LECTURES NOTE

ADVANCED CONSTRUCTION TECHNIQUES & EQUIPMENT

6th SEMESTER

DIPLOMA (CIVIL ENGINEERING)

Sri. Aditya Ranjan Patra

DEPARTMENT OF CIVIL ENGINEERING

BHUBANANANDA ORISSA SCHOOL OF ENGINEERING, CUTTACK

Gmail: patra.aditya134@gmail.com

Th 3. ADVANCED CONSTRUCTION TECHNIQUES & EQUIPMENT

Name of the Course: Diploma in Civil Engineering			
Course code:		Semester	6th
Total Period:	60	Examination	3 hrs
Theory periods:	4P/week	Class Test:	20
Maximum marks:	100	End Semester Examination:	80

A. RATIONALE

Current age construction industry is adopting state of art materials and technologies to improve aesthetics, strength, earthquake resistance, services relating to civil construction. The course will help the student to develop a general awareness on these advancements.

B. COURSE OBJECTIVES

On completion of the course students will be able to-

1. Select proper material during construction in domain of advanced materials including fibers, artificial timbers etc.
2. Select appropriate prefabrications in pursuance of standard codes
3. Adopt structural requirements and possible retrofits to improve earthquake resistance
4. Comprehend requirement of various services need to be operational
5. Understand the role of different construction earth moving equipments and select during planning
6. Comprehend necessity of soil reinforcing and prescribe appropriate strategy

C. TOPIC WISE DISTRIBUTION

Chapter	Name of topics	Hours
1	Advanced construction materials	10
2	Prefabrication	08
3	Earthquake Resistant Construction	08
4	Retrofitting of Structures	08
5	Building Services	08
6	Construction and earth moving equipments	10
7	Soil reinforcing techniques	08

D. COURSE CONTENT

1 Advanced construction materials

1.1 Fibers and Plastics-

Types of fibers- Steel, Carbon, glass fibers, Use of fibers as construction material, properties of Fibers.

Types of plastics- PVC, RPVC, HDPE, FRP, GRP etc. Colored plastic sheets.

Use of plastic as construction material.

1.2 Artificial Timbers – Properties and uses of artificial timber. Types of artificial timber available in market, strength of artificial timber.

1.3 Miscellaneous materials – Properties and uses of acoustics materials, wall claddings, plaster boards, micro-silica, artificial sand, bonding agents, adhesives etc.

2 Prefabrication

2.1 Introduction, necessity and scope of prefabrication of buildings, history of prefabrication, current uses of prefabrication , types of prefabricated systems, classification of prefabrication, advantages and disadvantages of prefabrication,

2.2 The theory and process of prefabrication, design principle of prefabricated systems, types of prefabricated elements, modular coordination

2.3 Indian standard recommendation for modular planning.

3 Earthquake Resistant Construction

3.1 Building Configuration

3.2 Lateral Load resisting structures

3.3 Building characteristics

3.4 Effect of structural irregularities-vertical irregularities, plan configuration problems.

3.5 Safety consideration during additional construction and alteration of existing Buildings.

3.6 Additional strengthening measures in masonry building-corner reinforcement, lintel band, sill band, plinth band, roof band, gable band etc.

4 Retrofitting of Structures

4.1 Seismic retrofitting of reinforced concrete buildings :

4.2 -Sources of weakness in RC frame building

4.3 -Classification of retrofitting techniques and their uses

5 Building Services

5.1 Cold Water Distribution in high rise building, lay out of installation

5.2 Hot water supply – General principles for central plants-layout

5.3 Sanitation –soil and waste water installation in high rise buildings

5.4 Electrical services – i) requirements in high rise buildings ii) Layout of wiring - types of wiring iii) Fuses and their types iv)Earthing and their uses

5.5 Lighting – Requirement of lighting, Measurement of light intensity

5.6 Ventilation - Methods of ventilation (Natural and artificial Systems of ventilation) problems on ventilation

5.7 Mechanical Services- Lifts, Escalator, Elevators – types and uses.

6 Construction and earth moving equipments –

6.1 Planning and selection of construction equipments

6.2 Study on earth moving equipments like drag line, tractor, bulldozer, Power shovel

6.3 Study and uses of compacting equipments like tamping rollers, Smooth wheel rollers, Pneumatic tired rollers and vibrating compactors

6.4 Owning and operating cost – problems

7 Soil reinforcing techniques

7.1 Necessity of soil reinforcing.

7.2 Use wire mesh and geo-synthetics.

7.3 Strengthening of embankments, Slope stabilization in cutting and embankments by soil reinforcing techniques.

E. Syllabus Coverage up to Internal Assessment: Chapters 1, 2, 3, 4

F. RECOMMENDED BOOKS

Sl. No	Name of Authors	Titles of Book	Name of Publisher
1	Agrawal & Shrikhande	Earthquake Resistant Design of Structures	Prentice-Hall of India Pvt. Ltd.
2	Swami Saran	Reinforced Soil and its Engineering applications	I.K.International Pvt. Ltd.
3	National building code of India_ BIS		
4	Fred & Greeno	Building Services Hand book	Routledge Publisher
5	B.L. Gupta & Amit Gupta	Construction Management & Machinery Limit	Standard Publishers
6	S.K. Duggal,	Earthquake resistant design of structures	Oxford
7	M.R. Samal	Advance Construction and Equipment	Platinum Publisher,Kolkata
8	Hand book on repair & rehabilitation of RCC buildings- CPWD		

ACTE

1 ADVANCE CONSTRUCTION MATERIAL

1.1 Fibers and Plastics –

Fibers -Fibers are thin filaments of materials of varying strength and physical properties used in different engineering applications. These may be of natural origin or artificially manufactured with desirable properties or required characteristics. Steel, carbon, glass fibers and synthetic fibers such as polypropylene fibers, fiber composites are in common use now-a-days.

Types of Fibers –

Steel fibers - Steel fibers are short, discrete lengths of steel with an aspect ratio from about 20 to 100 and with any one of several cross sections. Some steel fibers have hooked ends to improve resistance to pull out from a cement-based matrix. Various types of steel fibers like Hooked-end steel fibers, round steel fibers and flat crimped steel fibers etc. Round steel fibers are basically used which diameter may be vary from 0.25 to 0.75 mm. It is used in overlays of roads, airfield pavements etc.

Advantages of steel fibers -

(a) It is user-friendly for handling and faster in application.
(b) There is considerable saving of material when used as fiber.
(c) It results in excellent ductility and durability.
(d) Use of fiber leads to less rebound and voids.
(e) It gives rise to safer working environment.
(f) It exhibits consistent strength at all temperatures.

Carbon fibers - Carbon fibers are a type of high-performance artificial fiber available for engineering application. They are also called graphite fiber or carbon graphite. Carbon fibers are organic polymers, characterized by long strings of molecules bound together by carbon atoms in the form of crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio. Carbon filaments are typically between 5 and 8 microns in diameter and are combined into tows containing between 3000 to 12000 filaments. The tows are twisted into yarns and woven into fabrics. Carbon fibers have high tensile strength and are very strong for their size. In fact, carbon fiber might be the strongest material having very high elastic modulus and fatigue strength compared to other artificial fibers. Carbon fibers are twice as stiff as steel and five times as strong as steel (per unit weight) used in civil engineering, aerospace industry, sporting goods, military, medical appliances, automobile industry.

Advantages of carbon fibers -

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion make them very suitable for engineering, military and sports use. The following are the main advantages of carbon fibers as a construction material.
(i)They have high specific strength, i.e., strength-to-weight ratio that makes it possible to build higher components.
(ii) They have high value of rigidity or stiffness.
(iii) Carbon fiber is corrosion resistant and chemically stable.
(iv) They are fire resistant and chemically inert.
(v) They are electrically conductive.
(vi) Carbon fiber has good tensile strength or high ultimate strength.
(vii) Carbon fiber reinforced plastic is over 4 times stiffer than glass reinforced plastic.
(viii) Low coefficient of thermal expansion of carbon fibers makes them suitable for applications where small movements can be critical such as telescope and other optical machines.

Glass fibers - Glass fiber is also otherwise known as fiber-glass. It is a material made from extremely fine fiber of glass. Fiber glass is a light-weight, extremely strong and robust material. Although, its strength properties are

somewhat lower than those of carbon fiber; being less stiff and typically far less brittle, the raw materials are much less expensive too. As compared to metals, its bulk strength and weight properties are also very favorable and it can be easily formed using molding processes.

Advantages of glass fibers -

(i) Its high strength and lightweight property render a favorable strength-to-weight ratio.
(ii) It is corrosion resistant and chemically inert resulting in increased life span.
(iii) Its dimensional stability characteristic makes it suitable for use in precision equipment's.
(iv) It can be easily assembled and its low maintenance cost makes it economical.
(v) It is fire resistant and so it is used in firefighting jackets.
(vi) It being transparent, finds its use in optical and construction fields.
(vii) Both electrical and magnetic non-conductive characteristic makes it amenable for in measuring instruments.

Polypropylene fiber - Of the synthetic fibers, the important ones for upgrading cements and mortars or for use reinforced earth situations are polypropylene, polyethylene, polyester and polyamide. The first two are utilized in the manufacture of cement/ mortar composites; but all are used geosynthetics, especially to form geotextiles and geogrids. Synthetic fibers are the only one that can be engineered chemically, physically and mechanically to suit specific geotechnic engineering applications. Use of Polypropylene (PP) Fiber as a Construction Material Polypropylene fiber finds wide application in the diverse field of engineering. When added to cement mortar, it can be advantageously used in a variety of applications, like cement rendering. stucco work, texture coating, machinery base bedding, tunnel lining, low-cost housing, water tank and reservoir construction, mold filling (blocks, panels, architectural profiles etc.), slab jacketing (sunken floors, roads etc.), swimming pool finishing, creation of artificial park etc.

Advantages of Polypropylene Fibers -

(i) High specific strength.
(ii) Non-absorption of moisture.
(iii) High chemical resistance: It has excellent chemical resistance, being resistant to most acids and alkalis.
(iv) Low thermal conductivity: The thermal conductivity of polypropylene fibers is lower than that of other fibers and may be used in applications as thermal wear.

Plastics –Plastic is the generic name for a family of synthetic materials derived from petrochemicals, often is a product of two or more compounds. plastic is a material consisting of any of a wide range d synthetic or semi-synthetic organic that are malleable and can be molded into solid object of diverse shapes through industrial process involving heat and pressure. Due to their relatively low cost, ease of manufacture, versatility and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spacecraft. They have already displaced many traditional materials such as wood, stone, leather, paper, metal, glass and ceramic, in most of their former uses. Classification of Plastics can be classified based on their thermal behavior, structure or physical and mechanical properties. According to behavior with respect to heating, plastics divided into two groups**. *(I) Thermoplastic plastic (II) Thermosetting plastic***

Polyvinyl Chloride (PVC) - Polyvinyl chloride, commonly abbreviated as PVC, is a general purpose, strong but lightweight plastic used in construction. Like all other plastics its features are determined by its chemical composition and the type of molecular structure. Generally, PVC has an amorphous structure with polar chloride atoms in the molecular structure; both the features being inseparably related. PVC is made from petroleum. Polyvinyl chloride is produced by polymerization of the vinyl chloride monomer (VCM). PVC's relatively low cost, biological and chemical resistance and workability have resulted in it being used for a wide variety of applications. It is used for pipe applications where the cost and vulnerability to corrosion limit the use of metals.

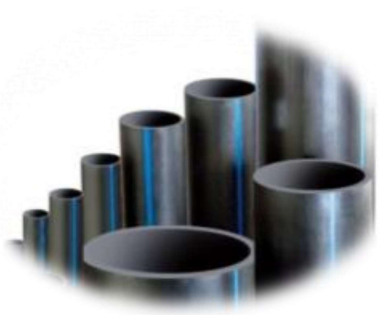
Application of PVC –

Flexible tubing, Electrical cable insulation, Containment membrane, Toys and novelties, Protective gloves and clothing, Fabrics, Automotive industry, Electrical insulating tapes.

Properties - The mechanical properties improve with the increasing molecular weight but decease with the increase in temperature. The elastic modulus of flexible PVC is 1.5 to 15 MPa.

PVC

RPVC



HDPE

Rigid Polyvinyl Chloride (RPVC) - Rigid polyvinyl chloride (RPVC) is a thermoplastic produced by chlorination of polyvinyl chloride (PVC) resin. It is significantly more flexible and can withstand higher temperatures than standard PVC. Its primary uses include hot and cold-water pipes and industrial liquid handling. When using RPVC, little waste is generated, especially when compared to materials used in disposable product applications. RPVC is a lightweight yet strong material based on the relatively low petroleum content, and is produced using a high energy-efficient process. Therefore, the need for non-renewable energy sources (such as oil and coal) is low compared to the need when using traditional materials such as polyethylene (PE), polypropylene (PP), polybutylene (PB), copper and steel etc.

Application of RPVC –

An extensive market for chlorinated PVC is there for use in office building, apartment and condominium fire protection. RPVC shares most of the features and properties of PVC. It is also readily workable, including machining, welding and forming.

Properties –

RPVC is ideally suited for self-supporting constructions where temperatures up to 200°F (90°C) are present. Due to its specific composition, dealing with RPVC requires.

High density polyethylene (HDPE) - High-density polyethylene (HDPE), or polythene high-density (PEHD), is a polyethylene thermo- plastic made from petroleum. It is sometimes called "alkathene" when used for pipes. A linear polymer, HDPE is prepared from ethylene by a catalytic process. The very absence of branching in molecules results in a more closely packed structure with a higher density and somewhat higher chemical resistance than LDPE or ordinary polyethylene. High density polyethylene is also somewhat harder and opaquer and it can withstand rather higher temperatures (120°C for short periods and 110°C continuously). It also lends itself particularly well to blow molding. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping.

Properties –

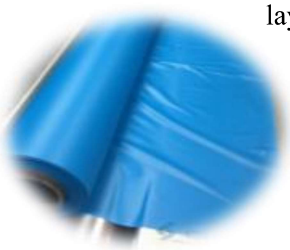
HDPE is known for its large strength-to-density ratio. The density of HDPE can range from 0.93 to 0.97 g/cm^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene. The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample and to some degree on the international standardized testing methods employed to identify these properties for a specific process. It has good impact and wears resistances & being flexible it can have very high elongation before breaking. Generally, HDPE has good chemical resistance, Toughness quality of HDPE is also very good, and HDPE has good process ability.

Fiber reinforced plastic (FRP) - Fiber reinforced plastic (FRP), also called fiber-reinforced polymer is a composite material made up of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, although other fibers such as paper, wood or asbestos etc., have been used rarely. This FRP is a specific type of two-component composite material consisting of high strength fibers embedded in a polymer matrix with or without fillers to produce a bulk material having properties better than those of individual base materials. Fiber-reinforced plastics have found extensive use in aerospace automobile and marine industries during the past few decades due to their excellent engineering properties such as high specific strength and stiffness, lower density, high fatigue

endurance, high damping and low thermal expansion. FRP materials are being used for strengthening of concrete bridge girders by bonding them to the tension face of the girder as well as for the retrofitting of concrete columns. FRPs are available in the form of rods, grids, sheets and winding strands.

Glass Reinforced Plastic (GRP) - Glass reinforced plastic (GRP) is a type of fiber reinforced plastic or composite material of polymer where the reinforcement fiber is specially glass fiber. It is also known as glass fiber reinforced plastic or GFRP, where the glass fiber may be arranged randomly, flattened into a sheet (called a chopped strand mat), or woven into a fabric. The plastic matrix may be a polymer matrix - most often based on thermosetting polymers such as epoxy, polyester resin, or vinyl ester, or a thermoplastic. Fiber glass is unique in its properties with respect to specific strength. Glass fibers are made up of various types of glass depending upon their use. These glasses all contain silica or silicate, with varying amounts of oxides of calcium, magnesium. To be used in FRP, glass fibers have to be made with minimum defects. Fiber glass is a strong lightweight material which is used for many products. Although it is not as strong and stiff as composites based on carbon fiber, it is less brittle and its raw materials are much cheaper. Its bulk strength and weight are also better than many metals and it can be more readily molded into complex shapes. Glass reinforced plastic (GRP) areas of fiber glass include aircraft, boats, automobiles, bathtubs and enclosures, swimming pools, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards and edema door skins.

Polyethylene Sheets - Virgin polyethylene is the highest form of plastic sheeting today. These can be of thick sheets to thin films. The majority of plastic sheeting is made by laminating a woven mess of HDPE between two layers of LDPE (low density polyethylene). Additional chemicals such as calcium carbonate are added to both the woven core and the exterior laminations to add coloring to make the material flexible to add UV (ultraviolet) stability and to alter the opacity. These sheets are frequently printed with logos, manufacturing dates/batch numbers and markings to help with measuring. If reinforcement bands are added, they are usually welded on by the laminating machine. Reinforcement bonds are usually grey in color.



PVC sheets - Polyvinyl chloride is formed in flat sheets in a variety of thickness and colors. As flat sheets, PVC is often expanded to create voids in the interior of the material, providing additional thickness without additional weight and minimal extra cost (ex, closed-cell PVC foam board). Sheets may be cut using saw and rotary cutting equipment's. Plasticized PVC is also used to produce thin, colored or clear adhesive backed films which can be typically cut on a computer-controlled plotter on printed in a wide format printer. These sheets and films are used to produce a wide variety of commercial signage products including car body stripes and stickers. They can be of different variants. PVC clear sheet is water-clear and masked on two sides Extruded PVC sheet has normal impact and high corrosion resistance and comes in a dark grey color. Press laminated PVC sheets offer normal impact and high corrosion resistance and are available in thick gauges. They also come in dark grey color. The other types of PVC sheets although have the same properties as regular PVC, are modified to provide higher impact strength. They are available in light grey color or other shades.

1.2 Artificial Timbers –

The artificial timber is made of enhanced modified and thermoplastic material that is filled with wood fiber and plant fiber. It carries combining advantages of timber and plastic. It is good in corrosion resistance, warp free. It is the better option over the entire range of natural wood, jungle wood and exotic wood likes Burma teak, sag wood. It can be produced in desired shape and skilled labor can be minimized.

Properties –

Weather resistance, Durability, Fire resistance, Workability, Elasticity, Toughness and abrasion, Soundness, Hardness, Resistance to shear, Strength.

Application –

- It is used in maintenance work,
- used to make various structural member,
- used in celling proofing material in building construction,
- used to make door and window frame,
- used to making the planks, square and round shape for furniture.

Types –

A) Veneer - Veneers are thin sheets or slices of wood of superior quality, having thickness varying between 0.4 mm to 6 mm or more. The Indian timbers which are suitable for the preparation of veneers are teak, Sisson, mahogany, oak, rosewood etc. These good quality woods are cut into logs of 1.5 to 2.5 m length and steamed. They are then cut into thin sheets by rotary cutting machines or by slicing manually. More than 90% of veneers are manufactured by rotary cutting. The veneers after being removed are dried in kilns to remove moisture. The veneers are too thin to be used as separate entities, but are glued or cemented together or are glued to other inferior quality of wood to enhance the appearance and to protect their surface Veneers when cemented in layers, with the grains of successive layers crossing each other provide stiffness and resistance to shrinkage, and lower the danger of cracking. Such multiple veneers are used in the construction of aircraft. The veneers form the starting point in the manufacture of plywood, Lamin boards and batten boards. Their specifications are governed by BIS code. IS:303.

B) Plywood - Plywood is a wood structural panel, which is of course, the original engineered wood product. Plywood is manufactured from sheets of veneer or thicker boards (plies) banded under heat and pressure with durable moisture-resistant adhesives, where the panel strength and stiffness in both the directions are maximized by alternating the grain directions of veneers from layer- to-layer or cross-orienting. Thus, the directions of veneers in successive layers are kept at right angles to each other so as to get uniformly good strength in all directions. The outside layers are called faces, while the central portion is called the core and others are called cross-bands. However, in order to have good appearance as well as to maintain economy, one face veneer a made of very good quality while the bulk is of ordinary quality. Plywood frequently contains an odd number of plies so that the system is balanced around the central veneer, some plywood, however, may contain even number of plies, but in that case, the two central plies have the same orientation, thereby ensuring that the plywood is balanced on each side of the central glue line.

Plywood of the following types are manufactured,

(a) Ordinary grade used as a packing material.
(b) Exterior grade, made of good quality wood and bonded with waterproof glue
(c) Marine grade, in which the core and exterior, are of superior quality.

C) Fiber Board - These are rigid boards and are also known as pressed wood or reconstructed wood. They are made by breaking down hardwood or softwood residuals into wood fibers, combing with wax or a resin binder and forming panels by applying high temperature and pressure. They may be either homogeneous or laminated. They vary in thickness from 3 mm to 12 mm and available in lengths varying from 3 m to 4.5 m and in widths of 1.2 m to 1.8 m. However, the weight of fiber boards depends on the pressure applied during manufacture, the maximum and minimum limits being 9600 N/m² and 500 to 600 N/m² respectively. Depending upon their form and composition, fiber boards are classified as insulating boards, medium hard boards, hard boards, super hard boards and laminated boards. They are also available under various trade names such as Eurekas, Indianite, Insulate, Masonite, Nordex, Teletex etc. Again, based on their manufacturing process, they may be divided into dry-process fiber board and wet-process fiber board.

uses - The fiber boards form an ideal base for practically all types of decorative finishes such as distemper, oil paints etc. The hard boards are also suitable for polishing and varnishing. Several patterns of fiber boards with pre-decorated surfaces are available in the market and thus the necessity of treating them after fixing in position is eliminated. They are used for internal finish of rooms such as wall paneling, suspended ceilings,

paring or flooring material, flush doors and table tops etc. These are used for fire and sound insulation in large commercial buildings and cinema houses. They are also used in making partitions and finishing cover to furniture.

D) Batten Board - A batten board is a board having a core made up of strips of wood usually 80 mm wide, each laid separately or glued or otherwise joined to form a slat which is glued between two or more outer veneers with the direction of the grain of the core running at right angles to that of the adjacent outer veneers, The batten boards are light and strong and these boards are used for door panels, table tops etc.

1.3 Miscellaneous materials –

A) Acoustic Materials - Acoustic is a term used for the science of sound in general. Sometimes it is more commonly used for the special branch of that science called architectural acoustics which deals with construction of that areas so as to enhance the hearing of speech or music. In majority of cases, the acoustics of an enclosure are considered satisfactory if a proper balance between sound-absorbing and sound-reflecting materials is created. In achieving this reverberation as a factor should be taken into consideration. For modifying reverberation the architect has two types of materials, sound-absorbent and sound reflecting, to coat the surfaces of ceilings, walls and floors. Soft materials, such as cork and felt, absorb most of the sound that strikes them, although they may reflect some of the low frequency sounds. Hard materials such as stone and metals reflect most of the sound that strikes them. The acoustic of a large auditorium may be very different when it is full when it is empty; the empty seats reflect sound, whereas an audience absorbs sound. Hence, a study of the acoustic properties of various building materials is necessary to facilitate the selection of quality materials that will ensure good acoustics all round a space.

Properties - it is important to distinguish between the loss due to sound absorption and sound transmission. Sound absorbing materials control sound with the spaces, and function by allowing the sound to pass through them easily. They are generally porous and absorb sound as a result of many interactions. Conversely, a material, or system that provides a good sound transmission loss is usually non-porous and a good reflector of sound.

B) Cladding For Buildings - The term cladding generally refers to the components that are attached to the primary structure of a building to form non-structural external or internal surfaces. This is as opposed to the buildings in which the external surfaces are formed by structural elements themselves, such as masonry walls or applied surfaces such as render. Thus, cladding is the application of one material over another to provide skin or layer intended to control the infiltration of weather elements, or for aesthetic purposes. Cladding does not necessarily have to provide a waterproof condition but is instead a control element. This control element may only serve to safely direct water or wind in order to control run off and prevent infiltration into the building structure. This is also a central element for prevention of noise from entering or escaping. While cladding is generally attached to the structure of the building, it typically does not contribute to its stability. However, cladding does play a structural role, by transferring wind loads, impact loads, snow loads and its own self-weight back to the structural frame-work. In particular, wind causes positive and negative pressure on the surface of buildings, thus the cladding must have sufficient strength and stiffness to resist this load, both in terms of its type and its connections back to the structure.

Glass Cladding

Brick Cladding

Concrete Cladding

Stone Cladding

Home interior Cladding

Tile Cladding

Ceramic Cladding

Wood/timber Cladding

Metal Cladding

C) Plaster Board -

Plaster board, or dry wall, is a remarkably versatile product consisting of gypsum paste sandwiched between layers of thick paper. It is generally used on walls and ceiling and can be plastered over or painted. Thus, plaster board is basically an inner layer of gypsum sand witched between two outer layers of lining paper including various additives in the gypsum layer and varying the weight and strength of the lining paper, will give the finished board different properties. There are various types of plaster boards to cater for most situations found in the domestic or commercial environment. Plaster board is a popular building product and has become a standard covering for stud partitioning and ceilings. It is also used to line internal masonry walls where the sheets are simply attached to the masonry by using dab of adhesive. Such wall linings are referred to as dry lining. Variations to the plaster recipe or the sandwiching material can result in plaster board sheets which are water resistant or can be used for sound proofing. However, the glass fiber-reinforced gypsum board is not made in the traditional way with paper lining. Instead, the boards are strengthened with layers of glass-fiber immediately below each surface. This gives them good all-round performance; a high-quality durable plaster finish and enables them to be easily bent for use on curved structures. They are excellent for semi-exposed areas such as soffits or the like. Of course, while standard plaster board is ideal for most environments, it should not be used in constantly wet conditions. For kitchens, bathrooms and similar wet areas, specially designed fiber boards with silicone additives in the core or a highly water-resistant non-combustible glass reinforced gypsum board, should be used. Various makes of plaster board are used for different situations and hence a different type of board is used when the surface is to be plastered as opposed to be painted.

D) Micro-Silica -

Micro-silica, also known as silica fume, is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultra-fine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical silicon oxide particles with an average particle diameter of 150 nanometer (nm) or 0.15 μ and extremely high specific surface. Silica fume is usually categorized as a supplementary cementitious material; exhibiting pozzolanic properties, cementitious properties and a combination of both the properties. Due to these properties, it can affect the behavior of concrete in a variety of ways, the main field of application being as pozzolanic material for high performance concrete. When added to concrete in doses of around 30 kg/m^3, it changes the theology and reacts with the cement hydration products to dramatically improve concrete's strength, durability and impermeability, thereby allowing concrete to be used in ways never possible before. It has also been found useful in combination with fly ash. Early-age strength development of concrete in which fly ash replaces cement tends to be slow because fly ash is relatively inert during this period of hydration. Adding micro-silica, which is

more reactive in early hydration, can up speed strength development. Durability of OPC based concrete is considerably enhanced due to the use of micro-silica.

E) Artificial Sand -

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles, being finer than gravel and coarser than silt. The main natural and cheapest source of sand is river or n allah. Natural, or river, sands are weathered or worn-out particles of rock and are of various grades or sizes depending upon the amount of wearing. Also, the composition of sand varies depending on the local sources and conditions. Because of the rapid growth of population and consequent brisk construction work, there is huge demand for this kind of sand, whereas the natural resources are running low. Now-a-days, good sand is not readily available and it has to be transported from a long distance. Also, use of sand in large quantities has resulted in extensive dredging operation, raising several environmental concerns and thus the government have banned reckless dredging of sand from the river bed. This has necessitated to find some suitable substitute for natural river sand called artificial or manufactured sand. The artificial sand of required gradation and characteristics produced by proper machines has been found to be a better replacement of natural sand. However, artificial sand affects the workability of concrete adversely making it stiff, which can be improved by the use of fly ash.

F) Bonding Agents -

Bonding agents are natural, compounded or synthetic materials used to enhance the joining of individual members of a structure without employing mechanical fasteners. These products are often used in repair applications such as the bonding of fresh concrete, sprayed concrete or sand cement repair mortar to hardened concrete. The main types of bonding agents used in the construction industry are latex emulsions and epoxies Although good adhesion may be obtained even without a bonding agent, generally a bonding layer consisting of cement and sand slurry, cement/latex slurry or epoxy, increases the bond strength.

G) Adhesives -

An adhesive is any substance that when applied to any one surface, or both surfaces of two separate item bind them together and resist their separation. Any substances that is capable of joining materials by attachment of their surfaces can be grouped as an adhesive. It may be used interchangeably with the names like glue, cement, mucilage or paste. Different adjectives may be used in conjunction with the word "adhesive" to describe properties based on the substance's physical and chemical form, the type of materials joined or the conditions under which it is applied. The process of joining the materials using adhesives is called Adhesive Bonding and is a class in itself like welding, soldering and fastening. The use of adhesives offers many advantages over binding techniques such as sewing, mechanical fastening, thermal bonding etc. Adhesives may be found naturally or produced synthetically. In the course of time and during their development, adhesives have gained a stable position in an increasing number of production processes.

Classification or grouping of adhesives –

- Glues from animal and vegetable sources
- Thermoplastic adhesives
- Thermosetting adhesives
- Elastomer adhesives
- Ceramic adhesives

Types of adhesives –

- Reactive adhesives
- Non-reactive adhesives
- Natural adhesives
- Synthetic adhesives

2. PREFABRICATION

2.1 Introduction, Necessity and Scope of Prefabrication

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub- assemblies to the construction site where the structure is to be located.

The term is used to distinguish this process from the more conventional construction practice of transporting the basic materials to the construction site where all assembly is carried out. The term prefabrication also applies to the manufacturing of things other than structures at a fixed site.

It is frequently used when fabrication of a section of a machine or any movable structure is shifted from the main manufacturing site to another location, and the section is supplied assembled and ready to fit.

It is not generally used to refer to electrical or electronic components of a machine, or mechanical parts such as pumps, gearboxes and compressors which are usually supplied as separate items, but to sections of the body of the machine which in the past were fabricated with the whole machine. Prefabricated parts of the body of the machine may be called 'sub-assemblies' to distinguish them from the other components.

Necessity and Scope of Prefabrication

Prefabrication avoids the need to transport so many skilled workers to the construction site, and other restricting conditions such as a lack of power, lack of water, exposure to harsh weather or a hazardous environment are avoided.

The prefabricated construction method helps in reducing the adverse impacts on the environment and offers an environment friendly construction. Hence, prefab construction technique is much more efficient and sustainable. The better-quality control may be achieved if this technology is adopted for repetitive type of works.

- *Economy in cost.*
- *To improve the quality.*
- *To speed up construction.*
- *To use locally available materials with required characteristics. To use the material which possess their characteristics like light weight, easy availability, thermal insulation, non-combustible.*

History of Prefabrication

Prefabrication has been used since ancient times. For example, it is claimed that the world's oldest known engineered roadway, the Sweet Track constructed in England around 3800 BC, employed prefabricated timber sections brought to the site rather than assembled on-site.

Sinhalese kings of ancient Sri Lanka have used prefabricated buildings technology to erect giant structures, which dates back as far as 2000 years, where some sections were prepared separately and then fitted together, especially in the Kingdom of Anuradhapura and Kingdom of Polonnaruwa. After

the great Lisbon earthquake of 1755, the Portuguese capital, especially the Baixa district, was rebuilt by using prefabrication on an unprecedented scale.

Also in Portugal, the town of Vila Real de Santo António in the Algarve, founded on 30 December 1773, was quickly erected through the use of prefabricated materials. The first of the prefabricated stones was laid in March 1774. By 13 May 1776, the centre of the town had been finished and was officially opened. In 19th century Australia a large number of prefabricated houses were imported from the United Kingdom.

Current Uses of Prefabrication

The most widely used form of prefabrication in building and civil engineering is the use of prefabricated concrete and prefabricated steel sections in structures where a particular part or form is repeated many times.

Prefabricating steel sections reduces on-site cutting and welding costs as well as the associated hazards. Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units.

The quality of prefabricated housing units had increased to the point that they may not be distinguishable from traditionally built units to those that live in them. The technique is also used in office blocks, warehouses and factory buildings.

Prefabricated steel and glass sections are widely used for the exterior of large buildings. Detached houses, cottages, log cabin, saunas, etc. are also sold with prefabricated elements. Prefabrication of modular wall elements allows building of complex thermal insulation, window frame components, etc.
On an assembly line tends to improve quality over on-site construction of each individual wall or frame. Wood construction in particular benefits from the improved quality. However, tradition often favours building by hand in many countries, and the image of prefab as a "cheap" method only slows its adoption.

Classification of Prefabrication

1. *Small Prefabrication*
2. *Medium Prefabrication*
3. *Large Prefabrication*
4. *Partial Prefabrication*
5. *Open Prefabrication*
6. *Closed Prefabrication*
7. *Total Prefabrication*
8. *Cast in site Prefabrication*
9. *Cast off site Prefabrication*

Small Prefabrication

Elements using in that construction for example, brick is a small unit precast and used in building. This is called as small prefabrication. That the degree of precast element is very positioning.

Medium Prefabrication

Suppose the roofing systems and horizontal members are provided with pretested elements those construction is known as medium prefabricated construction here the degree of precast elements is moderate.

Large Prefabrication

In large prefabrication most of the members like wall panels, roofing / flooring Systems, beams and columns are prefabricated. Here degree of precast elements is high.

Partial Prefabrication

In this method of construction, the building element (mostly horizontal) required are precast and then erected. Since the costing of horizontal elements (roof/floor) often takes their time due to erection of form work the completion of the building is delayed and hence this method is restored.

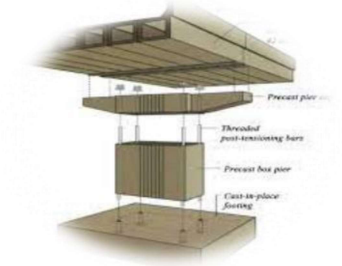
In most of the building sites this method is popular more. In industrial buildings when the elements have longer spanned. Use of double tees, channel units, cored stabs, slabs, hyperboloid shall etc., are some of the horizontal elements. This method is efficient when the elements are readily available when the building reached the roof level.

The delay caused due to erection of formwork, delay due to removal eliminated completely in this method of construction Suitable for any type of building provided lifting and erection equipment's are available.

Small Prefabrication

Medium Prefabrication

Large Prefabrication



Partial Prefabrication

Open Prefabrication

Closed Prefabrication

Total Prefabrication

Cast in site Prefabrication

Cast off site Prefabrication

Open prefabrication

In the total prefabrication systems, the space framers are casted as a single unit and erected at the site. The wall fitting and other fixing are done on site. This type of construction is known as open system of prefabrication.

Closed system of prefabrication

In this system the whole things are casted with fixings and erected on their position.

Total Prefabrication

Very high speed can be achieved by using this method of construction. The method can be employed for frame type of construction or for panel type of or the total prefabrication can be on site or off-site. The choice of these two methods depends on the situations when the factory produced elements are transported and erected site we call if off-site prefabrication. If this method is to be adopted then we have a very good transportation of the products to site.

If the elements are cast near the building site and erected, the transportation of elements can be eliminated, but we have considered the space availability for establish such facilities though it is temporary. The choice of the method of construction also depends on the following,

- *Type of equipment available for erection and transport.*
- *Type of structural scheme (linear elements of panel).*
- *Type of connection between elements.*
- *Special equipment devised for special method construction.*

Cast in site Prefabrication

One of the main factors which affect the factory prefabrication is transport. The width of mad walls, mode of transport, vehicles are the factors which prefabrication is to be done on site on factory. Suppose the factory situated at a long distance from the construction site and the vehicle have to cross a congested traffic with heavy weighed elements the cost in side prefabrication is preferred even though the same condition is the cast in site.

Cast off site Prefabrication

Prefabrication is preferred only when number of houses and more for small elements the conveyance is easier with normal type of lorry and trailers. Therefore, we can adopt factory (or) off site prefabrication for this type of construction.

Types of Prefabrication –

There are two main types of prefabrication, namely **volumetric** (often referred to as 'modular) and **panellised.** Both of these types of construction can be achieved in timber, steel and concrete, and can also be mixed within the same scheme. Steel systems for housing are usually light gauge galvanised steel.

Timber systems can be relatively traditional in that the construction mirrors what might be produced on site using components such as timber studs and sheathing It can make use of timber, I beam which give longer spans with a relatively lightweight beam. One factor that differentiates all prefabricated timber systems from what might be termed traditional timber frame is the amount of work undertaken in the factory.

While there does not appear to be a formal definition separating the two, the prefabricated panel might include any insulation material, the sheathing boards and possibly some services.

volumetric

panellised

Classification of prefabrication member according to their statical function -

- Floors & beam
- Columns & load bearing walls
- Prefabricated stains
- Large pipes
- Foundations

Classification of prefabricated member according to their materials and strength characteristics -

- Reinforced concrete
- Pre-stressed concrete
- Mixed-structural element
- Special concrete element

Advantages of Prefabrication

- Moving partial assemblies from a factory often costs less than moving pre-production resources to each site.
- Deploying resources on-site can add costs prefabricating assemblies can save costs by reducing on-site work.
- Factory tools jigs, cranes, conveyors, etc. can make production faster and more precise. Factory tools shake tables, hydraulic testers, etc. can offer added quality assurance.
- Consistent indoor environments of factories eliminate most impacts of weather on production.
- Cranes and reusable factory support can allow shapes and sequences without expensive on-site falsework.
- Higher-precision factory tools can aid more controlled movement of building heat and air, for lower energy consumption and healthier buildings.
- Factory production can facilitate more optimal materials usage, recycling, noise capture, dust capture, etc Machine-mediated parts movement, and freedom from wind and rain can improve construction safety.

Disadvantages of Prefabrication

- Transportation costs may be higher for voluminous prefabricated sections than for their constituent materials, which can often be packed more densely.
- Large prefabricated sections may require heavy-duty cranes and precision measurement and handling to place in position.

2.2 Process and Theory of Prefabrication

An example from house-building illustrates the process of prefabrication. The conventional method of building a house is to transport bricks, timber, cement, sand, steel and construction aggregate, etc.to the site, and to construct the house on site from these materials.

In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof are prefabricated (assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together.

Prefabrication is used in the manufacture of ships, aircraft and all kinds of vehicles and machines where sections previously assembled at the final point of manufacture are assembled elsewhere instead, before being delivered for final assembly.

The theory behind the method is that time and cost is saved if similar construction tasks can be grouped, and assembly line techniques can be employed in prefabrication at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be reduced.

The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed. Prefabrication

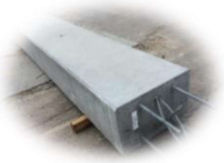
avoids the need to transport so many skilled workers to the construction site, and other restricting conditions such as a lack of power, lack of water, exposure to harsh weather or a hazardous environment are avoided.

Design Principle of Prefabricated System

- Design for prefabrication, preassembly & modular construction.
- Simplify & standardize connections details.
- Simplify & separate building system.
- Consider worker safety.
- Minimize building components & materials.
- Select fittings, fasteners, adhesive & sealants that allow for quicker assembly & facilitate the removal of reusable material.
- Reduce building complexity.
- Design for reusable material.
- Design for flexibility & adaptability.
- Types of prefabricated elements

Types of Prefabricated elements

Precast beam –



There are two main categories of beams**.**
Internal beams: where floor loading is approximately symmetrical.
External beams: where floor loading is predominantly non-symmetrical.

Precast columns -

For structures of five storeys or less, each column will normally be continuous to the full height of the building. For structures greater than five storeys two or more columns are spliced together.

Edge columns: symmetrical in one direction.
Internal columns: symmetrical in all directions.
Corner columns: not symmetrical at all.

Precast floor slabs -

The main types of slabs are used in the precast frames are Hollow cored slab and dual tee slab.

Precast walls -

Precast concrete walls serve as Stability.
As walls or boxes surrounding staircases & lift shafts.
Walls may be classified as infill or cantilever.

Precast Staircases -

Three options are available for precast staircases.
A single precast unit containing all the flights & landings.
Separate precast flights & landings.
Parts of the flights & landings are made in one piece.

Modular Coordination

Modular coordination is a concept for coordinating dimensions and space for which building, components are positioned. Basic unit of MC is module 1M which is equal to 100mm. MC is internationally accepted by the International Standard of Organization (ISO).

The introduction of MC in building facilitates proper planning, design construction and assembly of building components. The principal objective of implementation of MC is to improve productivity, more flexibility in design and construction activities.

Modular co-ordination Grid

Structural Grid - It is used to locate the structural components such as beam and columns.

Planning Grid - It is used for locating the space for building components like rooms.

Controlling Grid - It is used for locating internal walls. Modular coordinated grid is used for locating the building components and the grids can be available in both horizontal and vertical planes. The grids are generated by measurement in modules.

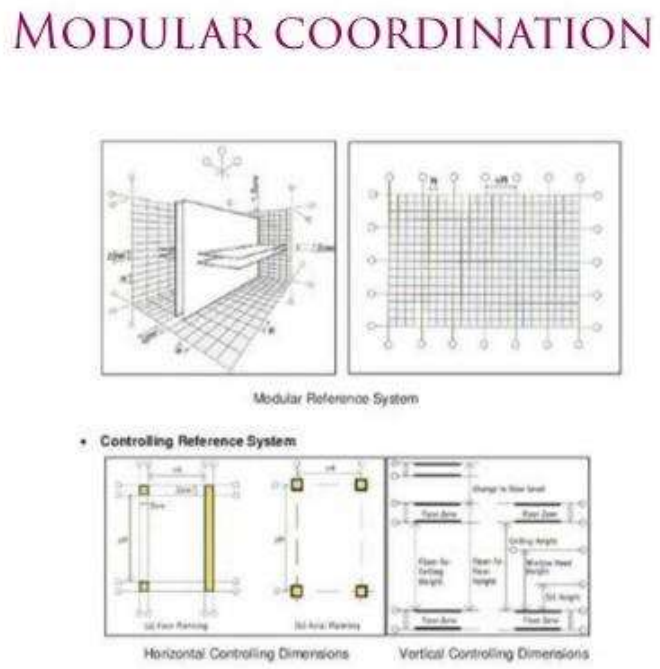
Dimensional Grid - Modular coordinated grid network defines the space available for placing the components**.** An important factor is that the component must always undersized to grid size for providing space for joint space.

Manufactured length of unit nominal length 11½ inch grid size would be 12 inch because of units were designed to be placed with ½ inch joints. In modular coordination system, in place of geometric serious, a different system of preferred dimensions is used.

For larger dimensions it is represented in modules like 1M-0.1m, for smaller dimensions sub modular increments 50mm or 25mm are used.

Modular coordination system provides

- Defining coordinating spaces for building elements and components.
- Rules for maintaining the component size while manufacturing.
- Rules for selecting the component size and providing the required grid size in building.
- The MC system allows standardization in design of building components, it encourages manufacturers and assemblers to enter in open market.
- It is difficult to manufacture the component in SI unit mm tolerance. But it is easier for manufacturer to make in module tolerance system.



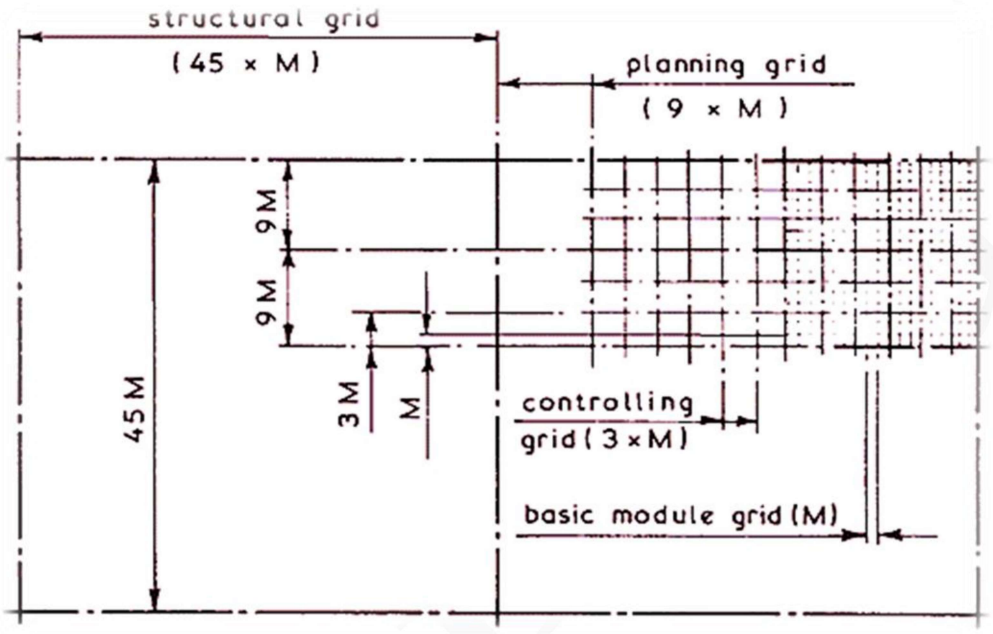
Advantages of Modular Coordination

- Facilitate cooperation between building, designer, manufacturer, traders, contractors. Improves freedom in design and permits flexibility. Encourages the possibility of interchanging the components.

- Simplifies positioning and placing of components. Ensures dimensional coordination between component with the rest of the building.

- It is possible to get maximum economy in the production of components. Reduces the need for making special sizes. Increases the number of choices of components because of interchangeability. Improves quality and productivity of construction.

- Wastage in production and time taken for installation of components is reduced. It helps to achieve the responsibility in constructing the building.



2.3 Indian Standard Recommendation for Modular Planning

- This Indian standard was adopted by the Indian standards institution on 27th February 1987 after the draft finalized by the modular co-ordination sectional committee had been approved by the civil engineering division council.

- This standard was 1st published in 1975. This revision has been prepared incorporating the advancement made in the modular planning & design since more than a decade.

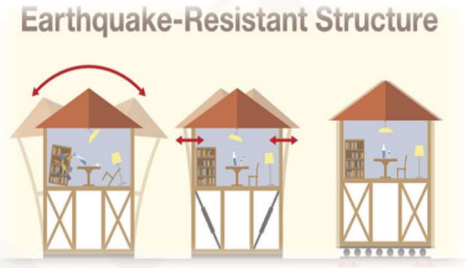
- In the preparation of this standard, considerable assistance has been rendered by the National building's organisation, New Delhi.

- This standard is applicable to the construction of all types of buildings, materials & construction techniques & in accordance with the principles of modular coordination.

ACTE

3. EARTHQUAKE RESISTANT CONSTRUCTION

To avoid a great earthquake disaster with its severe consequences, special consideration must be given. Engineers in seismic countries have the important responsibility to ensure that the new construction is earthquake resistant and also, they must solve the problem posed by existing weak structures. The problem of earthquake engineering can be divided into two parts, first to design new structures to perform satisfactorily during an earthquake and second to retrofit existing structures so as to reduce the loss of life during an earthquake. The design of new building to withstand ground shaking is prime responsibility of engineers and much progress has been made during the past 40 years. Many advances have been made such as the design of ductile reinforced concrete members. Earthquake resistant construction requires seismic considerations at all stages from architectural planning to structural design to actual constructions and quality control.



Causes of Earthquake - *Tectonic activity*
Volcanic activity
Land-slides and rock-falls
Rock bursting in a mine
Nuclear explosions

Effects of Earthquake or Seismic Hazards - *Ground shaking*
Structural hazards
Liquefaction
Ground failure/Landslides
Tsunamis, and Fire

3.1 Building Configuration - Requirements of earthquake design as per IS 4326: 1993

Separation of building section

A gap of specified width between adjacent buildings parts of the same building should be provided. Either the gap width may be left uncovered or covered suitably to permit movement in order to avoid hammering due to earthquake.

Centre of rigidity

The point in a structure where a lateral force shall be applied to produce equal deflections of its components at any one level in any particular direction. Translational displacements are occurred at the centre of rigidity while applying lateral loading.

Shear wall

A wall designed to resist lateral force in its own plane. Braced frames which subjected primarily to axial stresses, shall be considered as shear walls for the purpose of this definition.

Space frame

A three-dimensional structural system composed of interconnected members, without shear or bearing walls, so as to function as a complete self-contained unit. It may be provided with or without the horizontal diaphragms or floor bracing systems.

- *Vertical load carrying frame* - It is a space frame designed to carry all the vertical loads and the horizontal loads being resisted by shear walls.
- *Moment resistant frame* - It is a space frame capable of carrying all vertical and horizontal loads by developing bending moments in the members and at joints.
- *Moment resistant frame with shear walls* - It is a space frame with moment resistant joints and strengthened by shear walls to assist in carrying horizontal loads.

Box system of houses

A bearing wall structure without a space frame, the horizontal forces being resisted by the walls acting as shear walls.

Band

A reinforced concrete or reinforced brick runner provided in the walls to the them together and to impart horizontal bending strength in them. For example, instead of a lintel beam, a complete belt of beam that connects all the lintel beams should be provided. It ties the wall together and resists diagonal cracks during earthquake.

Continuity of construction

As far as possible, the parts of the building should be tied together in such a manner that the building acts as one unit. Parts of buildings between separation or crumple sections or expansion joints, floor slabs shall be continuous throughout as far as possible. Concrete slabs shall be rigidly connected or integrally cast with the support beams.

***Configuration of building**

If symmetry of the structure is not possible in plan, elevation or mass, provision shall be made for torsional and other effects due to earthquake forces in the structural design or the parts of different rigidities may be separated through crumple sections. The length of such building between separation sections shall not preferably exceed three times the width Buildings having plans with shapes like, L, T, E and Y shall preferably be separated into rectangular parts by providing separation sections at appropriate places.

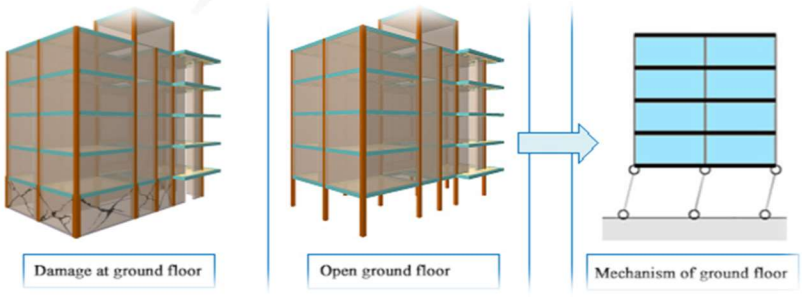
- **General Requirements of Earthquake Resistant Design**

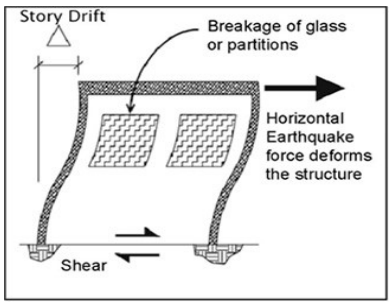
The structures should not be brittle or fail suddenly, rather it should be tough and able to deflect or deform considerable amount. The resisting element such as bracings and shear wall must be provided evenly throughout the building. All elements such as roof, walls etc should be tied together so as to act as an integrated unit during the earthquake shaking transferring forces across the connections and preventing separations.

Structural safety of building - The structural safety of a building is solely depending upon the strength and stiffness of the structural elements in building.

Strength - Sufficient strength is necessary to ensure that a structure can support imposed loads without exceeding certain stress values. Stress refers to the internal forces within a material or member that are created as the structural member resists the applied load.

Stiffness - Stiffness is measured by deflection, the extent to which a structural member, such as a floor, roof, or wall structure, bends when loaded. The inner partition walls of the building shall be designed to resist all loads to which they are subjected. The deflection under the loading shall not exceed 1/240 of the span of wall for brittle finishes and 1/120 of the span of walls for smooth finishes.





Drift - Drift may impose more severe requirements on members than the strength requirements. Drift is expressed as the difference of the deflections at the top and bottom of the story under consideration. Drift limits serve to prevent possible damage to interior or exterior walls that are attached to the structure and which might be cracked or distorted if the structure deflects too much

laterally. Thus, the International Building Code (IBC) requires that drift be limited in typical buildings to between 0.02 and 0.01 times the building height, depending on the occupancy of the building.

Flat roof or floor - Flat roof or floor shall not preferably be made of terrace of ordinary bricks supported on steel, timber or reinforced concrete joists, nor they shall be of a type which in the event of an earthquake is likely to be loosened and parts of all of which may fall.

- ***Pitched Roofs -*** For pitched roofs, corrugated iron or asbestos sheets should be used in preference to country, Allahabad or Mangalore tiles or other loose roofing units. All roofing materials shall be properly tied to the supporting members. Heavy roofing materials should generally be avoided.
- ***Pent Roofs -*** All roof trusses should be supported on and fixed to timber band reinforced concrete band or reinforced brick band. The holding down bolts should have adequate length as required for earthquake and wind forces.

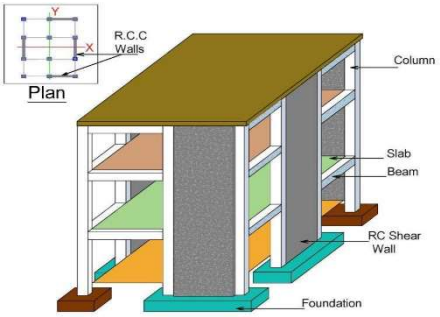
Staircases - The interconnection of the stairs with the adjacent floors should be appropriately treated by providing sliding joints at the stairs to eliminate their bracing effect on the floors. Ladders may be made fixed at one end and freely resting at the other. Large stair halls shall preferably be separated from rest of the building by means of separation or crumple section. Three types of stair construction may be adopted.

- *Separated Staircases*
- *Built in staircases*
- *Staircases with sliding joints*

Fire Safety - Fire frequently follows an earthquake and therefore buildings should be constructed to make them fire resistant in accordance with the provisions of relevant Indian Standards for fire safety. The relevant Indian Standards are 15 1641: 1988, IS 1642: 1989, 15 1643:1988,15 1644:1988 and IS 1646: 1986.

3.2 Lateral Load Resisting Structures

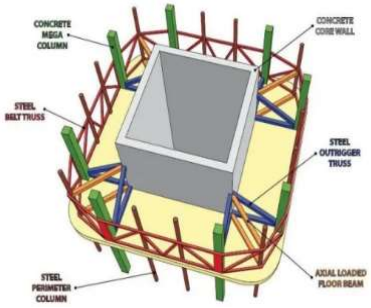
- *Shear wall system*
- *Braced system*
- *Outrigger system*
- *Rigid frame system*
- *Frame tube system*
- *Bundle tube system*
- *Trussed tube system*
- *Diagrid system*



Reinforced Concrete Shear Wall

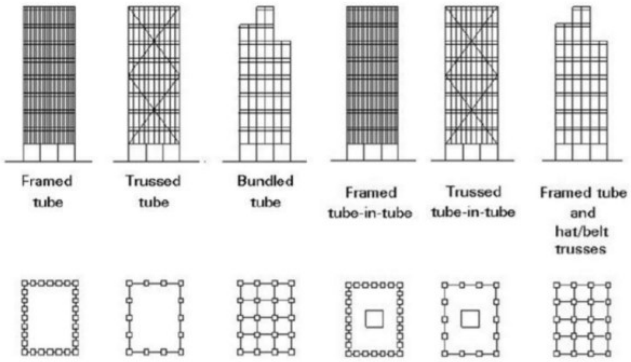
- **Shear wall system -** A shear wall is a vertical element of a lateral force-resisting system that is designed to resist in-plane lateral forces, typically wind and seismic forces. The shear wall serves both architecturally as partitions and structurally to carry gravity and lateral loads. Shear wall generally starts at foundation level and are continued throughout the building height. It has very effective stiffness as well as strength which make them ideal for high rise buildings. In a shear wall structure, such walls are entirely responsible for the lateral load resistance of the building. Shear wall structures can be economical up to about 35 stories.
- **Braced system -** Steel bracing systems can be used effectively for seismic retrofitting of existing RC buildings as well as for seismic design of new buildings. In braced frames, the lateral resistance of the structure is provided by diagonal members that together with the beams form the web of the vertical truss with the columns acting as chords. Because the horizontal shear on the building is resisted by the horizontal components of the axial tensile and compressive actions in the web members bracing systems are highly efficient in resisting lateral loads. Generally, braces are of two types, concentric and eccentric.

- **Outrigger system –** The outrigger structural system is one of the lateral loads resisting systems. Outriggers are rigid horizontal structures designed to improve building overturning stiffness and strength by connecting the belt truss ties all the external columns on the periphery of the structure



and the outriggers connect these belt trusses to the central core of the structure thus restraining the exterior columns from rotation. This system is functionally efficient as there is a free floor space between the central core and the exterior columns.

- **Rigid frame system -** A rigid frame is the load-resisting framework constructed with straight or curved members connected by essentially rigid connections which resist movements induced at the joints of members. Rigid frame also called as moment-resisting frames. Its members can take bending moment, shear, and axial loads. A rigid-frame high-rise structure typically comprises of parallel or orthogonally arranged bents consisting of columns and girders with moment-resistant joints.
- **Frame tube system** - Framed tube system is one of the most widely used tube systems. Compared to tube-in-tube system, it featured a much stiffer exterior tube in this type of system. The stiff tube was achieved through closely spaced columns connected by deep spandrel beams in which are firmly joined together to make the stiff exterior shell.
- **Bundle tube system -** The bundled tube system involves, instead of one tube, several individual tubes interconnected to form a multi-cell tube. Together they work to resist the lateral loads and overturning moments. Not only is this system economically efficient but it also allows for more versatile building designs, adopting interesting shapes and bundled in dynamic groupings rather than being simply box-like towers.

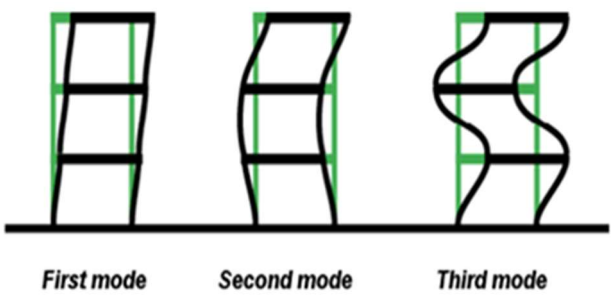


- **Trussed tube system -** Trussed (also known as braced) tube systems are similar to the framed tube but have fewer exterior columns space further apart. To compensate for the fewer columns, steel bracing or concrete shear walls are introduced to tie the columns together. By interconnecting all the exterior columns, it forms a rigid box which is capable of resisting lateral shears by axial in its members rather than through flexure (bending or curving).
- **Diagrid system -** Diagrid System is nothing but the grids of RCC or Steel provided in structure diagonally with the specific geometry. Also, it is a structural system of triangulated beams, straight or curved and horizontal ring that together make up a structural system for a high-rise building. In short, it is made up of intersecting diagonal and horizontal components. The configuration and efficiency of a diagrid system reduce the number of structural elements required on the façade of the buildings, therefore less obstruction to the outside view.

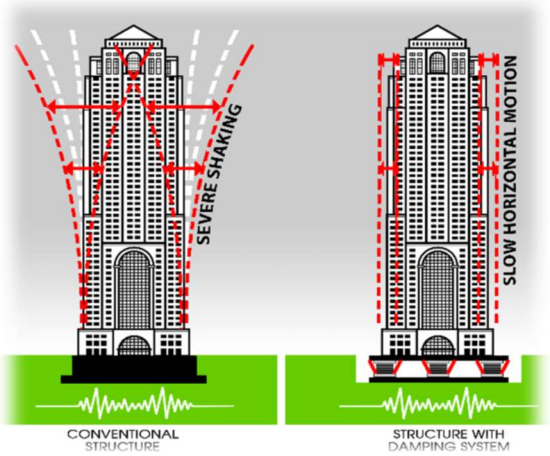
3.3 Building Characteristics

Buildings oscillate during earthquake shaking. The oscillation causes inertia force to be induced in the building. The intensity and duration of oscillation, and the amount of inertia force induced in a building depend on features of buildings, called dynamic characteristics of building. The important dynamic characteristics of buildings are; **Modes of Oscillation & Damping.**

- Natural period
- Natural frequency
- Effect of stiffness
- Effect of mass
- Effect of column orientation
- Effect of building height
- Effect of unreinforced masonry infills
- Mode shape



Response of structure - The earthquakes cause vibratory motion which is cyclic about the equilibrium. The fundamental natural frequency of most civil engineering structures lies in the range of 0.1 sec to 3.0 sec or so. This is also the range of frequency content of earthquake-generated ground motions. Hence, the ground motion imparts considerable amount of energy to the structures. Initially, the structure responds elastically to the ground motion however, as its yield capacity is exceeded, the structure responds in an inelastic manner. During the inelastic response, stiffness and energy dissipation properties of the structure are modified. Response of the structure to a given strong ground motion depends not only on the properties of input ground motion, but also on the structural properties.

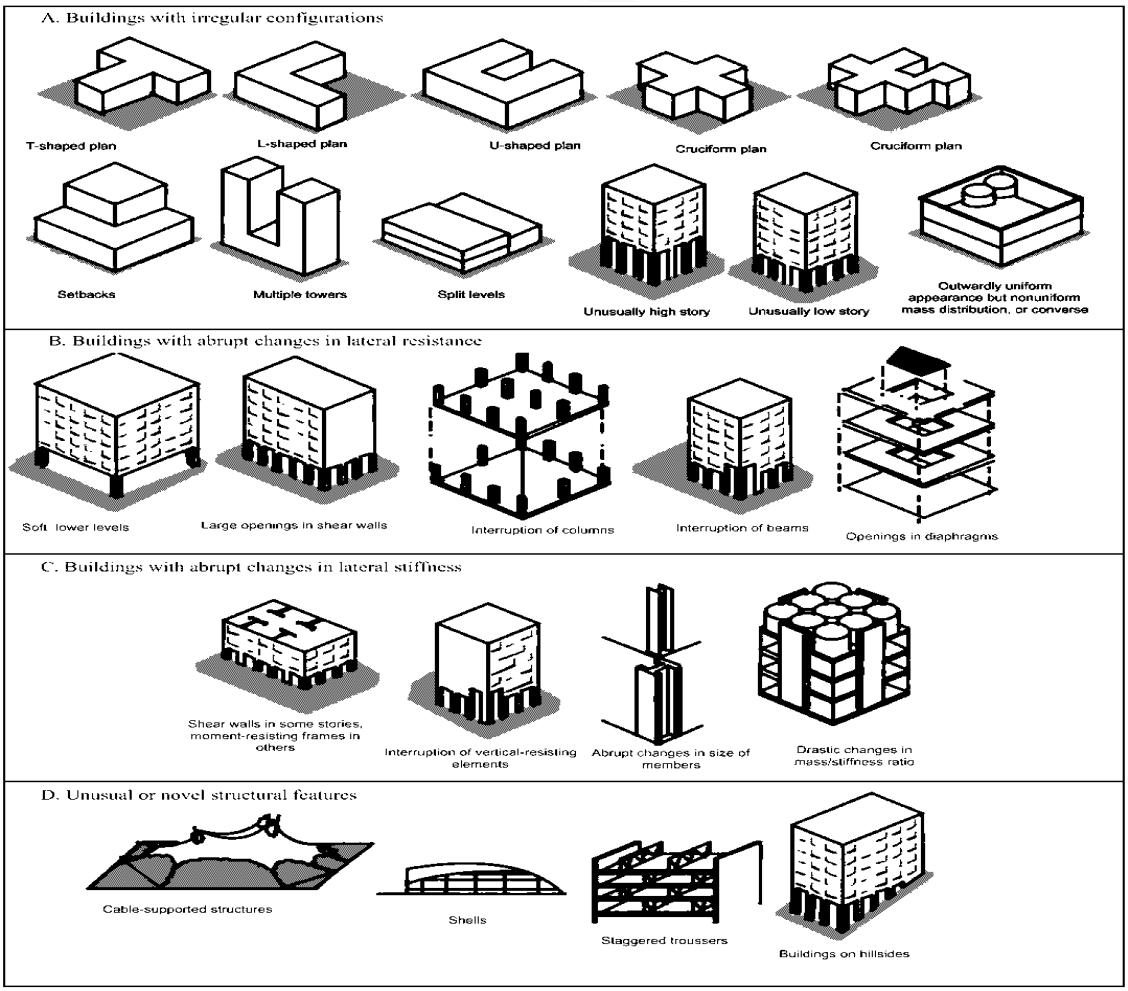


3.4 Effect of Structural Irregularities-Vertical Irregularities, Plan Configuration Problems.

There are numerous examples of past earthquakes in which the cause of failure of reinforced concrete building has been ascribed to irregularities in configurations. Irregularities are mainly categorized as

- Horizontal Irregularities
- Vertical Irregularities

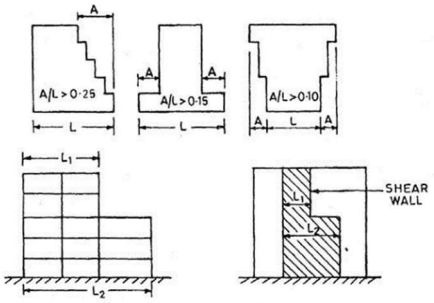
A) Horizontal Irregularities - Horizontal irregularities refer to asymmetrical plan shapes (e.g., L, T, U, F) or discontinuities in the horizontal resisting elements (diaphragms) such as cut-outs, large openings, re-entrant corners and other abrupt changes resulting in torsion, diaphragm deformations, stress concentration.



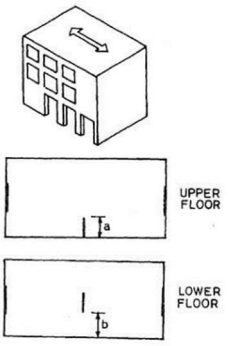
- ***Torsion Irregularity -*** To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift. computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure.
- ***Re-entrant Corners -*** Plan configurations of a structure and its lateral force resisting system contain re- entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction.
- ***Diaphragm Discontinuity -*** Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next.
- ***Out-of-Plane Offsets -*** Discontinuities in a lateral force resistance path, such as out-off plane offsets of vertical elements.
- ***Non-parallel Systems -*** The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements.

B) Vertical Irregularities - Vertical irregularities, referring to sudden change of strength, stiffness, geometry and mass, result in irregular distribution of forces and deformation over the height of building.

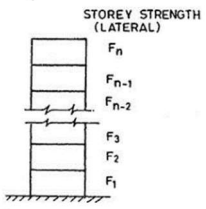
- ***Stiffness Irregularity - Soft Storey &extreme soft storey -*** A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above. An extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above.
- ***Mass Irregularity -*** Mass Irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. The irregularity need not be considered in case of roofs.
- ***Vertical Geometric Irregularity -*** Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.
- ***In-Plane Discontinuity in Vertical Elements Resisting Lateral Force -*** In-plane offset of the lateral force resisting elements greater than the length of those elements.
- ***Discontinuity in Capacity - Weak Storey -*** A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above. The story lateral strength is the total strength of all seismic force resisting elements sharing the many shears in the considered direction.



4 C Vertical Geometric Irregularity when $L_2 > 1.5\,L_1$



4 D In-Plane Discontinuity in Vertical Elements Resisting Lateral Force when $b > a$



4 E Weak Storey when $F_i < 0.8\,F_i + 1$

3.5 Safety Consideration During Additional Construction & Alteration of Existing Buildings.

- In sufficient precaution with respect to safety of works are not taken, there are chances of serious accident involving having loss of man & materials.

- Suitable packing piece must be provided at the required points. The chains should be dropped gradually from a height procedure should never be overloaded.
- The legs brother chain should be open out to search as angle so as endangered the stability of the work. The levels of panel points on the false work should be maintained as per the desired chamber for truss to avoid strain.
- The lifting devices & mechanisms should be maintained in perfect running order so as to avoid their sudden failure without notice.

Reduction of earthquake effects -

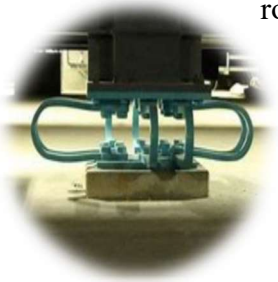
- The conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements (like glass facades) and to some structural members in the building.
- This may render the building as non-functional after the earthquake, and it is problematic in structures like hospitals, schools etc.
- Special techniques are required to design buildings such that they remain practically undamaged even in severe earthquake. Two basic technologies are used to protect buildings from damaging earthquake effects.

A. Base isolation devices

B. *Seismic dampers*

A) Base isolation technique

The concept of base isolation is like a building resting on a frictionless roller. When the ground shakes, the rollers freely roll, but the building above does not move and hence no force is transferred to the building due to the shaking of the ground.



The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base-isolated buildings. The main feature of the base isolation technology is that it introduces flexibility in the structure. It is a technique to avoid the earthquake forces by isolation of the structure from the ground motion which actually imposes the forces on the structure.

B) Seismic dampers

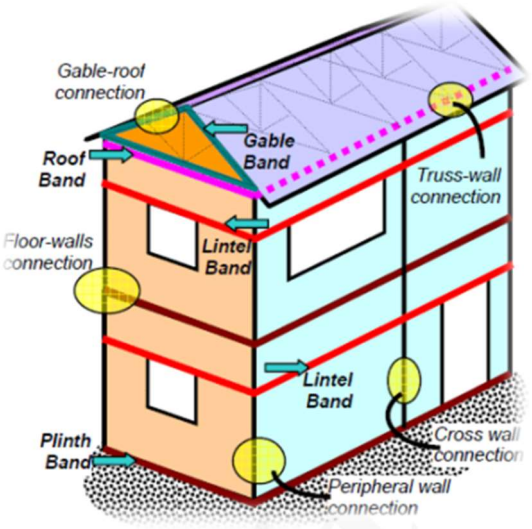
The seismic dampers are another way to reduce earthquake forces by incorporating the dampers in the structural elements such as diagonal bracings. Its function is similar to that of a shock absorber in cars. When seismic energy is transmitted through them, dampers absorb part of it, and thus damp the motion of the building. The common types of the dampers are the viscous dampers and the friction damper. In India the friction dampers are widely used.

3.6 Additional Strengthening Measures in Masonry Building - Corner Reinforcement, Lintel Band, Sill Band, Plinth Band, Roof Band, Gable Band Etc.

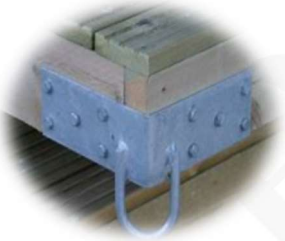
Low Strength Masonry constructions should not be permitted for important buildings. It will be useful to provide damp-proof course at plinth level to stop the rise of pore water into the superstructure.

- **Corner Reinforcement -** The earthquake force shall be calculated for the full dead plus the percentage of imposed load. The properties of imposed load indicate above for calculating the lateral design forces for earthquake are applicable to average conditions. Lateral design force for earthquakes shall not be calculated on construction of impact effects forms the imposed loads.

- **Lintel band -** During earthquake shaking, the lintel band undergoes bending & pulling actions. To resist these actions, the construction of lintel band requires special attention. Bands can be made of wood or of reinforced concrete, the RC bands are the best. The straight lengths of the band must be properly connected at the wall corners. Small lengths of wood spacers (in wooden bands) or steel links are used to make the straight lengths of wood runners or steel bars act together.



- **Sill band -** Sill band do two work, 1st it is a tie beam between two columns & 2nd it is transferred wall load above it to connecting columns. It also avoids unequal settlement of foundation.
- **Plinth band -** Plinth band is just to take care of lateral load transfer mechanism from earthquake point of view, it also keeps in uniform distribution of one load to foundation.
- **Roof band -** A roof band is a load bearing member of a roof at roof level. Sometimes roof band is not required because the roof slab of load bearing wall masonry also plays the role of a band. Roof beams are generally provided in the building with flat timber or G.I. sheet roof. However, in buildings with flat timber or G.I. sheet roof, a roof band needs to be provided. In buildings with pitched or sloped roof, the roof band is very important.
- **Gable band -** This is the common type of sloping, which slopes is two directions. The two slopes met at ridge, at the end face, vertical triangles are formed.



Corner reinforcement

Lintel band

Sill band

Plinth band

Roof band

Gable band

4. RETROFITTING OF STRUCTURES

Retrofitting is to upgrade the strength and structural capacity of an existing structure to enable it to safely withstand the effect of strong earthquakes in future.

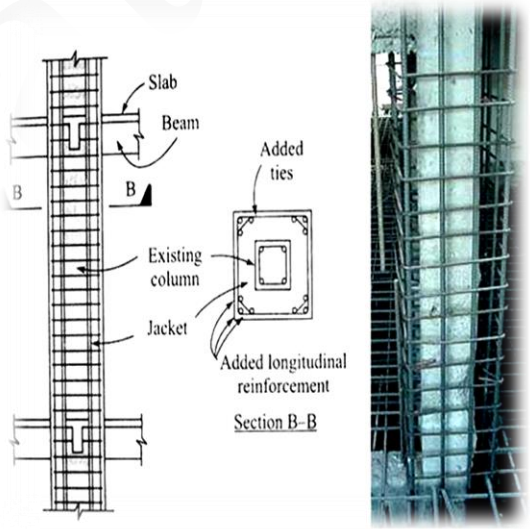
4.1 Seismic Retrofitting of Reinforced Concrete Buildings

Need of seismic retrofitting of buildings

- The buildings have been designed according to a seismic code, but the code has been upgraded in later years. Buildings designed to meet the modern seismic codes, but deficiencies exist in the design and construction.
- Essential buildings must be strengthened like hospitals, historical monuments and architectural buildings. Important buildings whose service is assumed to be essential even just after an earthquake.
- Buildings, the use of which has changed through the years, Buildings that are expanded renovated or rebuilt.

Problems Associated with Retrofitting

- To obtain sufficient records of buildings.
- Architectural and structural drawings.
- Structural design calculations.
- Material properties.
- Details of foundation and geo-technical reports.
- Records of at least natural period of the buildings etc.
- Retrofitting and issues of their structural safety.
- Guidelines or codes of practice on retrofitting.
- Methods of seismic assessment of existing buildings.



Concept of Retrofitting

- Up gradation of the lateral strength of the structure.
- Increase in strength and ductility of structure.
- The decision to repair and strengthen a structure depends not only on technical considerations as mentioned above but also on a cost/benefit analysis of the different possible alternatives.
- It is suggested that the cost of retrofitting of a structure should remain below 25% of the replacement as major justification of retrofitting.

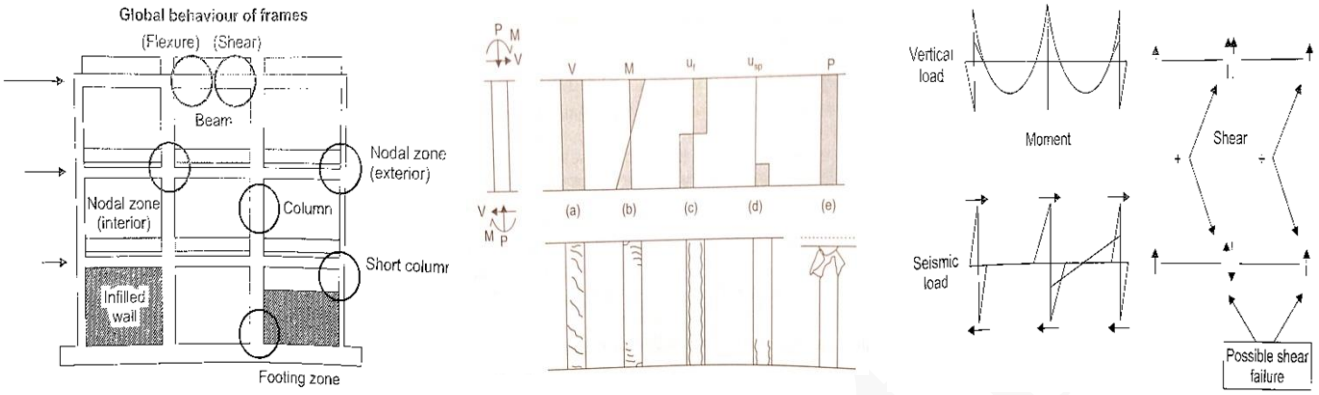
Consideration of Retrofitting Structures

- Retrofitting principally depends on the horizontal and vertical load resisting system of the structure and the type of materials used for parent construction.
- It also relies on the technology that is feasible and economical.
- The understanding of mode of failure, structural behaviour and weak and strong design aspects exercise considerable influence on selection of retrofitting methods usually, retrofitting method is aimed at increasing the lateral resistance of the structure.
- To predict initial and final stiffness of the retrofitted structure need clarification and quantification.
- Avoid an irregular stiffness distribution in the retrofitted structure. It is suggested that the design of retrofitted schemes should be based on drift control rather than on strength consideration alone.
- The use of three-dimensional analysis is recommended to identify and locate the potential weakness of the retrofitted buildings.

4.2 Sources of Weakness in RC Frame Building

The following main sources of weakness in reinforced concrete moment resisting frame buildings;

- Discontinuous load path/ interrupted load path/irregular load path.
- Lack of deformation compatibility of structural members.
- Quality of workmanship and poor quality of material.



Structural damage due to discontinuous load path/ interrupted load path/irregular load path –

- Every structure must have two load resisting systems.
  - Vertical load resisting system for transferring the vertical load to ground.
  - Horizontal load resisting system for transferring the horizontal load to vertical load system.
- It is imperative that the seismic forces should be properly collected by the horizontal framing system and properly transferred into vertical lateral resisting system.
- Any discontinuity/irregularity in this load path or load transfer may cause one of the major contributions to structural damage during strong earthquakes.

Lack of deformation compatibility of structural members -

- The major problems in the structural members of moment-resisting frame buildings are the limited amount of ductility and the inability to redistribute load in order to safely withstand the deformations caused by the seismic loads.
- The regions of failure may be in columns, beams, walls, slabs and beam-column joints. It is also pertinent to consider the consequence of member failure or structural performance.
- Inadequate strength and ductility of a structural member leads to local or complete failure of the system. The different modes of failure in various structural members are reviewed.

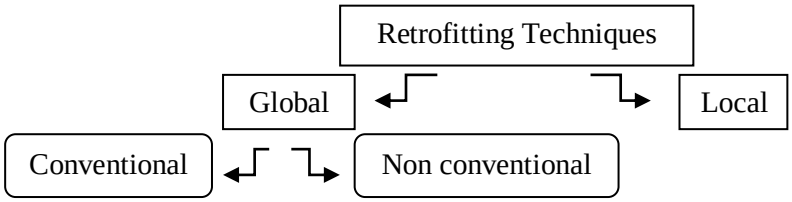
Quality of workmanship and poor quality of material -

- There are numerous instances where faulty construction practices and lack of quality control have contributed to the damage.
- The faulty construction practices may be like, lack of amount and detailing of reinforcement as per requirement of code particularly when the end of lateral reinforcement is not bent by 135 degrees as the code specified.
- Many buildings have been damaged due to poor quality control of design material strength as specified, spelling of concrete by the corrosion of embedded reinforcing bars, porous concrete, age of concrete, proper maintenance etc.

4.3 Classification of Retrofitting Techniques & Their Uses

Broadly, two methods are employed to enhance the seismic capacity of existing structures. The first is a structural-level approach of retrofitting involving global modifications to the structural system. The

second is a member-level approach of retrofitting or local retrofitting which deals with an increase of the ductility of components with adequate capacities to satisfy their specific limit states.

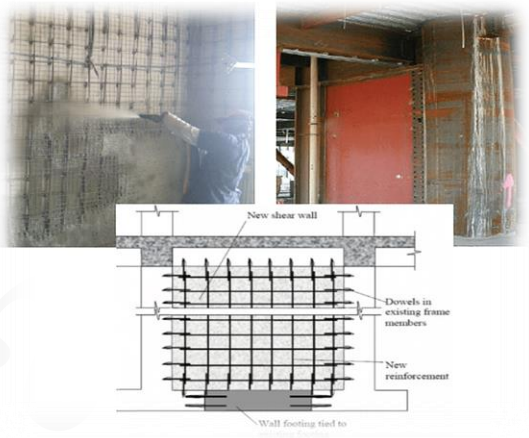


A. Structural/Global retrofit methods

- **Conventional methods**

Conventional Methods are based on increasing the seismic resistance of existing structure. The main categories of these methods are as follows;

- Addition of in filled walls
- Addition of new external walls
- Addition of bracing system
- Construction of wing walls
- Strengthening of weak elements



Addition of in filled walls

The construction of infill walls within the frames of the load bearing structures. This method can also be applied in order to correct design errors in the structure and more specifically, when a large asymmetric distribution of strength or stiffness in elevation or an eccentricity of stiffness in plan have been recognised. There are two alternatives methods of adding infill walls. Either the infill wall is simply placed between two existing columns or it is extended around the columns to form a jacket. The second method is specifically recommended in order to increase the strength in this region. In the situation where the existing columns are very weak a steel cage should be placed around the columns before constructing new walls and column jackets. In all cases, the base of any new wall should always be connected to the existing foundation.

Addition of new external walls

New cast-in-place concrete walls, constructed outside the building can be designed to resist part or all the total seismic forces induced in the building The new walls are preferably positioned adjacent to vertical elements (columns or walls) of the building and are connected to the structure by placing special compression, tensile or shear connectors at every floor level of the building. New walls usually have an L-shaped cross-section and are constructed to be in contact with the external corner of the buildings.

Addition of bracing systems

The construction of bracing within the frames of the load bearing structure aims for a high increase in the stiffness and a considerable increase in the strength and ductility of the structure.

Bracing is normally constructed from steel elements, rather than reinforced concrete, as the elastic deformation of steel aids the absorption of seismic energy. Bracing systems can be used in a similar way as that for steel constructions and can be applied easily in single storey industrial buildings with a soft storey ground floor level where no or few brick masonry walls exist between columns.

Construction of wing walls

There are two alternative methods of connecting the wing wall to the existing load bearing structure. In the first method, the wall is connected to the column and the beams at the top and the base of any floor level. Steel dowels or special anchors are used for the connection and the reinforcement of the new wall is welded to the existing reinforcement.

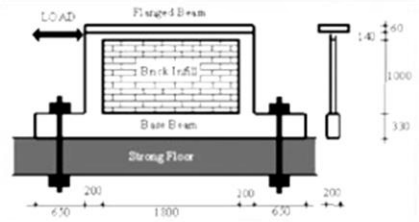
In the second method, the new wing wall is extended around the column to form a jacket. Obviously, in this case, stresses at the interface between the new concrete and the existing column are considerably lower when compared to the first method. The second alternative method is strongly recommended.

Strengthening weak elements

The selective strengthening of weak elements of the structure aims to avoid a premature failure of the critical elements of a building and to increase the ductility of the structures. Usually, this method is applied to vertical elements and is accompanied by the construction of fibre reinforced polymer (FR) Jackets. If a strength increase is also required, this method can include the construction of column jackets of concrete or reinforced concrete.

- **Non - conventional methods**
  - Seismic Base Isolation
  - Seismic Dampers

Addition of Shear Walls



Adding infill walls

Base isolation system

Jacketing of columns

Jacketing of beams

Beam column joint jacketing

B. Member/Local retrofits methods

The member level retrofit or local retrofit approach is to upgrade the strength of the members, which are seismically deficient. This approach is more cost effective as compared to the structural level retrofit. These are;

- Jacketing of beams
- Jacketing of columns
- Jacketing of beam column joints
- Strengthening of individual footings

Jacketing **-** The most common method of enhancing the individual member strength is jacketing. It includes the addition of concrete, steel or fibre reinforced polymer (FRP) jackets for use in confining reinforced concrete columns, beams, joints and foundation.

Types of jacketing -

- *Concrete jacketing*
- *Steel jacketing*
- *Strap jacketing*

Jacketing of beams

Jacketing of beams is required for several purposes as it gives continuity to the columns and increases the strength and stiffness of the structure. While jacketing a beam, its flexural resistance must be carefully computed to avoid the creation of a strong-beam-weak-column system. In the retrofitted structure, there is a strong possibility of change of mode of failure and redistribution of forces as a result of jacketing of columns, which consequently causes beam hinging. The location of the beam critical section and the participation of the existing reinforcement are taken into consideration.

Jacketing of columns

Jacketing of columns constitutes addition of concrete with longitudinal and transverse reinforcement around the existing columns. This type of strengthening improves the axial and shear strength of column while flexural strength of columns and the strength of beam-column joints remain the same. However, the jacketing of columns is not very effective in improving the ductility. The jacketing of columns is generally carried out by the following three methods;

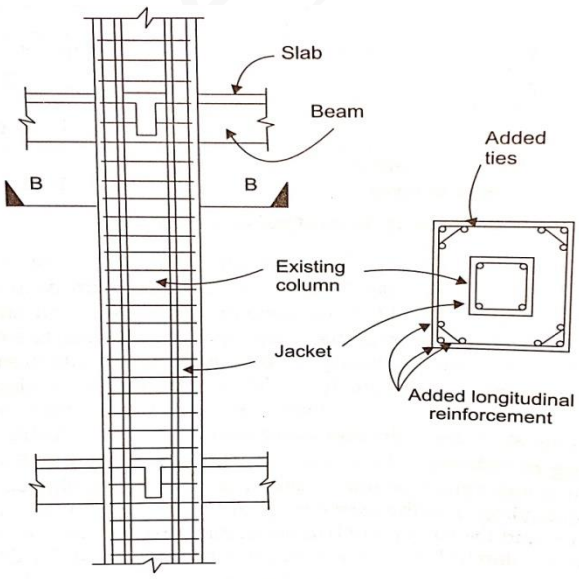
(i) Reinforced concrete jacketing,
(ii) Steel jacketing,
(iii) FRP jacketing.

Beam-column joints jacketing

Theoretically, a joint may be defined as a part of the column that is located through the depth of the beams and which intersect that column. This critical region should have enough confinement and shear capacity. However, due to lack of space in the joint region it is difficult to provide adequate confinement. Jacketing is effective in rehabilitating the joint, with improvement of strength, stiffness and energy dissipation characteristics of the existing joint. In these specimens, the dissipation of energy has been mainly concentrated at the beam's end. It is also very important to point out the need to have a very strong column as compared to the beam to avoid driving of the column or joint into significant inelastic behaviour.

Strengthening of individual footings

The repair or retrofitting of foundations is mainly required due to two types of problems: The change of loads on the foundation by strengthening the structure and the failure of foundation itself. In the first case, the most common practice has been the reinforced concrete jacketing of basement beams and the addition of new piles. Generally, segmented concrete piles are used for retrofitting.



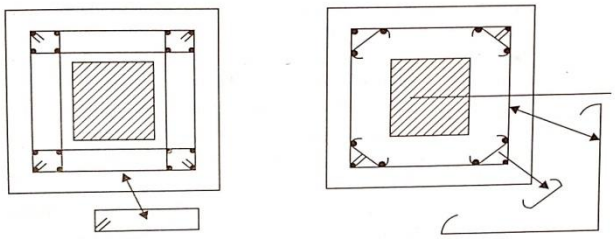
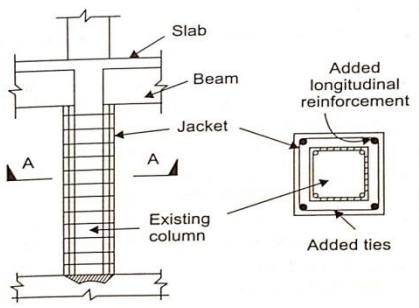


Fig. 6.15. Details for provision of longitudinal reinforcement

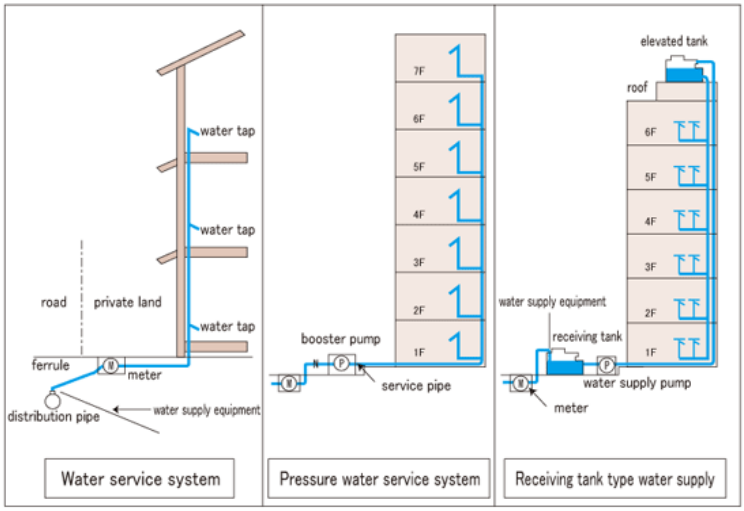


ACTE

5. BUILDING SERVICES

5.1 Cold Water Distribution in High Rise Building.

Water is heavy liquid, so the pumping system simply has to be capable of making heavy lifts to get the water to the top floor of a high rise building under enough pressure for the plumbing fire sprinkler & air-conditioning system to work properly. When you consider that pushing the water upon foot required 0.43 pounds of pressure, 500 feet of tall building would require 215 pound pressure, which is higher than the rated strength of most pipes. This is why pump must be installed at intervals to lift the water, or high pressure pipe systems & high pressure pump must be used with pressure reducing valves located at the supply to each floor.



The Major Components of Coldwater Distribution

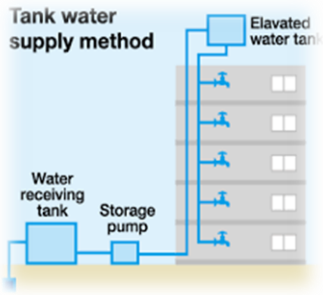
- Sump-tank & roof-tank - To transfer water from sump-tank to roof-tank.
- Up-feed pump - To provide water storage for coldwater system.
- Pneumatic booster pump - To boost up-water pressure for the top floor.
- Pressure reducing valve - To serve to reduce water to acceptable level for lower floors.

Cold Water Supply Distribution

- By normal water pressure.
- By over-head feed system.
- By air pressure system

By normal water pressure **-** The normal water pressure from the public water main is normally inadequate to serve buildings. The alternative solution is either by the over-head feed system or by the air pressure distribution system.

By over-head feed system **-** Water is pumped into a large tank on top of the building & is distributed to the fixtures by means of gravity.



Advantages

- Water is not affected by peak load hour.
- Not affected by power Interruptions.
- Time needed to replace parts will not affect the regular supply of water.

Disadvantages

- Water is subjected to contamination.
- High maintenance cost.
- Occupies valuable.
- Requires stronger foundation & other structure to carry additional load of tank & water.

By Air pressure system **-** When pressure supplied by city water supply is not strong enough. Compressed air is used to raise & push water into the system.

Advantages

- With compact pumping unit.

- Sanitary due to air tight water chamber.
- Oxygen in the compressed air serves as purifying agent.
- Economical (smaller pipe diameter)
- Less initial construction & maintenance cost.
- Adaptable air pressure.

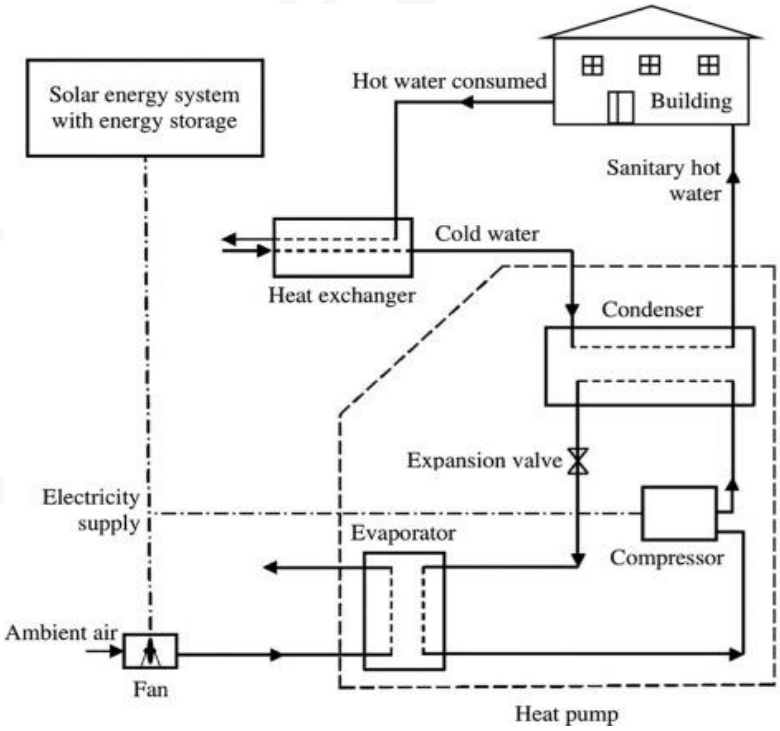
Disadvantages

- Water supply is affected by loss of pressure inside the tank in case of power Interruption.

5.2 Hot water supply – General principles for central plants-layout.

Hot water production in the apartments - With individual heater, a gas fired boiler or electric heater. A heat exchanger connected to a central heating system or district heating and central hot water production with circulation system.

Hot water production per apartment - There is hot water production with individual gas fired boilers, electrical heaters or heat pumps in combination with exhaust air. In case of a gas boiler account must be taken for the requirements for the flue gas discharge. For hot water storage tanks keep in mind the extra weight of the storage tank in each apartment.



Individual heat exchangers - This heating distribution system supplies the heat for the heating in the apartment using a heat exchanger, to produce hot drinking water there are double-wall heat exchangers to guaranty the water quality, both heat exchangers can be combined to one device.

The big *advantages* of this system are the simple layout of the water supply system & the individual metering**.** The water heaters are located close to the fixtures so there is a minimum in heat losses in the hot drinking water system.

A *disadvantage* is that by maintaining a permanent high temperature of the heating mains a beat loss occurs in the shaft which warms the cold water pipes in the same shaft.

Central hot water production - If a central hot water production is used, the hot water is distributed from the central hot water tank to the apartments with a hot water pipe & a hot water circulation pipe.

- Avoiding installing the circulation pipe in the apartments, use only supply pipes for the users.
- The maximum pressure in the distribution system is 600Kpa.
- The user pressure for each apartment has a minimum of 200Kpa.
- The maximum pressure for the hot water storage tank is 1000Kpa.

Each pressure zone needs a separate hot water system. It's not possible to locate the hot water storage tanks in the basement because of the high static pressure. This hot water concept provides space on the floors near the apartment. Each zone must have its own water heater, distribution piping, and circulation hot water piping & circulation pumps. It is always desirable to locate the heater at the top of the system. The pressure on the heater & circulation pump is subjected to be much less than at the base of the system.

5.3 Sanitation – Soil and Waste Water Installation in High Rise Buildings.

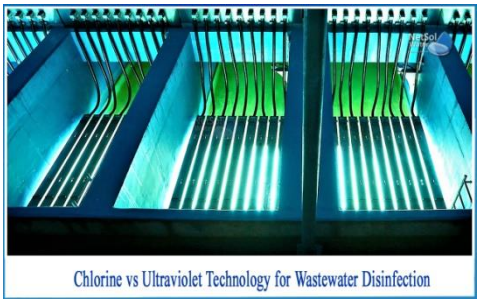
Principle of Planning and Design of House Drainage

- It is advisable to lay sewers by the side of building rather than below the building.
- The drains should be straight between the inspection chambers or manholes.
- The entire system should be properly ventilated.
- The house drain should connect to the public sewer only if the public sewer is deeper than house drain otherwise reverse flow from public sewer to the house drain.
- The house drain should contain enough number of traps at suitable points for efficient functioning of it. The joints of sewers should be water tight.
- The lateral sewers should be laid at proper gradient so that they develop self - cleaning velocity.
- The layout of house drainage system should permit easy cleaning and removal of obstructions.
- The rain water from houses is collected from roofs and conveys it to storm water drain through catch basins or inlets.
- The sewage formed should be conveyed as early as possible after its formation. The size of lateral sewers should be such that they will not overflow at the time of maximum discharge.

Grey water - All other house hold waste water from the bathroom showers, kitchen sinks & clothes wash areas & other taps water.

Grey water treatment - Grey water for irrigation & domestic grey water system decontaminated grey water is used for irrigation. A domestic grey water treatment system diminishes bacteria, chemical pollutants & solids. The treatment processes includes;

- Filtering.
- Settlement of solids.
- Flotation & separation of lighter solids.
- An aerobic digestion.
- Chemical or UV disinfection.


Chlorine vs Ultraviolet Technology for Wastewater Disinfection

Layout of Sanitary Fittings to House Drainage

- The layout should be simple and direct (both horizontal and vertical).
- Horizontal pipes should lay at designed slope.
- Concrete pads should be provided to support the pipes laid on earth fill.
- Long or short sweep quarter bends or two 45 or eight bends for making 90" turn should be provided.
- Only sanitary fees and quarter bends are used for a change of pipe from horizontal to vertical. Manholes should be provided at all points of intersections and change of direction of pipes.
- All soil pipes, waste pipes and ventilating pipes may be griped in shafts or ducts for easy inspection and maintenance.
- A clear minimum distance of 5cm should be maintained from walls to all surface pipes.
- The waste pipes should be separated from house drain by means of gully traps to prevent entry of foul gases, vermin, etc into the building.
- Traps are required for every sanitary fixture and they should be as close to the fixture as possible.

The layout of sanitary fittings to house drainage arrangements are of two methods;

- *House drainage in single storied building.*
- *House drainage in multi-storeyed building.*

House Drainage in Single Storied & Multi-storeyed Building

- The pipes should be laid in straight lines as far as possible both in horizontal as well as vertical direction.
- Any abrupt changes in the direction of flow to be avoided.
- Horizontal pipes may be supported and set as to maintain the designed slope.
- Man holes should provide at all points of intersection.
- All surface pipes should have minimum clear distance of 5cm from the walls.
- The waste pipes should be separated from house drains by means of gully trap.
- In the case of multi-storeyed building sanitary blocks is arranged one above the other on different floors.
- This facilitates the same soil pipe or waste pipe or vent pipe to serve the various fixtures in different floors.
- Inspection chamber is provided at the ground where the solid pipe joins the house drain a vent pipe or anti siphon pipe is also provided to preserve the waste seals of sanitary fittings.
- The soil pipes and vent pipes are provided with wire cage at the top to avoid the birds making nests in the pipe.

5.4 Electrical Services

Wiring systems

- A network of wires/ cables connecting various electrical accessories for distribution of electrical energy from the supplier meter board to the number of electrical energy consuming devices such as lamps**.**
- Fans, TV refrigerator and other domestic appliances through controlling (switches) and safety (fuses, MCB etc.) devices are known as "Wiring System".
- The supply used in houses for lighting and power purposes is single phase supply (For Industries three-phase AC supply is employed).
- The single phase circuit is connected across 220/230 V, across one phase and neutral.

How Electric Supply Comes To Our House

- The supply is taken from the distribution line through service mains either by overhead line or underground cable.
- A pole fuse may be provided to protect the service line against over loading, the supply is directly fed to the energy meter and after energy meter a service fuse (Iron clad cut-out) is provided for safety purpose.
- Both energy meter and Iron clad cut-out are supplied by the supply authority (State Electricity Board), hence both are sealed-by supplier.
- From distribution board, the power is distributed to various sub-circuits. Separate phase and neutral is taken for each sub-circuit.
- According to Indian standards the maximum number of points of lights, fans, and 5 A socket-outlets that can be connected in one sub-circuit is 10 and the maximum load that can be connected in each sub-circuit is 800 watts.
- The earth wire is connected to the all metallic parts of the wiring and appliances except the current carrying conductors. Now-a-days instead of fuse. Miniature circuit breakers are used and instead of ICDP automatic used.

Choice of wiring system - The choice of any wiring system for a particular place depends on many factors**.** Hence, following points should be considered before selecting the type of wiring system.

- ***Durability*** - The wires used in any wiring must be durable and should be safe from fire and weather conditions etc.
- ***Safety*** - The wiring selected should not be risky to any human being.
- ***Cost*** - This is most important factor. The wiring selected should be economical.
- ***Appearance*** - The wiring must provide good outlook after its installation and it should be according to the construction and design of the building.
- ***Accessibility*** - The selected wiring should be easily accessible and easy to extend.
- ***Mechanical protection*** - The selected wiring system should provide enough mechanical protection during its use.

System of wiring - The various system of wiring used in our country are**;**

- *Cleat wiring*
- *Wooden casing and capping wiring*
- *CTS or TRS wiring*
- *Lead sheathed or metal sheathed wiring*
- *Conduit wiring*
  - *Surface or open type*
  - *Recessed or concealed type*

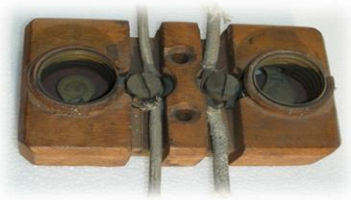
Cleat wiring - The wires/cables used in this system of wiring are either VIR or PVC type. The porcelain cleats are used to hold the cables about 6mm above the walls or ceiling. The cleats are made in two halves, the base and cover (cap). The base has grooves to accommodate the wires and is fixed on the wall and the cover is placed over it.

Advantages

- It is cheapest system of wiring.
- It requires less labour and workman ship.
- It requires less time for installation and less cost.
- It can be easily and quickly removed when not required. Extension and fault location in easy.

Disadvantages

- It is quite temporary system of wiring.
- Less life and less efficiency.
- Dust and dirt spoil the appearance.
- The wires are exposed to mechanical injury.
- The oil dust and smoke injure the wires.



Applications

It is used for purely temporary purpose like camps etc. It is not suitable in damp places, blacksmith shops etc. It is preferred where appearance is not so important and cost is main consideration.

Wooden casing and capping wiring - This system was introduced 60 years ago, when it was first considered necessary to provide some, protection to cables. The cables used in this system are either VIR or PVC insulated cables.

It consists of rectangular wooden blocks made from quality seasoned teak wood or any other quality wood called casing. The casing consists of V-shaped grooves into which the wires are laid.

Advantages

- This wiring has good appearance.
- The life is more compared to cleat wiring.
- Easy for installation and rewire.
- The wires are safe from mechanical damage, rats etc.
- Easy to inspect by opening capping.

Disadvantages

- No safety from fire.

- It requires better workman ship, so labour cost is high.
- Cannot be used in damp places.
- If not painted and varnished, the vermin's may eat the wood, which reduces the life of the system.

Application

This system is suitable for low voltage domestic installations in dry places. It should never be used where there is a risk of fire such as blacksmith, moulding shops etc and in damp places.

Fuse - A fuse is a short piece of metal inserted in the circuit which melts when excessive current flows through it & thus break the circuit.

High rupturing capacity (HIC) cartridge fuse - The primary objection low & uncertain breaking capacity on semi-enclose re-wearable fuses is over come in "HRC "cartridge fuse. It consist of a heat resisting ceramic body having metal end caps to which is welded silver current carrying element.

The space within the body surrounding the element is completely packed with a filling powder. The filling material may be chalk, plaster of Paris or marble dust & it acts as cooling medium.

Advantages

- They are capable of carrying high as well as low faults.
- They have high speed of operation.
- They require low maintenance.
- They are cheaper than other circuit interruption devices of equal breaking capacity.
- They permit consistence performance.

Dis-advantages

- They have to be replaced after each operation.
- Heat produced by the arc may affect the associate switches.

High voltage fuse - The low voltage fuses have low normal current rating & breaking capacity**.** Therefore they can be successfully used on modern high voltage circuit.

Type of high voltage fuses

- Cartridge fuse
- Liquid type fuse
- Metal clad fuse

Cartridge fuse - This is in general construction to the low voltages cartridge type accept that special designs features are in corporate. Some design employee for element wound in the form of helix on some of designs, there are two fuse element parallel, one of low resistance (silver wire) & the other of high resistance (tungsten wire).

Liquid type fuse - These fuses are filled with carbon tetrachloride and have the widest range of application to high voltage system. They may head for circuits up to range of about 100A rated current on systems up-to 132kb & may have breaking capacity of the order of 6100A.

Metal clad fuse – Metal clad oil immersed fuse having developed with the object of providing a substituted for the oil circuit breaker. Such fuses can be used for very high voltage circuit & operate most satisfactory under short circuit condition approaching their rated capacities.

Earthing - Earthing means the direct connection of the non-current carrying parts of electrical equipments such an metallic frame work, electric meter body metallic covering of cables, earth terminal of socket outlet, transmission etc to earth (ground) is known as "earthing or (grounding)".

Purpose/necessity of Earthing - The main purpose of earthing is;

- To save human life from electric shock.
- To avoid risk of fire due to earth leakage current through unwanted path.

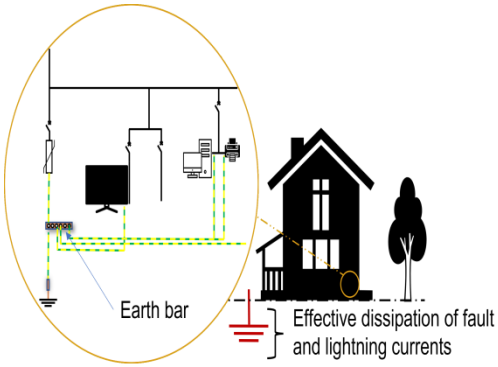
- To maintain the line voltage constant (since neutral of every alternate transformer is earthed).
- To ensure that no current carrying conductor resist a potential with respect to earth than its desired insulation.

Method of Earthing

- *System earthing*
- *Equipment earthing*

Types of Earthing

- *Road earthing*
- *Strip earthing or wire earthing*
- *Pipe earthing*
- *Plate earthing*



5.5 Lighting – Requirement of lighting, Measurement of light intensity

Aims of good lighting

Good lighting is necessary for all buildings and has three primary aims. The first aim is to promote work and other activities carried out within the building. The second aim is to promote the safety of the people using the building.

These aims can be achieved by following process;

- Planning of the brightness and colour pattern.
- Using direct lighting.
- Artificial lighting installation.
- Installation of emergency lighting systems.

Planning the brightness pattern;

In occupations where the visual demands are small, luminance recommendations are based on standards of welfare, safety and amenity judged appropriate to the occupations. Where work takes place over the whale utilizable area of room, the illumination over that area should be reasonably uniform and it to recommend that the miry ratio should be not less than 0.7 for the working area. When the task brightness appropriate to an occupation has been determined, the brightness of the other parts of the room should be planned to give a proper phases to visual comfort and interest.

The brightness patterns seen within an interior may be considered as composed of three main parts.

- The task itself.
- Immediate background of the task.

Glare – Excessive contrast or abrupt and large changes in brightness produce the effect of glare, when glare is present; the efficiency of vision is reduced and small details. Glare may be direct glare due to light sources within the field of vision.

Day lighting - The primary source of lighting for day lighting is the sun; the light received by the earth from the sun consists of two parts, namely, direct solar luminance and sky luminance.
For the purposes of day lighting design, direct solar luminance shall not be considered and only sky luminance should be taken as contributing to luminance of the building interiors during the day.

The relative amount of sky luminance depends on the position of the sun defined by its altitude, which in turn, varies with the latitude of the locality, the day of the year and the time of the day.

The external available horizontal sky luminance values which are exceeded for about 90 percent of the daytime working hours may be taken as outdoor design luminance values for ensuring

adequacy of day lighting design. The outdoor design sky luminance varies for different climatic regions of the country.

Daylight factor - The daylight factor is dependent on the sky luminance distribution, which varies with atmospheric conditions. A clear design sky with its non-uniform distribution of luminance is adopted for the purposes of design in this section.

Components of daylight factor - Daylight factor is the sum of all the daylight reaching on an indoor reference point from the following sources;

- The direct sky visible from the point.
- External surfaces reflecting light directly.
- Internal surfaces reflecting and inter reflecting light to the point.
- The daylight factors on the horizontal plane only are usually taken, as the working plane in a room is generally horizontal.

The factors is vertical planes should also be considered when specifying day lighting values for special cases such as day lighting on class room blackboards, pictures and paintings hung on walls.

5.6 Ventilation - Methods of ventilation (Natural and artificial Systems of ventilation) problems on ventilation.

Definition of ventilation - The process of removing used & also for ventilated air by fresh air from building is called ventilation in building. This can be done by natural method or artificial method.

Objectives of ventilation

- To remove the used air from the building.
- To supply oxygen or fresh air for human on the building.
- To remove the excessive moisture.
- To cool the body of human & remove the excessive heat.
- To prevent the suffocation of the elder.

Method of ventilation - The system of ventilation is broadly classified as follows;

- Natural ventilation
- Artificial ventilation

***Natural ventilation* -** It is the air movement within a work area due to natural wind, temp difference between the exterior & interior of a building or other factors, where mechanical air movement is not used. For ordinary building natural forces are used for the removal of polluted air & enter the fresh air in the building through ventilation inlet & outlet respectively.

***Artificial ventilation* -** The artificial ventilation system can be broadly divided into three times;

- Vacuum system
- Plenum system
- Air-conditioning system

***Vacuum system* -** Vacuum system is one in which uses of air is thrown out to the outside atmosphere by means of suitable exhaust fan install near the top ventilator this exhaustion of the warmer air from the roof causes lower pressure inside the roof. There by permitting inward leakage of new fresh atmospheric air through the doors, windows, etc. Various types of fan are used for this purpose. This system is largely used for kitchen, public halls, industrial plants, etc.

***Plenum system* -** The plenum system involve forcing or pumping in fresh air & causing the ventilated to be exhaust fan placed at the outlets. Provision of a cooler at a window with or without an exhaust fan & ventilator provides an example of such a plenum system of ventilation. In larger building such a plenum system may consist of distributing the incoming forced air at different points the building through systems of grills.

Air-conditioning system - The atmosphere in the modern cities contains highly polluted smoke, fumes, germs & bacteria, etc. In such environments, natural ventilation or even ordinary mechanical ventilation for bringing the outside polluted air into the building will not serve us any useful purpose.

In such conditions it is necessary to completely control the temp & quality of outside air, before it is admitted into the room. Air-conditioning thus provides a comfortable & whole some ventilation in the building Again air condition system is divided into two parts;

- Summer air-conditioner
- Winter air-conditioner

Summer air conditioner - In summer season, the external atmospheric temperature is high & the hot air has to be cold before it can be distributed in the building. During the process of cooling, however the humidity of this air increases because at low temperature with the same amount of moisture, the relative humidity increases. A dehumidifier is in the form of a substance like ammonia calcium chloride, etc or the air is cold & dried air is then finally forced out into the spaced to be condition.

Winter air conditioner - In winter season the external atmospheric temp is low & this cold atmospheric air has to be heated up before, it can be distributed in the conditioned room. During this process of pre-heating however the humidity of air reduces because at high temperature with the same amount of moisture, the relative humidity decreases. Hence after heating it become necessary to increase the humidity of this air by carrying it through a humidifier where air may be mixed with the water vapour by throwing water over the air with the help of spray nozzles.

System of industrial ventilation - In various industrial enterprises & potentially hazard condition exist which can effects the health & safety of people working there. Fumes & vapours are given off from storage tank, processing tank & other types of processing equipment.

5.7 Mechanical Services

Lift/Elevator - An elevator can be defined as an electric lift which is used as vertical transportation of goods as well as people among the floors in buildings using bins otherwise silos.

- As usual these are activated with the electrical motors that also to drive counter weight system cables for drive transaction such as a host, otherwise, pump hydraulic fluid for raising a cylindrical piston such as a jack.
- These are used in many areas like agriculture, manufacturing, etc. Elevators are classified into different types based on our requirement.
- Elevators are frequently used in the latest multi-storey constructions, in particular wherever ramps of wheelchair would be not practical.
- The working principle of an elevator or lift is similar to the pulley system. A pulley system is used to draw the water from the well.
- Basically, an elevator is a metal box in different shapes which is connected to a very tough metal rope. The tough metal rope passes through a sheave on the elevator in the engine room.
- Here a sheave is like a wheel in pulley system for ditching the metal rope strongly. This system can be operated by a motor. When the switch is turned ON, the motor can be activated when the elevator goes up and down or stops.
- The elevator can be constructed with various components or elevator parts that mainly include speed controlling system, electric motor rails, cabin shaft, doors (manual and automatic), drive unit, buffers, and safety device.

Different Types of Elevator

- *Hydraulic elevator*
- *Pneumatic elevator*

- *Cable driven or traction elevator*
- *Capsule lift*
- *Building lift*
- *Passenger lift*
- *Freight lift*
- *Residential elevator*

Escalator - An Escalator in a moving staircase that moves people between different floors of a building. They are powered by motors. The steps run on tracks. There is a handrail that moves with the escalator, that you hold onto when riding the escalator. There is also an emergency stop button, which stops the escalator and a key switch that restarts the escalator in the up or down direction.

Different Types of Escalator

- *Step type escalator*
- *Bell type escalator*
- *Cleat type escalator*
- *Spiral escalator*
- *Levytator*

 *Hydraulic elevator*	 *Pneumatic elevator*	 *Cable driven*
 *Capsule lift*	 *Building lift*	 *Passenger lift*
 *Freight lift*	 *Residential elevator*	 *Step type escalator*
 *Levytator*	 *cartridge fuse*	 *metal clad fuses*

6. CONSTRUCTION & EARTH MOVING EQUIPMENTS

The type of equipments to be used in a building project depend upon the scope of work. The equipment to be used can be either a standard type equipment which can be used for a umber of situations or can be a special type which meets the requirements or the particular project. The operation cost of equipment and its working expenses.

The basis for payment to be made to contractor should be based upon;

- Cast of owning equipment
- Depreciation
- Lubrication charges
- Fuel cost

The cost of owning the equipment must include;

- The initial cost price
- Interest charges
- Excise taxes and control sales tax
- Insurance fee
- Storage rent

The operation cost of an equipment includes;

- Initial investment cost
- Major repairs cost
- Labour charges
- Lubricant and fuel cost
- Servicing repair charges
- Overhead expenditure

6.1 Planning And Selection of Construction Equipments

The type of equipment to be used in a building project depends up on the scope of work**.** The equipment to be used can be either standard type equipment which can be used for a no. of site action or can be a special type which meets the requirement of the particular project. The operation cost of equipments includes both the cost of owning & equipment & its working expenses.

Planning of equipment - Planning for equipment operation means best utilisation of machines for satisfactorily &efficient working of the project. In order to achieve this, it is necessary that the working of different group of machines should be arranged & co-ordinated that a continuous working stream is formed.

Selection of equipment - The selection, management & maintenance of construction equipment is particularly important when consider in the contest of earth moving & excavation plan. The selection of particular equipment is the complex exercise because of the wide variety of choice available for all classes of plant. Final choice is usually based upon experience.

The final selection depends upon following factors:

- Availability of equipment
- Utility of equipment & Durability of project
- Production cost of equipment
- Availability of spare parts
- Availability of skilled operator

Factors Affecting Selection of Equipment

- Use of equipment available with the organization.
- Suitability for job condition with special reference to climatic and operating conditions.
- Uniformity of type.
- Size of equipment.
- Use of standard equipment.
- Country of origin
- Unit cost of production.
- Availability of spare parts and selection of manufacturers.
- Suitability of local labour for operation.

6.2 Study on Earth Moving Equipments Like Drag Line, Tractor, Bulldozer, Power Shovel

Construction machinery - In this case of huge construction projects, Proper use of the appropriate equipment contributes to economy, quality, safety and timely completion of a project**.** Equipment is use for highway projects, irrigation, buildings, power projects etc**.** 15-30% of total project has been accounted towards equipment and machinery.

Classification of Construction Equipments

- Excavation equipments
- Compaction equipments
- Hauling equipments
- Cranes
- Conveying equipments

Types of crawlers - A crawler excavator is a tracked vehicle which is used to dig and move large and heavy objects. They are high horsepower excavators used in mining and for other heavy tasks. The main difference between crawler excavator and other types of excavators is the chassis. They operate on track mechanism in place of wheels. Crawler excavators have increased stability, efficiency and balance.

- Backhoe
- Dragline
- Suction excavators
- Long reach/long arm
- Crawlers and compact excavators
- Power shovels

Types of Pneumatic tyred - Depending upon the project requirement and soil to be compacted, different types of rollers are used for compaction work.
The various types of rollers which are used for compaction are;

- Cylindrical Rollers
- Sheep's foot Rollers
- Pneumatic tyred Rollers
- Smooth wheeled Rollers
- Vibratory Rollers
- Grid Rollers

Excavation equipments - Excavation is the process of cutting or loosening and removing earth including rock from its original position, transporting and dumping it as a fill or spoil bank. The excavation or cutting may be needed in soil, soft rock or even in hard rock before preparing the sub grade. The selection of excavation equipment and the cost analysis is made based on the stiffness of the materials to be excavated**.** Earth excavation work may be divided as excavation or cutting, grading and compaction**.** The various excavation equipments used in building projects include

tractors, bull dozers, angle dozers, scrapers, power shovels, draglines, clam shell, hoes, and dredgers. The selection of equipment for particular building project depends upon the nature of the mechanical job size, distance method of disposal, and construction time assigned etc.

Different Types of Excavation Equipments

Bull dozer - Bulldozer is considered to be a versatile machine for many construction projects. A blade is attached to the front side of the tractor. It is used for clearing site, opening up pilot roads, moving earth for short haul distance of about 100 m and also in several other jobs.

Scrapers - One of the useful earth moving equipment. Used for digging, loading, carrying, dumping, spreading. It is a self operating and it can dig haul and discharge the materials in uniformly thick layers, however scrapers are not capable of digging very stiff materials.

Grader - Graders are commonly used in the construction and maintenance of dirt roads and gravel roads. In the construction of paved roads they are used to prepare the base course to create a wide flat surface for the asphalt to be placed on. Graders are also used to set native soil foundation to finish grade prior to the construction of large buildings. Graders can produce inclined surfaces, to give (camber) to roads. In some countries they are used to produce drainage ditches with shallow V-shaped cross-sections on either side of highways.

Tractors - It is important equipment for earth movement. It converts engine energy into tractive energy. Tractors are usually worked by diesel engines having horse power ranging from 20 HP to 200 HP. They are either:

- Crawler or track type
- Wheel or pneumatic type

The crawler type moves on an endless chain. They are slower in speed than wheel type. Generally, they have a speed about 12 kmph. They are used for uneven and rough ground. It best operates on gravel or earth. Wheel tractors move on pneumatic tyres and have a speed of about 50 kmph. They operate best on smooth roads. Tractors are used to pull, or push other equipments. Hence, they are provided with various attachments such as dozer, scraper, harrow, plough, etc.

Power shovel – To capable of excavating all types of earth excepts hard rock**.** Size varies from 0.375 m^3 to 5 m^3**.** Basics parts of power shovel including the track system, cabin, cables, rack, stick, boom foot-pin saddle block, boom, boom point sheaves and bucket.

Applications;

- Suitable for dose range of work.
- Capable of digging very hard materials.
- Can remove big sized boulders
- It is used in various types of jobs such as digging in gravel banks, clay pits, digging cuts in road works, road-side, etc.

Factors affecting output of power shovel;

- Class of material
- Depth of cutting
- Angle of swing
- Job condition and Physical condition of the shovel.
- Management condition and Skill of the operator.
- Size of hauling units.

Drag line - The drag line is so name because of its prominent operation of dragging the bucket against the material to be due unlike the shovel, it has a long light crane boom and the bucket is

loosely attached to the boom through cables. Because of this construction, a dragline can dig and dump over larger distances than a shovel can do. Drag lines are useful for digging below its track level and handling softer materials. The basic parts of a drag line including the boom, hoist cable, drag cable, hoist chain, drag chain and bucket.

Applications

- It is the most suitable machine for dragging softer material and below its track level.
- It is very useful for excavating trenches when the sides are permitted to establish their angle of repose without sharing.
- It has long reaches. It is mostly used in the excavation for canals and depositing on the embankment without hauling units.

Clam shell - This is so named due to resemblance of its bucket to a clam which is like a shell- fish with hinged double shell. The front end is essentially a crane boom with a specially designed bucket loosely attached at the end through cables as in a drag line. The capacity of a clam shell bucket is the closing line, hoist line, sheaves, brackets, tagline, shell and hinge.

Applications

- Used for handling loose material such as crushed stone, sand, gravel, coal etc.
- Main feature is vertical lifting of material from one location to another.
- Mainly used for removing material from coffer dam, sewer main holes, well foundations etc.

Dredgers - These are the equipments used for excavation of the bed of a river, lake or sea for the purpose of deepening. They are of following three types.

Dipper dredgers **-** Dipper dredgers excavate all type of underwater soil and discharge the loaded bucket either on the bank or a floating vessel. These dredgers can excavate up to 50 cum/hr. They can operate up to 20 m depth and have a range up to 35 m.

Ladder dredgers **-** Ladder dredger is comprised of a bucket elevator mounted on the vessel. The bucket when dipped into the soil is lifted with the help of belting. The bucket in the lifted position discharges into the hopper at the top of the elevator from which another system of belt conveyor discharges the material into standing vessel.

Suction or Hydraulic dredgers **-** This is a heavy duty pump mounted on a vessel or barge. The suction line is supported by means of a ladder up to the river bed. The pumped material is conveyed with the help of discharge up to a distance of 3 m and height of 30 m. The ladder is hinged at the top end so that free end can be raised or lowered with winches.

Bull dozer

scrapers

Graders

Tractors

Power shovel

Drag line

Clam shell

Dredgers

Tamping roller

Smooth wheeled roller

Pneumatic tyred roller

Vibrating compactors

6.3 Study & Uses of Compacting Equipments

Machines such as rollers to expel air from a sell mats and so achieve a high density South wheel roles are best for gravels, sands, and gravels and-clay toils with reasonably high moisture contents. Different types of compaction equipment rollers in these process heavy weights in the form of rollers are used to press the soil particles together Smooth wheeled rollers are typical examples of compaction equipment which operate on this principle.

Types of compaction equipments;

- Tamping roller
- Smooth wheeled roller
- Pneumatic tyred roller
- Vibrating compactors

Smooth wheeled rollers **-** There are two types of smooth wheeled rollers;

- Three wheeled or macadam rollers
- Tandem rollers

The gross weight of the former type ranges between 4-18 tones where as that of the latter type with two axle varies between 1-14 tones. The compacting efficiency of the smooth wheeled roller depends on the weight width and diameter of each roller. The smooth wheeled rollers are suitable to roll a

wide range of soils, preferably granular soils and pavement materials for the various layers. These are particularly found to be useful in compacting soils and other materials where a crushing action is advantageous.

Pneumatic tyred rollers **-** In this type number of pneumatic wheels are mounted on two or more axles, under a loading platform. These rollers are pulled by tractors. They pneumatic tyred rollers are considered to be most suitable to compact non plastic silts and fine sands. In addition to the direct pressure due to rolling, there is also a slight kneading action.

Sheep's foot roller **-** This type of roller consists of hollow steel cylinder with projecting feet. The weight of the roller can be increased by filling the drum with wet soil. The weight, diameter and width of the roller may be varied and also the shape and size of the feet. These may be pulled by tractors. The efficiency of the sheep's foot rollers depends on the weight of the roller and the number of feet in contact with the ground at a time. The thickness of compacting layer is kept about 5 cm more than the length of each foot. About 24 or more number of passes of the roller may be necessary to obtain adequate compaction.

6.4 Owning & Operating Cost

Ownership cost is the cumulative result of those cash flows an owner experiences whether or not the machine is productively employed in a job. The most significant cash flows affecting ownership cost are;

- Purchase expenses
- Salvaged value
- Tax saving
- Major repair & ever hauls
- Property tax
- Insurance
- Storage miscellaneous

Purchase Expenses **-** The case out flow, the firm experience in occurring ownership of a machine is the purchase expense. It the total delivered cost including amounts for all option shipping & tax less the cost of tired if the machine as rubber tyres.

Salvaged value **-** Salvaged value is the cash flow a farm receives if a machine still has value at the time of its disposal. This revenue will occur at future data, used equipment prices are difficult to predict.

Tax saving **-** The tax saving from depreciation are the phenomenon of the tax system in the United States. Under the tax laws of united state the depreciating a machine loses in value will as lesser the net cost machine ownership.

Measure repairs & over hauls **-** Measure repairs & over hauls are included under ownership cost because they result in an extension of a machines service life. They can be considered an investment in a new machine because a machine commonly works on many different projects considering major repair as an ownership cost, these expenses to all jobs. These causes should be added to the basis of the machine & depreciated.

Property taxes **-** In this context taxes refer to those equipment ownership taxes that charged & government sub division. They are commonly used as a percentage rate applied against the book value of the machine. Depending upon location property taxes can range up to about 4.5% in much location. There will be no property tax on equipment over the service life the machine. They will decrease in magnitude as the book value decreases.

Insurance **–** Insurance as considered here includes the cost to cover fire, theft and damage to the equipment.

Storage & miscellaneous **-** Between job or during bad weather a company will require storage facilities for its equipments. The cost maintaining the storage place a facility should prorated to that machine that requires such harborage. The rate may range from nothing to perhaps 5%.

Operating cost - Operating cost is the sum of those experiences by working a machine on a project. Typical expenses include;

- Fuel
- Lubricants
- Repair
- Tyres
- Replacement of high wear items

Fuel **-** Fuel expenses is best determined by measurement en the job. Good service record tells the how many gallons of fuel a machine consumes over that period of the time & under what job condition. Hourly fuel consumption can be calculated directly, when company record is not available manufactures consumption data can be used to construct fuel estimate.

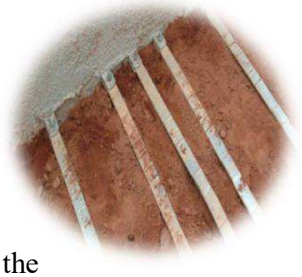
Lubricants **-** The cost of lubricants filters & greases will be depending on the maintenance practice of the company & the condition. In either case hourly cost arrive at by the operating hour between changes & consumption centre.

Repairs **-** Repairs are referring to here mean normal maintenance type repair. These are the repairs expenses include on the job site where the machines are operated & would include the cost of parts & labors.

Tyres **-** Tyres for wheel type equipment are a measure operating cost because they have a short life in relation to the iron of a machine. Tyre cost is including repair & replacement charges. These costs are very difficult to estimate because of the variability in tired wire with project site condition & operator skill.

Replacement of high wire items **-** The cost of replacing those items that have very short service lives with respect to machine service live can be a sustainable operating cost.

ACTE



7. SOIL REINFORCING TECHNIQUES

7.1 Necessity of Soil Reinforcing.

Soil reinforcement is a technique which is commonly used to improve the strength and stiffness of soil by utilizing geo-engineering methods. This allows the soil to resist more loads. In geotechnical engineering, reinforcement of soil is vital and necessary in lands where erosion is high.

Soil reinforcement techniques are commonly used in area with soft soil as it doesn't provide sufficient support to any building/construction. Reinforcement of soil is performed by placing tensile elements in the soil to enhance the stability and strength of the soil. Soil reinforcement is a cost-effective technique which is used to improve tensile and bearing strength of the soil.

It is opted to improve the engineering and mechanical properties of soil. Reinforced soil bed increase the bearing capacity of the soil and reduce the differential settlement of soil bed. To reduced the quantity of earth fills. Steeper embankment slopes reduce the land take required.

Soil Reinforcement May Be Made With Number of Materials;

- Oven geo-textile polymer
- Geo-grid of polyethylene
- Polyester & fiber glass
- Steel strips
- Weld wire mesh

Reinforced soil structure fall broadly into three classes;

- Mechanically stabilized earthwork
- Reinforced slopes & embankment
- Reinforced foundation

Selection of reinforcement should include an evaluation of candidate products for serviceability during construction.

7.2 Use Wire Mesh And Geo-Synthetics.

The wire mesh and geo-textile materials possesses some good properties, such as cost-effectiveness, high strength-to-weight ratio, significant flexural performance, and compatibility with concrete, thus can be used as strengthening material.

The term 'geo-synthetics' has two parts: the prefix 'geo' referring to an end use associated with improving the performance of civil engineering works involving earth/ground/soil and the suffix "synthetics', referring to the fact that the materials are almost exclusively man-made.

The materials used in the manufacture of geo-synthetics are primarily synthetic polymers generally derived from crude petroleum oils; although rubber, fiber glass, and other materials are also sometimes used for the purpose.

- **Geo-textiles -** These are planar, permeable, polymeric textile products in the form of flexible sheets. Currently available geo-textiles are classified into the following categories based on the manufacturing process;
  - *Woven geo-textile*
  - *Non woven geo-textile*
  - *Knitted geo-textile*
  - *Stitched geo-textile*
- **Geo-grids -** These are planar, polymeric products consisting of mesh or net-like regular open network of intersecting tensile-resistant elements, called ribs, integrally connected at the junctions. Extruded geo-grids are classified into the following two categories based on the direction of stretching during their manufacture; UN axial and BI axial geo-grids.

- **Geo-nets -** These are planar, polymeric products consisting of regular dense network of integrally connected parallel sets of ribs overlying similar sets at various angles.
- **Geo-membranes -** These are planar, relatively impermeable, synthetic sheets manufactured from materials of low permeability to control fluid migration in a project as a barrier or liner.
- **Geo-composites -** This is a term applied to the product that is assembled or manufactured in laminated or composite form from two or more materials, of which at least one is a geo-synthetic of some type, which, in combination.
- **Geo-cell -**A three-dimensional, permeable, polymeric honeycomb or web structure, assembled from geo-grids and special bodkin couplings in triangular or square cells.
- **Geo-foam -** A polymeric material manufactured by the application of the polymer in semi-liquid form through the use of a foaming agent to have a lightweight material in slab or block form with high void content for use as lightweight fills, thermal insulators and drainage channels.
- **Geo-mat -** A three-dimensional, polymeric structure and permeable made of course and rigid filaments bonded at their junctions used to reinforce the roots of vegetation such as grass and extend the erosion control of vegetation for permanent installation.
- **Geo-mesh -** A geo-synthetic or geo-natural generally with a planar woven structure having large pore sizes, which vary from several millimeters to several centimeters for use in mainly erosion control works.
- **Geo-pipe -** A plastic pipe (smooth or corrugated with or without perforations) placed beneath the ground surface and subsequently backfilled.
- **Geo-spacer -** A three-dimensional polymeric molded structure consisting of cuspidate or corrugated plates with large voids.
- **Geo-strip -** A polymeric material in the form of a strip.

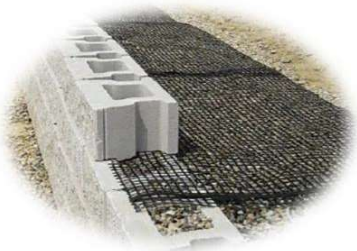
Functions of Geo-synthetics

For any given application of a geo-synthetic, there can be one or more functions which it is expected to serve during its life of performance. Selection of a geo-synthetic for any field application, thus it's highly governed by the functions to be performed by it for that specific application.

Geo-synthetics always perform one or more of the following basic functions when used in contact with soil, rock and/or any other civil engineering-related material:

- *Reinforcement*
- *Separation*
- *Filtration*
- *Drainage*

Geo textile

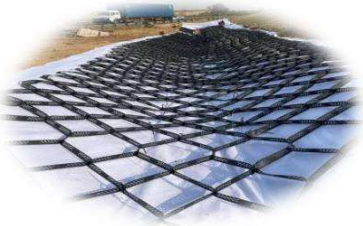


Geo grid

Geo net

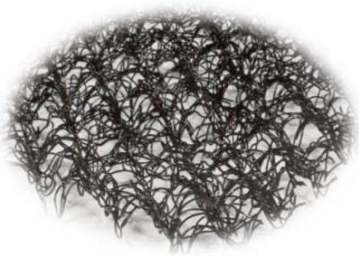
Geo membrane

Geo composite



Geo cell

Geo foam



Geo mat

Geo mesh

Geo pipe

Geo spacer

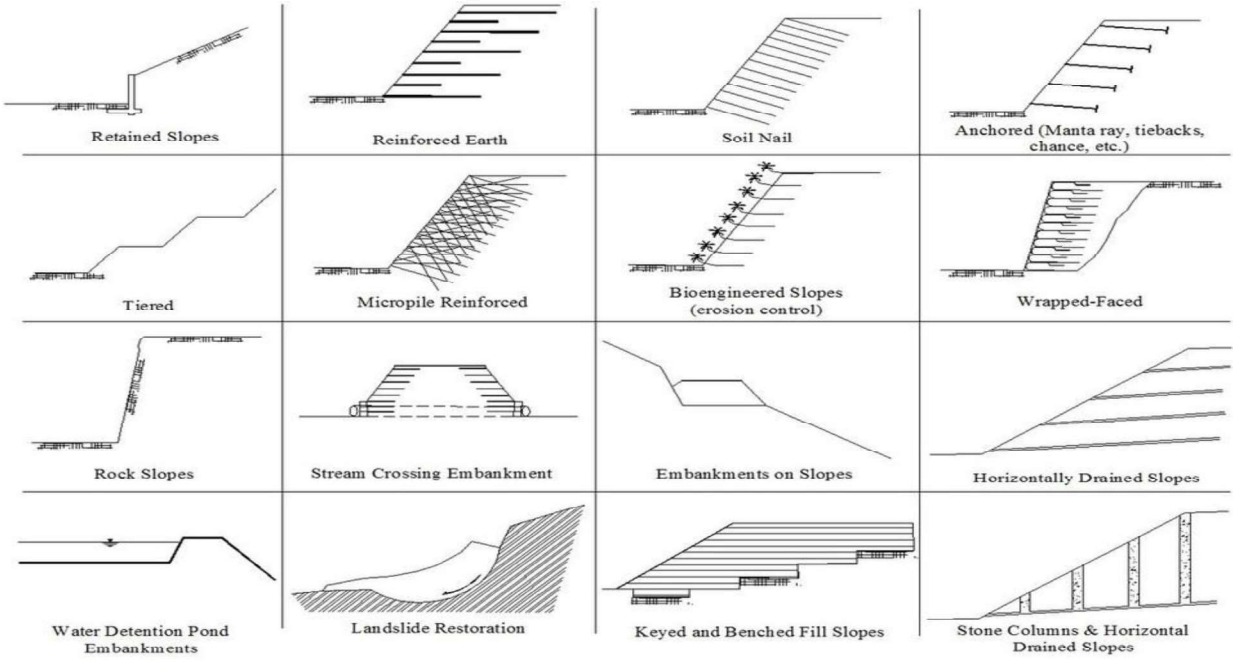
Geo strip

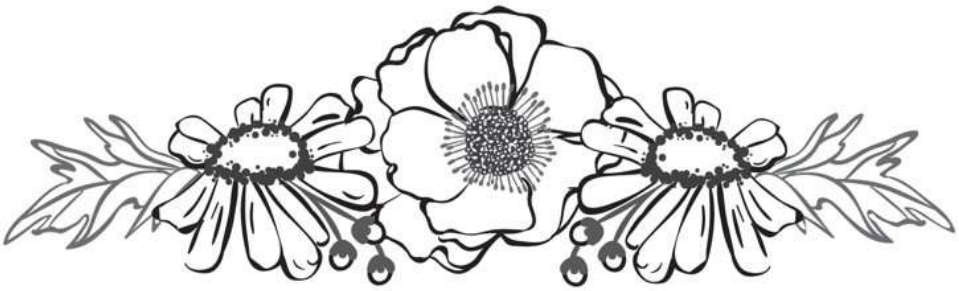
7.3 Strengthening of Embankments, Slope Stabilization in Cutting & Embankments by Soil Reinforcing Techniques.

Reinforcement is the most effective way to strengthen slopes and increase the stability of embankments on weak base. Reinforced materials and soils have better physical and mechanical characteristics than unreinforced ones. Slopes can be stabilized by adding a surface cover to the slope, excavating and changing (or regarding) the slope geometry, adding support structures to reinforce the slope or using drainage to control the groundwater in slope material.

Several methods for slope stabilization including:

- Soil nailing. This is a cost effective method for long-term stabilization of over-steepened soil slopes, on or around your site.
- Slope drainage. Slope drainage is an important part of ensuring the future stability of a slope.
- Facing systems.
- De-vegetation.





THANK YOU