Concrete

- Concrete is a mixture of sand, gravel with a paste of cement and water.
- Sometimes one or more admixture is added to change certain characteristics of the concrete such as workability and time of hardening.

Advantages of R.C

- High compressive strength when compared with other materials.
- High resistant to fire and water.
- Reinforced concrete structures are very rigid.
- Economical material available.
- Has the ability to cast into any shapes from simple slabs, beams and columns to arches.

Disadvantage of R.C

- Concrete has a very low tensile strength, requiring the use of tensile reinforcing.
- Forms are required to hold the concrete in place until it hardens sufficiently.

Compressive Strength as the main Quality indicator

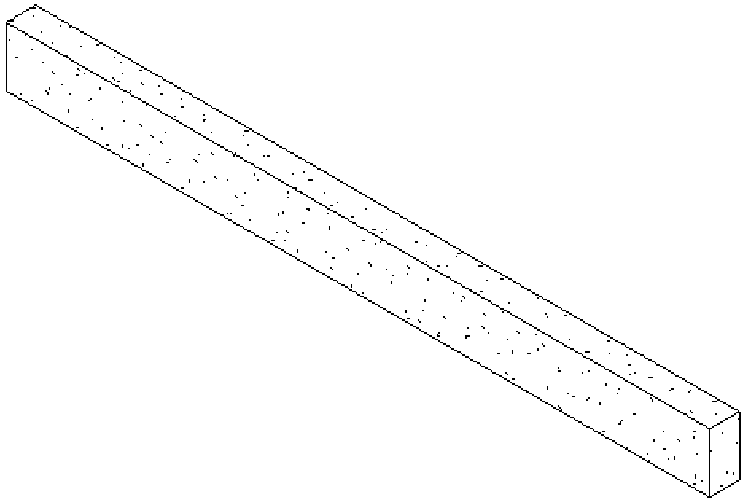
- The main measure of the structural quality of concrete is it is compressive strength.
- Test for this property are made on cylindrical spacemen's of height equal to twice the diameter, usually 150 x 300 mm and subjected to uniaxial loading.

Type of Elements

1. Beam

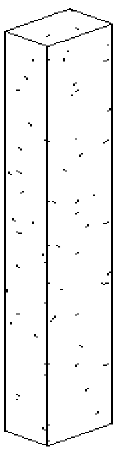
Beams are usually straight horizontal members used primarily to carry **vertical loads**.

- Quite often they are classified according to the way they are supported.



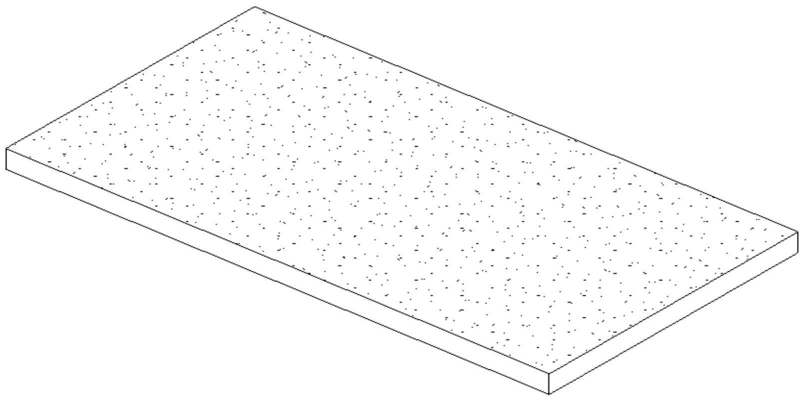
2. Column

Columns are Members that generally vertical and resist **axial compressive loads** are referred to as ***columns***. Circular and square cross sections with reinforcing rods are used for those made of concrete. Occasionally, columns are subjected to both an axial load and a bending moment.



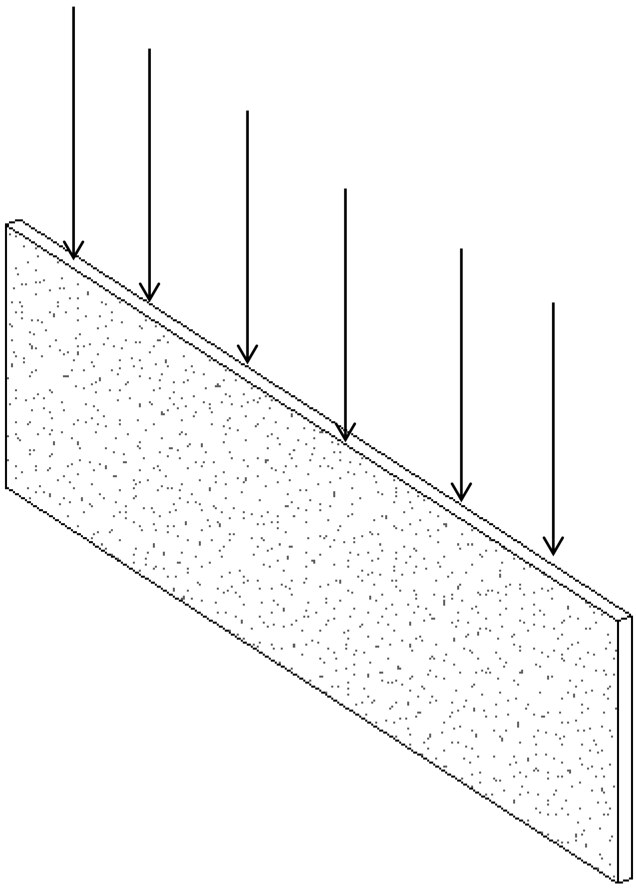
3. Slabs

A reinforced concrete slab is a structural member, usually horizontal whose depth h, is small compared to their length, L and width, S.



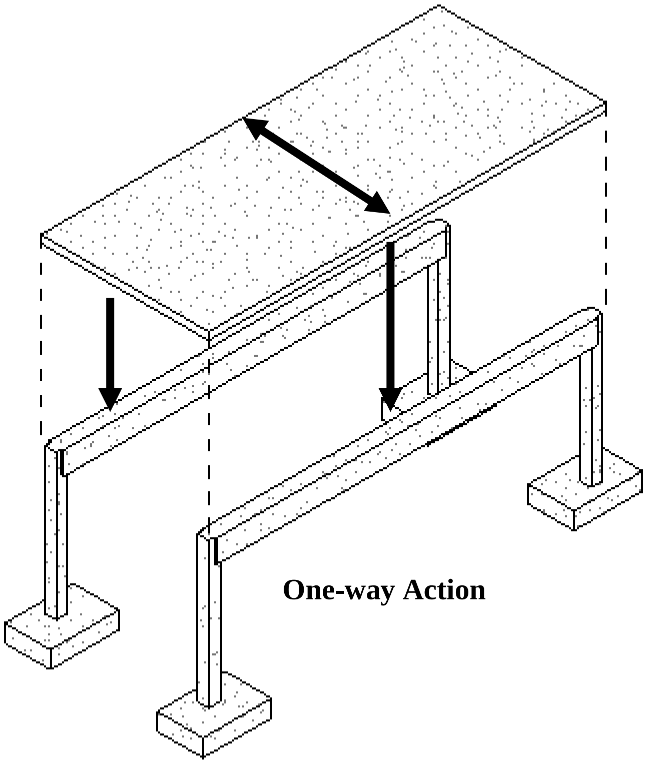
4. Bearing Wall

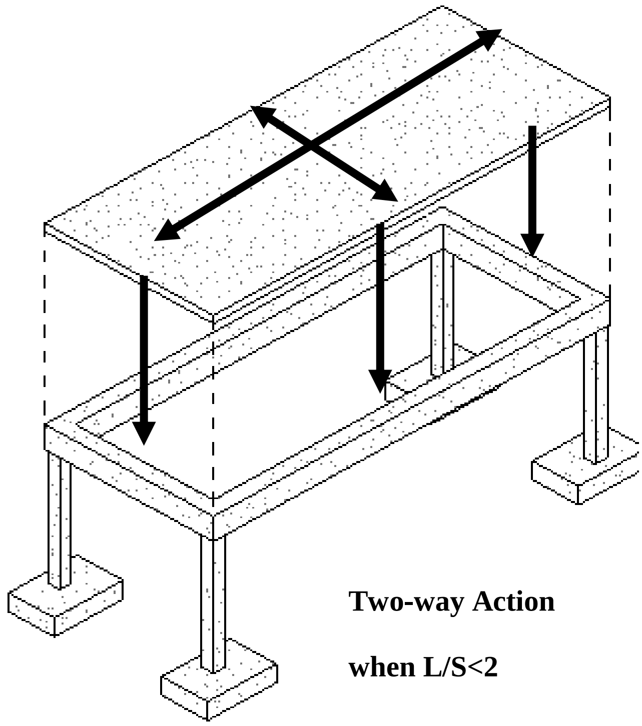
Bearing wall is subjected to an axial load.

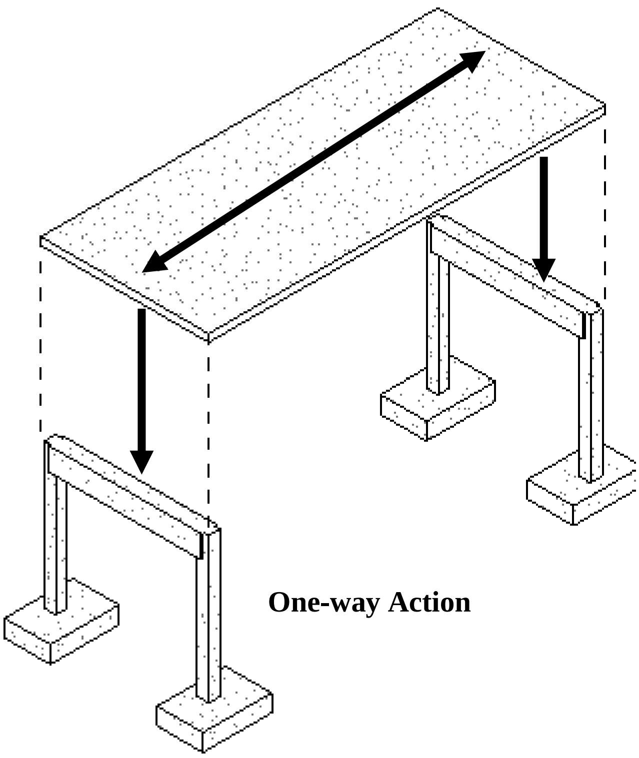


Loads Path

Load will be carried by slab to supporting beam by one-way or two-way action then carried to column and then to foundation.







Loads

Loads that act on structures can be divided into three broad categories: **dead load**, **live load**, and **environmental loads**.

1.1.1 Dead loads

- Are those that are constant in magnitude and fixed in location throughout the lifetime of the structure.
- Usually the major part of the dead load is the weight of the structure itself.
  This can be calculated with good accuracy from the design configuration, dimensions of the structure, and density of the material.
- For buildings, floor fill, finish floor, and plastered ceilings are usually included as dead loads.

1.1.2 Live loads

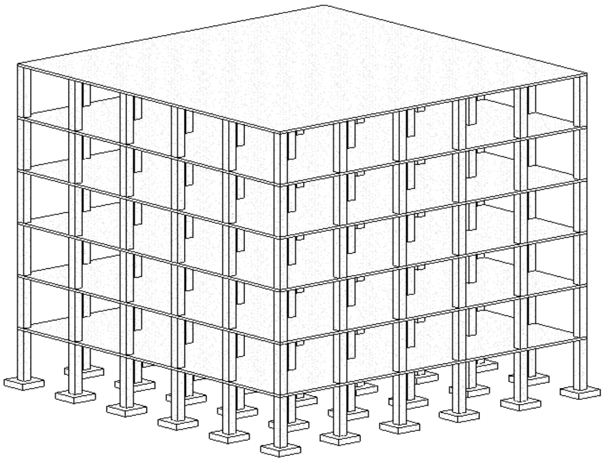
Consist chiefly of occupancy loads in buildings and traffic loads on bridges. They may be either fully or partially in place or not present at all, and may also change in location. Their magnitude and distribution at any given time are uncertain, and even their maximum intensities throughout the lifetime of the structures are not known with precision for values for live load to be used in building are found in **ASCE 7-10**.

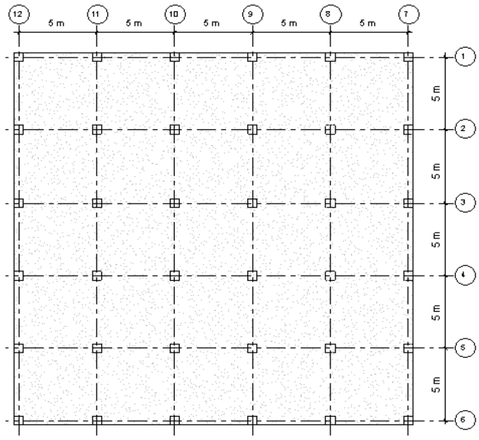
1.1.3 Environmental loads

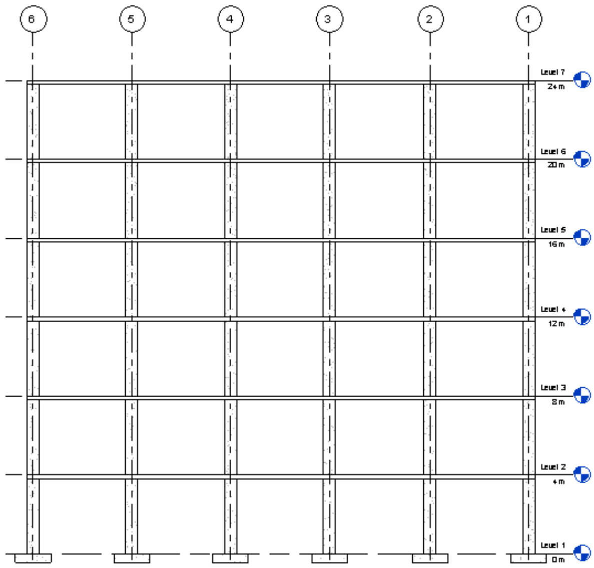
Consist mainly of snow loads, wind pressure, earthquake loads, soil pressures on subsurface portions of structures, loads from possible ponding of rainwater on flat surface, and force caused by temperature differentials. Like live load s, environmental loads at any given time are uncertain in both magnitude and distribution.

Example: For the flat plate system shown below in figure below is proposed for a hospital building. Almost all floors to be patient rooms.

- According to requirements of ASCE 7-10, select an appropriate value for floor live load.







Solution:

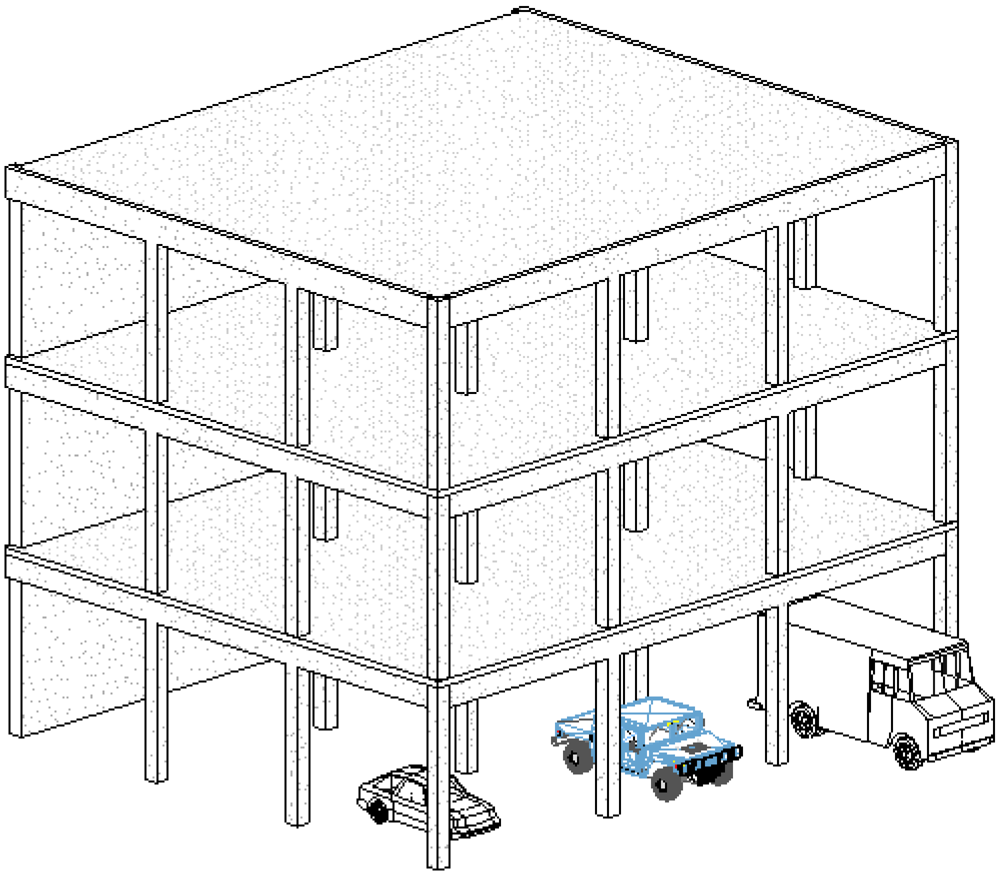
According to **Table 4-1** from **ASCE 7-10**

Minimum live (W_L) load for hospitals for patient rooms is equal to 1.92 kN/m^2 ■

Hospitals	
Operating rooms, laboratories	60 (2.87)
Patient rooms	40 (1.92)
Corridors above first floor	80 (3.83)

Example: For the flat plate system shown below in figure below is proposed for a residential building. Almost all floors to be public rooms and corridors serving them.

- According to requirements of ASCE 7-10, select an appropriate value for floor live load.



Solution:

According to **Table 4-1** from **ASCE 7-10**

Minimum live (W_L) load for residential building and all floors to be public rooms is equal to 4.79 kN/m^2 ■

Design Philosophy

Uncertainties in the analysis, design and construction of reinforced concrete structures can be summarized in the diagram below:

Uncertainty in the analysis and Design of Reinforced concrete Structures can be classified into:

Uncertainty in prediction the applied load: this is due to

- Usually, there is a difference between the actual and predicted loads
- Generally, the actual loads have a distribution that differs from the assumed one.

Uncertainty in computed theoretical or nominal strength: this is due to

- Actual member dimensions are different from that shown in the drawings and assumed in the calculations.
- Actual materials strength are not exactly the same to that assumed in the design calculations.

Load combinations

Structural failures usually occur under combinations of several loads. In recent years these combinations have been presented in what is referred to as the companion action format. This is an attempt to model the expected load combinations. The load combinations in **ACI Code Section 5.3** are examples of companion action load combinations chosen to represent realistic load combinations that might occur.

Table 5.3.1—Load combinations

Load combination	Equation	Primary load
$U = 1.4D$	(5.3.1a)	D
$U = 1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1b)	L
$U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.5W)$	(5.3.1c)	L_r or S or R
$U = 1.2D + 1.0W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1d)	W
$U = 1.2D + 1.0E + 1.0L + 0.2S$	(5.3.1e)	E
$U = 0.9D + 1.0W$	(5.3.1f)	W
$U = 0.9D + 1.0E$	(5.3.1g)	E

Where:
L = live load that is a function of use and occupancy
Lr = roof live load
S = roof snow load
R = roof rain load
W=Wind load
E=earth quake load

For the common case of a member supporting dead and live load only, ACI Eq. (5.3.1b) is written as:

$$U=1.2D+1.6L$$

Strength

Design strength of any element in terms of moment, axial force, shear and torsion shall be taken as the nominal strength **Sn** multiplied by strength reduction factor φ.

Strength-Reduction Factors, ACI Code Section 21.2.1

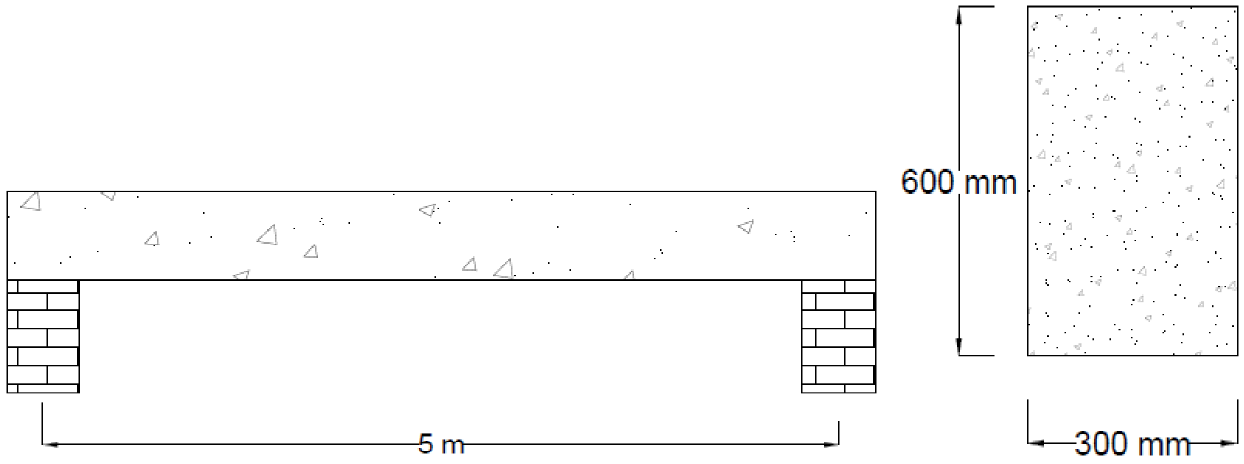
TABLE 1.3
Strength reduction factors in the ACI Code

Strength Condition	Strength Reduction Factor ϕ
Tension-controlled sections[a]	0.90
Compression-controlled sections[b]	
Members with spiral reinforcement	0.75
Other reinforced members	0.65
Shear and torsion	0.75
Bearing on concrete	0.65
Post-tensioned anchorage zones	0.85
Strut-and-tie models[c]	0.75

- Based on above discussion, a section to be classified as adequate according to strength requirement of the ACI code, it should satisfy the following relation.

$$\varphi\ Sn \geq U$$

Example: check the adequacy for the simply supported beam shown below if the beam is subjected to uniform dead load (2) kN/m^2 **(neglect the self-weight)** and uniform live load (3) kN/m^2 , the beam nominal strength is equal to 50 kN.m **(this will be computed in details in upcoming chapters),** assume tension control failure.



Example: check the adequacy for the cantilever beam (beam length is 5 m) shown below; the beam is subjected to uniform dead load (3) kN/m^2 and uniform live load (5) kN/m^2, the beam nominal strength is equal to 50 kN.m, assume tension control failure.