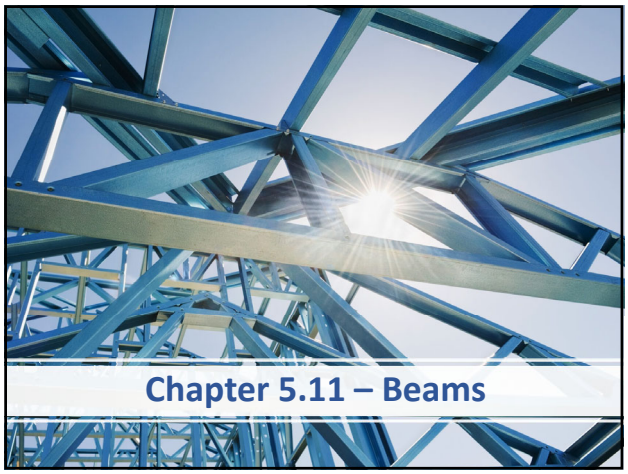


1

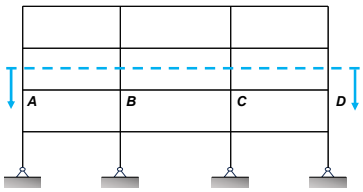
Chapter 5 – Floor and Roof Beams

- When a ***distributed load*** acts on an area such as a ***floor*** in a building, certain portions of that load are supported by various components of the floor system.
- The actual distribution is difficult to determine, but it can be approximated quite easily.
- The basic idea is that of ***tributary areas***.
- The concept of tributary areas was first discussed in ***Section 3.8*** in the coverage of ***tension members in roof trusses***.

2

Chapter 5 – Floor and Roof Beams

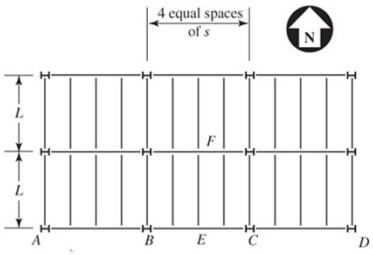
- Consider a typical multistory building.
- Here is one of the rigid frames comprising the building.



3

Chapter 5 – Floor and Roof Beams

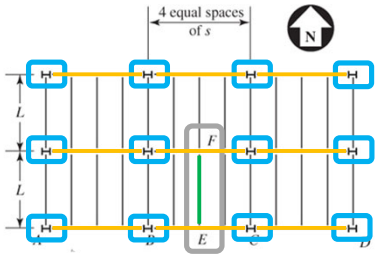
- Here is a ***horizontal section*** where a cut is made through the building above one of the floors, and the lower portion is viewed from above.



4

Chapter 5 – Floor and Roof Beams

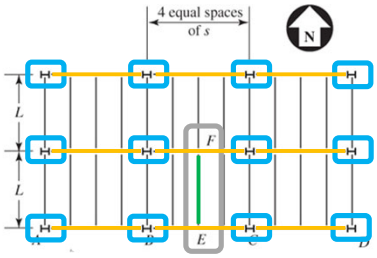
- The gridwork consists of the ***column*** cross sections, ***girders*** connecting the columns in the E-W direction, and ***floor beams*** such as EF spanning between the girders.



5

Chapter 5 – Floor and Roof Beams

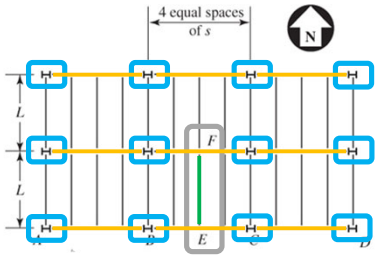
- ***Girders*** are defined as ***beams that support other beams***, although sometimes the term is applied to large beams in general.



6

Chapter 5 – Floor and Roof Beams

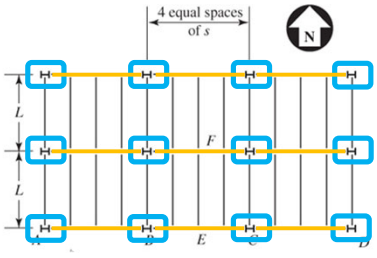
- The ***floor beams***, which fill in the panels defined by the columns, are sometimes called ***filler beams***.



7

Chapter 5 – Floor and Roof Beams

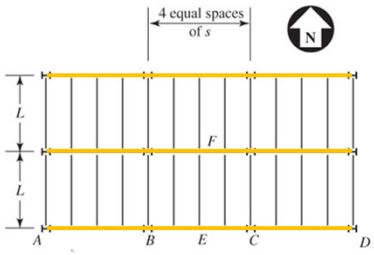
- The ***columns*** and ***girders*** along any of the east-west lines make up an ***individual frame***.



8

Chapter 5 – Floor and Roof Beams

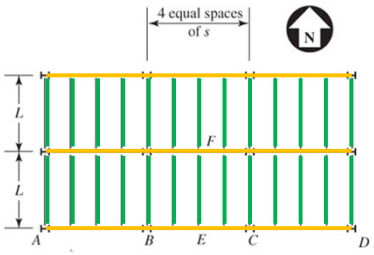
- The ***columns*** and ***girders*** along any of the east-west lines make up an ***individual frame***.



9

Chapter 5 – Floor and Roof Beams

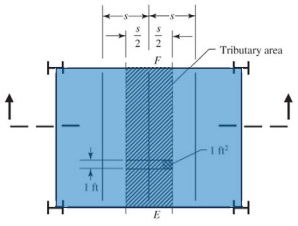
- The ***frames*** are connected by the ***beams in the north-south*** direction, completing the framework for the building.



10

Chapter 5 – Floor and Roof Beams

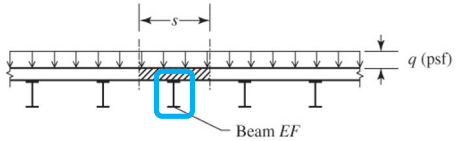
- Consider a typical bay of the floor framing system.
- When columns are placed in a rectangular grid, the region between four columns is called a ***bay***.



11

Chapter 5 – Floor and Roof Beams

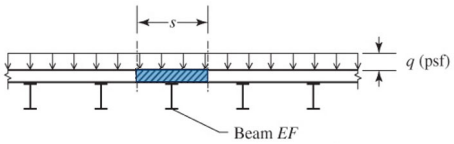
- Here is a cross-section of this bay, showing the ***floor beams*** as wide-flange steel shapes.



12

Chapter 5 – Floor and Roof Beams

- Here is a cross-section of this bay, showing the ***floor beams*** as wide-flange steel shapes.
- Supporting reinforced concrete floor slabs.



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Chapter 5 – Floor and Roof Beams

- One of the objectives of a structure is to ***transmit loads to the foundation***.
- For floor loads, this transmission of loads is accomplished as follows:
  1. Floor loads, both ***live and dead***, are supported by the ***floor slab***.
  2. The weight of the slab, along with the loads it supports, is supported by the ***floor beams***.
  3. The floor beams transmit their loads, including their own weight, to the ***girders***.

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Chapter 5 – Floor and Roof Beams

- One of the objectives of a structure is to ***transmit loads to the foundation***.
- For floor loads, this transmission of loads is accomplished as follows:
  4. The girders and their loads are supported by the ***columns***.
  5. The column loads are supported by the ***columns of the story below.***

     The column loads accumulate from the top story to the ***foundation***.

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Chapter 5 – Floor and Roof Beams

- The ***route taken by the loads*** from one part of the structure to another is sometimes called the ***load path***.
- This is a fairly accurate representation of what happens, but it is not exact.
- For example, part of the ***slab*** and its load will be supported directly by the ***girders***, but most of it will be carried by the ***floor beams***.

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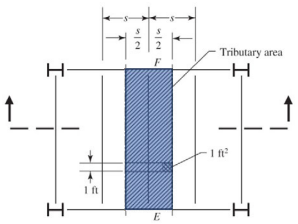
Chapter 5 – Floor and Roof Beams

- The ***tributary area*** for beam *EF* is the ***shaded area***.
- It consists of ***half the floor*** between beam *EF* and the adjacent beam on each side.



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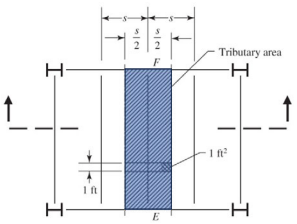
Chapter 5 – Floor and Roof Beams

- Thus, the total width of the floor being supported is equal to the ***beam spacing, s,*** if the spacing is uniform.
- If the load on the floor is uniformly distributed, we can express the uniform load on beam *EF* as a ***force per unit length***.



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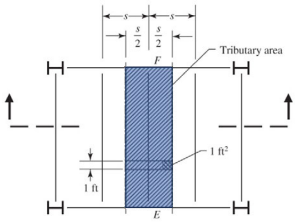
Chapter 5 – Floor and Roof Beams

- The weight of a ***reinforced concrete floor slab*** is usually expressed in pounds per square foot (*psf*) of floor surface.
- This way, the ***slab weight*** can be combined with other loads similarly expressed.



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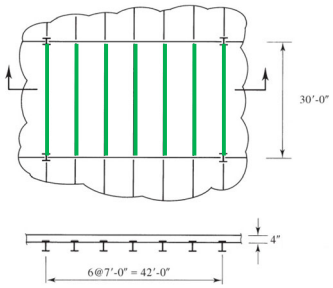
Chapter 5 – Floor and Roof Beams

- **Example 5.15:** Consider a floor framing system with a 4-*in* thick reinforced concrete floor slab of normal-weight concrete is supported by floor beams spaced at 7 *ft*.



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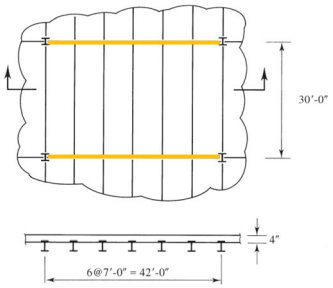
Chapter 5 – Floor and Roof Beams

- **Example 5.15:** The floor beams are supported by girders, which in turn are supported by the columns.



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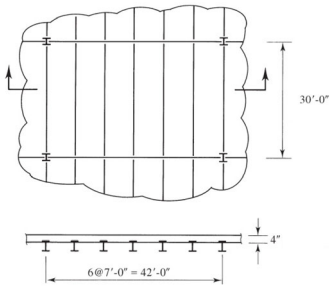
Chapter 5 – Floor and Roof Beams

- **Example 5.15:** Loads include a uniform live load of 80 *psf* and moveable partitions, which are accounted for using a uniformly distributed load of 20 *psf* on the floor surface.



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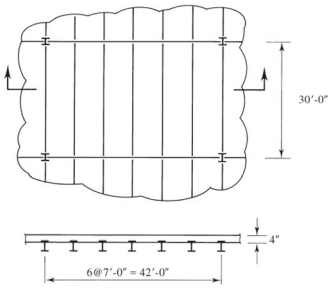
Chapter 5 – Floor and Roof Beams

- **Example 5.15:** The maximum live load deflection must not exceed ***L***/360.



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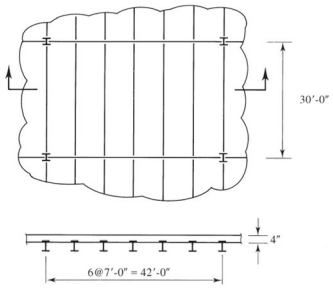
Chapter 5 – Floor and Roof Beams

- **Example 5.15:** Use ***A992*** steel F_y = 50 *ksi* and design the floor beams. Assume that the slab provides continuous lateral support for the floor beams.



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Chapter 5 – Floor and Roof Beams

- **Example 5.15:** The slab weight is:

$$w_{slab} = \frac{t}{12in/ft}(150psf) = \frac{4in}{12in/ft}(150psf) = 50psf$$

Each beam supports a 7-*ft* width (tributary width) of floor.

Slab: $= 50psf(7ft) = 350lb/ft$

Partitions: $= 20psf(7ft) = 140lb/ft$

Live load: $= 80psf(7ft) = 560lb/ft$

The ***beam weight*** will be accounted for once a trial selection has been made.

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Chapter 5 – Floor and Roof Beams

- **Example 5.15:** Since the partitions are movable, they will be treated as live load. The dead and live loads are:

$w_D = 0.350k/ft$

$w_L = 0.560k/ft + 0.140k/ft = 0.7k/ft$

LRFD solution:

$$w_u = 1.2(0.35k/ft) + 1.6(0.7k/ft) = 1.54k/ft$$

The typical floor beam connection provides virtually no moment restraint, so the beams can be treated as ***simply supported***.

$$M_u = \frac{w_u L^2}{8} = \frac{(1.54k/ft)(30ft)^2}{8} = 173k\,ft$$

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Chapter 5 – Floor and Roof Beams

- **Example 5.15:** The maximum permissible live-load deflection is:

$$\Delta_L = \frac{5w_L L^4}{384EI} \qquad \Delta_L = \frac{L}{360} = \frac{360in}{360} = 1.0in$$

$$\Rightarrow I_{required} = \frac{5w_L L^4}{384E\Delta_L} = \frac{5(0.7k/ft)(1ft/12in)(360in)^4}{384(29{,}000ksi)(1.0in)}$$

$$= 440in^4$$

Since the beams have continuous lateral support, the I_x table can be used to select a trial shape that will satisfy the moment requirement.

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Chapter 5 – Floor and Roof Beams

- **Example 5.15:**

From Table 3-3 (**3**-29):

W18 x 35

$I_x = 510in^4$

$> I_{required}$

O.K.

Table 3-3 (continued)
W-Shapes
Selection by I_x

Shape	I_x in.^{4}	Shape	I_x in.^{4}	Shape	I_x in.^{4}	Shape	I_x in.^{4}
W30×90	3610	W24×62	1550	W18×40	612	W12×22	156
W12×305[H]	3550	W18×86	1530	W12×72	597	W8×40	146
W24×117	3540	W14×132	1530	W16×45	586	W10×26	144
W18×175	3450	W16×100	1490	W14×53	541	W12×19	130
W14×257	3400	W21×68	1480	W10×88	534	W8×35	127
W27×94	3270	W12×152	1430	W12×65	533	W10×22	118
W21×132	3220	W14×120	1380	W16×40	518	W8×31	110
W12×279[H]	3110	**W24×55**	**1350**	**W18×35**	**510**	**W12×16**	**103**
W24×104	3100	W21×62	1330	W14×43	428	W8×28	98.0
W18×158	3060	W18×76	1330	W12×58	475	W10×19	96.3
W14×233	3010	W16×89	1300	W10×77	455	**W12×14**	**88.6**
W24×103	3000	W14×109	1240	W16×36	448	W8×24	82.7
W21×122	2960	W12×136	1240	W14×43	428	W10×17	81.9
W27×84	**2850**	W21×57	1170	W12×53	425	W8×21	75.3
W18×143	2750	W18×71	1170	W10×68	394	W10×15	68.9
W12×252[H]	2720	**W21×55**	**1140**	W12×50	391	W8×18	61.9
W24×94	2700	W16×77	1110	W14×38	385		

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Chapter 5 – Floor and Roof Beams

- **Example 5.15:**

From Table 3-2 (**3**-26):

$\phi_b M_n = 249kft > M_u = 177kft$

O.K.

$$V_u = \frac{w_u L}{2} = \frac{(1.54k/ft)(30ft)}{2} = 23.1k$$

$\phi_v V_n = 159k > V_u$

O.K.

Table 3-2 (continued)
W-Shapes
Selection by Z_x
$F_y = 50$ ksi

W18 x 35

Shape	Z_x in.^{3}	M_{ax}/Ω_b ASD kip-ft	$\phi_b M_{px}$ LRFD kip-ft	M_{rx}/Ω_b ASD kip-ft	$\phi_b M_{rx}$ LRFD kip-ft	BF/Ω_b ASD kips	$\phi_b BF$ LRFD kips	L_p ft	L_r ft	I_x in.^{4}	V_{nx}/Ω_v ASD kips	$\phi_v V_{nx}$ LRFD kips
W18×35	**66.5**	**166**	**249**	**101**	**151**	**8.14**	**12.3**	**4.31**	**12.3**	**510**	**106**	**159**
W16×36	64.0	160	240	98.7	148	6.24	9.36	5.37	15.2	448	93.8	141
W14×38	61.5	153	231	95.4	143	5.37	8.20	5.47	16.2	385	87.4	131
W10×49	60.4	151	227	95.4	143	2.46	3.71	8.97	31.6	272	68.0	102
W8×58	59.8	149	224	90.8	137	1.70	2.55	7.42	41.6	228	89.3	134
W12×40	57.0	142	214	89.9	135	3.66	5.54	6.85	21.1	307	70.2	105
W10×45	54.9	137	206	85.8	129	2.59	3.89	7.10	26.9	248	70.7	106
W14×34	**54.6**	**136**	**205**	**84.9**	**128**	**5.01**	**7.55**	**5.40**	**15.6**	**340**	**79.8**	**120**
W16×31	**54.0**	**135**	**203**	**82.4**	**124**	**6.86**	**10.3**	**4.13**	**11.8**	**375**	**87.5**	**131**
W12×35	51.2	128	192	79.6	120	4.34	6.45	5.44	16.6	285	75.0	113
W8×48	49.0	122	184	75.4	113	1.67	2.55	7.35	35.2	184	68.0	102

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Chapter 5 – Beam Design Charts

- **Example 5.15:** In this example, the design was controlled by ***serviceability*** rather than ***strength***.

This is not unusual.

Although there is ***no limit on the dead load*** deflection in this example, this deflection may be needed if the beam is to be ***cambered***.

$$\Delta_D = \frac{5(w_{slab} + w_{beam})L^4}{384EI} = \frac{5(0.35k/ft + 0.035k/ft)(1ft/12in)(360in)^4}{384(29{,}000ksi)(510in^4)}$$

$$= 0.474\,in$$

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Chapter 5 – Beam Design Charts

Let's work on some problems

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Chapter 5 – Beams

Any questions?

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