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CIVIL ENGINEERING

ENGINEERING MECHANICS

BY-AMIT KAKKAR SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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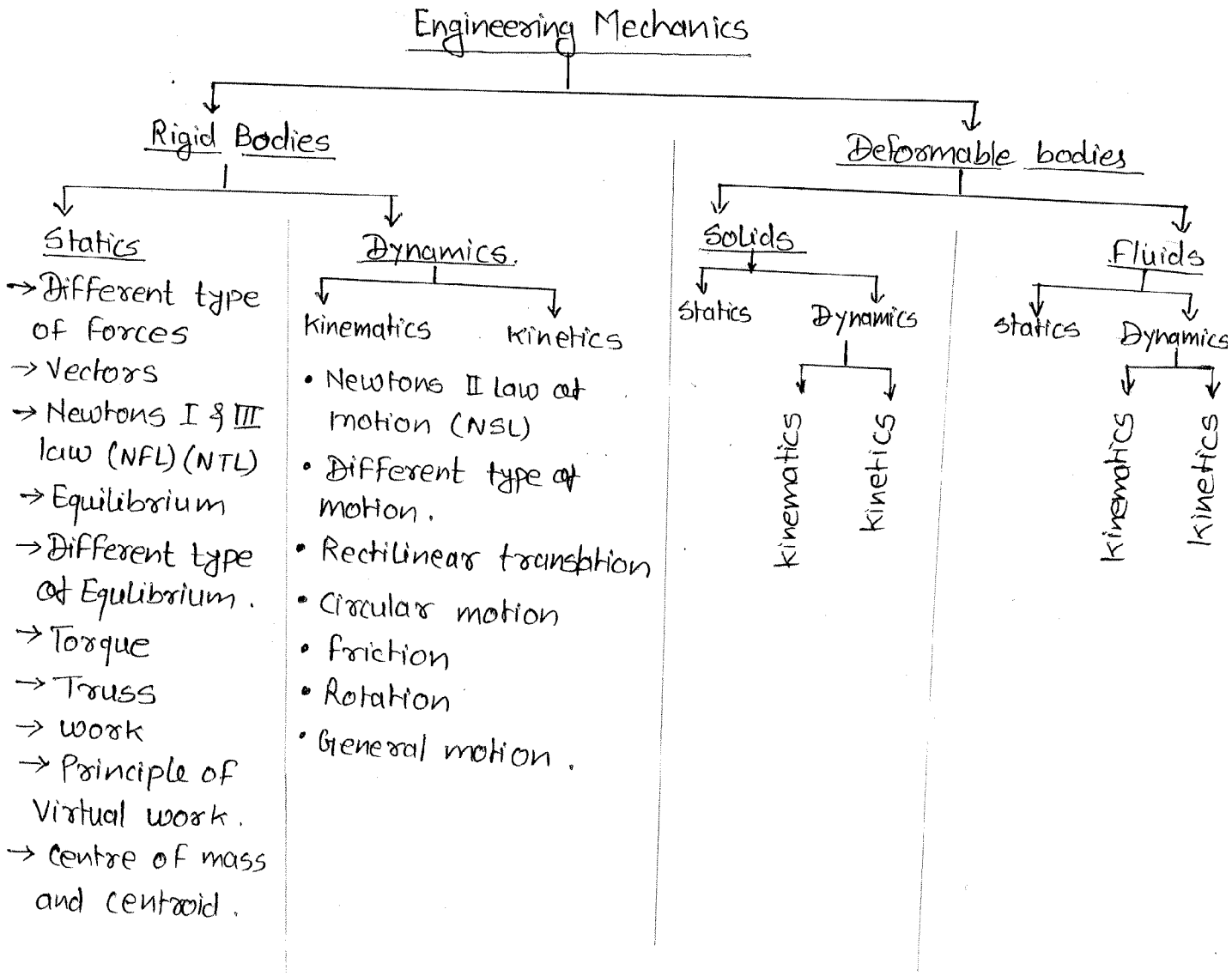
* Engineering Mechanics

→ "It is a science which deals and predicts the condition of the system either at rest or in motion under the action of external force."



Different ideal concepts in engineering mechanics

1> Rigid body

→ whenever loads applied on body, body deforms but if the deformations are negligible wrt size of the body then we can neglect those deformations and we can treat the bodies as a rigid body.

2> Continuum

→ Even in solids there is void space between the adjucent molecules and atoms we know that these void spaces are microscopic therefor if the size of body is sufficiently good that means microscopic then we can neglect the void spaces and we can assume adjucent to one molecule there is another molecule hence the entire body is treated as continuous distribution of mass known as continuum.

3> Body as a Particles

Real Real

Force ($\vec{F}$)

→ Action of one body to the other body.

Vector Quantity

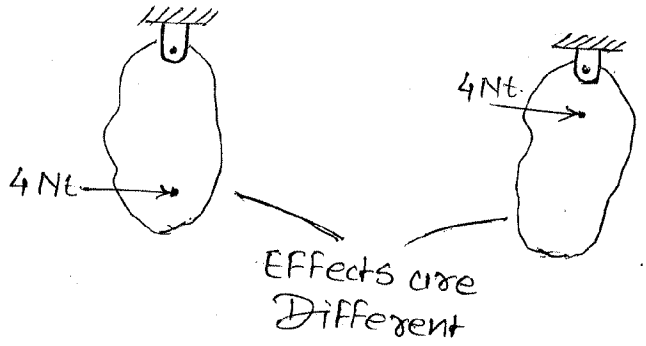
→ Quantities having magnitude and direction.

- When the force is applied on the body this implies that it is applied on some of the particles of body.

Then to define force:

- Magnitude
- Direction
- Point of application

} Required.



Whenever the force is applied on the body, then for that force ($\vec{F}$), two bodies will exist.

- One body → which is applying force
- Second body → on which the force is applied.

Note

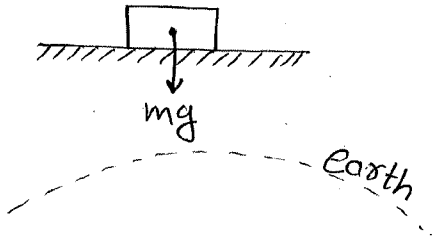
→ If a force is acting on the body, but there is no other body which is applying this force, that force is called Pseudo force (Artificial force)

Different type of forces

[most frequently appearing in EM]

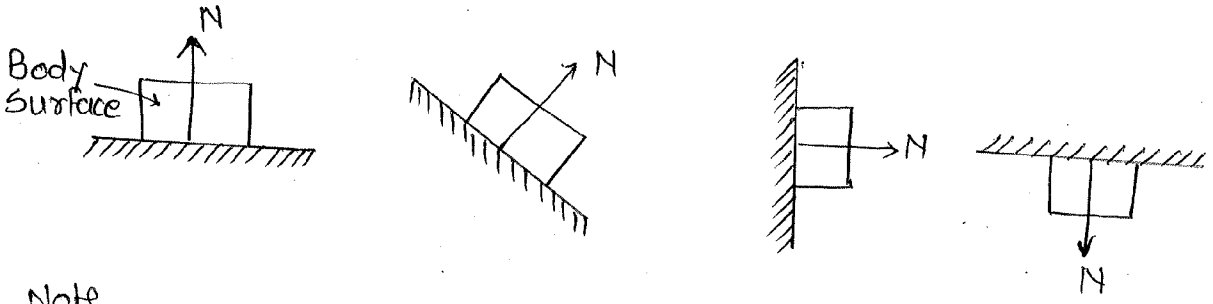
1) Weight (w) (mg)

→ force acted on the body by the earth.
→ It is a body force.



2) Normal Reaction (N) :-

→ Surface force
→ Acts on the body by the surface exactly in the direction perpendicular to the surface.
→ It is due to pressing effect between contacting surface.



Note

→ IF the surface are touching but not pressing then,

$$\boxed{N = 0}\ **$$

3) Friction: (Dry friction)

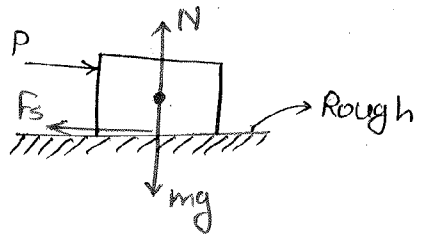
→ Surface force
→ Along the surface
→ It resists the relative motion or tendency or relative motion between the contacting surface.

Static Friction (fs)

→ Due to the tendency of relative motion between the contacting surface {no relative motion}.

→ It is a variable friction.

$$\boxed{0 \leq f_s \leq \mu_s N}$$ $\mu_s \rightarrow$ Coefficient of static friction.



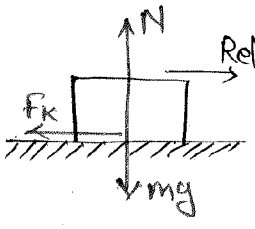
Applied force	Static Friction (fs)
0	0
1Nt	1Nt
2Nt	2Nt
3Nt	3Nt
⋮	⋮
$\mu_s N$	$\mu_s N$

→ Static friction is conservative force

$$\boxed{\text{Energy loss} = 0}$$ **

It is a tendency of relative motion is more than the $f_{s\max} = \mu_s \cdot N$.

- If relative motion starts friction developed is called kinematic friction (f_k) ~~due~~ this friction is developed due to the relative motion between the contacting surfaces.



$$\boxed{f_k = \mu_k \cdot N}$$

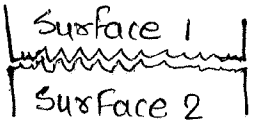
$\mu_k \rightarrow$ Coeff. of kinetic friction

Constant friction = Non conservative force

Energy loss.

Coefficient of friction (μ_s, μ_k)

→ Every surface is having surface irregularities

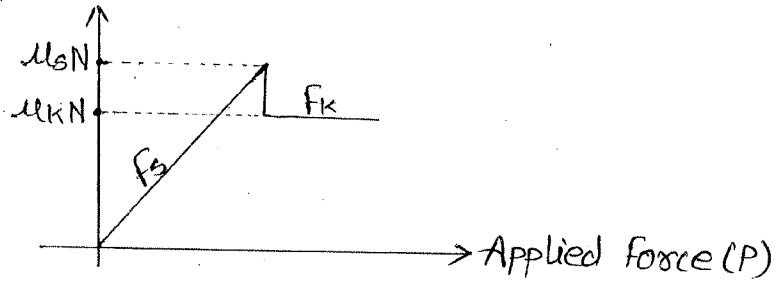


Depends upon

1) Surface irregularities
2) How irregularities are interlocked.
3) No. of interlocking.

"μ_s" is slightly more than "μ_k"

→ Because a little bit decrease in strength of interlocking at the moment when relative motion starts.

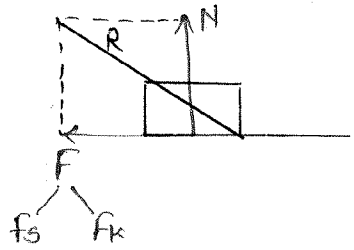


Total Contact Force: ($\vec{R}$)

$$\vec{R} = \vec{N} + \vec{F}$$

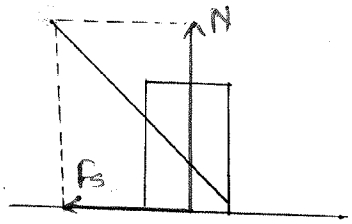
f_s f_k.

Resultant of friction & normal reaction.



Angle of static friction (ϕ_s)

→ Angle between the normal reaction and total contact forces when body is at verge of Relative motion.

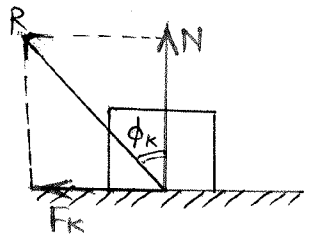


$$\frac{R\sin\phi_s = f_{s\,max} = \mu_s N}{R\cos\phi_s = N}$$

$$\boxed{\mu_s = \tan\phi_s} \; **$$

Angle of kinetic friction (ϕ_k)

→ Angle between normal reaction and total contact force when body is in relative motion.



$$\frac{R\sin\phi_k = F_k = \mu_k N}{R\cos\phi_k = N}$$

$$\boxed{\mu_k = \tan\phi_k} \; **$$

Note • If only one coefficient of friction. (μ)

$$\Rightarrow \boxed{\mu_s = \mu_k = \mu}$$

• If only one angle of friction (ϕ) is given.

$$\boxed{\mu_s = \mu_k = \tan\phi_s = \tan\phi_k = \tan\phi = \mu}$$

—×—

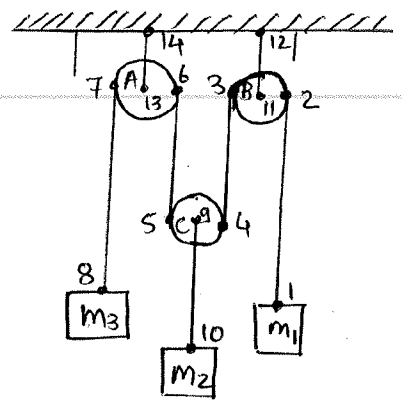
4) Tension (Tension in string):-

→ It is a pulling force.

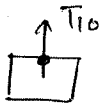
→ Tension always acts along the string.

→ It is always away from the body (system).

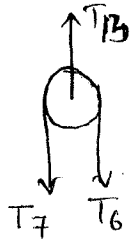
Consider the following system.

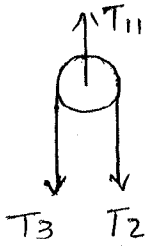


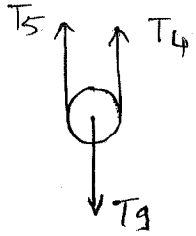
m_1: 

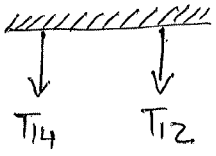
m_2: 

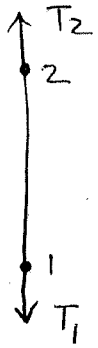
m_3: 

Pulley A: 

Pulley B: 

Pulley C: 

Support 

1-2 Portion of string 

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INTRODUCTION TO ENVIRONMENTAL ENGINEERING

TEACHER - SAGAR DODEJA (IES)
SR. FACULTY, MADE EASY

These are interactive notes for Made Easy Classroom Students and Made Easy Online Students. These notes contain basic knowledge only and classes need to be attended thoroughly for in-depth explanations and solving WorkBook Questions.

All the blank spaces are intentionally left for the students to write during the lectures.

Students should keep a separate copy of 200 pages with them at all times to solve all WorkBook questions.

These notes are already tried and tested successfully on thousands of students and the notes provided have ensured maximum output from them.

With these notes, students can focus entirely on concept building and developing problem solving skills as basic theory, diagrams and facts are already written clearly in the notes. This also minimises errors during writing.

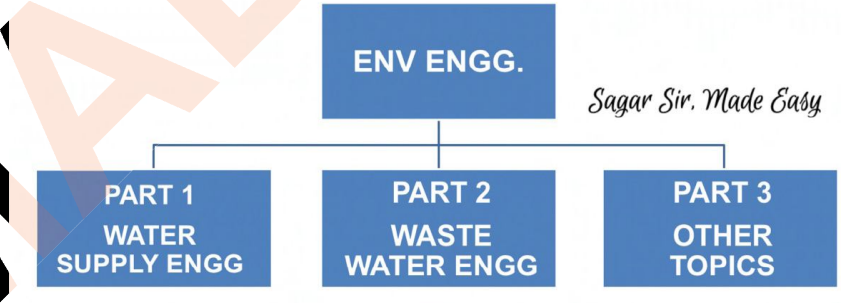
ENJOY THE LEARNING EXPERIENCE!

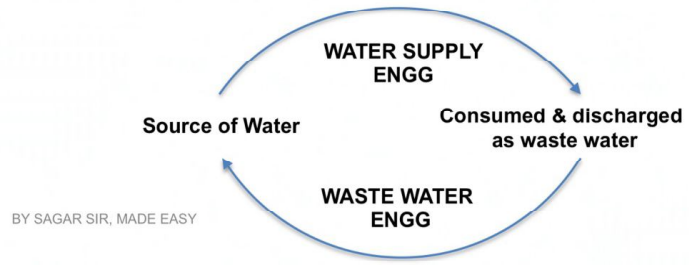
Weightage in ESE

ESE	OBJECTIVE	CONVENTIONAL	TOTAL
2014	36.67	56	92.67
2015	38.33	56	94.33
2016	33.33	56	89.33
2017	26.72	105	131.72
2018	36	100	136
2019	26	96	122
2020	30	110	140
2021			

Weightage in GATE

GATE YEAR	MARKS
2016 average	10
2017 average	12
2018 average	11
2019 average	11
2020 average	11
2021 average	15
Average	**11**





Flow of Course

Part 1 Water Supply Engineering

S NO.	DESCRIPTION	INSTRUCTIONS FOR STUDENTS
1	WATER DEMAND - Population Forecasting - Various Types of Demand	-SOLVE WB AS SOON AS IT ENDS
2	SOURCES OF WATER - Focus on Sub Surface Sources - Geological Formations - Well Hydraulics	-SOLVE WB AS SOON AS IT ENDS
3.	WATER QUALITY PARAMETERS -Physical, Chemical & Biological Parameters	-REVISE AS MUCH AS POSSIBLE -MEMORIZE KEY POINTS OF IS 10500 -SOLVE WB ALONG WITH CLASS
S.NO.	**DESCRIPTION**	**INSTRUCTIONS FOR STUDENTS**
4	TREATMENT OF WATER -General process of treatment - Screening, Aeration, Coagulation, Flocculation, Sedimentation, Filtration & Disinfection -Minor methods of treatment - Lime Soda Process, Ion Exchange, Demineralisation, Nalgonda, Prashanti and other techniques.	-DESIGN DATA NOT REQUIRED FOR GATE. - SOLVE WB TWICE BEFORE EE ENDS
5	WATER DISTRIBUTION -Types of Distribution Networks -Types of Pipes, Valves and Joints -Balancing Reservoir/ Distribution Reservoir Design	-SOLVE WB AS SOON AS IT ENDS

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Note : All the reforms for water treatment which were extensively adopted by the Water Act of 1974 are also included in the lectures along with the standard GOI Manuals & IS Codes.

Part 2 Waste Water Engineering

S.NO.	DESCRIPTION	INSTRUCTIONS FOR STUDENTS
6	WASTEWATER MICROBIOLOGY	-MEMORIZE IT BEFORE NEXT CHAPTER
7	QUALITY CHARACTERISTICS OF WASTEWATER	-SOLVE WB AS SOON AS IT ENDS
8	DISPOSAL OF WASTEWATER - Self purification Mechanism in Rivers - Disposal in Land, Sea - Lake characteristics and terminologies	- SOLVE WORKBOOK AS SOON AS IT ENDS Sagar Sir, Made Easy
9	TREATMENT OF WASTEWATER -Primary, Secondary & Tertiary Treatment -Sludge Handling -Oxidation Ponds, Septic Tanks, Imhoff tanks etc.	- SOLVE WORKBOOK QUESTIONS TWICE ALONG WITH CLASS
10	SEWERS AND SEWERAGE SYSTEM - Components and Layout of Sewerage System - Design of sewers - Hydraulic characteristics	- SOLVE WORKBOOK AS SOON AS IT ENDS

Part 3 - Small but an important portion

CHAPTER NO.	DESCRIPTION
11	SOLID WASTE MANAGEMENT -Sources and classification of Solid Wastes -Municipal Solid Waste Management – Characteristics, generation, collection & disposal - Generation of energy - Characteristic terminologies
12	AIR POLLUTION - Types of pollutants, sources, impacts, control, air quality standards & limits - Air Pollution Meteorology - Lapse Rates, types of atmosphere - Plume behaviour
13	NOISE POLUTION Impacts of noise, permissible limits, measurement of noise, & control of noise pollution Various terms such as Leq, Ln etc

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CHAPTER WISE ANALYSIS

CHAPTER NAME	ESE	GATE
WATER DEMAND	2.3%	1%
SOURCES OF WATER	7.2%	5%
WATER QUALITY PARAMETERS	10.3%	18.3%
TREATMENT OF WATER	22.5%	21.9%
CONVEYANCE & DISTRIBUTION SYSTEMS	3.6%	3.1%
WASTE WATER CHARACTERISTICS	5.4%	13%
DISPOSAL OF WASTE WATER	4%	2%
WASTE WATER TREATMENT	17.3%	15.5%
DESIGN OF SEWERS & SEWERAGE SYSTEMS	6.7%	3.5%
MUNICIPAL SOLID WASTE MANAGEMENT	6.45%	4.3%
AIR & NOISE POLLUTION	14.3%	12.4%

Reference Books

- GOI Manuals
- Environmental Engg – Peavy, Rowe & Tchobanoglous
- Environmental Engg – Metcalf & Eddy
- Water Supply Engg - S K Garg
- Waste Water Engg – S K Garg
- Environmental Chemistry - Sawyer, McCarty, Parkin
- Environmental Engineering - Davis & Cornwell

- *Everything related to GATE & ESE will be covered in class itself. If anything else is required, above materials can be referred.*

MANUALS

- GOI Manual on Water Supply & Treatment, 1999
- GOI Manual on Sewerage and Sewage treatment (Part A, B & C), 2013
- GOI Manual on Municipal Solid Waste Management, 2016

Note : All manuals are developed by CPHEEO (Central Public Health & Environmental Engineering Organization) under MoUD (Ministry of Urban Development)

Download link : http://cpheeo.nic.in/

Apart from GOI Manuals, there will be references to various IS Codes in the lectures

start of

WATER SUPPLY ENGINEERING

Faculty : Sagar Dodeja (Ex. IES) MADE EASY EDUCATION PRIVATE LIMITED

CHAPTER 1
WATER DEMAND

CONTENTS

Students should write this after chapter completion. This provides with overall view & acts as a tool for active recalling.

CHAPTER 1

WATER DEMAND.

Water Demand – Water Demand implies water quantity estimation. The quantity of water required for municipal uses for which the water supply scheme has to be designed requires the following data –

1. Forecasted population.
2. Rate of consumption (l/c/d or lpcd)

Design Period

The quantity of water is worked out for requirement of future population. The provision for water supply system involves construction of huge structures such as dams and reservoirs, complex and costly structures such as distribution network, various water treatment units etc. which cannot be easily replaced or modified.

The future period for which the water supply scheme is designed to cater for the future population is known as Design period. The Design period is kept neither very high nor very less. Why?

PART 1

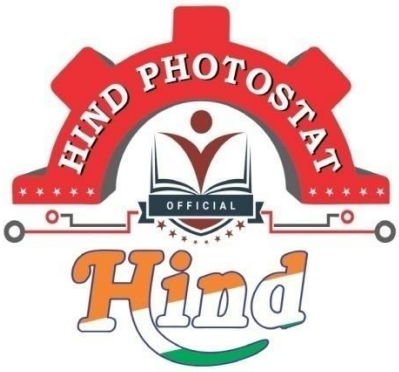
Population Forecasting → Mathematical Methods
→ Graphical Methods.

Mathematical Methods.

1. Arithmetic Increase Method.
2. Geometric Increase Method.
3. Incremental Increase Method.
4. Decreasing Rate of Growth Method.

1. Arithmetic Increase Method (AIM)

- This method is based on the assumption that the population increases at a constant rate from the last known population. An average increase in population ($\bar{x}$) is considered to compute the future population.
- It is used for those cities which are sufficiently large and are already established.



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,GATE , TEST @

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- **GATE**

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GATE + ESE

1. Basic properties
2. Working stress method (SRB/ WSM) - concepts
3. Limit state method (LSM) - concepts
   a) Single Reinforced
   b) Doubly Reinforced
   3) T/L sections.
4. Shear & Torsion
5. Bond & Dev. length
6. Beam & Lintels
7. slab
8. Column
9. Pre- stressed concrete.
   a) Material Properties
   b) Analysis of stress
   c) Losses
   d) Slope & Deflection
   e) Design of PSC member

ESE syllabus + addation to GATE + ESE

10. Foundation
11. stair case
12. Retaining wall
13. Water Tank
14. Masonary structure
15. Earthquake Engineering

Important in codes

① IS 456 — 2000 : Design of RCC structures.
② IS 1893 : Earthquake Resistant design of structure.
③ IS 13920 : Design & Ductile detailing of RCC structures.
④ IS 3370 : Pt I to IV — Design of water tanks.
⑤ IS 1343 : Pre stressed concrete.
⑥ IS 1905 : Design of load bearing walls (massonary wall)

Important in Handbooks

Design Handbooks :-

* 1 SP 16 → 1980 Design Aids for RC to IS 456
* 2 SP 23 → 1982 Handbook — Concrete Mixes
* 3 SP 24 → Explanatory Handbook — IS 456 - 1978
* 4 SP 34 → Handbook — Concrete Reinforcement and Detailing.

BASIC Properties of Cement Concrete and steel

RCC (Reinforced Cement concrete) :-

① Cement concrete – * Mainly for compression
– * Tensile strength is very low.

② Steel Reinforcement – * for resisting mainly tension
– * as well as compression

Cement concrete

* → Mixture of Water, Cement, Sand (Fine Aggregate), Stone (Coarse Aggregate) & Admixtures.
* Cement concrete with Reinforcement is called Plain Cement concrete.

Cement Mortar = Cement + Sand + Water

Cement concrete = Cement + Sand + Water + Stone aggregate + admixture.

Cement concrete →

Cement concrete reinforced by steel is called RCC (Reinforced cement concrete).

Plain cement concrete (PCC) is without steel

① Water for concrete → P

* Water fit for human are good for concrete
* Water used for concrete should be clean &
  → free from oil, salts, sugar, organic materials etc.
  → that may not harm concrete.
* Sea water should not be used for RCC.
* Salt of sea water is harmful for concrete.

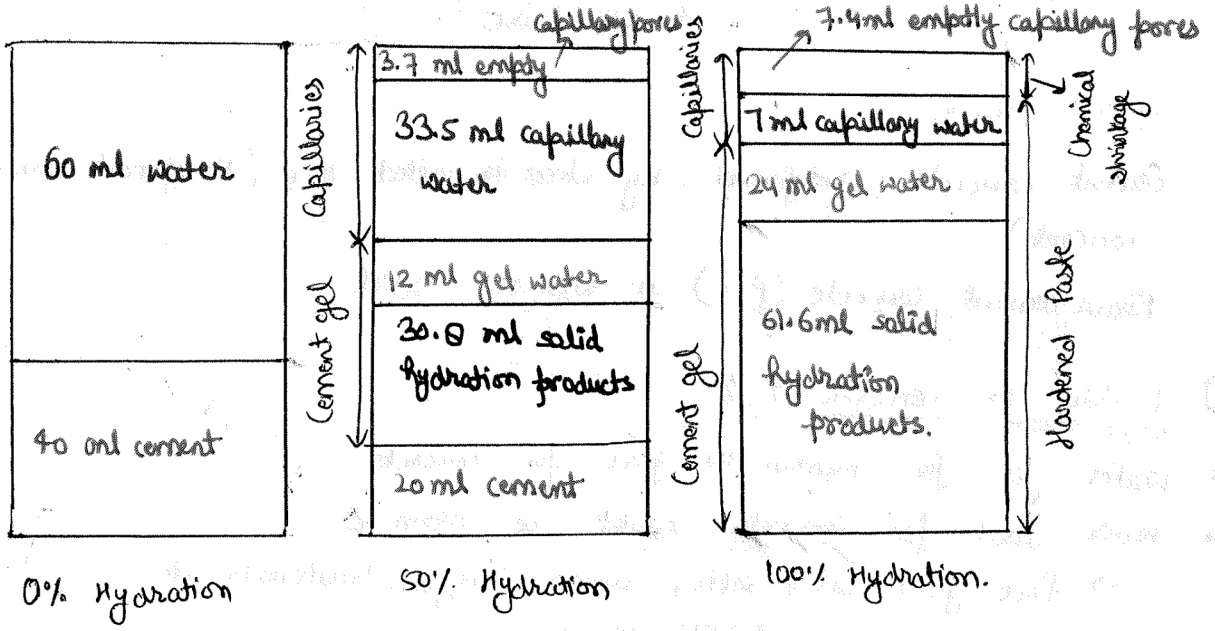
* In extreme case it may be used for PCC
* The pH value of water shall not be less than 6.
* pH < 6 → Highly acidic :- Not acceptable
* pH = 6 → acidic :- Acceptable
* pH = 7 → Neutral :- Best water for concrete.
* pH > 7 → Slightly alkaline water is also acceptable.

Water in Cement Concrete is for :-

① Combined water → Chemically combined water with the cement for hydration. it is non-evaporable.

② Gel water → Held physically or adsorbed on the surface area of the 'cement gel'. A fraction of gel water is evaporable.

③ Capillary water → Occupies the 'capillary pores' that constitute the space in the cement paste. This water is easily evaporated.



Q Maximum limit of suspended matter in water

a) 200 mg/ Litre
b) 2000 mg/L ✓
c) 3000 mg/L

Q Maxm limit of Organic matter in water

a) 200 mg/L ✓
b) 2000 mg/L
c) 3000 mg/L

Permissible Limits of Solids in water

Tested for	Permissible Limits
* Organic	200 mg/L
* Inorganic	3000 mg/L
* Sulphates	400 mg/L
* Chlorides	2000 mg/L — for PCC 500 mg/l — for RCC
* Suspended matter	2000 mg/l

② Cement

① OPC ordinary Portland cement →
   a) 33 Grade OPC
   b) 43 grade OPC
   c) 53 grade OPC

② Rapid Hardening cement — Becomes hard rapidly

③ Portland Pozzalana cement — Use Pozzalana

④ Hydrophobic cement — water repellent

⑤ Low Heat cement — Produce less Heat

⑥ Sulphate resisting Portland cement.

③ Aggregates →

a) Fine Aggregates = Sand (up to 4.75 mm size)

b) Coarse Aggregates = Stone chips of mixed sizes
4.75 mm to 20 mm or
4.75 mm to 40 mm.

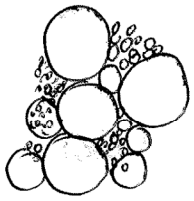
* Size > 4.75 mm & larger
* Angular are better than rounded aggregates.
* For RCC – 20 mm aggregates are generally used.
  → (Size 20mm or less – mixed sizes)
  → Well graded stone aggregates are better
  → Uniformly (Poorly) graded not suitable.
* 10mm size – for closely places steel sections.
* 40mm size – for PCC etc.

Classification of Aggregates →

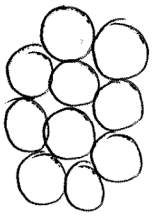
① Fine Aggregate → Sand and/or crushed stone
→ < 4.75mm
→ Fine Aggregate usually 35% to 45% by mass or volume of total aggregate etc.

② Coarse Aggregate → Gravel & crushed stone
→ > 4.75mm
→ Typically b/w 9.5 & 37.5mm

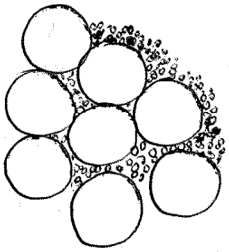
Types of Aggregates :-



Well Graded



Poorly Graded



Gap Graded.

NOTE → Concrete Pump used for Pumping Concrete.
Concrete vibrator used for proper compaction of concrete.

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Fluid Mechanics

- GATE (3-4 Q) Numerical Problems Mainly
- ESE (6-7 Q) Numerical & theoritical Problems

Text Books

Fluid Mechanics & Hydraulic Machines ——— R K BANSAL

Hydraulics And fluid Mechanics ——— P N MODI, S M SETH

fluid Mechanics ——— CENGEL, CIMBALA

Syllabus

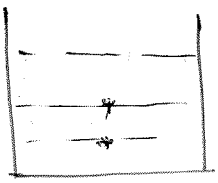
1. Introduction & properties of fluids
2. Pressure & It's Measurement
3. Hydrostatic force on surfaces
4. Buoyancy & flotation
5. fluid Kinematics
6. fluid Dynamics
7. Dimensional Analysis
8. Pipe flow
9. Laminar flow
10. Boundary Layer Theory
11. Turbulent flow in pipe
12. flow over Submerged Bodies.

- Class Workbook
- Previous Gate Problems
- Previous ESE Problems
- TEST SERIES

f/M

fluid statics

"Study of fluid when it's in static condition."



fluid kinematics

"Study of the motion of fluid without considering the cause of motion."

Eqⁿ used -

$$\vec{v} = \frac{d\vec{s}}{dt} \quad \frac{d\vec{s}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

fluid Dynamics

"Study of the motion of fluid with considering the cause of motion."

Eqⁿ used

$$\vec{F} = \frac{d(m\vec{v})}{dt}$$

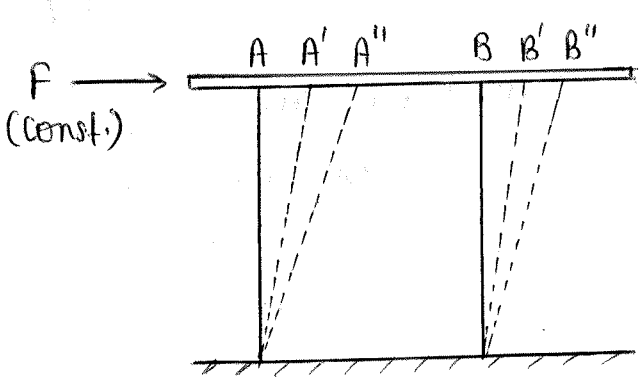
In General

Solid

Liquid } fluids
Gas }

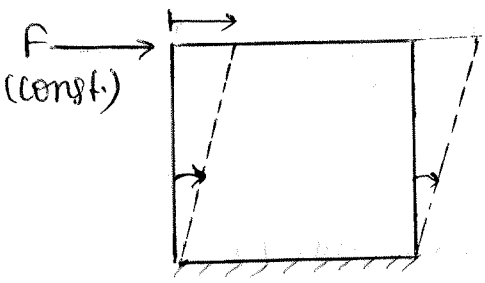
fluid

continuous Deformation



Solid

fixed Deformation



"In fluids, rate of deformation is important."

1. "Fluid is a substance that deforms continuously under the application of tangential force, no matter how small it is."

2. Liquid And Gases both having a very important property of continuous deformation under the application of tangential force.

Fluid as a Continuum

In Macro Systems, when the inter molecular distances are negligible as compare to dimension of the system we can assume that adjacent to one molecule there is another molecule without any space therefore the entire fluid mass system can be treated as continuous distribution of mass and such continuous mass of fluid is known as Continuum.

$$\text{Knudsen No. } (Kn) = \frac{l}{L}$$

l = Mean free path

L = characteristic Dimension

$Kn < 0.01$ — "Continuum is Valid"

$0.01 < Kn < 0.1$ — "Slip flow"

$0.1 < Kn < 10$ — "Transition flow"

$Kn > 10$ — "free Molecular flow"

Not in our Study

* fluid properties such as density etc. can be defined as continuous function of space variable.

* Continuum is invalid at very low pressure (At high elevations).

fluid Properties

1] Density (ρ) :- It's defind as mass per unit vol^m of a substance.

$$\rho = \frac{m}{\forall}$$

$\forall$ = Volume

units :-

In MKS — kg/m^3

In CGS — gm/cm^3

$$1\ gm/cm^3 = \frac{10^{-3}}{10^{-6}}\ kg/m^3$$

$$1\ gm/cm^3 = 1000\ kg/m^3$$

2] Specific weight :- It's defind as weight per unit vol^m of a substance.
(OR)
Weight Density

$$\text{weight density} = \frac{m \cdot g}{\forall}$$

$$= \rho \cdot g$$

unit :- In SI — N/m^3

3] Specific Gravity (G):-

$$S = \frac{\text{Density of fluid Substance}}{\text{Density of Std. fluid substance}}$$

for Liquids	for Gases
Std. fluid ⇒ H_2O at 4°c	Std. fluid ⇒ Air
$\rho_W = 10^3$ kg/m³	

eg. $S_{Hg} = 13.6$

$$\frac{\rho_{Hg}}{\rho_W} = 13.6$$

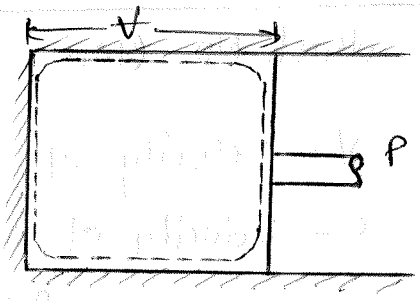
$$\rho_{Hg} = 13.6 \times 10^3 \text{ kg/m}^3$$

4] Compressibility (β):- It's defind as the reciprocal of Bulk Modulas of Elasticity.

$$\boxed{\beta = \frac{1}{K}}$$

K = Bulk Modulas of Elasticity

$$\boxed{K = -\frac{dP}{\left(\frac{dV}{V}\right)}}$$



Constant → $m = \rho \cdot V$

Diff^n it

$$\cancel{dm}^{0} = \rho \cdot dV + \cancel{V} \cdot d\rho$$

$$-\rho dV = V\, d\rho$$

$$\boxed{-\frac{dV}{V} = \frac{d\rho}{\rho}}$$

$$K = \frac{dP}{d\rho/\rho} \quad \text{(or)} \quad \boxed{K = \rho \cdot \frac{dP}{d\rho}}$$

$$\boxed{\beta = \frac{1}{\rho}\frac{d\rho}{dP}}$$

If density is not changing w.r.t. pressure –

$$\frac{d\rho}{dP} = 0$$

$$\boxed{\beta = 0} \text{ (Incompressible)}$$

If density is changing w.r.t. pressure –

$$\frac{d\rho}{dP} \neq 0$$

$$\boxed{\beta \neq 0} \text{ (compressible)}$$

For Liquids

$T = 20^\circ C$

$P = 1$ atm , $\rho_w = 998$ kg/m³

$P = 100$ atm , $\rho_w = 1003$ kg/m³

$$\% \text{ change} = \frac{1003 - 998}{998} \times 100$$

$$= 0.5$$

$$\boxed{\beta \simeq 0}$$

Generally, liquids are treated as Incompressible.

For Gases

(Highly compressible)

$P = \rho \cdot RT$

$\rho \propto P$

Mach No. (Ma) $= \frac{V}{C}$

V = Velocity of fluid flow

C = Velocity of sound in the medium

"If $Ma \leq 0.3$, the flows are considered as Incompressible."

for Ideal Gas

Eqⁿ of State

1) $\boxed{P\forall = n\bar{R}T}$

$\bar{R}$ ← universal Gas constant

n ← No of moles

2) $P\forall = \frac{m}{M} \cdot \bar{R} \cdot T$

M ← molecular Mass

$= m \cdot \left(\frac{\bar{R}}{M}\right) \cdot T$

$\boxed{P\forall = m \cdot R \cdot T}$

R ← characteristic Gas constant

3) $\boxed{P = \rho \cdot R \cdot T}$

Isothermal Compressibility of Gases

(T = Constant)

$P\forall = \text{Const}$

$\frac{P}{\rho} = \text{Const}$

for Ideal Gas: $P = \rho RT$

$P\rho^{-1} = \text{Const.}$

Diffⁿ it

$\rho^{-1} dP - \rho^{-2} P \cdot d\rho = 0$

$\rho^{-1}\left(dP - P \cdot \frac{d\rho}{\rho}\right) = 0$

$dP = P \frac{d\rho}{\rho}$

$K_{ISO} \leftarrow \left(\frac{dP}{d\rho/\rho}\right) = P$

$\boxed{K_{ISO} = P}$ $\quad \boxed{\beta_{ISO} = 1/P}$

Adiabatic Compressibility of Gases

$m = \rho \cdot V$ ← const.

$P\forall^{\gamma} = \text{Const.}$

$P \cdot \left(\frac{m}{\rho}\right)^{\gamma} = \text{Const.}$

$P \cdot \rho^{-\gamma} = \text{Const.}$

Diffⁿ it

$\rho^{-\gamma} \cdot dP - \gamma \cdot \rho^{-\gamma-1} \cdot P \cdot d\rho = 0$

$\rho^{-1}\left(dP - \gamma P \cdot \frac{d\rho}{\rho}\right) = 0$

$dP = \gamma \cdot P \cdot \frac{d\rho}{\rho}$

$K_{Adia} \leftarrow \left(\frac{dP}{d\rho/\rho}\right) = \gamma \cdot P$

$\boxed{K_{Adia} = \gamma \cdot P}$

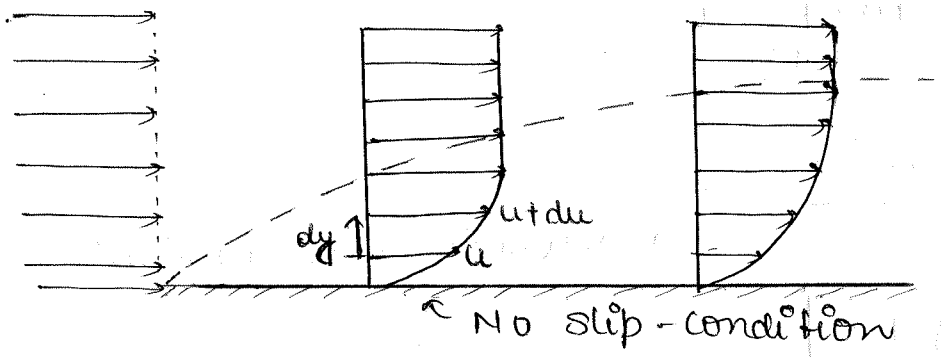
$\boxed{\beta_{Adia} = (\gamma \cdot P)^{-1}}$

for monoatomic gas $\boxed{\gamma = 1.67}$ $\left(\gamma = \frac{C_p}{C_v}\right)$

for Diatomic gas $\boxed{\gamma = 1.4}$

In General

flow over a flat Plate



When a Real fluid flows over a Solid Body, the fluid particles at the surface of the Body. flow with the same velocity as that of the surface to ~~Sais~~ satisfy 'No slip-condition' So the Relative Velocity of fluid particles at the surface of Solid Body is 'zero'.

Away from the Solid Body, in the transverse dir^n the velocity of fluid particles increases Gradually thus the velocity Gradient exist in this region ~~do~~ closed to boundary.

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26-05-2022

Cement Chapter-1

→ It is a binding material imparts cohesive (Eg- lime), adhesive (Alumina) property both, made up by Calcareous & Argillicious compound.

→ It is founded in 1824-25 by Joseph Aspadin.

Cement

Calcareous Compound (Calcium)
→ lime stone {Ca}
Chalk
Marl
Marine shell, Alkali base

Argillicious Compound (Silica, Al etc.)
→ Clay {Si, Al}
Shale
Slate
Ash

+ Water

↓

Portland Cement

↓

Stiff paste looked like a stone founded at Portland.

→ Both Calcareous & Argillicious compound impart binding property.

→ Cement is a artificial building Material.

Constituents of Cement :-

L > S > A > C > I > M > S > A

lime, Silica, Alumina, $CaSO_4$, Iron oxide, MgO, SO_3, alkali

$CaSO_4$ → gypsum
↳ It is not the constituent of cement, it is extra
It is mandatory admixture i.e why considered as the constituents

1) Lime (62% - 67%) - CaO

- Impart **strength** to cement.
- If excess → Present in free form of lime (CaO) then → Unsoundness means increasing of volume.

$CaO + H_2O \longrightarrow Ca(OH)_2$

↓

hydraulic lime

↓

→ Volume of hydraulic lime is more than CaO
So, excess of lime impart **Unsoundness**

↓

Means cracks develop → Area required for load transfer is lost

↓

Strength reduces.

→ If deficiency - Reduce the strength.

2) Silica (17 - 25%) - SiO_2

→ Impart **strength**

→ If in excess → Setting time increase or Setting get delayed. → Setting means to reduce plasticity.

→ Excess of silica depends on Requirement.

↓

If transportation is quite long.

Plasticity ↑

↓

So plasticity loose
hame me lime
jada lagega. i.e why setting get delayed.

→ If in deficiency - Reduce the strength.

3) Alumina (3–8%) - Al_2O_3

Jabtak cement plastic stage me hoga, plastic shrinkage aayega.

Aluminium agne tarag attract karta hai i.e. why flash set occurs

→ Causes flash set (quick set)

↓ Means

High heat of hydration → Reaction with water.

↓

Water evaporates.

↓

Volume ↓ (total)

Plastic Shrinkage crack

dyiciency in required water for complete hydration

∴ Strength ↓

→ When calcium, alumina reacts with sulphur, it forms a compound known as calcium alumino sulphate, volume of which is 227% more than original volume. That means excess of Alumina reduces the sulphate resistance. → So the large cracks will develop becz. sulphate will react in the presence of alumina.

→ Advantage of Alumina is, it acts as flux which reduces clinking temperature & makes the manufacturing economical.

4) Gypsum (3–4%) - $CaSO_4$ ($CaSO_4 \cdot 2H_2O$)

↳ get removed in kiln

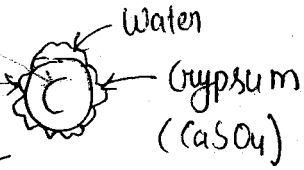
→ Presence of Gypsum increases initial setting time because it controls over the reactivity of alumina.

→ It is mixed in cement clinker during grinding in tube mill.

→ During mixing in tube mill, Gypsum lost its crystalization water^, that will be recollected when we mix the water in cement. due to very high temp

→ As a result little stiffness occured in cement paste due to hardening of gypsum, known as false setting.

Means lagega ki cement hard ho gya but actually wo ho nahi rahi



This layer is temporary thats why retard only initial setting.

→ Recollect $2H_2O$

↓

becomes hard

5) Iron oxide (3-4%) - Fe_2O_3

→ It imparts strength, hardness & ruddish brown colour tinge (greyish colour) to the cement.

6) Magnesium oxide (1-3%) - MgO

→ It also impart strength hardness & yellow tinge to the cement.

7) Sulphur (1-3%) - SO_3

→ It make the cement unsound due to sulphur attack.

Note-1) Irong oxide & MgO helps lime & silica to fuse with each other during burning.

Note-2) Excess of MgO, imports unsoundness in cement.

8) Alkali (base) - (0.2-1%)

Ca/Mg + Al $\xrightarrow{\text{Sulphur}}$ Calcium Alumino Sulphate / Magnesium alumino Sulphate ($V_{final} = 227\% V_{ini}$)

→ Alkali in cement result in efflorescence which means white stains / white spot over the finished surface.

→ When alkali react with aggregate, it also impart the unsoundness (cancer of concrete). (not with cement)

→ Alkali also accelerate setting Process ~~time~~ of cement.

→ Alkalid does not impart unsoundness to the cement, it impart unsoundness to the aggregate used

Note- Unsoundness (To cement) → Lime, MgO, Sulphate, ~~Alkali~~.

⇒ All the above constituents of cement intergriend burn & fuse with each other & forms the complex compound known as Bougues Compound.

Bougue's Compound :-

at f.o all Bougue's compound start reaction but their rate are diff.

1) C_3A (Tricalcium Aluminate) ($3CaO \cdot Al_2O_3$) (4–14%) (Celite)
(Early setting)

→ Imparts flash set (due to Alumina)

→ Release high heat of hydration → Per day 865 J/g, at 90 day 310 cal/gm

→ High rate of hydration (80% hydrated within 24 hours)

→ Causes plastic shrinkage crack (Water evaporates, V↓)

→ Weakens the cement (required water is not present)

→ Reduce sulphate resistance (becz. form Calcium alumina sulphate whose vol. is more which crack/fail the concrete)

→ 'Harmful ingredient'

2) C_4AF (Tetracalcium alumino Ferrite) (10–18%) ($4CaO \cdot Al_2O_3 \cdot Fe_2O_3$)
(Felite) (Final Setting)

→ Rate of hydration is highest (90% hydrated within 1 hour)

→ Release heat of hydration (419 J/g or 90 days → 100 cal/gm)

→ Sulphate resistance is less but better than C_3A.

→ Also impart flash set (due to Alumina)

→ No role in imparting strength or any further binding property. becz. ye starting me hi sabkuch poora react kar chuka

→ 'Worst Compound'.

3) C_3S (Tricalcium Silicate) ($3CaO\ SiO_2$) (45–65%) (Alite)
(Early Strength)

→ It is responsible for imparting early strength. becz. both lime & silica is in high amount.

→ It get hydrated within 7 days

→ heat of hydration (502 J/g 90 days → 105 cal/gm)

→ Road construction, Prefabricated structure, cold weather construction) construction related to less stripping time. means, jaha bhi early strength ki requirement hogi

→ $C_3S + H_2O \longrightarrow C\text{-}S\text{-}H + 3Ca(OH)_2$

C-S-H gel ↓ Impart strength

$3Ca(OH)_2$ ↓ Portlandite.

→ C_3S imparts high resistance against grant action, because the size of molecule of C_3S reduces its permeability. (C_3S ka size kum hota hai)

→ When C_3S react with water, it forms C-S-H gel known as calcium silicate hydrated gel or Tobermite gel or Thumbohydrated gel which actually responsible for imparting strength.

→ When C_3S react with water it also liberate hydrated lime known as portlandite.

→ Leaching out of portlandite makes the finished surface porous which finally reduces the durability of finished surface, but presence of portlandite makes the surrounding alkaline. (due to presence of OH^- ion, ∴ pH > 13) as the result corrosion of reinforcement can be prevented.

→ Presence of Portlandite also participate for sulphur attack when it is used for foundation work.

4) C_2S (Di-calcium Silicate) (15-35%) ($2CaO \cdot SiO_2$) (Belite)

→ It imparts later or ultimate strength (Final strength) → (less % lime is less)

→ It gets hydrated after a long time (Yearly)

→ heat of hydration. (260 J/g , 90 days → 40 cal/gm)

→ $C_2S + H_2O \longrightarrow C\text{-}S\text{-}H + Ca(OH)_2$ (C-S-H gel)

→ Used for dam construction, Bridge construction or all type of mass concreting. because of less amount of leaching of portlandite. so surface finishing is good.

→ As reaction of C_2S & H_2O releases comparatively less amount of portlandite, so it founds more durable.

→ It also increases the resistance against chemical attack (less reactivity is Now)

Note-1 - Rate of hydration -

$C_4AF > C_3A > C_3S > C_2S$

Note-2 - Binding property - Binding occur when cement start to gain strength no when start setting.

$C_3S > C_2S > C_3A > C_4AF$ - kuki ye bacha hi nahi means got fail in imparting strength. 1 hr me hi 90% hydrate ho jata hai.

- C_3S → Alite → A-grade
- C_2S → Belite → B-grade
- C_3A → Celite → C-grade
- C_4AF → Felite → fail.

Note-3 - Amount of bougue's compound -

$C_3S > C_2S > C_4AF > C_3A$

Note-4 - Amount of heat of hydration -

If asked generally -

$C_3A > C_3S > C_4AF > C_2S$

Note-5 - Water requirement -

$C_3S > C_2S > C_3A \approx C_4AF$

24% 21% 20%

Ex-For Note-6

Sample = 500gm

C_3A → 10% → 50gm → 310×50 = 1550[illegible]

C_4AF → 15% → 75gm → 100×75 = 7500

C_3S → 50% → 250gm → 105×250 = 2625[illegible]

C_2S → 25% → 125gm → 40×125 = 5000

So in absolute term or in mass considering amount of heat of hydration of C_3S is more than C_3A.

Note-6 - Because amount of C_3S is higher than amount of C_3A i.e why in absolute term or in mass conc. high amount of heat is released by C_3S.

Note-7.) For complete the hydration process 23% of water (by weight of cement) is required, but 15% water gets interrupted in voids/pores of cement so we must add 38% of water is added to complete the hydration process.

→ For complete hydration 38% water to be added.

- 23% - Combined water which reacts with cement particles
- 15% (in voids)
  - Capillary pore
  - Interlayer water
  - gel water

  } Free form → Cause for shrinkage

Jo water free hota hai means except 23% will be responsible for shrinkage & strength reduction

↓ yahi [illegible] hai jo [illegible]

⇒ Water cement ratio (w/c) > 0.38 → Strength ↓ → Free water evaporates.

⇒ Water cement ratio (w/c) < 0.38 → Strength ↓ → Required amount of water is not present.

Testing of Cement :-

1) Field Test -

i) It should be uniform grey colour { shows fusion of all ingredient }

ii) It should feel smooth, when rubbed b/w fingers { Shows fineness }

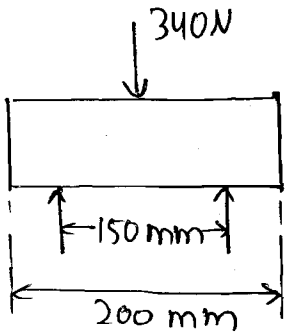
iii) When we insert hand in cement bag it should feel cool & no lumps should be found (otherwise it signifies prehydration of cement)

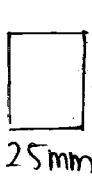
iv) A thin paste of cement should feel sticky { shows binding }

v) When cmnt particles thrown into the water, it should sink { shows specific gravity }

vi) A thick cement paste (faster) should placed in water for 24 hrs over a glass plate, it should not show any sign of crack. { shows soundness / presence of free lime }

vii)





→ Should not crack under given load. → shows Strength.

2) Lab Test -

1) Fineness Test :-

→ Fineness of cement increases the rate of gain in strength, rate of evolution of heat, rate of setting, rate of prehydration, rate of alkali aggregate reaction etc.

→ More fine cement has more specific surface area. so everything will increases

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CONSTRUCTION PLANNING & MANAGMT

SYLLABUS :

CH. 01 : Basics of Project Managment and Network Rule.

CH. 02 : PERT Analysis

CH. 03 : CPM Analysis

CH. 04 : CPM Cost Model Analysis (Crashing and updating of a CPM network).
Resource Allocation, Resource levelling, A-O-N Network, and Ladder Network.

CH. 05 : Engineering Economy [IMP.]

CH. 06 : Construction Equipment ESE only

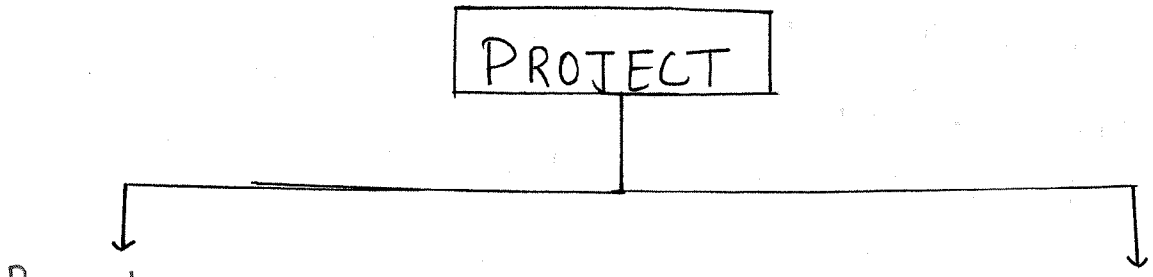
CH. 07 : Contracts and Tenders. ESE

CH. 08 : Quality Control, Safty and Welfare. ESE only

CH. 09 : Estimating Costing. ESE only

CH. 10 : Site investigation and Mangment and, Productivity and operations. ESE only

INTRODUCTION:-



Research or development Type of Project

Repetitive type of Project like Civil Engineering, Construction Project and Machenical Engineering, Production Project.

Done by CPM Analysis

t → Time of Completion of an Activity

Proposed Plan:

Construction of Village Roads.

→ Desk Study via Map

→ Field Survey and Transmit Work for Verification of Alignment

→ Formations of DPR (detailed Project Report).

→ TA (technical Approval) by Head quarters engineers
Signalled by PIU. [JE, AEE, AEE].

→ AA (adminstrative Approval)

→ TS (Technically Sanctioned by –
STA: State Technical Authority
CTA: Central Technical Authority.

→ NT: (Notice inviting Tender)
Published in leading newspaper.

→ Formation of BOQ (Bill of quantity).

→ Uploading of BOQ on Website of department.

→ Tender

→ Submission of Tender by bidder including 2% Earnest Money (EM) With Paper cutting of NIT. → To avoid unnecessary Competition.

→ CS Comparitive Statement

→ Tender Awarded

→ Contractor and Engineers Will Visit site to stand the work.

→ Work started by Contraction

→ Payment Made to Contractor after deduction of 10% of SD (Security deposity) inclusive of E.M from each running bill.

→ Now 8%. SD has deducted i.e 8 Lac Rupees from Running Bill.

1 Cr Running Bill

↓

2%. EM = 2 Lac. → Already deposited at the time of tender.

EM → To avoid unnecessary competitions.

S.D → As a Security when Contractor Will not complete the Work or any defect in Work

S.D will Refund after six Month (or) one Monsoon Season of completion of Work after.

1. BASICS OF PROJECT MANAGEMENT AND NETWORK RULE.

Project Management :- It deals with Material and human resources both to increase Productivity and efficiency.

The Project should be completed in Minimum time by using optimum resources.

For Completion of a Project, two basics things are required:

(1) Material Resources
(2) Manpower Resources.

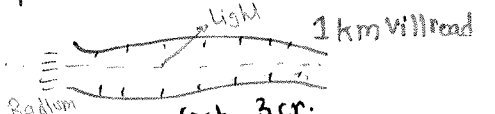
} Active Resorces ⇒ Money is passive Resources.

Every Project whether it is big (or) Small has three objectives:

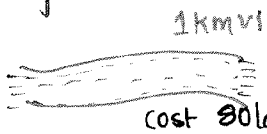
(1). It should be completed in Minimum time. (optimum time).

(2). It should use available Man Power and material resources as far as possible Without delaying in Completion of a Project.

(3). It should be completed With minimum of Capital investment.



Cost 3 cr.
Not feasible
Rejected.



cost 80 lakh
(Feasible)

If Man Power is available locally When Contractor labour is not available then use Man Power available locally even little price higher. These price is later adjusted.

1 KM State Highway

time of completion: 9 Month.

↓

Minm duration for completion of a project.

There are 3 important Phases of Project Management :-

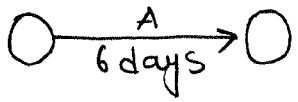
(1). Planning (or) Project Planning :

This is most important ~~Phase of~~ Phase of Project Mangement. Planning involves defining the objective of a project, listing of job (activity) or arrangement of jobs that must be Performed, determining gross requirement for material, equipment, man power and prepairing estimate of Cost and durations for Completion of Project.

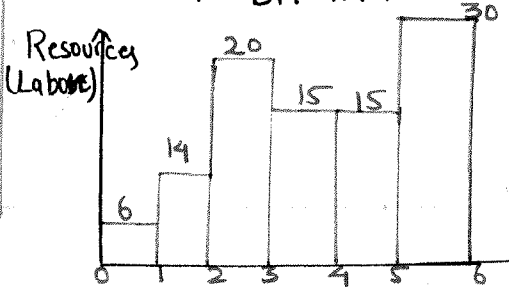
(2). Scheduling (or) Project Scheduling :

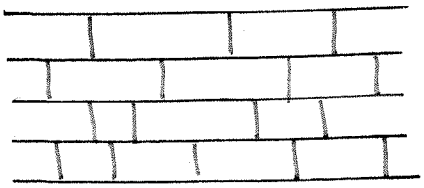
Scheduling is the allocation of resources such as material resources equipments, man power resources in appropriate manner such that it results in efficient Working. Scheduling also involves Sequencing of Activities.

Note:- In tradional technique of design, Planning and Scheduling are perfored as Single Step.



A : Brick work



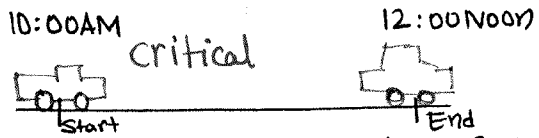


6days : No. of labor - 100labor

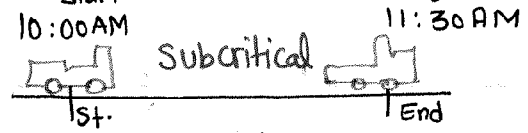
→ Resource allocation.
(This Allocation is not good. Not uniform)

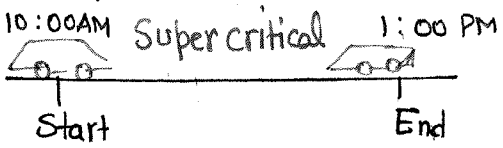
(3) Controlling (or) Project Controlling :

It is the Process to identify Critical Activity (running on Schedule time), Sub-critical Activity (non-critical activity i.e already completed beforre the schedule duration) and Super Critical Activity (delayed activity i.e Completed after Scheduled duration of projects).

1) 

Travel duration = 2hr allowed.

2) 

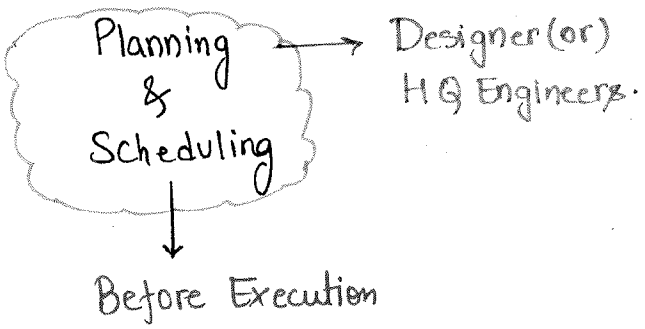
3) 

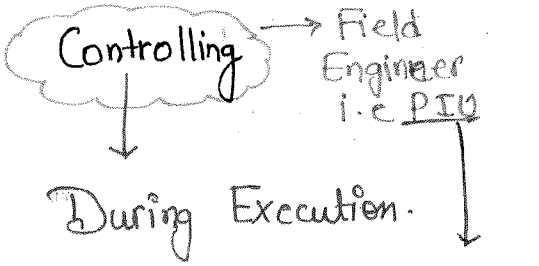
Critical and Supercritical activities are given extra attention in a Project.

Therfore, of regular interval of times Network is updated and project Progress is reviewed.

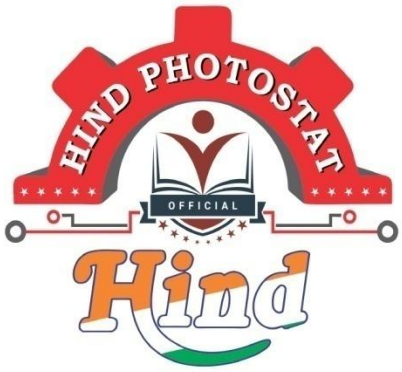
Frequency of updating will increase towards completion of a Project.

Note:- Planning and scheduling are performed before execution of Project Wheras ~~Scheduling~~ Controlling is Carryied on during execution of the project.





PIU: Program implementation Unit.



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TRANSPORTATION ENGINEERING

Syllabus

1) Introduction
2) Geometric design
3) Traffic Engineering
4) Pavement design
5) Highway material & Construction.

1) INTRODUCTION

Highways :- Highways are special type of road which are designed to permit high speed of vehicles. It is generally constructed over an embankment due to following advantages -

a) Better drainage facility
b) Safety in flood time
c) No lateral entry of traffic / animal / Public eg. Nation Highway, State highway.

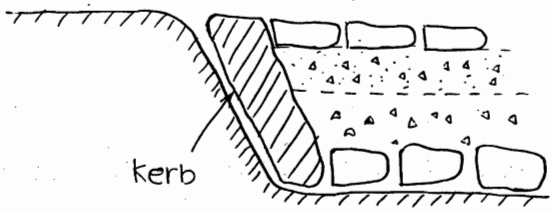
Express Highway :- Express highways are superior type of highway. designed as a direct connectivity b/w two places. Express highway organise the traffic in channelised way.
e.g. Yamuna express highway, Mumbai - Pune express highway.

Development of Roads :-

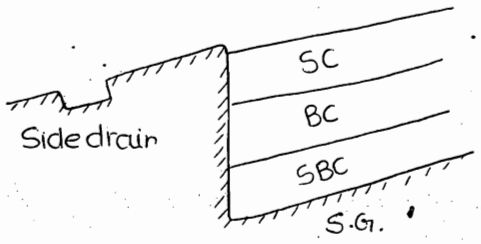
i) Roman Roads
ii) Tresaguet Roads
iii) Telford Construction
iv) Mecadam Construction

Modern Construction ⟶ Macadam + CBR

Roman Roads



Macadam Roads



drawback -

i) No camber

ii) No drainage System

iii) Large foundation stone.

Highway Planning in India :- In Nov. 1927 Govt. appointed a road development committe headed by Mr. M.R. Jayakar.

-Recommendations of Jayakar Committe :-

i) Road development should be considered as National interest.

ii) An extra tax should be charged on Petrol & diesel for road development & maintenance.

Result - Central Road Fund (CRF) established in 1929

Note :- Current rate of CRF is ₹6/lit.

iii) A semi-technical body should be established for road design & specification.

Result :- Indian Road Congress (IRC) established in 1934.

iv) A research & development organisation should be established for road development.

Result :- Central Road Research Institue (CRRI) established in 1950.

v) Jayakar committe gave more stress for long term planning.

Result - Various 20 years road plan.

• Comparison b/w various 20 years road plan.

	1st 20 year Plan	2nd 20yr Plan	3rd 20 yr Plan
Name	Nagpur	Bombay	Lucknow
Duration	1943-1963 (completed in 1961)	1961-1981	1981-2001
Road density	16km/100 km²	32km/100 km²	82km/100 km²
Pattern	Star & grid	—	—
Express-highway	—	1600 km added	2000 km
Classification	- NH - SH - MDR - ODR - VR	Same	- Primary Roads (EH+NH) - Secondary Roads (SH+MDR) - Rural roads (ODR+VR)

• Length of road as per 3rd 20yr Plan:-

i) Total length of road = Max. { 4.74 x No. of towns & villages ; Road density x Area }

ii) Length of NH = $\left(\frac{\text{Area (km}^2\text{)}}{50}\right)$

iii) Length of SH = Max. { $\left(\frac{\text{Area (km}^2\text{)}}{25}\right)$; 62.5 x No. of towns - Length of NH }

iv) Length of MDR = Max. { $\left(\frac{\text{Area (km}^2\text{)}}{12.5}\right)$; 90 x No. of towns }

Q-41) Pg-9)

Area = 13400 km²

No. of towns = 12

Length of NH = $\frac{13400}{50}$ = 268 km

Length of SH = $\frac{13400}{25}$ or $62.5 \times 12 - 268$ (Max

= 536 or 482

= 536 km

Length of MDR = $\frac{13400}{12.5}$ or 90×12

= 1072 or 1080

= 1080km

Total length of Road = 4.74×12 or $\frac{82}{100} \times 13400$

= 56.88 or 10988

= 10988 km

Primary Roads (EH + NH)

= 268 km

Secondary Roads (SH + MDR)

= 536 + 1080

= 1616 km

Rural roads (ODR + VR)

= Total length - (Primary + Secondary)

= 10988 - 268 - 1616

= 9104 km.

Engineering Survey for highway alignment :- Before a highway alignment is finalised, engineering survey are to be carried out in following stages -

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Hydraulic Machines

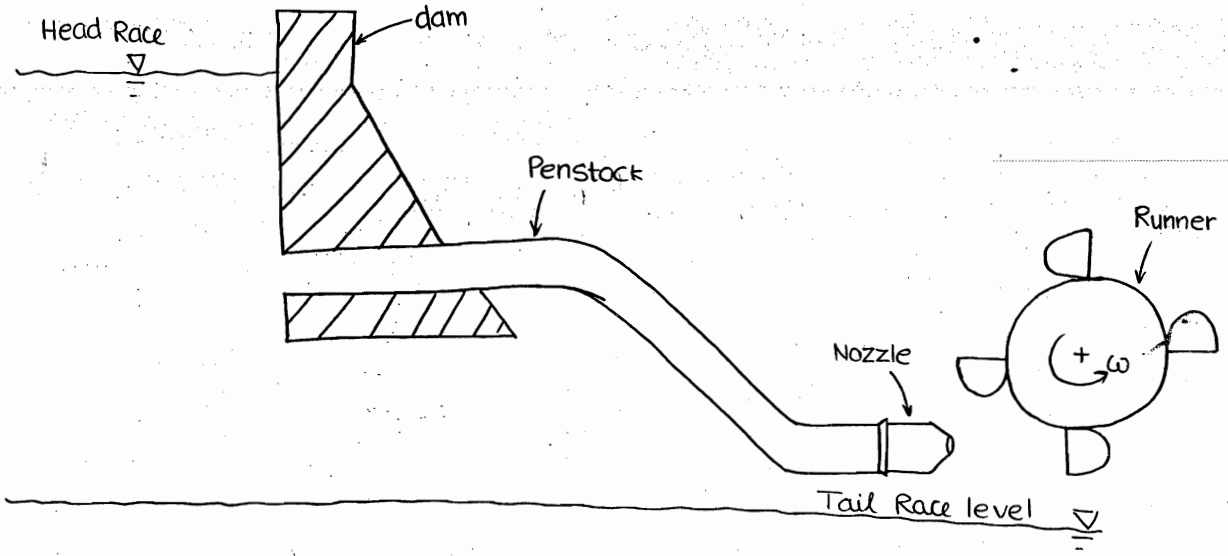
Flow in motion ⟶ Fluid dynamics

Classification of hydraulic Machines -

Work is done by the water (Ex- turbine)

Work is done on the water (Ex- Pump)

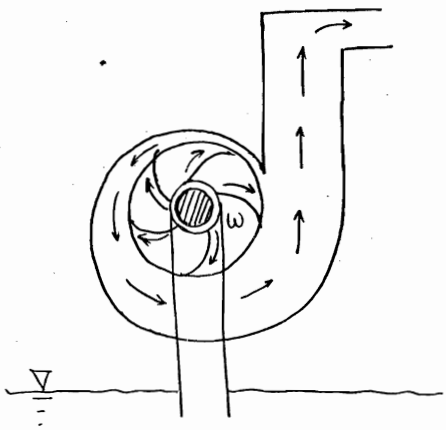
Layout of hydro electric Power plant -



Hydraulic Energy → Mechanical shaft power output → Electric Power Output

Turbine

Pump :-



Electric Energy → Mechanical shaft power input → Hydraulic Energy

Pump

In General-

Energy (Joule)

$= mgH$

$= \frac{1}{2} m V^2$

$= F \times (X)$ (Workdone)

Power (Joule/sec)

$= \dot{m} g H$

$= \frac{1}{2} \dot{m} V^2$

$= F \times u \left(\frac{\text{Workdone}}{\text{sec}}\right)$

$= T \times \omega$

Work done per sec per unit weight of water striking per sec

$= \frac{\text{Work done per sec}}{\dot{m} g} = H \text{ (m)}$

In General-

Water

(System)

A/C to Newton's 2nd law of motion

$$\vec{F} = \underbrace{\dot{m}\vec{V}_2}_{\text{Momentum of water leaving per sec.}} - \underbrace{\dot{m}\vec{V}_1}_{\text{Momentum of water entering per sec.}}$$

$\dot{m}$ = mass flow rate actually striking over vane.

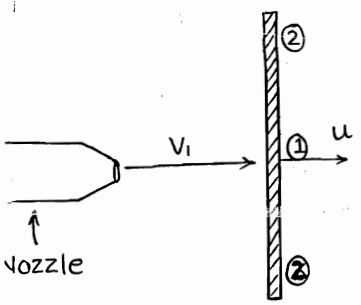
$\vec{F}$ = Force. applied on the water by the vane.

Force applied by the water on the vane $= -\vec{F}$

$= \dot{m}\vec{V}_1 - \dot{m}\vec{V}_2$

In General-

Notations :-



inlet of vane ⇒ 1

exit of vane ⇒ 2

$\vec{V}_1$ = absolute velocity of water at the inlet of vane

$\vec{u}_1$ = absolute " " vane " " " " "

$\vec{V}_{r_1}$ = Relative " " water " " " " "

$\vec{V}_2$ = Absolute velocity of water at the exit of vane.

$\vec{u}_2$ = Absolute " " vane " " " " "

$\vec{V}_{r_2}$ = Relative " " water " " " " "

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/E D E /KE E /E / **6.** KD /

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ENGINEERING HYDROLOGY.

** SYLLABUS :- **

CH: 01 Basic Concepts :

(i) Precipitation and its Measurements.
(ii) Evaporation and its Measurements
(iii) Infiltration and its Measurements. *
(iv) Transpiration and Evapotranspiration.

CH: 02 Stream flow Measurements

CH: 03 Hydrograph Analysis *

CH: 04 Floods and Flood Routing

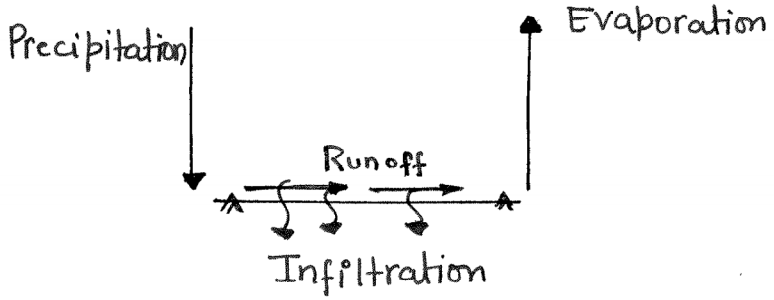
** ESE - Prelims 6 to 7 questions **
- Mains 30 - 35 Marks *

** GATE - 3 to 4 Marks. **

1. BASIC CONCEPTS.

⇒ Hydrology

It is the science which deals with the occurance of water, its flow on ground and movement of the moisture into the atmosphere.



Q: What is difference between hydrology and engineering hydrology ??

The Study which is mainly concerned with academic aspects (back year record) is known as ~~engineering~~ hydrology

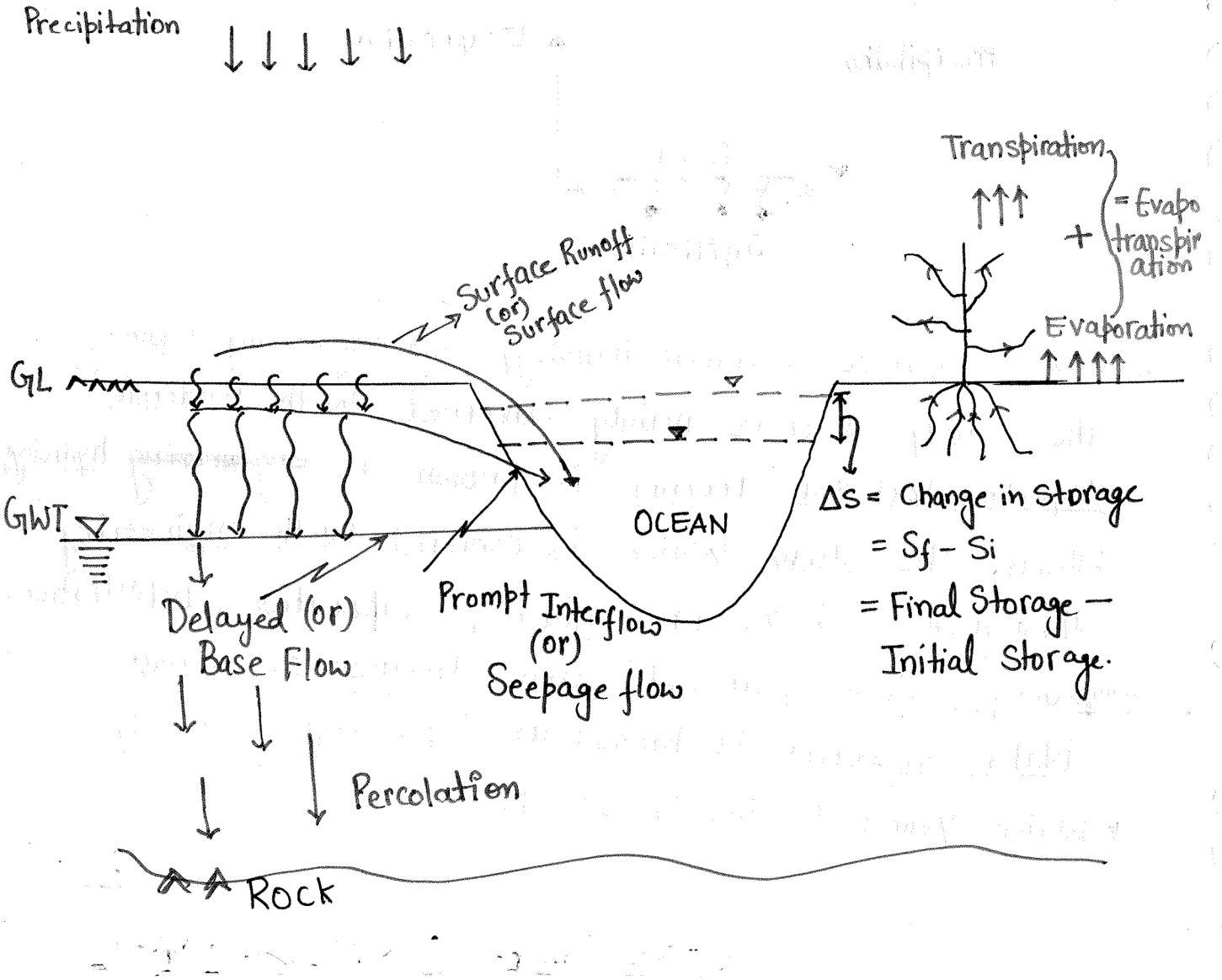
Wheras, the Study which is concered with engineering application such as precipitation, evaporation, Infiltration, evapotrans, Runoff, floods, droughts and estimation of various water resources is known as Engineering hydrology.

→ Water year : 1st june to 31st May.

→ **Hydrolgical Cycle :**

Precipitation and Evaporation Continues forever therefore a balance is maintained between the Two.

This process is known as hydrolgical cycle [(or) Water cycle]



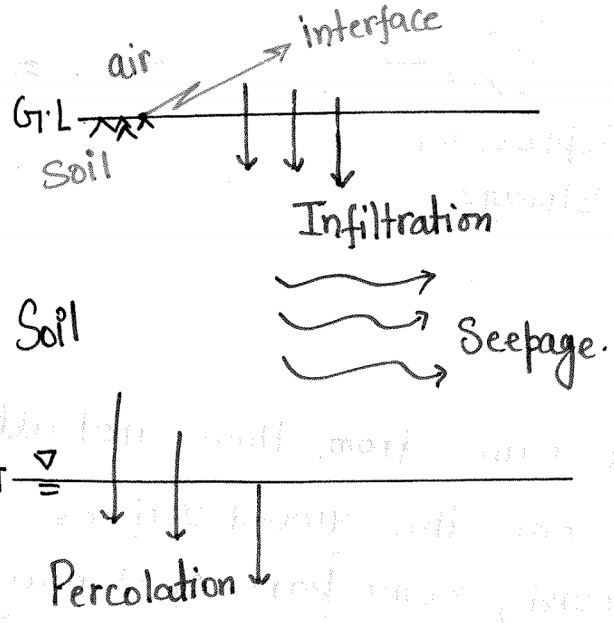
Note:

1) Infiltration, Percolation and Seepage:

Infiltration and Percolation are both process in which Water moves in the pores of the soil.

The main difference between these two process is that infiltration occurs closer to the the surface of the soil and interface is essential in infiltration process.

In percolation, Water moves from unsaturated Zone to ~~Surface~~ Saturated Zone.



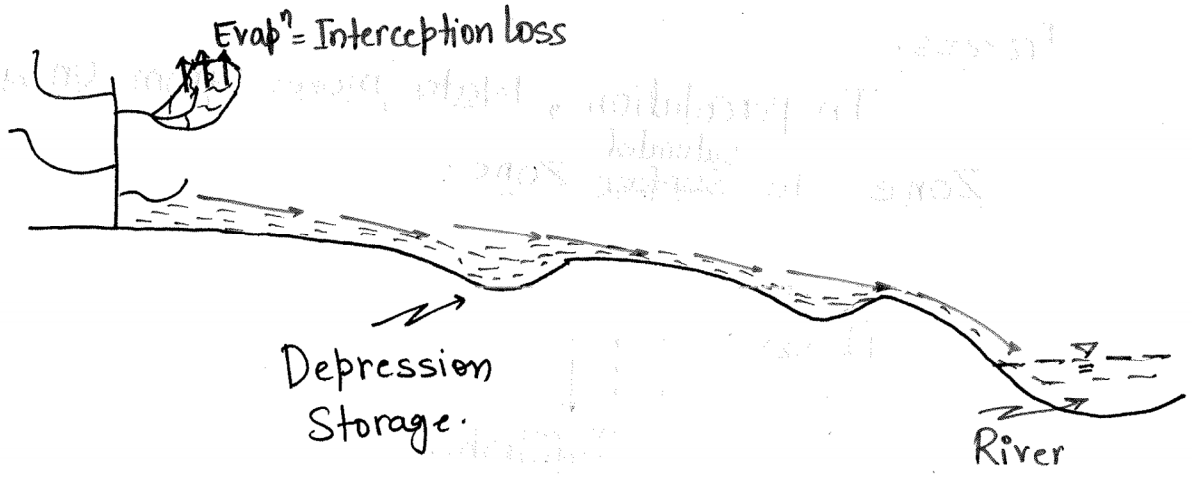
Seepage:- Flow of Water in any arbitrary direction other than downward movement.

Max. Capacity of Seepage is permeability.

Note:

Initial losses → (I) Interception loss
Initial losses → (II) Depression Storage.

Precipitation ↓ ↓ ↓ ↓



Interception loss:

When there is a rain ~~from~~ then not all the precipitati -on fall directly onto the ground surfaces. Before it reaches on the ground, some part of it may be received by vegetations and consequently evaporated back to the atmosphere. The Volume of Water loss is called Interception loss.

Depression Storage:

When there is a rain then before it flow on the ground, it must fill all depressions.

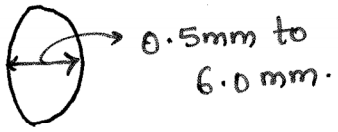
The Volume of Water trapped in these depressims are called depression Storage.

1. PRECIPITATION AND ITS MEASUREMENTS:

Precipitation: The term precipitation denotes all forms of Water that reaches on the earth from atmosphere.

Various forms of Precipitation:

(i) **Rain:** This term is mainly used When Water droplets are of Size **0.5 mm to 6.0 mm.**



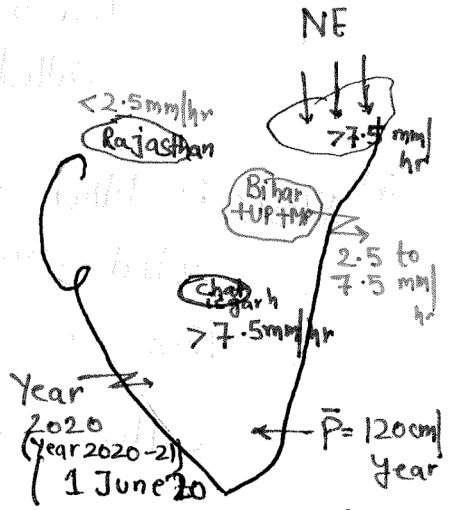
Classification of Rain:

Intensity (mm/hr)	Rain
< 2.5 mm/hr	Light Rain
2.5 mm/hr to 7.5 mm/hr	Moderate Rain
> 7.5 mm/hr	Heavy Rain

* If Total rain in a day is more than 2.5mm then that day is called Rainy day.

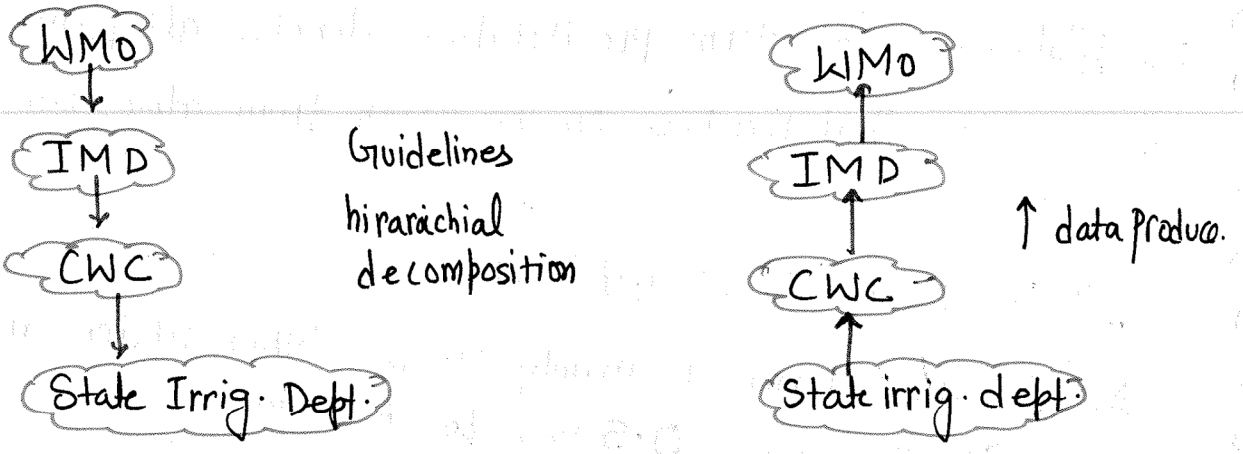
* In India, avg annual ppt^n is about 120cm Which is greater than World avg. ppt^n of 100 cm/year.

→ In order to find avg. annual rainfall of a place, a minimum of 30 years data has been taken as per W.M.O (Water Meterological organisation



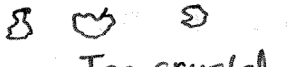
eg: $\overline{P_{2020}} = \frac{P_{1991} + P_{92} + \cdots P_{2020}}{30}$

Note:



(ii) **Snow:** Snow Consists of ice crystal having average density of 0.1 gm/cc.

In India, Generally occurs in Himalayan Zones. The accumulation of Snow may result into formation of glaciers.



(iii) **Drizzle :-** When rain drops are of size less than 0.5mm and intensity is less than 1mm/hr then it is called Drizzle.

(iv) **Glaze :-** When rain(or) drizzle Comes in contact With Solid body (or) ground at freezing temperature then it forms ice coating and this coating is Called Glaze.

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BY-Sagar Dodeja SIR

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CHAPTER 1
INTRODUCTION TO IRRIGATION & METHODS OF IRRIGATION

CONTENTS

Students should write this after chapter completion. This provides with overall view & acts as a tool for active recalling.

Course Structure

1. Introduction to Irrigation, Methods of Irrigation.
2. Water Logging, Quality of Irrigation Water (CWC, IARI) AS PER
3. Water Requirement for Crops. ***
4. Canal design.
5. Analysis of Gravity Dams.
6. Conveyance and Regulating Structures for Canals.
7. Theories of seepage.
8. River Training and Diversion Headworks.
9. Dams, Spillways and Energy Dissipators.

Weightage

YEAR	ESE (PRE)	GATE
2014	14 Q	1.5 M (AVG)
2015	15 Q	1.5 M (AVG)
2016	11 Q	1.5 (AVG)
2017	10 Q	2 (AVG)
2018	11 Q	1 (AVG)
2019	11 Q	1 (AVG)
2020	12 Q	3 (AVG)
2021	14 Q	3 (AVG)

Official GATE Syllabus

Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapo-transpiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures.

Official ESE Syllabus

2. Hydrology and Water Resources Engineering:

Hydrological cycle, Ground water hydrology, Well hydrology and related data analysis; Streams and their gauging; River morphology; Flood, drought and their management; Capacity of Reservoirs. Water Resources Engineering : Multipurpose uses of Water, River basins and their potential; Irrigation systems, water demand assessment; Resources - storages and their yields; Water logging, canal and drainage design, Gravity dams, falls, weirs, Energy dissipaters, barrage Distribution works, Cross drainage works and head-works and their design; Concepts in canal design, construction & maintenance; River training, measurement and analysis of rainfall.

27/12/2021

Usage of water:→
82% → Agriculture
6% → domestic & Municipal need
12% → industries.

WHAT IS IRRIGATION?

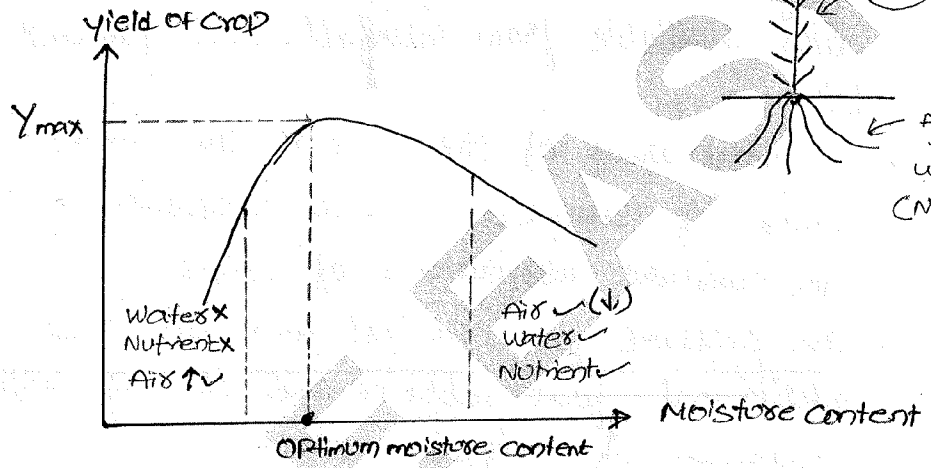
- Irrigation is the artificial application of water to soil throughout the crop period to assist in the production of crops.
- Irrigation water is supplied to supplement the water available from rainfall and ground or soil.
- In many areas of the world, the amount and timing of rainfall are not adequate to meet the moisture requirements of crops
- The pressure for survival and the need for additional food supplies are causing rapid expansion of irrigation throughout the world.

Advantages of Irrigation

1. Increase in food production – Exact quantity required can be supplied as different crops have different water requirements and the same crop may have different water requirements at different places, depending upon the variation in climate, type of soil, method of cultivation, useful rainfall etc.

Crop yield → Soil, Nutrients, Water availability, Temp & Humidity

2. Ensuring Optimum Growth in Field – Maximum yield is obtained when just sufficient quantity is supplied and the corresponding moisture content is called as optimum moisture content.



3. Elimination of Mixed Cropping – Farmers have a tendency to cultivate more than one type of crop in the same field such that even if one dies without the required water, atleast he would get the yield of the other.
   - However, this reduces the overall yield from the field.
   - With assured water from irrigation, farmer would cultivate only one type of crop at any time, which would increase the yield.

Prepare interview for ex: State multiple Projects (Dams) like Nagarjuna Sagar dam: Srisilam dam.

Note - Mixed Farming & Mixed Cropping are being used interchangeably in irrigation engineering. (Refer class for clarity in both definitions).

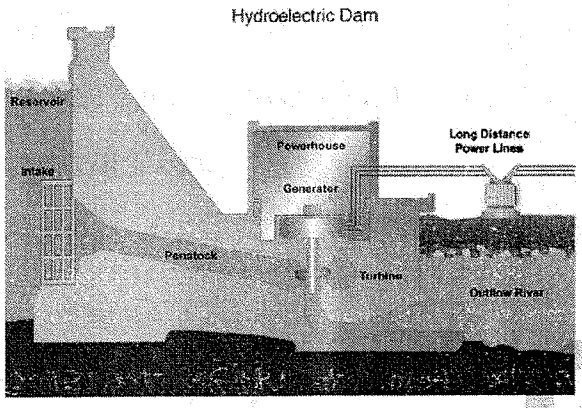
Mixed farming is a method in which multiple crops are grown in the field to utilize the space (or) land more effectively. In addition to that, it helps to prevent (or) control soil erosion.

4. Domestic & Industrial Water Supply - The canal system can be utilized for domestic and industrial water supply for nearby areas.

5. Flood Control - Provision of various techniques such as building of canals, flood cushioning, embankments and dykes, flood plain zoning, flood proofing etc.

6. Generation of Hydroelectric Power - Various multipurpose projects generate hydro-electric power. It is a clean, reliable and renewable energy source. Eg → Bhakra-Nangal project, Hirakud project, Nagarjuna Sagar project, Damodar Valley Project to name a few.

Potential head → K.E → Mechanical head → Electrical energy.



7. Draught Control – Good irrigation practices promote soil conservation, water harvesting and development of ground water which in turn reduces draughts.

DEMERITS OF IMPROPER IRRIGATION

1. Over irrigation may cause water logging which reduces the crop yield. The roots of most crops require oxygen for respiration and hence, full saturation leads to restricted growth. However, exceptions such as rice, jute etc. which demand standing water for their growth. Rice → close growing crop.
2. Excessive irrigation may cause leaching of pesticides, insecticides, nitrates etc. to ground water.
3. Water logging due to over irrigation leads to creation of favourable conditions for the spread of diseases like dengue and malaria.
4. Over irrigation may increase the salinity of soil (CH-2)
5. Excessive pumping out of groundwater for irrigation decreases the ground water level which increases the risk of land subsidence.
6. Needless to say, it leads to wastage of our valuable water.

9/04/2021

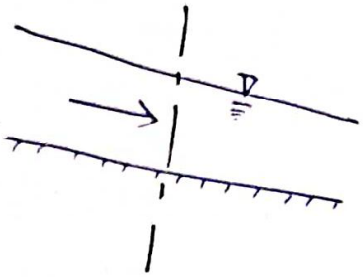
Gate: 2-4 marks.
ESE: OBJ → 5-6 Q
CONV → 50-60 marks

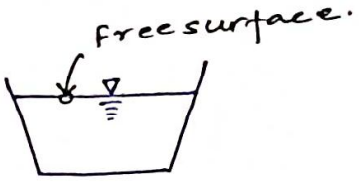
1. Introduction:
2. Uniform Flow
3. & Energy Depth Relationship.
4. Gradually varied flow.
5. Rapidly Varied Flow ⟶ Hydraulic Jump
6. Surges

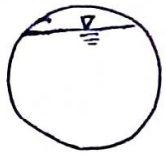
Introduction:

→ Open channel flow refers to the flow of liquid in channel open to atmosphere or is a partially filled conduit.

→ It is characterised by the presence of liquid-gas interface called free surface.







Partially filled conduit.

NOTE: • The driving force in an open channel flow is gravity.

• Shear stress on the free surface is zero.

Types of Channels:

(i) Prismatic and Non-prismatic channel:

If cross-section, shape, size, bed slope remains constant in the direction of flow then the channel is called prismatic otherwise non-prismatic.

(ii) Rigid and Mobile Boundary channel:

A. Rigid Boundary channel: Only depth varies with space and time.
Boundaries not deformable.

→ Shape and roughness parameter are not function of flow.

eg: lined canal and sewer.

b. Mobile Boundary channel:

→ In this case the depth, width, bed slope as well as lagent are functions of space and time.

eg: Unlined canals.

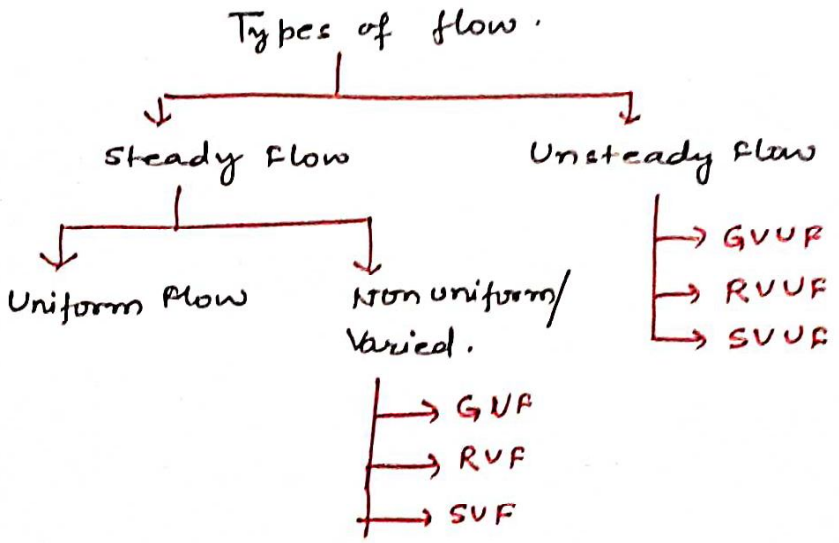
NOTE: The rigid boundary channel has one degree two of freedom while mobile boundaries has four degrees of freedom.

We will study only rigid boundary channels.

Rigid Boundary ⟶ Prismatic

Prismatic ⟶ Rigid Boundary.

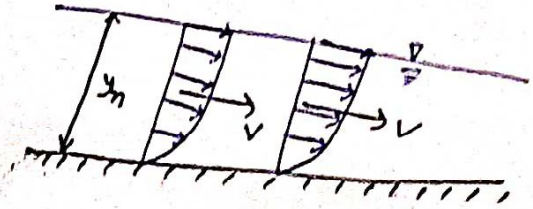
Types of flow:



Uniform Flow:

→ Flow is called steady uniform if the depth of flow does not vary in space.

→ The underlined assumption that is that the velocity also does not vary which means that the cross-section parameter, roughness parameter, slope parameter are not varying.



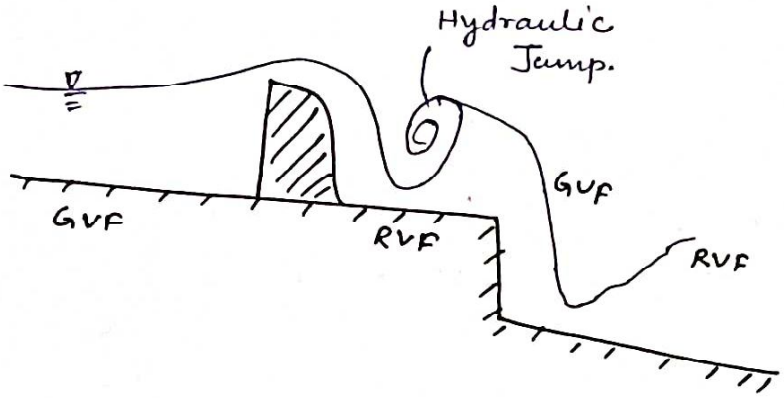
y_n = depth of flow.

V = Avg. velocity of flow.

→ In uniform flow the energy gained due to elevation fall is lost due to flow i.e frictional losses.

→ In prismatic channel, constant depth flow means uniform flow and the depth of flow is called normal depth of flow. (y_n)

2. Non-uniform / Varied flow:



→ Presence of obstruction in channel such as weir, dropping bed, change in slope or cross-section causes the flow to vary, this flow is called non-uniform flow or varied flow.

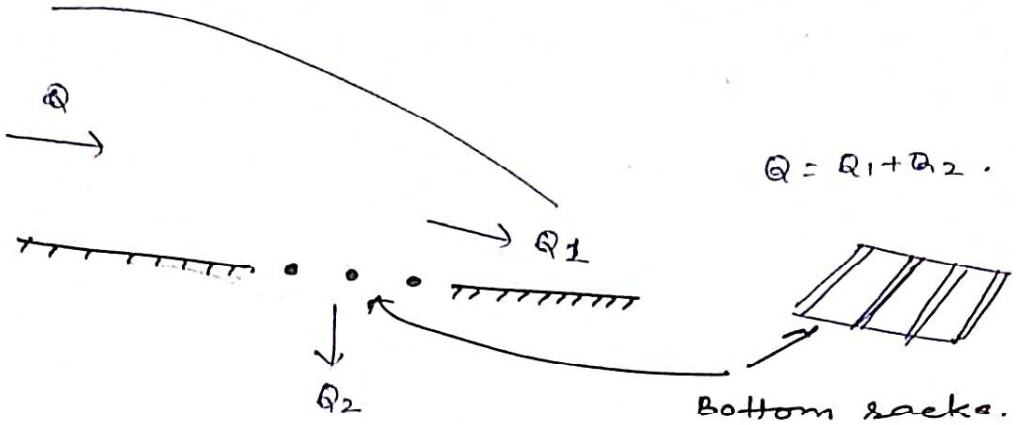
→ Flow is called gradually varied if the depth changes gradually over a long distance of channel.

→ Curvature of streamline is gentle in this case.

→ If the depth of flow changes significantly over a short distance such that the curvature changes rapidly, the flow is called rapidly varied flow.
eg: Hydraulic Jump.

NOTE: Friction plays an important role in GVF but not important case of RVF.

If some flow is added or extracted from the system, the flow is called spatially varied flow.
eg: flow over bottom rack.

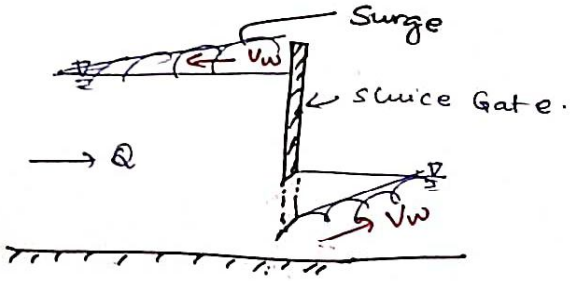


Unsteady flow:

a. Gradually varied Unsteady flow:
   eg: Passage of flood wave in rivers.

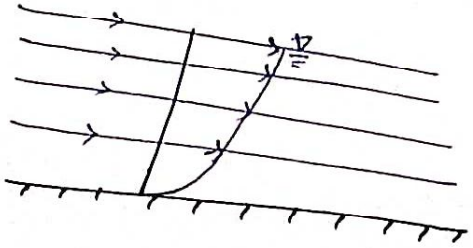
b. Rapidly varied unsteady flow:
   eg: surges, tidal bores, breaking of waves on shore.

c. Spatially varied Unsteady flow:
   eg: Surface runoff due to rain fall.



Laminar Flow and Turbulent flow:

→ When the flow occurs such that one layer of the liquid slides pas the other as if one lamina is sliding over the other, the flow is called Laminar flow, where there would be no momentum transfer between different layers.



→ However if water from one layer goes into the other and visa-versa, there could be momentum transfer between different layers such a flow is called turbulent flow.

$$Re = \frac{VR}{\nu}$$

Re = Reynold's number. (dimensionless)

V = Avg. velocity.

R = Hydraulic Radius.

$= \frac{A}{P}$ A = Area of x-section.

P = wetted perimeter.

ν = Kinematic viscosity. (m^2/s)

$\nu = \frac{\mu}{\rho}$ μ = Dynamic viscosity. (Pa-s)

if Re < 500 Laminar flow.

500 < Re < 2000 Transition flow.

Re > 2000 Turbulent flow.

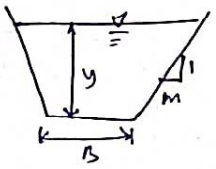
Critical / Subcritical / Super-critical flow:

$$Fr = \frac{V}{\sqrt{gA/T}}$$

Fr = Froude's no. (Dimensionless)

A = Area of x-section.

T = Top width.



$T = B + 2my$.

$A = By + my^2$

Critical	Subcritical	Super-critical
Fr = 1	Fr < 1	Fr > 1
$V = V_c$	$V < V_c$	$V > V_c$
$y = y_c$	$y > y_c$	$y < y_c$

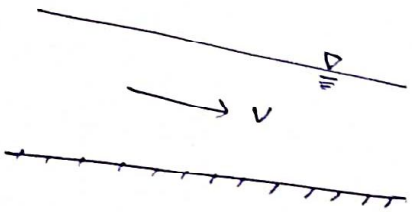
V_c = critical velocity = $\sqrt{gA/T}$ y_c = critical depth.

Celerity (C_0):

Denominator of Froude's no. represents a speed with which disturbance created to flow travels in still water, is called Celerity (C_0).

$$C_0 = \sqrt{gA/T} = \sqrt{g L_c}$$

L_c = characteristic Length.



$$\left(V_{(wave/ground)}\right)_{U/S} = \left(V_{(wave/water)}\right)_{U/S} + \left(V_{(water/ground)}\right)_{U/S}$$

$$\left(V_{wave/ground}\right)_{U/S} = C_0 - V$$

For subcritical flow.

~~For super-critical:~~

$Fr < 1$

$\frac{V}{C_0} < 1$

$C_0 - V > 0$

d/s control.

→ At low flow velocity ($Fr < 1$) a small disturbance to the flow will cause disturbance wave which travels U/s with the velocity $C_0 - V$ wrt a stationary observer.

→ Due to upstream movement of wave, upstream condn gets affected. Thus in case sub-critical flow condition upstream is affected by the condn at downstream. and down stream section is taken as control section.

For super-critical flow:

$Fr > 1$

$\frac{V}{C_o} > 1$

$C_o - V < 0$

U/s control.

At high flow velocity $Fr > 1$, the upstream flow velocity of wave $(C_o - V)$ will become negative ie the disturbance wave will not travel upstream, it will travel downstream with a velocity of $(V - C_o)$

Hence, flow condn downstream will be affected and <u>super critical flow has upstream control</u>.

NOTE: Sub-critical flow has downstream control while super-critical flow has upstream control.

When $Fr = 1$, flow is critical and the disturbance velocity $C_o - V = 0$ ie distrubance wave will not travel at all.

Q: A wide rect. channel is 1m deep and has a velocity of flow $V = 2.13$ m/s. If the disturbance is caused and elementary wave can travel upstream with a velocity of

a) 1 m/s

b) 3.13 m/s

c) 2.13 m/s

d) 5.26 m/s.

$C_o = \sqrt{g A/T} = \sqrt{g \times \frac{By}{B}}$

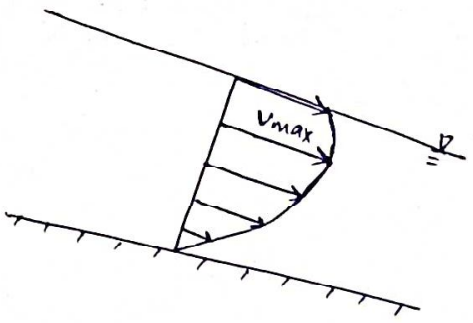
$= \sqrt{g \cdot y}$

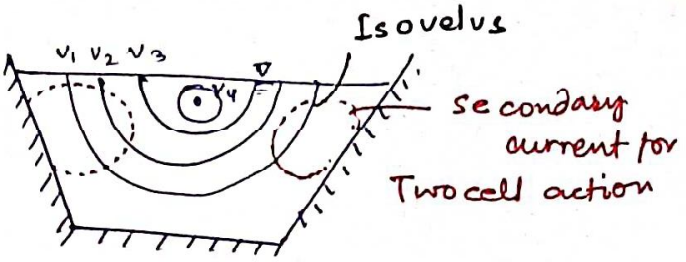
$C_o = \sqrt{9.81}$

3.13 m/s.

$(V_{wave/Ground}) = C_o - V = 3.13 - 2.13 = 1$ m/s

Velocity Distribution:





$V_4 > V_3 > V_2 > V_1$

Isovelves: contours of equal velocity

Aspect Ratio = $\frac{\text{Depth}}{\text{width}}$.

Reduction or dip in the velocity is because of secondary current which is a function of aspect ratio.

If aspect ratio is large, depth at which maxm velocity occurs is deeper.

10|04|21

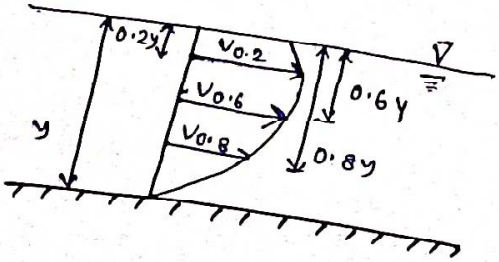
Average Velocity

1. $$V_{avg} = \frac{\int v \, dA}{A}$$

V = Average velocity.

v = Actual velocity.

2.



$$V_{avg} = \frac{V_{0.2} + V_{0.8}}{2}$$

or

$$V_{avg} = V_{0.6}$$ (less reliable)

Akanksha

Structural Analysis

Structural Dynamics by MARIOPAZ

#CONTENTS :

(1) Analysis of statically determinate trusses (Methods of joints and Method of sections).

(2) Deflection in statically determinate trusses (using strain energy method (or) unit load Method).

(3) Analysis of statically indeterminate trusses (using strain energy (or) unit load method).

(4) Influence line diagram for statically determinate trusses.

(5) Influence line diagram for Inderminate structures.

(6) Deflection in statically Determinate frames (using strain energy or unit load method)

(7) Analysis of inderminate Structure - Moment Distribution method.

(8) Slope deflection method

(9) Analysis of cables (only tension)

(10) Analysis of 3-hinged Arches.

(11) Analysis of 2-hinged Arches.

(12) Approximate methods in structural analysis (Portal and cantilever method)

(13) Static Indeterminancy, kinematic indeterminancy, stability of structures.

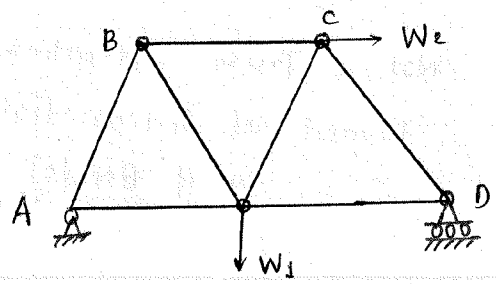
(14) Stiffness Matrix Method (15) Flexibility Matrix Method

(16) Structural Dynamics

Ch : 01 Analysis of Statically Determinate Trusses

 # Truss - It is a structure in which all members are subjected to axial forces only. (Tension and compression).

Bending Moment is zero everywhere in this structure.

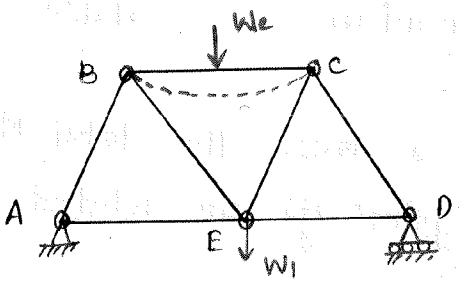


: Truss (In a truss, all members are called links).

NOTE - (i) **Link** :- If any structural member connected by pins at the ends and Not loaded at intermediate location, is called a link.

(ii) **Frame** :- It is a structure in which members are subjected to bending moment also. (In addition to tension and compression.)

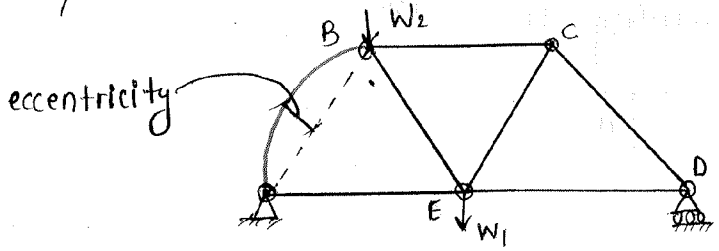
(To called a truss members must behave like a link)

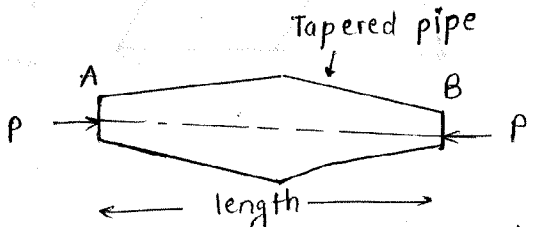


: Frame (as member BC Bends).

(3) Assumptions in the Analysis of Trusses.

(a) All members must be straight and connected by smooth pins at the ends (otherwise, if the members are curved, then they will bend and the structure cannot be called as a Truss.)



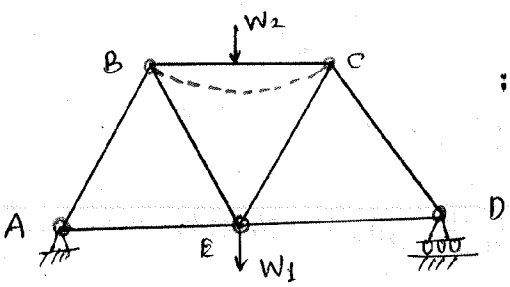


used as a compression member.

2M Members must be straight but need NOT to be Prismatic.

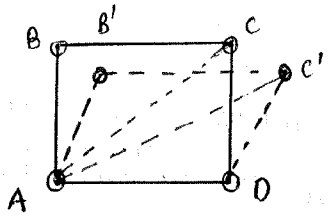
Prismatic – Having same c/s throughout its length.

(b) Loads must be applied only at the joints (otherwise, if the loads are applied at intermediate locations of the members, then they will bend and the structure cannot be called as a Truss.

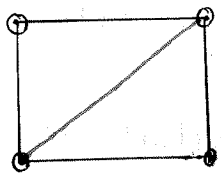


: Not a Truss (Member BC is loaded at intermediate location, so it Bends).

(4) Mechanism – unstable structure. (without increasing stress strain coming).



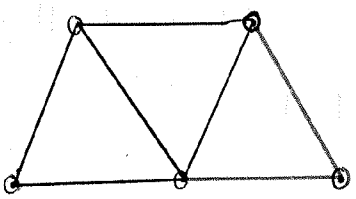
4 link Mechanism



stable structure

Conclusion :- In a truss, the total No. of members (m) and total no. of joints (j) are related by :

$$\boxed{(m) = (2j - 3)}$$ **



For the first 3 joints, 3 members are required. For each additional joint, 2 members are required.

combining these two statements,

$$\boxed{m = 2J - 3}$$

NOTE :- If the above condition is satisfied, then we get a stable, triangulated and determinate truss.

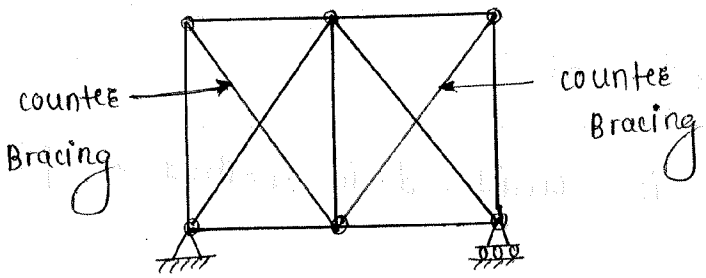
2M

(5) (a) If $m = (2J-3)$ - perfect, stable Truss

(b) If $m < (2J-3)$ - Deficient or unstable Truss

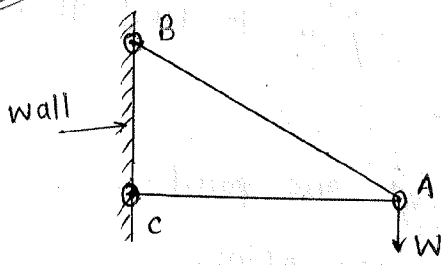
(c) If $m > (2J-3)$ - Redundant Truss [We provide more members than $(2J-3)$ to make the structure more stable.]

This additional members are called counter Bracing.



Que: (1) For the structure shown in fig., Bending moment exists in the member. (a) AC (b) AB (c) Both AB, AC (d) No Member

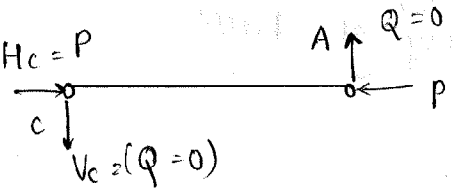
2M



Note: 1) since all members are straight connected by pins and loaded at intermediate locations, they behave like links So No member Bends.

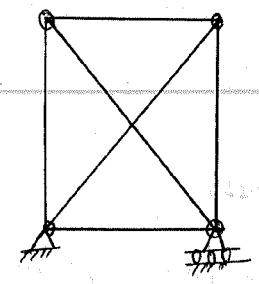
Note:

(a)



Link { If $Q \neq 0$, anticlockwise couple cannot be Balanced and it will not be in equilibrium }.

Que: (2) The truss shown in Fig. (a) Perfect (b) Deficient (c) Redundant (d) None



$m = 6$
$J = 4$

$m \quad (2J-3)$
$6 \quad (2\times4-3)$
$6 > 5$

conclusion : Redundant Truss (1 countee Bracing member).

Analysis of Trusses
- (a) Method of joints (particular case of method of section only.)
- (b) Method of sections

(a) Method of Joints :~

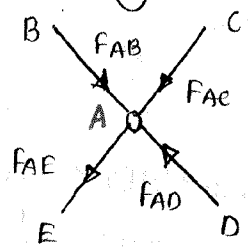
(1) Equillibrium of a joint is considered in method of joints.

(2) Procedure :~

(I-step) - Find the support reactions by considering equillibrium of entire truss.

step-II] - consider equillibrium of a joint where only 2 unknown forces are available and use $\Sigma X = 0$ $\Sigma Y = 0$ to find them.

similarly, proceed to the othee joint.



: Coplanar, concurrent force system.

concurrent - Meeting at one point.

coplanar - Lying in one plane.

system - Group of Forces.

$\boxed{\Sigma X = 0}$

$\boxed{\Sigma Y = 0}$

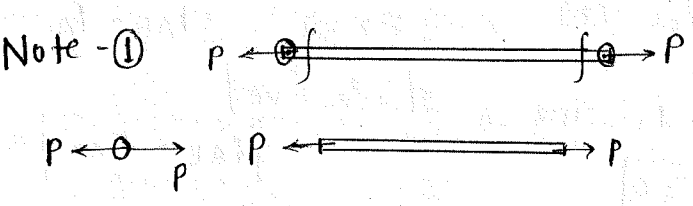
$\boxed{\Sigma M_A = 0 \quad \Rightarrow 0 = 0}$

conclusion - In a coplanar, concurrent force system the No. of equations of equilibrium available are only two. ($\Sigma x = 0$ $\Sigma y = 0$).

2M

With two eqn's. we can only find two unknown forces. so, we must select a joint where only two unknown forces are available.

Note - (1)



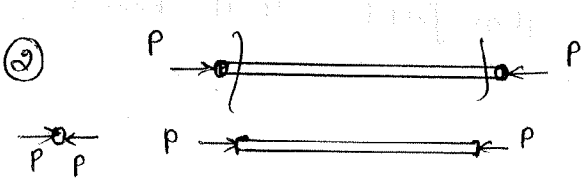
FBD of Bolt

FBD of a Member

FBD of Bolt or pin.

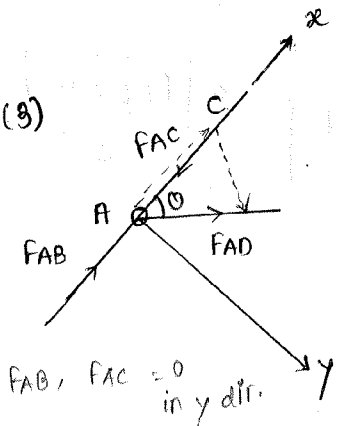
conclusion :- If arrow mark is away from joint or bolt it means that Force in the member is Tensile.

(2)



conclusion :- If the arrow mark is towards the pin or bolt then it means that the force in the member is compressive.

(3)



tail to head ⋯→

collinear - same line of action.

$\Sigma y = 0$

$+F_{AD} \cdot \sin\theta = 0$ (only).

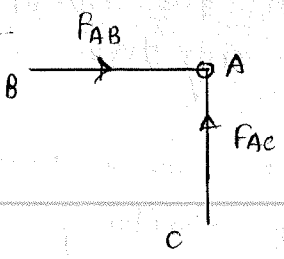
$\sin\theta \neq 0$

[↑ +ve ↓ -ve]

$\boxed{F_{AD} = 0}$

conclusion - At a joint, if three members or 3 forces are meeting, 2 members are collinear, then force in the third member is Always zero.

(4)



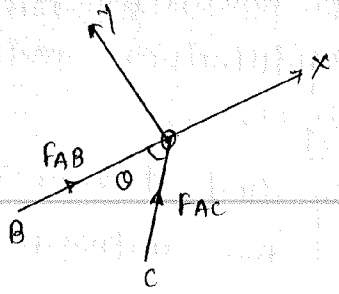
Two Non-collinear Forces (at $\theta = 90°$)

$\Sigma X = 0 \Rightarrow \boxed{F_{AB} = 0}$

$\rightarrow$ +ve $\leftarrow$ -ve

$\Sigma Y = 0$

$[\uparrow$ +ve $\downarrow$ -ve$]$ $\Rightarrow \boxed{+F_{AC} = 0}$

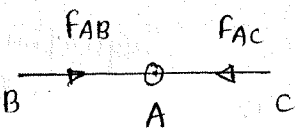


Two Non-collinear Forces (θ)

$\Sigma Y = 0 \Rightarrow F_{AC} \cdot \sin\theta = 0$

$\boxed{F_{AC} = 0}$

$\Sigma X = 0 \Rightarrow \boxed{+F_{AB} = 0}$



Two collinear forces

$\Sigma X = 0 \quad +F_{AB} - F_{AC} = 0$

$[\rightarrow$ +ve $\leftarrow$ -ve$]$

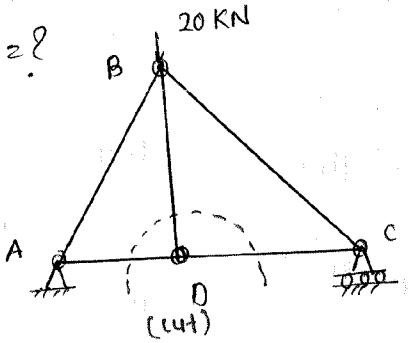
$\boxed{F_{AB} = F_{AC}}$ *

$F_{AB} \neq 0$

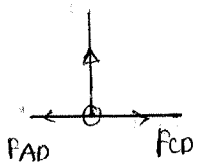
$F_{AC} \neq 0$

conclusion- At a joint, if two Non-collinear members are meeting with No external load at that joint then Forces in Both members will be zero.

Que: (3) $F_{BD} = ?$



two collinear At third $F_{BD} = 0$ (Ans)



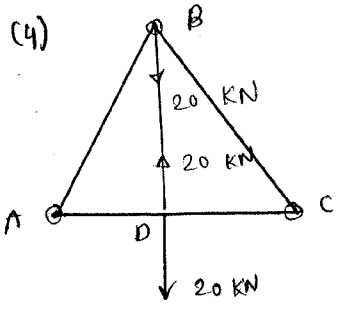
F.B.D. of Bolt at D

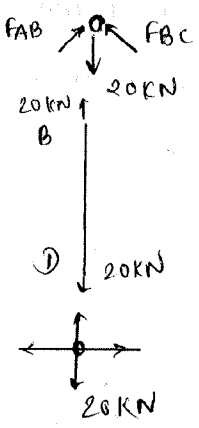
$\Sigma Y = 0$

$[\uparrow$ +ve $\downarrow$ -ve$]$

$\therefore \boxed{F_{BD} = 0}$: Ans

Que: (4)





FBD of Bolt at B

FBD of member BD

FBD of Bolt at D.

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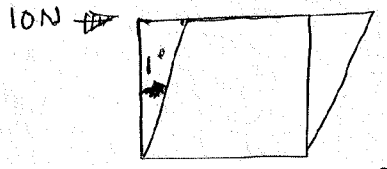
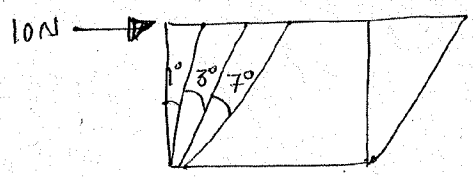
1-a

Engg. Science

- Solid Mechanics
- Fluid Mechanics
- Properties of Material



t = 2 Sec → 1°
t = 5 Sec → 1°
t = 10 Sec → 1°



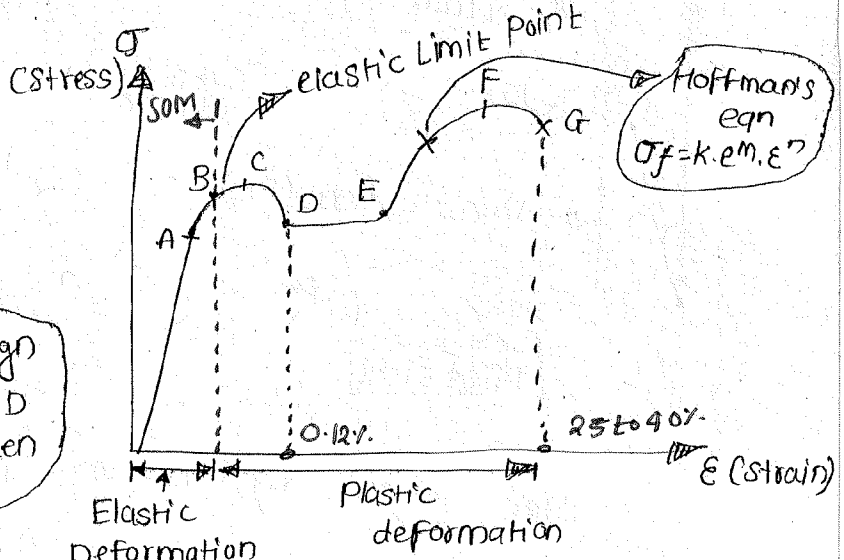
t = 2 sec = 1°
t = 5 sec = 8°
10 sec = 7°

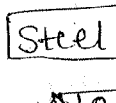
- Engg. Mechanics
- SOM / MOS / MOHDB — Mechanics of Highly Deformed Body.

Deformation
- Elastic
- Plastic

upto A, $\sigma \propto \varepsilon$

For design A, B, C, D is taken same





δ, θ very small

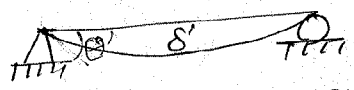
$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}} \Rightarrow \frac{1}{R} = \frac{d^2y}{dx^2} \Rightarrow \frac{M}{EI} = \frac{d^2y}{dx^2}$$

($\frac{dy}{dx} \to 0$)

$$M = EI.\frac{d^2y}{dx^2}$$

Hard Rubber



$\delta' \neq \frac{PL^3}{48EI}$.

$\frac{1}{R} \neq \frac{d^2y}{dx^2}$.

δ', θ' is Large

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

$\neq 0$

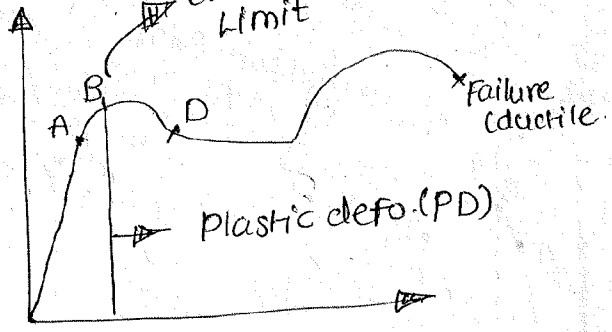
Plastic Deformation is greater than Elastic Deformation

1-(b)

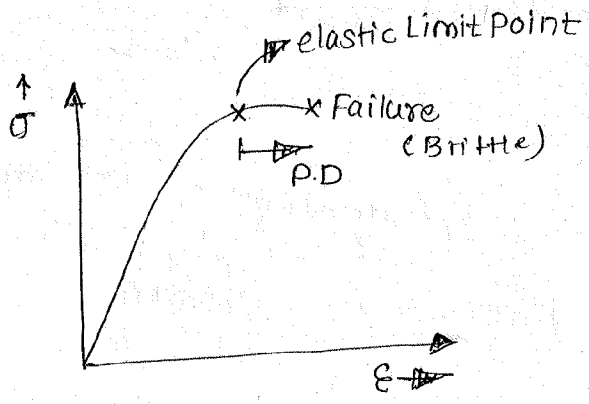
Failure of Material:-

- Plastic Deformation (Ductile)
- Fracture (Brittle)

$\sigma_B \approx \sigma_D \approx 250 MPa$



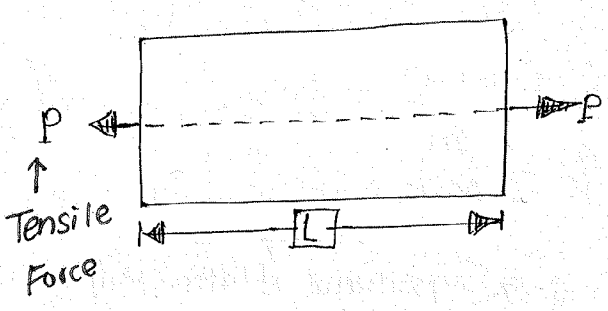
Mild steel

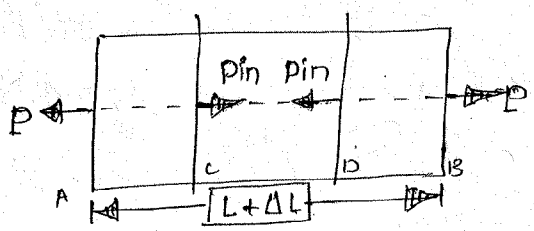


Cast Iron

More Plastic deformation More ductility

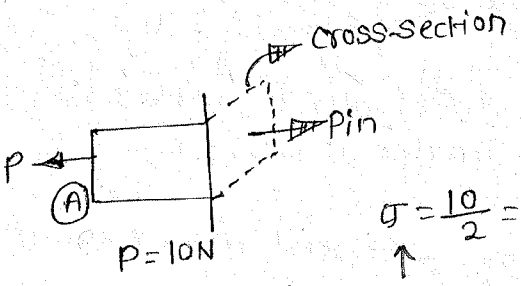
*. Difference B/w **Strength** and **Stress** :





$\varepsilon = \frac{\Delta L}{L}$

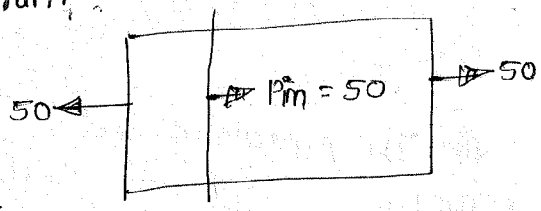
Tensile strain



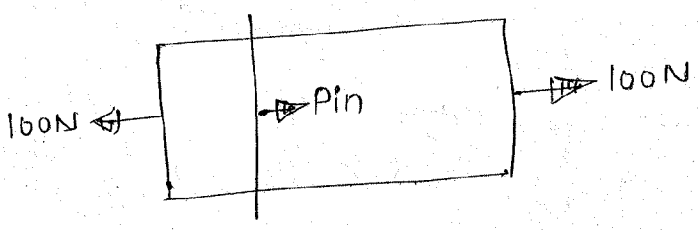
$A_C = 2\,mm^2$

$\sigma = \frac{10}{2} = 5\,N/mm^2$

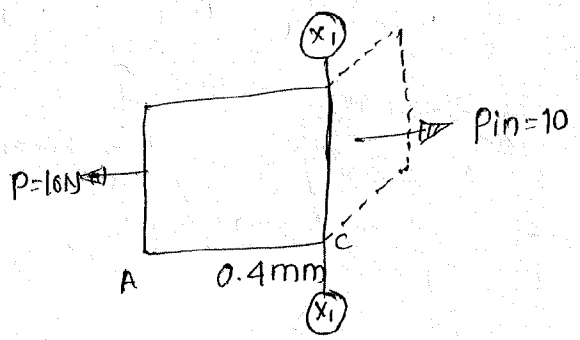
Tensile Stress

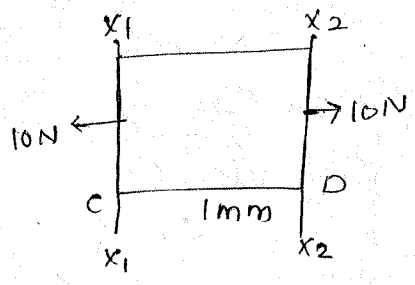


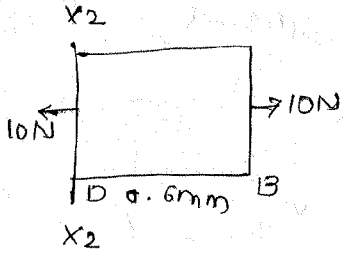
$\sigma = \frac{50}{2} = 25\,MPa$



$\sigma = \frac{100}{2} = 50\,MPa \Rightarrow$ Strength







* Strain is a cause of Stress.

Stress is a internal resisting force offered by material against deformation.

* Hook's Law: (Axial Deformation)

$$\varepsilon = \frac{\Delta L}{L}$$

$$\sigma = \frac{P_{in}}{A_c} = \frac{P}{A}$$

Hook's Law

$$\sigma \propto \varepsilon$$

$$\sigma = E\varepsilon$$

$$\varepsilon = \frac{\sigma}{E} = \frac{P/A}{\Delta L/L}$$

$$\boxed{\Delta L = \frac{PL}{AE}} \Rightarrow \text{Constitutive relationship.}$$

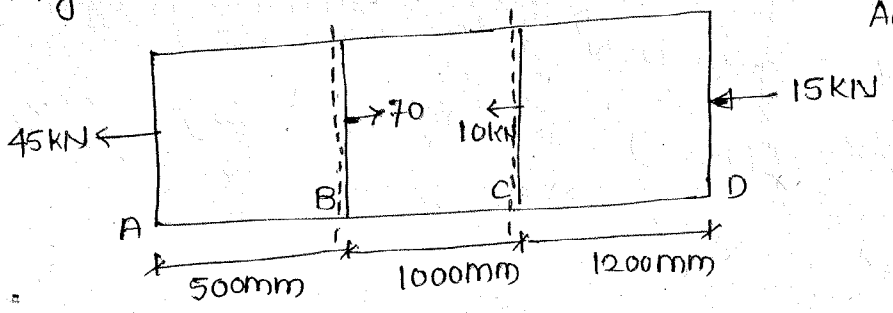
☞ The equation relating stress and strain is called Constitutive Equation because, it depend on material behaviour.

statically determinate problem.

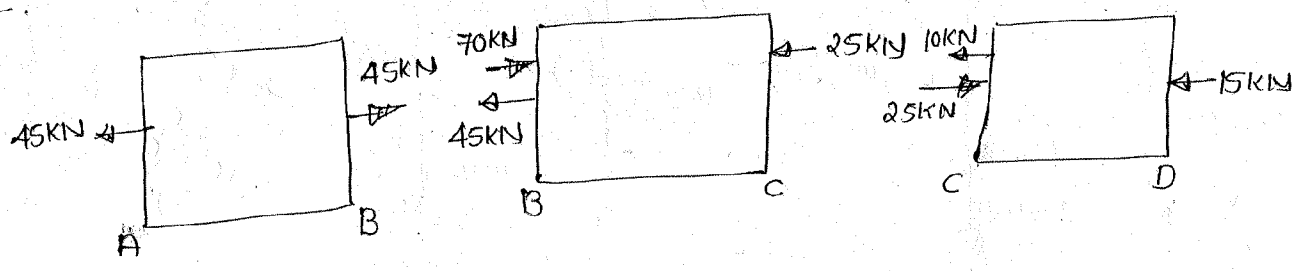
Que: A rectangular c/s Bar having cross-sectional area 800mm² is subjected to axial Loading as shown. Determine the total change in Length of Bar.

E = 100GPa

A_c = 800mm²



Soln:-



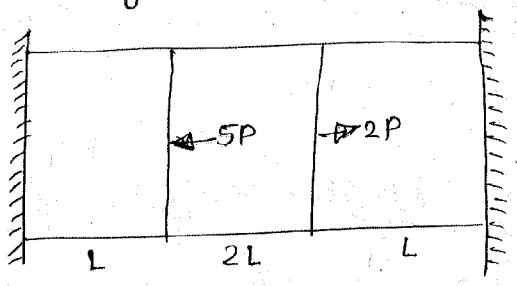
$$\Delta_{Total} = \Delta_1 + \Delta_2 + \Delta_3$$

$$= \frac{1}{(800\,mm^2)(100\times10^3)\frac{N}{mm^2}} \left[\{(45\times10^3)(500)\} + ((-25\times10^3)(1000) + ((-15\times10^3)\times1200) \right]$$

$$= -0.25625\,mm$$

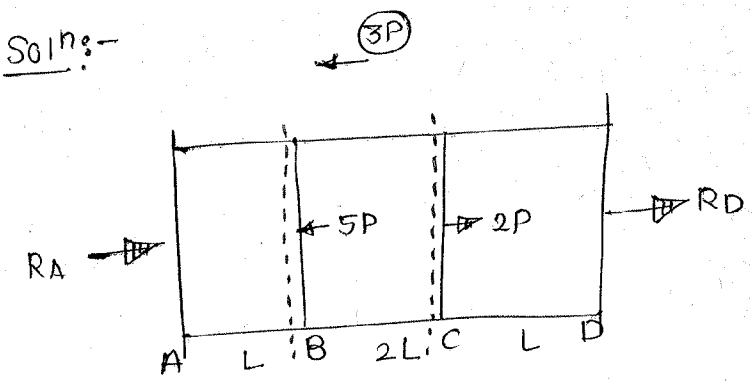
Que: $E = 100\ GPa$ Statically Indeterminate Problem

$A_c = 800\ mm^2$

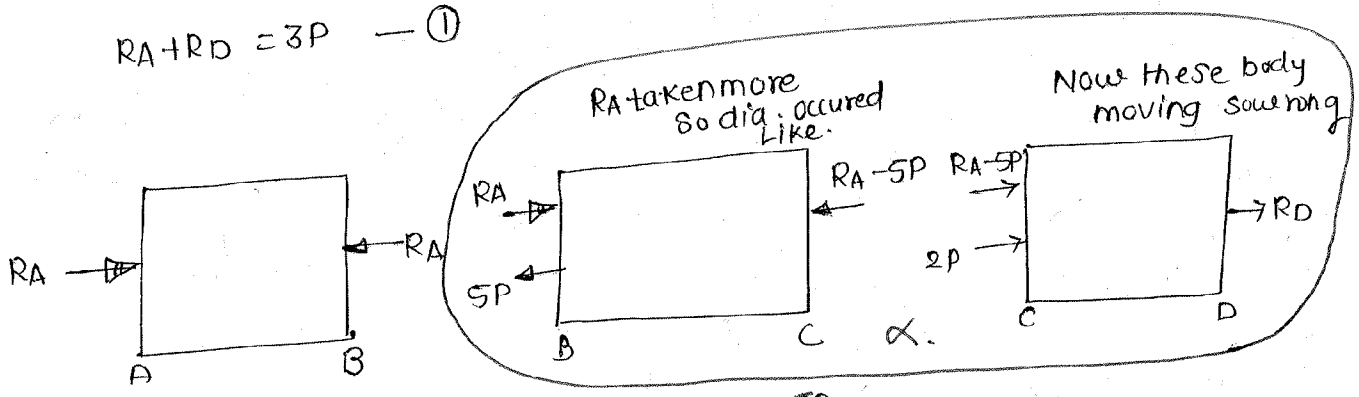


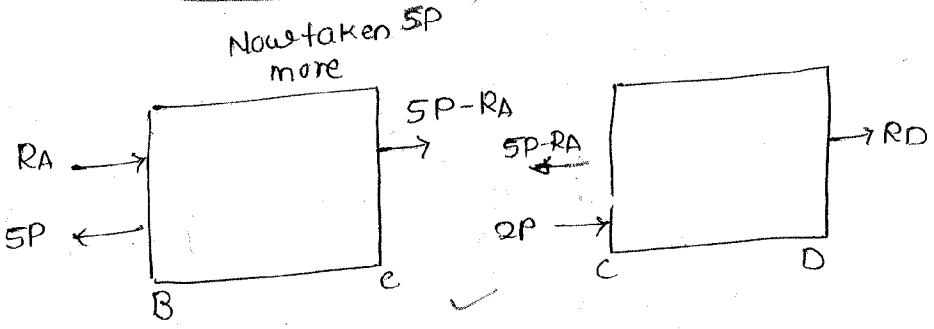
A bar arrangement as shown. Determine Support Reaction and draw axial Force diagram

Soln:-



$R_A + R_D = 3P$ — ①





$5P - R_A - R_D - 2P = 0$

Δ Total = 0 (bcz both ends are fixed)

$R_A + R_D = 3P$ checked.

$\Delta_1 + \Delta_2 + \Delta_3 = 0$ (compatibility eqn)

$$\frac{1}{AE}\left[\{(-R_A \cdot L)\} + \{(5P - R_A)2L\} + \{(+R_D \cdot L)\}\right] = 0 \quad \text{— ②}$$

$$-R_A \cdot L + 10PL - 2R_A L + R_D \cdot L = 0$$

$$-R_A + 10P - 2R_A + R_D = 0$$

$$-3R_A + 10P + R_D = 0$$

$$3R_A - R_D = 10P \quad -(2)$$

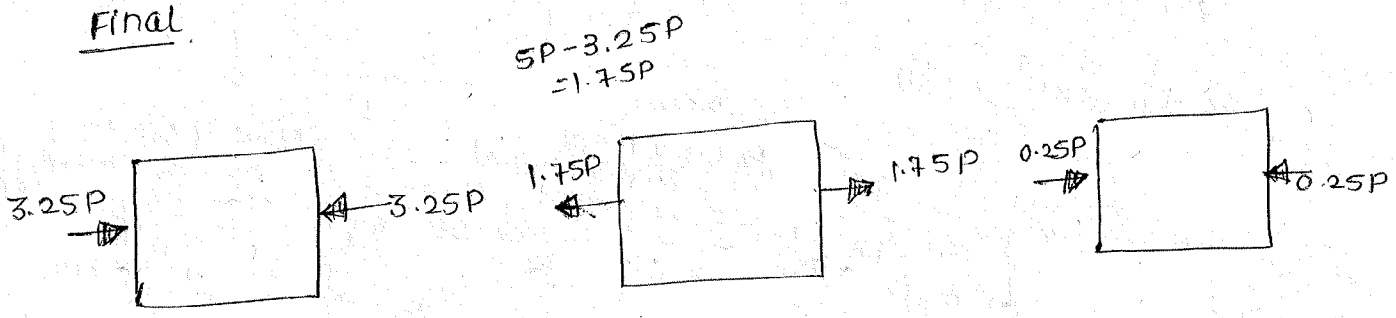
$$R_A + R_D = 3P \quad -(1)$$

$$4R_A = 13P$$

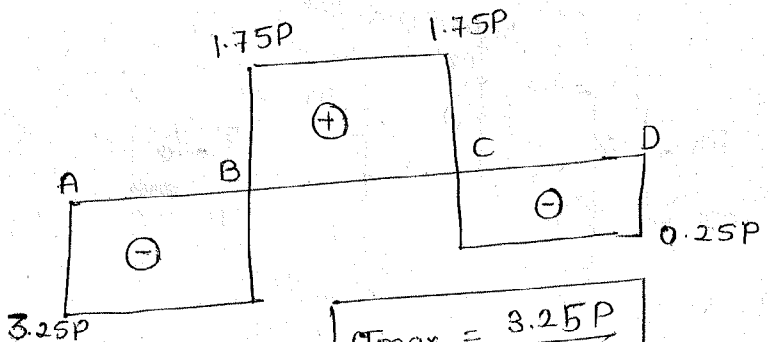
$$R_A = \frac{13P}{4} = 3.25P$$

$$\therefore R_D = -0.25P$$

Final



Axial Force Diagram ⇒ (equillibrium Diagram)



$$\sigma_{max} = \frac{3.25P}{A_c}$$

⇒ Compatibility Equation is the relationship b/w unknown forces and known Deformation.

* Stress Tensor:

Scalar → Magnitude → Zero order Tensor

Vector → Mag + Direⁿ → 1st order Tensor Fx, Fy

Tensor → (Direction + plane) → 2nd order Tensor

↓

Stress, strain, M.I, P.M.O.I. (polar M.I.)

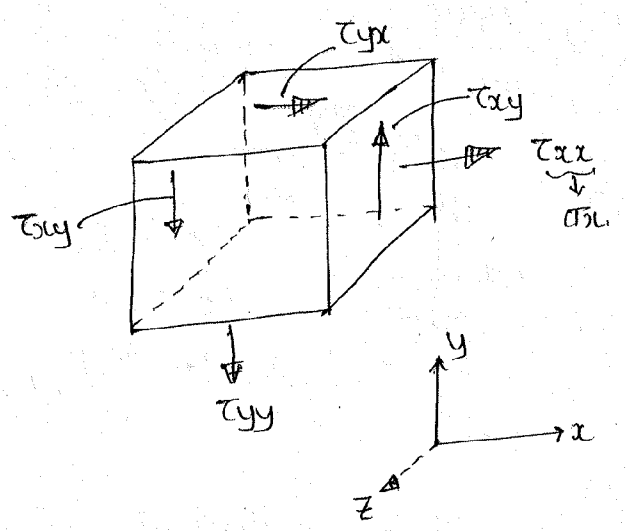
τ_{xy}, τ_{xz}, σ_x → τ_{xx}.

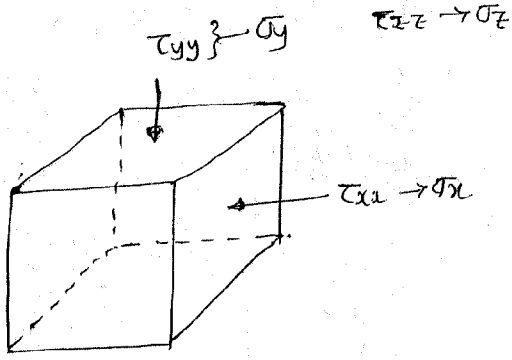
Stress Representation :

τ_{ij} → represent the stress direction

↓

represent the plane (outward Normal) at which stress acting.



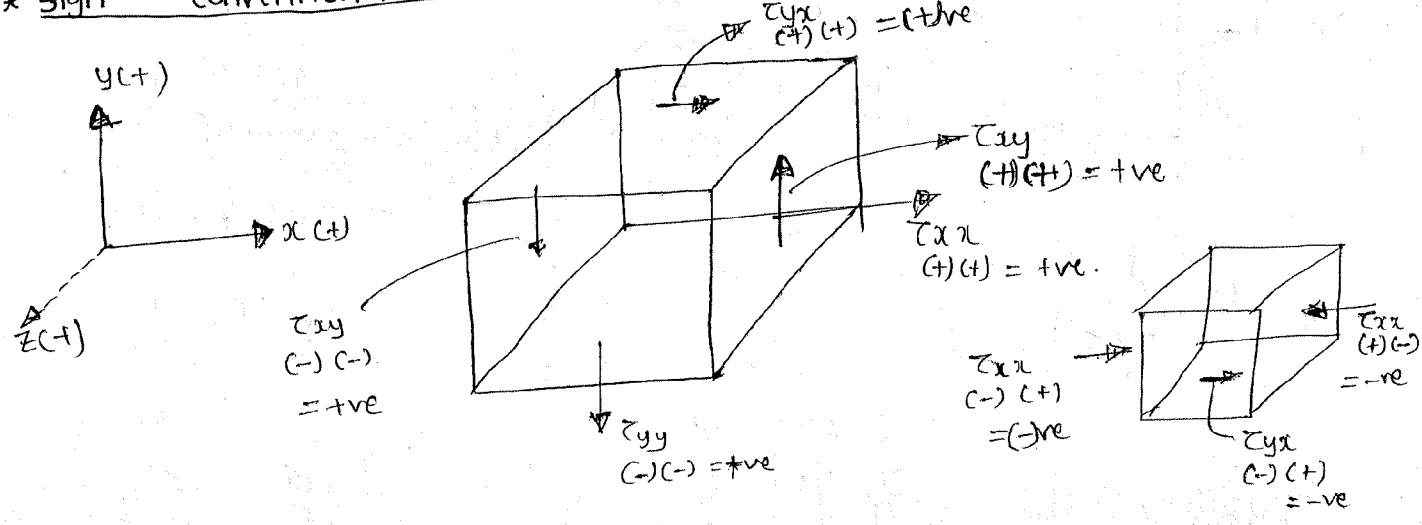


τ_{xx}, τ_{yy} → Normal Stress

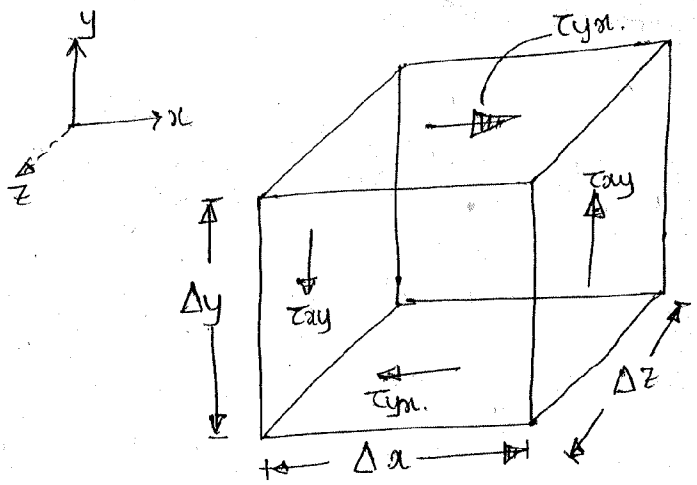
$\tau_{xy}, \tau_{yz}, \tau_{zy}$ → shear stress.

* Sign Convention for stress:

पहले subscript में plane को देखना then arrow को देखना

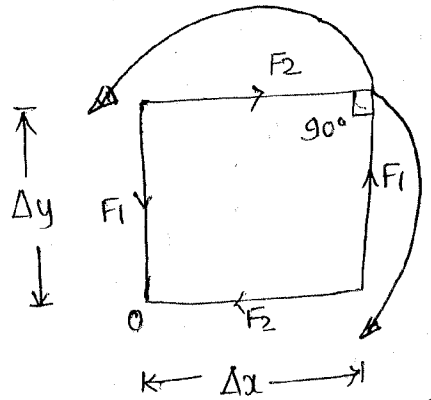


Equality Of Shear Stress: (2.10)



$F_1 = \tau_{xy} (\Delta z \cdot \Delta y)$

$F_2 = \tau_{yx} \cdot (\Delta x \cdot \Delta z)$



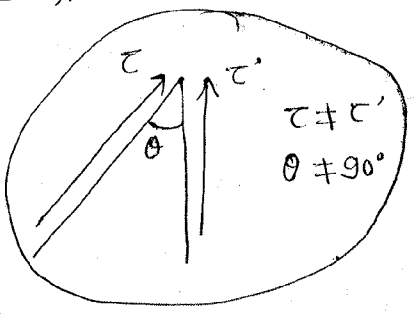
By moment Equillibrium condition

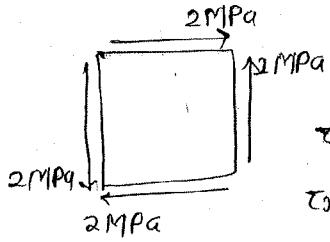
$\Sigma M_O = 0$

$F_1 \cdot \Delta x = F_2 \cdot \Delta y$

$\tau_{xy} \cdot (\Delta z \cdot \Delta y) \Delta x = \tau_{yx} \cdot (\Delta x \cdot \Delta z) \cdot \Delta y$

$$\boxed{\tau_{xy} = \tau_{yx}}$$



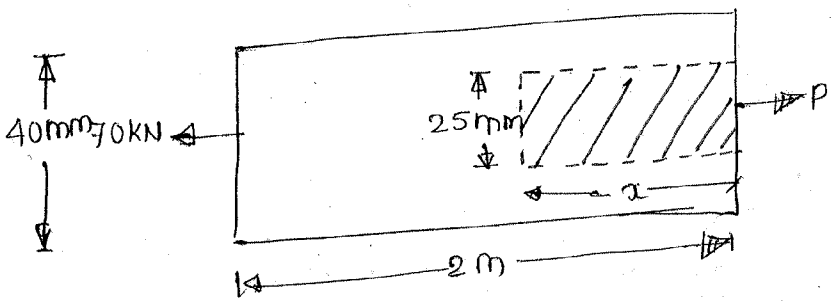


$\tau_{xy} = \tau_{yx}$

$\tau_{xz} = \tau_{zx}$

$\tau_{yz} = \tau_{zy}$

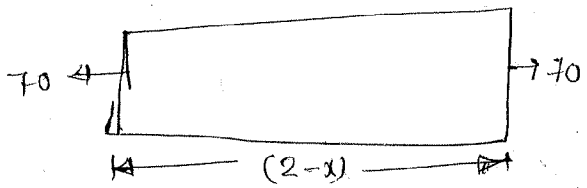
Que:6: WB:CH-02



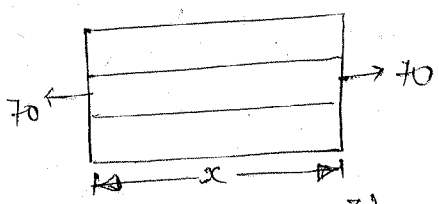
When No Boring

$$\delta = \frac{(70\times10^3)(2\times10^3)}{\frac{\pi}{4}(40)^2 E}$$

When Boring Complete



$$\delta_1 = \frac{(70\times10^3)(2-x)\times10^3}{\frac{\pi}{4}(40)^2 \times E}$$



$$\delta_2 = \frac{(70\times10^3)(x\times10^3)}{\frac{\pi}{4}(40^2-25^2)E}$$

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Design of Steel Structure

GATE :- 2M — 1Q = 2M
2Q - 1M = 2M
→ 4M

ESE: (Prel) :- 10 - 15Q (20-30M)

(Mains) :- 60M

BARC
ISRO
DRDO
} 10% Q Steel

[S.K Duggal]

IS 800:2007 [L.S.M]
800:1984 (WSM)
Steel Table

Syllabus

2] Design Philosphy (ESE)
→ WSM
→ Plastic Method of design
→ Limit State method of Design

3] Connection Design

- Simple Connection
  - Rivets
  - Bolts
  - Welding
  (GATE/ESE)
- (GATE) Eccentric
  - Type I
  - Type II

4] Member Design (ESE)

- Tension Member
- GATE Compression Member
- GATE Flexural Member
  - → Beam → Base Plate
  - → Built up Beam → Splices
  - only ESE → Gantry Girder
  - only ESE → Plate Girder

6] Industrial Roof (ESE)

→ Roof truss

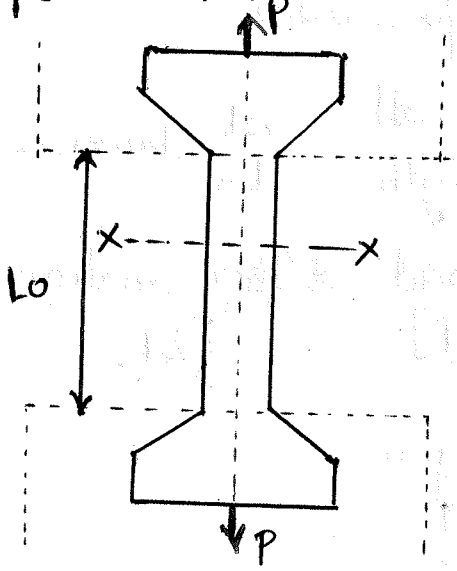
→ Purlin

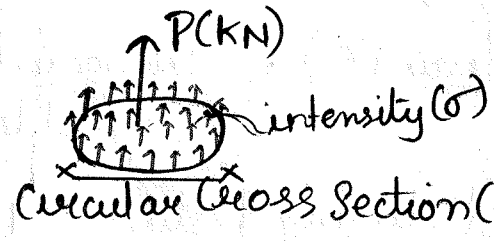
Chapter 1 : Plastic Analysis of Beams & Frame

Stress Strain Curve for Mild steel

→ A tensile test is conducted on a Mild steel specimen (ie Coupon)

→ Specimen is tested in universal testing machine (U.T.M)



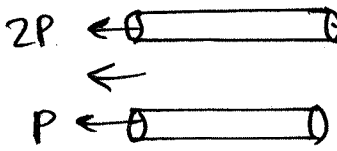


Ao → Original Cross sectional area (mm^2)

P → Applied load (KN)

σ → Nominal Tensile stress

$$\sigma = P/A_o$$



$\Sigma F = 0$ {Rigid body Translation}

→ As material is assumed to be homogenous & Isotropic, the ~~intensity~~ distribution of load on the cross section can be assumed to be equal

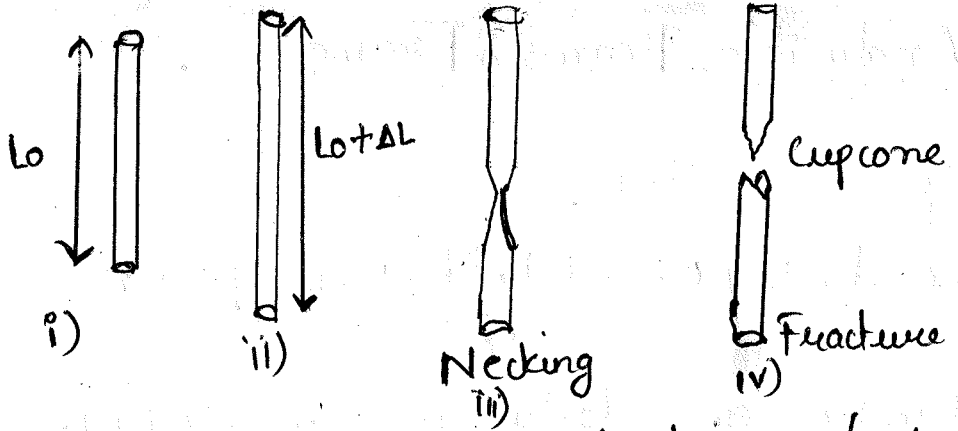
→ The intensity of load over cross-sectional is termed as Stress

$$\left[\sigma = \frac{P}{A_o} \quad \frac{(N)}{(mm^2)} \rightarrow \text{Unit } N/mm^2 \text{ or } MPa\right]$$

→ The length over which specimen is tested is called as gauge length & it is given by

$$\boxed{L_o = 5.65\sqrt{A_o}}$$

→ Specimen is subjected to gradually increasing tensile loading

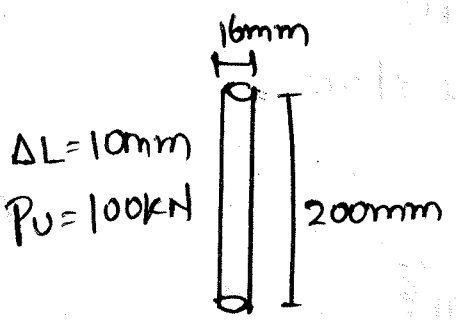


ΔL = Change in length (mm) / Extension / Deformation

→ Normal tensile strain (ϵ) ⇒ $\frac{\text{Change in length}}{\text{Original length}} = \frac{\Delta L}{L_o}$ (Dimensionless)

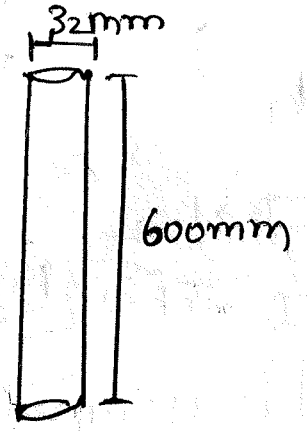
→ Reading observed during testing → Load [P] & Deformation [ΔL]

Always (same) Stress Strain



$\sigma_u = \frac{P_u}{A_o} = \frac{100 \times 10^3}{\frac{\pi}{4} \times 16^2} = 497.36$ N/m²

$\epsilon = \frac{\Delta L}{L} = \frac{10}{200} = 5 \times 10^{-2}$



$\sigma_u = \frac{P_u}{A_o}$ ∴ $497.36 = \frac{P_u}{\frac{\pi}{4} \times 32^2}$

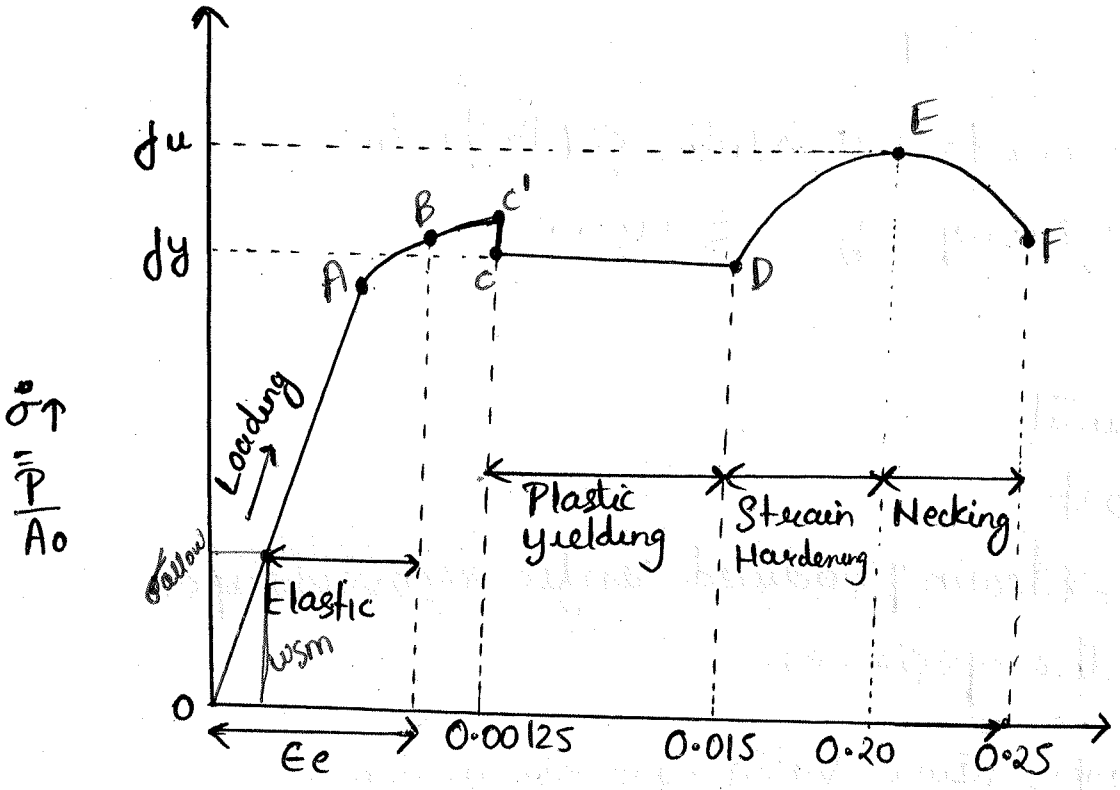
$P_u = \underline{400kN}$

$\epsilon = 5 \times 10^{-2} = \frac{\Delta L}{600}$

$\Delta L = 30mm$

→ P-Δ graph will be different for different size of specimen

→ Hence σ-ε curve is plotted for specimen {It will be same for a given material}



$$\frac{\Delta L}{L_0} = \varepsilon \rightarrow$$

σ_y = yield strength (N/mm²)

σ_u = Ultimate tensile strength (N/mm²

	(y) P	(x) ΔL	Slope = $\frac{dy}{dx} = \frac{y_2 - y_1}{x_2 - x_1}$
	0	0	
i)	10KN	1mm	$\frac{20-10}{2-1} = 10$KN/mm
ii)	20KN	2mm	
iii)	30KN	3mm	$\frac{30-20}{3-2} = 10$KN/mm
iv)	38KN	4mm	$\frac{38-30}{4-3} = 8$KN/m

ex. law graph

$y = m \cdot x$

$\boxed{y \propto x}$

⇒ Imp Points :-

1] Region OA

→ A is a proportional limit

→ Graph is linear (ie slope is constant)

→ $\sigma \propto E$ (Hook's law)

→ $\sigma = E \cdot \epsilon$, $\frac{\sigma}{\epsilon} = E$

→ E = Elastic constant / Modulus of Elasticity

E = tanθ → Slope of σ, ε curve

2] Region AB

→ B → Elastic limit

→ Linearity is lost

→ upto point B, strain produced can be recovered upon unloading of the specimen

→ Assume: Hook's law is Valid upto elastic limit

3] Region B - C' - C

→ C' = upper yield point {transient → short interval}

→ C = Lower yield point {stable, designates yield strength of material}

→ It is a point below which material behaves elastically

(Or)

Above which material behave plastically

4] C - D Region

→ Plastic yielding or yield Plateau

→ Material/specimen deforms to very large extent without resisting any stress

→ It is a limiting slope

→ Fielding Failure

5] Region D-E

→ Strain Hardening

→ Specimen re-crystallizes due to which it resist stresses along with its further extension

→ It occurs upto point E

→ E ⇒ Point of Ultimate strength

→ Till Date this part is not used in design

6] E-F Region

→ ~~Neglecting~~ ⇒

→ Necking : Reduction in cross sectional area

→ F ⇒ Breaking point / Fracture point

→ Fracture is also termed as Rupture

→ Shape : Cup & Cone failure

⇒ Mechanical property from σ & ε Curve

1) f_y 3) E

2) f_u 4) Ductility

⇒ Ductility : Ability of material to undergo large deformation without breaking. It is measured in terms of % Elongation

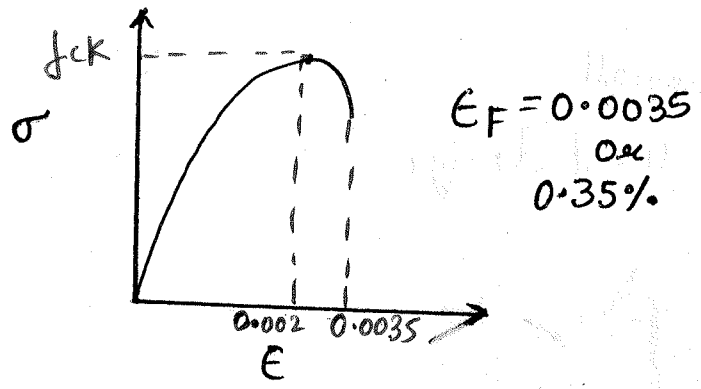
$$\% \text{ elongation} = \frac{\text{Final length} - \text{Gauge length}}{\text{gauge length}} \times 100$$

% Elongation	Material
> 15 %	Ductile (steel, Al)
15 – 5 %	Interm. Ductile (Mn)
< 5 %	Brittle (concrete, cast iron)

→ Hardness :- Resistance to Wear & Tear (ie Abrasion)

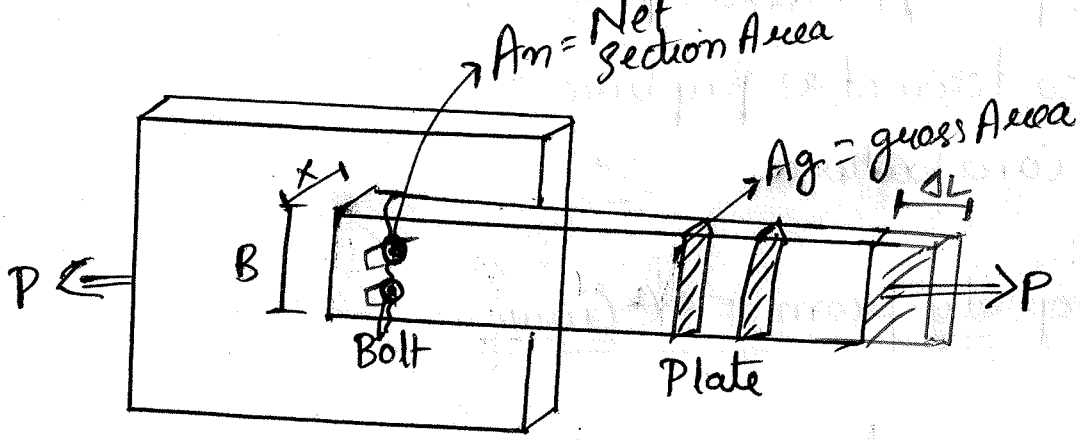
→ Toughness :- Resistance to impact loading

Concrete Compression test



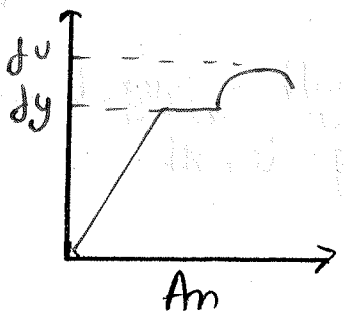
$\epsilon_F = 0.0035$ or 0.35%

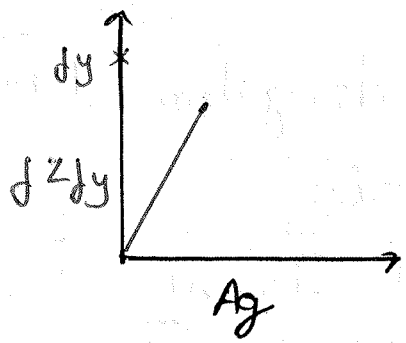
⇒ Practical Case of Tension member



There are two type of limiting stage

1) Gross Section yielding
2) Net-Section Rupture





Note:

→ For design of tension member connected with Rivet/Bolts there are two types of limit state

1) Gross Section yielding 2) Net section Rupture

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INTRODUCTION

Surveying -

It is the art of determining relative positions of points through direct or indirect measurements of distance, dirn and elevation. It also includes establishment of points on ground which are predetermined ~~in nature~~ on paper.

Types of Surveying -

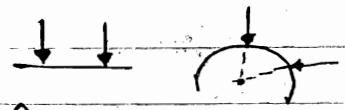
① Plane Survey.

Survey in which curvature of earth is not considered. Suitable for a small area.

② Geodatic Survey -

Survey in which curvature of earth is consider ed. Suitable for a large area.

Note ① - Two plumb lines at two different places will be parallel to each other in plane survey. However in geodatic survey they will intersect at centre of earth.



② - Generally geodatic survey considered for an area more than 250 km^2

③ Observations -

ⓐ - For a line of length 12 km in plane survey geodatic length will be only one centimeter extra

ⓑ For a triangle with area 195.5 km^2 sum of internal angle will be just one second extra in geodatic survey.

Classification of Survey-

(a) Land Survey - Survey on surface of earth

(I) Topographical Survey - To know about general topography of area.

(II) Cadastral Survey - To know about property lines

(III) City Survey - To provide different services in city eg. Road network, water supply & sewer pipelines etc.

(b) Hydrographic Survey - To know about underwater features

(c) Astronomical Survey - To know about positions of stars, planets moon, sun etc.

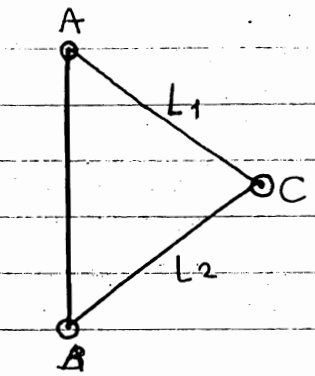
Principle of Survey

Principle (1) - To do work from whole to part (Refer to a common datum)

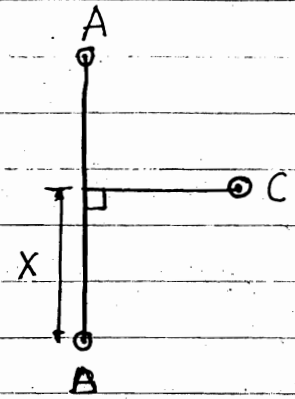
Larger measurments are taken by high degree of precision then smaller measurements are taken even with low degree precision. In this way errors of smaller measurement will not be reflected in larger measurements.

Principle (2) - Location of point w.r.t. two reference points

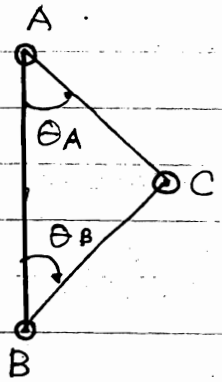
Any point can be established on the ground using two reference points.



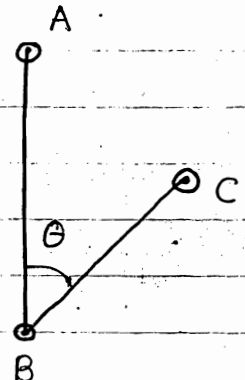
Chain Method



Offset Method



Compass method



Traversing Method

② Linear Measurement & Chain Surveying

Linear Measurement -

Linear measurement on horizontal plane is called distance & Linear measurement on vertical plane is called elevation.

Scale -

It is a technique to measure & represent ground distance on the sheet of paper.

$$\text{Scale} = \frac{\text{Map Distance}}{\text{Ground Distance}}$$

Representation of scale

① 1cm = 10m
② Scale = $(\frac{1cm}{10m})$
③ 1cm : 10m

Representative Factor (RF)

$$RF = \frac{1cm}{(10 \times 100)cm} = \frac{1}{1000}$$

scale = 1:1000

Area scale

$(1cm)^2 = (10m)^2$

$1cm^2 = 100m^2$

Vernier Scale -

It is secondary unit of main scale used for exact reading. Through vernier scale we can measure the distance/angle which is even lesser than least count of main scale.

Types of Vernier -

① Direct Vernier.

This vernier is callibrated in same dirⁿ of main scale. This vernier has devision slightly smaller than devision on main scale.

→ (n-1) devision of main scale are distributed into 'n' devision of vernier scale.

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Soil Mechanics and Foundation Engineering

Gate → 15-18 MARKS

ESE → Pre → 16-21Q
ESE → Main → 100-110M

Syllabus

***	1. Properties of Soil.	obj + conv + int
	2. Classification of Soil.	obj
**	3. Effective Stress.	obj + conv
***	4. Permeability & Seepage.	obj + conv + int
	5. Stress Distribution.	obj
	6. Compaction	obj
***	7. Consolidation.	obj + con + int
***	8. Shear Strength.	obj + conv + int
**	9. Earth Pressure.	obj + conv
	10. Stability of Slope.	obj

FOundation Engineering

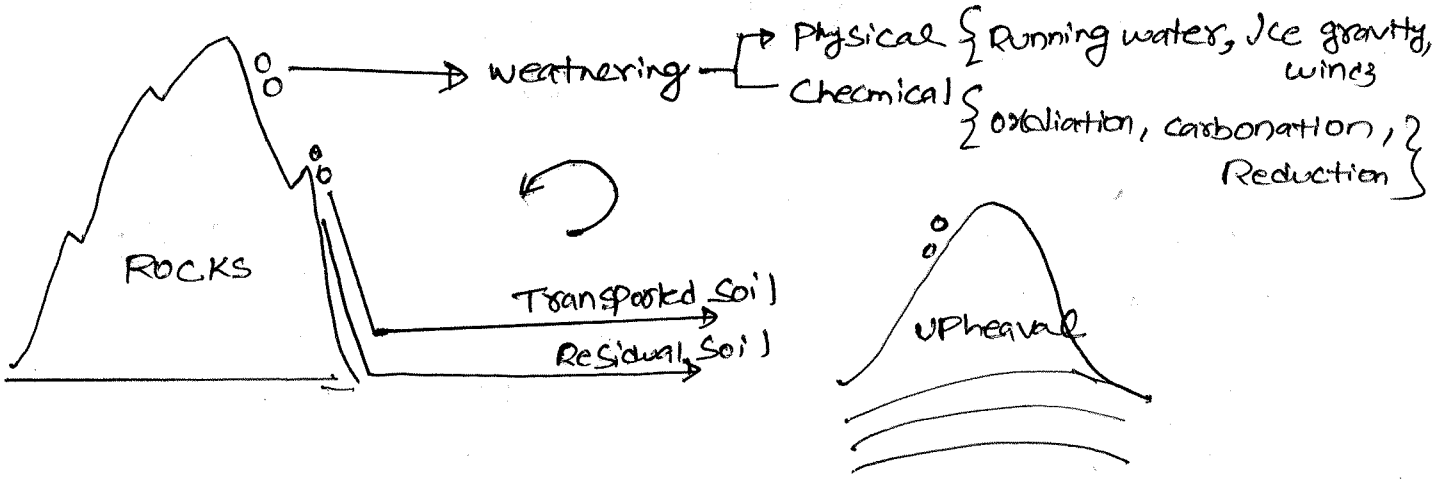
***	11. Shallow foundation.	obj + conv + int
**	12. Pile foundation.	obj + conv

Misllenous

13. Soil Exploration.

12/10/2021

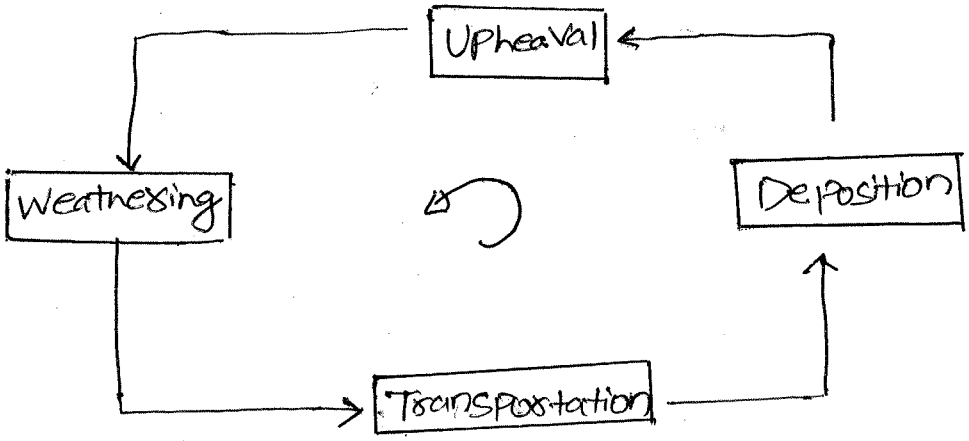
1. Properties of Soil



→ Soil is the disintegrated parts of rocks.

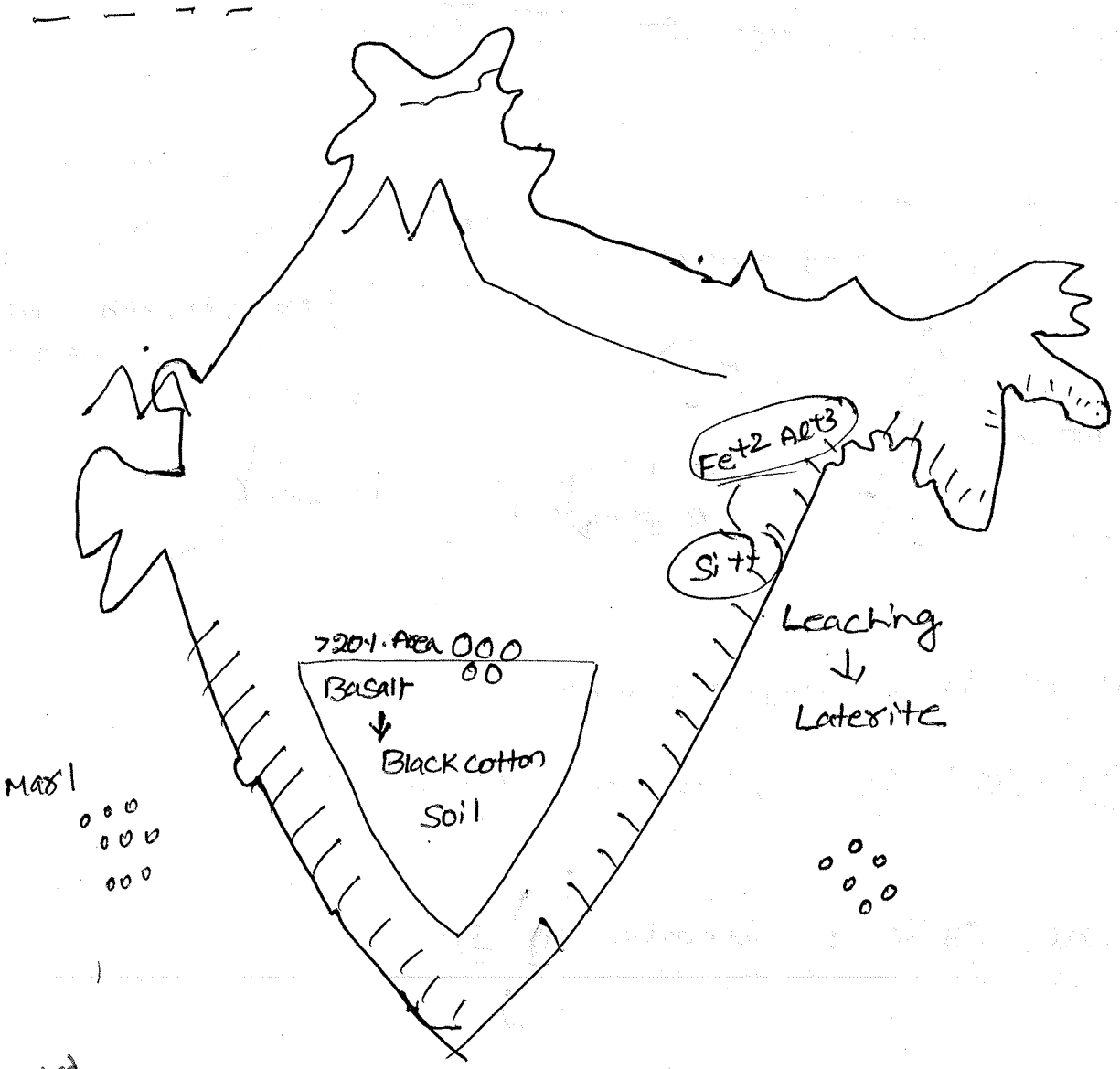
→ Pedogenesis :→ Process of formation of soil.

Geological cycle of formation of Soil



- Karl Terzaghi :→ father of Soil Mechanics.

Types of Soil



Transported

Type of Soil	Agents	Region
1. Alluvial Soil	Running water	Near River banks
2. Lacustrine	Fresh y Still water	Lacks y Ponds
3. Marine Soil	Sea water	Sea Shores
4. Glacial (Till)	Ice	Glaciers
5. colluvial (Talus)	Gravity	Mountain valleys
6. Aeolian (Sand dunes)	wind	Desert
7. Loess when it becames wihe wet His collapse.	wind blown Silt	Desert

Chemical weathered Soils

1. Marl Soil

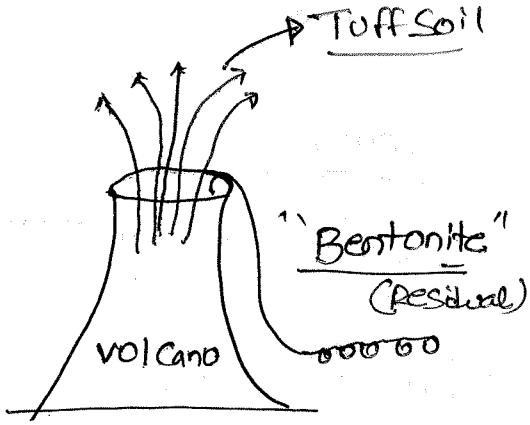
- It is fine grained calcium carbonated soil of marine origin.
- It is formed by chemical decomposition of acquitic plants and animal bones

2. Black Cotton Soil

- It is residual soil formed from basalt by chemical weathering.
- It contains high amount of clay mineral "Montmorillonite"
- It shows high compressibility, high plasticity, high swelling and shrinkage and low shear strength.

3. Tuff soil

- It is transported volcanic ashes
- Transported wind (or) water.



4. Bentonite Soil

- It is chemically weathered volcanic ashes.
- Generally used as lubrication in drilling operation.
- It is clay containing high amount of Montmorillonite hence it shows high swelling and shrinkage and low shear strength

5. Laterite Soil

- Formed due to Leaching (washing out of Silicious compound and accumulation of iron oxide and aluminum oxide).
- Found in humid areas like Eastern ghat, western ghat and great North east.

6. Organic Soils

(a) MUCK Soils

- It is the mixture of Organic matters and in-organic soil.

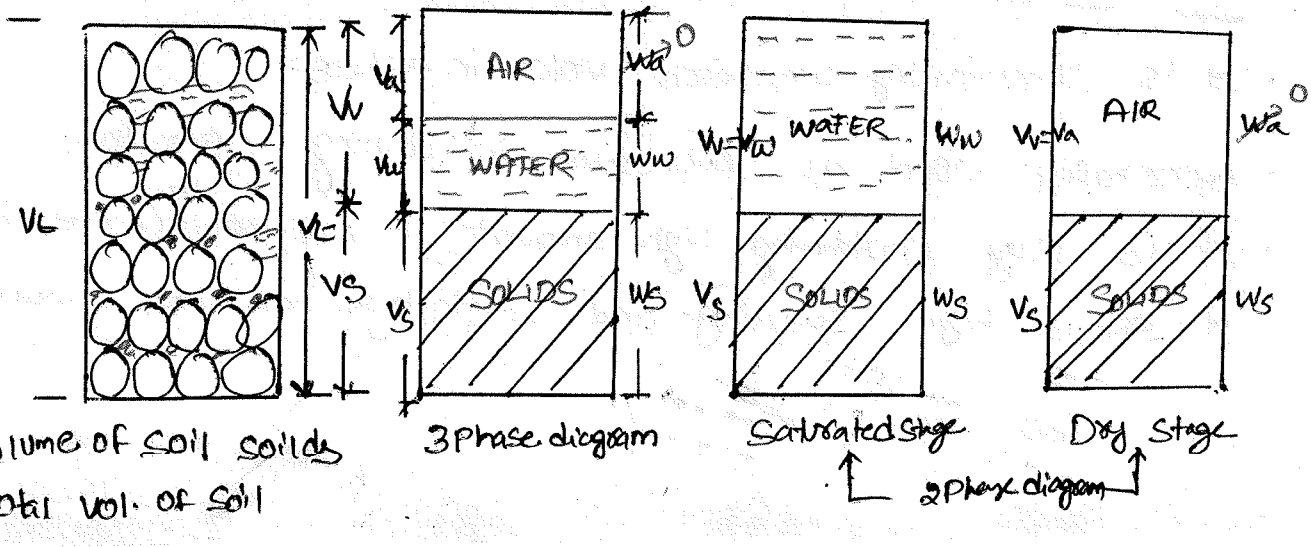
(b) Peat Soils (Pt)

- In almost entrily Consist of vegetative matters @ different stages of decomposition.
- It Possess organic odour and black to dark brown colour.

7. Loam

- It is the mixture of Sand, Silt and Clay.

Phase Diagram



V_S → volume of soil solids
V_t → Total vol. of Soil

3 Phase diagram

Saturated Stage

2 Phase diagram

Dry Stage

Important Definitions

1. Water content (w)

**

$$w = \frac{\text{wt. of water}}{\text{wt. of solids}} \times 100$$

$$w = \frac{W_w}{W_s} \times 100 = \frac{M_w}{M_s} \times 100$$

Note :- 1 :- Range of w

$$w \geq 0\%$$

Note :- 2 :- Relation b/w w, W_s & W_{total}

$$w = \frac{W_w}{W_s}$$ adding 1 both side

$$1 + w = 1 + \frac{W_w}{W_s}$$

$$1 + w = \frac{W_s + W_w}{W_s} = \frac{W_{total}}{W_s}$$

**

$$W_s = \frac{W_{total}}{1 + w}$$

Note 3 :- → Water content can also represents total wt of soil mass

$$w' = \frac{\text{wt. of water}}{\text{Total wt of soil}} \times 100$$

$$w' = \frac{W_w}{W_t} \times 100 = \frac{M_w}{M_t} \times 100$$

Range of $w' \Rightarrow 0 \leq w' \leq 100\%$

$w' \neq 100\%$ bez

$w' = 100\%$ then i.e. $W_w = W_t$ which is not possible in Soil mass

Relation b/w w & w'

$$w' = \frac{W_w}{W_t} = \frac{W_w}{W_w + W_s} = \frac{W_w}{W_w\left(1+\frac{W_s}{W_w}\right)} = \frac{1}{\frac{1}{w}+1}$$

$$w' = \frac{w}{1+w}$$

w in terms of w'

$$\boxed{w = \frac{w'}{1-w'}}$$

- Total wt. of Soil mass changes with Change in wt. of water hence Siginificance of 'w' is more than 'w'' because Soilds are still on quantity.

2) Void Ratio (e)	(3) Porosity (n)
$\boxed{e = \frac{\text{Volume of voids}}{\text{Volume of Soilds}} = \frac{V_v}{V_s}}$ ***	$\boxed{n = \frac{\text{Volume of voids}}{\text{Volume of Soilds (Total)}} \times 100 = \frac{V_v}{V_t} \times 100}$ ***
Note-1 Range of e $\boxed{e>0}$	Note-1 Range of n $\boxed{0<n<100\%}$
$e \neq 0$	• $n \neq 0$ & $n \neq 100\%$
• Generally represented as decimal fraction	∵ If $n = 100\%$ then i.e. $V_v = V_t$ which is not possible in Soil mechanics mass.

Not-2 :⇒ Though size of void is more in Coarse grain Soil but the total no. of voids is more in fine grain soil hence fine-grain soils are more porous it means void ratio and porosity is more.

Note 3:→ Relation in b/w ~~e and~~ V_S, V_L & e

$$e = \frac{V_V}{V_S}$$ adding '1' on both sides

$$1+e = 1+\frac{V_V}{V_S}$$

$$1+e = \frac{V_S+V_V}{V_S}$$

$$1+e = \frac{V_L}{V_S}$$

$$\boxed{V_S = \frac{V_L}{1+e}} \quad **$$

Note 4:→ Relation in b/w e & n

$$n = \frac{V_V}{V_L} = \frac{V_V}{V_S+V_V} = \frac{V_V}{V_V\left(\frac{V_S}{V_V}+1\right)} = \frac{1}{\frac{1}{e}+1}$$

$$\boxed{n = \frac{e}{1+e}} \quad **$$

e in terms of 'n'

$$n = \frac{1}{\frac{1}{e}+1} \Rightarrow \frac{1}{e}+1 = \frac{1}{n}$$

$$\frac{1}{e} = \frac{1}{n}-1$$

$$\boxed{e = \frac{n}{1-n}} \quad **$$

4. Degree of Saturation (S)

**

$$S = \frac{\text{Volume of water}}{\text{Volume of voids}} \times 100$$

$$S = \frac{V_w}{V_v} \times 100$$

5. Air content (a_c)

**

$$a_c = \frac{\text{Volume of air}}{\text{Volume of voids}} \times 100$$

$$a_c = \frac{V_a}{V} \times 100$$

In dry condition → $S = 0$ → $a_c = 100\%$.

In saturation condition → $S = 100\%$ → $a_c = 0$

In partially saturated → $0 < S < 100\%$ → $0 < a_c < 100\%$.

Relation in b/w S & a_c

$$S = \frac{V_w}{V_v} = \frac{V_v - V_a}{V} = 1 - \frac{V_a}{V} \rightarrow a_c$$

**

$$\therefore S + a_c = 1$$

6. Percentage of air voids (n_a)

$$n_a = \frac{\text{Volume of air}}{\text{Total volume}} \times 100$$

$$n_a = \frac{V_a}{V_t} \times 100$$

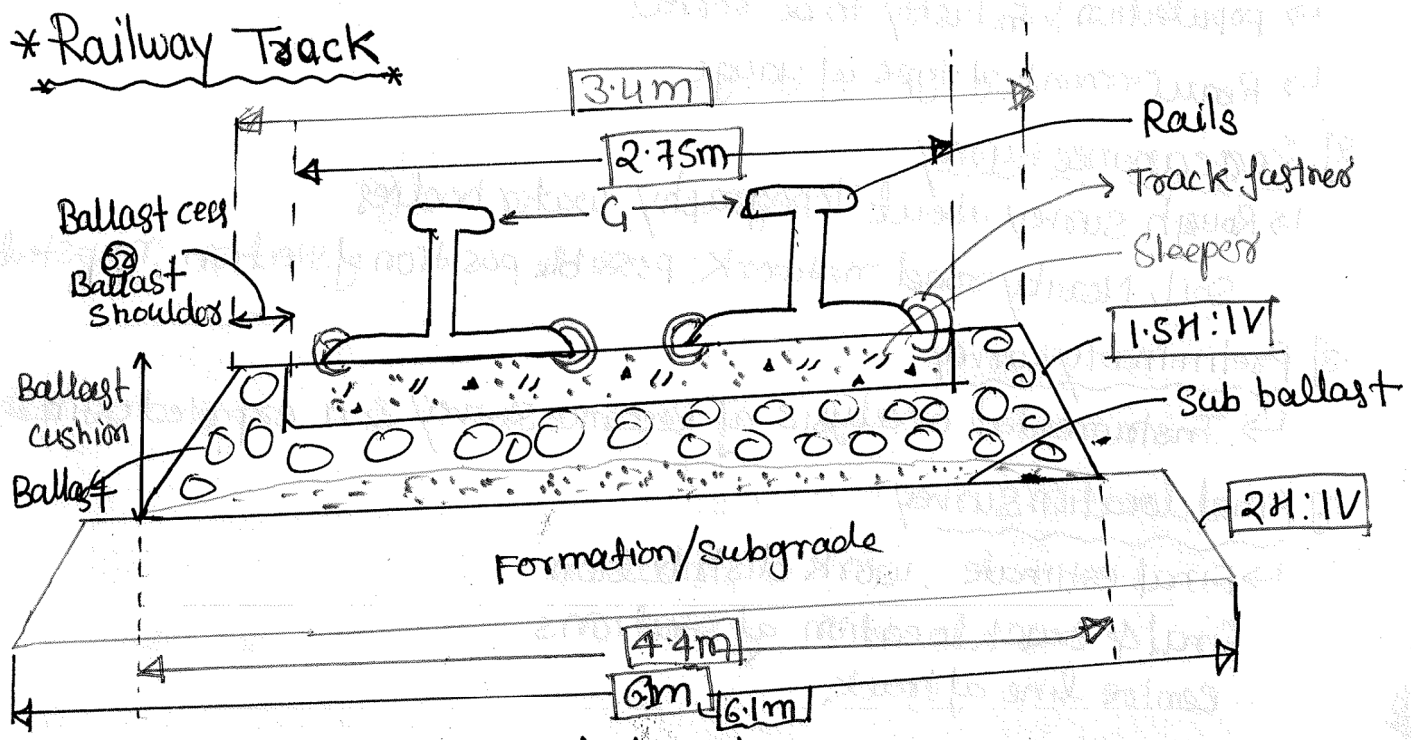
$$0 \leq n_a < 100\%.$$

$$n_a \neq 100\%.$$

Lecture-1 ★ Railway Engineering ★ 22 October 21

↳ Railway is very huge, rapid and reliable transportation system all over the world.

* Railway Track



Rails ⇒ Allows movement of Train

Sleeper ⇒ hold rail in position & take load from rails

Ballast ⇒ hold Sleeper & Rail in position & distribute load coming from sleeper.

Track fastner ⇒ Attach rail & sleeper together

Formation/subgrade ⇒ working as a formation of track.

Sub ballast ⇒ → made from murrom soil (Fine grained soil)
↳ Decomposition of laterite
↳ less permeable soil

Survey Required Before Railway track construction

1] Traffic Survey
- ↳ Number & type of train
- ↳ population & Industry to be served
- ↳ Requirement of type of gauge

2] Reccanance survey
- ↳ Rough survey about topography, water bodies Soil, Nearby road network, possible position of station., map study

3] Preliminary survey
- ↳ Instrumental analysis of Reccance survey & a expected estimate

4] Final location survey
- ↳ Final estimate, work distribution
  Final & exact location of stations
  centre line of track

☆ Chapter 1 ☆ Rails

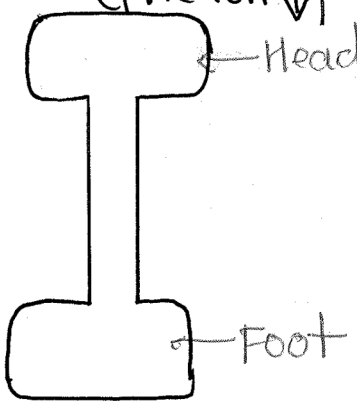
→ Strong, smooth, Frictionless

→ parallel, levelled, & continuous

→ it is a continuous girder as it allows movement of train ie moving load.

→ ∵ Contact Area of wheel is very less with compare to perimeter, so moving load considered as point load

(Friction ↓)

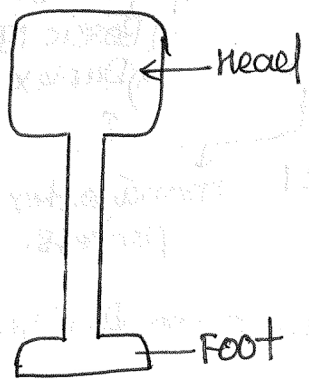


→ equal thickness of Head & Foot

→ Purpose to use from both side but found lot of wear & Indentation mark at bottom due to movement of train.

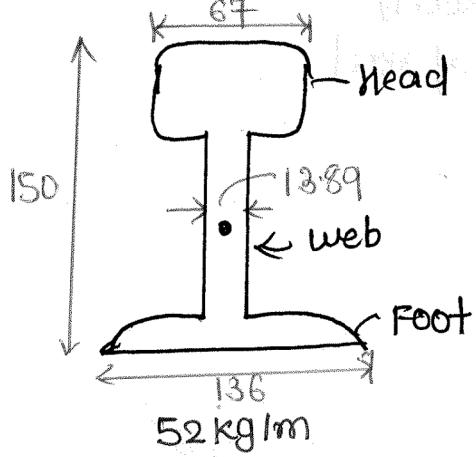
1] Double Headed

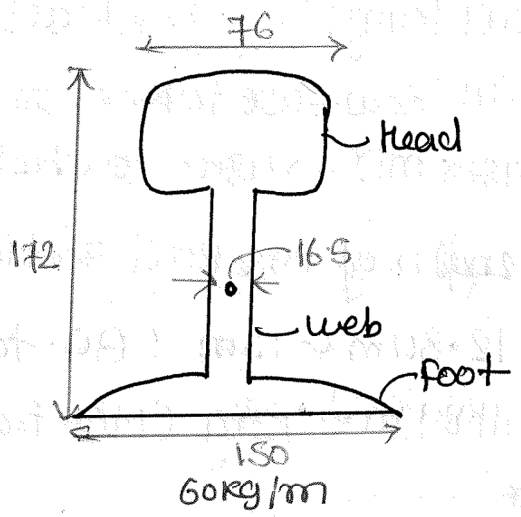
2] Bull headed Rail



→ Top head thickness increased

3] Flat Footed Rail





→ Carbon > Magnese > Silica > Phasporous > Sulphur.

→ Equal distributed of material

→ CG must be in centre to reduce chances of development of bending stress

→ Head ⇒ Should be enough thick to provide vertical Stiffness

→ web ⇒ Should be enough thick to provide flexural Rigidity in horizontal plane

→ foot → Should be flat, to resist overturn & start distribution of load.

	Speed	UTS(Mpa)	A(mm²) ☆	GMT (Gross million Tonn per year per Km)
52 kg/m	130 kmph	710	6615	20-25
60 kg/m	160 Kmph	880	7686 ☆	35

Note① Identification of Rail

IRS-52-710-SALT-XI-17-OB

- IRS → Rail Section
- 52 → weight (kg) → UTS
- 710 → UTS
- SALT → Company → Manufacture
- XI → Roman (11) → month
- 17 → year like 2017 → year
- OB → process → 1) open breath 2) Basic Bessmer 3) Duplex → manufacturing process.

Note② Falling weight test & Tup test to be done on Rail section.

Note③ Rail tongue – to hold rail

Jim (Row – use to bend or break Rail)

Vises mid → used to check level of rail

Note④ Length of one Rail section

= 12.80 m ≃ 13m (BG-track)

= 11.89 m ≃ 12m (MG-track)

Important

Defects in Rail

1] Corrugation in Rail / Roaring Rails {Rail pe dhul mitti jamna}

↳ Minute depression over top of rail surface (spreading in nature)

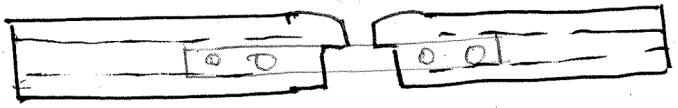
↳ when train moves from it makes roaring sound (Train becomes चीता)

↳ it can also occur due to accumulation of dust over rail surface

↳ generally cause behind depression is break application, accelration etc.

2] Hogging in Rail

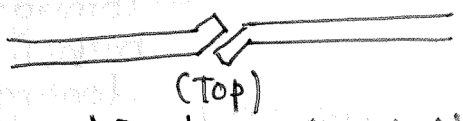
↳ due to loose fish plate & bolt



③ Kinking in Rail (Ye bolt loose hone ke vajah se)

↳ Placing of ballast becomes loose alongwith Fish plate and Fish bolt.

↳ Rails misalignment (out of tract)

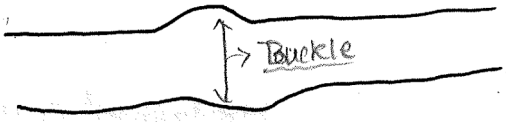


4] Buckling of Rail (Ye bolt tight hone ke vajah se)

→ Due to tights bolts & close packing of rails, if further temprature increase rail buckles in lateral Direction

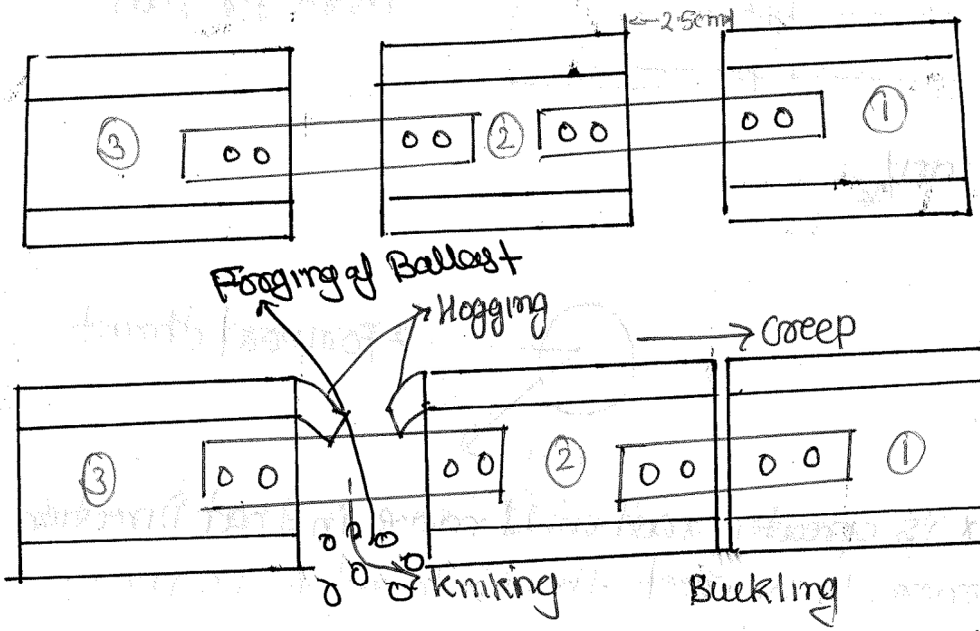
→ Misaliangment → widening of gauge.

→ downword deflection will not occur due to continuous support.



VVImp

5] Creep in Rail (विशेष)



⇒ The movement of rail w.r.t sleepers in the direction of traffic known as creep of track

⇒ ≯150mm or 6 continuous rail should not be subjected to creep.

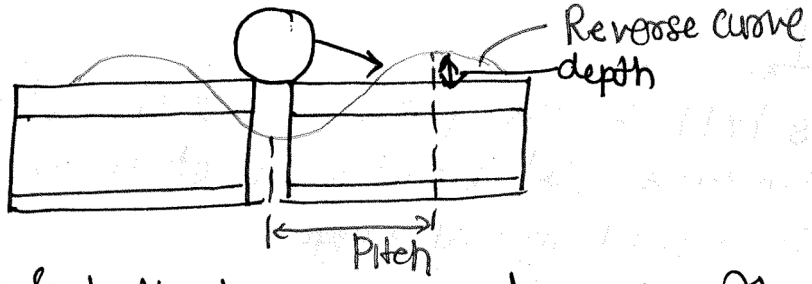
⇒ Atleast with in 3 months

⇒ Creep indicator.

⇒ If joint is close from one side & open from other side signifies creep

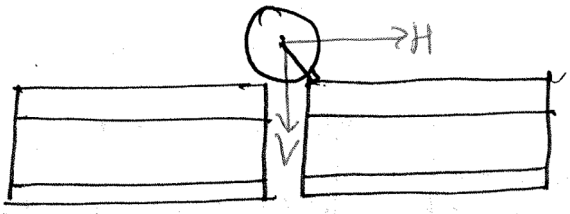
⇒ Closing of joint ⇒ Buckling
Opening of joint ⇒ Hogging, Kinking, Fouling of Ballast.
↳ coming out of ballast due to loosing of packing

① Wave Theory



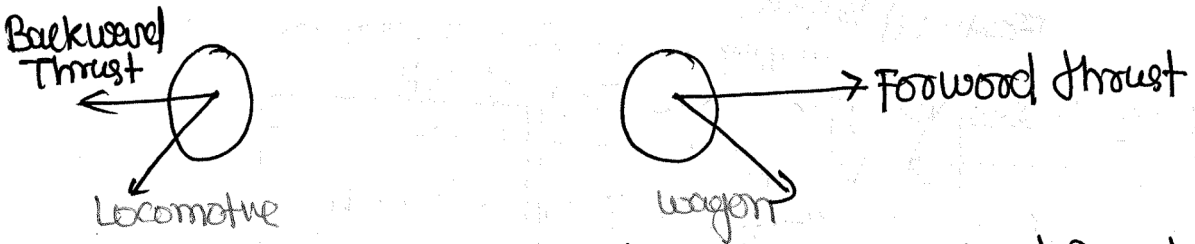
↳ Pitch & depth of wave depend on Strength, Stability & Track modulus.

② Percushion Theory



Horizontal component of Impact force will move the rail.

③ Drag Theory *



→ whichever is greater, rail will move in that Direction
(Generally forward thrust found to be more)

6] Wear in Rail

↳ Due to abnormal loading, high speed of train when stress on the rails becomes more than the yield stress metal will flow know as wear of the rails

↳ It can occur

At Top
- → Corrugation
- → Skidding & Slipping of wheel
- → Vertical loading
- → Corrosion & humidity

At Side ⇒ Due to Shrinkage of wheel Flane

At Ends ⇒ Due to Creep, Hogging, Kinking etc

Total wear ≯ 5%
Top wear ≯ 25%

Rail Joint

↳ Rail joint are suppose to be weakest portion in a railway track

↳ Ideally Rail joint should be elastic

↳ As the Number of joint Increases the chances of Creep, hogging Kinking and also increases lots of cost because of the Number of fish plate, and bolts

↳ So to make it economic and more stronger welding of rail is done.

↳ welding provides such a restrained at the ends of rail So that fastners can do the work propely (Resisting the Buckling)

↳ Sucess of welded rail depends upon strength of fastners

↳ welding of rail reduces no. of joint, chances of failure, make it economical also reduces the maintainee

Type of welded Rail

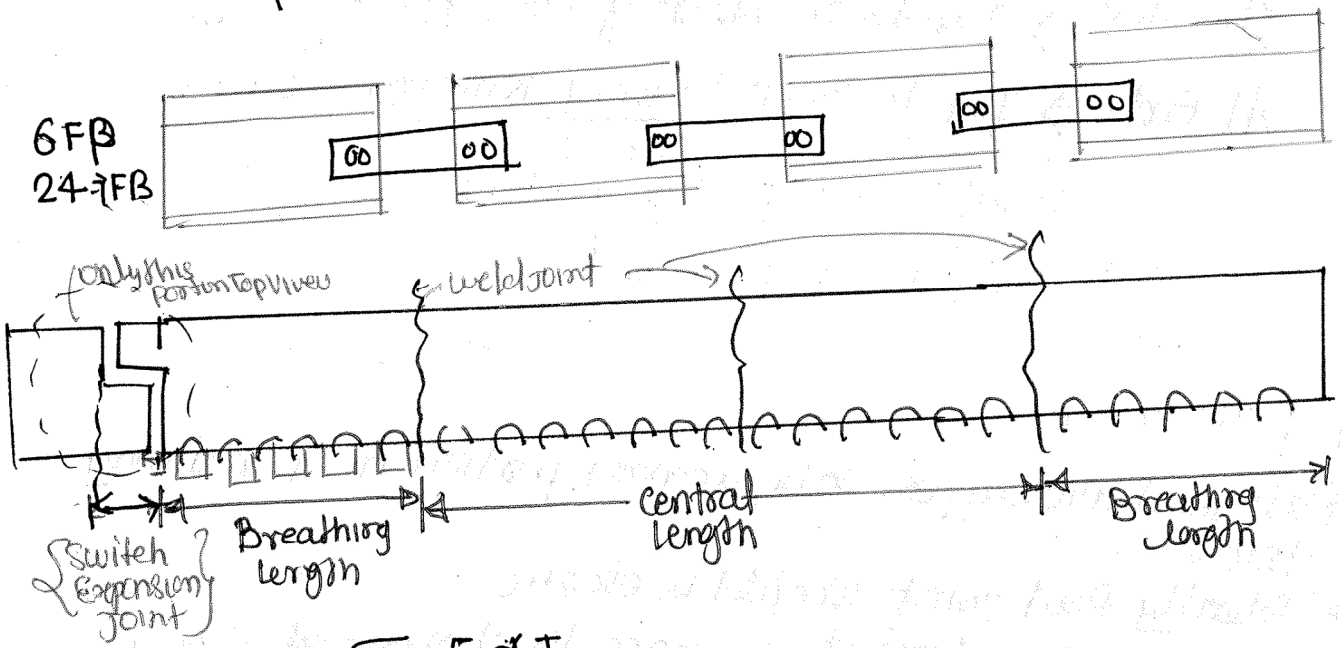
① Short welded Rail ⇒ 3, 5 or upto 10 rail

↳ As a entire length of short welded rail is subjected to temprature. so not suggested that.

② Long welded Rail (LWR) ⇒ 200–300m upto 1000m

↳ In Long welded rails the centre portion of is not allow to expand because of fastners.

↳ The end length of either sides of LWR is allow to expand is known as breathing length.



$$\sigma = E\alpha T$$

$\therefore F = AE\alpha T$ (Force to be resisted due to Temprature Increment)

R = Resisting capacity of sleeper

$$\text{No. of Sleeper} = (n) = \frac{F}{R}$$

$$\text{Breathing length } (L) = (n-1)S$$

S ⇒ spacing between sleeper.

③ Continuous welded Rail (CWR)

– welding > 1km (Station to Station)

→ Not suggestable.