Steel and concrete structures

Introduction

What is concrete?

- Concrete is a stonelike material obtained by permitting a carefully proportioned mixture of cement, sand, aggregate, and water to harden in forms of the shape and dimensions of the desired structure.

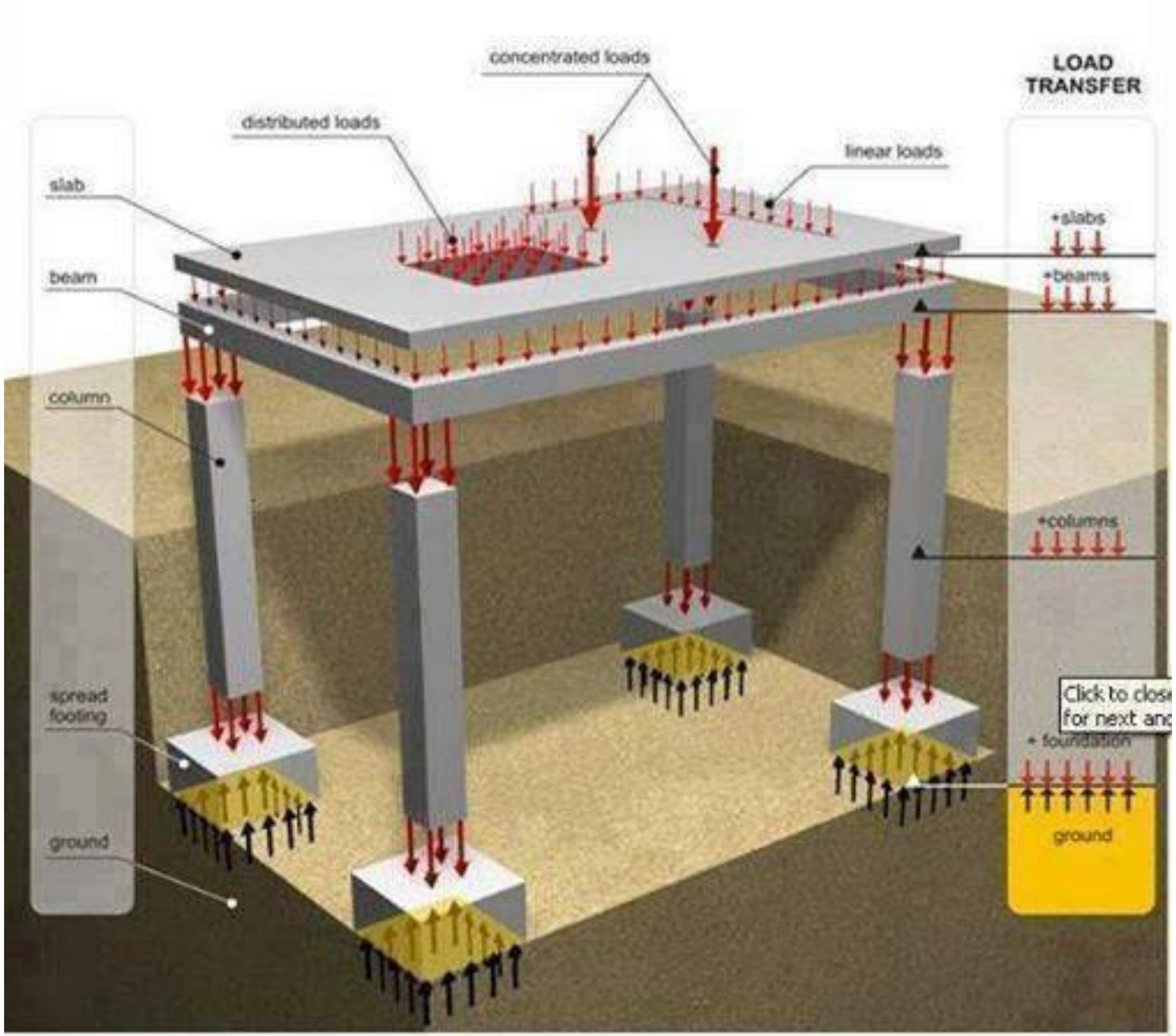
- Concrete has been widely used in construction for centuries, as it is strong in compression and easy to produce and handle.

Disadvantages of concrete

- Low tensile strength.
- Brittle material.

- Both of these problems are fixed by adding reinforcing steel to the concrete.

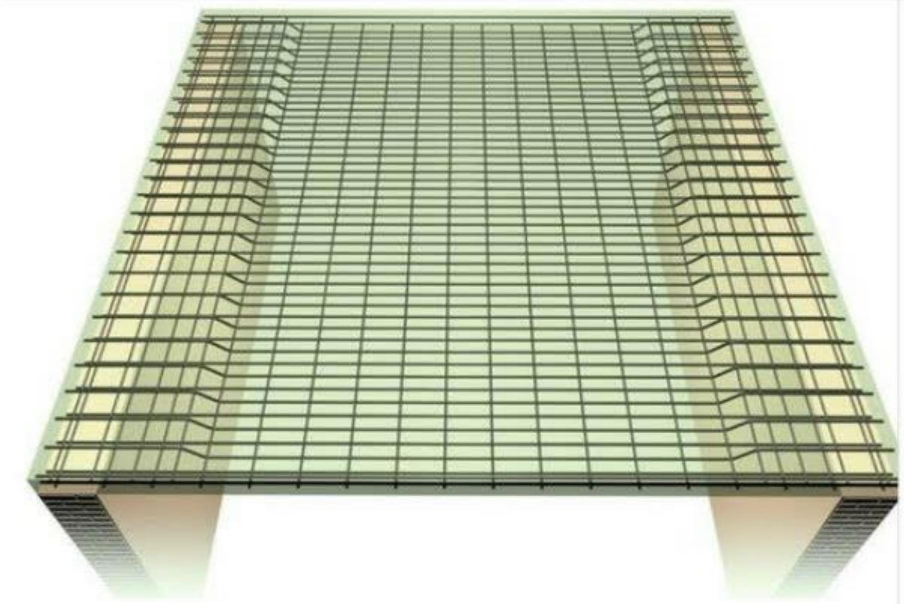
Load path



Load path from the structure's slab to the ground

Reinforced Concrete Structural forms

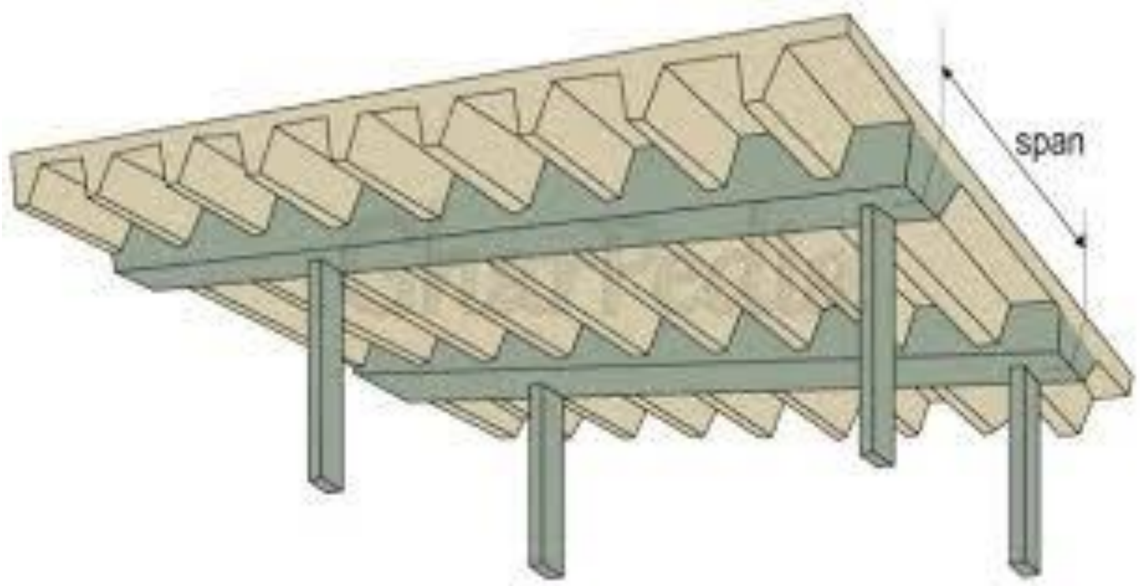
- One-way solid slabs
- Two-way solid slab



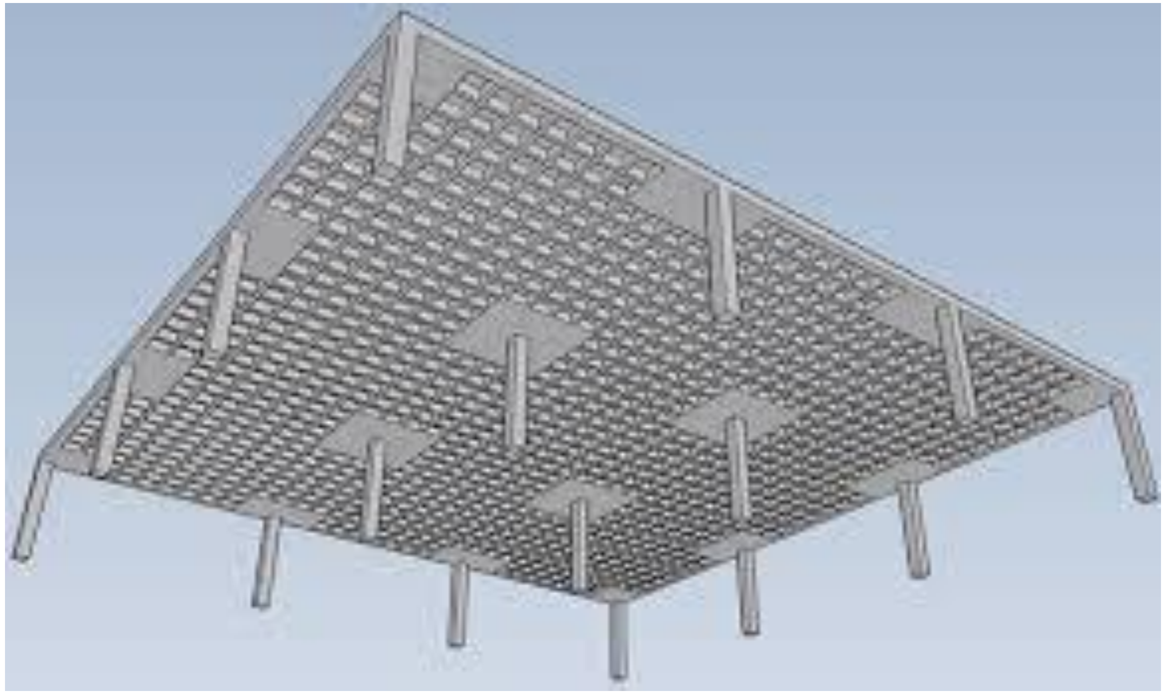
One Way Slab

Two Way Slab

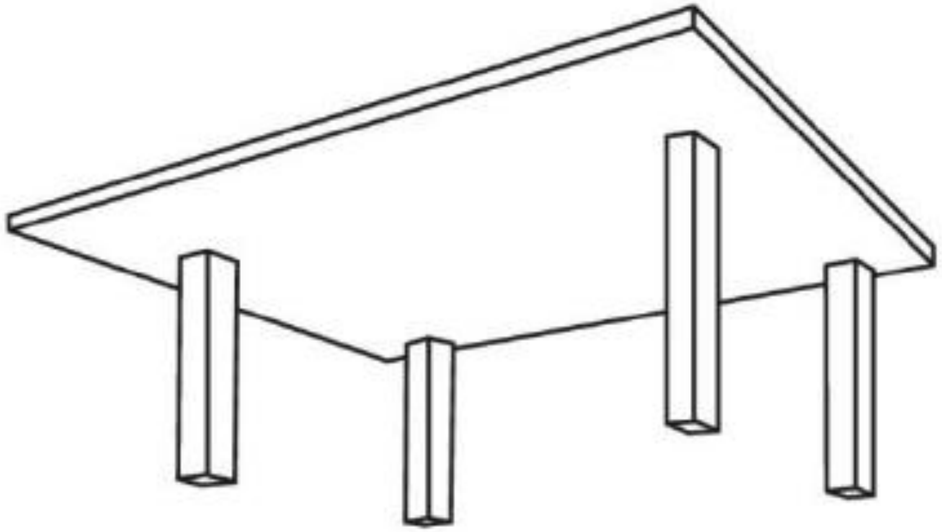
- One-way ribbed slab

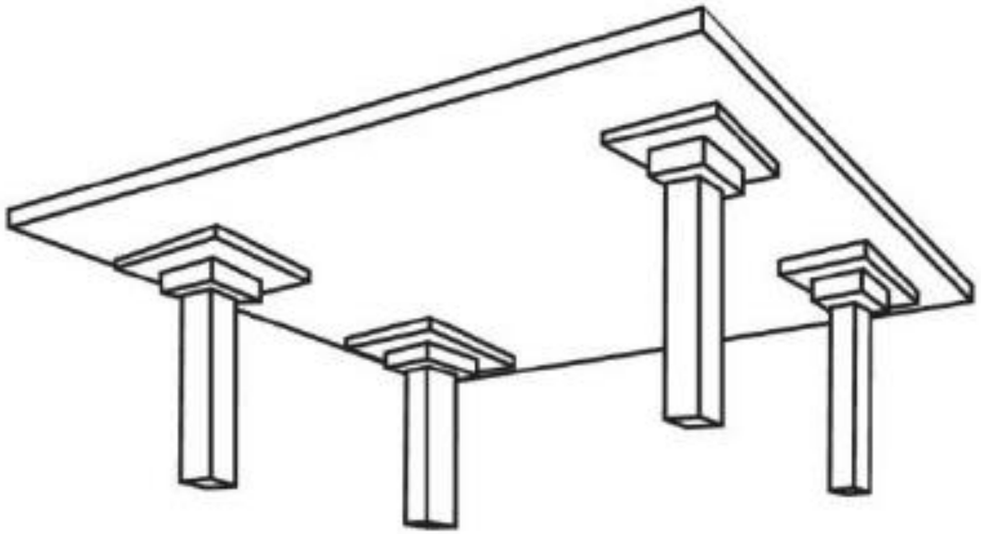


- Two-way ribbed slab (waffle slab)



- Flat slabs (no interior beams)





- Shells

- Bridges

- Water tanks

- Retaining walls

Loads

- Dead Loads (D): Constant in magnitude and fixed in location throughout life time of the structure.
- Live Loads (L): occupancy loads in buildings and traffic loads on bridges. Usually specified in building codes.
  - Uncertain loads.
  - Minimum, more can be added, concentrated loads might be added too.
  - Some reductions are permitted.
  - Not fully loaded all the time.

- Environmental loads (Uncertain in both magnitude and distribution):
  - Snow Loads (S),
  - Wind Loads (W),
  - Earthquake Loads (E),
  - Soil Pressure (H),
  - Fluid pressure (F),
  - Temperature Differentials (T).

Design bases

- Serviceability design

Serviceability requires that deflections be adequately small, that cracks, if any, be kept to tolerable limits, and that vibrations be minimized.

- <u>Strength design</u>
- The basic RC design concept is to select the concrete member dimensions and the reinforcing bars diameter and number/spacing, so that the member strength is adequate to resist forces resulting from certain hypothetical overload stages, significantly above loads expected actually to occur in service. This design concept is known as strength design.
- A member designed by the strength method must also perform in a satisfactory way under normal service loading.

Design Codes

- The design of concrete structures is generally done within the framework of codes giving specific requirements for materials, structural analysis, member proportioning, etc. ACI code has requirements for serviceability design and for strength design.

Design provisions of ACI code

Design strength ≥ required strength

$$\varphi S_n \geq U$$

The nominal strength S_n for different members will be computed within this course, and the required strength U is calculated by applying appropriate load factors to service loads.

- Hence, if a member is subjected to moment, shear, and axial load,

then it must conform to:

$$\varphi M_n \geq M_u$$

$$\varphi V_n \geq V_u$$

$$\varphi P_n \geq P_u$$

- n is the nominal strengths and u is the factored load (moment, shear, and axial load).

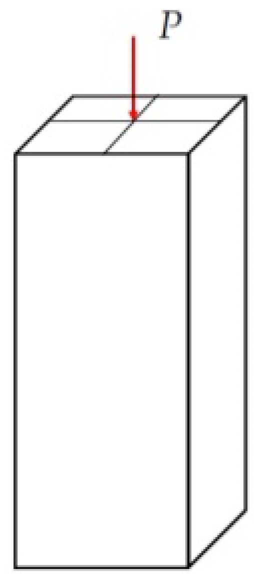
- When computing the factored loads, load factors may be applied either to the service loads themselves or to the internal load effects calculated from the service loads.
- For individual loads, lower factors are used for loads known with greater certainty, e.g., dead load, compared with loads of greater variability, e.g., live loads.
- In all cases in the combination table, the controlling equation is the one that gives the largest factored load effect U.

- The strength reduction factors ϕ in the ACI Code are given different values depending on the accuracy with which various strengths can be calculated. Thus, the value for bending is higher than that for shear or bearing.
- Also, ϕ values reflect the probable importance, for the survival of the structure.
- For both these reasons, a lower value is used for columns than for beams.

Columns load example

- What is the strength design factored loading (P_u) for the following column subjected to the following loads?

Load type	Load (kN)
Dead	300
Live	220
Earthquake	50
Snow	0
Fluid	0
Soil	0
Rain	20
Wind	0
Temperature	0

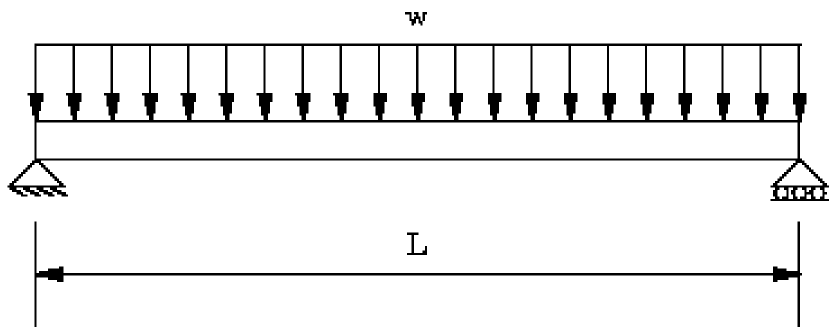


Load Combination	Load (kN)
$U = 1.2D + 1.6L$	712
$U = 1.4(D + F)$	420
$U = 1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$	737
$U = 1.2D + 1.6(L_r \text{ or } S \text{ or} R) + (1.0L \text{ or } 0.8W)$	660
$U = 1.2D + 1.6W + 1.0L + 0.5 (L_r \text{ or } S \text{ or} R)$	605
$U = 0.9D + 1.6W + 1.6H$	270
$U = 1.2D + 1.0E + 1.0L + 0.2S$	630
$U = 0.9D + 1.0E + l.6H$	320

Beam load example

- What is the strength design factored loading (M_u) for the following beam subjected to the following loads?

Load type	Load (kN/m)
Dead	22
Live	35
Earthquake	0
Snow	10
Fluid	0
Soil	0
Rain	0
Wind	0
Temperature	4



Load Combination	Load (kN/m)
U = 1.2D + 1.6L	82.4
U = 1.4(D +F)	30.8
U = 1.2(D + F + T) + 1.6(L + H) + 0.5(L_r or S or R)	92.2
U = 1.2D + 1.6(L_r or S orR) + (1.0L or 0.8W)	77.4
U = 1.2D + 1.6W + 1.0L + 0.5 (L_r or S orR)	66.4
U = 0.9D + 1.6W + 1.6H	19.8
U = 1.2D + 1.0E + 1.0L + 0.2S	63.4
U = 0.9D + 1.0E + l.6H	19.8

- If the span of the beam is L=6 m, What is Mu?
- What is the required Mn for this section (tension controlled)?