LECTURE NOTES

ON

ADVANCED CONSTRUCTION TECHNIQUES & EQUIPMENT

Ganesh Institute of Engineering and Technology

SCTE &VT, BHUBANESWAR
ODISHA

6TH Semester Diploma in Civil Engineering

(As per Syllabus prescribed by SCTE&VT, Odisha)

By

Subject Coordinator: Er. Arasmita Dash

SR. LECTURER, CIVIL ENGINEERING

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		

Ch-01 ADVANCE CONSTRUCTION MATERIAL 06-01-2020

Fibre :-

→ The fibre is a filament or thread like piece of any material. This term sometimes also refers to a raw material that can be drawn into thread.

→ Fibre is a small piece of reinforcing material possessing certain characteristics properties. It is a long and thin material can be circular or flat.

→ Fibre is derived by a parameter called aspect ratio.

Aspect ratio :-

It is the ratio of length of fibre to its diameter or least lateral diameter or dimension in case of flat fibre. It ranges from 30 - 150.

Types of fibre :-

a) steel fibre
b) carbon fibre
c) Glass fibre
d) plastic fibre
e) Asbestos fibre
f) Jute fibre
g) cellulose fibre

a) Steel fibre :-

→ steel fibres is one of the most commonly used fibres. Generally round fibres are used. The diameter may vary from 0.25 - 0.75mm.

→ The steel fibre is likely to get rusted and lose some of its strength.

→ Use of steel fibre makes significant improvements in flexural, impact and fatigue strength of

→ The steel fibres have fairly high tensile strength i.e., 280 N/mm² - 410 N/mm² as well as high young's modulus. These are useful for imparting more flexural strength as compared to polypropylene fibres.

Properties of steel fibres :-

Following are the properties of steel fibre.

a) steel fibres are more strong, tough and hard.

b) They are more elastic in nature and avoid corrosion and rust stains.

c) They increase the tensile strength of concrete.

Uses :-

a) This fibre has been extensively used in various types of structures and for overlays of roads, airfield pavements and bridge deck.

b) steel fibres are used in shotcrete.

c) They are used in precast concrete construction.

d) They are used in tunnel lining work.

b) Carbon fibre :-

→ Carbon fibres have very high tensile strength 2110 N/mm² - 2815 N/mm² and Young's modulus chopped carbon fibres with random arrray may used. These are very costly.

→ It has been reported that cement composite made with carbon fibre as reinforcement will have very high modulus of elasticity and flexural strength. The limited studies have been shown good durability.

Properties of carbon fibres :-

→ Carbon fibre are chemically inert and are resistant to Ac corrosion.

→ They have high tensile strength.

→ Carbon fibre have low thermal expansion and the fibres contens about 85 % carbon has good flexural strength.

→ They are available in low weight.

Uses :-

→ The use of carbon fibres for structures like cladding, panels and shells will have promising future.

→ Carbon fibres are more commonly used to reinforcement composite materials.

→ These are used in reinforcement carbon in which they increase tensile strength of concrete.

⇒ Glass fibre :-

→ Glass may be softened and drawn mechanically into thread or glass wool that is finer than silk. A glass stand composed of 60 filaments: each filament having a diameter of 0.0036mm possesses the tensile strength approaching 70,000 kg/m².

→ A stand glass fibre may be 1/15 of the diameter of human hair but have a tensile strength of steel. These may be woven into fabric or used in loosely packed form for both sound and thermal insulation in building

→ Thermal conductivity of the material ranges from ~~0.035~~ 0.035 - 0.045 kcal/m/hr. By depending upon the bulk density. Tests have shown that 25mm of glass cool is equivalent in terms of thermal insulation of 42mm of brick or 62cm of concrete.

Properties of glass fibre :-

→ Glass fibres has good thermal insulation.

→ It has excellent corrosion resistance and moisture resistance.

→ It has good tensile strength.

Uses of Glass fibre :-

→ The glass reinforced plastic is used in the manufacturing corrugated sheeting, mainly used for roof lights and also used for interior panelling and decoration.

→ It is used for sound deadening and thermal insulation in walls, floors and ceilings.

→ Natural jute fibres are used in plumbing works.
→ The glass fibres are used for packing and making fabrics and felts.
→ Used for making acid-proof and fire proof fabrics.
→ Used for material of packing for heat, sound, electric insulation.

Q Write down the uses of fibres as construction material?

Ans⇒ Fibre is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fibre is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fibre is the ratio of its length to its diameter. Typical aspect ratio ranges from 30-150.

→ Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres.

→ Fibre-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fibre reinforced normal concrete are mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts either alone or with hand-tied rebar.

→ Concrete reinforced with fibres is less expensive than hand-tied rebar, while still increasing the tensile strength many times. Shape, dimension and length of fibre is important. A thin and short fibre for example short hair-shaped glass fibre, will only be effective the first hours after pouring the concrete but will not increase the concrete tensile strength.

D - 08 - 01 - 2020

4) Plastic fibre :-

→ High polymers are the magic construction materials of the current era. They include engineering materials like plastics, rubber, fibre glass etc.

→ Plastic specially have occupied an indispensable position in our daily life. They have replaced a number of traditionally used materials.

→ The present themselves in every ~~work~~ search of life. All modern industries like radio, telephone, automobiles, electric motors etc. are basically dependend upon plastics.

→ Plastic is any substance which shows the property of plasticity. Plasticity is the property, by virtue of which, a material undergoes a permanent deformation, when subjected to heavy and continuous stress or pressure.

→ Therefore, in its broadest meaning, many materials like rubber, glass, shellac can be termed as plastic. But now the term plastic has a precise and limited meaning.

Properties of plastics :-

→ Plastics are very light in weight.
→ Plastics have low electrical conductivity.
→ Plastics have low thermal conductivity.
→ Plastic can be transparent, translucent or opaque.
→ Plastics can be formed and moulded into any shape.
→ Plastics have good sound absorption properties, good tensile strength, good resistance to peeling and good dimensional stability.

Advantages of plastics :-

→ Plastics are available in a wide range of colours and shades.
→ Plastics offered good resistance to attack by organic acids, bases, salts and living organisms.

1) Thermosoftening plastics :-

These are also called thermoplastics and are formed by addition polymerization. These plastics can be softened by heating, reshaped and reused as many times as desired. These are soluble in suitable organic solvents.

The common e.g of this plastic are polythene, polyvinyl, cellulose nitrate etc.

2) Thermo setting plastics :-

This type of plastics are formed by condensation polymerization. These plastics are cannot be remoulded and reused. The thermosetting plastics are insoluble in organic solvents.

The E.g → Bakelite, polyester etc.

THERMOSOFTENING PLASTICS	THERMO SETTING PLASTICS
→ These are formed by polymerization by addition.	→ These are formed by polymerization by condensation.
→ They consists of linear structure of long chains with negligible number of cross-links.	→ They have three dimensional networks of chains, joined by prominent cross-links.
→ The secondary bonds between the chains are very weak can be easily broken by heat or pressure.	→ The bond retain strength upon heating. which donot get broken on applying heat or pressure.
→ Heat converts these plastics into a fluid material. Hence, they can be reshaped and reused.	→ They retain their original shape and structure even on heating. So they can not be reshaped & reused.
→ They are usually weak, soft and less brittle.	→ They are strong, hard and more brittle.
→ Because of weak bonds, they are soluble in organic solvents.	→ Because of strong bonds, they are insoluble in organic solvents.

PVC (polyvinyl chloride) :-

→ It is one of the most commonly used polymers produced by the polymerization of vinyl chloride. It is widely employed in the fabrication of plastics.

→ PVC is usually available commercially in the form of a white amorphous powder having a density of about 1.49 cm^{-3}

→ PVC can be manufactured in expended or cellular form. It is available in two forms in flexible and in rigid form. It can be easily moulded and extruded into desired shape. The joints are obtained by solvent welding.

→ This is the cheapest and most widely used plastic.

Properties of PVC :-

→ It is flexible, strong, tear resistance and good ageing properties

→ PVC has tendency to decompose when it is heated or exposed to sunlight with time.

→ It is resistance to impact invariably deteriorates with time

→ It becomes soft beyond 80°c. When heated to more than 160°c, it disintegrates and give off hydrogen chloride.

→ Its electrical properties are not as good as those of rubber, but it offers more resistance to oxygen, ozone and sunlight.

→ It has light weight and resistance to wear.

Uses of PVC :-

→ It is used for flooring, wall facing, various extrusions like hand rails, skirting boards, pipes, fillets etc.

→ It is used for cable jackets, lead-wire insulation, fabric coating etc.

→ It is used for corrugated roofing sheets, rain water goods.

→ It is used to manufacture water pipes and it is accessories rain coats and shower curtain.

→ It is used in plastic pressure pipe system for pipelines of water and sewer.

→ It is used in magnetic strip cards, vinyl siding, window profiles, plumbing and conduit fixtures, gramphone records etc.

RPVC (Rigid polyvinyl chloride) :-

The Rigid polyvinyl chloride (RPVC) is also known as Ultra-plasticized polyvinyl chloride (UPVC). This material is available in a range of colours and finished including a photo-effect wood finish and is used as a substitude for painted wood.

Properties of RPVC :-

→ RPVC is more durable and hard.
→ It has high tensile strength.
→ It is more rigid and has high resistance to chemical action.
→ It is corrosion resistance.

GRP (Glass Reinforced Plastic) :-

This is a composite material made of a plastic reinforced by fine glass fibres. This plastic is formed by combining the glass fibres and plastic resins. The glass fibres are very strong in tension but weak in compression, where as the plastic resins are strong in compression and weak in tension.

CPVC (chlorinated polyvinyl chloride) :-

→ CPVC stands for chlorinated polyvinyl chloride. It is a thermoplastic pipe fitting material made of compounds.
→ CPVC products are specifically used for potable water distribution and corrosive fluid handling industry etc. It is very cost-effective system.

HDP (High Density polyethylene) :-

→ It is a thermoplastic polymer produced from monomer ethylene.

→ It is some times called alkathene or polythene.

Properties of HDP :-

Density = 940 kg/m³

melting point = 130-8°c.

uses :-

It is used in house and plastic mailing envelope.

Fibre reinforced polymer :-

→ It is also called fibre reinforced plastic.

→ It is a composite material made up of a polymer matrix reinforced with fibre.

→ The fibres are usually glass, carbon and basalt.

→ FRP are commonly used in the aerospace, automatic marine and construction industries.

→ It is also used for strengthening the beam, column and slab of a building and bridge.

Artificial timber :-

Properties of artificial timber :-

1) weather Resistance :-

It should possess adequate resistance against weathering effects such as alternate drying and wetting, alternate heating and cooling because of temperature variations, wide effects etc.

2) Durability :-

It should be capable of resisting the various action due to fungal insects, chemical, physical and mechanical agencies.

3) Fire Resistance :-

The artificial timber should offer sufficient resistance against fire so that it does not easily ignite. It helps in fire protection in buildings.

4) Workability :-

The artificial timber should be easily workable and should not clog the teeth of saw. It should also be capable of being easily planned or made smooth.

5) Elasticity :-

This timber should be capable of regaining its original shape when load causing deformation is removed. This property is important when it is should be used for bows, carriage shafts, sports goods, wooden beams and wooden floors.

6) Toughness and abrasion :-

It should be capable of offering resistance to shocks due to vibration and should not deteriorate due to mechanical wear.

7) soundness :-

It is should have sufficient weight an artificial timber with sufficient weight is considered to be sound and strong.

8) Hardness :-

It should have sufficient hardness, i.e., resistance penetration. when the artificial timber is hard. It resists the abrasive action as for it is used for flooring, mallets, tool handles, rollers and bearing shafts.

9) Resistance to shear :-
The artificial timber having closely interlocked is very strong in shear across and even along the grains.

10) Strength :-
The artificial timber should be strong enough to load whether being applied slowly or suddenly. It should possess enough strength in direct compression and transverse direction.

Uses of artificial timber :-
→ The artificial timber is corrosion resistant, and hence it can be used where the corrosion is likely to occur in the structures.
→ It is convinient in maintainance and superficial similarity to wood.
→ It is used to make various structural members.
→ It is used in maintainance work.
→ It is also used as a ceiling proofing material in building construction.
→ It is used to make doors and window frames.
→ It is used for making the planks, square and round shape for furniture.
→ Density can be varied in between 0.8 - 1.2 kN/m³ depending on the requirement.

Types of artificial timber :-
a) veneers
b) Ply woods
c) Particle board
d) Fibre boards
e) Batten boards.

a) Veneers :-

→ There are thin sheet of wood, which are obtained by slicing timber or by rotary cutting or by peeling of logs of wood. Now a days, rotary cutting is more common as this produces veneer of large size and reduces amount of joining.

→ However, more attractive decorate figures occur on radial face and are obtained by slicing woods like Teak mahogany, walnut and oak. veneers are normally cut from wood at higher moisture contents and are dried before application of adhesive and assembly. Then veneers are pressed together using hot pressing method.

→ Veneers are used in the manufacture of plywood, each veneer being at right angles to the adjacent veneer. So that cross sectional movement can be restrained, with the aid of modern high strength adhesives. veneers are also used in manufacture of batten board, particle board.

b) Plywood :-

→ Plywoods are formed together by gluing thin sheets of odd numbers of veneers. The sheets are placed in such a way that, grains of one layer are at right angles to the others.

→ As a result, on application of load on the sheets, movements in both the direction is reduced. The outer piles are decorative in nature and are called as face piles and the inner ones are called as core or cross bands. band.

c) Particle Board :-

→ In particle boards, particles or chips are randomly mixed with strong adhesive and are compressed together under high pressure to form a board.

→ In particle board, the movement is randomly oriented in all directions and restraint is dependent on strength and concentration of adhesive.

→ particle ~~is~~ board is much weaker than plywood because, the adhesive joints between the individual chips involve end grains surface. Properties of plywood largely involve depend upon wood species used where as, in particle ~~wo~~ board, it largely depends upon the adhesives and particle shape.

→ If particle of boards are all cubes, the formation of the board will result in large portion of joints involving end grains; thus producing weak boards.

→ In contact, long thin chips will overlap, rather than butt and will result strong boards. With long and flat chips coarse. To avoid this sometimes boards are manufactured in three layers.

d) Fibre-Board :-

→ Fibre boards also called as pressed woods are rigid boards manufactured using wood waste like saw dust, small piece of wood, etc.

→ Wood is chipped into small pieces of about 20mm size; and boiled in water. These wet particles are then passed to an autoclave, where it is subjected to steam pressure of 2300 kN/m² for about 1/2 minute and there after to a pressure of 7000 kN/m² for new seconds.

e) Batten Boards :-

→ In all these boards, thin veneers are used on faces and are glued to core. veneers may be decorative or non-decorative. Grains of veneers are at right angle to those of core.

→ In batten boards, core consists of about 8 cm wide wooden strips called as battens. If the width of strips is less than 2.5 cm. It is called as block board. In laminated boards, width of core strip is less than 7 mm.

→ Batten boards and block boards are used for making partitions, packing cases, furniture panelling, ceiling, interior decoration, bus bodies, etc. However are liable to crack or split, Laminated boards are stronger than block boards and are not liable to crack or split.

D - 13-01-2020

Strength of artificial timber :-

→ Artificial timber should be strong enough to withstand the loads whether being applied slowly or suddenly. It should possesses enough strength in direction of direct compression and transverse direction.

ACOUSTIC MATERIAL :-

Acoustic is the science of sound including its production, transmission and effects. Acoustic is a broad field which embraces music, radio, sound reproduction and other fields.

Properties of acoustic material :-

→ Acoustic material has low reflection and high absorption of sound.
→ It controls the sound and noise levels from machinery and other sources.
→ It suppresses revibration echoes and reflection.
→ It has capacity to capture and absorb the sound energy
→ It reduces the sound energy waves.

Types of acoustic material :-

The acoustic material can be broadly classified into following 3 groups.

a) **Soft material :-**

These have sufficient porousity and are good sound absorbers. Rock wools, glass silk fall in this category.

b) **Semi-hard material :-**

These are steep enough to stand rough handling can also serve as building panels. Mineral wool board, cane fibre are included under this category.

c) **Hard material :-**

These are hard material which have been made porous during manufacture. They also serve as protective surfaces. The porous tiles of masonry are commonly employed for this purpose.

Acoustic tiles :-

→ Advantages of such tiles is that the absorption of sound is uniform from tile to tile and can be easily fixed to any other surface and they are costly but most suitable for smaller area where acoustical treatment to be given.

→ The materials are available in market under different trade names. It is made in factory.

D - 20-01-2020

1) Acoustic plaster :-

→ This is mainly composed of asbestos and cellulose fibre mixed with certain binders and preserving chemicals.

→ This dry fibrous material, on addition of water becomes plastic and can be applied to wall and ceiling surfaces to a thickness of upto 2cm.

→ The material is applied in layers of 6 mm thickness, in the same manner as plaster. Being plastic it is easily shaped and finished.

2) Fibrous plaster :-

→ This type of material is also known as acoustic plaster. It is made by mixing of cement and granular insulating material.

→ The preparation of cement should be properly be maintained so as to become plaster more effective for acoustics.

→ The acoustic plaster boards are also used and can be fixed on the wall. The acoustic plaster should have an absorbers coefficient of 0.30 at

3) Straw board :-

→ This material can also be used as absorption of 0.30 at 500 cycles per second. These boards are available in 13 mm size.

→ It is comparatively cheap, therefore economical.

5) Unifil acoustical plaster :-

→ This is an inert, feather weight, granular substance manufactured from vermiculite. Gypsum and lime or portland cement is the other constituent.

→ water is added to the material to make it plastic for application.

→ The material is adapted to every type of architectural treatment and is used mainly for interior finishes.

6) Acoustical boards or tiles :-

→ They are usually made of either compressed cane or wood fibre or mineral wool.

→ These boards and tiles have uniform physical and sound absorption characteristics.

→ They are prefinished at the factory and can be painted or coloured to give desirable decorative appearance and light reflection characteristics.

→ These tiles are very costly as compared to other acoustical materials.

7) Limpet asbestos :-

→ This is asbestos fibre which is applied to a surface by means of a special spray gun.

→ The asbestos fibres are fed to the hopper of a machine from which they are carried to a boiler. The dry fibre is then conveyed in an air system and then passed through a spray gun where it gets damp before the final application.

CLADDING

Cladding is a type of skin or extra layer on the outside of a Building. It can be attached to a building framework or an intermediate layer of battens or spacers. Cladding does not have to be waterproof, but it often controls how elements hit or fall on a surface.

It was usually a hard substance like cedar wood or stone, or a material resistant to corrosion like copper, brass band bronze. Such metals will react with the elements, but they still protect what's beneath them.

Types of cladding used in construction :-

1) Stone cladding :-

Stone cladding helps create a natural stone look while bringing in a touch of style and elegance to your walls. Perfect for both interior and exteriors, stone cladding uses thin layers of natural or faux stone to lend your home a brilliant earthy and rustic look. Stone cladding panels are extremely easy to install. Virtually maintainance free and gracefully ages with time.

2) Wood cladding :-

It helps create a stunning facade and is a great way to protect your home from the elements. Suitable for both interiors and exteriors, it helps create a highly distinctive character as nothing beats the look of real wood while blending well with any decor. Exterior cladding is individually

placed and protects the structural integrity of your house while also enhancing the exterior appearance by several notches. Extremely durable and highly energy efficient owing to its insulation properties, wood cladding helps to make your home a tranquil haven.

3) uPVC cladding :-

It helps add a different dimensions to your home and requires absolutely zero maintainance. This basically translates to no time consuming painting or cumbersome repairs. Ideal for both internal and external walls, uPVC cladding not only suits every kind of home but also not prone to severe damage by weather elements. Besides being economical, it's quite easy to add insulation as well, can be fully customized and comes in a range of colours.

4) Tile cladding :-

A ~~fair~~ fairly new entrant to the cladding world, tile cladding is an extremely versatile cladding option and comes in the form of a panel or tile suited for both exteriors and interiors of your house. Long lasting and easy to maintain, these can transform your house to a contemporary abode. You can play with either sleek modern designs or opt for a natural textured look. Incredibly durable and long lasting, you can even combine tiles that are of different shapes and sizes to give your house a truly unique and suave look. Moreover, these tiles also act as great insulators thus providing to be energy efficient as well.

5) Glass cladding :-

It help transform your building exteriors and offer a range of customization and design options. Glass always impress and this cladding is available in wide range of tempered, laminated, curved and enameled options while being cost effective and economical. Furthermore, glass creates a remarkably modern and contemporary look while offering enormous freedom in shape, design, composition and size, making it optimally suited for modern cladding applications.

6) Aluminium composite panel (ACP) :-

This cladding system is made from lightweight aluminium and is frequently used for ~~extremely~~ external cladding as it's very rigid and strong despite its light weight. Moreover, being aluminium being weather and UV resistant facilities for a bevy of customization options including colours, prints, patterns and shading. Available in varying thickness levels; it enables quick installation while also being versatile enough to be used for fascias, canopies, partitions and even false ceiling.

7) Ceramic cladding :-

This solutions have been around for ages and been a popular choice for architects around the world for decorative purposes. Being lightweight, it requires very little maintainance while ~~ferreting~~ a superior resistance to chemical and atmospheric attacks from population, acid rain and smog. It's innovative design and durability also facilitate greater versatility in terms of tile size and arrangement.

8) Porcelain cladding :-

It is widely used as a mean for external cladding because of its exceptional properties. Scratch and abrasion resistant with a surface together than granite or steel, its durable, tough and extremely strong and does not accumulate surface dirt. Additionally its, non-porous and impervious to chemical while also being freeze and thermal shock resistant which makes it the ideal material for creating cost-effective, low-maintainance, hard-wearing surfaces.

D - 25-01-2020

Micro silica :-

→ Micro silica is a light grey cementitious material composed of at least 85% ultra fine, amorphous non-crystaline (glassy) spherical silicon dioxide (SiO_2).

→ It is also called as silica fume. It is produced as a by-product during the manufacturing of silicon metal or ferrosilicon alloys by reduction of high purity quartz in a sub-merged-arc electric furnance heated to 2000°C with coal, coke and wood chips as fuel.

→ The micro silica, which is condenses from the gases escaping from the furnance, has very fine spherical particles having diameter of 0.1 micrometer.

→ Ferro silicon alloys are produced with nominal silicon mass contents 60% - 98%. As the silicon content increases in the alloys, the SiO_2 content increases in the micro silica.

Properties of micro-silica :-

→ Specific gravity of micro silica is 2.20.
→ Its bulk density varies from 200 kg/m³ - 250 kg/m³
→ It has minimum surface area of 15,000 to m²/kg
→ The content of SiO_2 is at least 85%.
→ It gives long term corrosion protections.

Uses of micro silica :-

→ This material has very recently found its application in our country in the nuclear power plants and bridge construction.
→ Micro silica have been used extensively in off-shore concrete platforms, high rise multistoried buildings and various other structures demanding high performance in very aggressive environmental conditions.

D - 27 - 01 - 2020

Artificial sand :-

→ Natural sands are obtained by the weathering action, abrasion of particles of rocks along with flow of stream. Depending on parent rock, action on particles size and grading of natural river sand varies from place to place.
→ Dams are constructed on upstream of river, so now-a-days sands are not available on downstream of dams. At locations, grading of sand available may not contain certain fractions which are required for ideal grading.

→ strength, durability of concrete mix depends on size, shape, grading of fine aggregate. Since good quality sand may not be available, crushed sand is produced. It also helps in protecting ecological balance, by restricting use of natural resources to minimum.

→ Artificial sand is a specific purpose produced materials which will satisfy the strength, durability, size, shape, grading requirements of fine aggregate in concrete mix. The stone metal or crushed stone waste, below 25mm from good parent rock is fed to disintegrator.

Properties of artificial sand :-

→ The density of artificial sand lies in between 18 kN/m³ – 25 kN/m³.

→ It does not contain any organic impurities.

→ water absorption in case of artificial sand is almost negligible.

→ specific gravity of artificial sand lies in between 2.65 – 2.8.

Advantages of Artificial sand :-

→ Artificial sand is well graded.

→ This sand is having superior surface texture.

→ It can be compacted properly to reduce voids.

→ Less quantity of cement materials required.

→ It can be produced in required quantity and desired quality.

→ If economy at large is considered, artificial sand, many times proves to be economical.

Adhesives :-

→ Adhesion is attraction between unlike surfaces. Cohesion is attraction between like surfaces. Usually due to primary or secondary forces of attraction, adhesives are used to join two or more parts into a unit.

→ There are advantages of adhesive bonding over methods of assembly like bolting, riveting, welding etc.

→ Adhesives join the surfaces in three ~~layer~~ ways :- Specific adhesion of surfaces are joined together by intermolecular forces of attraction; mechanic adhesion, if the adhesive fill the voids of porous or rough surfaces and hold the surfaces by interlocking action, and fusion of surfaces which are partially dissolved in the adhesive or its solvent.

Advantages :-

→ Corrosion may be prevented between different metals joined by adhesives.

→ The joints become impermeable for water and gas.

→ Adequate strength is produced by using adhesive.

→ The adhesive application process is economical, easy and speedy.

→ Leakage problem of water can be stopped by the application of adhesives.

Disadvantages :-

→ Adhesive requires time to attain desired strength
→ Specific adhesive is required to be used for specific substances.
→ Adhesives are unusable at high temperature.

1) Animal Protein Glues :-

These glues are obtained from hide trimmings, bones and flashing by boiling these by hot water. Animal glues provide strong, tough, easily made joints; but they are affected by damp and moist conditions. It is supplied in the form of flakes, pearls, sheets, cakes, granules, cubes or jelly. Animal glues having three grades depending upon the water absorption. i.e.; 1g, 1.5, 10 times the dry weight of glue.

Use of animal protein glue :-

This is used in the manufacture of plywood, laminated timber.

2) Blood Albumin Glues :-

It is made by drying to raw blood and affected by damp and moist conditions. This glue has good water resistance properties and also durable.

Use of blood ad albumin glues :-

They have good adhesive properties for paper, textile and metals, hence largely used in food packaging leather dressing and for wood working.

Starch adhesives :-

→ It is made from vegetables starch having good dry strength but not resistant to moisture. Alkali or acid modifiers are used to make starch paste thick and sticky. This glue has poor resistant but bond quickly to paper and textile. They are cheaper than animal glues.

use of Starch adhesives :-

→ This glue is spread and dried easily.
→ They are used in automatic package machines.
→ These glues are also used in manufacture of low strength and low water resistance plywood.

Gum arobic :-

→ These forms the most useful natural resin adhesive.
→ It contains mixed mineral salt of arobic acid, which is obtained from acacie trees.
→ It is used for joining paper and wood and in high speed packing and labelling machine.

Bonding agent :-

→ Bonding agents are natural compound or synthetic material used to enhance the joining of individual member of a structure without using mechanical fasteners.
→ These products are often use in repaired applicatio

such as:- bonding of fresh concrete, spread concrete, fresh mortar and old concrete.

→ when bonding agent applied on the old concrete that time surface of old concrete work should be clean for proper bonding.

D:-28-01-2020

Pre-fabrication :-

Definition :-

The pre-fabrication is practice of assembly components of a structure in a factory or other manufacturing site and transporting complete assembly to the construction site where the structure is to be located.

use of pre-fabrication :-

→ The most widely used form of pre-fabrication in building and civil engineering is the use of pre-fabricated concrete and pre-fabricated ~~concrete~~ steel sections in structures.

→ Pre-fabricated steel section reduces on site cutting and welding cost as well as the associate hazards.

→ Pouring concrete sections in a factory brings the advantages of being able to reuse and the concrete can be mixed on the spot without having to be transported and pumped weight on a constructed constructions site.

Disadvantages :-

→ careful handling of pre-fabricated components such as concrete pannel and steel or glass pannel is required.

→ Attention has to be made to the strength and corrosion resistant of the joining of fabricated section to avoid failure of the joining.

→ similarly tears can be formed at the joint in fabricated components.

→ Transportation cost may be higher for a given volume.

Pre-fabricated section are required more volume than raw material used in in-site construction

Principle :-

The main reason to choose pre-cast construction method over conventional method :-

→ Economy in large scale profect with high degree of repitition in work experience.
→ The special requirement in finishing.
→ consistency in for structural quality control.
→ fast speed of construction.
→ constrainter in availability of site resources. (Labour & material).
→ Large group of building from the same type of pre-fabricated elements.

Pre-fabrication elements :-

→ flooring and roofing system.
→ Pre-cast column.
→ Pre-cast slab
→ Pre-cast beam

Classification :-

1) small pre-fabrication
2) Medium pre-fabrication
3) Large pre-fabrication
4) cast in site pre-fabrication
5) factory pre-fabrication.
6) closed system pre-fabrication.
7) open system pre-fabrication
8) Partial pre-fabrication
9) Total pre-fabrication

D - 03-02-2020

1) small pre-fabrication :-

→ The first 3 types are mainly classified according to their degree of pre-cast.

→ Elements using in their construction for e.g → brick is a small unit precast and used in building.. this is called a small pre-fabrication (the degree of precast element is very low).

2) Medium pre-fabrication :-

Suppose the roofing system and horizontal members are provided with pre-stressed element there construction are known as medium pre-fabricated construction. (here the degree of pre-cast element are moderate)

3) Large pre-fabrication :-

In large pre-fabrication most of the member like wall panel roofing or flooring system beam and column are pre-fabricated. (here the degree of pre-cast element are high).

4) Cast in site pre-fabrication V/s site (factory) pre-fabricat

→ one of the main factor which affect the factory pre-fabrication is transport.

→ the width of pre-fabricated walls are difficult to transport and vehicles or mode of transportation are the factors which pre-fabrication is to be done on side or factory are the factors which affects cast in site pre fabrication.

5) open system pre-fabrication :-

→ In the total prefabrication system is are carried as single unit and erected at site.

→ The wall fitting and other fixing are done on side. There type of construction is known as

open system fabrication.

6) closed system prefabrication :-

In the system the whole things are cased with fixings and erected on the position.

7) partial pre-fabrication :-

→ In the method of construction building element (mostly horizontal) are required for pre-fabrication

→ since the casting of horizontal elements (roof, or floor) often take their time due to erection of formwork and to get complete strength. So that building is delayed and hence this method is restored.

→ In most of the building site this method is popular.

8) Total pre-fabrication :-

→ Very high speed can be achieved by the using this method of construction.

→ This method can be employed for frame type of construction or for pannel type of construction.

→ The total pre-fabrication can be done on site or off site.

→ The choice of this 2 methods depend on the situation when the factory produced elements are transported and erected at site to ca off site pre-fabrication.

→ on this method is to be adopted then we have a very good transport of product to site.

→ if the elements are cast nearly building site and erected the transportation of the elements can be eliminated but we have to consider the space availibility for establish such facilities though it is temporary.

→ The choice of method of construction also depends on the following :-

a) Type of equipment available for erection & transport
b) Type of structural scheme (Linear element or panel)
c) Type of connection between elements.

D - 04 - 02 - 2020

Q- Write down the materials used in pre-fabrication system.

Ans- 1) Concrete
2) Steel
3) Treated wood
4) Aluminium
5) Cellular concrete
6) Light weight concrete element
7) Ceramic products.

Prefabricated material buildings use galvanized steel and Galvalume as the chief materials for building. Galvalume is a form of steel coated with aluminium zinc. This is to protect the building against corruption rust and fire.

It also provides a study and protective covering to the prefabricated building. Almost all the components of a metal building such as beams, frames columns walls and roofs are made of steel. Most fabricated military buildings use steel or aluminium frames. Synthetic materials are used for the walls and roofs.

To provide enhanced security a combination of both material metal and cloth materials are used plastic flooring materials can be quickly assembled and are very durable. Prefabricated building materials used for small Prefabricated buildings are steel, wood, fibre glass plastic or aluminium materials.

These materials are cheaper than regular brick and concrete buildings. materials like steel, fibre glass, wood and aluminium are used as prefabricated building materials for sports buildings. These materials provide flexibility and are preferred for making structures and accessories like stands and seats for stadium and gyms.

For making low cost houses prefabricated materials like straw, ferro cement consists of a cement matrix reinforced with a mesh of closely spaced iron rods or wires. In this type of construction the techniques used are simple and quick. Using prefabricated material one can make durable, water and fire resistant and cheap prefabricated buildings. Most of the pre-fabricated building materials are eco-friendly and affordable.

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 supports can allow shapes and sequences without expensive on-site false work.

→ 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.

Ch → 03

D - 12 - 02 - 2020

Earthquake Resistance construction :-

Building configuration :-

→ Building configuration may be defined as the overall size and shape of the building together with nature and location of more elemen of the building that are significant to its seismic performance.

→ Is : 1893 - 2016 has recommended building configurati system in section for the better performance of building during earthquake.

→ To perform well in earthquake a building shal possesses four main attributes.

a) simple and regular configuration.

b) Adequate lateral strength

c) Stiffness

d) Ductility

→ Building having simple and regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than building with irregular configuration.

→ A building shall be consider as irregular for the purposes of this standard if at least one of the following condition is applicable.

Definition of irregular building :-

Plan irregularities :-

→ Torsional irregularities
→ Reentrant corners
→ Floor slabs having excessive cut-outs or opening.
→ Out-of plane offset in vertical elements.
→ Non-parallel lateral force system.

Vertical irregularities :-

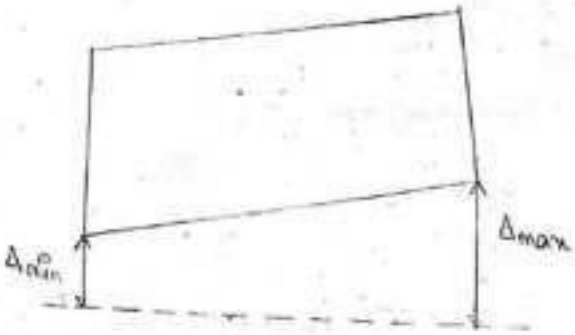
→ Stiffness irregularity (Soft storey).
→ Mass irregularity.
→ Vertical geometry irregularity.
→ In plane discontinuity in vertical element resisting lateral force.
→ Strength irregularity
→ Floating or stub column.
→ Irregular modes of oscillation in two principal plan direction.

Torsional Irregularity :-

A building is said to be torsionally irregular, when
→ the maximum horizontal displacement of any floor in the direction of the lateral force at one end of the floor is more than 1.5 times its minimum horizontal displacement at the far end of the same floor in that direction; and
→ the natural period corresponding to the fundamental torsional mode of oscillation is more than those of the first two translational modes of oscillation along each principal plan direction.

In torsionally irregular buildings, when the ratio of maximum horizontal displacement at one end and the minimum horizontal displacement at the other end is.

$\Delta_{max} > 1.5\,\Delta_{min}$



(Plan)

(TORSIONAL IRREGULARITY)

Re-entrant corners :-

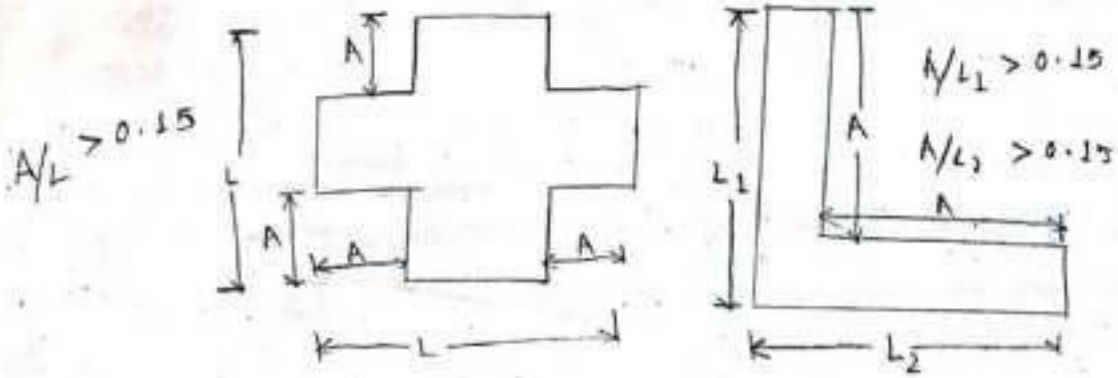
A building is said to have a re-entrant corner in any plan direction, when its structural configuration in plan has a projection of size greater than 15 percent of its overall plan dimension in that direction.

In building with re-entrant corners, three-dimensional dynamic analysis method shall be adopted.

Floor slabs having Excessive cut-outs or openings :-

openings in slabs result in flexible diaphragm behaviour, and hence the lateral shear force is not shared by the frames and/or vertical members in proportion to their lateral translational stiffness. The problem is particularly accentuated when the opening is close to the edge of the slab. A building is said to have discontinuity in their in-plane stiffness, when floor slabs have cut-outs or openings of area more than 50 % of the full area of the floor slab.

In buildings with discontinuity in their in-plane stiffness, if the area of the geometric cut-out



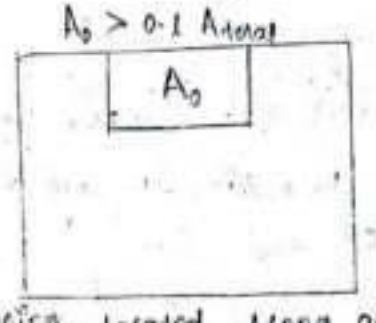
(Re-entrant corners)

Out-of-plane offsets in vertical elements :-

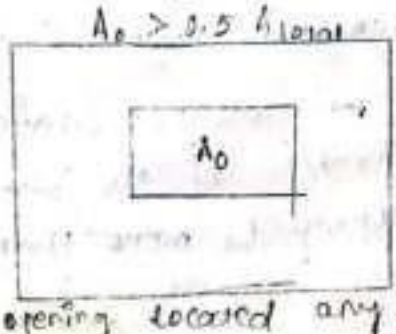
Out-of-plane offsets in vertical elements resisting lateral loads cause discontinuities and detours in the load path, which is known to be detrimental to the earthquake safety of the building. A building is said to have out-of-plane offset in vertical elements, when structural walls or frames are moved out of plane in any storey along the height of the building.

Non-parallel lateral force system :-

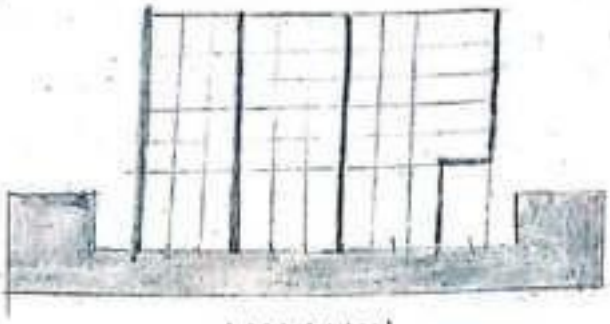
Buildings undergo complex earthquake behaviour and hence damage, when they do not have lateral force resisting systems oriented along two plan directions that are orthogonal to each other. A building is said to have non-parallel system when the ~~vertically oriented structural system when the~~ vertically oriented structural systems resisting lateral forces are not oriented along the two principal orthogonal axes in plan.



opening located along any edge of the slab

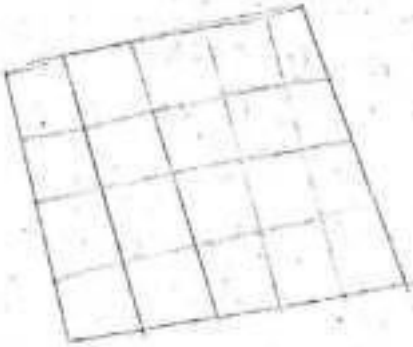


opening located anywhere in the slab



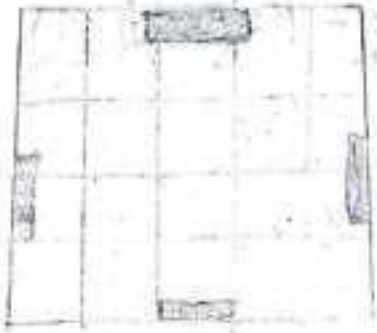
ELEVATION

(3D diagram of RCC office in vertical irregularity)



Plan

(2)



Plan

(2)

Types of vertical irregularities :-

1) Stiffness Irregularity (Soft storey)

A soft storey is a storey whose lateral stiffness is less than that the storey above.

2) Mass Irregularity :-

Mass irregularity shall be considered to exist, when the seismic weight of any floor is more than 150 % of that of the floors below.

3) Vertical Geometric Irregularity :-

It shall be considered to exist, when the horizontal dimension of the lateral force resisting system in any storey is more than 125 % of the storey below.

4) In-plane Discontinuity in vertical Elements resisting lateral force :-

In-plane discontinuity in vertical elements which are resisting lateral force shall be considered to exist, when in-plane offset of the lateral force resisting elements is greater than 20% of the plan length of those elements.

5) Strength irregularity (weak storey) :-

A weak storey is a storey whose lateral strength is less than that of the storey above.

6) Floating or Stub Columns :-

Such columns are likely to cause concentrated damage in the structure.

7) Irregular modes of oscillation in Two principal plan directions :-

Stiffness of beams, columns, braces and structural walls determine the lateral stiffness of a building in each principal plan direction.

Q. Describe different building characteristics from seismic performance point of view.

Ans → The seismic weight of the whole building is the sum of the seismic weights of all the floors.

→ Any weight supported in between storeys shall be distributed to the floors above and below in inverse proportion to its distance from the floors.

→ For calculating the design seismic forces of the structure the imposed load on roof need not be considered;

→ The seismic weight of each floor is its full dead load plus appropriate amount of imposed load,

→ While computing the seismic weight of each floor the weight of columns and walls in any storey shall be

equally distributed to the floors above and below the storey.

→ The total design seismic base shear along any principal direction shall be determined by the following expression.

$$V_B = a_h \times W$$

where, a_h = design horizontal acceleration spectrum value.

W = seismic weight of the building.

Q What is lateral load resisting system?

Ans The first step in architectural planning of a building is to select the lateral load resisting system. The load resisting system must be of closed loops, so that it is able to transfer all the forces acting either vertically or horizontal to the ground.

Q Enumerate safety considerations during additional construction and alteration of existing building.

Ans If sufficient precautions w.r.t. safety of work are not taken, there are chances of serious accidents involving heavy loss of men and materials. Some of the safety rules to be observed during the erection process of structures are as follow:-

→ All guys and anchorages should be closely viewed regularly so as to ascertain their being capacity of load.

→ Suitable packing pieces must be provided at the required points so as to avoid the slipping of load.

→ The chains should not be dropped from a height, but should be lowered gradually.

→ The equipment and devices employed in the erection procedure should never be over-loaded.

→ The legs of brother chains should not be opened out to such an angle so as to endanger the stability of the work.

→ The levels of panel points on the falsework should be maintained as per the desired camber for truss to avoid strain or distraction during assembly.

→ The lifting devices and mechanisms should be maintained in perfect running order so to avoid their sudden failure without notice.

→ The lifting should be carried out smoothly without sudden shocks.

D-03-03-2020

Earthquake resistance in masonary building :-

→ Masonry walls are slender because of their small thickness compare to their height and length

→ A simple way of making these wall behaves as well in earthquake shaking is by making them act together as a box along with the roof and the top and with the foundation at the bottom.

→ This can be achieved by

a) Ensuring good interlocking of masonry courses at the junction.

b) Employing horizontal band at various levels, particularly at the lintel level, the size of door and window opening need to be kept small.

1) Lintel Band :-

During earthquake shaking, the lintel band undergoes bending and pulling actions. To resist these actions, the construction of lintel band requires special attention. Bands can be made of wood or of reinforced concrete (RC). The straight lengths of the band must be properly connected at the wall corners. This will allow the band to support walls loaded in their weak direction by walls loaded in their strong direction. Small lengths of wood spacers on steel links are used to make the straight lengths of wood runners or steel bars act together. In wooden bands, proper nailing of straight lengths with spacers is important. Likewise, in RC bands, adequate anchoring of steel links with steel bars is necessary. Lintel band is provided at the lintel level on all internal and external longitudinal as well as cross walls except, partition walls.

2) Sill Band :-

Sill band is provided at sill level for all internal and external longitudinal walls as well as cross walls. For full integrity of walls at corners and junctions of walls and effective horizontal bending resistance of bands, continuity of reinforcement is essential.

The band should be made of reinforced concrete of grade not leaner than M15 or reinforced brick work in cement mortar not leaner than 1:3.

3) Plinth Bands :-

Plinth band is a band provided at plinth level of walls on top of the foundation wall. This is to be provided where strip footings of masonry are used and the soil is either soft or uneven in its properties, as it frequently happens in hill tracts. This band will serve as damp proof course as well.

4) Roof band :-

Roof band is a band ~~on floors~~ provided immediately below the roof or floors. In buildings with ~~floors~~ flat reinforced concrete or reinforced brick roofs, roof band is not required because the roof slab also plays the role of a band. However, in buildings with flat timber or CGI sheet roof, roof band needs to be provided. In buildings with pitched or sloped roof, roof band is very important.

5) Gable Band :-

A gable band is a horizontal member which is placed at the top of the ridge of the sloping slab to support the ends of the ~~ref~~ rafters and transferring loads to posts or gable end walls.

1) Lintel Band :-

During earthquake shaking, the lintel band undergoes bending and pulling actions. To resist these actions, the construction of lintel band requires special attention. Bands can be made of wood or of reinforced concrete (RC). The straight lengths of the band must be properly connected at the wall corners. This will allow the band to support walls loaded in their weak direction by walls loaded in their strong direction. Small lengths of wood spacers or steel links are used to make the straight lengths of wood runners or steel bars act together. On wooden bands, proper nailing of straight lengths with spacers is important. Likewise, in RC bands, adequate anchoring of steel links with steel bars is necessary. Lintel band is provided at the lintel level on all internal and external longitudinal as well as cross walls except partition walls.

2) Sill Band :-

Sill band is provided at sill level for all internal and external longitudinal walls as well as some cross walls. For full integrity of walls at corners and junctions of walls and effective horizontal bending resistance of bands, continuity of reinforcement is essential.

The band should be made of reinforced concrete of grade not leaner than M15 or reinforced brick work in cement mortar not leaner than 1:3.

3) Plinth Bands :-

Plinth band is a band provided at plinth level of walls on top of the foundation wall. This is to be provided where strip footings of masonry are used and the soil is either soft or uneven in its properties, as it frequently happens in hill tracts. This band will serve as damp proof course as well.

4) Roof band :-

Roof band is a band ~~on floors~~ provided immediately below the roof or floors. In buildings with ~~floors~~ flat reinforced concrete or reinforced brick roofs, roof band is not required because the roof slab also plays the role of a band. However, in buildings with flat timber or CGI sheet roof, roof band needs to be provided. In buildings with pitched or sloped roof, roof band is very important.

5) Gable Band :-

A gable band is a horizontal member which is placed at the top of the ridge of the sloping slab to support the ends of the ~~ref~~ rafters and transferring loads to posts or gable end walls.

Ch-04 RETROFITTING OF STRUCTURES

1) What are the sources of weakness in RCC framed building ?

Ans- Source of weakness in RCC frame building :-

Earthquake engineering is not a pure science rather it has been developed through the observation of failure of structure during earthquake. Damage survey reports of past earthquakes reveal the following main sources of weakness in reinforced concrete moment resisting frame buildings.

→ discontinuous load path.
→ lack of deformation compatibility of structural members.
→ quality of workmanship and poor quality of materials.

i) Structural Damage due to Discontinuous Load path :-

Every structure must have two load resisting system :-

a) vertical load resisting system for transferring the vertical load to the ground and
b) horizontal load resisting system for transferring the horizontal load of the 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 in this load path or load transfer may cause one of the major contributions to structural damage during strong earthquake.

(ii) Structural Damage due to lack of Deformation :-

→ The main problems in the structural members of moment resisting frame building are the limited amount of ductility and the inability to redistribute load in order to safety with stand the deformations imposed upon in response to seismic load.

→ The regions of failure may be in columns beams walls and beam column joints.

→ It is important to consider the consequences for member failure of structural performance.

→ Inadequate strength and ductility of the structural member can and will result in local or complete failure of the system.

(iii) Quality of workability and materials :-

→ There are numerous instances where faculty construction ~~practic~~ practices and lack of quality control have contributed to the damage.

→ The faculty construction practices may be like, lack of amount and detailing of reinforcement as per requirements 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, spalling of concrete by the corrosion of embedded reinforcing bars, porous concrete, age of concrete, proper maintenance etc.

D-04-03-2022

2) Classify retrofitting techniques and describe their uses.

Ans:- **Retrofitting :-**

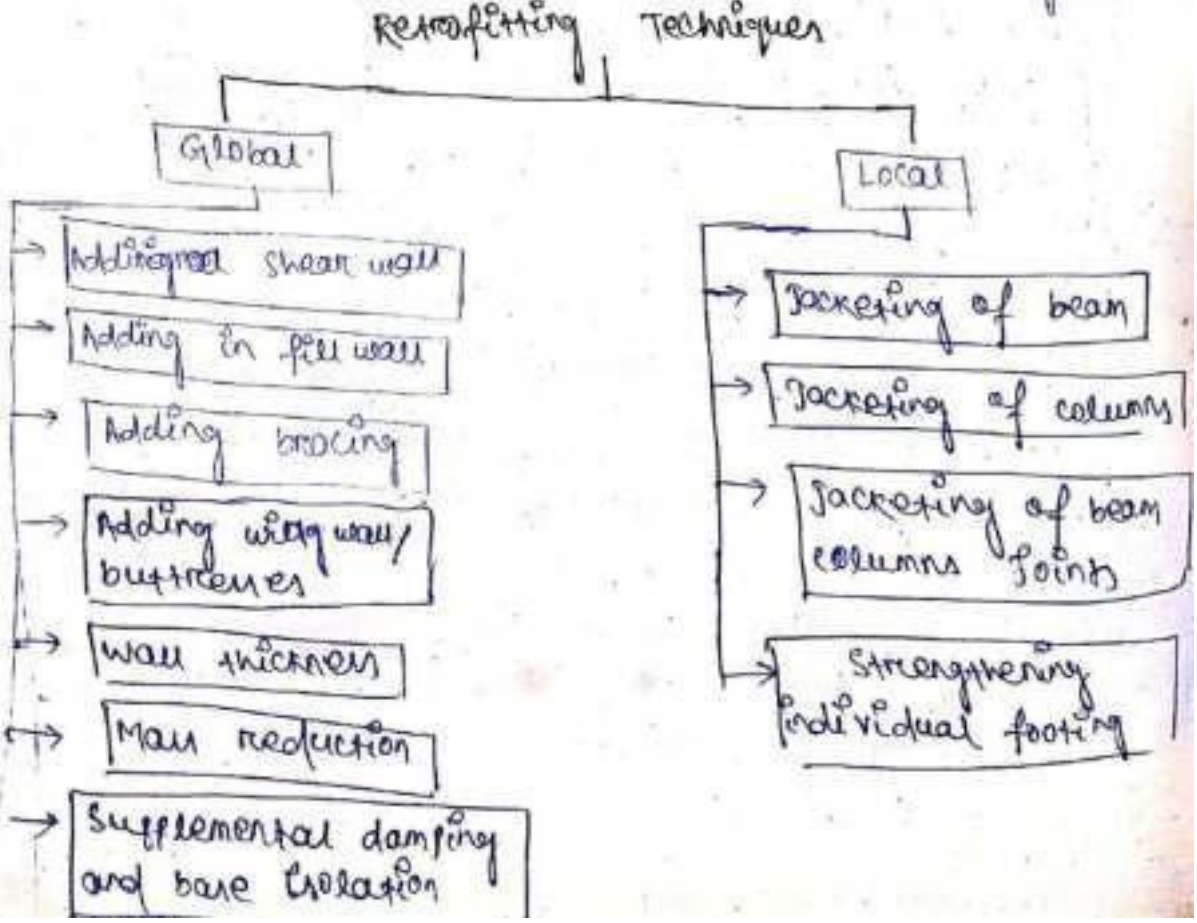
→ It is the seismic strengthening of existing damaged or undamaged structures.

→ It is an improvement over the original strength when the evaluation of the building indicates that the strength is available before the damage was insufficient and restoration alone will not be adequate in future quakes/earth quakes.

objectives of retrofitting :-

→ Increasing the strength (lateral) in wall or both direction by reinforcement or by increasing wall areas or the no. of walls and columns.

→ Giving unity to the structures by providing a proper connection between the resisting elements



There are 2 ways to enhance the seismic capacity of existing structures.

1) The first is a structural - level approach of retrofitting which involves global modifications to the structural system.

2) The 2nd 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 state.

Structural Level Global Retrofitting :-

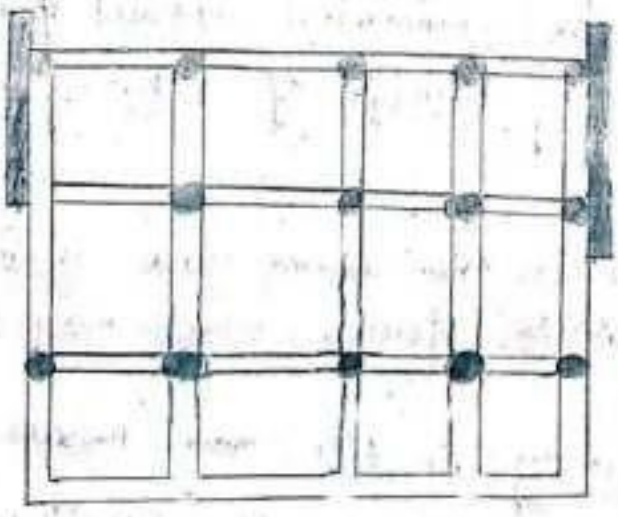
Adding New Shear walls :-

One of the most common methods to increase the lateral strength of the R.C. buildings. It is the last simple method.

Limitation :-

Increase in lateral resistance but it concentrated at a few places.

→ Increase dead load of the structure.



Adding steel bracing :-

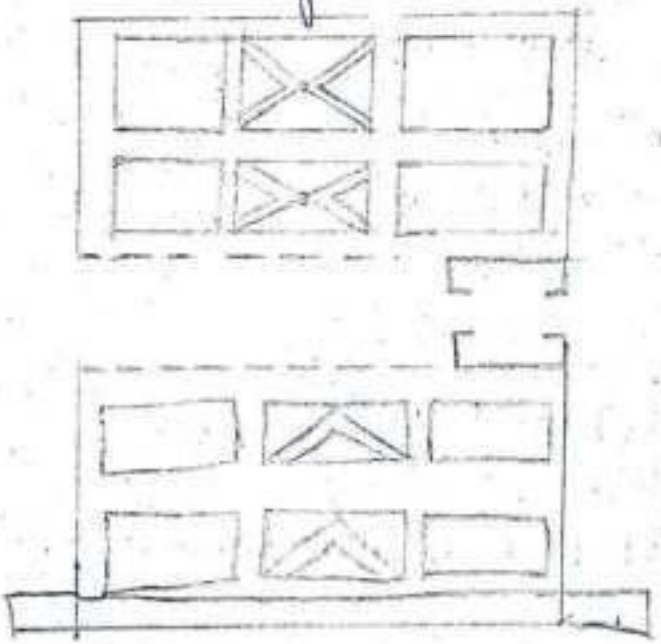
Higher strengths stiffness can be proved. opening for natural light can be made easily. It have much less cost.

Limitation :-

A moderate to high level of skilled labour is necessary.

→ Lack of information about the seismic behaviour of the added bracing.

→ undesirable changes takes place.



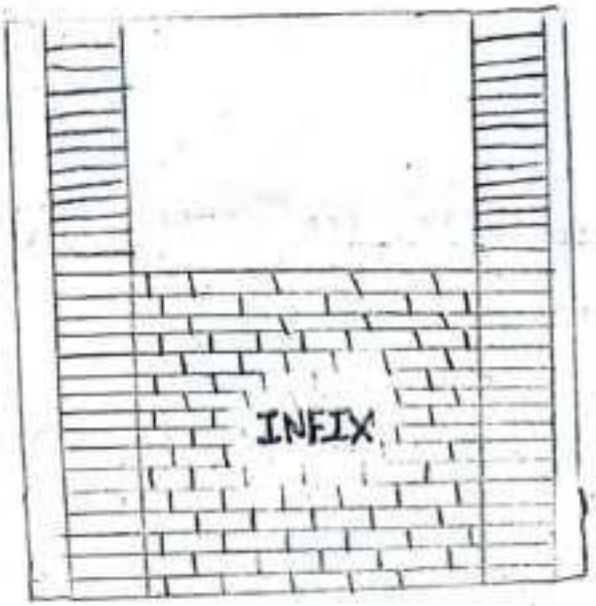
Adding Infill wall :-

It is an effective economical method for improving strengths reducing draft of existing frames.

Limitation :-

→ some columns in the frame are subjected to large axial tensile forces, which may exceed the capacity.

→ A strong masonry in fill may result in a failure of the columns of existing frame.



Local or member Retrofitting :-

→ Local retrofitting are typically used either when ~~the retrofit~~ the retrofit objectives are limited or direct treatment of the vulnerable components is needed.

→ The most popular frequently used method in local retrofitting is Jacketing or confinement by the Jackets of R.C. steel, fibre reinforced Polymer (FRP) carbon fibre etc.

→ Jacketing around the existing members increases its lateral load capacity of the structure in a uniformly distributed way with a minimal increase in loading on any single foundation with no alternative in the basic geometry of the building.

Jacketing :-

→ Jacketing is the most popularly used materials for strengthening of building.

→ The most common types are steel jacket, R.C., Jacket, fibre reinforced polymer composite Jacket, Jacket with high tension materials like carbon fibre.

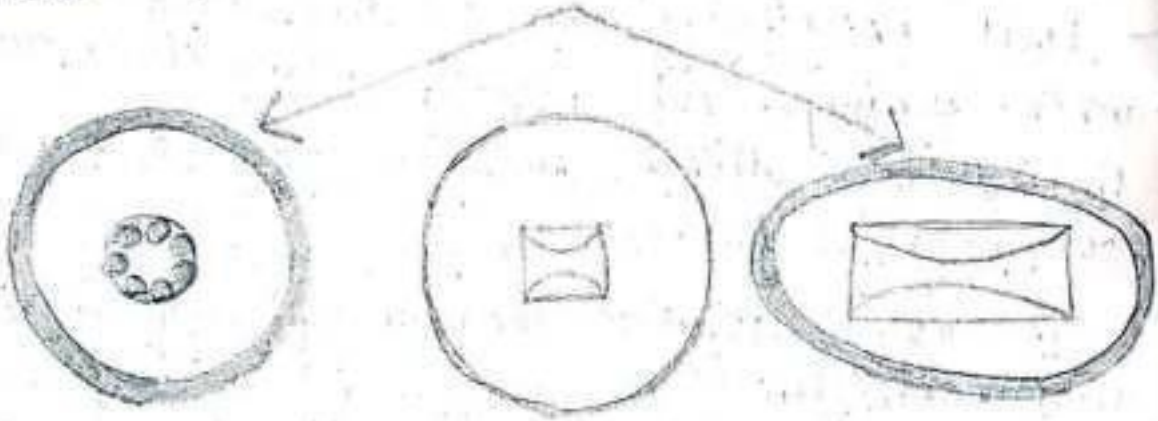
glass fibre etc.

Purpose :-

→ To increase concrete confinement by transverse fibre / reinforcement, especially for circular cross-sectional column..

→ To increase shear strength by transverse reinforcement.

→ To increase flexural strength by longitudinal fibre.



F.R.P jacketing :-

→ carbon fibre is flexible and can be made to contact the surface tightly for a high degree of confinement.

→ confinement is of high degree coz carbon fibre is of high strength and high modulus of elasticity.

→ It has light weight & rusting does not occur otherwise.