Load Tracing

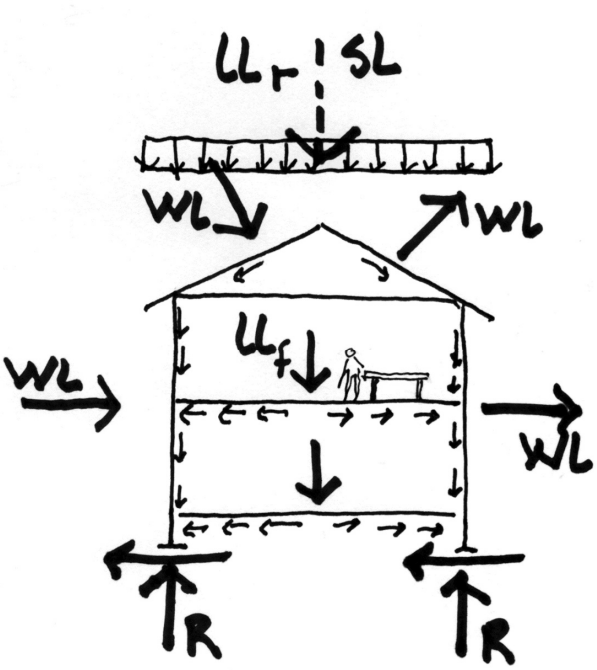
Gatti Wool Mill, Rome (Pier Luigi Nervi, 1951)

Load Paths
Load Diagrams
Floor Systems

Load Combinations – ASCE-7

Load Types

- Dead Load - D
- Roof Live Load - Lr
- Floor Live Load - L
- Snow Load - S
- Wind Load - W
- Earthquake - E



Load Combinations

Allowable Stress Design (ASD)

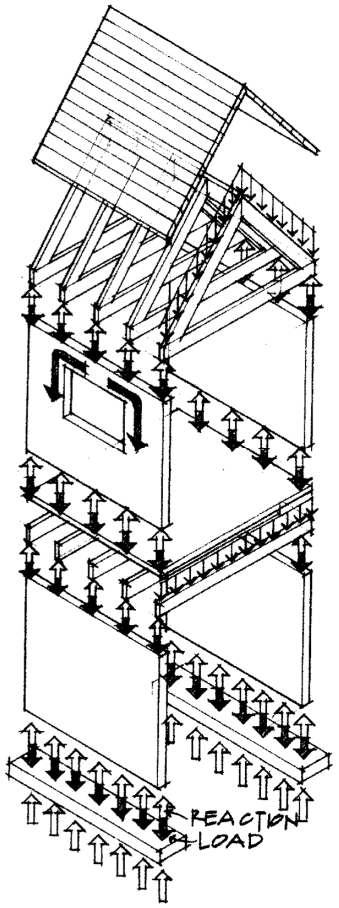
- D
- D + L
- D + (Lr or S)
- D + 0.75 L + 0.75 (Lr or S)
- D + (W or 0.7 E)

Load & Resistance Factored Design (LRFD)

- 1.4 D
- 1.2 D + 1.6 Lr + 0.5(Lr or S)
- 1.2 D + 1.6(Lr or S) + (L or 0.8W)
- 1.2 D + 1.6W + L + 0.5(Lr or S)
- 1.2 D + 1.6E + L + 0.2S

Load Paths

Gravity loads trace from top down to their resolution at the foundation.

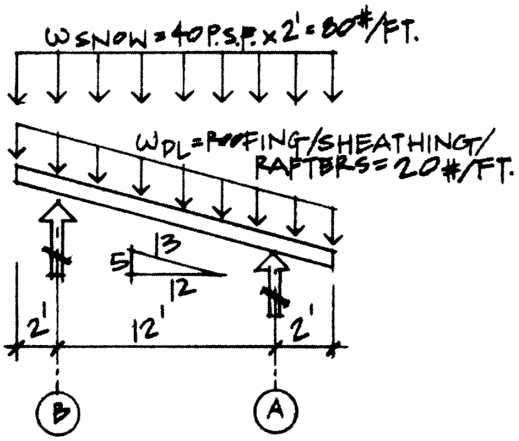


Load Paths

Roof Loads

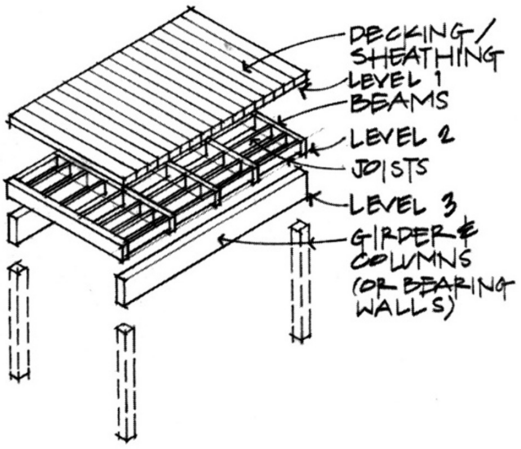
Roof loads can be applied as **projected** loads (e.g., snow or live loads)

or loads on the surface (e.g., dead or wind)



Load Paths

Floor Loads



Dead Load

weight of structure

Live Load

occupancy load

Member Hierarchy

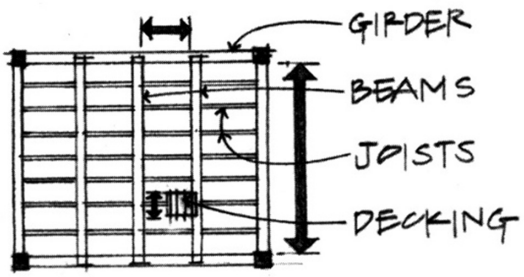
Flooring spans between joists

Joists span between beams

Beams span between girders

Girders span between columns

Columns carry load to ground



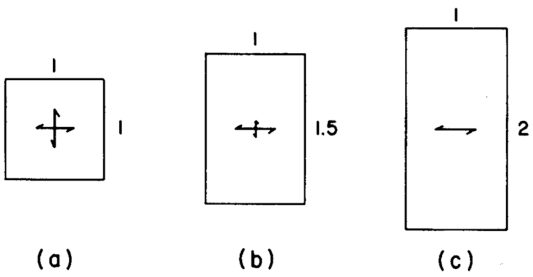
Load Paths

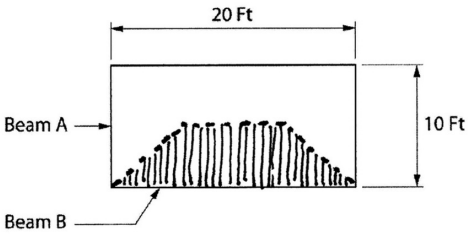
Floor Slabs

Concrete slabs span in the direction of the steel reinforcement.

One-way slabs should span the shortest direction.

Two-way slabs span in both directions. Aspect ratios should be square or less than 2:1. The load path divides at 45° from corner.



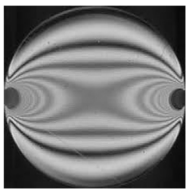


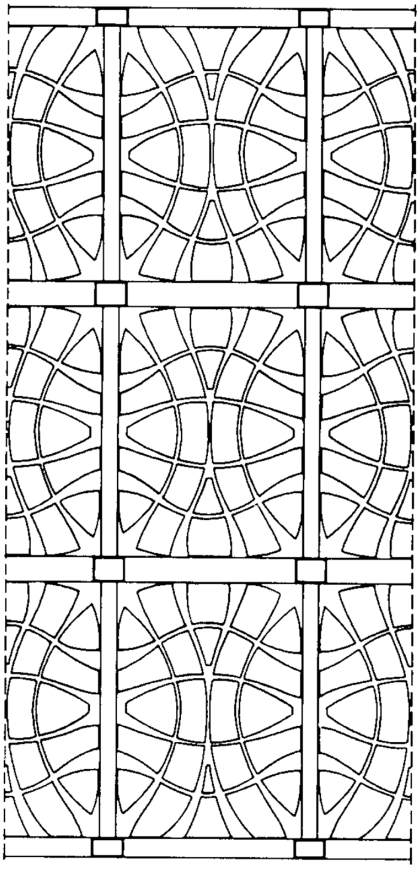
two-way slab tributary area of beam B

two-way waffle slab

Load Paths

Ideal load paths follow the **isoclines** of maximum tension and compression (principal stress patterns). These give the design with least material, but more complex form. They can be found using photoelastic models.



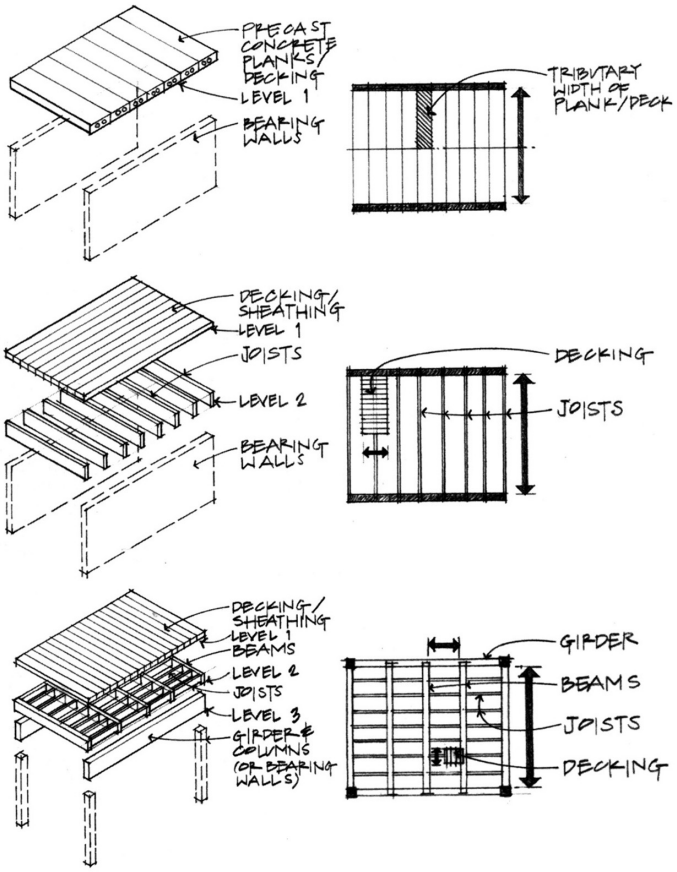


Cassa di Risparmio, Venice
by Pier Luigi Nervi

Tributary Area

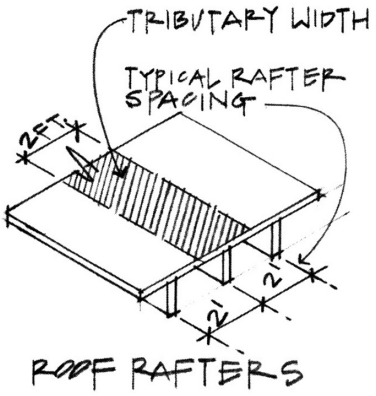
The **tributary area** is an area used to determine the load on a member.

If geometry and loading is symmetric, then load paths and reactions are also symmetric.

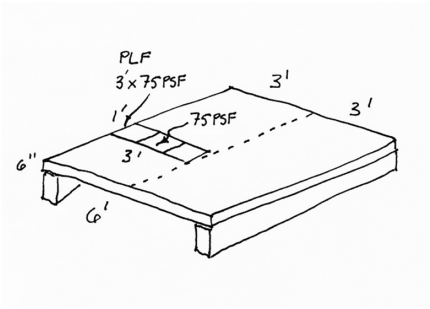


Tributary Area

The **tributary area** is an area used to determine the load on a member.



Each member has a tributary area that can be used to find the total load on that member.

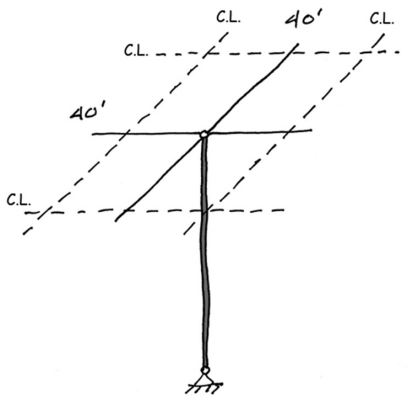


Quiz

The columns on the third floor are set on a 40 foot grid.

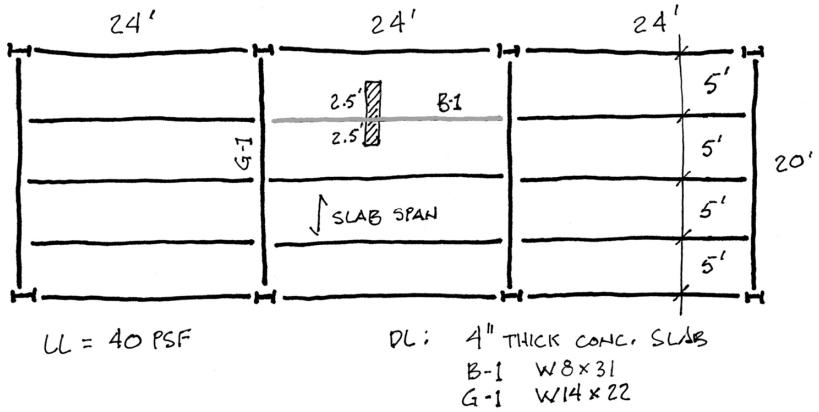
1. What is the tributary area of a central column?

2. For a roof DL = 15 psf + roof LL = 20 psf how much load would the column carry?



Load Transfer
example 1

Construct the load diagram and find end reactions for **Beam B-1** and **Girder G-1**



For Load on B1:

Floor Dead Load = 4" slab + W8x31 beam

DL slab = 150 PCF x (4/12)FT = 50 PSF
50 PSF x (2.5' + 2.5')SF/LF = **250 PLF**

DL beam W8x31 (selfweight) = **31 PLF**

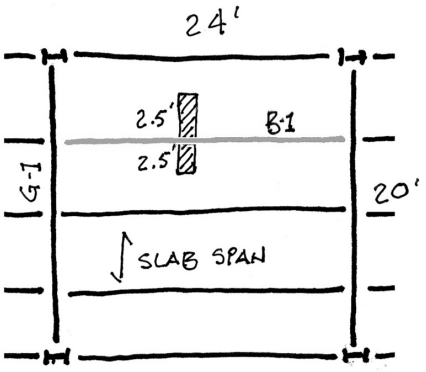
TOTAL DL = 250+31 = **281 PLF**

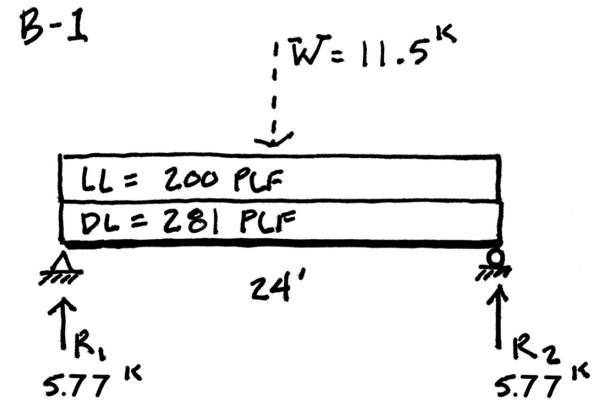
Floor Live Load = 40 PSF

40 PSF x (2.5' + 2.5')SF/LF = **200 PLF**

Load Transfer example 1

Construct load diagram and find end reactions for beam **B-1**





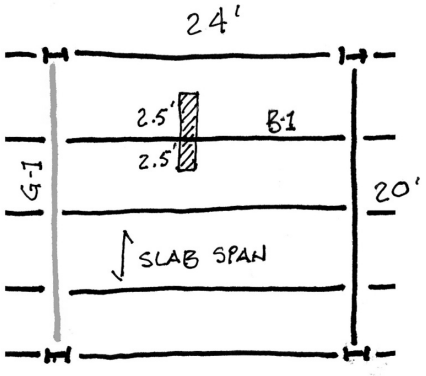
$W = wl = 481 \text{ PLF} \times 24' = 11544 \text{ LBS}$

$R_1 = R_2 = 5772 \text{ LBS}$ (BY SYMMETRY)

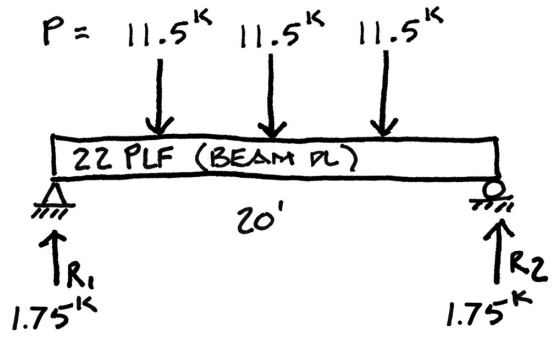
Load Transfer example 1

Construct load diagram and find end reactions for girder **G-1**

W14x22



G-1



BEAM DL = 22 PLF × 20' = 440 LBS

P = 5772 × 2 (from each side) = 11544 LBS

TOTAL LOAD = 3 × 11544 + 440 = 35072 LBS

$R_1 = R_2 = 35072 / 2 = 17536$ LBS

Floor System

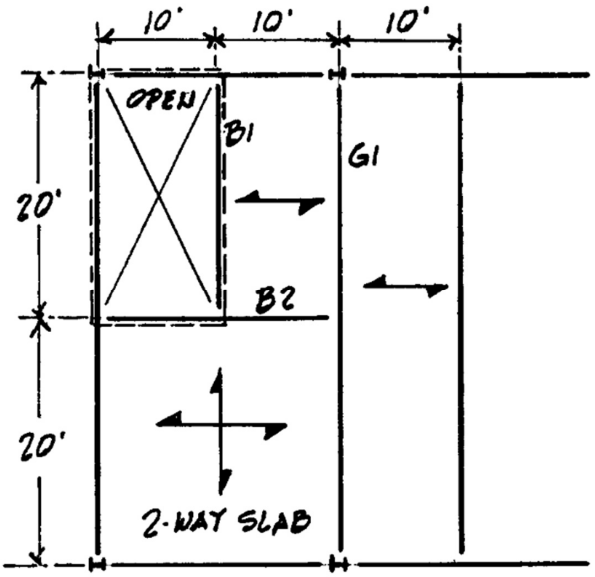
example 2

Find Load Diagrams for:
- B1
- B2
- G1

Dead Load
- wall 800 PLF
- floor slab 70 PSF

Live Load
- floor 90 PSF

Notice the order:
- B1, then B2, then G1



Concrete slab floor system spanning in directions shown

Floor System example 2 cont.

Find a beam not loaded by other beams, e.g., a joist or a simple beam.

Sketch the tributary area – ½ span to the next member.

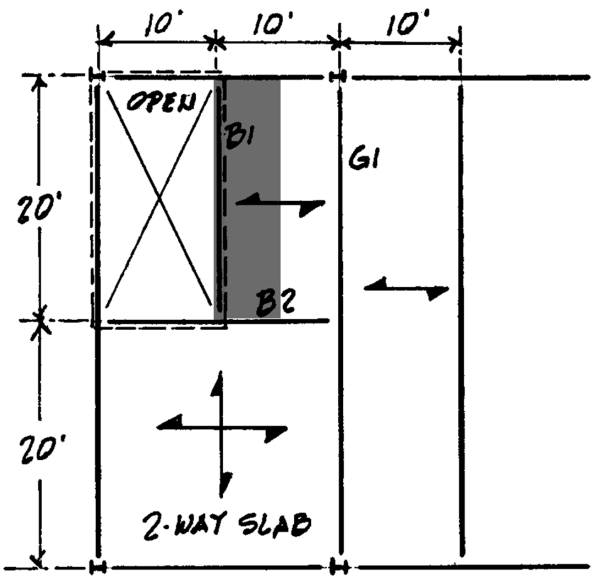
Sketch a load diagram

Calculate the distributed loads in PLF

(total DL+LL on floor = 160 PSF)
70 PSF + 90 PSF = 160 PSF

Floor:
160 PSF x 5 FT = 800 PLF

Wall:
800 PLF



Load diagram

Floor System example 2 cont.

From the PLF loading, calculate a total W load.

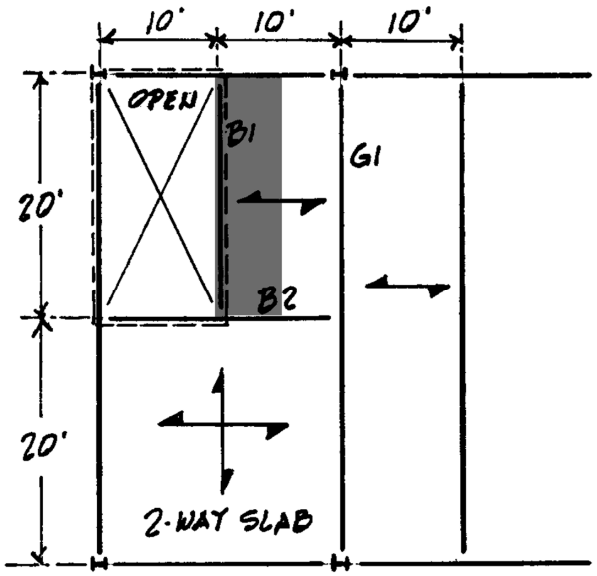
Locate W at the centroid of the distributed loading.

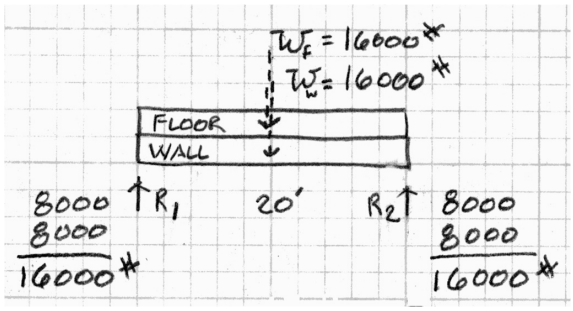
Solve the end reactions by summing moments about reactions or by proportions.

w x L = W

Floor:
800 PLF x 20 FT = 16000 LBS

Wall:
800 PLF x 20 FT = 16000 LBS





Load diagram

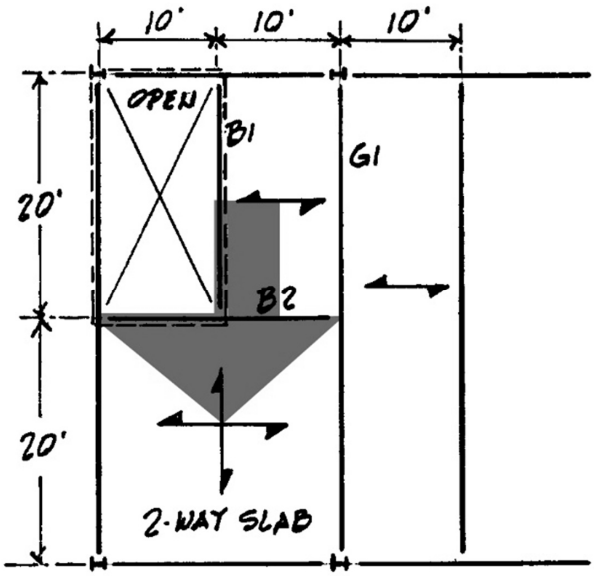
Floor System example 2 cont.

Continue with the next beam supporting a previously solved beam.

Sketch the tributary areas – 2-way slabs divide at 45° from each corner. Areas associated with reactions of other beams are proportional to the load distribution.

Sketch a load diagram

Calculate the distributed loads in PLF, finding peak values of varying loads.



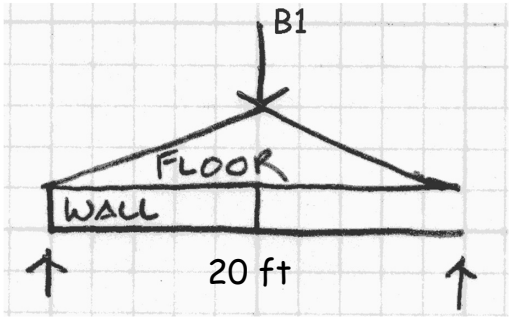
reaction from B1 = 16000 LBS

wall: DL = 800 PLF

floor: total DL+LL = 160 psf

2-way Slab (Peak Load)

160 PSF x 10 FT = 1600 PLF



Load diagram

Floor System example 2 cont.

From the PLF loading, calculate a total W load.

Locate W at the centroid of the distributed loading.

Solve the end reactions by summing moments or by proportions.

Reaction from B1:

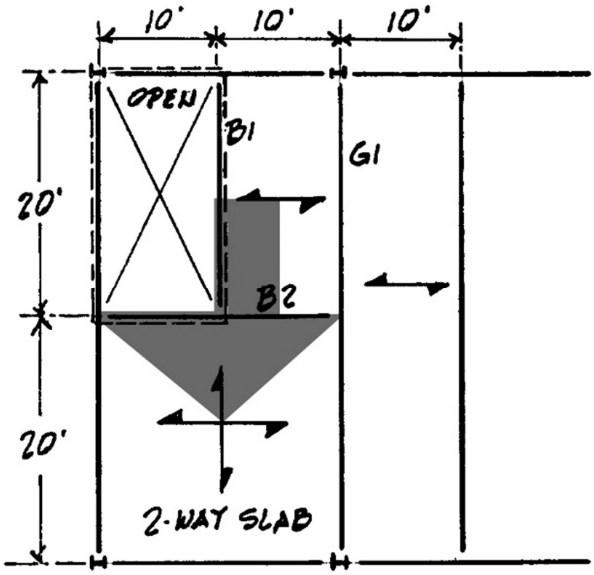
R = 16000 LBS

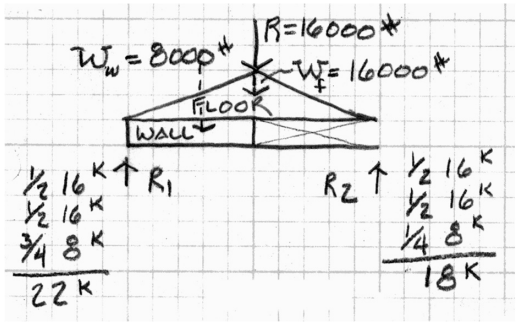
Wall:

800 PLF x 10 FT = 8000 LBS

Floor:

1600 PLF x 20 FT / 2 = 16000 LBS





Load diagram

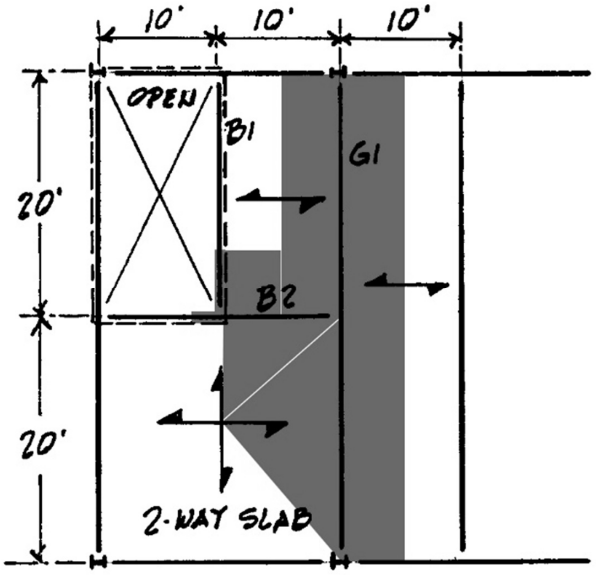
Floor System example 2 cont.

Continue with the next beam supporting a previously solved beam.

Sketch the tributary areas – 2-way slabs divide at 45° from each corner. Areas associated with reactions of other beams are proportional to the load distribution.

Sketch a load diagram

Calculate the distributed loads in PLF, finding peak values of varying loads.



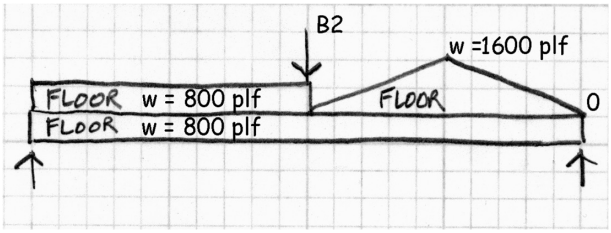
B2 = 18000 LBS

Peak Load on 2-way Slab:

160 PSF x 10 FT = 1600 PLF

Floor on one side of G1:

160 PSF x 5 FT = 800 PLF



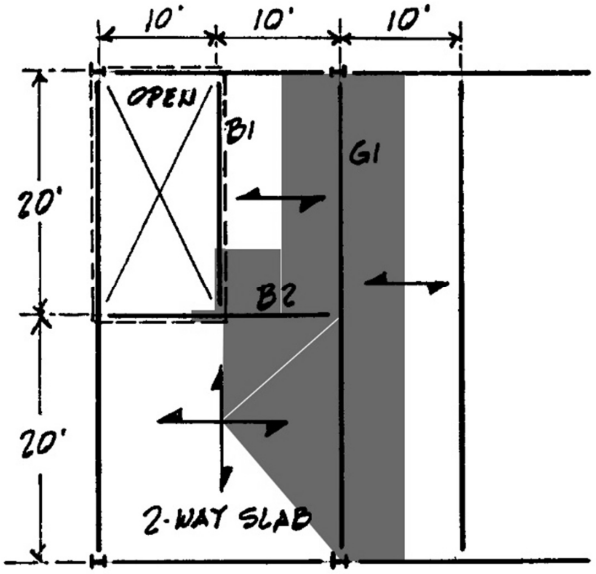
Load diagram

Floor System example 2 cont.

From the PLF loading, calculate a total W load.

Locate W at the centroid of the distributed loading.

Solve the end reactions by summing moments or by proportions.



reaction from B2:

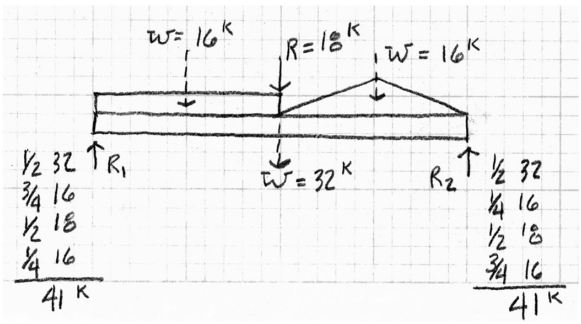
18000 LBS

Floor on G1:

800 PLF x 20 FT = 16000 LBS
800 PLF x 40 FT = 32000 LBS

2-way Slab:

1600 PLF x 10 FT = 16000 LBS



Load diagram