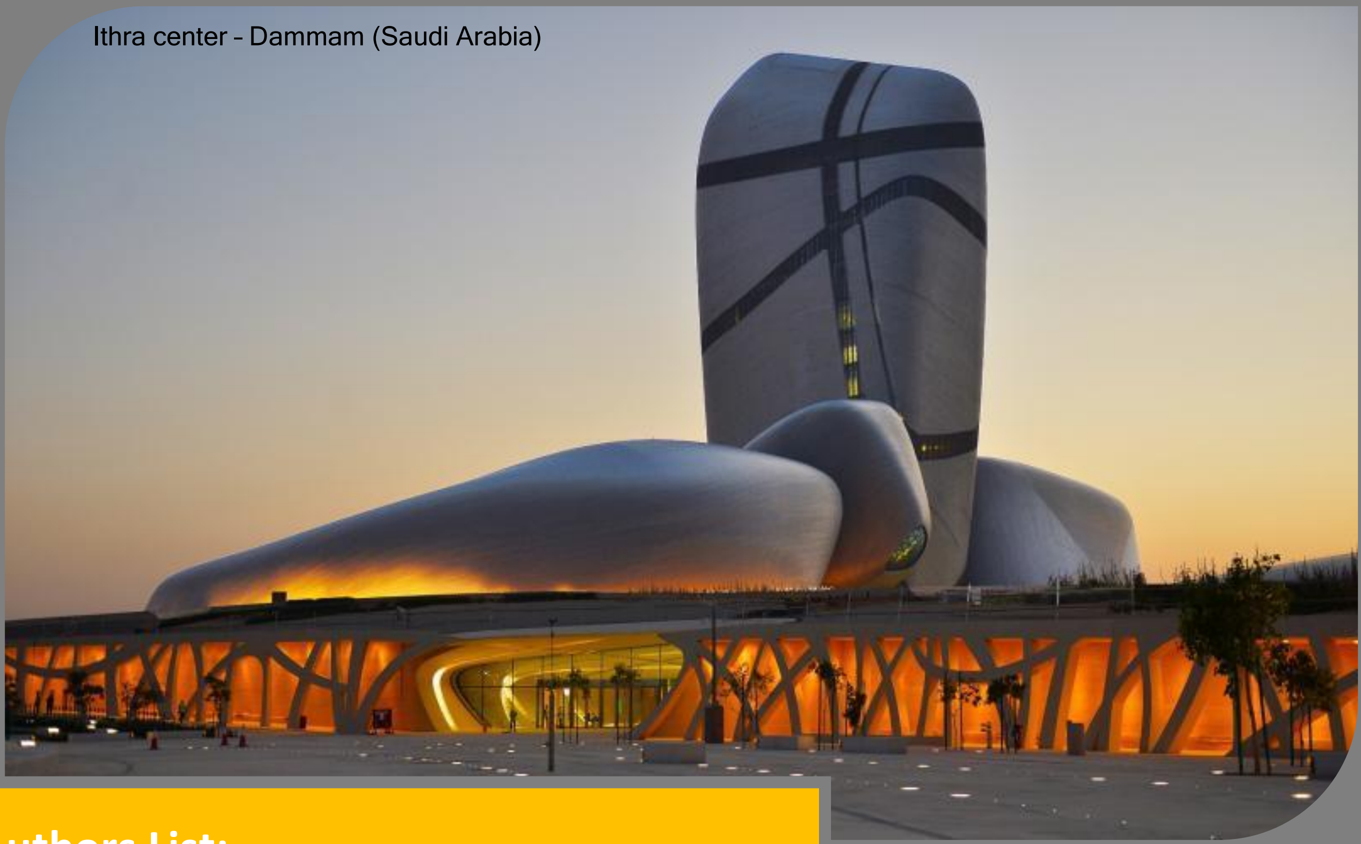
Basic Knowledge in

Civil Engineering



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Authors List:

1- AEHcivil07 – 19/01/2020

1 Introduction

Dear Engineer,

This paper was created to provide general information to fresh graduate civil engineers, to help refresh their memory before entering technical interviews to avoid any situations where the engineer will be embarrassed for forgetting what the unit of uniformly distributed load is! (which is kN/m BTW).

all informations are basic to avoid complexity as most interviews will be about simple, general and basic information.

The author authorizes any updates or follow-ups on his work, as the main reason for this paper is to help engineers in their interviews, so any additional improvement will add value to this paper, just don't forget to add your name to the authors list above and the date of the update to leave your print in helping other engineers.

I encourage every engineer to put time and effort in reading the paper, it helped me for sure! And it might help you to.

ولا تنسوني وكل من ساهم من دعواتكم

Regards,

AEHcivil07

Contents

2 Basic definitions

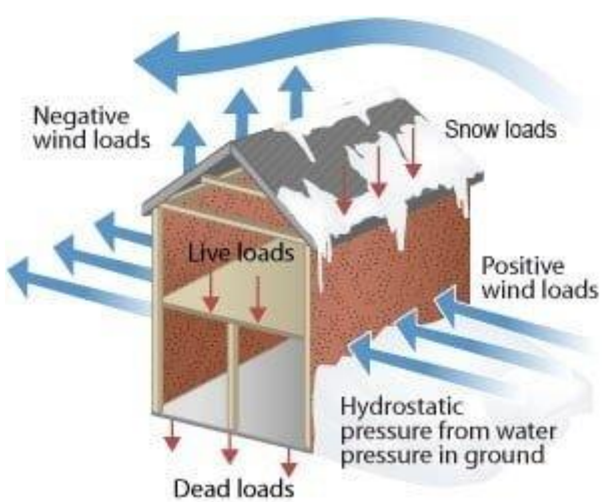
2.1 Loads:

The types of loads acting on structures for buildings and other structures can be classified as:

1- **Vertical load, and it can be divided into:**
   a. **Dead load:** is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipment's and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column and the safety factor for this load is lower than live load.
   b. **Live load:** The second vertical load that is considered in design of a structure is imposed loads or live loads. Live loads are either movable or moving loads with out any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc.. Live loads keeps on changing from time to time. These loads are to be suitably assumed by the designer.
   b.1 Snow load.
   b.2 Rain load.

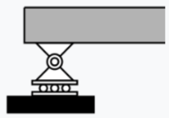
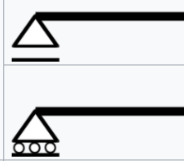
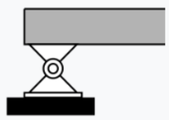
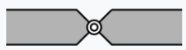
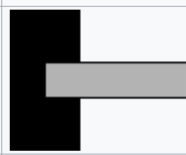
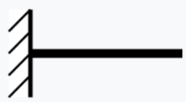
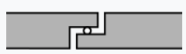
2- **Horizontal load, and examples of that is:**
   a. Wind load.
   b. Earthquake load.

3- **Accidental loads:**
   Accidental load can be defined as "rear but possible loads" a good example for that can be a structure located in the sea such as oil rigs and bridge supports, these structural elements are subjected to a scenario that a ship can possibly impact with it so the designer must design for such incident.



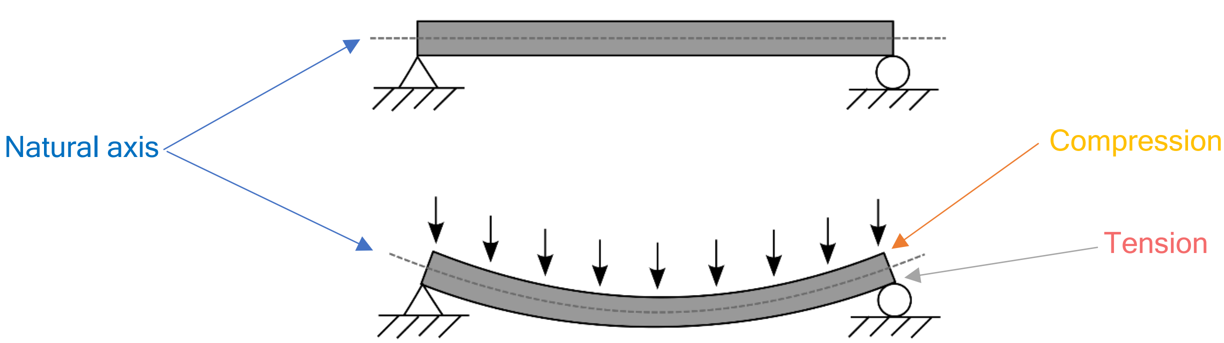
2.2 Supports:

supports is a part of a building or structure providing the necessary stiffness and strength in order to resist the internal forces (vertical forces of gravity and lateral forces due to wind and earthquakes) and guide them safely to the ground. And types of supports are:

Name	Schematic diagram	Simple figure	Allowed movement			Reaction	
			Vertical	Horizontal	Rotation (Moment)	Direction	Number
Roller or simple (movable) support			No	Yes	Yes		1
Pinned or hinged support			No	No	Yes		2
Middle hinge (for axial member)			No	No	Yes		2
Fixed support			No	No	No		3
Middle hinge (for beam member)			No	Yes	No		2

2.3 Natural axis:

The neutral axis is an axis in the cross section of a beam (a member resisting bending) or shaft along which there are no longitudinal stresses or strains. If the section is symmetric, isotropic and is not curved before a bend occurs, then the neutral axis is at the geometric centroid. All fibers on one side of the neutral axis are in a state of tension, while those on the opposite side are in compression.

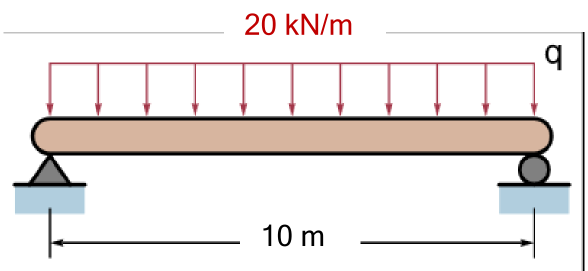


3 Basic calculations and Diagrams

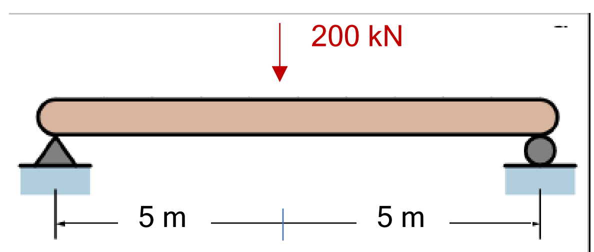
3.1 Reactions:

a. UDL:
A uniformly distributed load (UDL) is a load that is distributed or spread across the whole region of an element such as a beam or slab. In other words, the magnitude of the load remains uniform throughout the whole element. And the unit is kN/m

If, for example, a 20 kN/m load is acting on a beam of length 10m, then it can be said that a 200 kN load is acting throughout the length of 10m (20kN x 10m).



Uniformly distributed Load

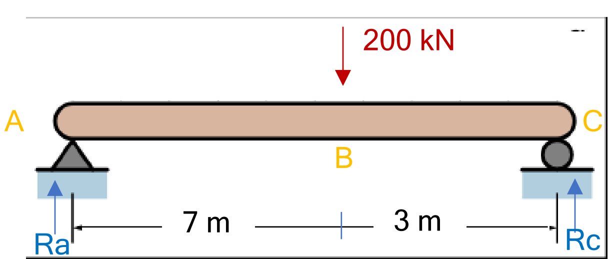


Point Load

b. PL:
Is a load focusing on a single point on the structural element, if unknown and the reactions provided it can be calculated as follows: if Ra is 100 and Rb is 100, you add both reaction Ra + Rb = 100 + 100 = 200 kN.

If both reactions are unknown you simply divvied by 2 to get both reactions, 200 kN / 2 = Ra=100 kN, Rb=100 kN (this only work if the PL is in the center of the beam).

But What if the PL wasn't centered? Lets see in this example:



1.Take moment about A:

Rc x (7+3) = 200 x 7

10Rc = 1400

Rc= 1400/10

Rc= 140 kNm

2. now calculate forces:

Ra+Rc=Rb

Ra+140=200

Ra=200-140

Ra= 60 kN

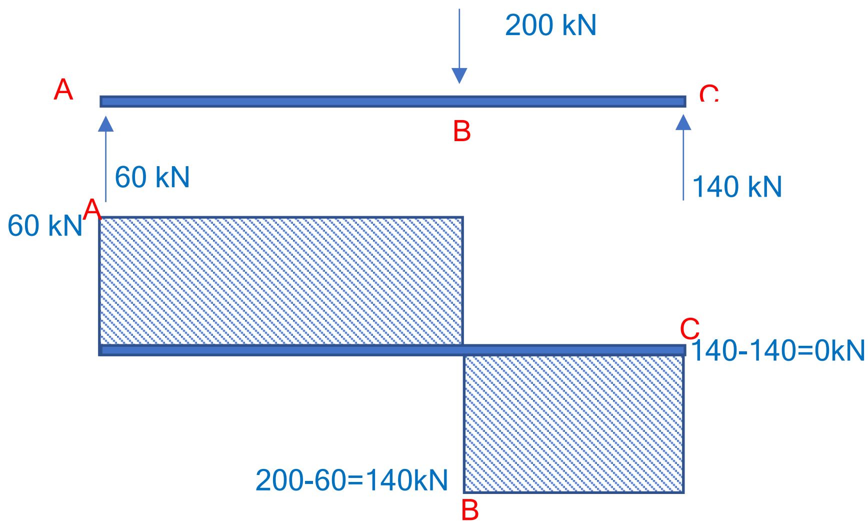
Now you have both!

3.2 Shear force:

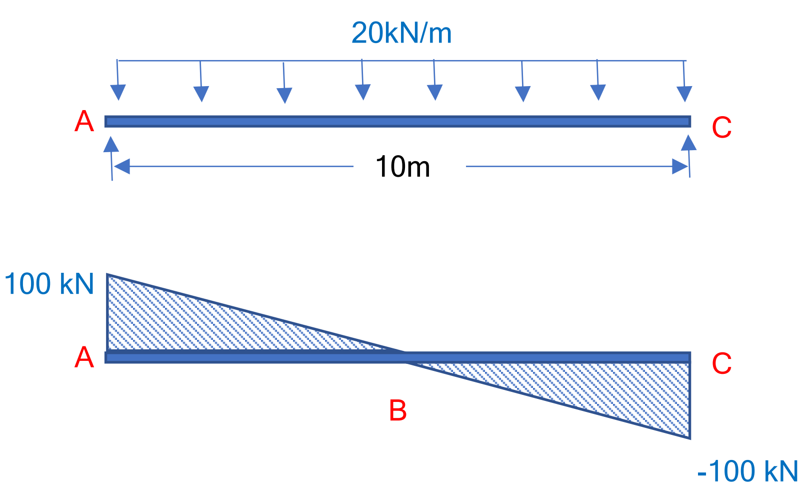
Shear stress is the force applied on per unit area of the member whereas the Shear force is the resultant force acting on any one of the parts of the beam normal to the axis.

Shear force diagram:

With accordance to the last example, this how the SFD of it will look like:



As we see this how a SFD should look like if the beam was subjected to a point load, however, if it was subjected to Uniformly distributed load the shape changes to triangle as shown below:

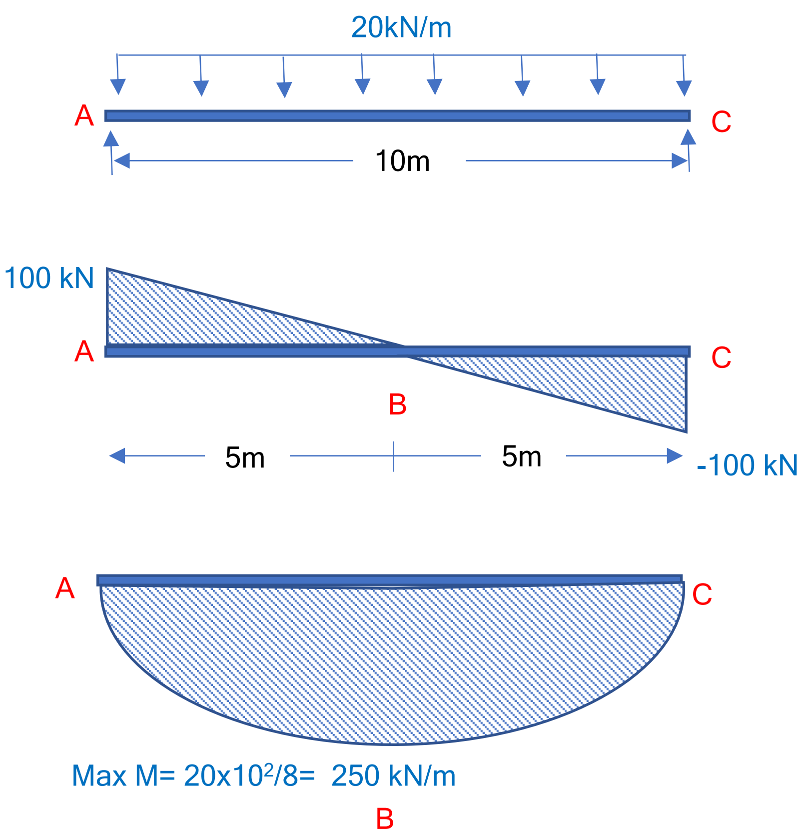


3.3 Bending Moment:

A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. Unit is kNm, Moment = force x distance. Where shear =0 moment is at max.

BMD:

With accordance to the previous example, bending moment will parabolic in shape (curved) because of the UDL:



BEAM BENDING

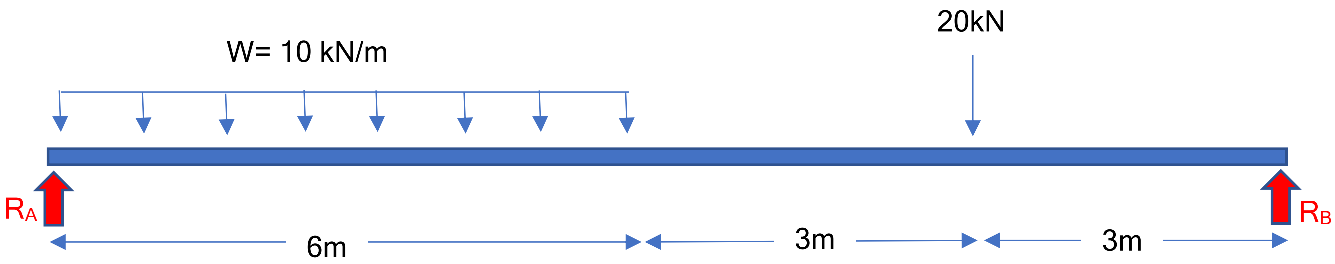
L = overall length, W = point load, M = moment, w = load per unit length	End Slope	Max Deflection	Max bending moment
M	$\frac{ML}{EI}$	$\frac{ML^2}{2EI}$	M
W	$\frac{WL^2}{2EI}$	$\frac{WL^3}{3EI}$	WL
w	$\frac{wL^3}{6EI}$	$\frac{wL^4}{8EI}$	$\frac{wL^2}{2}$
M M	$\frac{ML}{2EI}$	$\frac{ML^2}{8EI}$	M
W, ½ L, ½ L	$\frac{WL^2}{16EI}$	$\frac{WL^3}{48EI}$	$\frac{WL}{4}$
w	$\frac{wL^3}{24EI}$	$\frac{5wL^4}{384EI}$	$\frac{wL^2}{8}$
A, W, c, B, a, b; $a \le b$, $c = \sqrt{\frac{1}{3}b(L+a)}$	$\theta_B = \frac{Wac^2}{2LEI}$, $\theta_A = \frac{L+b}{L+a}\theta_B$	$\frac{Wac^3}{3LEI}$ (at position c)	$\frac{Wab}{L}$ (under load)

This table shape show the formula for max bending moment for each loading condition

This table shows the BMD shapes when the load condition changes:

No internal loading (linear moment diagram) — L	Uniform internal loading (parabolic moment diagram) — q, L	Concentrated internal loading (triangular moment diagram) — P, L
Uniform moment (ψ=1) — M, ψ=1, M	Pinned-Pinned support conditions — +qL²/8	Pinned-Pinned support conditions — +PL/4

3.4 Comprehensive example:

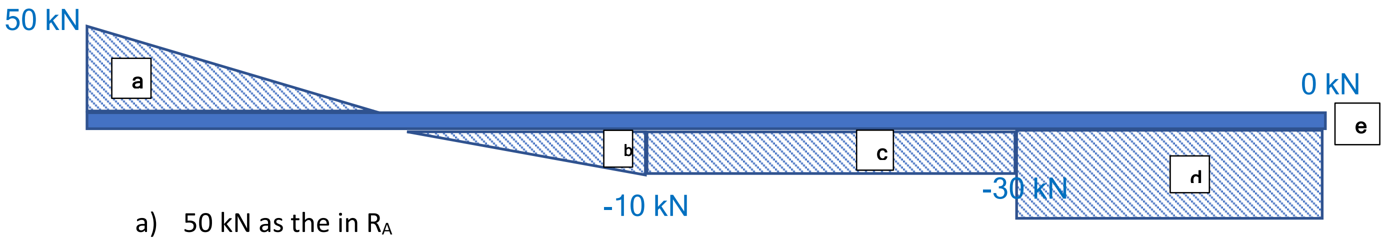


1. Reactions:

$\sum M_A$= (10x6)(3) + (20x9)= R_B x 12 → R_B = 180+ 180 / 12 → R_B = 30 Kn

$\sum F$= 60+20-30 → R_A = 50 Kn

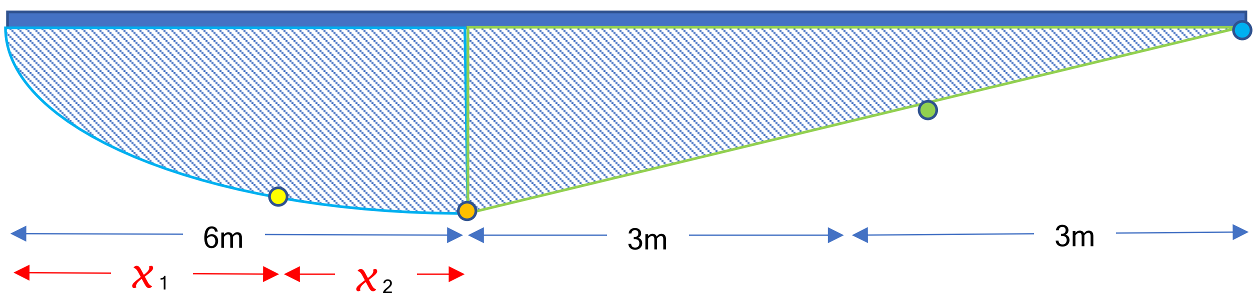
2. Shear force diagram:



a) 50 kN as the in R_A
b) 50 -60 = -10 kN
c) Stays at 10 kN as there is no forces affecting shear.
d) Due to the 20 kN force shear will drop, -10+ (-20) = -30
e) -30+(R_B) = -30 + 30 = 0

3. Bending moment diagram:

Parabolic Shape (Because of UDL) Sharp Shape (Because of PL)

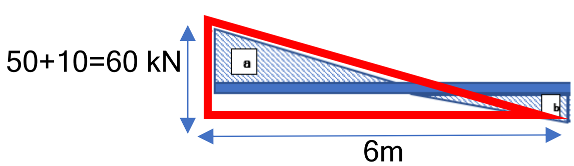


To calculate moment at each point we just calculate areas in SFD:

- (yellow) Triangle area =0.5xbxh=0.5xX_1x50 **=>** as we notice distance at this point is unknown so we do **=>**

  50/X_1= 60/6 **=>** X_1= 5m **=>** after finding distance we can calculate area **=>** 0.5x5x50=125 kNm

This diagram shows how we found 60/6



- 60m is the sum of heights in both triangles => 50m+10m=60m
- 6m is the span of the both triangles combined

- (orange) Triangular area= 0.5xbxh=0.5xX_2 x50 **=>** X_2 = 6m-5m=1m **=>** 0.5x1x10=5kNm **=>** 125-5= 120kNm
- (green) rectangular area= bxh=10x3 = 30 kNm **=>** 120-30= 90 kNm
- (blue) moment at each simply supported end is always = 0 kNm

4 Materials

4.1 Concrete

Concrete has relatively high compressive strength (it doesn't crack under weight), but significantly lower tensile strength (it cracks when being pulled) in other word concrete is **strong at compression** and **weak at tension**. The compressive strength is typically controlled with the ratio of water to cement when forming the concrete, and tensile strength is increased by additives, typically steel, to create reinforced concrete. In other words we can say concrete is made up of sand (which is a fine aggregate),balast (which is a coarse aggregate), cement (can be referred to as a binder) and water (which is an additive)

4.1.1 properties of concrete:

Properties of concrete are influenced by many factors mainly due to mix proportion of cement, sand, aggregates and water. Ratio of these materials control the various concrete properties. concrete properties can be shown as follows:

4.1.1.3 Grades of concrete:

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm^2.
Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

4.1.1.2 Compressive & Characteristic strength of concrete:

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

Characteristic strength of concrete It is defined as the value of the strength below which not more then 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)

4.1.1.3 Creep and shrinkage of concrete:

Creep is a time-dependent deformation of concrete due to applied loads, and it will appear as cracks on the concrete section. The creep rate decreases with time until it becomes negligible. If we analyse the creep in a concrete structure, it can be noticed that approximately a 1/4 to 1/3 of the total creep value will occur within the first month after the concert sets, and by estimation, a 1/2 to 3/4 of the total creep value will occur within the first six months after construction.

As with creep, shrinkage is also a time-dependent deformation, caused by the evaporation of water within the concrete, resulting in volumetric changes within the concrete

4.1.1.4 Unit wight of concrete:

The unit weight of concrete depends on percentage of reinforcement, type of aggregate, amount of voids and varies from 23 to 26 kN/m^2. The unit weight of plain and reinforced concrete as specified by IS:456 are 24 and 25 KN/m^3 respectively

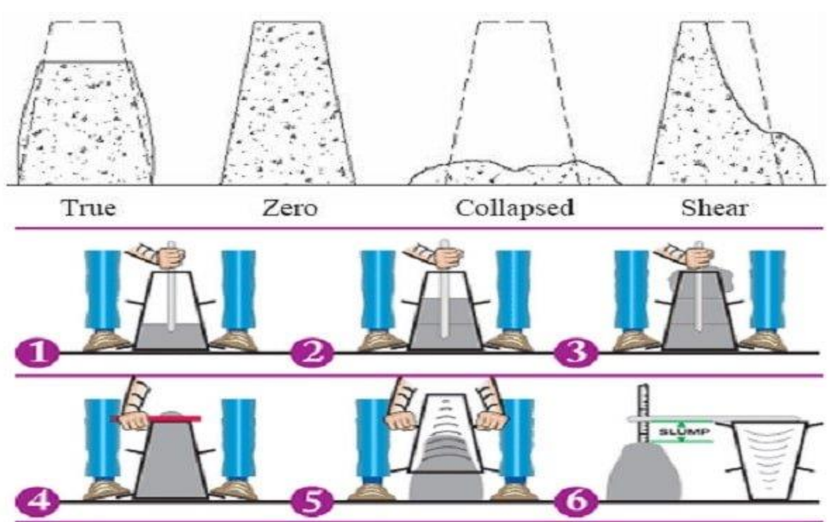
4.1.2 Concrete Tests:

4.1.2.1 Compressive strength test of cubes and cylinders:
Engineers usually **specify the required compressive strength of concrete**, which is normally given as the 28-day compressive strength in megapascals (MPa) or pounds per square inch (psi). Twenty eight days is a long wait to determine if desired strengths are going to be obtained, **so three-day and seven-day strengths can be useful to predict the ultimate 28-day compressive strength** of the concrete.

4.1.2.2 Slump test:
The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to **check the workability of freshly made concrete**, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch.

The slumped concrete takes various shapes and according to the profile of slumped concrete, the slump is termed as **true slump**, **shear slump** or **collapse slump**. If a shear or collapse slump is achieved, a fresh sample **should be taken and the test repeated.**

Only a true slump is of any use in the test. A collapse slump will generally mean that **the mix is too wet or that it is a high workability mix**, for which the slump test is not appropriate. Very **dry** mixes having slump **0 – 25 mm** are typically used in **road making**, **low workability** mixes having slump **10 – 40** mm are typically used for **foundations** with light reinforcement, **medium workability** mixes with slump **50 – 90** mm, are typically used for **normal reinforced concrete** placed with vibration, **high workability** concrete with slump **> 100** mm is typically used where **reinforcing has tight spacing**, and/or the concrete has to **flow a great distance**.



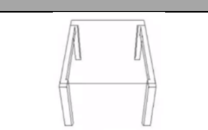
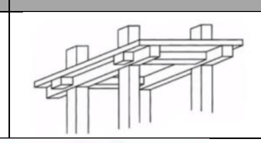
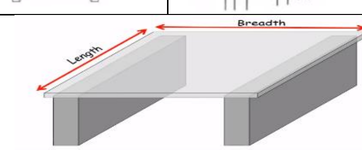
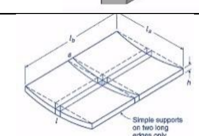
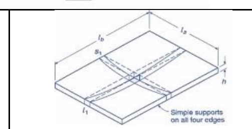
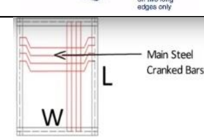
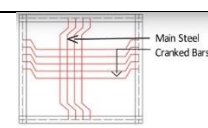
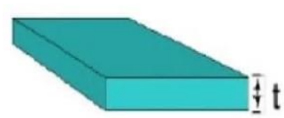
4.1.3 Reinforced concrete:

is a composite material in which concrete's relatively **low tensile** strength and **ductility** are counteracted by the inclusion of **reinforcement having higher tensile strength or ductility**. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before the concrete sets. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that **might cause unacceptable cracking and/or structural failure**.

For a strong, ductile and durable construction the reinforcement needs to have the following properties at least:

- High relative strength
- High toleration of tensile strain
- Good bond to the concrete.
- Thermal compatibility, not causing unacceptable stresses (such as expansion or contraction) in response to changing temperatures.
- Durability in the concrete environment, irrespective of corrosion or sustained stress for example.

4.1.3.1 One and two way spanning slabs:

The differences between one way and two slabs				
Conditions	One Way	Two Way	One Way	Two Way
Supports	Supported by beams On two edges	Supported by beams On all four edges		
Ratio	Length/breath = or>2 **Where b is the shorter span**	Length/breath < 2 **Where b is the shorter span**		
Bending	Bends in one direction (Normal Bend shape)	Bends in both directions (dish shape)		
Reinforcement	Main bars are placed in one direction	Main bars are placed in two directions		
Thickness	Less use of steel = Thicker slab	More use of steel= Thinner slab		

4.1.4 Precast concrete:

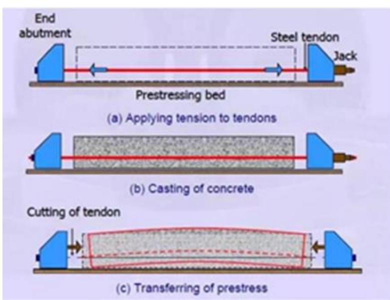
Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place

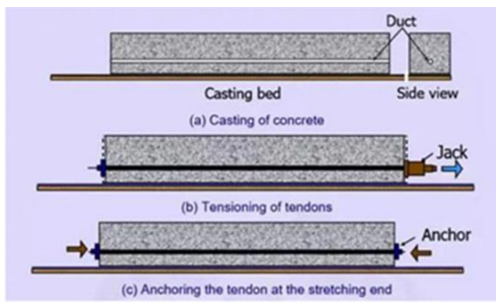
4.1.5 Prestressed Concrete:

Prestressed concrete is a form of concrete used in construction. It is substantially "prestressed" (compressed) during its fabrication, in a manner that strengthens it against tensile forces which will exist when in service.

This compression is produced by the tensioning of high-strength "tendons" located within or adjacent to the concrete and is done to improve the performance of the concrete in service.

Its used for the ability if constructing a longer span slabs in bridges and buildings.





4.1.6 Concrete curing:

Concrete curing is the process of maintaining adequate moisture in concrete within a proper temperature range in order to aid cement hydration at early ages.

Careful control of moisture and temperature of your in-situ concrete during curing is an essential part of quality control and quality assurance of your concrete structure. Proper curing techniques will prevent in-situ concrete from drying, shrinking, and/or cracking, and ultimately affecting the performance of your structure

Spraying of water: on walls, and columns can be cured by sprinkling water.

Wet covering of surface: can be cured by using the surface with wet gunny bags or straw

Ponding: the horizontal surfaces including the slab and floors can be cured by stagnating the water.

Steam curing: of pre-fabricated concrete units steam can be cured by passing it over the units that are under closed chambers. It allows faster curing process and results in faster recovery.

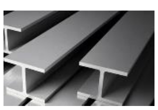
Application of curing compounds: compounds having calcium chloride can be applied on curing surface. This keeps the surface wet for a very long time

4.2 Steel:

4.2.1 properties of steel:

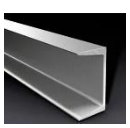
- **Characteristics** - Structural steel differs from concrete in its attributed compressive strength as well as tensile strength.
- **Strength** - Having high strength, stiffness, toughness, and ductile properties, structural steel is one of the most commonly used materials in commercial and industrial building construction.
- **Constructability** - Structural steel can be developed into nearly any shape, which are either bolted or welded together in construction.
- **Fire resistance** - Steel is inherently a noncombustible material. However, when heated to temperatures seen in a fire scenario, the strength and stiffness of the material is significantly reduced.
- **Corrosion** - Steel, when in contact with water, can corrode, creating a potentially dangerous structure. Measures must be taken in structural steel construction to prevent any lifetime corrosion.

4.2.2 Steel section types:



1. **I –** Section:
   I sections which are also called as steel beams or rolled steel joist are extensively used as beams, lintels, columns

2. **L** – Section:
   Angle sections are widely used for roof truss constructions and for filler joist floors



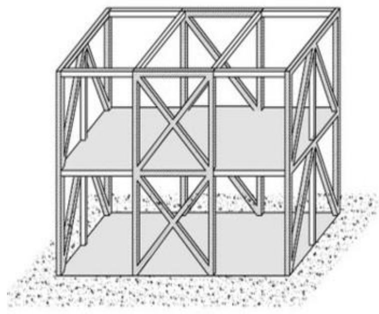
3. **C** – Section:
   The channel section or C- section consists two equal flanges connected to web at both ends. Channel sections are extensively used in steel framed structures.

4. **T** – Section:
   T section consists of flange and web arranged in "T" shape. They are used in steel roof trusses to form built up sections.

5. Square section:
   Square bars contain square cross sections and these are widely used for gates, windows, grill works etc.

5.2.3 Bracing:

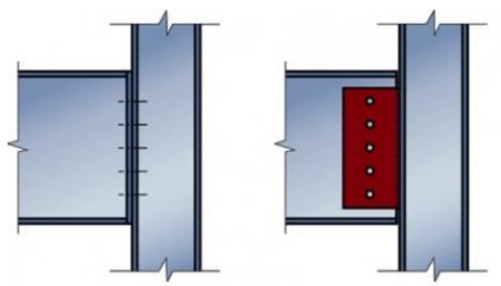
A braced frame is a structural system designed to resist wind and earthquake forces. Members in a braced frame are not allowed to sway laterally.



5.2.4 Steel connections:

In a simple way of putting it Steel can be connected by:

- Bolts
- Plates



4.2.5 Hot and cold rolled steel:

It's important to note that the main difference between hot rolled and cold rolled steel is one of process. "Hot rolling" refers to processing done with heat. "Cold rolling" refers to processes done at or near room temperature. Although these techniques affect overall performance and application. Cold roll steel is harder and stronger than hot rolled.

5.2.5 Coating and fire protection:

Steel can be coated by paint, concrete or other metals such as zinc to prevent corrosion and fire proof the steel structural element.

5 Soil Mechanics and Foundations

5.1 soil:

Soil lyres under a certain structure can vary, it can be clay sand and in some cases it can reach to the rock layers, and when constructing we must know what type of soil we are working with, to design the structure to as the soil capacity can hold.

Some times we face Water tables which is simply underground water in a certain depth of the ground, and that must be known so we can prevent corrosion and calculate settlement of the structure.

5.2 Types of foundations:

Foundation is that part of structure through which load is finally transmitted to the soil. Foundation can be simplified in this flow chart.

Foundation

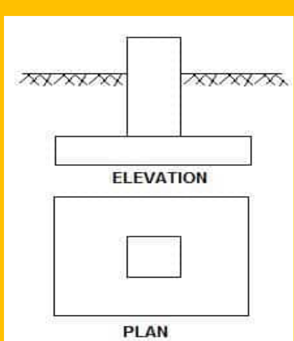
Shallow

- Individual Footing
- Combined Footing
- Mat foundation
- Strip Footing

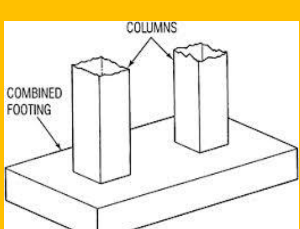
Deep

- Piles
- Drilled Shafts or caissons

Individual footing is the most common type of foundation. This foundation is constructed for single column and it also called pad footing. it can be square or rectangle in shape and is used when loads from structure is carried by the columns. As for combined is the same but it includes two column instead of one and it used when two columns are close enough to combine them.

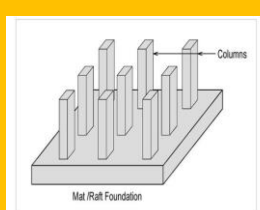


Individual Footing

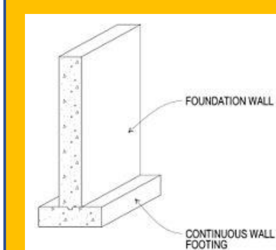


Combined Footing

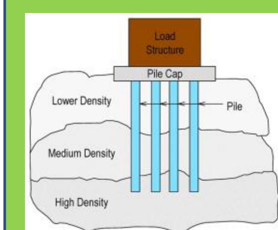
Raft or mat foundations are the types of foundation which are spread across the entire area of the building to support heavy structural loads .The use of mat foundation is for columns and walls foundations where the loads from structure on columns and walls are very high. This is used to prevent differential settlement of individual footings.



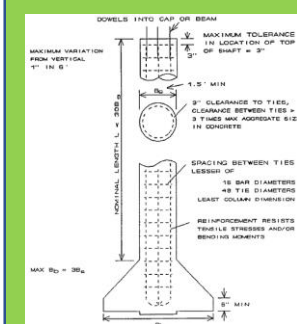
A strip footing is provided for a load-bearing wall. A strip footing is also provided for a row of columns which are so closely spaced that their spread footings overlap or nearly touch each other.



Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to a hard rock strata much deep below the ground level.



Drilled shafts, also called as caissons, is a type of deep foundation and has action similar to pile foundations, however, Drilled shafts can transfer column loads larger than pile foundations. It is used where depth of hard strata below ground level is location within 10m to 100m



6 Surveying

6.1 equipment and tools:

1. Theodolite:

A Theodolite is a instrument for measuring both horizontal and vertical angles

2. Surveyor's level:

Surveyor's level is an instrument used in surveying to measure the height of distant points in relation to a bench mark.

3. Levling staff:

A level staff, also called levelling rod, , used with a levelling instrument to determine the difference in height between points or heights.

4. Prism:

In surveying, a prism is a corner cube or retroreflector, normally attached on a surveying pole, used as a target for distance measurement using

6.2 Types of surveying:

Based upon Nature of field

I. Land Survey
II. Marine Survey
III. Astronomical Survey

Based upon Object of Survey

I. Geological Survey (Object is to survey different strata in the earth crust)
II. Mine Survey (Mineral wealth such as coal, gold)
III. Military Survey (Points of strategic importance)

Based upon Method Employed

I. Triangulation
II. Traversing
III. Based upon Instrument Used
IV. Surveying by Total Station
V. Chain Survey
VI. Theodolite Survey
VII. Compass Survey
VIII. Plane Tabling
IX. Photographic and Aerial Surveys

Land Survey can be further divided into:

1. Topographical Survey

Determine natural features of a country such as hills, valleys, lakes woods etc. and also arterial features such as roads, buildings, canals, towns etc.

2. Cadastral Survey

Details such boundaries of houses, town, fields and other properties pathways are determined.

City Survey.

Engineering Survey

Engineering Survey can be further divided into:

Reconnaissance (To determine the feasibility and rough cost of the scheme)

Preliminary Survey (For collecting more precise data)

Location Survey (For setting out the work on the ground)

7 Hydraulics:

Hydraulics includes the study and analysis of fluids when in motion (as in pipes or drainage systems)and stationary(as in dams). The part of Hydraulics which deals with the study of static behavior and interaction of fluids is called as Hydrostatics; the part dealing with fluid in motion is called Hydrodynamics. Hydraulics deals with the study of fluids, their behavior, motion of fluids and the interaction of fluids with other bodies.

7.1 Basic Principles:

1. **Pressure:**
   Pressure can be defined as “the force acting on unit area, applied in a direction perpendicular to the surface of the object".

   Pressure = Force/ Area

2. **Density:**
   ρ = m / V

   where
   ρ = density [kg/m3],
   m = mass [kg]
   V = volume [m3]

   ρ of water is always = 1000 kg/m^3

3. **Velocity:**

$$velocity = \frac{((final\ position) - (initial\ position))}{time} = \frac{(change\ in\ the\ position)}{time}$$

$$v = \frac{x_f - x_i}{t} = \frac{\Delta x}{t}$$

v = velocity (m/s)

xf = the final position (m)

xi = the initial position (m)

t = the time in which the change occurs (s)

Δx = short form for "the change in" position (m)

7.2 Bernoulli's principal:

For fluid energy, the law of conservation of energy is represented by the Bernoulli equation(for ideal fluid only):

$Z_1+p_1/w+V_1^2/2g=Z_2+p_2/w+V_2^2/2g$

where

Z_1= elevation, ft (m), at any point 1 of flowing fluid above an arbitrary datum

Z_2= elevation, ft (m), at downstream point in fluid above same datum

p_1= pressure at 1, lb/ft2 (kPa)

p_2= pressure at 2, lb/ft2 (kPa)

w or ρ = specific weight of fluid (Density), lb/ft3 (kg/m3)

V_1= velocity of fluid at 1, ft/s (m/s)

V_2= velocity of fluid at 2, ft/s (m/s)

g= acceleration due to gravity, 32.2 ft /s2 (9.81 m/s2)

8 Highways:

More Research Required