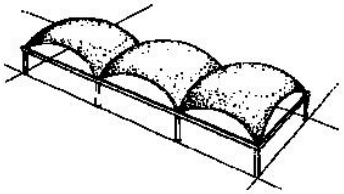
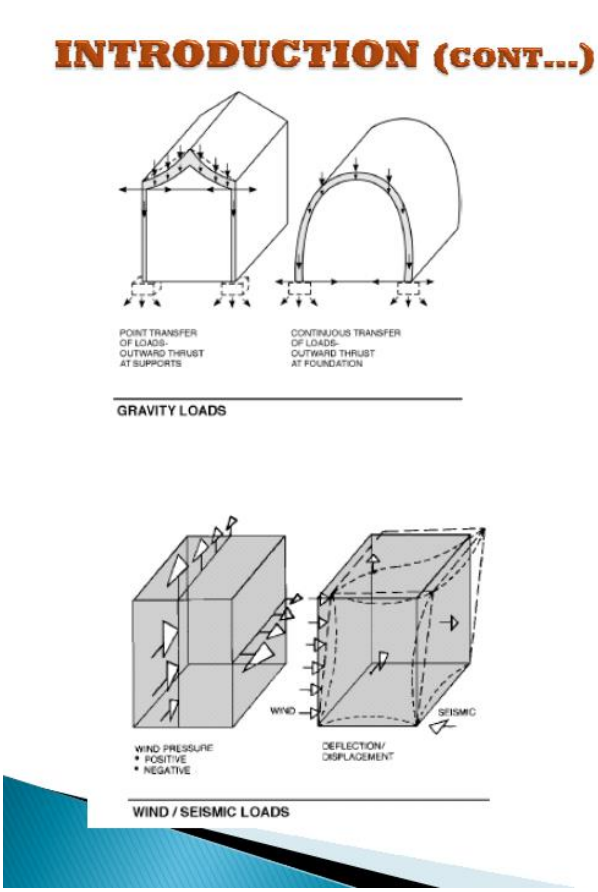


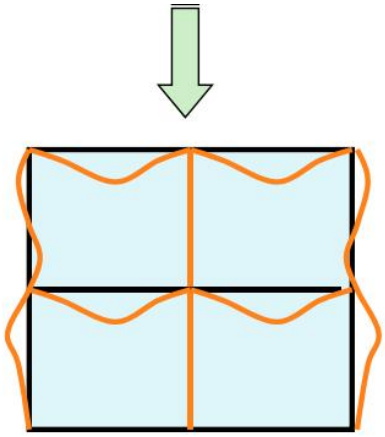
## CONTENTS



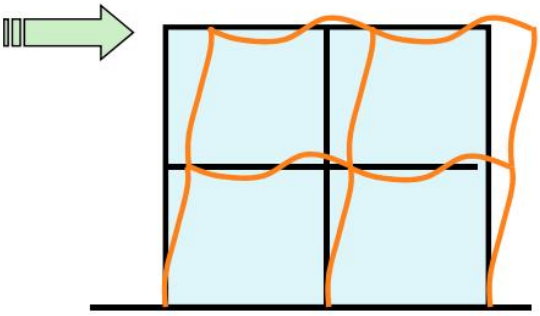
## INTRODUCTION

- Structural systems of a building support all loads and resist all constraining forces that may be reasonably expected to be imposed on them during their expected service life, with out:
  - hazard to users,
  - dangerous deformations,
  - excessive side sway (drift) or
  - annoying vibrations.
- Loads and environmental forces acting on structural systems are:
  - gravity loads
  - wind/seismic loads
  - expansion/contraction of material
  - heat and cold
  - moisture and precipitation



*Gravity Load*



*Lateral Loading*

## INTRODUCTION (CONT...)

- The structural systems could be either concrete, steel, timber, prefabricated element or a combination.
- The selection of the appropriate structural system or combination of systems depends on:
  - Soil conditions
  - The program and concept (function of a building)
  - Applicable codes
  - Type of building
  - Material delivery and construction timing
  - Local construction capabilities and preferences
  - Ease of construction and schedule
  - Cost of the selected system
  - Cost impact on other systems
  - Appearance and aesthetic potential

## REINFORCED CONCRETE STRUCTURE (CONT...)

### Classification based on density

| Classification of concrete based on density | |
|---|---|
| **Classification** | **Density ($Kg/m^3$)** |
| Normal-weight concrete | 2400 |
| Light weight concrete | 1800 |
| Heavy weight concrete | 3200 |

### Classification based on strength

| Classification based on strength | | |
|---|---|---|
| **Classification** | **Maximum strength** | **Type** |
| Ordinary concrete | < 20 | Low-strength |
| Standard concrete | 20-40 | Medium-strength |
| High-strength concrete | 40-80 | High-strength |

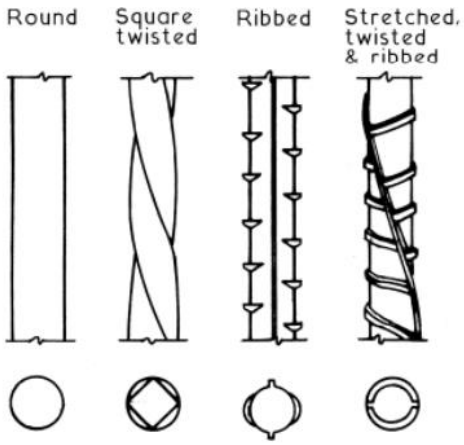
# REINFORCED CONCRETE STRUCTURE (CONT...)

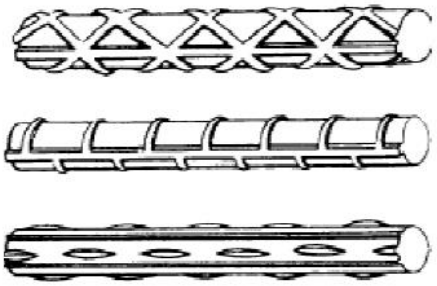
## Advantages and disadvantages of concrete structures

| Advantages | Disadvantages |
| --- | --- |
| • High compressive strength<br>• High stiffness (rigidity)<br>• Ability to be cast<br>• Low thermal and electrical conductivity<br>• Economical<br>• Durable<br>• Fire resistant<br>• Energy-efficient<br>• Onsite fabrication<br>• Aesthetic properties | • Low tensile strength<br>• Limited ductility<br>• Little resistance to cracking<br>• Volume instability<br>• Low strength to weight ratio<br>• Forms and shoring |

## REINFORCED CONCRETE STRUCTURE (CONT...)

- **Reinforced concrete** (**RCC**) is a concrete in which steel reinforcement bars have been incorporated to eliminate the major weakness of concrete (**tensile strength**).
- The number, diameter, spacing, shape and type of bars to be used have to be designed.



## REINFORCED CONCRETE STRUCTURE (CONT...)

### REINFORCED CONCRETE STRUCTURAL MEMBERS

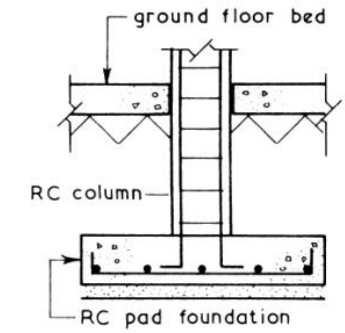
- A reinforced concrete structure is made up of many types of reinforced structural members, including:
  - ✓ **footings**,
  - ✓ **columns**,
  - ✓ **beams**,
  - ✓ **slabs**,
  - ✓ **walls**, and so forth

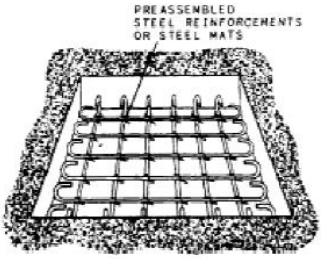
### FOOTINGS

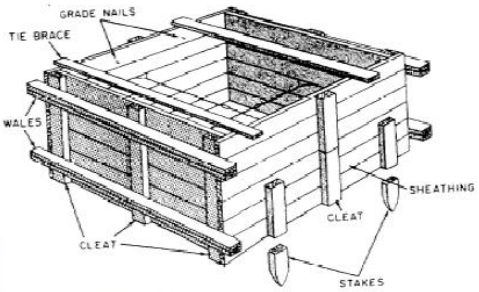
- Footings support the entire structure and distribute the load to the ground.
- The size and shape of a footing depend upon the design of the structure.

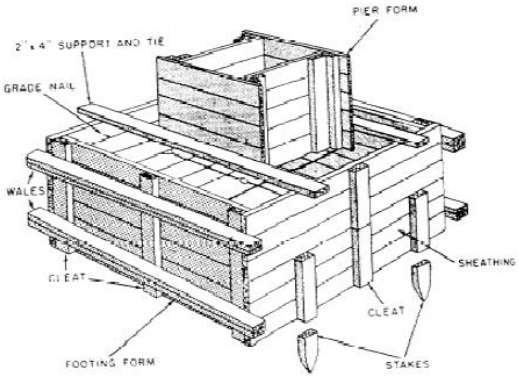
# REINFORCED CONCRETE STRUCTURE (CONT...)

## FOOTINGS (CONT...)



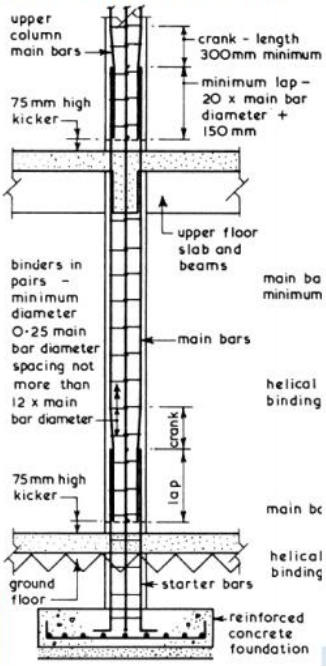



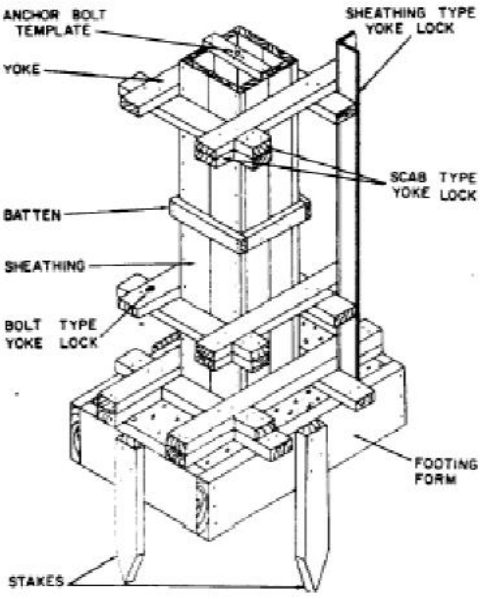




# REINFORCED CONCRETE STRUCTURE (CONT...)

## COLUMNS

- These are the vertical load bearing members of the structural frame which transmits the beam loads down to the foundations.

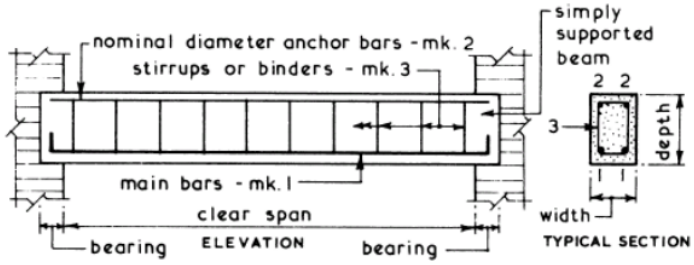


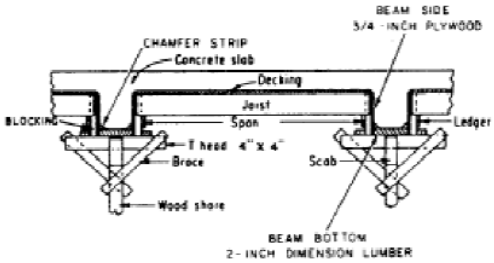



# REINFORCED CONCRETE STRUCTURE (CONT...)

## BEAMS

- These are horizontal load bearing members which are classified as either
  - **Main beams** which transmit floor and secondary beam loads to the columns or
  - **Secondary beams** which transmit floor loads to the main beams.

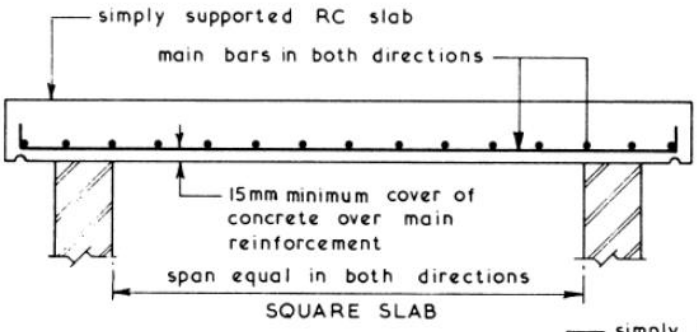


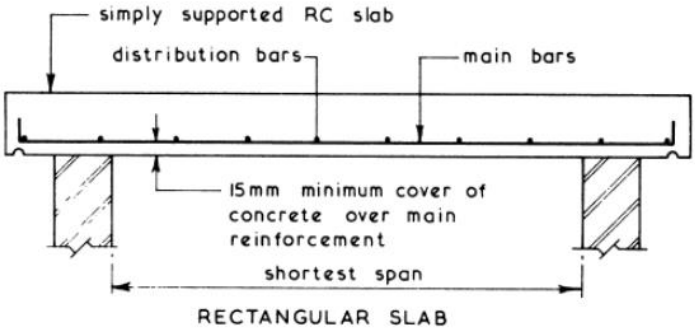




# REINFORCED CONCRETE STRUCTURE (CONT...)

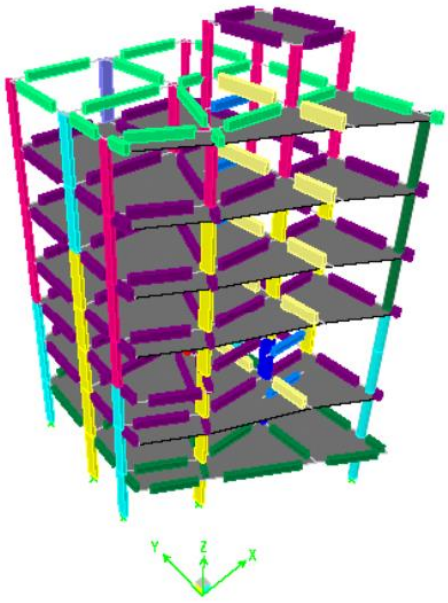
## SLABS

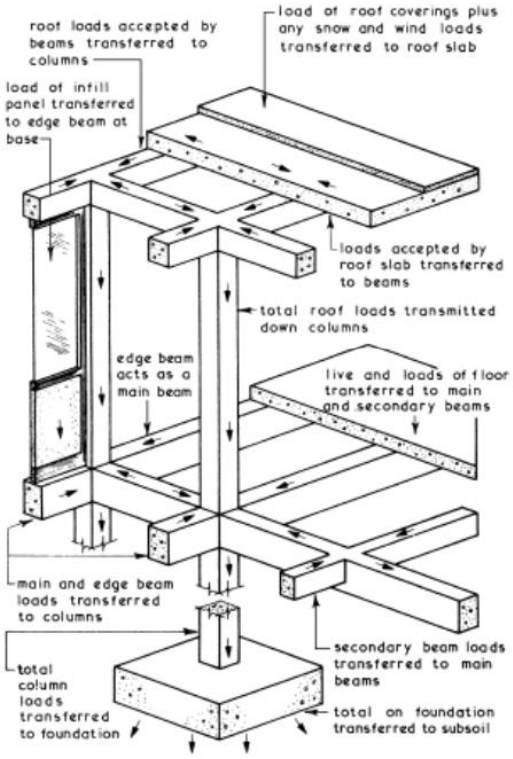
- Carry the live loads of the building and transfer them to the beams.



## REINFORCED CONCRETE STRUCTURE (CONT...)



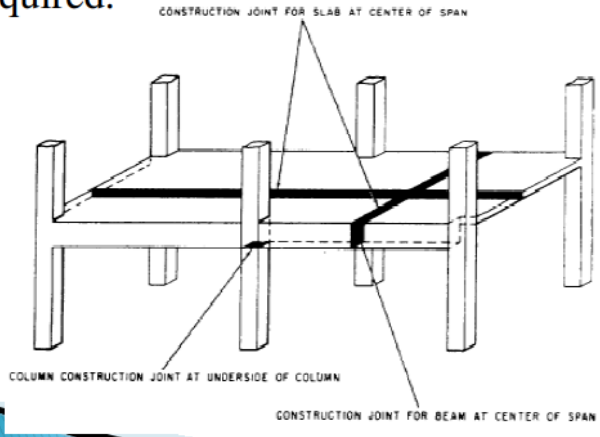


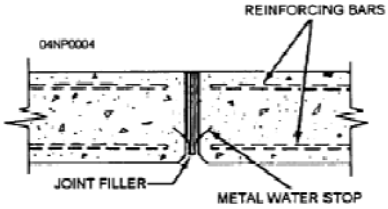

## REINFORCED CONCRETE STRUCTURE (CONT...)

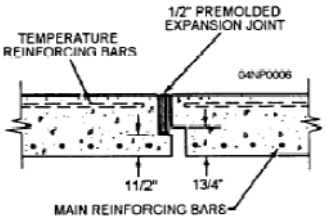
### JOINTS IN CONCRETE STRUCTURES

**Contraction joints**: the purpose of contraction joints is to control cracking caused by temperature changes.

**Expansion joints**: Wherever expansion might cause a concrete slab to buckle because of temperature change, expansion joints are required.



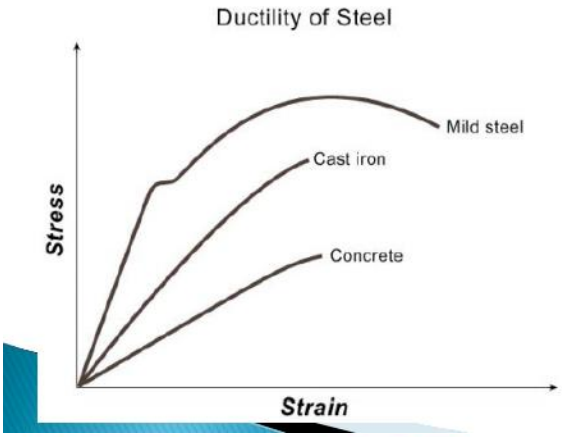



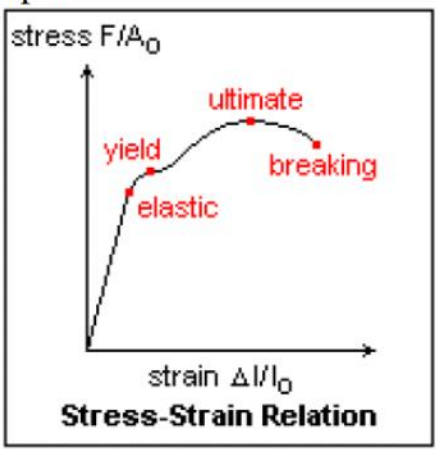



# STEEL STRUCTURE

## INTRODUCTION

- Steel has the maximum number of properties which are not found in any other materials.
  - ✓ High tensile and compressive strength
  - ✓ Ability to deform plastically with out damage
  - ✓ Can be easily welded, forged and riveted
  - ✓ Large displacement before collapse



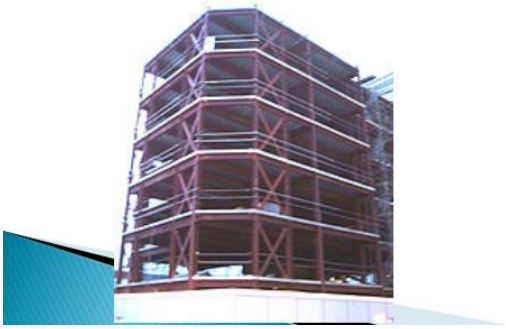

# STEEL STRUCTURE (CONT...)

## INTRODUCTION (cont...)

- Steel is the only material which is equally strong both in tension and compression.
- Steel is suitable for all construction purposes in the present day practice.
  - Steel bars are used as reinforcement
  - Construction of steel bridges
  - Construction of buildings
    - Skeleton construction
    - Long span construction
  - Erection of towers, etc
- The construction of a framework of structural steel involves two principal operation: **fabrication** and **erection**.

## STEEL STRUCTURE (CONT...)

### INTRODUCTION (cont...)

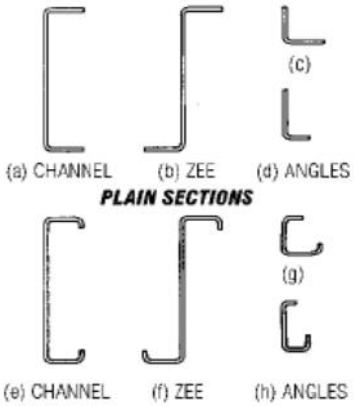


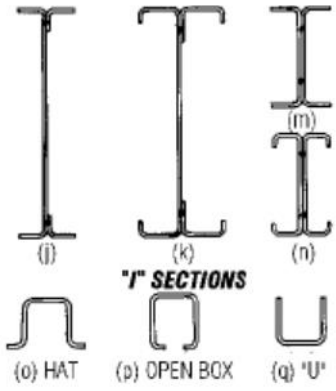
## STEEL STRUCTURE (CONT...)

### STEEL SECTIONS

**Cold rolled sections:** Cold-formed shapes are relatively thin sections made by bending sheet or strip steel in roll-forming machines, press brakes, or bending brakes.

- Door and window frames, partitions, wall studs, floor joists, sheathing, and moldings are made by cold forming.

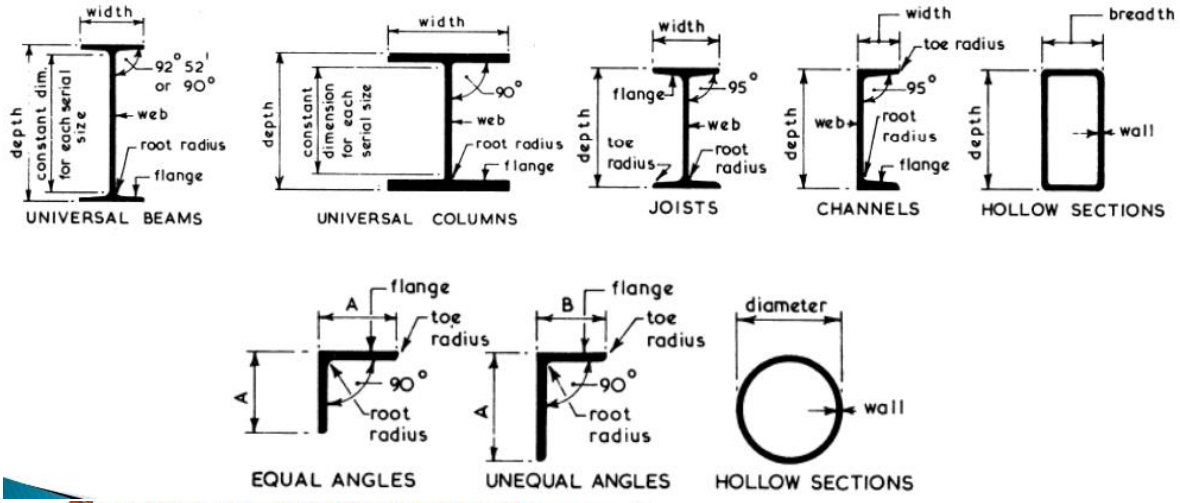


# STEEL STRUCTURE (CONT...)

## STEEL SECTIONS (cont...)

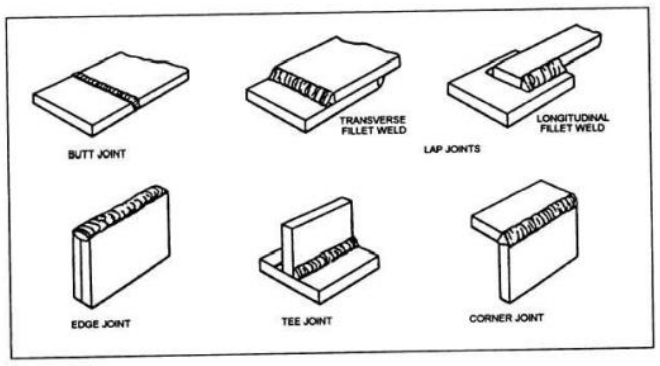
**Hot rolled sections:** these are structural steel available in wide range of size, shape and weight.



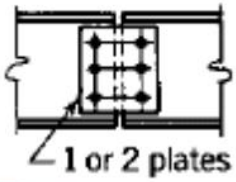

# STEEL STRUCTURE (CONT...)

## STRUCTURAL STEEL CONNECTORS

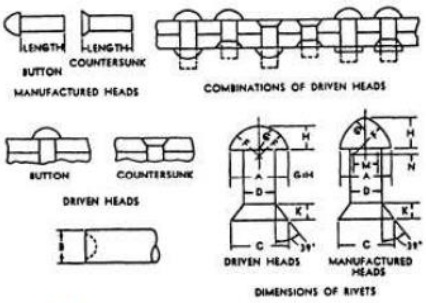
- There are four basic connectors used in making structural steel connections. They are **bolts**, **welds**, **pins**, and **rivets**.



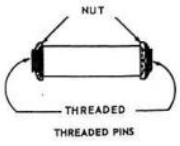

Welding

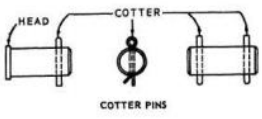



Bolts




Rivets




Pins

# STEEL STRUCTURE (CONT...)

## Advantages and disadvantages of steel structures

| Advantages | Disadvantages |
|---|---|
| • High strength to weight ratio<br>• Non-combustible<br>• Recyclable<br>• Consistent material quality<br>• Safety: offers greater protection<br>• Flexibility<br>• Inorganic: will not, warp, split, creep, crack<br>• Dimensional stability<br>• Straight walls, corners<br>• Speedy construction | • Energy intensive material<br>• Susceptible to rust and corrosion<br>• Requires fire proofing<br>• Highly conductive<br>• Emission of gases during production<br>• Extra cost for protective coating |

# TIMBER STRUCTURE

## INTRODUCTION

- Wood has always been a very good construction material since olden times. And it is steel used extensively for construction purpose, railways, furniture, formwork, miscellaneous articles, transportation.

- Wood that is suitable for structural work is called timber. It can be used as:
  - Beams, joists and rafters
  - Studs and posts
  - Girders
  - Trusses
  - Decking
  - Piles
  - Structural laminated members

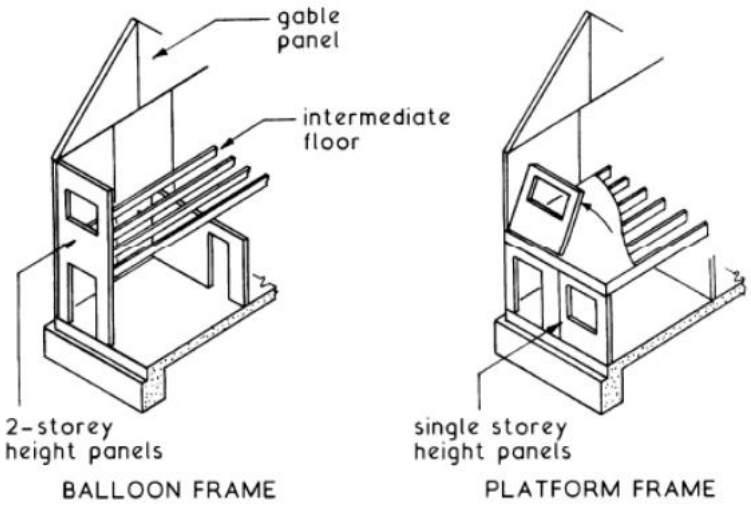
- The qualities of timber depend upon:
  - Type of tree
  - Maturity of tree
  - Time of felling
  - Method of seasoning
  - Type and process of preservation

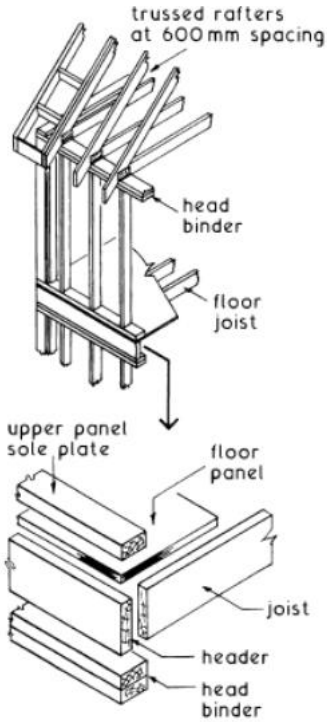
## TIMBER STRUCTURE (CONT...)

### Structural uses of timber

## TIMBER STRUCTURE (CONT...)

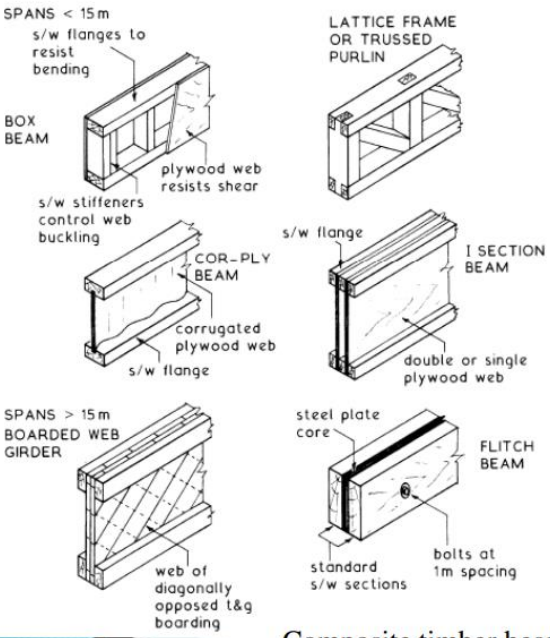
### Timber frame construction



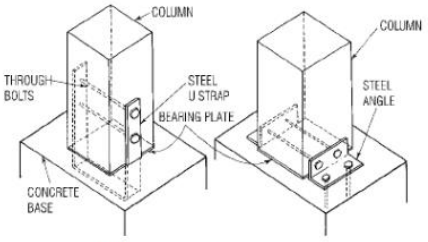



## TIMBER STRUCTURE (CONT...)

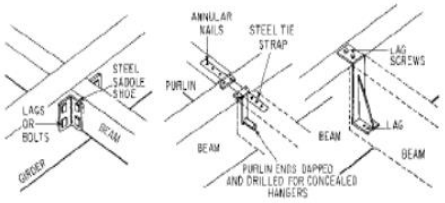
### Timber frame construction




Composite timber beams




Column to base connection




Beam to beam connection

## TIMBER STRUCTURE (CONT...)

### Advantages and disadvantages of timber structures

| Advantages | Disadvantages |
|---|---|
| • Quick erection time<br>• Reduced site labour<br>• Reduced construction waste<br>• Easily converted to any shape<br>• Economical and cheap<br>• High strength to weight ratio<br>• Light weight structural members<br>• Easy alteration and repairs<br>• Energy efficient in its production<br>• Non conductor of heat and sound | • Additional design and engineering time<br>• Susceptible to decay<br>• Very likely to warp and crack<br>• Not fire resistant<br>• Requires regular maintenance<br>• Lack of experience of following trades |

# PREFABRICATED BUILDING SYSTEMS

## INTRODUCTION

- Prefabrication may be in general terms defined as a continuity of production implying:
  - A steady flow of demands
  - Standardization
  - Integration of different stages of production
  - High degree of organization of work
  - Mechanization to replace manual labour
- The prefabrication practice have advantages with respect to **cost**, **time**, **quality**, **safety** and **environment**.
- Types of prefabrication approach:
  - Fully Pre-fabricated Construction Method
  - Partially pre-fabricated Construction Method
  - Prefabrication of elements of the construction

# PREFABRICATED BUILDING SYSTEMS (CONT...)

## Precast structural elements

# PREFABRICATED BUILDING SYSTEMS (CONT...)

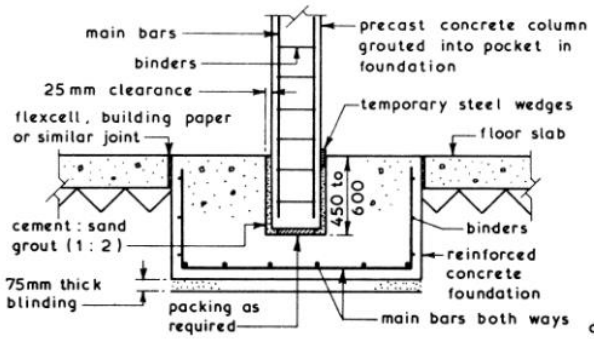
## Precast structural elements

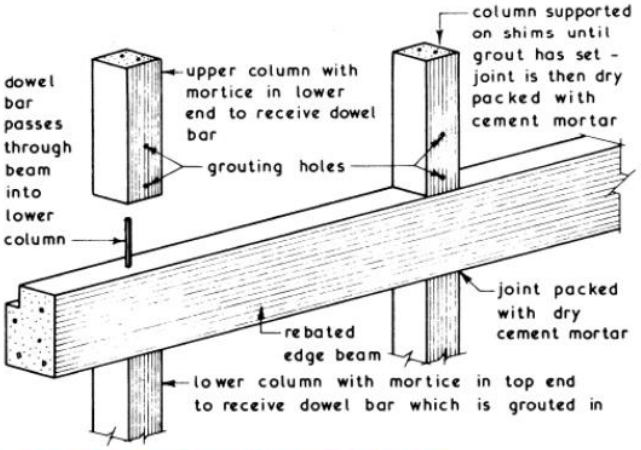
# PREFABRICATED BUILDING SYSTEMS (CONT...)

## Precast concrete buildings in Addis Ababa

# PREFABRICATED BUILDING SYSTEMS (CONT...)

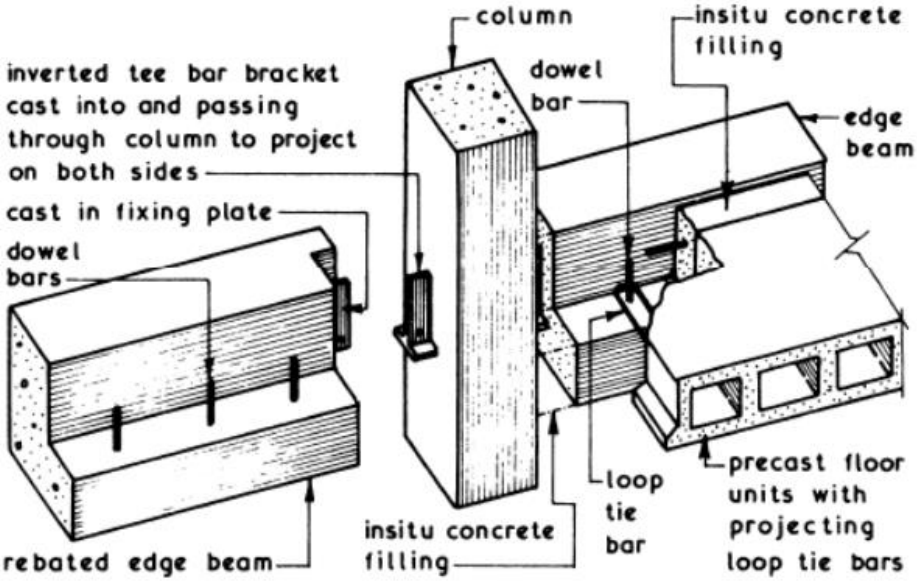
## Connections in precast concrete structures




# PREFABRICATED BUILDING SYSTEMS (CONT...)

## Connections in precast concrete structures (cont...)



# REINFORCED CONCRETE STRUCTURE

- Concrete is a product obtained artificially by hardening of the mixture of
  i. binding material (cement),
  ii. fine aggregate (sand),
  iii. coarse aggregate (gravel), and
  iv. water, in predetermined proportions.
- The property of concrete depend on the characteristic of the ingredients and the proportion of the mix.
- In mix proportioning **workability**, **strength**, **durability** and **economy** should be taken into consideration.
- Concrete works are classified as:
  - **Class I** - works under the direction of qualified supervisor
  - **Class II** – works with lower level of quality

# PREFABRICATED BUILDING SYSTEMS (CONT...)

## Advantages and disadvantages of precast concrete

| Advantages | Disadvantages |
|---|---|
| • More time efficient<br>• Ensures high quality<br>• Better cost savings<br>• safety<br>• Lower maintenance cost<br>• Erection at every weather condition<br>• Less formwork<br>• Early return of the investment<br>• Less wet work at the site<br>• Better fire protection | • Very heavy members<br>• Problems at connections<br>• Requirements for lifting device<br>• Limited building design flexibility<br>• Accommodation for last minute change<br>• Additional reinforcements for handling<br>• Transportation cost |

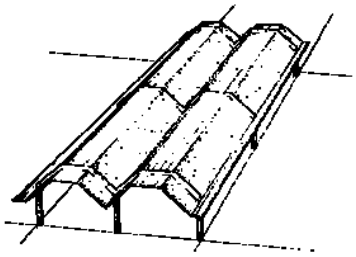
# SHELL AND DOME STRUCTURES

## Shells

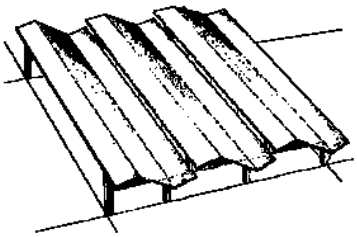
- A shell is structural curved skin covering a given plan shape and area where the forces in the shell or membrane are compressive and in the restraining edge beams are tensile.
- The main factors of shell roofs are:
  - The entire roof is a structural element
  - Basic strength is inherent in its geometrical shape and form
  - Comparatively less material is required than other forms of roof structure
- Advantages:
  - The curved shapes are naturally strong structures
  - Allow wide areas to be spanned
  - No use of internal supports
  - Gives an open and unobstructed space
  - Ideally suited for architectural applications

# SHELL AND DOME STRUCTURES (CONT…)

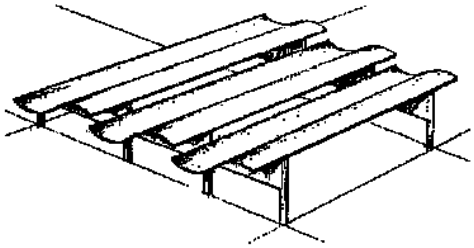
## Types of shell structures



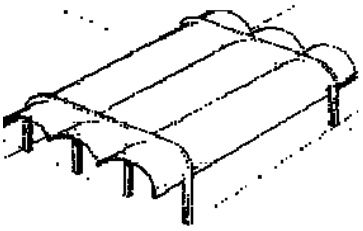
folded plates



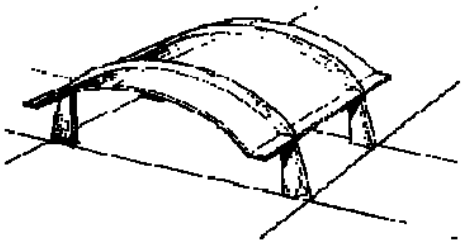
Z shell



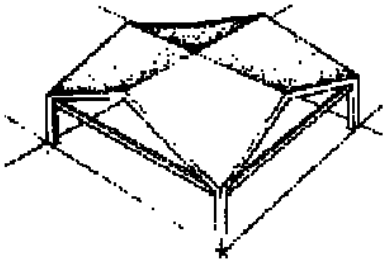
The lazy S



Barrel shells



Short shells



Hyperbolic parabolic

# SHELL AND DOME STRUCTURES (CONT...)

## Shell structures

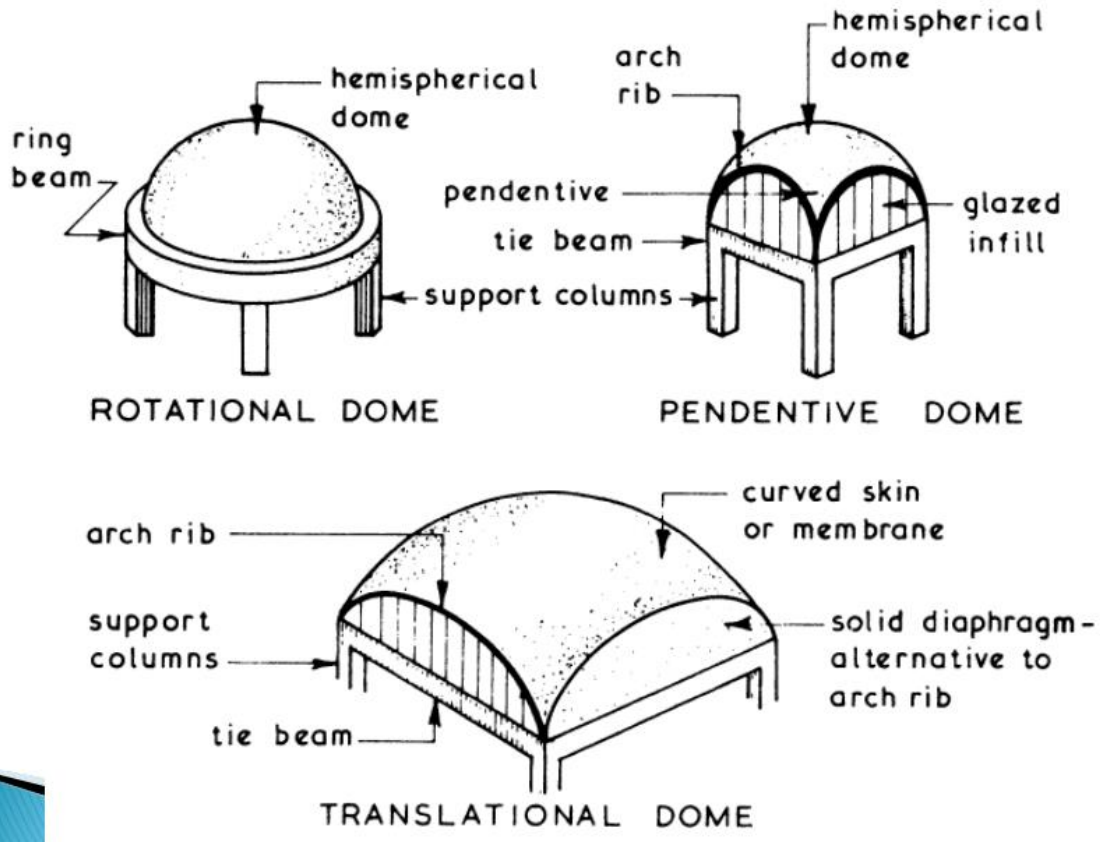
# SHELL AND DOME STRUCTURES (CONT...)

## DOMES

- Domes are double curvature shells which can be rotationally formed by any curved geometrical plane figure rotating about a central vertical axis.
- These are shells curved in two directions. They are one of the oldest types of construction.
- Advantages:
  - They are completely span-free
  - Have high ratio of thickness to span
  - Aesthetically very pleasing
  - Virtually any size and number of openings are possible
  - excellent for athletic facilities, schools, auditoriums, churches, convention halls, museums etc.

# SHELL AND DOME STRUCTURES (CONT...)

## Types of dome structures



# SHELL AND DOME STRUCTURES (CONT...)

## Dome structures