Structural Members

- In trusses:
  - All the members are connected using pin/hinge connections.
  - All external forces are applied at the pins/hinges.
  - All truss members are subjected to axial forces (tension or compression) only.
- In frames:
  - The horizontal members (beams) are subjected to flexural loads only.
  - In braced frames:
    - The vertical members (columns) are subjected to compressive axial forces only.
    - The diagonal members (braces) are subjected to tension/compression axial forces only.
  - In moment frames
    - The vertical members (beam-columns) are subjected to combined axial & flexural loads.

Structural Connections

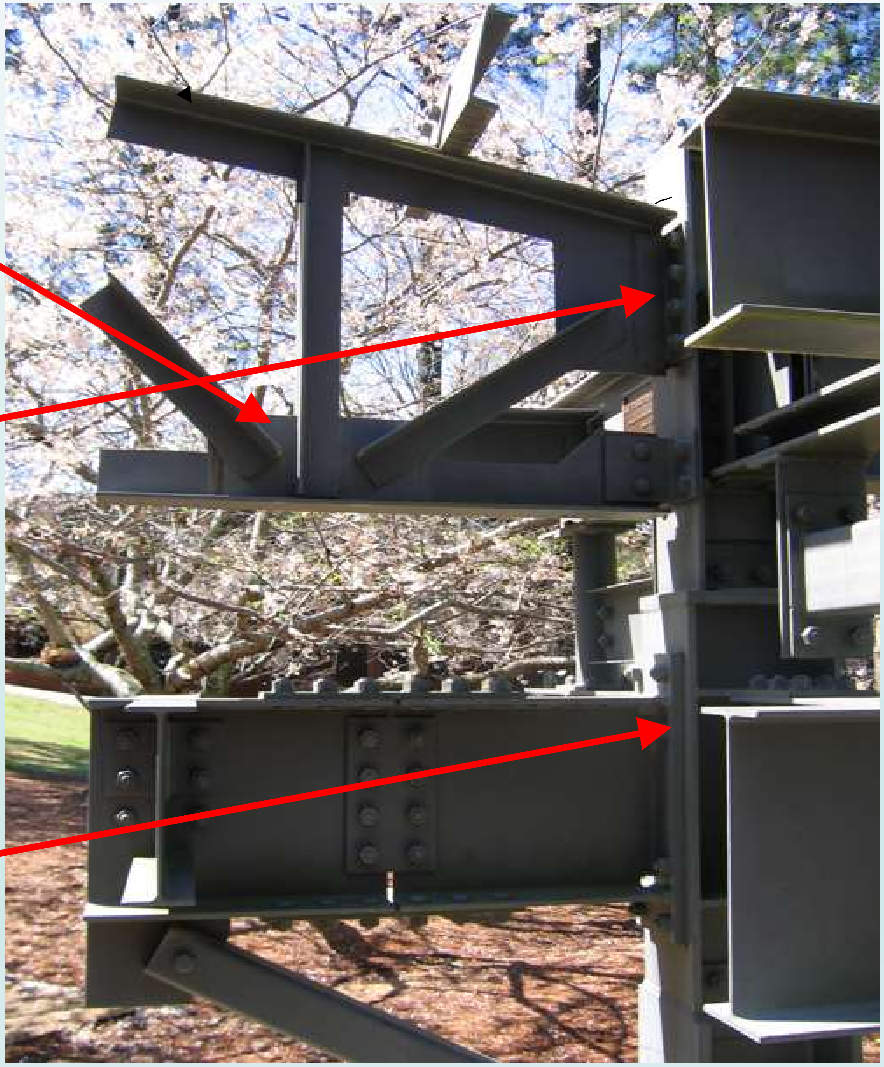
- Members of a structural frame are connected together using connections. Prominent connection types include:
  - Truss / bracing member connections are used to connect two or more truss members together. Only the *axial forces* in the members have to be transferred through the connection for continuity.
  - Simple shear connections are the *pin connections* used to connect beam to column members. Only the *shear forces* are transferred through the connection for continuity. The *bending moments* are not transferred through the connection.
  - Moment connections are *fix connections* used to connect beam to column members. Both the shear forces & bending moments are transferred through the connections with very small deformations (*full restraint*).

Structural Connections

Truss connection

Simple Shear connection

Moment resisting connection



Structural Loads

- The building structure must be designed to carry or resist the loads that are applied to it over its design-life. The building structure will be subjected to loads that have been categorized as follows:
  - Dead Loads (*D*): are permanent loads acting on the structure. These include the self-weight of structural & non-structural components. They are usually *gravity* loads.
  - Live Loads (*L*): are non-permanent loads acting on the structure due to its use & occupancy. The magnitude & location of live loads changes frequently over the design life. Hence, they cannot be estimated with the same accuracy as dead loads.
  - Wind Loads (*W*): are in the form of *pressure* or *suction* on the exterior surfaces of the building. They cause horizontal lateral loads (forces) on the structure, which can be critical for tall buildings. Wind loads also cause *uplift* of light roof systems.

Structural Loads

- Snow Loads (*S*): are vertical gravity loads due to snow, which are subjected to variability due to seasons & drift.
- Roof Live Load (L_r): are live loads on the roof caused during the design life by planters, people, or by workers, equipment, & materials during maintenance.
- Values of structural loads can be computed based on the design code.

Dead Loads (D)

- Dead loads consist of the weight of all materials of construction incorporated into the building including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding & other similarly incorporated architectural & structural items, & fixed service equipment such as plumbing stacks & risers, electrical feeders, & heating, ventilating, & air conditioning systems.

- In some cases, the structural dead load can be estimated satisfactorily from simple formulas based in the weights & sizes of similar structures. For example, the average weight of steel framed buildings is 3 - 3.6 kPa, & the average weight for reinforced concrete buildings is 5 - 6 kPa.

Dead Loads (D)

- From an engineering standpoint, once the materials and sizes of the various components of the structure are determined, their weights can be found from tables that list their densities. See Tables 1.2 & 1.3, which are taken from Hibbeler, R.C. (1999), *Structural Analysis,* 4th Edition.

Dead Loads (D)

Table 1–2 Minimum Densities for Design Loads from Materials*

	lb/ft^3	kN/m^3
Aluminum	170	26.7
Concrete, plain cinder	108	17.0
Concrete, plain stone	144	22.6
Concrete, reinforced cinder	111	17.4
Concrete, reinforced stone	150	23.6
Clay, dry	63	9.9
Clay, damp	110	17.3
Sand and gravel, dry, loose	100	15.7
Sand and gravel, wet	120	18.9
Masonry, lightweight solid concrete	105	16.5
Masonry, normal weight	135	21.2
Plywood	36	5.7
Steel, cold-drawn	492	77.3
Wood, Douglas Fir	34	5.3
Wood, Southern Pine	37	5.8
Wood, spruce	29	4.5

Table 1–3 Minimum Design Dead Loads*

Walls	psf	kN/m^2
4-in. (102 mm) clay brick	39	1.87
8-in. (203 mm) clay brick	79	3.78
12-in. (305 mm) clay brick	115	5.51
Frame Partitions and Walls		
Exterior stud walls with brick veneer	48	2.30
Windows, glass, frame and sash	8	0.38
Wood studs 2 × 4, (51 × 102) unplastered	4	0.19
Wood studs 2 × 4, (51 × 102) plastered one side	12	0.57
Wood studs 2 × 4, (51 × 102) plastered two sides	20	0.96
Floor Fill		
Cinder concrete, per inch (mm)	9	0.017
Lightweight concrete, plain, per inch (mm)	8	0.015
Stone concrete, per inch (mm)	12	0.023
Ceilings		
Acoustical fiberboard	1	0.05
Plaster on tile or concrete	5	0.24
Suspended metal lath and gypsum plaster	10	0.48
Asphalt shingles	2	0.10
Fiberboard, $\frac{1}{2}$-in. (13 mm)	0.75	0.04

*Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ANSI/ASCE 7-95. Copies of this standard may be purchased from ASCE at 345 East 47th Street, New York, N.Y. 10017-2398.

Live Loads – Summary Table

- Building floors are usually subjected to uniform live loads or concentrated live loads. They have to be designed to safely support these loads.

Type of occupancy	kPa
Offices	2.5 - 5
Corridors	5
Residential	2
Stairs and exit ways	5
Stadiums	5
Sidewalks	12

Wind Loads

- Design wind loads for buildings can be based on: (a) simplified procedure; (b) analytical procedure; & (c) wind tunnel or small-scale procedure.
- Refer to ASCE 7-05 for the simplified procedure. This simplified procedure is applicable only to buildings with mean roof height less than 18 m or the least dimension of the building.
- The wind tunnel procedure consists of developing a small-scale model of the building & testing it in a wind tunnel to determine the expected wind pressures etc. It is expensive & may be utilized for difficult or special situations.
- The analytical procedure is used in most design offices. It is fairly systematic but somewhat complicated to account for the various situations that can occur:

Wind Loads

- Wind velocity will cause pressure on any surface in its path. The wind velocity & hence the velocity pressure depend on the height from the ground level. Equation 1.3 is recommended by ASCE 7-05 for calculating the velocity pressure (q_z) in SI

$$q_z = 0.613\, K_z\, K_{zt} K_d\, V^2\, I \text{ (N/m}^2\text{)}$$

Wind Loads

q_z *– Static wind pressure*

V *- the wind velocity in m/s*

K_d *- a directionality factor (= 0.85 see Table 6.4 page 80)*

K_{zt} *- a topographic factor (= 1.0)*

I *- the importance factor (=1.0)*

K_z *- varies with height z above the ground level (see Table 6.3 page 79)*

exposure B structure surrounded by buildings/forests/… at least 6m height

exposure C open terrain

Wind Loads

- A significant portion of Palestine has V = 100 km/h. At these location

$$q_z = 402\ K_z\ (\mathrm{N/m^2})$$

The velocity pressure q_z is used to calculate the design wind pressure (p) for the building structure conservatively as follows:

$$p = q\ GC_p\ (\mathrm{N/m^2})$$