Teaching Materials

Engineering Structure Development (ES 3205)

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Dept. of Agric. Eng. & and Soil Science,

Rajarata University of Sri Lanka

Engineering Structure Development

ES 3205 (2/25:10)

Teaching Materials

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PREFACE

These teaching materials on Engineering Structure Development (ES 3205) is prepared by myself, to be submitted to the 219th Faculty Board, Faculty of Agriculture, RUSL on 04th May, 2022. Hereafter, these materials could be used by the undergraduates who are enrolled for the Engineering Structure Development (ES 3205) in B.Sc. (Agric.) Special Degree programme in Rajarata University of Sri Lanka to improve their learning environment.

April, 2022 Dr. G.V.T.V. Weerasooriya

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1. INTRODUCTION

1.1 Course Capsule

Introduction; Strength of materials: tensile, compressive shear and torsion effects, stress-strain relationship; Equilibrium of rigid body, Analysis of simple, supported trusses, beam and evaluation of engineering structures; Fundamentals of planning farm buildings; Building materials, parts of farm building; Concrete structures, Wood preservation; Application of engineering structure; Road construction and fencing.

1.2 Course ILOs

The students will be able to,

1. acquire the basic knowledge on material science such as stress, strain and their relationship.
2. explain the equilibrium of rigid body and analyze engineering structure
3. explain and identification the fundamental of planning of building, building materials and parts of the buildings
4. identify the application of engineering structures
5. explain basic concept of road constriction and fencing

1.3 Lesson Sequence

Week	Lesson Title	Number of hours			Methods of teaching	Methods of Assessing	Change of attitudes
		T	P	IL			
1-2	Introduction	1	0		L, V	Q/A	PL
	strength of material:	3	2	2	L, TU	TU	PL
3,4	stress-strain relationship	2	1		L, TU	TU	
	Tutorial discussion	3			GD	GR	TW, LS, CU
5,6	equilibrium of rigid body	2	1		L, TU	TU	

	Tutorial discussion	3		2	GD	GR	TW, LS, CU
7,8	analysis of trusses	2	2		L, TU	TU	
	Tutorial discussion	2			GD	GR	TW, LS, CU
9,10	analysis of beam	2	2		L, TU, P	TU, IR	
	Tutorial discussion	2			GD	GR	TW, LS, CU
11	evaluation of engineering structures	1	2	2	L, TU, P	TU, IR	
12	fundamentals of planning farm buildings	2	0		L, V	QZ	PL, H
	building materials	1	0	2	L, TU	TU, IR	
13	parts of farm building	2	0		L, V	QZ	PL, H
	concrete structures	1	0		L, TU, V	TU, IR	
14	wood preservation	1	0	2	L	QZ	PL, H
	applications of engineering structures	2	0		L, V	QZ	PL, H
15	road construction and fencing.	3	0		L	QZ	PL, H
TOTAL		**25**	**10**	**10**			
Q/A – Questions and answers, TU- Tutorials, D –Discussions, L- Lectures, FV – Field Visits, P- Presentations, DM- Demonstrations, LW – Laboratory Work, CS- Case Study, V-Videos, GD- Group discussion,							
CM- Communication, CA – Continuous attention, LS- Leadership, TW –Team work, O- Organization/ Care, CR- Creativity, SB- Situational behavior, PL- Punctuality, H- Honesty							
PR- Peer review by students, GR – Group Report, QZ- Quizzes, IR- Individual Report, EE – End semester Examination, AS- Assignments, GP- Group presentation,							

1.4 Assessment Strategy

End semester examination 70%

Continuous assessments 30%

2. STRENGTH OF MATERIALS

Material differs widely in their capacities to resist forces. This feature can be checked by testing machines. The maximum force per unit of cross section is call ultimate strength of material.

2.1 Elasticity

Elasticity is a property of the material which is the ability of regain its original position, after the removal of force due to deformation.

2.2 Elastic Materials

A material which regains its original position after the removal of force which causes its deformation.

2.3 Plastic Materials

A material which not regain its original position after the removal of force which causes its deformation. Some residual deformation can be seen.

2.4 Mechanical Properties of Materials

2.4.1 Ductility

The property of the material which allows to be drawn out by tension to reduce section. Eg: wire drawing

2.4.2 Brittleness

Lack of ductility.

2.4.3 Malleability

The ability of the material to be beaten or rolled in to sheet.

2.4.4. Hardness

The resistance of the material to abrasion, cutting or scratching. The Rockwell hardness test is used to measure the hardness of the material (Figure 2.1)

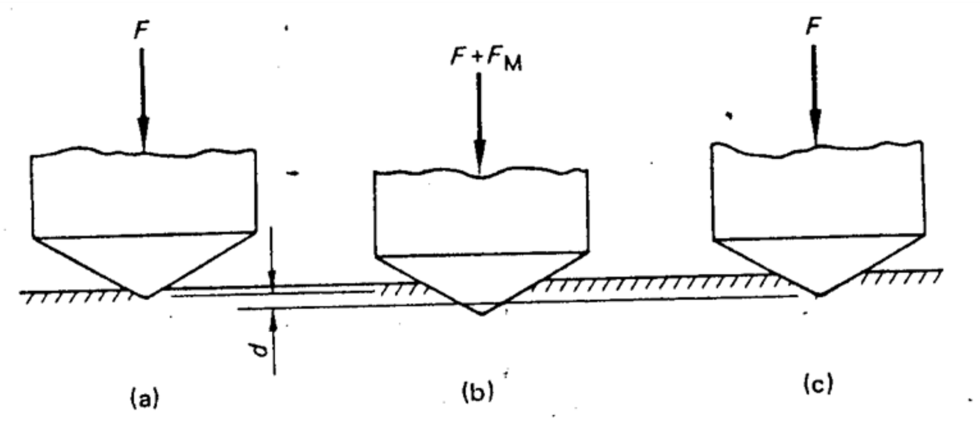


Figure 2.1. Rockwell Hardness Test

2.5 Stress

When a material is subjected to the action of an external force, internal forces are set up to the material. These internal forces are known as stress (Figure 2.2).

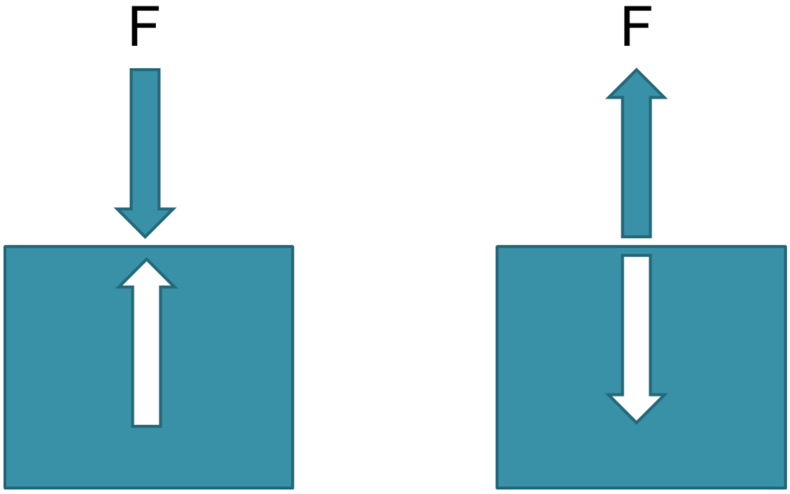


Figure 2.2 External Force and its Reaction

The intensity of stress is defined as the force acting on unit area of cross section (N/m^2). There are different types of stress (Figure 2.3).

$$\text{Stress} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

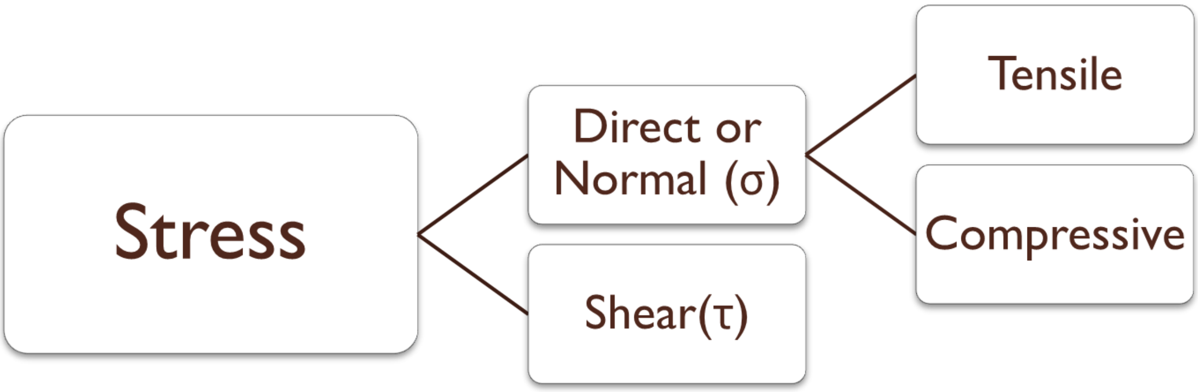


Figure 2.3 Types of Stress

2.5.1 Direct or Normal Stress

Direct stress may be tensile (σt) or compressive (σc) and result from forces acting perpendicular to the plane of the cross-section.

Direct Tensile Stress (σt)

When a section is subjected to two equal and opposite pulls, the body tends to increase the length. This stress is called tensile stress and consider it as (+) (Figure 2.4).

Figure 2.4 Direct Tensile Stress (σt)

Direct Compressive Stress (σc)

When a section is subjected to two equal and opposite pushes, the body tends to decrease its length. This stress is called compressive stress and consider it as (-) (Figure 2.5).

Figure 2.5 Direct Compressive Stress (σc)

2.5.2 Shear Stress (τ)

Shear stress are produced by equal and opposite parallel forces which are not in one line. This force tends to make slide over each other. It is an essential character of shear stress (Figure 2.6).

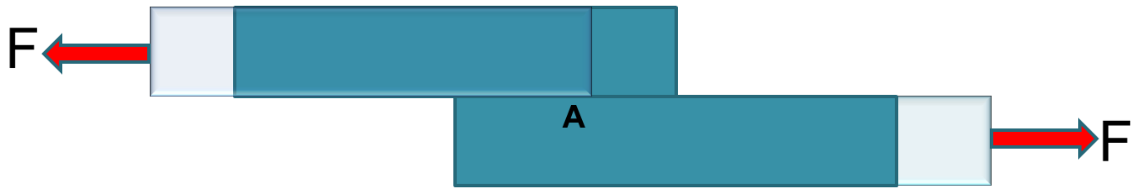


Figure 2.6 Shear Stress

Example 2.1: Calculate the tensile stress of solid bar of 28 mm diameter, when subjected to a tensile force of 44 000 N.

Example 2.2: If the safe working stress of mild steel is 80 MN/m^2. Calculate the minimum diameter of a circular bar to safety withstand a load of 20,000 N.

Example 2.3: A pipe of outside diameter 80 mm and inside diameter 60 mm is used as a strut to support a compressive load of 99,000 N. calculate the compressive stress.

2.6 Strain

When the load is applied to the material, stress is produced and deformation (change the shape of material) is happened.

Deformation – The Point of a body shows the displacement respect to each other. The manner of deformation depends on the way of lording

- Simple tension – tends to stretch
- Simple compression - tend to contract

If uniform cross-sectional area, the stress will be same throughout the length So, each unit of length will extend or contact by the same amount. The total change in length corresponding to a given stress will depend on the original length. The deformation per unit length of a body is called as strain and no dimensions. There are different types of strains (Figure 2.7).

$$\text{Stress} = \frac{\text{Deformation}}{\text{Original length}}$$

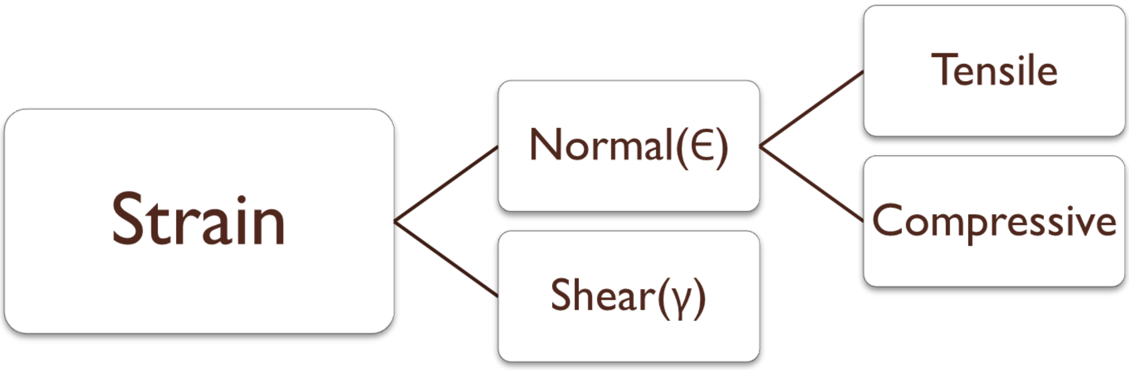


Figure 2.7 Types of Strains

2.6.1 Normal strain (Є)

This is due to tensile/compression force. The change in length of member is considered (Figure 2.8).

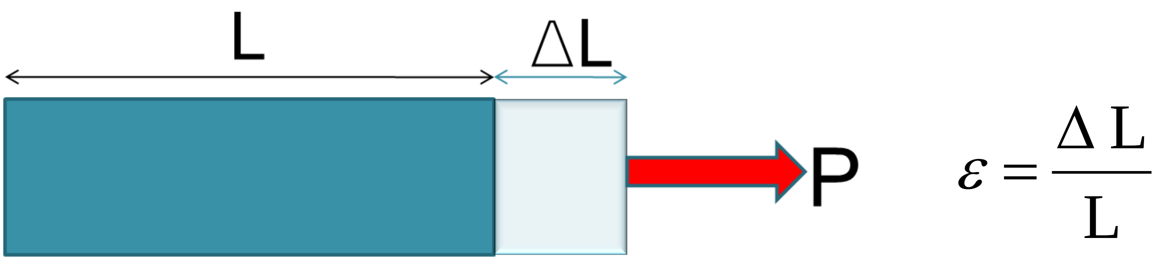


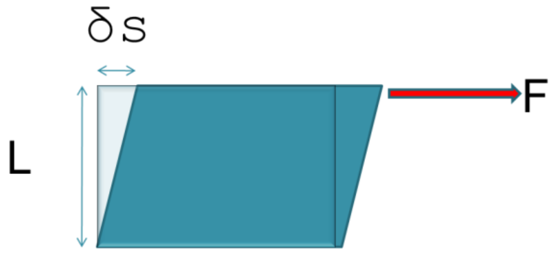
Figure 2.8 Normal Strain

Similarly, for compression by amount, ΔL: Compressive strain = - ΔL/L. Strain is positive for an increase in dimension and negative for a reduction in dimension.

Example 2.4: Calculate the tensile strain when a bar of original length 2.5m extends by 0.1 mm

2.6.2 Shear strain (γ)

This is Due to shear fore and consider the change in angle of the member (Figure 2.9).



$$\gamma = \frac{\delta s}{L} = \tan\theta$$

Figure 2.9 Shear Strain

For small angles (θ), the shear strain becomes the change in the right angle. It is dimensionless and measured in radians.

2.7 Poisson's Ratio (ν)

Lateral strain is proportional to the longitudinal strain. The constant of proportionality is called as Poisson's ratio. For most materials Poisson's ratio is 0.28 to 0.33.

Example 2.5: Due to the tensile fore, the iron bar of 8m original length and 0.505m diameter was subjected to the deformation as 8.036m in length and 0.036 m in diameter. Calculate the poison's ratio.

2.8 Thermal Strain

The strain due to the temperature changes is called temperature strain.

If, Temperature change = *t*; Original length = *l,* Extended length = *x*

$$x \propto t$$
$$x \propto l$$
$$x \propto tl$$
$$x = \alpha tl$$

$$\text{Thermal Strain (e)} = \frac{x}{l}$$
$$= \frac{\alpha tl}{l}$$
$$\text{e} = \alpha t$$

α = Coefficient of linear thermal expansion

Table 2.1 Coefficient of linear thermal expansion

Materiel	**Coefficient of linear thermal expansion (α)**
Carbon Steel	12×10^{-6}/0C
Stainless Steel	18×10^{-6}/0C
Aluminum	24×10^{-6}/0C
Copper	17×10^{-6}/0C
Cast iron	10×10^{-6}/0C
Brass	16×10^{-6}/0C
Bronze	18×10^{-6}/0C
Nickel Steel	12.5×10^{-6}/0C

Example 2.6: A Cupper bar is subjected to 200 MN/m^2. stress and the temperature raise of 35^0C. Calculate the thermal strain of this cupper bar.

2.9 Total Strain

Sum of thermal and elastic strain is called total strain.

Total Strain = e + ε

2.10 Torsion Effect

Twisting effect of the shaft. When a uniform circular shaft is subjected to a torque, it can be shown that every section of the shaft is subjected to a state of pure shear. The moment of resistance developed by the shear stresses being everywhere equal to the magnitude, and opposite in sense, to the applied torque (Figure 2.10).

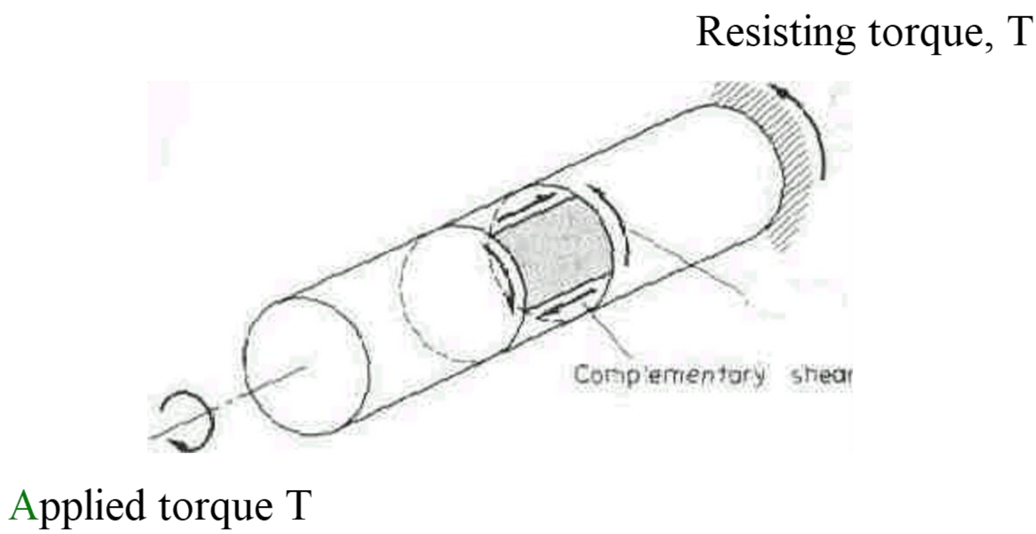


Figure 2.10 Torsion Effect of the Shaft

2.11 Stress Strain Relation Ship

All solid materials deform when they are stressed, and as stress is increased, deformation also increases. If a material returns to its original size and shape on removal of load causing deformation, it is said to be elastic. If the stress is steadily increased, a point is reached when, after the removal of load, not all the induced strain is removed. This is called the elastic limit.

2.11.1 Hook's Low

When a material is loaded within its elastic limits, Stress is proportional to strain

Stress ∞ Strain

Stress = E Strain

E = Young's Modules/Module of Rigidity

E = Stress/Strain

Unit Nm^{-2}

Young's Module (E)

This is due to Due to the normal stress.

$$E = \frac{\text{Stress } (\sigma)}{\text{Strain } (\varepsilon)}$$

Module of Rigidity (G)

This is due to Due to the Shear stress.

$$G = \frac{\text{Stress } (\tau)}{\text{Strain } (\gamma)}$$

Table 2.2 Young modules and modules of rigidity in different materials

Material	Young's Module (E) Nm^{-2}	Module of Rigidity (G) Nm^{-2}
Steel	207×10^3	83×10^3
Copper	83×10^3	39×10^3
Brass	69×10^3	37×10^3
Wood	9.6×10^3	0.55×10^3

2.11.2 Stress – Strain Diagrams

Use to determine the young's module of a material by the extensometer (Figure 2.11). Spaceman of material is subjected to tensile test.

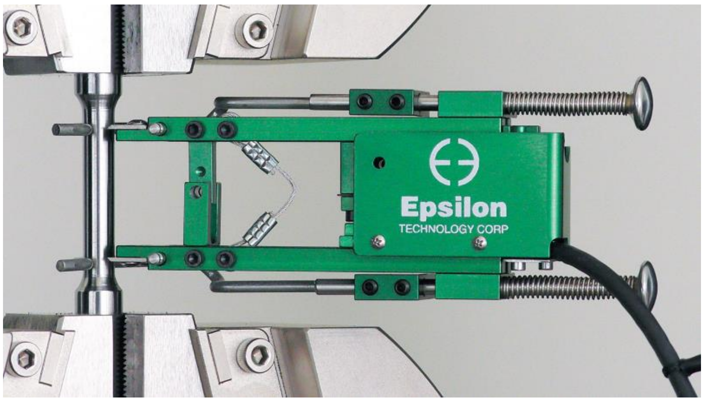


Figure 2.11 extensometer

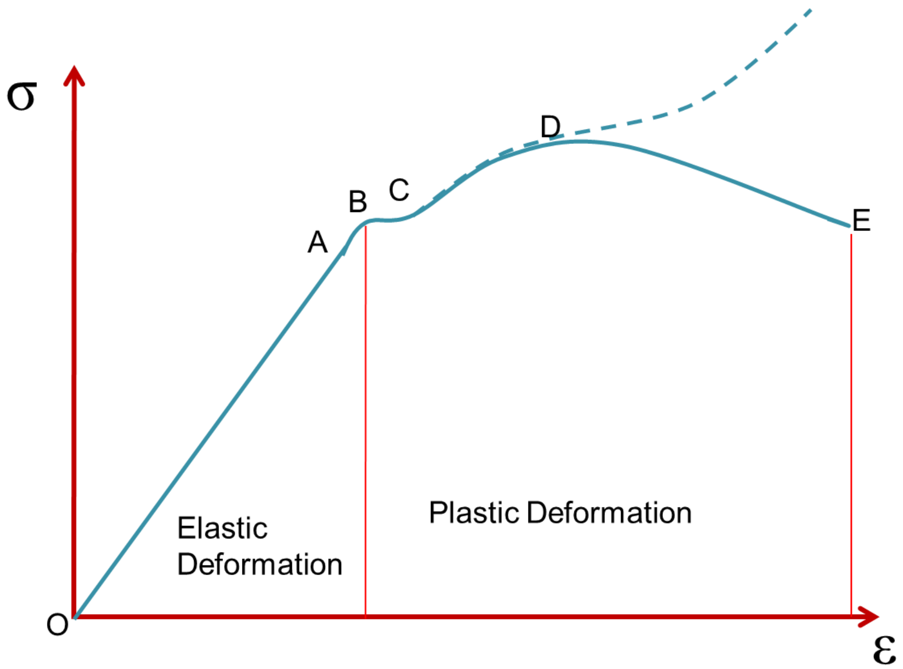


Figure 2.12 Stress – Strain Diagram

Elastic Stage – *OA*, Stress is proportional to strain, obey Hook's law, graph is a straight line

Limit of Proportionality – After that point material is not obey Hook's law

Elastic Limits – The stress at which permanent extension occur, no longer elastic, very close to limit of proportionality, Difficult to distinguish

Permanent Set – Material is loaded beyond elastic limit, then un-loaded, remain permanent extension (Figure 2.13).

Yield Stress – Point B, show considerable increase in strain without appreciable increase in stress,

B is called as Yield Point, corresponding stress called as Yield Stress.

Proof stress – With non ductile materials, similar to yield stress, corresponding load – Proof load

Plastic Stage

Point D – The end of the uniform extension, ultimate load/stress,

Beyond point D – Reduce the cross section, stress is still increase

Point E is the breaking point

2.12 Safety Factor

The load which any member of a machine carries is called working load, and stress produced by this load is the working stress. Obviously, the working stress must be less than the yield stress, tensile strength or the ultimate stress. This working stress is also called the permissible stress or the allowable stress or the design stress.

Some reasons for factor of safety include the in-exactness or inaccuracies in the estimation of stresses and the non-uniformity of some materials.

$$\text{Factor of safety} = \frac{\textit{Ultimate or yield stress}}{\textit{Design or working stress}}$$

Safety factor > 0

3. EQUILIBRIUM OF RIGID BODY, ANALYSIS OF SIMPLE, SUPPORTED TRUSSES, BEAM AND EVALUATION OF ENGINEERING STRUCTURES

3.1 The Force

Nature of the force

Change the state of rest or motion of a body. Represents the action of one body on another. Applied either; Direct physical contact between bodies or Remote action – Gravitational, Electrical, magnetic.

Characteristics of Force

Can be defined completely by; magnitude, direction (line of action), and point of application which force is exerted.

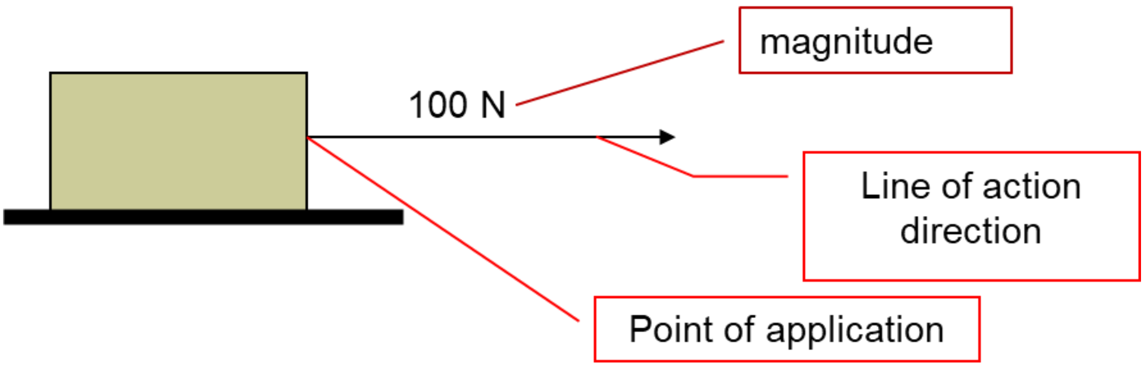


Figure 3.1 Characteristics of Force

3.2 Mechanics

The science of the action of forces on the bodies.

The physical science which describes or predicts the conditions of rest or motion of bodies under the action of forces. Mechanics can be divided as illustrated in figure 3.2.

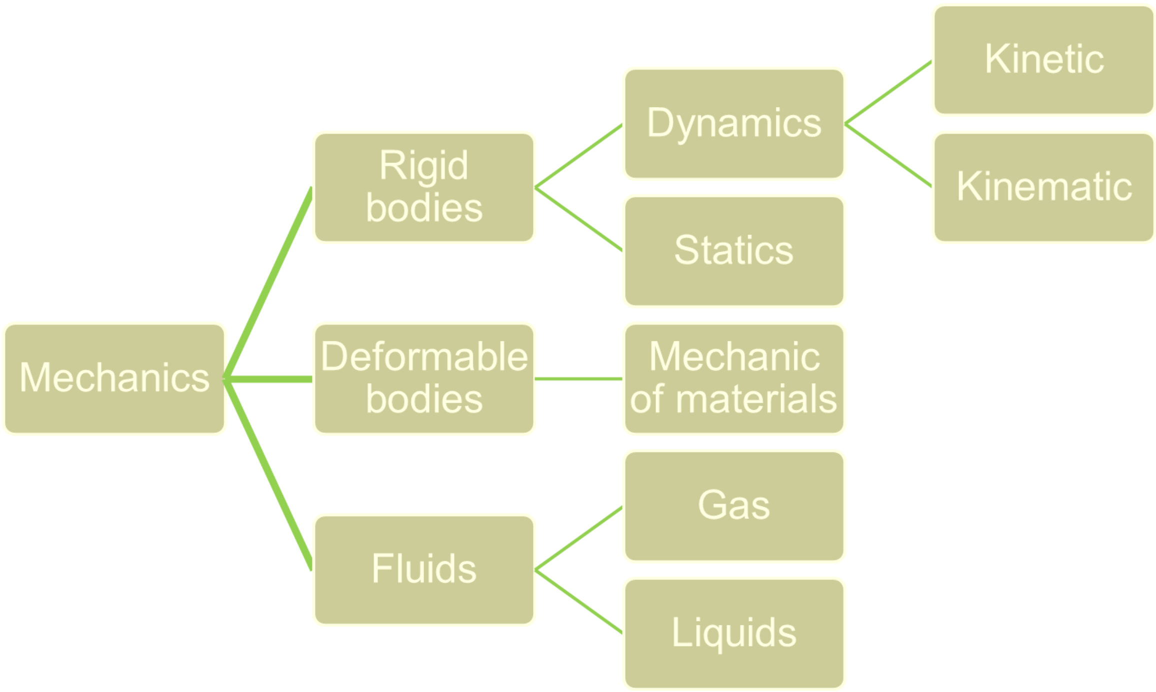


Figure 3.2 Sub Divisions of Mechanics

Rigid bodies – A body is considered rigid which the distance between any two points in the body remain as constant

1. Statics – Rigid bodies in equilibrium
2. Dynamics – Rigid bodies in motion
    a) Kinetic – bodies in motion due to force
    b) Kinematic – bodies without reference to force

Deformable bodies **–** Mechanic of materials

Fluid Mechanics

1. compressible – gas
2. incompressible - liquids

Static

The equilibrium of the bodies under the action of balanced forces. Assume the bodies to be perfectly rigid, no deformation. This is never true in the real world; everything deforms a little when a load is applied. These deformations are small and will not significantly affect the conditions of equilibrium or motion, Therefore, we will neglect the deformations.

3.3 Equilibrium of rigid body

For an object to be in equilibrium, all the forces and moments must be balanced for; each particle in a rigid body, each rigid body and each object made up of rigid bodies.

3.4 The Basic Equations of Static

There are two basic balances that must exist in any static problems.

EQUILLIBRIUM OF FORCES	$\sum F = 0$
EQUILLIBRIUM OF MOMENTS (more later)	$\sum M = 0$

The problem cannot be solved with static methods, If the sum of the forces is not zero and if the sum of moments is not zero. At least one of these two equations will appear in every static problem.

3.5 General Condition of Equilibrium

- The sum of the components of the forces in each of two perpendicular directions is zero
- The sum of the moments of the forces about a point in their plane is zero.

The equilibrium equations are necessary to determine unknown forces and moments on a rigid body.

- The algebraic sum of the horizontal forces is equal to zero; $\sum Fx = 0$
- The algebraic sum of the vertical forces is equal to zero; $\sum Fy = 0$
- The algebraic sum of the moments of the forces about any point is equal to zero.

$$\sum M = 0$$

3.6 Free Body Diagrams (FBD)

When solving a static problem important to describe external forces acting on a body. Forces are divided into two categories on free body diagrams;

1. Internal - forces act only within a free body, and cancel out, unless we are looking at a section of a free body.
2. External - Forces act on a free body, and they induce reaction forces. Examples are gravity, and forces from other free bodies.

To investigate the equilibrium of a rigid body, we isolate the body from its surroundings and show the applied forces (External forces) & the reactions from the supports that act on it due to the surroundings bodies. A body so isolated is called “Free body”. A sketch showing the forces and reactions is called “Free-body diagram (FBD)”.

Free body diagram plays an extremely important role in the analysis of many mechanics’ problems. Constructing on appropriate free body diagram is the single most important step for the solution of mechanics problem. Static analysis always depends on the successful completion of the free body diagram.

3.6.1 Construction of FBD

1. Isolated from its support or other parts of the body
2. Draw schematic diagram
3. Indicate clearly magnitude, direction & location of all external forces – Weight, Applied force, Reactions
4. Never drawn internal forces - Coupling force at joint between two connected bodies are not shown if two bodies are not separated at the joint

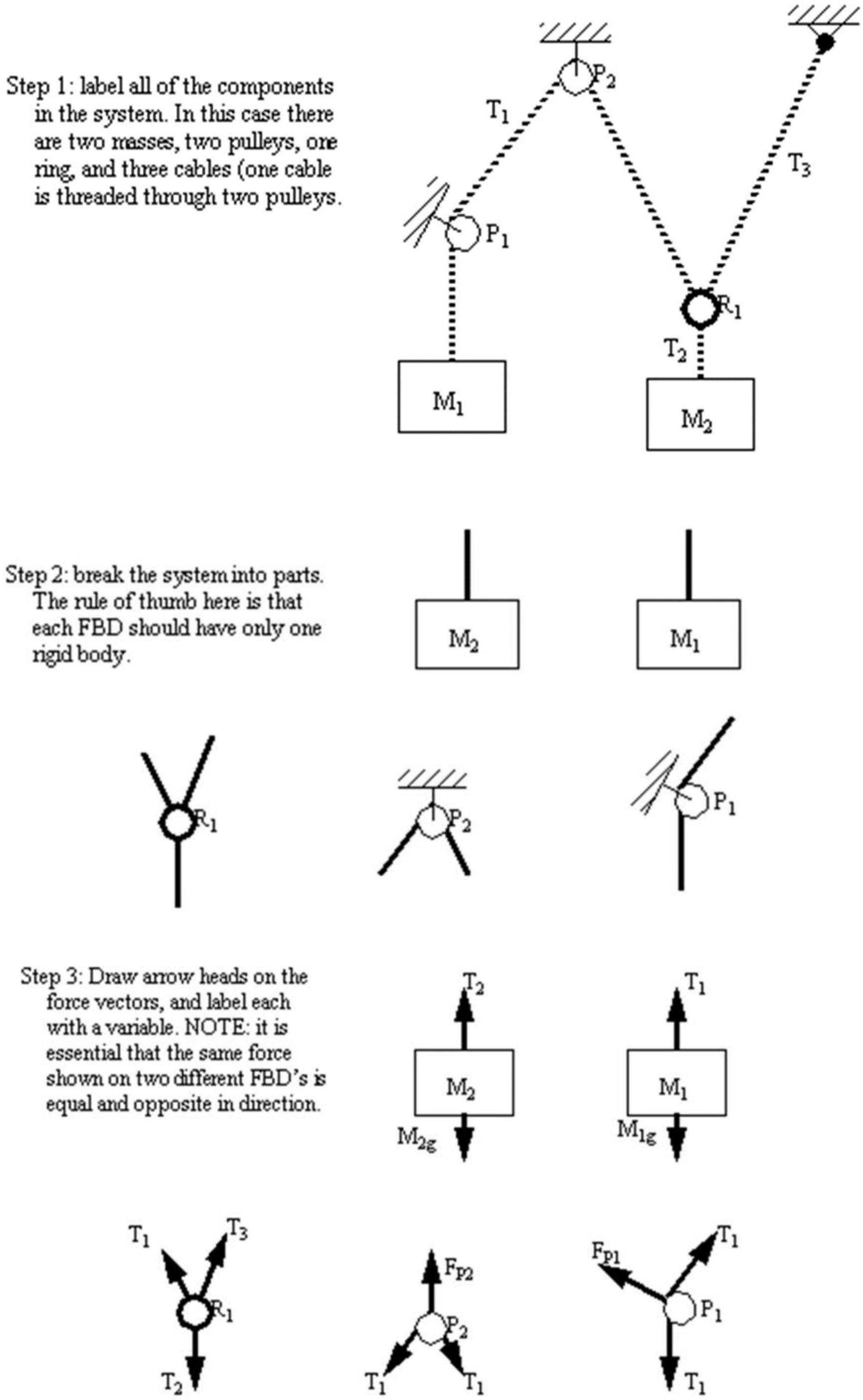


Figure 3.3 Construction of FBD

3.7 Types of Supports in Engineering Structures

A two-dimensional structure contains members that lie on the same plane. Support for these structures also lie on the same plane. There are three types of supports;

3.7.1 Roller support

One reaction force and perpendicular to the surface (Figure 3.4).

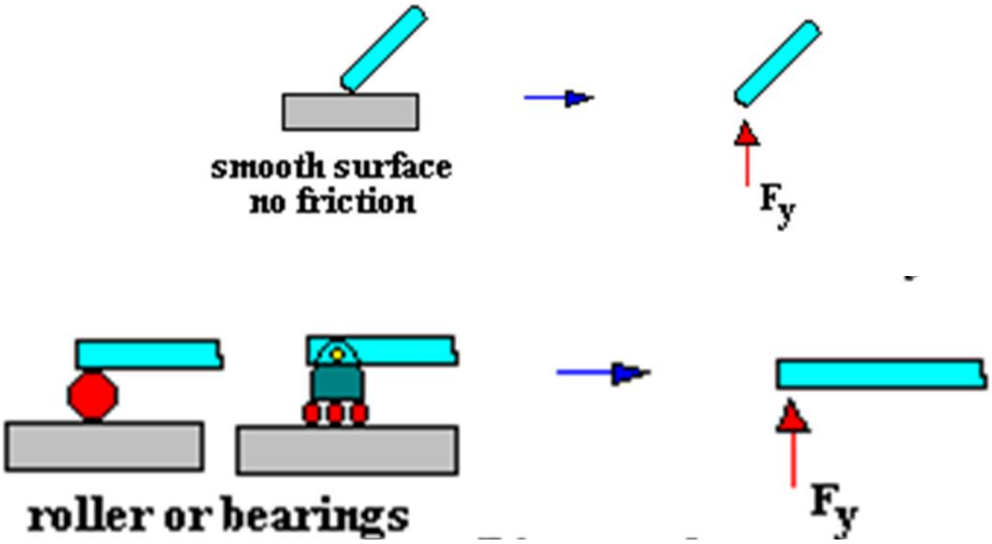
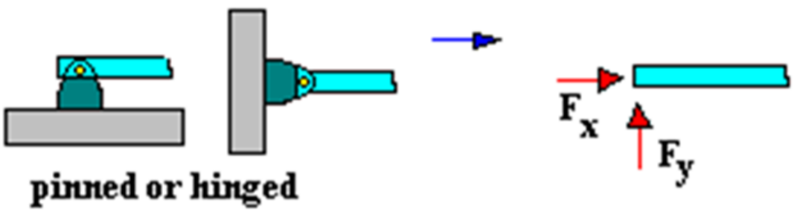


Figure 3.4 Roller Support

3.7.2 Hinge support

Prevent the structure from moving and two unknown components.



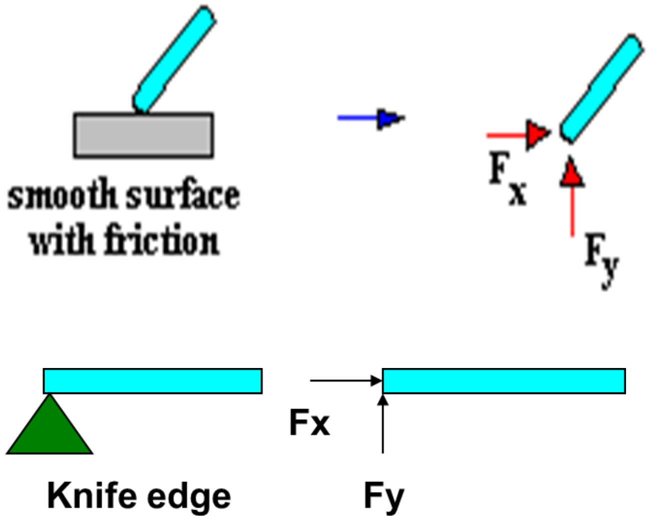


Figure 3.5 Hinge support

3.7.3 Fixed support

Resistance to linear & rotational movement. Contain three unknown elements (Two unknown force unknown moment)

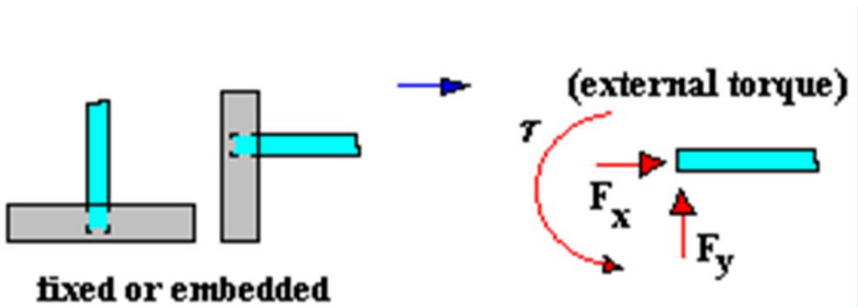


Figure 3.6 Fixed Support

3.8 Engineering Structures

It is made of supports and their joints. When applied a force, it is divided along the structure in protective way. Not change the shape of the structure. Mostly beams are used as supports (Figure 3.7).

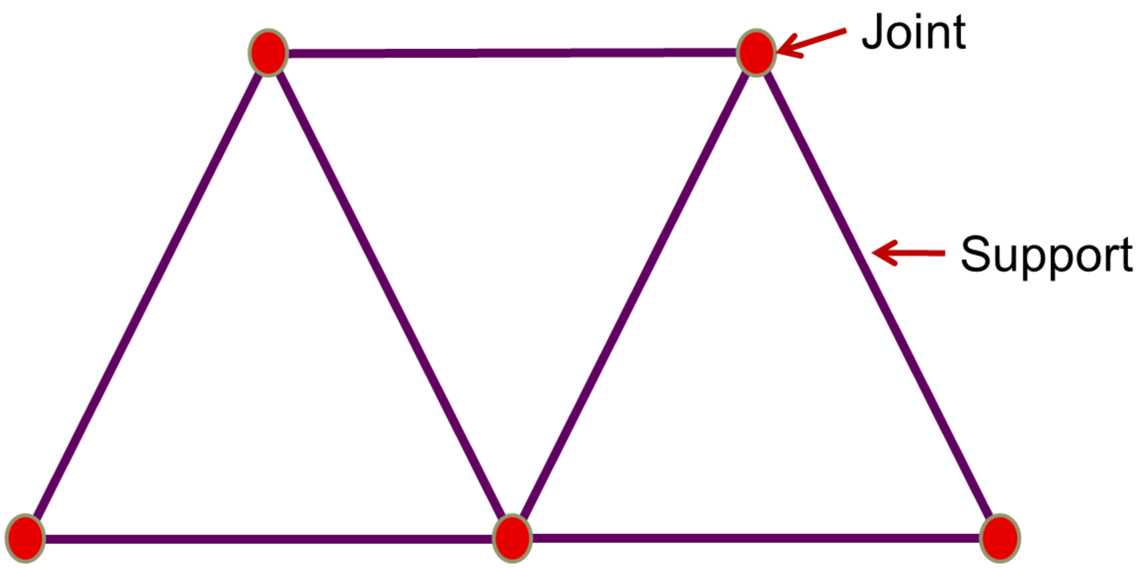


Figure 3.7 Engineering Structure

M +3 = 2J

M – Number of Supports (Members)

J – Number of Joints

3.8.1 Types of Engineering Structures

They are three types of engineering structures;

1. Trusses
2. Beams
3. Frame and machines

3.9 Analysis of Engineering Structures

Several analysis methods are used:

1. Joint method
2. Cross section method
3. Grafting method

3.10 Trusses

Trusses can be classified as illustrated in figure 3.8.

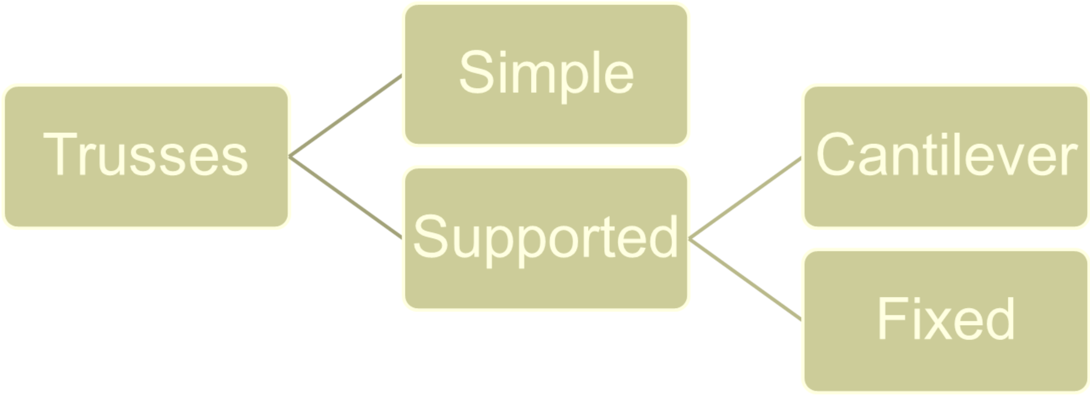
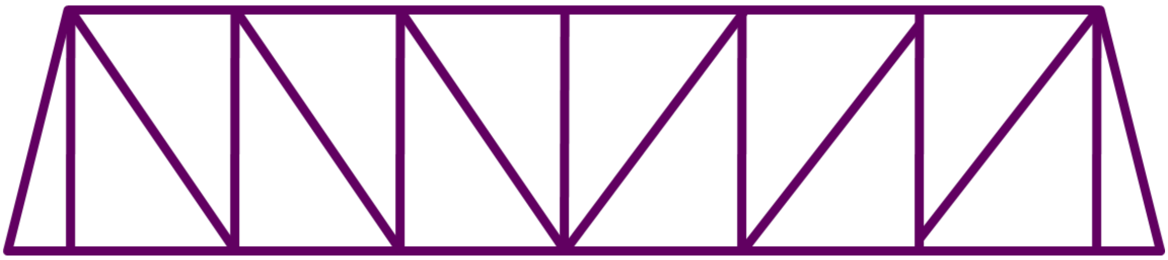


Figure 3.8 Type of Trusses

3.10.1 Simple/Plane Trusses

These structures show higher strength to weight ratio.

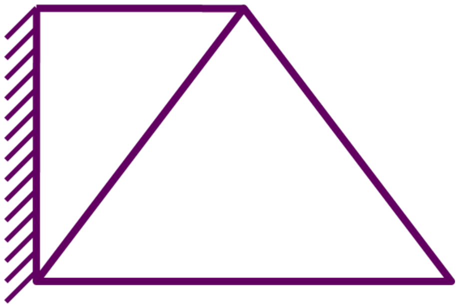
Roof Trusser



Bridge Trusser

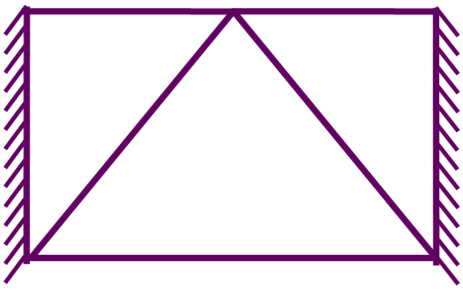
3.10.2 Cantilever Trusses

One end is fixed and other end is free.



3.10.3 Fixed Trusses

Both ends are fixed.



3.11 Assumptions for Trusses Analysis

1. All supports of structure are dual force members

2. Force activated on the support are equal, in one line and opposite in direction

3. The weight of the supports is negligible with comparing tis activated load

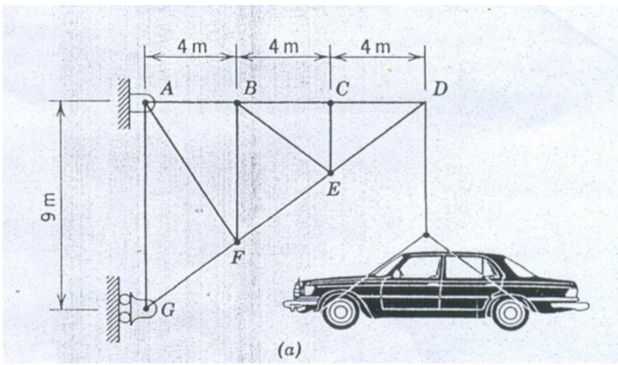
3.12 Analysis of Trusses (Procedure)

1. Draw the FBD
2. Supports are named with block letters
3. All joints are named in clock-wise
4. External forces also name in clock-wise
5. Internal forces are named according to the joints and should be indicate the direction

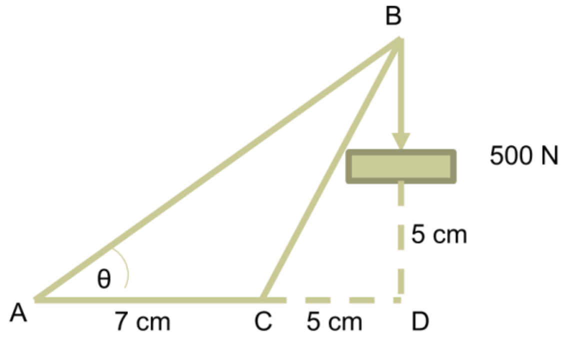
3.13 Analysis of Trusses (Cross-section Method)

Assume engineering structure is cut at particular line.

Example 3.1: Find force of AB of following figure.



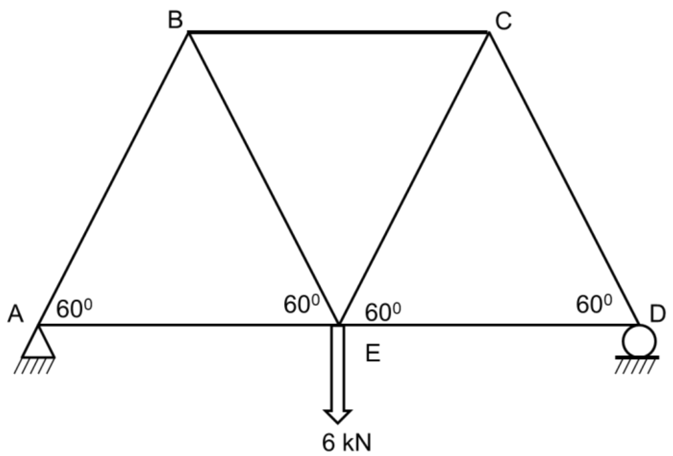
Example 3.2: Find tension of AB



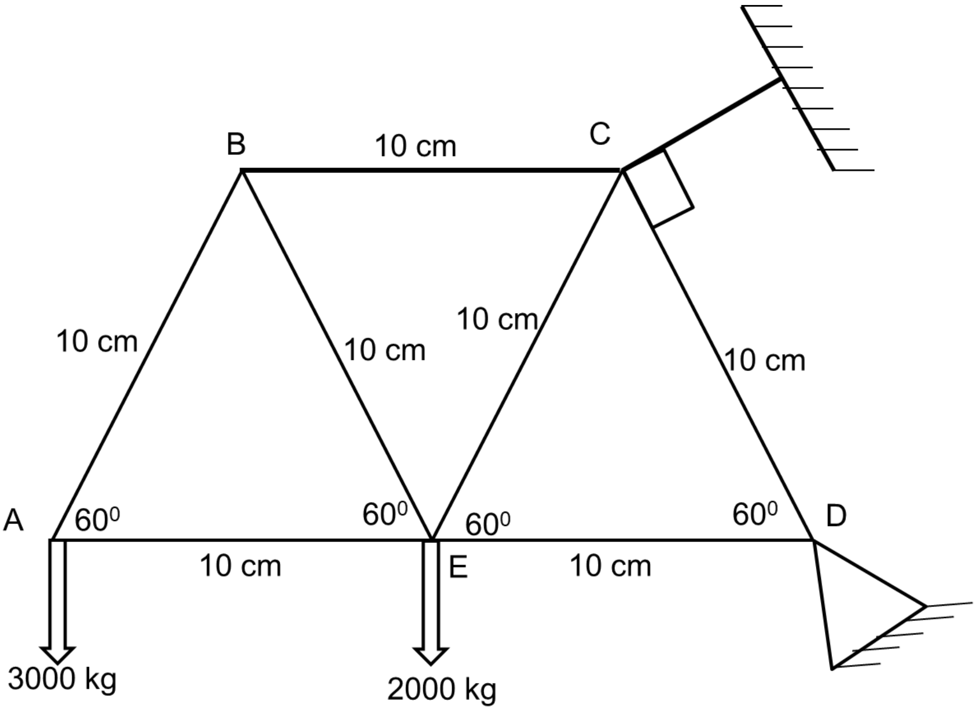
3.14 Analysis of Trusses (Joint Method)

1. Find all external forces
2. Marked all internal forces
3. Start from the joint with un-known force
4. There should not be more than two un-known values of force

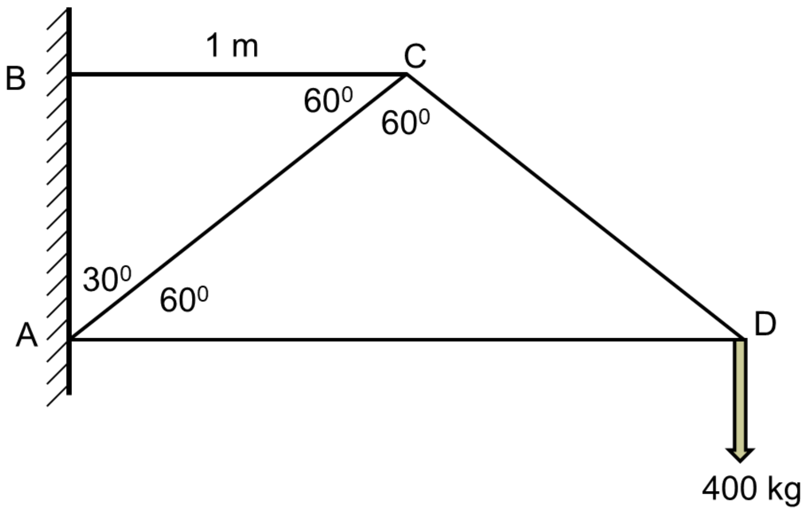
Example 3.3: Analysis this engineering structure



Example 3.4: Analysis this engineering structure



Example 3.5: Analysis this engineering structure



3.15 Beams

Supporting Structures, show resistant to bend because of loading, length of the beam > ø of the beam.

3.15.1 Types of the Beams

1. Simple beams

2. Cantilever beams

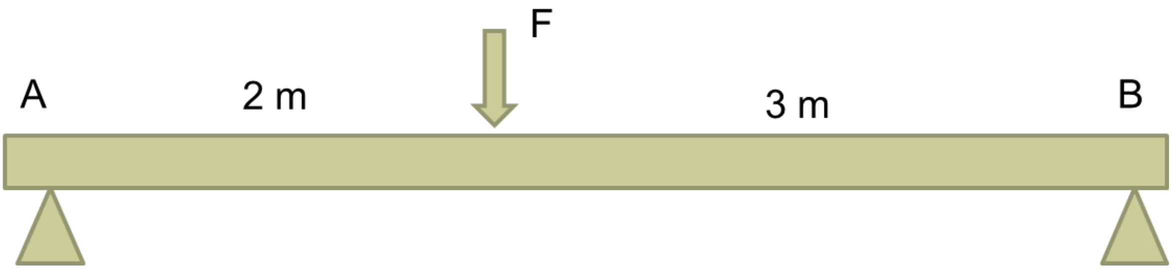
3. Fixed beams

3.15.2 Factors Effect on Bending of a Beam

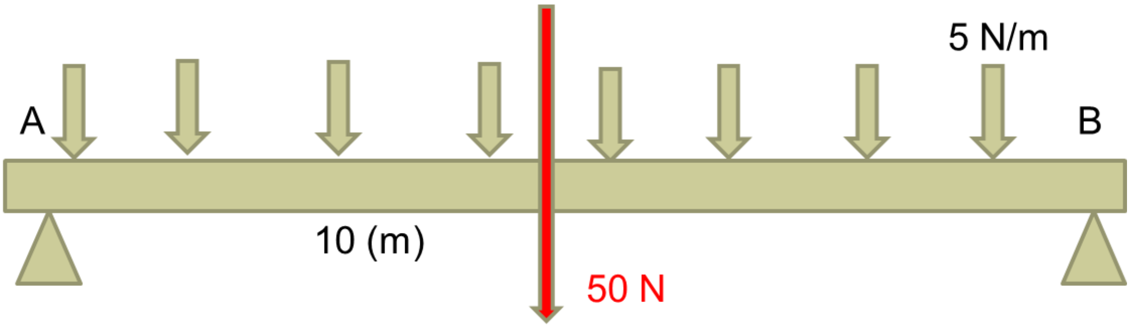
- Magnitude and the type of the load
- Length of the beam
- Type of the beam
- Reversion of the beam

3.15.3 Magnitude and the Type of the Load

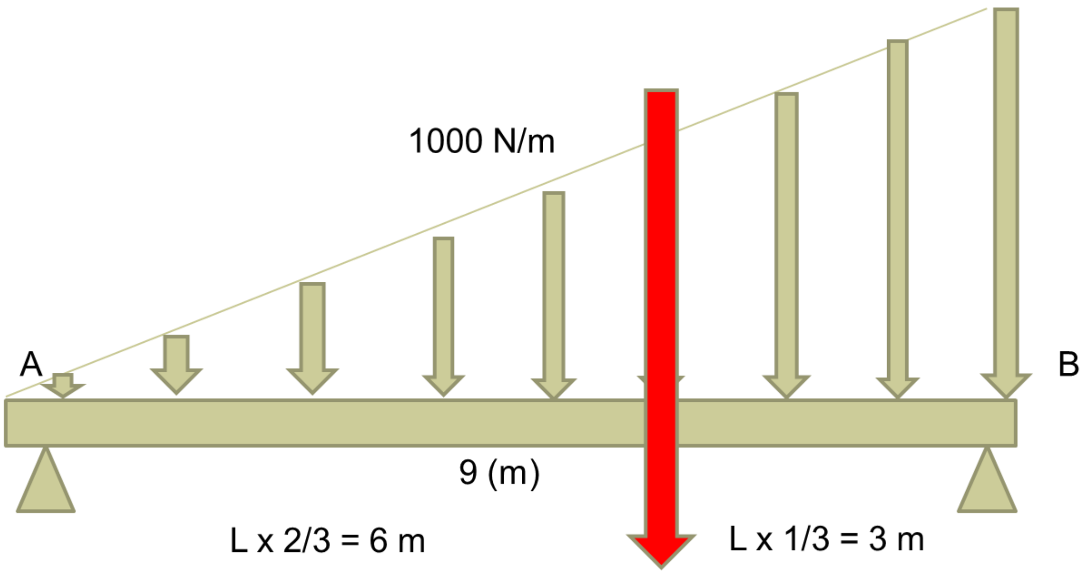
Load acting on particular place(S)



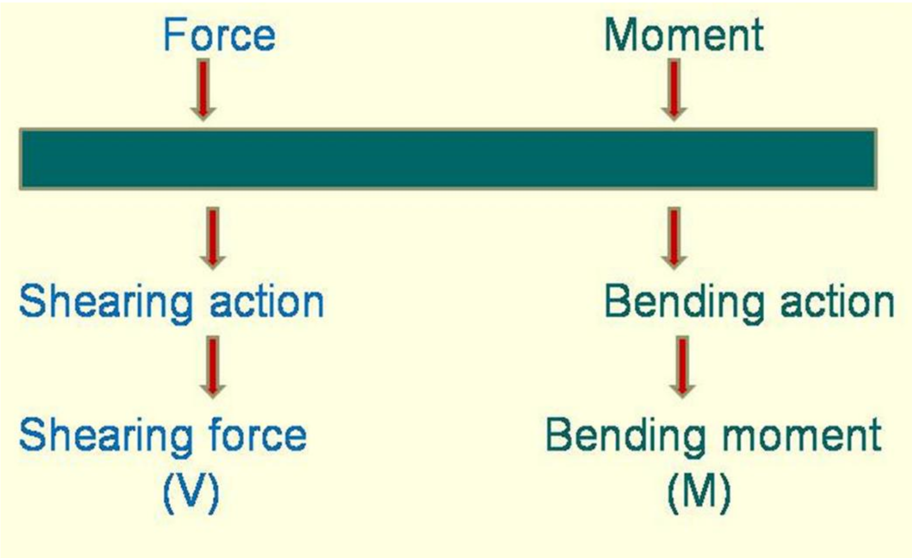
Applying uniform load throughout the beam



Applying variable force through the beam



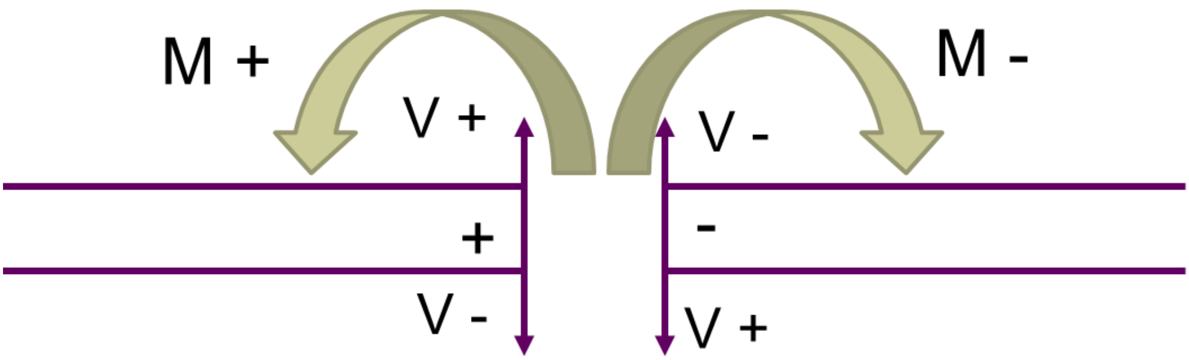
When Loading a Beam



3.16 Bending Moments

Bending moments are the internal turning forces that a beam has to resist, acting at any given point on an individual member.

3.17 FBD of theoretical cross section of the beam



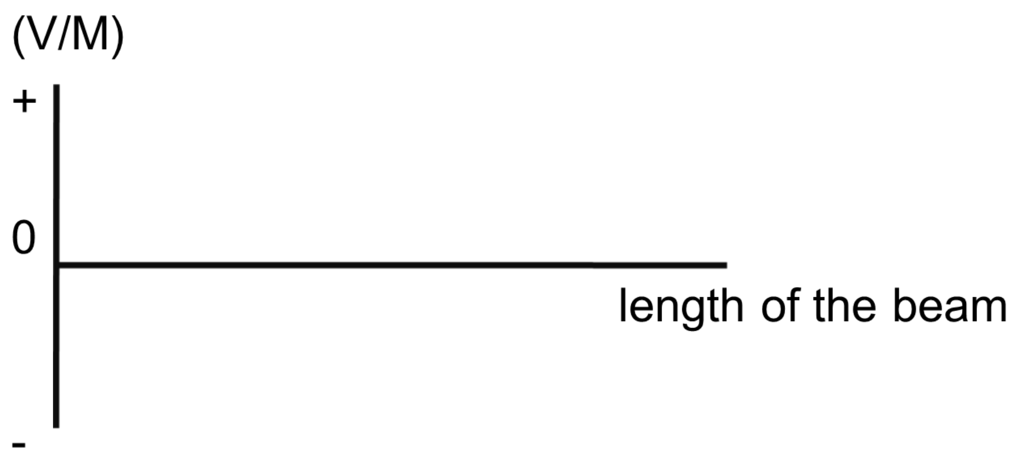
At equilibrium position

3.18 Analysis of Beams (Cross-section Method)

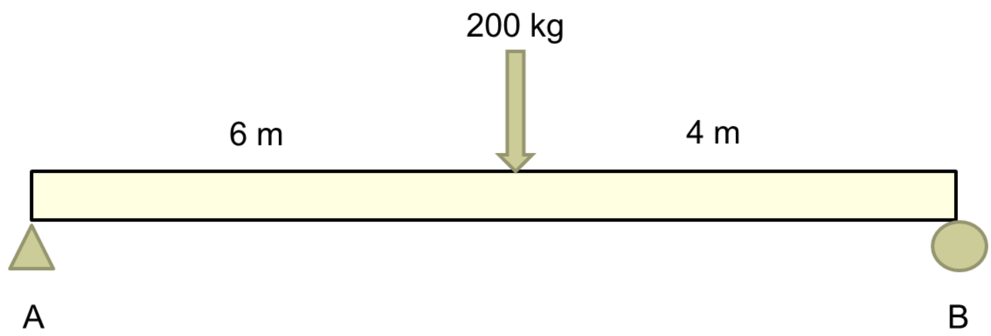
1. Drawing of FBD
2. Find external forces by static equations
3. Considering cross-section(s) calculate the Shearing force/Bending moment
4. Draw Shearing force/Bending moment diagrams

3.19 Shearing force/Bending moment diagrams

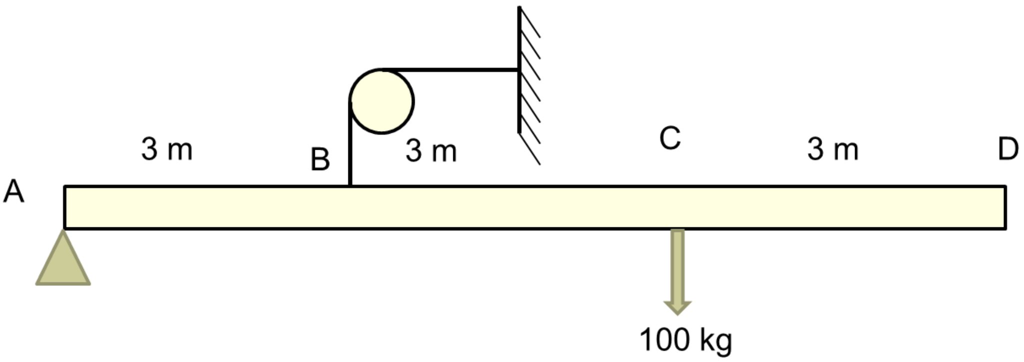
this diagram is used to show the shearing force/bending moment variation along the beam.



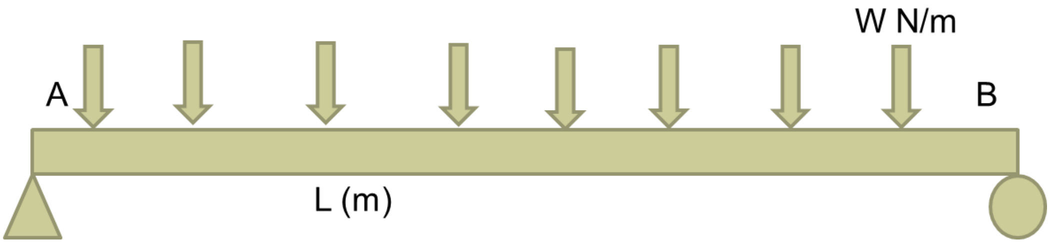
Example 3.6: Draw the shearing force and bending moment diagram***.***



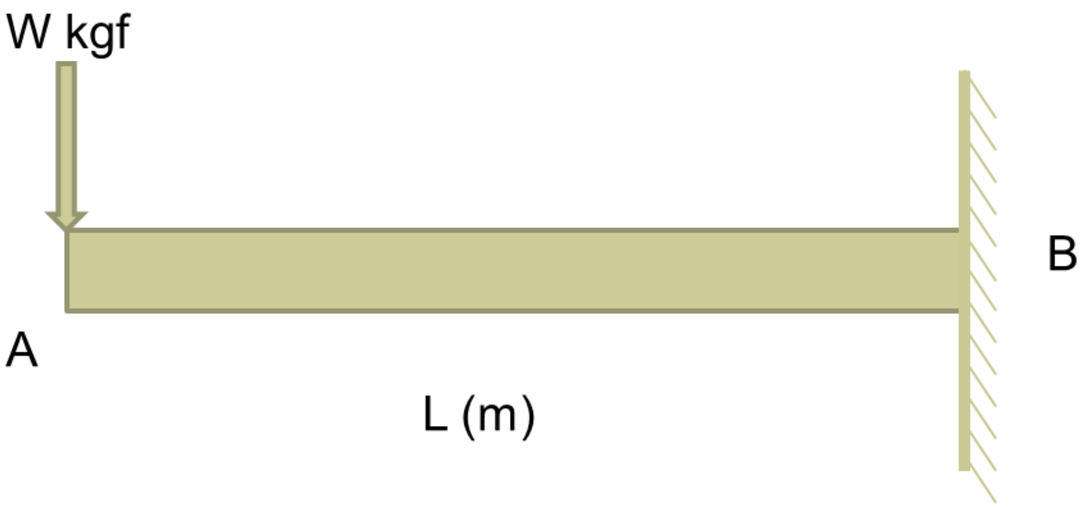
Example 3.7: Draw the shearing force and bending moment diagram.



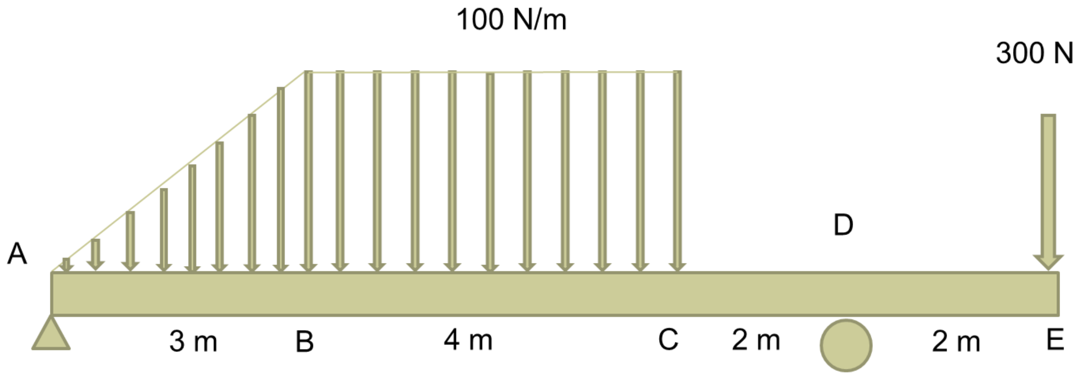
Example 3.8: Draw the shearing force and bending moment diagram.



Example 3.9: Analyze the beam



Example 3.10: Analyze this beam



4. FARM BUILDING

Farm buildings are used as; quarters, animal shades, stores/silos, milking house/slaughter house/green house

4.1 Fundamentals of Planning Farm Buildings

Following factors to be considered when planning a farm building;

- Size of the farm and the purpose of the farm building
- Relation of the buildings and placement

4.2 Site Selection for Farm Building

Factors such as; climate, direction, elevation, prospect, available facilities, services, sub soil, and water table to be considered when selecting site for the farm building.

4.3 Building material

Adoption to the environment, price of the material, accessibility are the factors to be considered when selecting building materials.

Bricks, cement, sand, stones, metal, concrete, timber, plastic, and porcelain are commonly used building materials.

Soil as a Building Material

In general soil are used to fill the foundations, make bricks, for wall building and for mud concrete etc.

lime stone as a building material

Lime stones are use as building material because its content following features; Usage, Durability, Fire resistance and External appearance.

4.3.1 Type of Bricks

Common bricks, face bricks, fire bricks and cement bricks are the commonly used bricks types.

4.3.2 Qualities of building construction materials

- Strength of material
- Durability
- Hardness
- Toughness
- Wear resistance
- Elasticity
- Workability
- Resistant to the corrosions
- Thermal properties
- Resistant to dimensional changes
- Imperviousness
- Acoustical property
- Cleaning ability

4.4 Main Parts of Farm Building

4.4.1 Foundation

The ground under the building has to bear the weight of a building. If it is weak soil, the foundations must be made stronger. If the building has more than one floor, the foundation must also be made stronger. It is better to use continuous foundations.

Materials for Foundation

Stones, metal, wood, concrete etc. are used as the foundation materials

Type of Foundation and their Usage

- Strip foundation
- Wide strip foundation
- Deep strip foundation
- Raft foundation
- Pad/column foundation
- Piled foundation

Area of the Foundation

$$\text{Area of the foundation} = \frac{\text{Column load + Weight of the foundation}}{\text{Allowable bearing pressure of the ground}}$$

4.4.2 Walls

Followings are the main function of the wall;

- To bear the weight of the roof and other stories
- Avoid the water leakages
- Maintain the inside temperature
- Sound controlling
- Fire resistant
- Give good appearance
- Give sufficient space for the doors and windows

4.4.3 Roof

Factors such as; weather resistance, durability, fire resistance, heat conduction, strength, and appearance to be considered when designing roof of farm buildings.

Selection of Roof Type

Factors such as; size and the shape of building, economy, appearance and other considerations – weather, maintenance, and accessibility to be considered when selecting a roof type.

Roofing Materials

Tile, asbestos, galvanized iron sheets, aluminum sheets are the commonly used roofing materials.

4.4.4. Floor

bear the weight of roof walls etc., avoid the leakages, to make comfort ability, supply the usable area are the functions of the floor.

Type of floor

Bricks, wooden or concrete are the commonly use floor types. Instant of that stones, floor tiles, rubber etc. are used to decorate the floor.

4.4.5 Door and window

Followings are the functions of door and window;

- Provide air and light
- To release air and sound inside of the building
- Control the entering of unnecessary sun light
- Get good appearance

4.5 Concrete

Concrete is a hard material which made from the cement, aggregates and water. Strength and quality of the concrete is depending on;

- Quality and quantity of the material
- Mixing pattern of the material
- Way of deposition and curing

Cement – Roman cement/Natural cement/Pot lend cement, aggregates and water are the main components of the concreate.

4.5.1 Cement

Roman cement

Volcanic ash + Lime stone ⟶ (▲) Roman cement

Called as hydraulic cement, because its hardening process is happened in side of water.

Natural cement

It a mixture of natural rocks and lime. This is not effective as other cements.

Pot land cement

Clay + lime stone $\xrightarrow{1500^0C}$ (▲) Clinker +Gypsum ⟶ Pot land cement

Composition of the cement

Lime	60 – 65%
Silica	10 – 25%
FeO, Fe_2O_3	2 – 4 %
Al_2O_3	5 – 10%

Instead of these, Gypsum is used to delay the hardening.

4.5.2 Aggregates

Use 66 – 78% aggregates for concrete. They are from fine sand to 6" rocks. Strength of the concrete is depending on the aggregates. There are two types of aggregates;

- Fine aggregates – diameter <¼"
- Coarse aggregates – diameter>¼"

Concrete can be made without aggregates, but it is very expensive.

Qualities of the Aggregates

- Durability
- Chemical stability
- Same compression share strength with cement
- Size of the aggregate - should be lower than the space of reinforce metal; If the smaller aggregates are used increase the relative surface area. It helps to reduce the space inside of the concrete
- handling ability of the aggregates - Using amount of aggregate is depend on the thickness of the concrete and handling ability of the aggregates

- Distribution ability of aggregates – This is very important quality which effect on the quality of the concrete and it can be determined by fines modular (2.5 – 3 good distribution).

4.5.3 Water

Water quality, quantity and the time take to mix with water are affected to the quality of the concrete.

Water quality

The water should be free from acids, oil, SO_4^- and organic matters. Therefore, drinking water is more suitable for the concrete. If there are organic and inorganic mattes, they should be lower than 200 mg/l and 300 mg/l respectively.

Water quantity

Water should be added to the concrete mixture, until it converts to the workable phase. If there is more cement, it is required more amount of water. Adding of excess water may cause separation of aggregates and cement. As well it may cause to deposit air bubbles in the concrete with affect to the strength of the concrete.

4.5.4 Mixing time

This mixing time is affected to the strength of the concrete and should be 2 minutes; however, it should not be extended up to 5 minutes. This mixing process can be done manually or using mechanical concrete mixtures. The mechanical concrete mixing is more effective for large application because it helps to quick mixing which cause the strength of the concrete.

4.5.5 Mixing rates of Concrete

***Mixture 01* –** for erodible places with bad climate conditions

(a) – for factory floor and pavements

(b) – Acidic environment

Mixture 02 – somewhat good climatic conditions, Eg: stores/tanks

Mixture 03 – good climate conditions

4.5.6 Advantages of Concrete

Highest compression strength, resistance to erosion, durability, good relationship with steel and cheap are the advantages of concreate

4.5.7 Disadvantages of concrete

Low resist to tension, shrinkage of concrete and permeable for water are the main disadvantages of concreate

4.5.8 Features of concrete

Strength

There are three types of strength; compression strength, tensile strength and shear strength. The concrete shows good compression strength. The concrete mixture; (Cement: sand: aggregate = 1:2:4) gives 280 kg/cm^2 compression strength, but average use concrete gives 157 kg/cm^2 only. The tensile strength is 10% of the compression strength. Shearing strength gives lower value as 7 kg/cm^2. It will take 5 years to become maximum strength of a concrete.

Shrinkage

This shrinkage process with time can be happened form 3 – 12 months until the mixture get equilibrium with environment. Temperature and humidity are the external factor affect for shrinkage process of concrete. However, this shrinkage should be controlled, if not the concrete may be cracked due to the tensile force. Curing process of the concrete may help to reduce the crack formation.

Hydration

This is an exothermic chemical reaction of cement with water. It is 80 cal/g for the pot land cement

Expansion

This expansion is happing due to the thermal strain. This can be controlled by reinforce of concrete by steel. Same liner thermal expansion co-efficient are shown in concrete and steel. Therefore, steel is a good reinforce material for concrete.

Liner thermal expansion co-efficient of steel $10.5 \times 10^{-6} – 11.5 \times 10^{-6}/^{0}C$

Liner thermal expansion co-efficient of concrete $9 \times 10^{-6} – 12.5 \times 10^{-6}/^{0}C$

Elasticity

Show very low elasticity values for concrete

Creep

The difference of internal movement of concrete among loading with fixed weight and free concrete is called as creep

4.5.9 Quality of the Concrete

The quality of concrete depends on three basic factors. They are; proper placement, proper finishing and proper curing

Proper Placement

There are three factors to be considered;

- Place of placement
- Method of placement
- Preparation practices

Place of Placement

The place which sand or gravel (free form organic matters) is the suitable place. The concrete frame should be enough strength with good drainage facilities to drain-off excess water. The concrete frames are made by wood, plastic sheets, metal sheet etc.

Method of Placement

Pump, conveyor belt, wheel barrows, buckets are the equipment that are used to bring mixture form mixing place to placement place. The amount of the concrete that can be deposited at one time is 6 to 18 inches. If not, aggregates are not distributed well. Otherwise, mixture should not be dropped than 3-4 ft., height.

Preparation practices

The concrete mixture should be prepared after placing on the frame to prevent the formation of large air cavity. It can be done by manually in small scale. Vibratos are using for large scale preparations.

4.5.9 Finishing of Concrete

The last phase of finishing a concrete. All surface damages are filled with filling agent.

4.5.11 Concrete Curing

Main objective of curing is; to improve the strength and impermeability of concrete. In curing process of concrete water is supplied to compensate the water requirement of hydration. The speed of the hydration process is at high speed at initially and then slows down with time. This curing process should be continued up to 28 days.

Curing Methods of Concrete

1. **Water curing -** Water is supplied to hydration by maintain a thing water layer on the concrete.
2. **Burlap/wet sack curing -** The concrete is covered by wetted gunny bags/hard cloth.
3. **Paper curing -** Concrete is covered by impermeable papers; therefore, stop the water vapor evaporation.
4. **Plastic sheeting -** concrete is covered by thin plastic layer and stop the evaporation
5. **$Cacl_2$** - $Cacl_2$ is spared on the concrete. Atmospheric water vapor is reacted with $Cacl_2$ and produce water for hydration.
6. **Steam curing -** good method, can get strength of concrete easily. Use in concrete tubing

4.5.12 Reinforce of Concrete

Steel/metal rods are used to reinforce concrete. Total surface of the reinforce material 0.8 – 8% of total surface area. Therefore, the diameter of reinforce material should be 12 mm – 5 cm.

4.6 Timber

Wood is used to made floor, roof, wall, door, window and furniture. There are two types of wood; Hard wood and soft wood

4.6.1 Physical Properties of Timber

- Density and weight
- Grain texture
- Hardness
- Tensile strength
- Stiffness
- Shock resistance

- Compression resistance
- Shear strength

4.6.2 Factors affecting for the Strength of Timber

- Moisture content – lower moisture content causes the high strength of timber
- Climate
- Insect and pest
- Cracks and damages

4.6.3 Curing of Timber

In this process, water is removed from the timber up to the equilibrium level with atmosphere (10 – 12%). It caused to increase the strength and develop resistance to decay of timber. There are two methods to curie of timber; Air method and Oven method

Air Method for Curing

In air method timber is exposed to the normal atmosphere. Take long period of time to remove water. As an example, to remove water up to 17%, it will take two years. It is very important to protect timber form direct sun light and rainfall.

Oven Method for Curing

Specially designed oven is used. Heated air is passed through the timber flanks. Relatively good curing method.

4.6.4 Weakness of Timber

- Natural weakness of tree – nodal/shakes/ bark pockets/decay/pitch pocket
- Weakness at curing process –check/ribbing/ wrap/chipped grain/torn grain
- Insect and pest attack – dry rot/wet rot

4.6.5 Wood preservation

Wood can be used for 10 – 12 years without preservation technique. With suitable preservative technique this time may be increased up to 40 - 60 years.

Wood Preservative Techniques

- Curing
- Painting
- Waxing - Paraffin
- Resins
- Toxic compound
- Put in water or muddy place
- Preserve form insects
- Preserve from fire
- Store in higher elevations
- Other methods

4.7 Load on Farm Building

There should be a resistance to bare the load which activating on the engineering structure. Because of that resistance farm structures are not change their shape for long lime period with the external forces. There are two types of loads activating on farm buildings; Dead load and Living load.

4.7.1 Dead load

The weight that created by the building materials. Most of the time it remains as constant

4.7.2 Living load

The external load on farm structures. This is changing time to time. Manmade load – can be controlled but Natural load – can't be controlled.

4.8 Structural Design

Beams and posts, trusses, arches, rigid frames, cylindrical tanks, and retaining walls are the examples for structural designs.

4.9 Road

Factors considered in road construction; Usage of the road, Land and cost.

4.9.1 Types of roads

Gravel road, concrete road and flexible road are commonly use roads types.

Gravel Road - Low cost. Suited for level surface up to 1000:3 slope

Concrete Roads - Relatively high cost. Easy to maintain

4.10 Fencing

Demarcation, control the farm animal entering and exit and grazing are the main objectives of fencing.

4.10.1 Type of fence

Close boarded fence, wooden post and rail fence, wood palisade, woven wire fence, strained line wire fence, and Electric fence are the commonly use fence types.

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