10X12	0.190	0.997	1.210	1.400	

Percent of Dead Load Used for Camber Calculation = 80.00%
(Constr Dead Load for Unshored)
Camber Increment (in) = 0.250
Minimum Camber (in) = 0.750

Composite Beam Summary

Beam Summary

RAM Steel v8.1
DataBase: tech2 — 10/26/04 13:24:07
Building Code: IBC — Steel Code: AISC LRFD

STEEL BEAM DESIGN SUMMARY:

Floor Type: typical floor

Bm #	Length ft	+Mu kip-ft	-Mu kip-ft	Mn kip-ft	Fy ksi	Beam Size	Studs
40	32.33	151.6	0.0	183.9	36.0	W12X19	26
37	32.33	151.6	0.0	183.9	36.0	W12X19	26
22	29.33	173.7	0.0	205.4	36.0	W14X22	8, 2, 9
23	32.33	141.2	0.0	166.9	36.0	W12X16	26
30	32.33	151.1	0.0	183.9	36.0	W12X19	26
33	32.33	155.0	0.0	183.9	36.0	W12X19	26
43	30.67	324.5	0.0	394.2	36.0	W18X35	14, 2, 14
29	32.33	196.6	0.0	233.6	36.0	W16X26	18
41	32.33	151.6	0.0	183.9	36.0	W12X19	26
38	32.33	151.6	0.0	183.9	36.0	W12X19	26
24	29.33	281.8	0.0	338.6	36.0	W16X31	13, 3, 15
36	32.33	141.2	0.0	166.9	36.0	W12X16	26
31	32.33	151.1	0.0	183.9	36.0	W12X19	26
34	32.33	155.0	0.0	183.9	36.0	W12X19	26
25	32.33	89.7	0.0	108.7	36.0	W10X12	18
28	32.33	196.6	0.0	233.6	36.0	W16X26	18
42	32.33	151.6	0.0	183.9	36.0	W12X19	26
39	32.33	151.6	0.0	183.9	36.0	W12X19	26
27	32.33	141.2	0.0	166.9	36.0	W12X16	26
32	32.33	151.1	0.0	183.9	36.0	W12X19	26
35	32.33	155.0	0.0	183.9	36.0	W12X19	26
26	32.33	89.7	0.0	108.7	36.0	W10X12	18

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

Composite Floor Map

Alternative Spacing (Page 1 of 2)

Beam Design Criteria

RAM Steel v8.1
DataBase: tech2-spacing — 10/26/04 14:49:55
Building Code: IBC — Steel Code: AISC LRFD

TABLES SELECTED:
Master Steel Table: ramaisc
Default Steel Table: ramaisc
Alternate Steel Table: ramaisc

UNBRACED LENGTH:
Check Unbraced Length
Do Not Consider Point of Inflection as Brace Point
Noncomposite Beam Design:
  Deck Perpendicular to Beam Braces flange
  Deck Parallel to Beam does not Brace flange
Calculate Cb for all Simple Span Beams
Use Cb=1 for all Cantilevers

SPAN/DEPTH CRITERIA:
Maximum Span/Depth Ratio (ft/ft): 0.00

DEFLECTION CRITERIA:

Default Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	360.0	0.0
Total Superimposed:	240.0	0.0
Total (Init+Superimp-Camber):	240.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	360.0	0.0
Total Load:	240.0	0.0

Alternate Criteria	L/d	delta (in)
Unshored		
Initial (Construction Load):	0.0	0.0
Post Composite		
Live Load:	0.0	0.0
Total Superimposed:	0.0	0.0
Total (Init+Superimp-Camber):	0.0	0.0
Shored		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0
Total Load:	0.0	0.0
Noncomposite		
Dead Load:	0.0	0.0
Live Load:	0.0	0.0

Alternative Spacing (Page 2 of 2)

Beam Design Criteria

RAM Steel v8.1 | Page 2/2
DataBase: tech2-spacing | 10/26/04 14:49:55
Building Code: IBC | Steel Code: AISC LRFD

Total Load:	0.0	0.0

Note: 0.0 indicates No Limit

CAMBER CRITERIA FOR COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
(For Unshored Composite the specified % of Construction DL is used)
Camber Increment (in): 0.250
Minimum Camber (in): 0.750
Maximum Camber (in): 4.000

CAMBER CRITERIA FOR NON-COMPOSITE BEAMS:

Do not Camber Beams with Span < 0.0 ft
Do not Camber Beams with Weight < 0.0 lbs/ft
Do not Camber Beams with Weight > 1000.0 lbs/ft
Do not Camber Beams with Depth < 0.0 in
Do not Camber Beams with Depth > 100.0 in
Percent of Dead Load used for Camber: 80.00
Camber Increment (in): 0.250
Minimum Camber (in): 0.500
Maximum Camber (in): 4.000

STUD CRITERIA:

Stud Distribution: Use Optimum
Maximum % of Full Composite Allowed: 100.00
Minimum % of Full Composite Allowed: 25.00
Maximum Rows of Studs Allowed: 3
Minimum Flange Width for 2 Rows of Studs (in): 5.500
Minimum Flange Width for 3 Rows of Studs (in): 8.500
Maximum Stud Spacing: Per Code

Alternative Spacing Beam Deflection Summary

Beam Deflection Summary

RAM Steel v8.1
DataBase: tech2-spacing — 10/26/04 14:49:55
Building Code: IBC — Steel Code: AISC LRFD

STEEL BEAM DEFLECTION SUMMARY:

Floor Type: typical floor

Composite / Unshored

Bm #	Beam Size	Initial in	PostLive in	PostTotal in	NetTotal in	Camber in
44	W12X19	0.124	0.913	1.061	1.185	
47	W12X19	0.124	0.913	1.061	1.185	
50	W12X19	0.124	0.913	1.061	1.185	
53	W12X19	0.124	0.914	1.061	1.185	
56	W12X19	0.124	0.914	1.061	1.185	
59	W12X19	0.124	0.905	1.049	1.173	
45	W12X19	0.124	0.913	1.061	1.185	
48	W12X19	0.124	0.913	1.061	1.185	
51	W12X19	0.124	0.913	1.061	1.185	
54	W12X19	0.124	0.915	1.061	1.185	
57	W12X19	0.124	0.915	1.061	1.185	
60	W12X19	0.124	0.905	1.050	1.173	
46	W12X19	0.124	0.913	1.061	1.185	
49	W12X19	0.124	0.913	1.061	1.185	
52	W12X19	0.124	0.913	1.061	1.185	
55	W12X19	0.124	0.914	1.061	1.185	
58	W12X19	0.124	0.914	1.061	1.185	
61	W12X19	0.124	0.905	1.049	1.173	

Noncomposite

Bm #	Beam Size	Dead in	Live in	NetTotal in	Camber in
22	W21X48	0.196	0.764	0.960	
23	W18X40	0.212	0.971	1.183	
43	W24X76	0.200	0.641	0.842	
29	W18X40	0.981	0.624	0.854	3/4
24	W24X68	0.191	0.623	0.814	
36	W18X40	0.212	0.971	1.184	
25	W16X31	0.213	0.952	1.165	
28	W18X40	0.980	0.624	0.854	3/4
27	W18X40	0.212	0.971	1.183	
26	W16X31	0.213	0.952	1.165	

Percent of Dead Load Used for Camber Calculation = 80.00%
(Constr Dead Load for Unshored)
Camber Increment (in) = 0.250
Minimum Camber (in) = 0.750

Alternative Spacing Beam Summary

Beam Summary

RAM Steel v8.1
DataBase: tech2-spacing 10/26/04 14:49:55
Building Code: IBC Steel Code: AISC LRFD

STEEL BEAM DESIGN SUMMARY:

Floor Type: typical floor

Bm #	Length ft	+Mu kip-ft	-Mu kip-ft	Mn kip-ft	Fy ksi	Beam Size	Studs
44	32.33	169.1	0.0	199.2	36.0	W12X19	32
47	32.33	169.1	0.0	199.2	36.0	W12X19	32
50	32.33	169.1	0.0	199.2	36.0	W12X19	32
22	29.33	274.9	0.0	321.0	36.0	W21X48	
23	32.33	170.6	0.0	235.2	36.0	W18X40	
53	32.33	165.4	0.0	195.3	36.0	W12X19	30
56	32.33	165.4	0.0	195.3	36.0	W12X19	30
59	32.33	162.9	0.0	195.2	36.0	W12X19	30
43	30.67	479.0	0.0	600.0	36.0	W24X76	
29	32.33	205.1	0.0	235.2	36.0	W18X40	
45	32.33	169.1	0.0	199.2	36.0	W12X19	32
48	32.33	169.1	0.0	199.2	36.0	W12X19	32
51	32.33	169.1	0.0	199.2	36.0	W12X19	32
24	29.33	442.0	0.0	531.0	36.0	W24X68	
36	32.33	170.6	0.0	235.2	36.0	W18X40	
54	32.33	165.4	0.0	195.3	36.0	W12X19	30
57	32.33	165.4	0.0	195.3	36.0	W12X19	30
60	32.33	162.9	0.0	195.2	36.0	W12X19	30
25	32.33	102.8	0.0	162.0	36.0	W16X31	
28	32.33	205.1	0.0	235.2	36.0	W18X40	
46	32.33	169.1	0.0	199.2	36.0	W12X19	32
49	32.33	169.1	0.0	199.2	36.0	W12X19	32
52	32.33	169.1	0.0	199.2	36.0	W12X19	32
27	32.33	170.6	0.0	235.2	36.0	W18X40	
55	32.33	165.4	0.0	195.3	36.0	W12X19	30
58	32.33	165.4	0.0	195.3	36.0	W12X19	30
61	32.33	162.9	0.0	195.2	36.0	W12X19	30
26	32.33	102.8	0.0	162.0	36.0	W16X31	

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

Alternative Spacing Floor Map