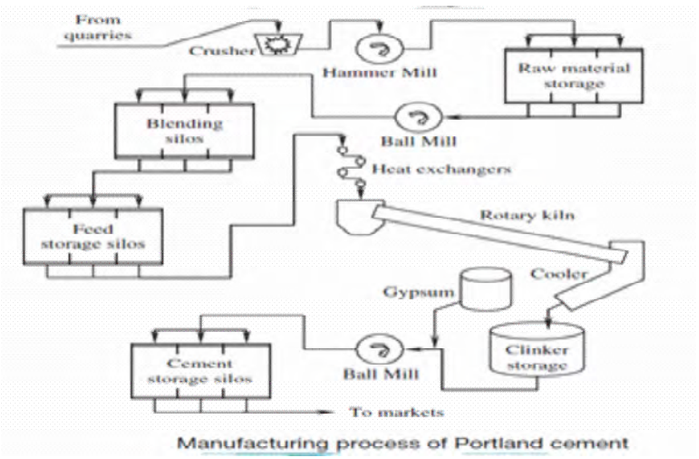
9

Construction Technology and Workshop



Manufacturing process of Portland cement

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Technical and Vocational Stream
Learning Resource Material

Construction Technology and Workshop

(Grade 9)

Civil Engineering

Government of Nepal
Ministry of Education, Science and Technology
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Sanothimi, Bhaktapur

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for civil engineering has been developed in line with the Secondary Level civil engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students, parents and concerned stakeholders.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Jagat Kumar Shrestha, Dr. Bhim Kumar Dahal, Er. Anisha Lamsal, Er. Gita Lamichhane, Er. Durga Bahadur Pun is highly acknowledged. This learning resource material is compiled and prepared by Er. Jagadishchandra Karki, Er. Kedarnath Dahal, and Er. Ashish Sharma Ghimire. The subject matter of this material is edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala. Similarly, the language is edited by Mr. Saroj Kumar Mandal. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes creative and constructive feedback for the further improvement of the material.

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Sanothimi, Bhaktapur

Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

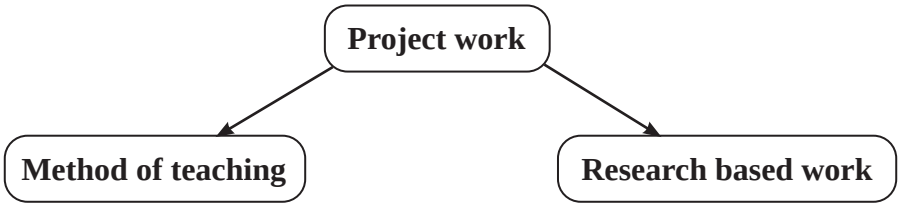
Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions. Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional

resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.
- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.
Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.
Homework exercises: Assign tasks that provide ongoing feedback on individual progress.
Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.
Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.
Peer feedback forms: Provide structured forms for students to assess their peers.
Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.
Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.
Reflection statements: Ask students to write reflective statements about their work.
Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.
Performance observations: Assess practical skills through direct observation.
Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Unit 1 : Construction Materials

1.1 Introduction to Construction Material

The material which is used for construction of civil-engineering structure is called construction material. various material used in the construction of civil-engineering structure such as:

a) Stone
b) Rock
c) Mud
d) Aggregate
e) Cement
f) Lime
g) Brick
h) Tile
i) Plastic
j) Bamboo
k) Timber/Wood
l) Steels
m) Glass
n) Paint
o) Asbestos sheet

a) Stone

Stone is a natural material of construction which are used in the construction of structure. The stone are mixture of two or more minerals which is generally extracted from rock. It has been used for constructing different components of building like as, wall, roof, foundation and lintel, etc.

b) Rock

Rock is the term used to name a solid portion of the earth crust. It has no definite shape and chemical composition. It is generally very big in size. The rock has one or more than one material.

Classification of Rock /Stone

i. Geological classification

ii. Physical classification

iii. Chemical classification

i. **Geological Classification**

The classification based on the mode of formation of the rock from which the building stone is obtained. Geologically the rocks are classified into following types:

a) Igneous Rock

Igneous rock is those rock which is formed through the cooling and solidification of lava or magma. For example: granites, basalt, trap, etc.

b) Sedimentary Rock

These are formed by gradual deposition of disintegrated rock due to the atmospheric action such as rain, wind, temperature etc. Example: Limestone, Sandstone, Gypsum.

c) Metamorphic Rock

When sedimentary or even igneous rock are subjected to great heat and pressure inside the earth, a new variety of rock is formed which is known as metamorphic rock. Example: Marble and Slate. (Marble from limestone and Slate from shale).

c) Mud

Mud is a type of construction material which is used for low-cost structure because it has less strength comparison to cement. Mud is also called binding materials which is used for binding of stone or brick each other in stone masonry.

d) Aggregate

Aggregate are inert material such as, sand gravel, crushed stone which are used to make concrete.

e) Lime

The raw-material for the, manufacture of lime (Ca O) is calcium carbonate (CaCo3) which is obtain by calcination of lime stone. lime is obtained by burning of limestone at temperature about 800^{o}c generally lime is used for binding purpose plastering work and decorative purpose.

f) Cement

Cement is one type of binding materials which is capable bonding together particle of solid matter into compact durable mass. It is adhesive and cohesive materials which is capable of bonding together particles of solid mass into a compact durable mass. It is obtained by mixing lime stone and clay, burning them and grinding to fine powder.

Type of Cement

a. OPC (Ordinary Portland Cement)

i. Commonly used for all type of construction work.

ii. Widely used in residential construction when special type of cement property is not required.

iii. It is a common type of cement available in market.

iv. It possesses sufficient resistance against dry shrinkage and cracking but less resistance to chemical attack.

b. QSC (Quick Setting Cement)

i. where the work needs to be done quickly.

ii. In under water construction.

iii. Cold and rainy weather condition.

c. PPC (Pozzolana Portland Cement)

i. It gains high compressive strength.

ii. It is cheap and affordable.

iii. Mainly used in building construction.

d. RHC (Rapid Hardening Cement)

i. This type of cement is used where high strength is need to be achieved initial stage quickly.

ii. Suitable for highway slab which are to be opened for traffic quickly.

iii. Suitable for cold weather area.

iv. This cement is used in construction field where strength should be achieved in more quickly.

v. Pre-cast concrete (beam, column).

Composition of Portland Cement

Oxide	Shorthand Notation	Common Name	Weight Percent
CaO	C	lime	64.67
SiO_2	S	silica	21.03
Al_2O_3	A	alumina	6.16
Fe_2O_3	F	ferric oxide	2.58
MgO	M	magnesia	2.62
K_2O	K	alkalis	0.61
Na_2O	N	alkalis	0.34
SO_3	$\overline{S}$	sulfur trioxide	2.03
CO_2	$\overline{C}$	carbon dioxide	—
H_2O	H	water	—

Table 1

Ingredient of cement

- Lime
  - Control strength and soundness
- Silica
  - Give strength
  - Excess of its cause slow setting
- Alumina
  - Provide quick setting
  - If added more it decreases strength
- Ferrous Oxide
  - Color material
- Magnesium oxide
  - It gives both color and hardness
  - If it is more, it gives crack to cement or mortar brings linkage
- Sulphur trioxide
  - If present in very small quantity, it makes cement sound
  - If present in excess, it makes cement unsound

- Alkalis.
    - Should be present in small quantities
    - If present in excess, it makes cement unsound

Manufacturing Process of Cement

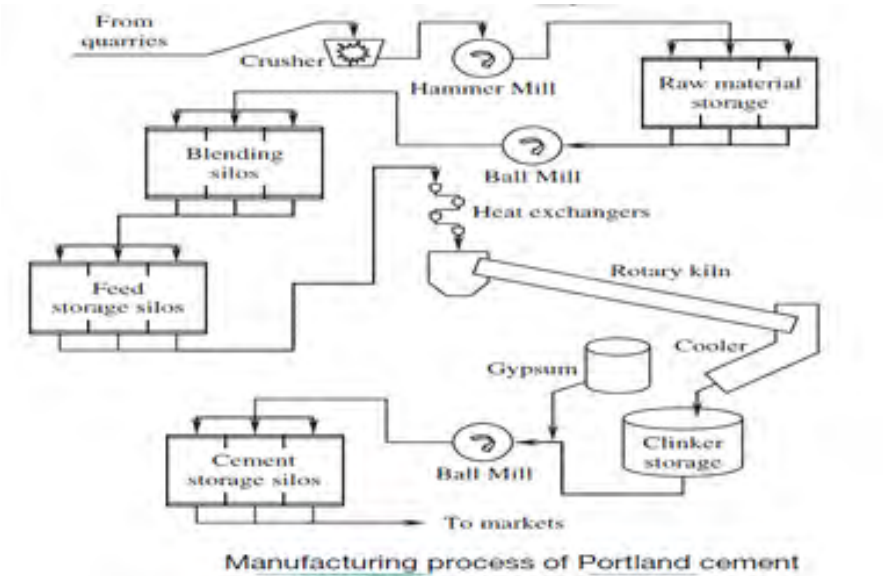


Fig.1

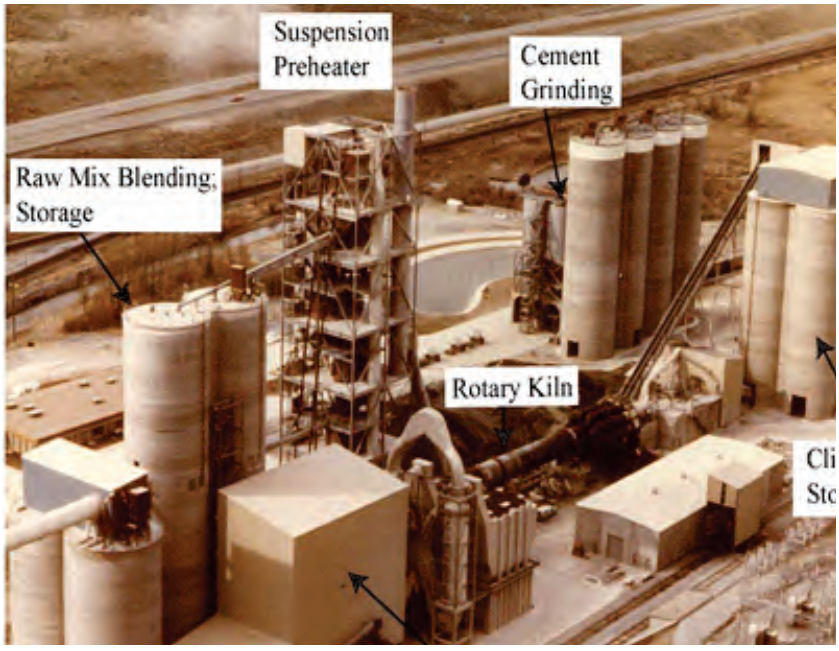


Fig.2

g) Brick

Brick is one of the clay products and the most extensively used material in construction and used for constructing wall column, roof, paving floor etc. bricks are made by molding clay to suitable shape and size and drying and burning them later. if burning is not done, they are called sundried brick. Bricks are generally classified into four groups

- First class brick
- Second class brick
- Third class brick
- Fourth class brick/jhamma /overburnt brick

h) Tile

Tile is also clay product tile are also used for covering roof flooring or making drain generally tiles are following type:

- Roofing
- Flooring
- Drain tiles etc.

i) Plastic

* It is a type of polymer In Greek words poly means many and meros means unit
* Plastic is non-metallic material they are natural or synthetic resin
* Material that show the property of plasticity is known as plastic

j) Bamboo

Bamboo is a building material has a high compressive strength and low weight has been one of the most used building materials. Bamboo as a building material used for construction of scaffolding bridge and other structure such as, roofing, trusses, shoring, door and windows, formwork, etc.

k) Timber/Wood

Wood is suitable for building or other engineering purpose is called timber. Timber is obtained from tree when it from part of living trees, it is called standing timber. Timber is one of the oldest materials of construction timber has been used in a variety of way in building construction, bridge, tunnel and many other engineering activities.

l) Steel

Steel is essentially verifying of iron containing 0.1 to 1.5% carbon in the form of cementing beside carbon, many metals may also be present in addition to iron giving rise to a great varies of steel.

- Type of steel
  - Mild steel (carbon containing 0.08 - 0.35)
  - Medium steel (carbon containing 0.35- 0.55)
  - High carbon steel (carbon containing 0.55 - 1.3)
- Property of steel
  - Its melting point is between 1300^{o}c to 1400^{o}c
  - it is a midway between cast and wrought iron containing 0.1-1.5 % carbon
  - It is tough and ductile
  - It is strong in compression as well as tension
- Uses
  - Used as reinforcement bar in RCC work; grills, steels column and beam, machine tool and hydraulics cylinder etc.

m) Glass

- Glass is an amorphous (non-crystalline) substance having a homogeneous texture.
- Glasses are typically brittle and optically transparent.
- silica is a common fundamental constituent of glass.
- It is widely used in mirror, door, window screen, bullet proof screen, glass fiber, electric bulb, bottle etc.
  - Type of glass
  - sodium lime glass (Soft Glass)
  - potassium lime glass (Hard Glass)
  - potassium lead glass (Flint Glass)

n) Paint

The fluid paste prepared by dissolving of base into a vessel along with coloring pigment is known as paint. Paints are used to protect metal, timber or plaster surface

from the corrosive effect of weather, heat, moisture, etc. they are also used to improve their appearance. it provides colorful, pleasant and decorative appearance to the surface.

1.2 Building Material

a) Good building stone

b) Brick

c) Block

a) Good Building Stone

A stone is a natural material construction which are used in the construction of structure. the stone are mixture of two or more minerals which is generally extracted from rock.

Properties of Good Building Stone

i. Appearance and color

ii. Strength

iii. Hardness

iv. Toughness

v. Durability

vi. Workability

vii. Water absorption

viii. Resistance to fire

ix. Specific gravity

i) Appearance and color

The good building stone should have good appearance and uniform color. stone which are used for decorative work should have uniform and attracted color. Stone are available in almost all color from milk white to blood red to black. Generally, black color stone are not used for building construction.

ii) Strength

For construction of any structure only the stone with high strength are suitable. Stone used for structure are usually subjected to compressive strength. So, they should have sufficient compressive strength. Compressive strength of stone

range from 280-2800 kg/cm^2. Transverse strength ranges from 20 to 300 kg/cm^2.

iii) Hardness

Hardness of stone may be defined as its capacity to resist stretching or abrasion. The stone must be hard. Generally, igneous rock show high hardness.

iv) Toughness

It is the property of rock that can stand. impact or vibrating road. Stone to be used in foundations under heavy machines where vibration may be common phenomenon must be enough.

v) Durability

Good stone must be hard, strong and durable. It is more durable in case it is compact homogeneous.

vi) Workability

The stone to be used for covering and architectural appearance should be easily and economically dressed. different shape is required while working.so stone should be convenient to work. Giving proper shape and dimension and surface finished to raw stone is dressing.

vii) Water Absorption

The good building stone should have less pores and minimum water absorption not more than 5 %.

viii) Resistance to Fire

A good building stone should have able to resist high temperature.

ix) Specific gravity

In general, it's varying from 2.4 to 3.8

Uses of Stone

Structure: stone are used in civil engineering structure like as; foundation, wall, roof, slate, floor, etc. paving stone: stones are used for paving road, footpath, etc.

i) Brick

Brick is one of the clay products and most extensively used material in construction and used for constructing wall column, roof, paving, floor, etc. Bricks are generally

classified into four categories:

a) First class Brick

* These bricks have uniform texture, uniform red color
* They should have plain rectangular face with parallel sides and sharp straight and right angle
* They should not absorb water more than 20% of its dry weight when emerged cold water up to 24 hours
* The minimum crushing strengths is 10.5N/mm^2
* Metallic ringing sound should come when two brick struck against each other

- **Uses of First-Class Brick**
  * use of exterior wall of building
  * use the first class brick when plaster is not needed
  * Expose facework in masonry structure, flooring, etc.

b) Second Class Brick

* They may have destroyed round edge
* They should have fine compact and uniform texture
* The minimum compressive strength is 7.5 N/mm^2
* Emit of clear ringing sound when struck against each other
* Water absorption not more than 20 to 22% of its dry weight when emerged in cold water up to 24 hours

- **Uses**
  * Interior wall of building
  * Unimportant masonry work

c) Third Class Brick

* These bricks are slightly overburnt or under burnt associated with flaw and crack
* They should not have uniform red color
* They should not have rectangular shape
* Minimum compression strength 3.5 N/mm^2
* Water absorption should not be more than 22 - 25% of its dry weight when emerged in cold water up to 24 hrs.

- **Uses**

* Used for temporary structure
* Uses for road construction or foundation

d) Fourth Class Brick or JHAMMA

* These bricks are irregular in shape
* These bricks shouldn't have uniform red color
* Crushing strength 15N/mm^2 or 150 kg/cm^2
* Water absorption is very low comparison to other class brick

- **Uses**
  * These bricks are generally used for road material and foundation.

ii) Block

Generally, block can be defined as the mixture of cement sand aggregate make with a different shape and size. generally, size of block is 410*200*200mm.

Type of Block

i. Hollow block
ii. Concrete block

i) **Hollow Block**

* They are precast concrete unit made up approximate mixture of cement, sand, aggregate, such as sand, reverbed gravel crushed stone
* Prepared by concrete block technology
* It can be produced in different shape and size for wall construction to fit different construction need
* Strength of hollow block can be specified as per the requirement

Advantage of Hallow Block

* Easily and spredly construction
* Have a good thermal insulation
* Reduce maintenance cost
* Durable and less water absorption
* No skill manpower required

* Economic and environmentally friendly
* Better acoustic fire and thermal insulation

ii) **Concrete Block**

* They are made from concrete that is Portland cement and aggregate usually sand and fine gravel for high density
* Nowadays concrete blocks are very common for load bearing wall of building infill wall of frame structure

Advantage of Concrete Block

* It can be made from locally available material
* Easily and speedly construction
* Have a good thermal insulation

1.3 Mortars

It is a material used in a masonry construction. to fill the gap between brick and block used in construction. It is a mixture of sand and binding material such as cement or lime and water is applied form of paste which is then set hard. It plays an important role imparting bond strength, flexural tensile strength and compressive strength masonry.

Function of Mortar

* Development of strength
* Workability should have ability to spread uniform
* Filling hollow part
* Resistance to cracking
* Low shrinkage
* Resistance to chemical attack
* Good compressive strength
* Development of strength
* Workability should have ability to spread uniformly

Properties of Mortar

* The mortar should be easily workable

* It should be sufficiently plastic
* It should be strong and durable after drying and hardening
* Should not develop any crack on drying
* Should be capable of retaining sufficient water during its application
* It should set and harden quickly to achieve speed in construction

Uses of Mortar

* Used to bond together stone or brick in stone or brick masonry
* Used to fill up space between stone or brick (for making wall and water tight)
* Use to improve the general appearance of structure
* Used to plastering to protect joint and surface of the brick and stone masonry
* Use to high defective masonry works
* Use for damp proof course
* Used to bind together different masonry wall
* Used in pointing

Type of Mortar

i. Mud mortar
ii. Cement lime mortar

i) **Mud Mortar**

* Mud mortar for masonry as building material is normally not used in present day in construction work because of its poor bonding quality or (Capacity) mud mortar does not attain strength when expose to moisture or rain
* Mud mortar gain some strength during construction
* Use for temporary and low-cost single storey building

ii) **Cement Sand Mortar**

Cement lime have a good quality of mortar as well as lime mortar i.e medium strength with good workability good water retentivity free from crack and good resistance against rain penetration. Commonly adopted proportion of mortar (Cement: sand) are 1:3 to1:6

Special type of mortar

- Cement clay mortar
- light weight and heavy weight mortar
- Decorative mortar
- Gypsum mortar
- Fire resistance mortar
- Sound absorb mortar
- X-ray shielding mortar
- Cement clay mortar
    - It is used for masonry joint and plastering
    - This mortar has better covering and mainly used in thin layer
- light weight and heavy weight mortar

In light weight mortar fiber or jute and hair cut into piece of suitable size or asbestos fiber can also be used. These are prepared from light porous, sand from pumice and other fine aggregate also by mixing wood powder with lime mortar or cement. They are used in heat and sound proof structure where load acting is very low.

- **Decorative Mortar**

  Such mortars are made by using coloring pigment, color cement and fine aggregate in suitable proportion. They are used where aesthetic work are needed.

- **Gypsum Mortar**

  It is prepared from gypsum binding material.

- **Fire Resistance Mortar**

  This mortar is obtained mixing powder of the fire brick or fire clay with aluminous cement.

- **X-ray Shielding Mortar**

  Aggregate are formed heavy rock mixed with binding material and suitable admixture are added to enhance this property. These are used for plastering of wall or ceiling of X-ray cabinet.

- **Sound Absorbs Mortar**

  Noise level can be reduced by using it.

1.4 Other Material

Bituminous and Asphaltic Material

The material in which bitumen, asphalt or tar are associated in some form are termed as bituminous or asphaltic material. It is extensively used in road construction.

Bitumen

* It is define as a solid or semi solid, black, stickily, ductile substance obtained as impart by product from the distillation of crude petroleum oil
* It is a binding material obtained from the distillation of crude petroleum oil

Properties of Bitumen

* It is a solid or semi solid block
* It melts of soften an application of heat
* It is completely soluble in carbon disulfide
* It is a binder in all type of asphalt
* It has high insulation resistance

Uses of Bitumen

* It is widely used as road making material
* used for manufacturing of bituminous paint
* used to filling up joint in leaky proof
* It is used as damp proof course

Type of Bitumen

- Cutback bitumen
- Plastic Bitumen
- Bitumen emulsion
- Straight run bitumen
- Air Blown Bitumen

✓ **Tar**

Tar is a black solid mass obtain during the destructive distillation of coal, wood or

other organic material. It is the by-product of the manufacturing of bituminous coke and is soluble in carbon disulfide.

✓ **Property of tar**

* It contains high percentage of carbon
* It contains (75 to 95%) of bituminous contained
* It hardness much quickly than asphalt
* It is black to dark brown in color

✓ **Uses**

* It is use for making roof and road construction
* It used for water proofing compound
* Coal tar is used as a preservative for timber
* It is painting for painting wall

✓ **Type of Tar**

* **Coal tar:** Destructive distillation of coal
* **Wood tar:** Produced from tree
* **Mineral tar:** Produced from bituminous shell

✓ **Asphalt**

* It is solid or semi solid product formed by distillation of certain petroleum oil
* It is available in natural state or it can be prepared artificially
* It is natural or artificial mixture in which bitumen is associated with inert material such as sand, gravel and crushed stone

✓ **Type of asphalt**

* **Natural asphalt:** In lake (3 to 60m) depth
* **Petroleum Asphalt:** destructive distillation of crude petroleum oil
* **Mastic Asphalt:** produced by heating natural asphalt with sand and mineral fillers
* **Asphalt Emulsion:** It is prepared by mixing asphaltic material

✓ **Properties of Asphalt**

* It is usually solid or semi solid in nature
* It is black or brown in color

* It becomes plastic and workable when heated
* It resists reaction with water
* It is ductile
* It is elastic
* It is good conductor of heat, sound and electricity

✓ **Uses**

* Use of DPC (damp proof course)
* Use for road construction
* Use for preparing asphaltic concrete
* Use for preparing electric insulating material
* Used for flooring purpose

✓ **Timber**

Wood is suitable for building or other engineering purpose is called timber. timber is obtained from tree when it from part of living trees, it is called standing timber. Timber is one of the oldest materials of construction timber has been used in a variety of way in building construction, bridge, tunnel and many other engineering activities.

✓ **Characteristics of Good Timber**

* It should be hard and durable
* It should have straight and close fibers
* It should be of uniform color
* It should give a clear ringing sound when struck together
* It should have a sufficient strength to resist heavy structural load
* It should be free from sap, dead knots, shakes and another similar defect
* Freshly cut surface should give sweet smell
* It should provide smoothened surface easily
* It should be well seasoned and easily workable

✓ **Glass**

Glass is an amorphous (non-crystalline) substance having a homogeneous texture. Glasses are typically brittle and optically transparent. Silica is a common fundamental constituent of glass.

✓ **Type of Glass**

- Sodium lime glass (Soft Glass)
- Potassium lime glass (Hard Glass)
- Potassium lead glass (Flint Glass)

✓ **Property of Glass**

* It is an amorphous material.
* It has high workability.
* It is transparent.
* It is extremely brittle.
* It is poor in resisting formal shock, impact stress etc.

✓ **Uses**

It is widely used in mirror, door, window screen, bullet proof screen, glass fiber, electric bulb, bottle, etc.

✓ **Plastic**

* It is a type of polymer In Greek words poly means many and meros means unit
* Plastic is non-metallic material they are natural or synthetic resine
* Material that show the property of plasticity is known as plastic
* The basic material used in the manufacturing of plastic are generally obtained from following natural substance
* Coal
* Salt
* Water
* Petroleum
* Sulphur
* Lime stone
* Air

✓ **Uses of Plastic**

* Floor tile
* Electrical insulator
* Lighting fixture

* Wall tiles
* Bath and sink units
* Overhead water tank
* pipe to carry cold water
* Foams for thermal insulation

✓ **Properties of Plastic**

* Light in weight
* Available in attractive color and finish
* Low electrical conductivity
* Good tensile strength
* Fairly good resistance offered to attack by on organic acid, base, and salt.
* Durable
* Can be easily fixed in position
* Easy to maintain etc.
* Bad conductor of heat

✓ **Type of Plastic**

- Thermo plastic
- Thermosetting plastic

✓ **Thermo Plastic**

* Plastic thar are soften easily after the application of heat are called thermo plastic
* They can be moulded in any desire shape
* Less strong
* For example: polythene, PVC (polyvinyl chloride)

✓ **Thermosetting Plastic**

These are the plastic that harden on the application of heat and cannot be re moulded to the desire shape after its first use.

* Stronger than thermoplastic
* They are tough hard and brittle
* Example: polyster, silicon, etc.

Exercise

Choose the correct answer from the given alternatives.

1. For a good building stone how much is the required crushing strength?
   a. Less than 50 N/mm^2 b. Greater than 100 N/mm^2
   c. 155 N/mm^2 d. 10 N/mm^2

2. First class bricks are used for:
   a. Brick ballast in R.C.C b. Boundary walls
   c. Low height walls d. Pavements

3. The minimum crushing strength of thirdclass brick is:
   a. 3.5 N/mm^2 b. 7 N/mm^2
   c. 10 N/mm^2 d. 20 N/mm^2

4. Which of the following is not a feature of secondclass bricks?
   a. Have small irregularities
   b. Water absorption is between 20-25%
   c. Rectangular in shape
   d. Free from cracks

Write short answer to the following questions.

1. Write properties of first class of brick?
2. Write types of mortars?

Write long answer to the following questions.

1. What are the properties of mortars? Write the uses of mortars?
2. Write properties and uses of CSEB and AAC block.

Project Work

1. Demo of different material: Brick, Sand, Cement, Stone, etc.
   Arrange the field trip on the brick factory

Unit 2 : Masonry Works

2.1 Introduction to Masonry Works

Masonry is an art of construction in which building units, brick, stone, etc, are arranged systematically and binder with cement and sand mixture. Masonry structures are the build from individual units laid and bounded by mortar. Masonry structures are highly durable structure. Common material of masonry construction are bricks, building stone such as, marble, granite, limestone, concrete block etc. The durability of overall masonry structure is affected by the material used quality of mortar, workmanship and building.

2.1.1 Use of Masonry

i. Widely used to construct large and small structures

ii. It is most commonly used in construction of wall (load bearing and non-load bearing, exterior, interior, partition)

iii. Retaining wall and breast wall

iv. Chimney, fire place (since masonry unit are fire resisting)

v. Piers vertical portion, column, intel, sill, bond beam, etc.

vi. Slope protection, paving, etc.

2.1.2 Advantage of Masonry Structure

i. Durable and long lasting

ii. Not combustible fire resisting

iii. More resistance to debris, hurricane, tornado

iv. Require no painting

v. Long life span

2.1.3 Disadvantage of Masonry Structure

i. High cost

ii. Required more skill level

iii. They are heavy and must be built upon a strong foundation.

2.1.4 Structural Limitation

Have a high compressive strength under vertical road but have a less tensile strength unless reinforced.

2.2 Technical Term Used in Masonry

a. **Header:** It is a full brick or stone which is laid with its length perpendicular to the face of the wall.

b. **Stretcher:** Length is parallel to the face of the wall.

c. **Bond:** it is term applied to the overlapping of brick or stone in a wall in alternate course to bind the whole wall together.

d. **Courses:** A horizontal layer of brick or stone is termed as course.

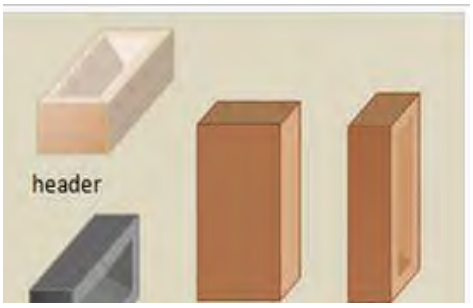


Figure 3

e. **Header course:** It is a course of brick work entirely composed of header.

f. **Stretcher course:** It is a course of brick work in which all the bricks are laid in stretcher.

g. **Bed:** It is termed used to indicate the lower surface of brick or stone in each course.

h. **Face:** The surface of wall exposed to weather is termed as face.

i. **Facing:** The material used in face of the wall is called facing.

j. **Back:** The inner surface of the wall which is not exposed to weather is termed as back.

k. **Backing:** The material used in forming the back of the wall

l. **Hearting:** The portion of wall between facing and backing is termed as Hearting.

m. **Joint:** The junction of two or more brick or stone is called joint. Joint may be cement mortar or lime mortar.

n. **Racking Back:** The process of

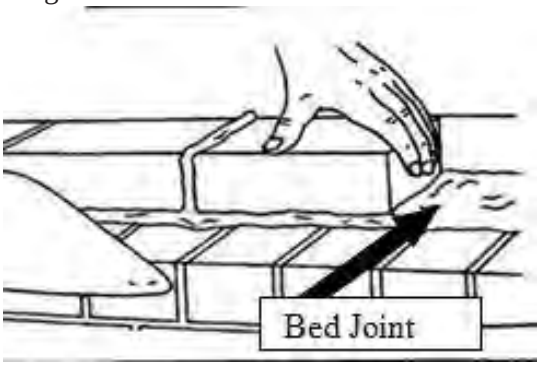


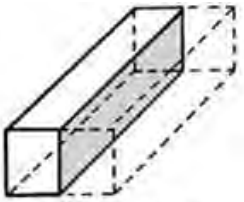
Figure 4

stopping the unfinished end of the wall in stepped fashion.

o. **Bat:** It is a portion of brick cut across the width or a brick cut by some fraction of its length.

p. **Closer:** It is a portion of brick cut in such manner that its one long face remains uncut.

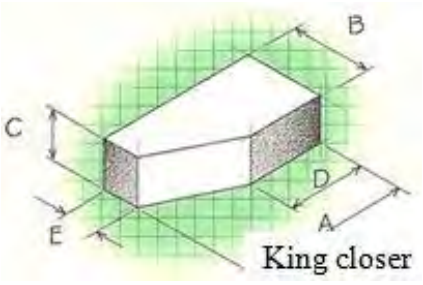
i. **King Closer:** It is formed by cutting of triangular piece between the center of end and center of one end. Queen closer: It is a portion of brick obtained by cutting a brick lengthwise into two portions.


Queen closer

ii. **Bevelled Closer:** It is the special form of king closer in which the whole length of the brick is bevelled in a such way that half width is maintained at one end and full width is maintained at other end.

iii. **Mitred Closer:** It is a brick where end is cut splayed (45^0 to 60^0) for full width.

q. **Cow Nose:** It is a special moulded brick with one edge via length or both end via length is rounded.



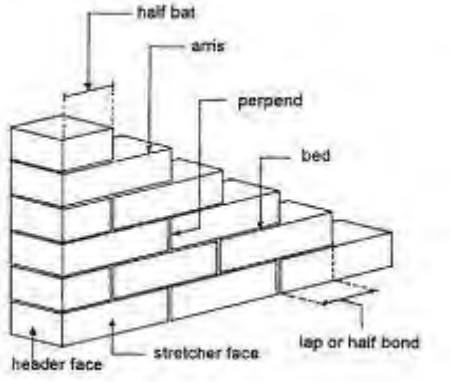
King closer

r. **Corbel:** It is a projecting stone which is usually provided to serve as support for truss etc.

s. **Cornice:** It is a projecting ornamental course near the top of the wall or at the junction of wall and the ceiling.

t. **Frieze:** It is the course of stone placed immediately below the cornice, along the face of wall.

u. **Lap:** It is the ho[1]rizontal distance between the vertical joint of successive brick courses.



v. **Quoin:** It is the corner the external angle on the face side of a wall.

w. **Too Thing:** It is the termination of the wall in such a fashion that each

alternate course at the end of project, in order to provide adequate bond if the wall is continued horizontally at a later stage.

x. **Perpend:** It is a vertical joint on the face of wall directly over vertical joint in alternative courses.

y. **Threshold:** It is the arrangement of steps provided from the plinth level of external door to the ground level.

z. **Frog:** It is the depression on the top face of a brick. Frog provides a recess for the mortar which on setting form a key and prevent the displacement of the brick above.

2.3 Stone Masonry

Stone used as a building unit are known as stone masonry. The stone used for masonry should hard durable tough sound and free from weathering decay or defect like crack sand hole patches of loose or soft material etc. Stone masonry is a form of construction using natural stone and mortar to make load bearing and non-load bearing wall.

2.3.1 Advantage of Stone Masonry

i. Helps to maintain thermal comfort in a building

ii. Reduce cost of painting

iii. Long life span

iv. Good fire protection and heat resistance

v. Attractive appearance

vi. In context of Nepal locally/easily available

2.3.2 Disadvantage of Stone Masonry

i. It affects the nature while quarrying

ii. Not as durable compare as stone

iii. It is hard to work with.

iv. It is difficult to repair or relocate.

2.3.3 Use of Stone Masonry

i. Creation of building, structure and sculpture

ii. Used for buildings shelters, temples, monuments, Artefacts, Fortifications, road,

bridge, etc.

iii. Famous work such as Egyptians, pyramid, Taj mahal, Angkor wat, etc.

2.3.4 Type of Stone Masonry

a) Rubble masonry

b) Ashlar masonry

a) Rubble Masonry

The stone masonry in which either undressed or roughly dressed stone are laid in a suitable mortar is called rubble masonry. This is the roughest and cheapest form of stone masonry. In this masonry the joint does not have uniform thickness. It is derived into following types**.**

a) Random rubble masonry

   i) Uncoursed Random rubble masonry

   ii) Coursed Random rubble masonry

b) Square rubble masonry

   i) Coursed Square rubble masonry

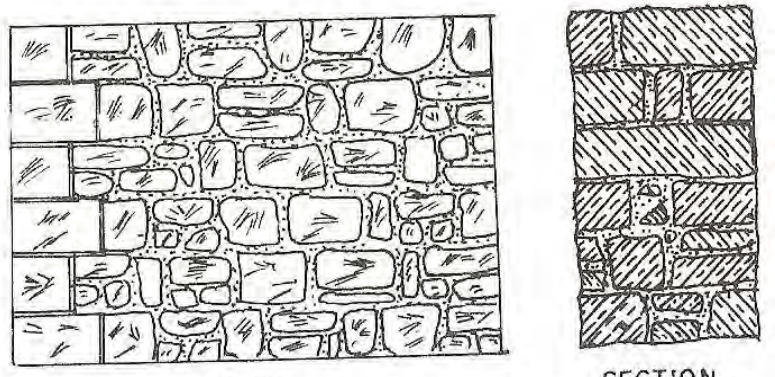
   ii) Uncoursed Square rubble masonry

c) Dry rubble masonry

d) Miscellaneous rubble masonry

   i) Polygonal rubble masonry

   ii) Flint rubble masonry



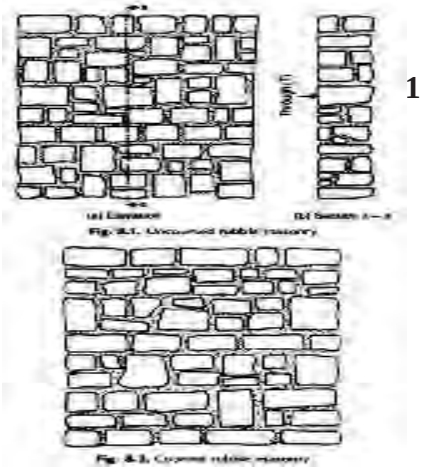
Randon Rubble Masonry

b) Random Rubble Masonry

The rubble masonry in which either undressed or hammer dressed stone are used is called random rubble masonry. Rubble masonry is rough, uneven building stone set in mortar, but not laid in regular courses.

i) Coursed Random Rubble Masonry

The random rubble masonry in which the stone are laid in layer of equal height is called CRRM. In this masonry the stone are laid in some what level courses. Header of one coursed height are placed at certain intervals. The stone are hammer dressed use for construction of residential building, boundary wall etc.



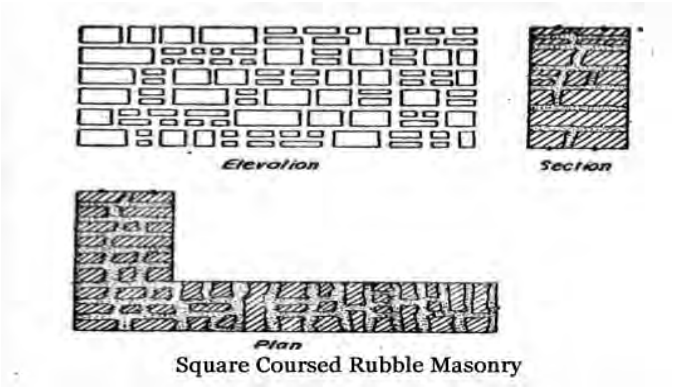
1

ii) Uncoursed Random Rubble Masonry

The random rubble masonry in which stones are laid without forming courses is known as uncoursed random rubble masonry. This is the roughest and cheapest type of masonry and has a varying appearance. The stone used in this masonry are of different size and shape. Before laying, all projecting corners of stones are slightly knocked off. Large stone are used at the corners and at jambs to increase their strength. Through stone is used for Every square meter of the face is for joining faces and backing. It is used for construction of wall at low weight in case of ordinary building.

c) Squared Rubble Masonry

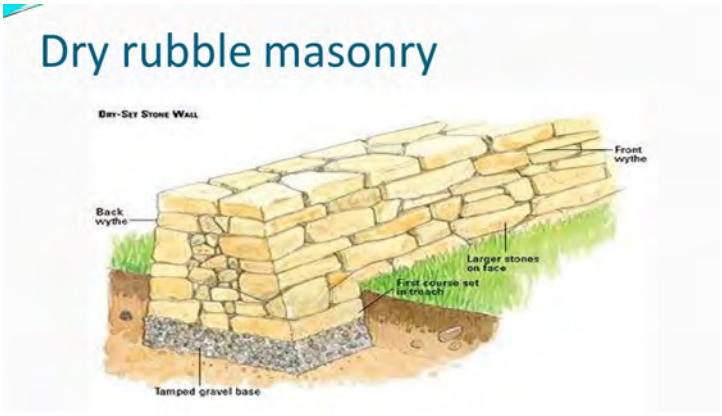
The rubble masonry in which the fresh stones are squared on all joint and beds buy hammer dressing or chisel dressing before their actual laying is called square rubble masonry. It is further divided into following types.



Square Coursed Rubble Masonry

i) Coursed Square Rubble Masonry

The square rubble masonry in which hammer or chisel dressed stone laid in courses is called CSRRM. This is a superior variety of rubble masonry. It consists of stone which are squared on all joint and laid in course the stones are to be laid on courses of equal layers and joint should also be uniform. Use for construction of public building, Hospital, School, Market, Modern residential building etc and in hilly area where good quality of stones are easily available.

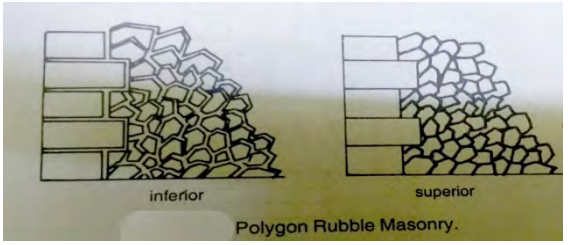


ii) Uncoursed Squared random rubble masonry: In this type of masonry hammer dressed stones are laid without making courses is called USRRM. It consists of stones which are squared on all joint and beds by hammer dressing all the stones to be laid are of different size used for construction of ordinary building in hilly areas where a good variety of stones are cheaply available.

d) Dry Rubble Masonry

The rubble masonry in which stones are laid without using any mortar is called dry rubble masonry. Sometimes shortly as 'dry stones'. It is an ordinary masonry and is

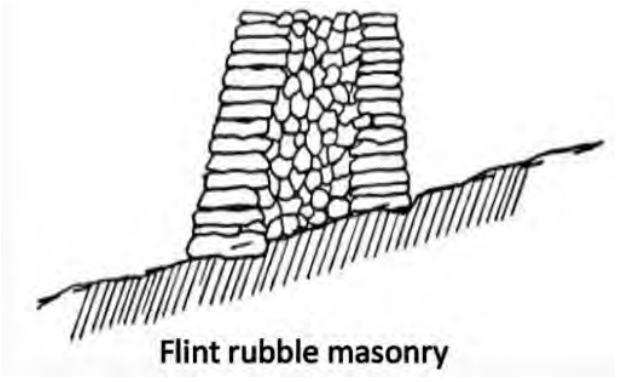
recommended for construction wall of height not more than 6m.



e. Miscellaneous Rubble Masonry

i) Polygonal Rubble Masonry

In this type of masonry stone are hammer finished on face to irregular polygonal shape stone are bedded in position to show face joint running irregularly in all direction. Two types of polygonal wall as rough, picked and close picked may be constructed.



ii) Flint Rubble Masonry

In this type of masonry stone used are flints or cobbles. These are irregularly shaped nodules of silica. The stones are extremely hard. But they are brittle and therefore they break easily.

b) **Ashlar masonry**

The stone masonry in which finely dressed stones are laid in cement or lime mortar is known as ashlar masonry. In this masonry the courses are of uniform height, all the joints are regular thin and have uniform thickness. This type of masonry is much costly as it's requiring dressing of stone. This masonry used for heavy structure, architectural building, high piers and abutment of bridge.

Ashlar fine rgular Masonry

a. Ashlar fine regular
b. Random coursed ashlar masonry
c. Rough tooled ashlar masonry
d. Rock or quarry ashlar masonry
e. Ashlar facing masonry
f. Chamfered ashlar masonry

a) Ashlar Fine Regular

In this type of stone masonry stone block of same height in each course are used. Every stone is fine tools in all sides. Thickness of mortar is uniform throughout. It is an expensive type of stone masonry as it's required heavy labours and wastage of materials while dressing.

b) Random Coursed Ashlar Masonry

This type of ashlar masonry consists of fine or course ashlar but the courses are varying thickness depending upon the character of building.

c) Rough Tooled Ashlar Masonry

In this type of ashlar masonry, the side of the stone are rough tooled and dressed with chisels. Thickness of joint is uniform, which does not exceed 6mm.

d) Rock or Quarry Faced Ashlar Masonry

This type of Ashlar masonry is similar to rough tooled type except that there is

chisel-drafted margin left rough on the face which is known as quarry faced.

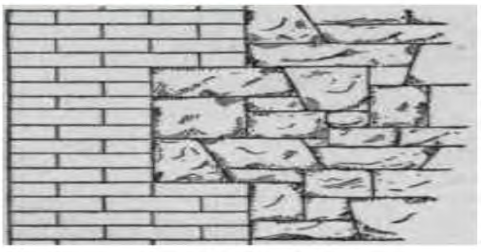
e) Ashlar Facing

Ashlar facing is the best type of ashlar masonry. Since this type of masonry is very expensive it is not commonly used throughout the whole thickness of wall except in works of great importance and strength.

Ashlar rock or quarry faced masonry

Ashlar rough tooled masonry

ASHLAR FACING



ASHLAR FACING

2.4 Dressing of Stone

It is a process of giving required shape size and finished to the raw stone for used in structure is known as dressing of stone.

2.4.1 Advantage of Dressing

i. Reduced cost of transportation.

ii. Obtained aesthetically (appearance) appealing finish

iii. Give a proper shape to the stone

iv. Freshly quarried stones contain some moisture called quarry gap which are comparatively soft and can be dressed easily

v. At quarry site it is possible to classify stone for different work

vi. Irregular and rough portions of the stone can be removed to facilitate easy transportation

2.4.2 Quarrying of Stone

The process of extraction of suitable stone from nature place of occurrence for using construction is called quarrying.

2.5 Brick Masonry

Brick unit bounded together with mortar to form a different structure during construction is known as brick masonry. Brick masonry strength depends upon the materials used quality of brick workmanship and bonding. The brick is used for brick masonry shall be standard, rectangular shape, burnt, hand formed or machine made and then crushing strength not less than 3.5 N/mm^2

2.5.1 Brick Bonding

Bonding is arrangement of brick in wall column or pier laid to maintain and adequate lap.

2.5.2 Purpose of Brick Bonding

* Obtain maximum strength for distributing the load to be carried throughout the wall column or piers
* Ensure lateral stability and resistance to thrust
* Create acceptable appearance

2.5.3 Type of Bond

a) Stretcher bond

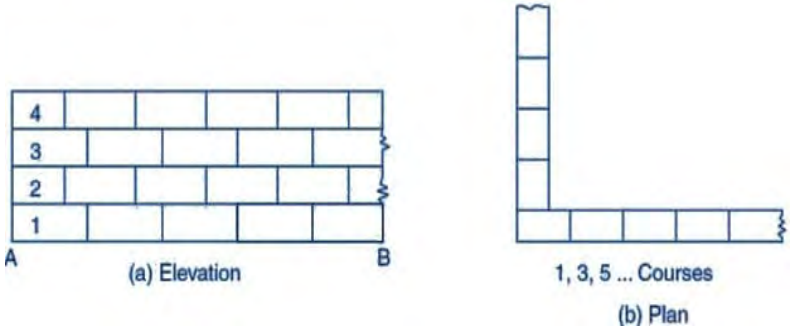
b) Header bond

c) English bond

d) Flemish bond

e) Rat trap bond

f) Dutch bond and other.

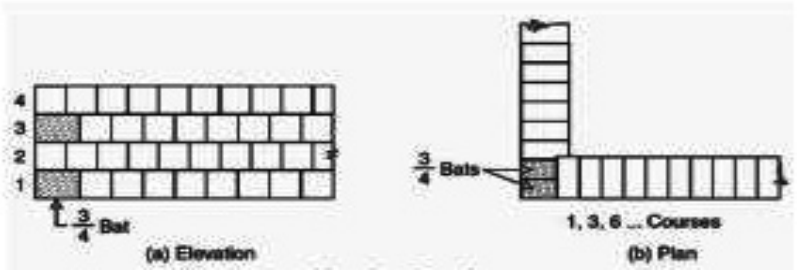


e) Stretcher Bond

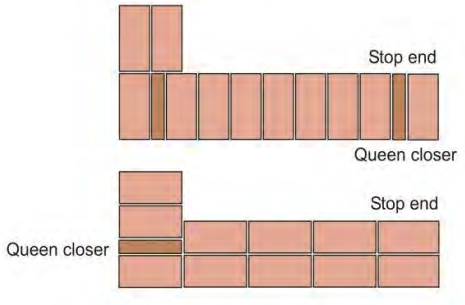
Stretcher bond is the bond in which the length of the brick is parallel to the face of the ground**.** This is simplest and most widely uses bond**.** All brick laid in stretcher course create a stretcher bond**.** Used for half brick wall, partition wall, etc. There is no header in such wall.

f) Header Bond

Header bond is the bond which width is Parallel to the face of the wall.

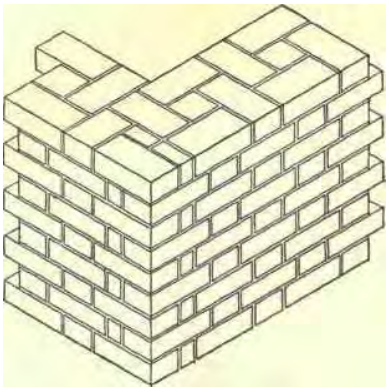


One brick wall - English bond



g) English Bond

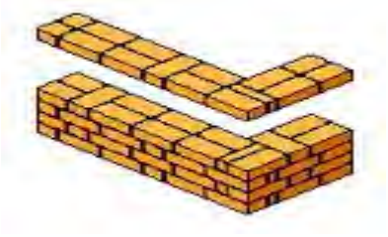
Generally used in practice. Consist of header and stretcher laid in alternative courses. Strongest of all bond. Progressive work is fast and no need of skilled manpower. Provide rough appearance specially for one brick thick wall.



h) Flemish Bond

* Consist of header and stretcher laid alternative in each course.
* Progress work is low.
* Provide good appearance specially for one brick thick wall.
* every alternate course starts with header with corner
* Low cost
* this bond is less strong for wall having thickness > 13.5 inch.

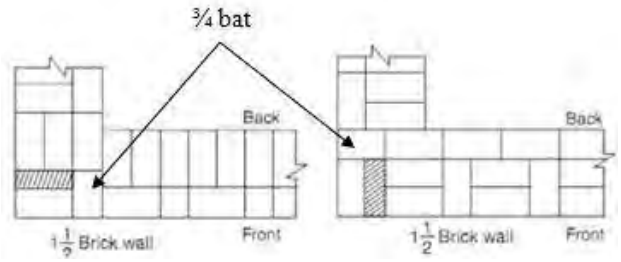
i) Double Flemish Bond



* Headers and stretchers are placed alternatively in front as well as back face.
* Half bat and three quarters bat will have to be used for walls having thickness equal to odd number of half bricks.
* For wall of thickness equal to even number of half brick,
* no bat will be required

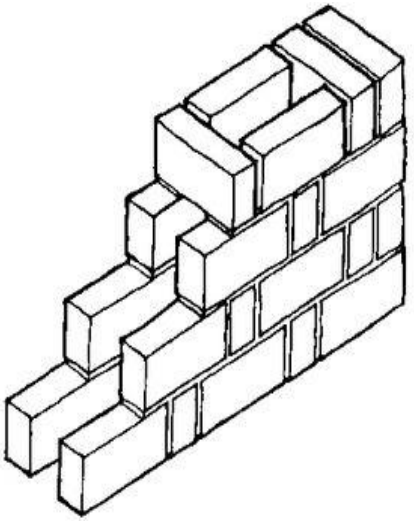
Figure 24

* This bond gives the better appearance than English bond.



j) Single Flemish Bond

* Front face of masonry is of Flemish bond and the back face is of
* English bond
* This bond as a combined effect of strength of English bond and the appearance of Flemish bond
* Minimum wall thickness required for this bond is 1½ brick thick
* Note: Hatch in the figure is queen closer



k) Rat-trap Bond

A "Rat-Trap Bond" is a type of wall brick masonry bond in which bricks are laid on edge (i.e. the height of each course in case of a brick size 230x110x55 mm, will be 110 mm plus mortar thickness) such that the shiner and rowlock are visible on the face of masonry. It helps maintain improved thermal comfort and keep the interiors colder than outside and vice versa.

Possible Layout

a) Each alternate course begins with ¾ bat and followed by the rowlock and the intermediate course begins with rowlock followed by shiner.

b) Each alternate course begins with a shiner, followed by a rowlock and the intermediate course begins with two rowlocks followed by a shiner.

Features

* Economic use of brick as compared to the solid wall in English or Flemish bond.
* Large reduction in cost of construction of masonry wall than English or Flemish bond.
* Increases thermal comfort due to presence of cavity in between wall.
* Due to the reduction in dead weight of wall, the foundation materials can be reduced.
* Plastering can be avoided because this wall provides the better aesthetical appearance.
* Plumbing, wiring and sanitary pipes can be easily fixed through the cavity during wall construction.
* Because this wall is not so strong in lateral direction, it cannot be used as lateral load supporting wall. This wall is only constructed to resist the imposed load not for more than 3 storied buildings.

2.6 Block Work

Generally, block can be defined as the mixture of cement sand aggregate make with a different shape and size. Generally, size of block is 410*200*200mm.

2.6.1 Type of Block

i. Hollow block

ii. Concrete block

i) **Hollow Block**

* They are precast concrete unit made up approximate mixture of cement, sand, aggregate, such as sand, reverbed gravel crushed stone.
* Prepared by concrete block technology
* It can be produced in different shape and size for wall construction to fit different construction need.
* Strength of hollow block can be specified as per the requirement.

✓ **Advantage of Hallow Block**

* Easily and speedily construction.
* Have a good thermal insulation.
* Reduce maintenance cost.
* Durable and less water absorption.
* No skill manpower required.
* Economic and environmentally friendly.
* Better acoustic fire and thermal insulation.

ii) **Concrete Block**

* **They are made from concrete that is Portland cement and aggregate usually sand and fine gravel for high density.**
* **N**owadays concrete blocks are very common for load bearing wall of building infill wall of frame structure.

✓ **Advantage of Concrete Block**

* It can be made from locally available material.
* easily and speedily construction.
* have a good thermal insulation.

2.6.2 Defects in Brick Masonry

a) Corrosion of embedded fixtures
b) Efflorescence
c) Shrinkage cracks
d) Sulphate attacks

a) Corrosion of Embedded Fixture

Iron or steel embedded in brick works gets corroded in the presence of dampness. On corrosion the metal expands in volume and trends to crack the brick work.

Corrosion is a natural process which converts Refined metal to a more chemically stable form such as the oxide, hydroxide or sulphide.

b) Efflorescence

Defect form due to crystallization of salts form bricks are known as efflorescence. presence of excessive soluble salts in the brick is the primary case of this type of

defect. when these bricks are comes in contact with water the soluble salt present the Rein gets dissolved and comes to surface in the form of white powder.

It is caused by soluble salts in solution being brought to the surface as water in the wall dries out. It is usually a harmless, temporary problem, often occurring in spring following wet winter. The main appearance caused by the white staining that is produces. persistent efflorescence may indicate a design or construction fault that allows the brick work to become and to remain saturated.

c) Shrinkage Circles

Formation of cracks in masonry joints bis one form of defects due to shrinkages. the shrinkages of brick create in formation of cracks in masonry joints is one form of defects due to shrinkage. As bricks are porous material it has tendency to absorb water. When it absorbs, water is smells and when water evaporates bricks creates cracks in brick masonry joints. The formation and type of mortar used in brick masonry.

d) Sulphate Attacks

Sulphate attack is a chemical breakdown mechanism where sulphate ions attack components of the cement paste. The compounds responsible for sulphate attack are water soluble. Sulphate containing salts such as alkali earth and alkali sulphate that are capable of concrete.

Sulphate salts present in bricks work react with alumina content of cement. It mainly occurs in boundary walls. This reaction cause increase in the volume of mortar and consequently leads to cracks, chipping and spalling of brickwork

2.7 Supervision of Brick Masonry

i. Before using the brick in construction. it should be checked for its physical properties (such as strength, dimension, water absorption, etc.)

ii. Brick must conform to the designer's specification

iii. Prior to use brick in construction, it should be soaked in water for sufficient time so that the water penetrates the whole depth of brick

iv. After completion of the soaking period, brick should remove from water and allowed to become surface dry, before used in construction

v. Always laid the bricks having its frog facing upw`ards

vi. The mortar should completely cover the bed and sides of the bricks

vii. During laying of bricks on mortar bed, it should be slightly pressed in to the mortar bed to ensure good bonding and uniform joint thickness

viii. All the joints in brick masonry should be so filled with mortar that no cavity is left in between

ix. Brick work construction should be started from its end or edge and it should be carried perfectly in line

x. The brick work should perfectly in level

xi. Check the vertical face of brick work by means of plumb bob and check the inclined surface by means of wooden templates

xii. Brick bond as suggested by the designer should be adopted

xiii. As for as possible try to use less number of bricks bats

xiv. Mortar of required consistency should be used

xv. The amount of mortar per use should be so prepared that it can be used within 30 minutes. Any mortar older than 30 minutes should not be used

xvi. After construction of brick masonry, it should be cured properly for a period of 1-2 weeks

2.8 Supervision of Stone Masonry

i. The stone used in masonry should be durable and strong

ii. All stone should be well watered before laying to avoid absorption of moisture from mortar

iii. All stone should be properly dressed

iv. The stone should be laid on their natural bed so that pressure at normal to their beds

v. The stone from opposite faces should make proper bond with each other

vi. The different sized stone should be placed so that continuity of vertical joint is broken in the structure

viii. Small stone chips should never be used in bed joints

ix. Quoins should be laid as stretcher and header in alternative course

x. Large flat stone used as bed plates should be provided under the end of beam, girders, etc.

xi. The hearting of the masonry should be properly packed with stone chips to avoid hollows

xii. The upper surface of old structure must be cleaned before placing fresh mortar

xiii. The joint on the surface should be raked at least 2.5 cm deep and pointed with reach cement mortar

xiv. After masonry is laid, it should be cured for a period of 2 to 3 weeks

Exercise

Choose the correct answer from the given alternatives.

1. In which bond brick is laid with its length in the direction of a wall?

   a. Header b. Flemish

   c. Stretcher d. English

2. Which of the below should be avoided in brick masonry?

   a. Horizontal joints b. Queen closer

   c. Brick bat d. Vertical joints

3. _____ bond is better in appearance than English bond.

   a. Flemish b. Double Flemish

   c. Single Flemish d. Poly Flemish

4. Which ratio of cement mortar is used for stone masonry?

   a. 1:6 b. 1:3

   c. 1:8 d. 1:4

Write short answer to the following questions.

1. Explain classification of stone masonry.
2. Define block work. What are the uses of block work?

Write long answer to the following questions.

1. Explain defects in brick masonry.
2. Explain with figure types of brick masonry.

Project Work

1. Practice on different bond: Header bond, stretcher bond, Flemish bond, English bond etc.

Unit 3: Concrete Works

3.1 Introduction to Concrete Works

Concrete work is defined as a solid rigid isolated form of mixture of sand, cement, and aggregate with admixture of different properties with water on drying property gain

Hardness to tough as smooth surface in finish work on doing construction work the essential part is concrete work and its uses throughout the civil work.

3.2 Materials Used in Concrete Works, Preparation, Properties and Uses

Components of Concrete Work

Material

i. Cement

ii. Sand

iii. Aggregate- fine and course

iv. Water

v. Admixture

Aggregate

It is the form of small size particles from the stone which is obtained directly from the crushes.

Types of aggregates

Rounded

Irregular

Angular

Rounded

It seems like rounded. If we use rounded aggregate there will be minimum (32-33) % void. It is not suitable for large scale work and high strength.

Irregular

Minimum void (35-38) %. It is not suitable for high strength work.

Angular

Minimum (38-40)%. It is suitable for high strength work due to good bond between the sand, cement and aggregate. Angular aggregate can be obtained from only crushes. So, it is expensive also.

Grading of Aggregate

It is the process of making the aggregate homogeneous of different qualities of aggregate for used in construction work.

Admixture

It is the material other than cement, water, aggregate which is used as ingredient of concrete. Aggregate is added before mixing their types and it is highly modified properties of ordinary cement by chemical reaction admixture the improved strength work ability.

- Air enter trapping agent
- Damp proofing agent
- Grounding agent
- Bonding agent

Water

Water is most essential component in the civil construction which will make the other component wet and make moisture. It also helps to became bonding between them by any through of chemical reaction.

Concrete Preparation

In the concrete work it has cement, sand and aggregate with other components which are prepared for the specific work with required quantity in its proportion.

- While making concrete proportion
- Help to improve the properties of concrete 1:2:4

Where

1. Cement
2. Sand
3. Aggregate

Which is mixed homogeneously by manually or mechanically and it is ready for the concrete work.

Properties of Concrete

1. Hardness

Hardness is rough finishing properties of concrete it caused due to the improper proportion less compaction large shape and size of course aggregate, low water contained and deficiency of sand.

2. Segregation

Separation of component of heterogeneous mixture so that these distribute no longer uniform when the course aggregate settle down the parties from plate. It is caused due to improper gradient water cement ratio (WCR) improper placing and vibration.

3. Bleeding

Bleeding is the phenomena to come out water from the concrete with cement paste of concrete and surface wall coming out water paste. It is also taken out sand and cement particle which caused shrinkage and task occur and also reduce bond among aggregate and reinforcement.

3.3 Formworks: Types (Steel, Timber and Plywood), Importance, Characteristics and Requirements of Formwork

3.3.1 Formworks

A formwork is the temporary structure used to support reinforcement of wet concrete, work man during construction of different types of structure in civil construction of civil work.

Removal of formwork

- Vertical Side
- Beam
- Column

A formal should be removed in such way that concrete is not damaged due to the soft vibration, then wedges are slowly gradually and carefully removed in other ton prevent from other damage. The load should not transfer suddenly to the concrete by removing formwork. In the slab, beam construction stripping a formwork should be done in a following way:

- Side of beam, Slab should be first.
- Under the sides of slab should be street and beam too lastly.
- The normal temperature for stripping the formwork should be 20® cool temperature.
- The stripping time is longer in generally 20 days of casting.
- After removable of formwork concrete work should be repair if it is defective.

3.3.2 Material in Formwork

- Plywood
- Timber
- Wood
- Steel
- Almonium
- Plastic

3.3.3 Requirement in Formwork

- Strength
- Low cost
- Finish
- Formwork true to design
- Proper material

i) Strength

Formwork is a temporary structure but also should be made in such way that carry the load of materials labors and other equipment used in construction.

ii) Low Cost

The formwork should be made in low cost but should be quality.

iii) **Finish**

The formwork should be finished improper way for the betterment of work.

iv) **Formwork True to Design**

Formwork should be designed in true manner that there is no any deflection. It should be in proper shape and size.

v) **Proper Material**

The material used in formwork should be proper specified so that the quality gives well.

3.3.3.1Characteristics of Formwork

1. It must be strong enough to carry weight of concrete
2. It should resist and carrying the load by workers
3. It should be strong enough to withstand to load coming on it such as, dead load of concrete, live load during and after casting of concrete
4. It should be strife enough to so that the deflection compacted by tamping or vibrating
5. It should have tight enough between adjacent sexual to prevent escape of liquid concrete
6. The formwork should be constructed in such a manner that it may permits the removal of various part in design sequent without damaging the concrete the material of formwork should be easily available and should be suitable for reused several time
7. The surface of formwork should be smooth and it should be easily stripping
8. The material of formwork should not be unripe when exposed to sun, rain or water during construction

3.3.3.2Construction of Formwork (technique of formwork)

a) Propping and centering

b) Shuttering

c) Provision of camber

d) Cleaning and surface treatment

a) **Propping and Centering**

Props used for centering may be steel or timber, bamboo, pillar made up of brick masonry with mortar are also used as crops. If wood post are used then it's base should be rest on square wood plate lead of ground. The plate should be at least of 0.1-meter square and 40mm thick with double way wedge are provided between the plate and the timber crops to permit the accurate adjustment of shuttering and to allow easily removable.

b) **Shuttering**

Shuttering are either timber planks plywood fixed to the timber frame and shuttering should be continuous so that the joint should be tight enough to prevent from the lockage of cement mortar. Shuttering is done on slab, beam, column as per required. Similarly, the opening for other fittings should be provided as per detail drawing.

Figure 27 : Props and shuttering

c) Provision of camber

The certain amount of deflection in the structure is not available. So, it is required to give upward and camber in the horizontal member of concrete the structure usually in the long span while fixing the formwork provisional camber at the rate of 4mm per meter per span. In the cantilever the camber at the free and should be normally taken as 7/5 of the projection of cantilever.

d) Cleaning the surface treatment

The surface of formwork should be clean and it should be had smooth surface.

3.4 Reinforcement, Importance, Placement and Concreting

Reinforcement

Reinforcement in construction refers to the addition of materials, typically steel bars or mesh, within a structure to enhance its strength, durability, and load-bearing

capacity. This crucial component plays a pivotal role in ensuring that buildings and infrastructure can withstand various forces and maintain their structural integrity over time. The primary purpose of reinforcement is to address the inherent weaknesses of concrete, especially its limited tensile strength and susceptibility to cracking.

3.4.1 Key Aspects of Reinforcement in Construction

Tensile Strength Enhancement:

Concrete is excellent in compression but relatively weak in tension. Reinforcement, commonly in the form of steel bars or mesh is strategically placed within the concrete to counteract tensile forces.

As the concrete undergoes loading or experiences external forces, the reinforcement absorbs tension, preventing cracks and failure.

Prevention of Cracking

Cracks in concrete can compromise the structural integrity of a building. By incorporating reinforcement, the formation and propagation of cracks are minimized, ensuring that the structure remains stable and durable.

Reinforcement acts as a barrier to crack propagation, distributing and absorbing forces that would otherwise cause the concrete to fail.

Improving Flexural Strength

Flexural strength is essential for structures subjected to bending or flexing forces, such as beams and slabs. Reinforcement enhances the flexural strength of concrete elements, allowing them to withstand bending without experiencing significant deformation or failure.

Load-Bearing Capacity

Reinforced concrete structures exhibit increased load-bearing capacity compared to non-reinforced counterparts. The combination of concrete's compressive strength and reinforcement's tensile strength allows for the construction of more robust and resilient buildings.

Long-Term Durability

Reinforcement contributes to the long-term durability of structures by minimizing the effects of environmental factors, such as weathering and corrosion. Properly

placed and well-protected reinforcement ensures that a structure can withstand the test of time.

Structural Stability

The strategic placement of reinforcement provides structural stability, particularly in areas prone to seismic activity or other dynamic forces. Reinforced structures can better absorb and dissipate energy, reducing the risk of collapse during extreme events.

3.4.2 Properties of Reinforcement

The properties of reinforcement, often in the form of steel bars or mesh play a crucial role in determining the effectiveness of the material in enhancing the strength and durability of concrete structures. Here are some key properties of reinforcement:

Tensile Strength

One of the primary properties of reinforcement is its high tensile strength. This allows the material to resist pulling or stretching forces, addressing the inherent weakness of concrete in tension.

Ductility

Reinforcement should exhibit ductility, the ability to deform without fracturing, especially in areas where structures may experience significant deformation during events like earthquakes. Ductility ensures that the reinforcement can absorb energy and undergo controlled deformation without sudden failure.

Bond Strength

The bond between the reinforcement and the surrounding concrete is crucial for effective load transfer. Good bond strength ensures that the forces acting on the structure are efficiently transmitted between the concrete and the reinforcement, enhancing the overall stability of the structure.

Corrosion Resistance

Reinforcement materials must possess resistance to corrosion, as exposure to environmental elements, moisture, and aggressive chemicals can lead to rusting. Corrosion-resistant reinforcement ensures the long-term durability of structures.

Yield Strength

Yield strength is the amount of stress at which the material undergoes permanent deformation. Reinforcement with high yield strength is desirable, as it allows the material to withstand significant loads without undergoing excessive deformation.

Modulus of Elasticity

The modulus of elasticity defines the stiffness of the material. A higher modulus of elasticity in reinforcement helps maintain the structural integrity of a concrete element under various loading conditions.

3.4.3 Coefficient of Thermal Expansion

The coefficient of thermal expansion is important to consider, especially in regions with extreme temperature variations. Reinforcement with a coefficient of thermal expansion close to that of concrete helps prevent issues like thermal cracking.

Fatigue Resistance

Structures often experience repeated loading and unloading cycles over their lifespan. Reinforcement with good fatigue resistance can withstand these cyclic loads without suffering from structural fatigue, ensuring long-term durability.

Weldability

In cases where on-site fabrication or connection of reinforcement is required, the material should possess good weldability. This facilitates the construction process and ensures the integrity of the structure.

Dimensional Stability

Dimensional stability is important to maintain the shape and alignment of the reinforcement during the construction process. This property ensures that the reinforcement can be accurately placed and secured within the concrete.

3.4.4 Placement of Reinforcement

The proper placement of reinforcement is a critical aspect of constructing durable and structurally sound concrete elements. Correct placement ensures that the reinforcement effectively reinforces the concrete, providing the necessary strength and integrity. Here's a guide to the placement of reinforcement:

1. **Structural Design and Planning**

   Begin with a thorough structural design that specifies the type, size, and layout of reinforcement based on the intended use and loading conditions of the structure.

   Plan the arrangement of reinforcement bars or mesh to accommodate the expected forces, considering factors such as tension, compression, and shear.

2. **Clear Cover**

   Maintain a clear cover, which is the distance between the surface of the reinforcement and the outer surface of the concrete. This cover protects the reinforcement from environmental factors and corrosion.

   Follow the specifications provided in the structural design to ensure the appropriate clear cover for different structural elements.

3. **Proper Spacing**

   Adhere to the specified spacing between reinforcement bars or mesh. Proper spacing ensures that the concrete adequately surrounds and engages with the reinforcement, allowing for effective load transfer.

   Incorrect spacing can lead to reduced structural performance and compromise the strength of the concrete.

4. **Reinforcement Lapping**

   In cases where the length of reinforcement is insufficient, provide lap splices by overlapping bars according to engineering specifications. This ensures the continuity of reinforcement along the length of the structure.

   Follow design guidelines to determine the appropriate lap length and location.

5. **Securing Reinforcement**

   Secure the reinforcement in place using ties, chairs, or other appropriate support devices. This ensures that the reinforcement maintains its position during the concrete placement process.

   Avoid displacement or movement of reinforcement during concrete pouring to prevent structural weaknesses.

6. **Vertical and Horizontal Placement**

   For vertical elements like columns and walls, ensure proper alignment and

secure vertical reinforcement in place using spacers and ties.

In horizontal elements like slabs and beams, maintain the correct position and spacing of reinforcement to distribute loads evenly.

7. Structural Joints

Pay special attention to reinforcement placement at joints, where structural elements connect. Properly reinforce joints to ensure continuity of load transfer and to prevent cracking or failure at these critical points.

8. Curvature and Bending

In curved or bent structural elements, take care to properly bend and shape the reinforcement according to design specifications. Incorrect bending can result in stress concentrations and reduced structural performance.

9. Inspection and Quality Control

Regularly inspect the placement of reinforcement during the construction process to verify compliance with design requirements.

Implement quality control measures to address any discrepancies or issues in the placement of reinforcement promptly.

10. Collaboration and Communication

Foster effective communication between the design team, construction team, and any relevant stakeholders to ensure that everyone is aligned with the reinforcement placement plan.

Address any questions or concerns promptly to avoid misunderstandings that could impact the structural integrity of the concrete elements.

By adhering to these guidelines, construction professionals can ensure that the reinforcement is correctly placed, providing the necessary support and strength to the concrete structure. Proper placement is essential for achieving the designed structural performance and ensuring the longevity of the constructed elements.

3.4.5 Concreting

Concreting is a fundamental and critical phase in the construction process, involving the placement, compacting, and finishing of concrete to create structural elements for buildings, bridges, roads, and various other infrastructure projects. This phase

demands careful planning, precision, and adherence to specific procedures to ensure the quality and durability of the concrete structure. Here is an overview of the key aspects of concreting:

1. **Concrete Mix Design**

   Before concreting begins, a carefully proportioned mix of concrete ingredients must be determined. This mix typically includes cement, aggregates (such as sand and gravel), water, and sometimes admixtures. The concrete mix design is crucial in achieving the desired strength, workability, and durability of the concrete.

2. **Formwork Preparation**

   Formwork, or molds, is constructed to shape the concrete into the desired structure. The formwork must be carefully designed and properly supported to withstand the weight and pressure of the fresh concrete.

   The formwork also defines the final shape and dimensions of the concrete element.

3. **Placement of Concrete**

   Concrete is transported to the construction site and poured into the prepared formwork. The placement process must be done with precision to avoid segregation and achieve uniform distribution of the concrete within the formwork.

   Special attention should be given to avoid trapping air pockets, which can weaken the concrete.

4. **Compaction**

   Once the concrete is placed, it needs to be compacted to eliminate voids and ensure maximum density. This is typically done using vibrators that are inserted into the concrete to remove air bubbles and enhance the bond between the aggregates.

   Proper compaction contributes to the strength and durability of the concrete.

5. **Finishing**

   Finishing involves the manipulation of the concrete's surface to achieve the desired appearance and texture. This can include smoothing, leveling, and

creating specific surface finishes.

Finishing may be done with hand tools or power tools, depending on the scale and requirements of the project.

6. Curing

Curing is a critical step that involves maintaining adequate moisture and temperature conditions to allow the concrete to gain strength and durability. Proper curing is essential to prevent cracking and ensure long-term structural integrity.

Common curing methods include covering the concrete with wet burlap, applying curing compounds, or using water curing.

7. Jointing

Construction joints and expansion joints are strategically placed to control cracking and allow for movement in the structure. These joints are typically formed during the finishing process.

Jointing helps accommodate temperature-related expansion and contraction and prevents uncontrolled cracking.

8. Quality Control

Throughout the concreting process, quality control measures are implemented to ensure that the concrete meets the specified standards. This includes testing the concrete's consistency, strength, and other relevant properties.

9. Health and Safety

Concreting involves the use of heavy machinery, exposure to concrete dust, and potential hazards during the pouring and finishing stages. Therefore, strict adherence to safety protocols, including the use of personal protective equipment, is crucial to prevent accidents and ensure the well-being of construction workers.

10. Post-Construction Inspection

After the concrete has cured and reached its specified strength, a thorough inspection is conducted to ensure that the finished structure meets design requirements and quality standards.

Any necessary repairs or adjustments are made during this stage to address

any defects or issues.

Concreting is a complex process that requires a combination of technical expertise, precision, and attention to detail. When executed with care and adherence to industry best practices, concreting results in durable and resilient structures that can stand the test of time.

Conclusion and Application

The successful integration of reinforcement, proper placement, and meticulous concreting is paramount to the construction of durable, safe, and resilient structures. Each phase in this process contributes significantly to the overall strength and longevity of a building or infrastructure. As we conclude our exploration of these elements, it's evident that a holistic understanding and precise execution are essential for achieving optimal results.

Reinforcement's Impact

The incorporation of reinforcement materials, such as steel bars or mesh, enhances the tensile strength of concrete, addressing its inherent weakness in tension.

Properly selected and placed reinforcement significantly contributes to the structural stability, load-bearing capacity, and overall resilience of constructed elements.

Placement's Significance

The meticulous placement of reinforcement is a crucial step in the construction process.

Correct spacing, lapping, and securing of reinforcement ensure that it functions as intended, providing effective support and preventing structural weaknesses.

Strategic placement is vital for the structural performance and long-term durability of concrete elements.

Concreting's Role

Concreting represents the culmination of the design and planning phases, bringing the structural vision to reality.

The concrete mix design, formwork preparation, precise placement, compaction, finishing, curing, and quality control collectively determine the quality and strength of the final structure.

Concreting is not only a construction process but also an art that requires attention to detail and adherence to established standards.

Application in Real-World Scenarios

Infrastructure Projects

In the construction of bridges, highways, and other infrastructure, reinforcement ensures the structures can withstand dynamic loads and environmental stresses.

Proper placement and concreting techniques are critical for ensuring the longevity and safety of these large-scale projects.

Residential Construction

In residential buildings, reinforcement provides the necessary strength to support the structure and resist potential seismic forces.

Correct placement and concreting techniques are essential for creating stable foundations, walls, and floors.

Commercial Structures

Large commercial buildings often require intricate reinforcement designs to support the varied loads and ensure the safety of occupants.

Precise placement and high-quality concreting are crucial for meeting stringent structural requirements.

Safety and Longevity

The application of these principles directly impacts the safety and longevity of structures.

Properly reinforced, well-placed, and well-constructed elements are more resistant to wear, environmental factors, and potential hazards, ensuring the safety of occupants and minimizing maintenance requirements.

Innovation and Sustainability

Ongoing research and technological advancements contribute to the evolution of reinforcement materials, placement methods, and concreting techniques.

Innovations in these areas support the construction of sustainable, eco-friendly structures with reduced environmental impact.

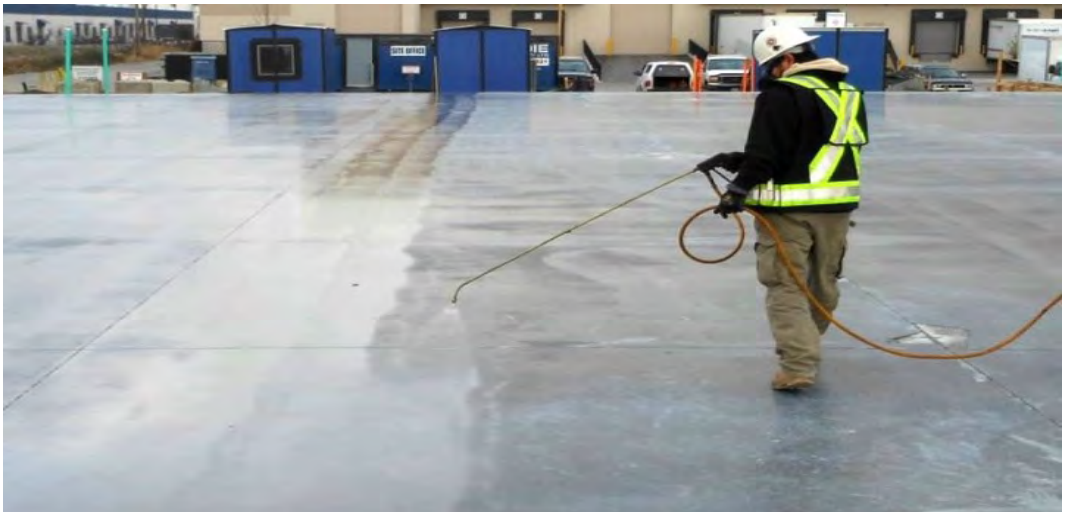
In essence, the successful application of reinforcement, proper placement, and meticulous concreting is the backbone of the construction industry with evolving technologies and growing demand for sustainable structures increases, integrating these principles will be

instrumental in shaping the future of construction practices. By emphasizing precision, safety, and adherence to best practices, construction professionals can contribute to the creation of structures that not only stand tall but also withstand the test of time.

3.5 Compaction and Curing of Concrete

Compaction

It is the process of making concrete work in each definite shape and size and removing air from after placement of concrete in a formwork doing remaining, tamping or vibrating to made homogeneous ratio in a concrete work.



Curing

It is the process of gaining strength to the concrete by providing water for the chemical reaction between cement, sand and concrete to make hydrate to the concrete.

Types of Curing

- Steam curing

- Chemical curing

- Water curing

- Ponding

- Cover with weight sack

- Sprinkle of water

3.6 Factor Affecting Strength of Concrete

Factor Affecting Strength of Concrete

Concrete strength is affected by many factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete.

Quality of Raw Materials

1. **Cement:** Provided the cement conforms with the appropriate standard and it has been stored correctly (i.e. in dry conditions), it should be suitable for using in concrete.
2. **Aggregates:** Quality of aggregates, its size, shape, texture, strength etc. determines the strength of concrete. The presence of salts (chlorides and sulphates), silt and clay also reduce the strength of concrete.
3. **Water:** Frequently the quality of the water is covered by a clause stating "The water should be fit for drinking.". This criterion though is not absolute and reference should be made to respective codes for testing of water construction purpose.

Water/Cement Ratio

The relation between water cement ratio and strength of concrete is shown in the plot as shown below:

1. The higher the water/cement ratio, the greater the initial spacing between the

cement grains and the greater the volume of residual voids not filled by hydration products.

2. There is one thing missing on the graph. For given cement content, the workability of the concrete is reduced if the water/cement ratio is reduced. A lower water cement ratio means less water, or more cement and lower workability.

However, if the workability becomes too low the concrete becomes difficult to compact and the strength reduces. For a given set of materials and environment conditions, the strength at any age depends only on the water-cement ratio, providing full compaction can be achieved.

Coarse/Fine Aggregate Ratio

Following points should be noted for coarse/fine aggregate ratio:

- If the proportion of fines is increased in relation to the coarse aggregate, the overall aggregate surface area will increase.
- If the surface area of the aggregate has increased, the water demand will also increase.
- Assuming the water demand increases, the water cement ratio will increase.
- Since the water cement ratio has increased, the compressive strength will decrease.

Aggregate/Cement Ratio

Following points must be noted for aggregate cement ratio:

- If the volume remains the same and the proportion of cement in relation to that of sand is increased the surface area of the solid will increase.
- If the surface area of the solid has increased, the water demand will stay the same for the constant workability.
- Assuming an increase in cement content for no increase in water demand, the water cement ratio will decrease.
- If the water cement ratio reduces, the strength of the concrete will increase.

Age of Concrete

The degree of hydration is synonymous with the age of concrete provided the concrete has not been allowed to dry out or the temperature is too low.

In theory, provided the concrete is not allowed to dry out, it will always be increasing albeit

at an ever-reducing rate. For convenience and for most practical applications, it is generally accepted that the majority of the strength has been achieved by 28 days.

Compaction of Concrete

Any entrapped air resulting from inadequate compaction of the plastic concrete will lead to a reduction in strength. If there was 10% trapped air in the concrete, the strength will fall down in the range of 30 to 40%.

Temperature

The rate of hydration reaction is temperature-dependent. If the temperature increases the reaction also increases. This means that the concrete kept at a higher temperature will gain strength more quickly than concrete kept at a lower temperature.

However, the final strength of the concrete kept at the higher temperature will be lower. This is because the physical form of the hardened cement paste is poorly-structured and more porous when hydration proceeds at faster rate.

Relative Humidity

If the concrete is allowed to dry out, the hydration reaction will stop. The hydration reaction cannot proceed without moisture. The three curves show the strength development of similar concretes exposed to different conditions.

Curing

It should be clear from what has been said above that the detrimental effects of storage of concrete in a dry environment can be reduced if the concrete is adequately cured to prevent excessive moisture loss.

Exercises

Choose the correct answer from the given alternatives.

1. What is concrete?
   a. A mixture of homogenous materials
   b. A mixture of material and hydrogen
   c. A mixture of cement and hydrogen sulphide
   d. A mixture of cement, water, and aggregates

2. Why concrete technology is needed?
   a. Concrete technology is needed to build a building
   b. Concrete technology is needed to address properties of concrete
   c. Concrete technology is needed to produce building materials
   d. None of the mentioned

3. Which type of concrete is classified based on the design of concrete?
   a. Plain
   b. Reinforced
   c. Prestressed
   d. All of the above

4. What are the ingredients of concrete?
   a. Binding material
   b. Fine aggregate
   c. Admixtures
   d. All of the above

5. Which of the following ratio is also known as water-cement ratio?
   a. Weight of water to the weight of aggregates
   b. Density of cement to the Density of cement
   c. Weight of water to the weight of cement
   d. Volume of cement to the volume of cement

6. The form work is usually removed after _____ for walls, columns, and the vertical faces of all structural components.
   a. 24 to 48 hours
   b. 72 hours
   c. 56 hours
   d. 24 hours

7. Water cement ratio is _____

   a. Volume of water to the volume of cement

   b. Volume of water to the volume of concrete

   c. Volume of concrete to the volume of cement

   d. Volume of water to the volume of aggregates

8. The _____ formwork is used for formwork when it is desired to reuse the formwork several times.

   a. Wooden b. Timber

   c. Steel d. Custom

Write short answer to the following questions.

1. Describe the concept of concrete work.
2. Define aggregate, sand, cement with their properties and uses.
3. Explain the types of formworks.
4. What is reinforcement? Write down its importance in construction technology.
5. Define compaction and curing of concrete.
6. Write down the steps of removal of formworks.

Write long answer to the following questions.

1. What are the materials used in concreting works? Write its preparation process.
2. Explain about the concrete works. Write the properties and uses of concrete work.
3. What are the types of formworks, write the importance of formworks?
4. What are the characteristics of formworks? Write and explain the requirements of formworks.
5. Explain the detail process of bar bending, placement and concreting on the basis of practical knowledge.
6. Define compaction and curing. Write the process of compaction and curing.

Project Work

1. Demonstration of Materials, tools and equipment's of concrete with explanation in classroom/laboratory in group of 4-5 students.

2. Demonstration of materials and tools for formworks and reinforcements with explanation in classroom/laboratory in group of 4-5 students.
3. Cutting and bending of reinforcement in lab.
4. Concrete preparation and mixing in lab.
5. Performing the slump test of prepared concrete mix (field test)
6. Placing of concrete (compaction and curing).

Unit 4 : Finishing Works

4.1 Introduction to Flooring Work

* The exposed top surface of the floor is termed as flooring or floor covering. The purpose of flooring is to provide a neat, clean and pleasing appearance.
* Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering.
* Floor covering is term to generically describe any finish material applied over a floor structure to provide a walking surface.

4.2 Floor

Floor are the horizontal element of building structure which divide the building into different level for the purpose of creating more accommodation. Within a restricted space one above the other and provides support for the furniture equipment etc for the building.

✓ Types of floor

- Basement of floor
- Ground floor
- Upper floor

✓ Basement of floor

A floor when provided for the accommodation below the natural ground level is termed as basement floor.

✓ Ground floor

The floor of building immediately above the ground is known as floor. In case part of the building has basement, the floor is termed as basement floor.

✓ Types of ground floor

- Solid ground floor

In this floor there is no gap between ground level and plinth level completely filled with solid material.

- Suspended ground floor

  Suspended ground floor is a timber floor that is not touching the ground level and it is suspended above the ground. In this floor a certain air gap between the ground level and the plinth level is maintained

✓ Upper floor

The floor which are situated above the ground level is known as upper floor.

4.3 Characteristics of Good Floor Finished

* How maintenance cost
* It should be durable
* It should be easy to clean
* Fire resistance
* Noiseless
* Have a good appearance

4.4 Special Type of Floor Finish

- Mud flooring
- Muram flooring
- Bricks flooring
- Flog stone flooring
- Cement concrete flooring
- Terrazzo flooring
- Mosaic flooring
- Marble flooring
- Timber or wood flooring
- Glass flooring
- Tiles flooring
- Asphalt flooring
- Mud flooring
  * This type of flooring is used only low-cost housing especially in rural areas
  * Cheap, hard, fairly impervious, easy to construct and maintain

- Good thermal insulating property due to which it retains cool in summer and fairly warm in winter
- To prevent a crack due to drying small quantity of chopped straw is mixed in moist earth 25 cm thick selected moist earth spread and is the rammer well to get compacted thickness of 15cm

- Muram flooring
  - Any disintegrated rock is called muram
  - Muram floors constructed in village in India and Nepal and have the same advantageous as that of mud flooring
  - Flooring has practically same properties as that of mud flooring
  - 15 cm thick layer of muram is laid over prepared sub grade, over it 2.5 cm thick layer of muram powder is spread and water is sprinkled and the rammed well

- Brick flooring
  - This type of flooring is commonly provided in warehouse stored go downs or in place where heavy particle or instrument are stored
  - At first sub-grade is compacted well over this 10 to 15 cm thick PPC
  - Brick are laid on 1mm thick bed of mortar
  - All the joint of brick are filled with mortar and finished
  - The work is then property cured
  - Well burnt brick of good color and uniform shape are used

- Flag stone flooring
  - Any laminated sand stone available in uniform thickness is known as flag stone
  - Any laminated sand stone available in 2 to 4 cm thickness in the form of stones slab of square (30 by 30) cm^2 (45*45) cm^2or (60*60) cm^2
  - Also called paving and laid concrete base
  - 10 to 15 cm thick PCC is laid over (20 to 25) mm Thick layer of bed mortar.

- Cement concrete flooring
  - Commonly used for residential, commercial, industrial building, etc.

- Cheap, durable, and easy to construct and maintain
- Floor consist two components: base concrete, wearing surface (Topping)

✓ Base concrete

Base course may be 7.5 to 10 cm thick either in plain cement concrete (1:5:6 to 1:5:10) or lime sand (or lime 1:1 surkhi:10) of coarse aggregate of 40 mm nominal size.

✓ Wearing Concrete

- Terrazzo flooring
  - On account of its decorative and good wearing properties, this type of flooring is become very popular these days and is being commonly provided in offices, school, hospital, residential building, bank etc.
  - This is a composite material made up of cement and marble chips
  - It is then mixed and poured in-situ into a concrete base
  - The chips are exposed by grinding the surface is then cleaned and wax police is applied to get final shiny surface
  - It is very useful in commercial situation, i.e. malls and shopping centre, etc.
  - It is very durable and easy to maintain
- Mosaic flooring
  - Made of small pieces of broken tiles of china glazed or marble or cement arranged in different patterns.
  - On a concrete base 5 to 8 cm thick cement sand mortar is spread and level. then 3mm thick cementing material in the form of paste of two parts of cement one part of powdered marble and one part of pozzolana materials spread and left to dry for about 4 hrs.
  - Then small pieces of broken tiles or marble pieces of different colors are arranged in definite patterns and hammered in to cementing layer
  - This is superior type of flooring used in bathroom and kitchens of residential, building in hospital, etc.
  - They are long lasting and durable
- Marble flooring
  - It comes in a numerous color such as white, grey, green

- Superior type of flooring used in bathroom, kitchen, etc.
- Marble slab may be laid in different size
- Concrete base is prepared in same manner as that for concrete flooring
- 20mm thick mortar of (1:4 cement sand) is spread under the area of each individual slab and laid over the base concrete by pressed with wooden hammer or mallet and level

- Timber Flooring

  Timber flooring is used for dancing hall, auditoriums, sitting room etc One of the main problems of timber flooring is dampness.

- Glass Flooring
  - Very costly and not commonly used in Nepal
  - Special purpose of flooring used where it is designed transmit light from upper floor to lower floor
  - Available in the form of tile and slab in varying thickness of 12 to 30mm

- Tile flooring
  - The flooring made for square, hexagonal or other shapes, made of clay, cement concrete or terrazzo, is called tile flooring
  - These are available in different size and thickness
  - These are commonly used in residential houses, offices, schools, hospitals, and other public building, as an alternative to terrazzo flooring

- Asphalt Flooring
  - This flooring is not favoured because of bad smell and ugly color of the asphalt.
  - But at present asphalt flooring can be carried out in a variety of a color and in different forms.
  - The asphalt flooring is recommended for swimming pools, because it is non-slippery and water proof.

Exercise

Choose the correct answer from the given alternatives.

1. The first step in flooring is.....

   a. Topping
   b. Base coat
   c. Sand filling
   d. R.C.C. layer

2. Which of the following is not an advantage of brick flooring?

   a. Waterproof
   b. Cost-effective
   c. Slip-resistant
   d. Fireproof
   e. None of these

Write short answer to the following questions.

1. Explain about types of building finishes?
2. Write any four example of finishing work.

Write long answer to the following questions.

1. What are the importance of building finishes?

Project Work

1. Demo of finished material and different practice: plastering and painting on wall

Unit 5 : Carpentry

5.1 Introduction to Carpenter

Carpentry is a term applied to that form of wood construction which has to resist stresses due to loads coming on it. Carpenter constructs structural timber works, such as roofs, floors, scaffolding, shoring, etc. Carpentry and joinery are treated as a single trade. The wood carpentry is used to indicate both carpentry and joinery, and the workman who handles the work of carpentry and joinery is called a Carpenter.

5.1.1 Importance of Carpenter

Carpenters construct, erect, install and repair structures made from wood and other materials. Carpenters are involved in many different kinds of constructions from the building, highways and bridges to the installation of kitchen cabinets. Carpenters perform many tasks that are important in overall building construction process which include timber and plywood. Making precise measurement, for example, reduce gap between windows and frames, limiting any leaks around the windows. Carpenters use varies tools and require good hand-eye coordination to avoid injury. Carpenters provide vital construction services for many types of construction project and remodeling projects.

5.1.2 The Following are Duties and Responsibilities of Carpenter

The duties and responsibilities of a carpenter:

- Ability to effectively communicate, both in person and over the phone when dealing with management, employees and guest.
- Stain-grade, trim work, hang doors, drill and set door hardware, set windows, layout for stairs and common rafters, etc.
- Read blueprints, mathematical and analytical skills are necessary to do materials estimates.
- Maintains general mathematical skills such as additions, subtraction, multiplication and division.
- Ability to work with carpentry tools and materials.
- Should be able to lift and manipulate objects of up to 36 KG when required.

- Always keep the work area clean and well organized.
- Possesses extensive knowledge of the carpentry trade as well as repair and maintenance of the property.
- Operates various types of wood working machines and electrical hand tools.
- Able to work under pressure and meet deadlines set for each task.
- Design, cuts, build and assemble wooden parts or furniture as requested.
- Assemble and set prefabricated pieces.

5.1.3 Scope of Carpenter

While the scope of the carpenter trade includes many aspects of building constructions, growing numbers of carpenters work primarily in one area of specialization within the trade, such as concrete forming, ramming, finishing, interior systems and scaffolding.

The bureau of labor statistics projects 20% job growth for carpenters from 2010-2020, driven by population growth and the need for infrastructure maintenance. This rate is 6% points higher than the average for all occupational groups. The majority of this job will rely on home renovation and government infrastructure needs. Compared with other constructions specialties, carpenters have a greater number of opportunities available to them because they are utilizing in every phase of a project.

5.2 Different Woodworking Professions (Furniture Maker/ Wood carver/Construction Carpenter)

5.2.1 Furniture Maker

A person who specializes in making furniture. It is also known as cabinet maker.

- **Wood Carver**

A person who carves wood professionally is known as wood carver and the form of wood working by means of a cutting tool (knife) in one hand or a chisel by two hands or with one hand on a chisel and one hand on a mallet, resulting in a wooden figure into ornamentation of a wooden object is known as wood carving.

- **Shuttering Carpenter**

A shuttering carpenter is a professional who specialize in creating formworks or shuttering in which temporary structures are used in concrete pouring process. Shuttering refers to a wooden boards or metal plates that are positioned and supported

by using rods and stakes known as false works. Once these boards or plates are in place, concrete can be poured within the created moulds.

- **Joiner**

It is an artisan who builds things by joining pieces of wood, particularly lighter and more ornamental work those done by carpenter, including furniture and the fitting of a house, ship, etc. Joiners may work in a workshop, because the formation of various joints is made easier by the use of non-portable, powder machinery, or on job site. A joiner usually produces items such as interior and exterior doors, windows, stairs, tables, bookshelves, furniture, etc.

- **Construction Carpenter**

Construction carpenters work with their hands, know how to use both hand and power tools, and have good mathematics skills. They apply their expertise to projects such as constructing house frame, applying aluminum siding, installing roofs, or putting in windows and doors for commercials or residential projects. Typically, they work for construction companies, but some are self-employed.

5.3 Various Types of Hand/Power Driven Tools/Equipment Required to Carpenter

5.3.1 Various Types of Hand Tools and Equipment

a. Hand saws
b. Hammers
c. Screwdrivers
d. Chisels
e. Planes
f. Hand drills
g. Levels
h. Squares
i. Measuring tools (tape measure, ruler, etc.)
j. Marking tools (carpenter's pencil, chalk line, etc.)
k. Clamps
l. Files
m. Mallets

a. **Hand Saws**

A hand saw is a carpentry tool with a blade featuring sharp teeth for cutting wood. Securely clamp or support the wood before cutting to prevent movement. Hold the saw firmly with one hand on the handle and the other supporting the blade near the cutting line. Use long, smooth strokes, angling the saw slightly to the waste side of the cutting line to avoid binding. Carefully remove the saw from the wood after cutting, and maintain it regularly for optimal performance.

b. **Hammers**

Hammers are tools with a heavy head and a handle used for hitting things. To use a hammer, hold it with one hand and hit the nail or object with the other. Make sure to aim straight and hit with enough force to do the job but not too hard. If you need to remove a nail, use the back part of the hammer called the claw to pull it out. Always pick the right size hammer for the job so it's easier to use.

c. **Screwdrivers**

Screwdrivers are handy tools used for driving screws into materials like wood or metal. They have a handle and a tip that fits into the head of the screw. To use a screwdriver, choose one with a tip that matches the screw head. Hold the handle firmly and place the tip into the screw head, applying pressure while turning clockwise to tighten or counterclockwise to loosen. Make sure to keep the screwdriver straight to prevent slipping and damaging the screw or surrounding surface.

d. Chisels

Chisels are tools with a sharp metal blade used for cutting and shaping wood or metal. They have a handle for gripping and controlling the tool. To use a chisel, hold it firmly with one hand and place the blade against the material you want to cut. Use a mallet or hammer to gently tap the end of the chisel, gradually increasing pressure until the desired depth or shape is achieved. Always work slowly and carefully to avoid damaging the material or injuring yourself.

e. **Planes**

Planes are carpentry tools designed to smoothen and flatten wood surfaces. They consist of a sharp blade set in a flat base with a handle for control. To use a plane, hold it firmly with both hands, placing one hand on the handle and the other on the front knob. Adjust the blade depth to remove thin shavings from the wood surface, moving the plane in a forward motion along the grain. Apply even pressure and keep the plane flat to achieve a smooth finish, adjusting as needed to maintain consistency.

f. **Hand Drills**

Hand drills are manual tools used for drilling holes in wood, metal, or other materials. Hold the drill firmly with one hand on the handle and the other on the crank or chuck. Place the drill bit against the material and turn the crank clockwise to rotate

the bit and bore into the material. Apply gentle and consistent pressure to ensure a smooth and precise hole. Adjust the speed and pressure according to the material being drilled for optimal results.

g. **Levels**

Levels are tools used to ensure surfaces are straight and even. Simply place the level on the surface you want to check, making sure it rests evenly. Look at the bubble in the vial - if it's centered between the two lines, the surface is level. Adjust the surface until the bubble is centered for accurate leveling. Levels are essential for tasks like hanging shelves, installing cabinets, or laying floors to ensure everything is straight and balanced.

h. **Squares**

Squares are essential tools for ensuring accurate right angles in carpentry and other tasks. To use a square, place it against the edge of the material you're working with. Make sure it sits flush against the edge. Then, use a pencil or other marking tool to trace along the side of the square, creating a precise line. Squares help maintain symmetry and precision in woodworking projects, ensuring each corner is perfectly

square for a professional finish.

i. **Measuring Tools**

Measuring tools like tape measures and rulers are indispensable for accurately determining lengths and dimensions in various projects. To use a tape measure, extend the tape along the surface you want to measure, ensuring it lays flat without bending. Read the measurement where the end of the tape meets the surface. For rulers, place one end flush against the starting point and read the measurement where the other end stops. These tools help ensure precise cuts, placements, and alignments, contributing to the success and quality of your project.

j. **Marking Tools**

Marking tools like carpenter's pencils and chalk lines are essential for accurately marking measurements and lines on various materials. To use a carpenter's pencil, hold it firmly and make clear, visible marks on the material according to your measurements or layout. For chalk lines, stretch the line taut across the material and snap it against the surface to leave a temporary chalk mark. These tools aid in ensuring precise cuts, alignments, and placements, guiding your work with clarity and accuracy.

k. **Clamps**

Clamps are indispensable tools in carpentry, used to securely hold materials together during glue-ups, assembly, or when working on intricate details. To use a clamp, position it over the materials you want to join, ensuring they are aligned properly. Tighten the clamp's screw or lever mechanism until it holds the materials firmly in place without damaging them. Clamps come in various sizes and types, including C-clamps, bar clamps, and spring clamps, providing versatile solutions for different project needs. With their ability to provide stability and support, clamps facilitate precise and efficient woodworking, ensuring professional results.

5.3.2 Various Types of Powered Tool/Equipment for Carpenter

a. Table saw

b. Circular saw

c. Compound miter saw

d. Wood router

e. Power scroll saw

f. Power drill

g. Jigsaw

h. Drill press

i. Power jointer

j. Random orbital sander

a. Table Saw

While the other wood power tools here have been more portable, a table saw is going to be your first big purchase. Woodworking is never complete without a table saw as it serves as the focus of many tasks ahead. It's big, so you definitely have to consider the space in your home or workshop.

A table saw can deal with cutting various sizes of wood with efficiency and accuracy because of how stable it is. If you're planning to buy a table saw, you should look at the features that it has and it fits well within your budget.

b. Circular Saw

Some people may think that a circular saw is more suited for carpentry then delicate woodworking, I beg to disagree. Among wood power tools, a circular saw's cutting versatility can't be replaced. Its blades are strong enough to cut through materials like plywood and fiberglass.

It's also a good alternative over buying a table saw if you don't have space at home or if you're on a budget. A circular saw should be the first wood power tool that you buy since it will be useful right off the bat. Check out safety tips on circular saws and other power tools here: do it yourself.

c. Compound Miter Saw

A compound miter saw is another big power tool purchased when it comes to woodwork. It's a wood power tool used to make compound-angled cuts that serve as the ends of wood. Compared to the basic power saws, the compound miter saw is powerful enough to cut through most materials with ease.

With its accuracy, it also serves as a training tool for using a circular hand saw. Consider your budget in looking for a compound miter saw as some companies put up lower prices but separate features that should be built-in already.

d. Wood Router

A wood router is regarded as the most versatile wood power tool in the world. You can do a lot such as cutting grooves on wood, making decorative finishes, trim wood flat, cut inlays, drill clean holes, and shape wood to a variety of forms. There are two types of wood router – a fixed-base router and a plunge-base router.

A fixed-base router is less expensive than a plunge-base, but if you're planning on making plunge cuts, you better invest in a plunge wood router instead.

e. Power Scroll Saw

In terms of getting the finest cuts on wood, there's nothing better than a power scroll saw. This is used for putting more intricate details on woodwork that serve as design. It's more accurate than a jigsaw and has a delicate feel to apply gentle decorations on wood. If you're planning on wood design, a power scroll saw is your tool of trade.

f. Power Drill

A power drill is one of the basic tools in wood power tools. While a cordless power drill may be handy and portable, a corded power drill is more reliable. Corded power drills are also less expensive than cordless ones.

There are several options in choosing power drills like having a keyed or keyless chuck, the size of the chuck, a straight power drill, or a hammer power drill. Knowing the best corded drill that suits your needs is important so that you won't waste your money.

g. Jigsaw

A regular saw best for cutting in straight lines but don't do well in curves. But a jigsaw can do well in cutting curved and circular designs on wood. It's one of the most important wood power tools to have if you want to design and craft wood with finesse. It feels lightweight and comfortable to hold, making it easy to use for beginners.

Jigsaws also come with a convenient blade-change system if you want to make different cuts.

h. Drill Press

A drill press is a more stable version of your power drill. It's used to bore small or big holes more accurately than a power drill. You can also adjust the specific depth of

the drill, so you don't have to worry about drilling too much.

Professional woodworkers prefer a drill press over a power drill since it's more efficient and less tiring to operate. It's also powerful enough to drill straight through steel.

i. Power Jointer

While most woodwork power tools deal with cutting wood, a power jointer is used to straighten and align twisted or bent wood flat. It's a great tool if you want to reuse wood that's partially damaged.

Paired along with other power tools, it's a good addition to your equipment in dealing with woodwork. If you're into making wooden furniture or home renovation with wood, a power jointer is a must. Take note that it's also a big purchase like a table saw, so consider your budget first.

j. Random Orbital Sander

A random orbital sander is used to apply finishing touches and smoothen wood. Among wood power tools, it's an easy-to-use tool that makes basic woodwork look better. Orbital sanders use a hook-and-loop system to fasten the sanding disks.

Compared to palm sanders, these come as a bit more expensive and use a random sanding motion to prevent any sanding marks and making a cleaner work. If you want to know how to refinish wooden furniture, check it here: DIY Network

5.4 Care and Maintenance of Tools/Equipment

Always allow enough time to pack up properly when you've finished a job. Cleaning your tools and putting them back where they belong help. Maintaining a safe and efficient work environment can save everyone a lot of time and inconvenience.

Cleaning

- Always clean your tools immediately after use
- Tools can be washed using a hosepipe and/or scrubbed with a wire brush
- Make sure that there is no risk of spreading pathogens while you are washing your tools
- Spray light oil on areas prone to rust

Storage

- Store tools in a dry, sheltered environment
- Place tools in racks for easy location and safety
- Place similar tools together so that people can see easily what is available

Maintenance

- Keep metal blades sharp and well-oiled

- Check any nuts, bolts, rivets, screws, blades, and springs regularly for wear or damage, and replace if necessary
- Sand wooden parts back regularly and oil with a 50/50 linseed oil
- Label damaged tools, place them out of the way and tell your supervisor or maintenance person

5.5 Safety and Precaution

The 10 Safety Rules Every Woodworker Should Know

Woodworking is among one of the safest and enjoyable hobbies you can do, provided you adhere to a set of rudimentary and easy to follow safety rules. This wood working safety rules are designed to be easy to remember and are mostly common sense. That being said, failure to comply with the safety rules can cause serious injury. The work shop is not the place to careless. It is the place to learn and adopt good safety working habits which will in turn make woodworking more fun and enjoyable.

1. Always Wear Safety Equipment

This might seem like a common-sense kind of rule, but it's an important one to remember. During usage of loud power tools like routers and surface planers, wearing ear protection is a noted advantage. Similarly, wear latex gloves while applying finishes. **NEVER BE WITHOUT YOUR SAFETY GLASSES**. These should be the first thing you reach for when entering the shop.

2. Wear The Right Clothes

The problem with wearing baggy or loose clothes is the very high chance that a part of them might get caught in a cutting head or saw blade. As a result, try to always wear clothes that you are a better match for the woodworking environment, but also protect you. Also always ensure that any dangling jewelry or metal such as chains or bracelets, are removed before commencing work.

3. Avoid Using Anything That Can Impair Your Reaction Time and Judgement

It's like when you're driving a car: you want to stay out of the alcohol and drug cabinets to avoid accidents. In the wood shop, the dangers are even higher by inadvertently using the wrong tool because you're too out of it to see what you are doing wrong. NEVER mix alcohol with work, even if it's just a beer…or ten.

4. Disconnect Power

Always remember to disconnect the power source itself before changing blades or bits on your power tools. In addition to ensuring the switch is off, make sure there is no electricity being powered to the tool, since the switch can malfunction and/or accidentally get turned on.

5. Use a Single Extension Cord

Using one heavy duty extension cord for all your power tools will ensure that you switch off the power for each tool. Too many cords can get confusing and be a tripping hazard.

6. Never Use Blunt Blades and Bits

While this might seem obvious seeing as how dangerous a dull cutting tool can be. Dull tools will need to be made to work harder to cut and as a result can bind or kick back. Sharp bits and blades will ensure cleaner cuts as well.

7. Check Stock for Existing Metal

Before sawing through or making a cut, ensure that the piece of stock doesn't have existing nails, screws or other pieces of metal lodged into it already. Spinning blades and nails (and other pieces of metal) don't mix well together causing damage to both the stock and the cutting head. It can also cause stock to kick back and cause injury, so always ensure (or use a metal detector to ensure for you) that the stock is clean.

8. Work Against the Cutter

Most power tools are built in a way that requires the direction a piece of wood moves through the tool, is the opposite direction of the cutting head's movement. So, you need to ensure that the blade or router bit cuts against the motion of the wood instead of with it.

9. Never Reach Over a Running Blade

Always wait until a spinning blade has stopped moving before reaching to remove waste or cut-offs etc. Or to be on the extremely safe side, remove waste by using a push stick or piece of scrap so as to ensure an inadvertent power tool switch malfunction, doesn't turn deadly.

10. Minimize Distractions

When dealing with distractions, you want to ensure that you finish what you were

doing (finishing a cut, especially when working with a power tool) before turning your attention elsewhere.

Exercises

Choose the correct answer from the given alternatives.

1. For twi2sting, pulling and gripping small jobs …….. is used.

   a. Files
   b. Spanner
   c. Piler
   d. Micrometer

2. To remove the nail from the wooden block, this hammer is used.

   a. Straight pin
   b. Ball pin hammer
   c. Clam hammer
   d. Cross pin hammer

Write short answer to the following questions.

1. Write any two duties of carpenter.
2. Write any two scopes of carpenter.
3. Write about furniture.

Write long answer to the following questions.

1. What is the difference between woods and timbers?
2. Write detail about construction carpeting.

Project Work

1. Demonstration of tools and equipment of carpentry in Carpentry Lab.

Unit 6 : Trees

6.1 Wood, Cross-Section of Tree with Name of Different Parts

Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants.

A detail cross-section of wood is shown below.

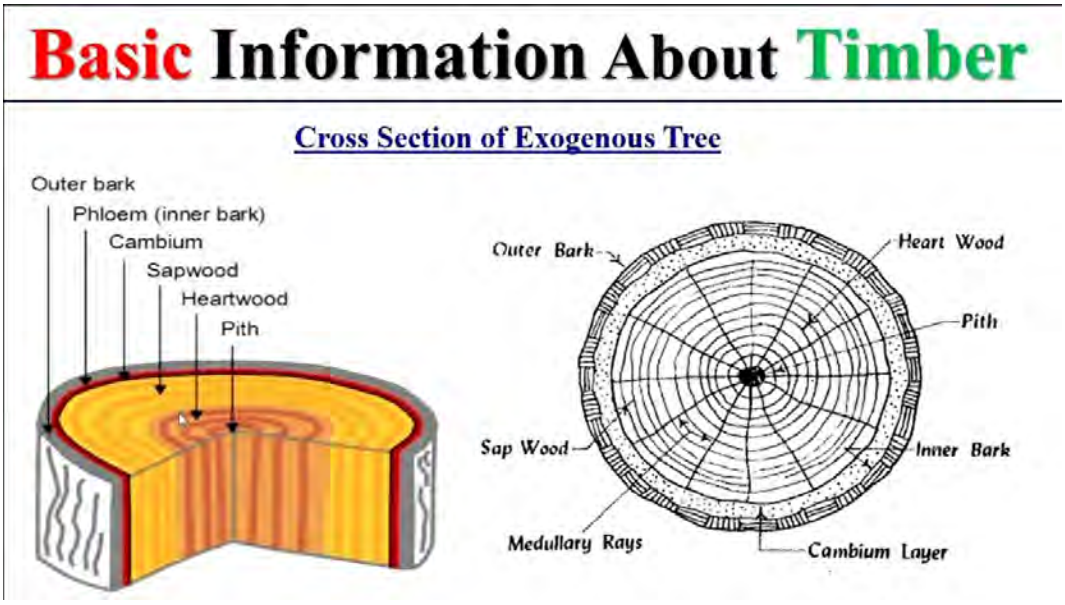


Fig: cross section of tree

6.2 Types and characteristics of common Nepalese trees

Followings are the common different type of trees found in Nepal:

1. Chir

It is generally found in Himalayas at heights ranging from 5000m to 2500m.

Characteristics

- It is pale grayish to yellowish or radish brown in color
- It weighs 560 kg/cum
- It is easily worked and seasons well

2. Deodar

It is a tall tree with pointed leaves found in western Himalayas from 1000m to 3000m height.

Characteristics

- Its color is yellow but darkens on exposure
- It weighs 560 kg/cum.
- It is easily worked

3. Sal

It grows in sub-himalayan ranges and in inner terai range.

Characteristics

- The timber is pale brown in color, darkening in exposure
- It weighs 860 kg/cum
- It is not easy to work upon and doesn't take good polish

4. Teak

It is a large deciduous tree growing in southern mountain.

Characteristics

- The wood is golden yellow to dark brown, in color darkening on exposure ultimately becoming almost black with edge
- It weighs 770kg/cum
- Its is easy to work upon and takes up smooth polish

5. Shisham (Sissu)

It is widely available in Terai region of Nepal. It is one of the most valuable timber of Nepal.

Characteristics

- The wood is dark brown in color with golden and dark brown streaks, darkening on exposure
- It weighs 880 kg/cum
- It is quite tough and durable

6. Mango

It is famous fruit tree.

Characteristics

- It is of deep grey color
- It weighs 650kg/cum
- It is easy to work

7. Walnut (Okhar)

It Grows in himalayas.

Characteristics

- Color of wood varies from light grayish brown to dark brown
- It weighs 650 kg/cum
- It is easily worked and doesn't split

6.3 Growth of Trees

A tree becomes taller only through growth at tips of the branches. It becomes thicker through the formation of cells just within the inner bark. A few annual rings next to the inner bark are less mature but more active than heart wood, and are known as sap wood. There is usually no great difference in strength between heartwood and sapwood, but heartwood is more resistance to decay.

In spring season roots of the tree suck a solution of salts from the soil-salt that are food for the tree and transmit the same through the trunk of tree to its branches and

leaves. This solution of salts loses some of the moisture because of evaporation because of evaporation and absorbs carbon dioxide from the air. This action in the presence of sun makes the solution of bit viscous. This transform viscous solution is known as sap. In autumn viscous sap descends below the bark and leaves a thick layer. It goes on gaining strength with the passage of time. A fresh layer is thus added on the outside the tree every year forming a new annual ring. The new repents a year's growth of tree. Modularly rays carry the sap from the below the bark to the interior they're by nourishing the tree.

6.4 Time of Felling Tree

The process of knocking down or cutting down or causing the trees to fall to the

ground is known as felling of trees.

The trees should be felled when they have just matured or when they are very near to maturity. Good timber trees generally arrived at maturity between 50 and 100 years.

The best time for felling trees is mid-summer or mid-winter. When the sap is minimum in quantity as it is then at rest. The timber is liable to decay if felled in spring or autumn when the tress contains maximum quantity of sap due to its vigorous moment.

6.5 Methods of Felling Tress

Make a deep cut with axe at the lowest possible point of the trunk. On the side opposite to which it is desired to be felled.

This cut is taken a little beyond its centre of gravity and a wedge is inserted into it.

Top of trees is then tied with ropes on all the four diametrically opposite side, having an angle of 60-90 degree between them.

The rope on the side of the tree to be felled is pulled and the one on the opposite side is loosened slowly.

The trees is then swung in the desired direction and pulled down slowly by applying force on ropes.

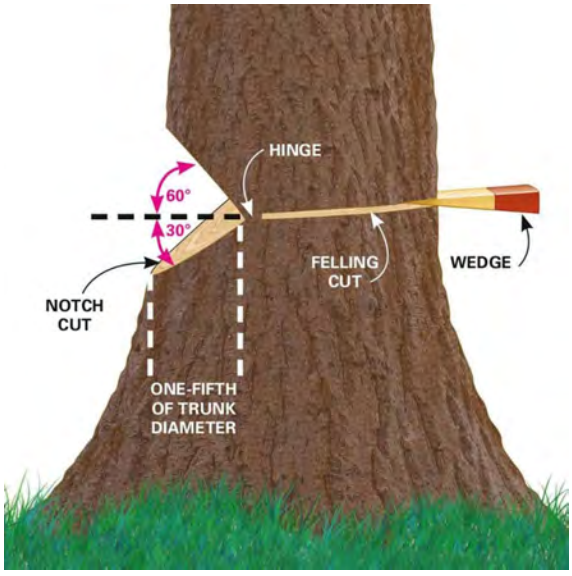


fig: Method of felling tree

6.5.1 Tool/Equipment/Required to Fell Trees

The size of the tree determines which felling tools we need to use. For the smallest tree we do not normally need the felling tools. Hand forced is enough, possibly with a long pole. The felling ways provides greater felling force than different types of breaking bar. In extreme cases, we can use rope and winch, which is the safest and most powerful way to fell a tree.

Foot breaking bar- It is suitable for small trees when thinning. Insert the foot breaking bar before completing the felling cut. Stand with all your weight on lever arm. The foot breaking bar is generally telescopic and can be carried in a holster on your logging belt.

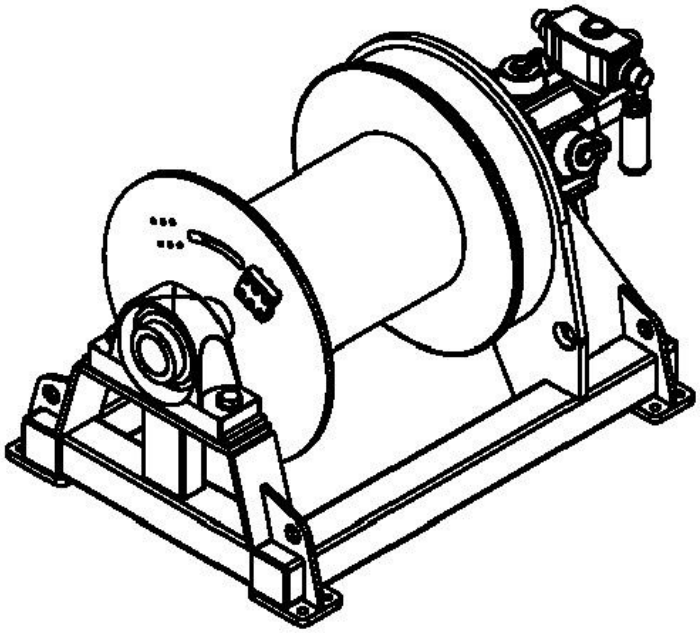
Breaking bar- It is used on relatively small trees. There are various breaking bars with different lever length. Insert the breaking bar before completing the felling cut. In order to maximize the lifting force, insert, if possible, the breaking bar in the middle of felling cut at the very back. Lift your legs and keep your back straight.

Impact bar- The impact bar is used in the same application as the breaking bar. It can also be used as striking tools when using felling wedge.

Felling Wedge- Felling wedge are the best for medium to large tress. They are inserted before the felling cut is complete and are knocked in with an axes or an impact breaking bar. Several ways are some time needed.

Fig: Quarter master

Winch- Winch is used in a situation where we need maximum force and safety. The wire is attached as high up in the tree as possible for maximum effect



6.6 Characteristics and Example of Soft and Hardwood

Softwood and hardwood are two different types of wood that come from different kinds of trees. Softwood comes from trees like pine and cedar, which usually have needles or cones. It's lighter and easier to work with, making it great for things like building houses and making paper. Hardwood, on the other hand, comes from trees like oak and maple, which have broad leaves. It's denser and harder, making it perfect for furniture, floors, and other things that need to be strong and durable. So, while softwood is good for simple projects, hardwood is better for things that need to last a long time.

6.6.1 Characteristics

Softwood and hardwood have distinct characteristics that differentiate them from each other:

Softwood

1. **Lightweight:** Softwood tends to be lighter in weight compared to hardwood.
2. **Fast-growing:** Softwood trees typically grow faster than hardwood trees, leading to a more readily available and affordable source of lumber.

3. **Straight grain:** Softwood usually exhibits a straighter grain pattern, which can make it easier to work with for certain projects.
4. **Easy to work with:** Softwood is generally easier to cut, shape, and sand, making it suitable for construction, carpentry, and other applications.
5. **Common uses:** Softwood is often used in construction, furniture making, paper production, and outdoor projects like decks and fences.

Hardwood

1. **Denser and harder:** Hardwood is denser and typically harder than softwood, providing greater strength and durability.
2. **Slower-growing:** Hardwood trees generally grow more slowly than softwood trees, resulting in a denser wood with tighter grain patterns.
3. **Varied grain patterns:** Hardwood often exhibits more complex grain patterns, including curls, waves, and knots, which contribute to its aesthetic appeal.
4. **Challenging to work with:** Due to its density and hardness, hardwood can be more difficult to cut and shape compared to softwood, requiring more effort and specialized tools.
5. **Premium applications:** Hardwood is prized for its durability, strength, and aesthetic qualities, making it suitable for high-quality furniture, cabinetry, flooring, musical instruments, and decorative items.

Exercise

Choose the correct answer from the given alternatives.

1. Rings that tree produce each year are…….

   a. Annual rings b. Cup rings

   c. Cambium layer d. Medullary rays

2. For cutting along the grains……. saws are used

   a. Rip saw b. Cross cut saw

   c. Dovetail saw d. Compass saw

Write short answer to the following questions.

1. What are the different parts of tree?
2. Write about the grain of tree
3. Write about hard wood and soft wood

Write long answer to the following questions.

1. Write characteristics of different tree found in Nepal.
2. Explain the methods of felling the tree and tools used.

Project Work

1. Draw cross section of tree, tools for feeling tree

Unit 7 : Timber

7.1 Introduction to Timber

Wood suitable for building and other engineering purpose is called timber. When it forms parts of living tree it is called standing timber. When the tree has been felled it is called rough timber. When it has been sawn to various market forms such as beams, battens and planks etc., it is called converted timber. It is applied to trees measuring not less than 0.6 m in growth.

- **Grain of Wood Section**

  Wood grain is longitudinal arrangement of fibers.

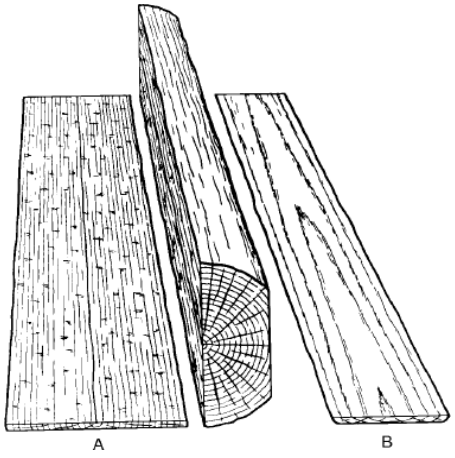
  R. Bruce Hoadley views that grain is a "confusingly versatile term" with numerous different uses, including the direction of wood cell (ex straight grain, spiral grain), surface appearance or figure, growth- ring placement (ex vertical grain),plain of cut(ex end grain), rate of growth (ex narrow grain), and relative cell size (ex open grain).

  Basic grain description and types includes:

  Straight Grain: It runs in a single direction, parallel axis of trees.

  Spiral Grain: It spirals around the axis of trees.

  Inter-locked Grain: It spirals axis of trees, but reverses its direction for period of years resulting in alternating direction of spiral grain.



Sketch of A- Quarter Sawn and B- flat sawn

- **Strength of Wood**

  The strength of timber increases as its density increases. When evaluating the density of wood, the level of moisture in which its mass and volume were measured most always be known. Most commonly density of wood is given as dry air density, whereby the mass and the volume of wood are measured with moisture content 12% or 15%. The density of Sal wood is approximately is g/cum.

  The strength of wood is fundamentally affected by the direction in which it is loaded in relation to the grain. In the direction of the grain, the bending strength is directly proportional to the density of wood. In uniform, flawless wood, the bending strength is as great as the tensile strength.

- **Proportion++++++++++++++++++++++++++ of Timber**

  Tensile strength in the grain is usually 10-20 % more than its strength perpendicular to grain.

  Shearing strength of wood is 10-15% of its tensile strength in the direction of grain.

7.2 Application, Advantage and Disadvantage of Timber Application

The followings are the general application of timber:

- Timber can be used for making furniture.
- Timber can be used for scaffolding.
- Timber can be used as shuttering and formwork.
- Timber can be used for construction of temporary structures like bridges, etc.

Advantage

- It is light in weight yet strong.
- It is easily available and can be quickly transported by simple means.
- It is good insulator of heat and sound.
- Boards may be cut rapidly by a saw and fastened firmly together with nails.

Disadvantage

- The greatest disadvantage is its ready combustibility.
- Frame buildings built closely together present a serious conflagration hazard.
- Timber is destroyed by decay induced by fungi and insects.
- Timber swells and undergoes shrinkage with changing atmospheric humidity.

7.3 Definition and Purpose of Conversion of Timber

The process of cutting logs into timber is called conversion.

There are several methods of conversion, each of which has some special advantage and disadvantage. For some timbers conversion must take place before the log has time to dry out and shrink.

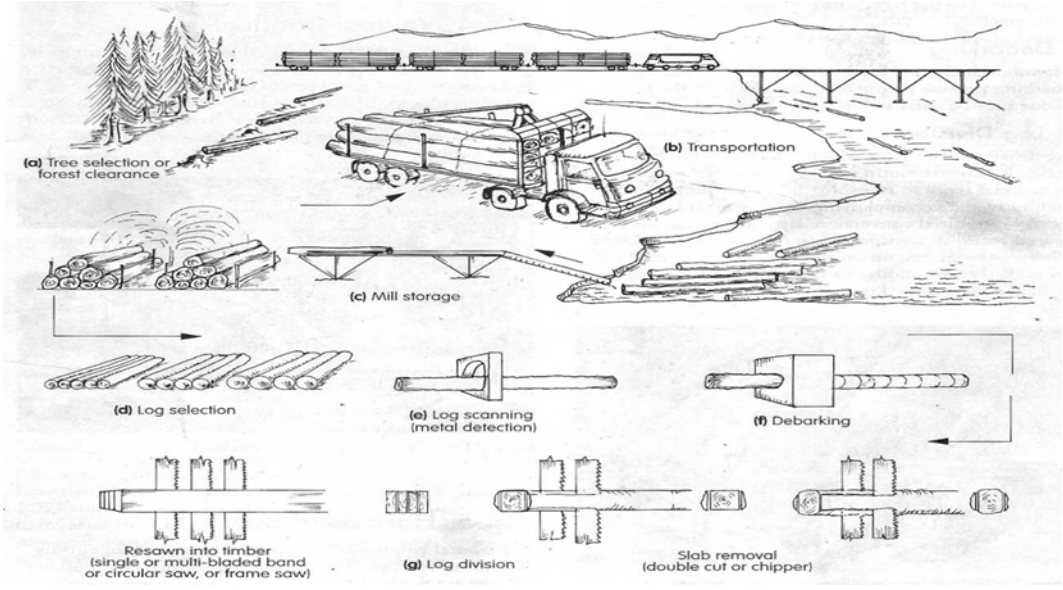


Fig. Conversion of wood

7.3.1 Purpose

The following are the purpose of timber conversion:

- Allow wood to dry faster
- Provides wood of useable size and shape
- Allows the quality of timber to be seen
- Minimize wastage

7.3.2 Methods of Conversion

There are four main methods of conversion of timber. They are:

a. Through and through sawn

b. Tangential sawn

c. Rift sawn or radial sawn

d. Quarter sawn

a. Through and Through Sawn

Through and through sawn which is sometimes called Plain or slash sawing. In plain sawing, the saw cut forms a tangent to one of the annual rings. There are several variations of plain sawing.

Fig: Through and through sawn

b. Tangential Sawn

In this method boards or planks are sawn tangentially to annual rings but such boards are not very suitable for flooring.

Planks obtained by this method of sawing wrap to much.

This method is adopted when the annual rings are very distinct and medullary rays are clearly defined.

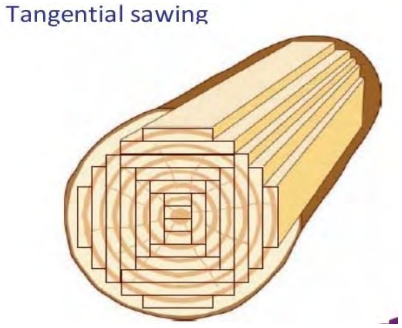


Fig: Tangential sawing

c. Rift or Radial Sawn

Milling rift sawn lumber takes more time and labor. It also has unique benefits over quarter and plain sawn lumber. Furniture makers depend on this cut of wood for the vertical grain that is shown from all sides. This linear grain pattern is achieved by

milled perpendicular to log's growth rings. The log is milled carefully on an angle between 45° to 75°.

Fig: Rift or radial sawn

d. Quarter Sawn

In quarter sawing, the saw cut is made at right angles to the annual rings. This method is used particularly to produce figured oak. A quarter sawn board will therefore expose the rays where as a plain sawn one would cut across them.

Fig: Quarter sawn

7.4 Definition and Purpose of Seasoning of Timber

Definition: Seasoning of timber is the process by which moisture content in the timber is reduced to required level. By reducing moisture content, the strength, elasticity and durability properties are developed. A well-seasoned timber has 15% moisture content in it.

Purpose

- To check/minimize the tendency of timber to shrink, wrap and split
- To increase strength, durability and electrical resisting power of timber

- To make the timber safe from attack of fungi and insects.
- To reduce the weight for transport purpose, handling, and thereby reduction in cost.
- To make timber fit for receiving of paints, preservatives, varnishes, etc.

7.5 Methods of Seasoning of Timber

There are two methods of seasoning of timber which are explained below:

a) Natural seasoning

b) Artificial seasoning

a) **Natural Seasoning of Timber**

Natural seasoning is the process in which timber is seasoned by subjecting it to the natural elements such as air or water. Natural seasoning may be water seasoning or air seasoning.

Water Seasoning

Water seasoning is the process in which timber is immersed in water flow which helps to remove the sap present in the timber. It will take 2 to 4 weeks of time and after that the timber is allowed to dry. Well-seasoned timber is ready to use.

Air Seasoning

In the process of air seasoning timber logs are arranged in layers in a shed. The arrangement is done by maintaining some gap with the ground. So, platform is built on ground at 300mm height from ground. The logs are arranged in such a way that air is circulated freely between logs. By the movement of air, the moisture content in timber slowly reduces and seasoning occurs. Even though it is a slow process it will produce well-seasoned timber.

b) **Artificial Seasoning of Timber**

Natural seasoning gives good results but takes more time. So, artificial seasoning of timber is developed nowadays. In artificial seasoning, timber is seasoned with in 4-5 days. Different methods in artificial seasoning are as follows :

i. Seasoning by Boiling
ii. Chemical seasoning
iii. Kiln seasoning
iv. Electrical seasoning

i. Seasoning by Boiling

Seasoning of timber is also achieved by boiling it in water for 3 to 4 hours. After boiling timber is allowed to drying. For large quantity of timber, boiling is difficult. So, sometimes hot steam is passed through timber logs in enclosed room. It also gives good results. The boiling or steaming process develops the strength and elasticity of timber but economically it is of heavier cost.

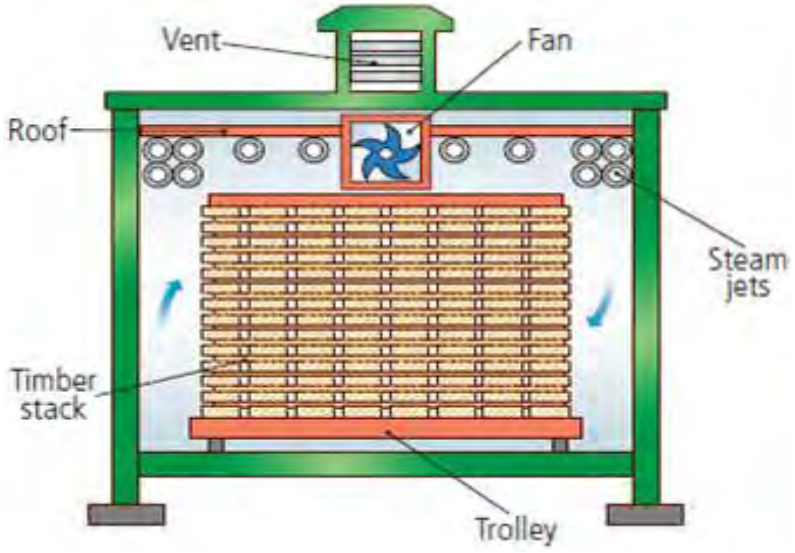
ii. Chemical Seasoning

In case of chemical seasoning, timber is stored in suitable salt solution for some time. The salt solution used has the tendency to absorb water from the timber. So, the moisture content is removed and then timber is allowed to drying. It affects the strength of the timber.

iii. Kiln seasoning

In this method timber is subjected to hot air in air tight chamber. The hot air circulates in between the timber logs and reduces the moisture content. The temperature inside the chamber is raised with the help of heating coils. When the required temperature is obtained moisture content and relative humidity gets reduced and timber gets seasoned. Even though it is costly process it will give

good results strength wise.



iv. Electrical Seasoning

In the method of electrical seasoning, timber is subjected to high frequency alternating currents. The resistance of timber against electricity is measured at every interval of time. When the required resistance is reached seasoning, process is stopped because resistance of timber increases by reducing moisture content in it. It is also called as rapid seasoning and it is uneconomical.

v. Combined Seasoning

If air and kiln seasoning is done simultaneously, this is called combined seasoning.

7.6 Moisture Content in Timber

In the timber industry the amount of moisture present in timber (or its moisture content) is defined as the mass of water present in the timber divided by the mass of the timber with all water removed, expressed as a percentage. The mass (measured in grams or kilograms) of water present can be determined from the difference in the mass of the timber with water (initial mass) to the mass of timber with the water removed (oven dry mass). Hence the following equation is used to determine the moisture content of timber:

%mc(moisture content) = (mass of water present)/(oven dry mass)×100%

= (initial mass-oven dry mass)/(oven dry mass)×100%

7.6.1 Moisture Meter

Moisture meters are used to measure the percentage of water in a given substance. This information can be used to determine if the material is ready for use, unexpectedly wet or dry, or otherwise in need of further inspection. Wood and paper products are very sensitive to their moisture content. Physical properties are strongly affected by moisture content and high moisture content for a period of time may progressively degrade a material.

7.6.2 Meters for Wood

Newly-cut logs can have a moisture content (MC) of 80% or more, depending on species. Since wood shrinks, and can also split, twist or otherwise change shape as it dries, most wood is dried before being used. This is most often done using a kiln, but may use the air-drying method, which is much slower. In most parts of the United States, the minimum moisture content that can be generally obtained in air drying is about 12 to 15 percent. Most air-dried material is usually closer to 20 percent moisture content when used.

Exercise

Choose the correct answer from the given alternatives.

1. Seasoning of timber is the process of.....

   a. Burning timber
   b. Adding preservatives
   c. Removing water
   d. Adding glaze

2. Which of the below changes do not occur after seasoning?

   a. Increase durability
   b. Decrease stiffness
   c. Workable timber
   d. Reduction in weight

Write short answer to the following questions.

1. What is seasoning of timber?
2. Write the properties of timber.
3. Write the used of timber.

Write long answer to the following questions.

1. What is the method of seasoning of timber? Explain.
2. Explain about the timber conversion.

Project Work

1. Draw different types of seasoning of timber

Unit 8 : Defects of Timber and Methods of Preservation

8.1 Definition

In all kinds of wood/timber, several natural defects occur. These are caused by the nature of the soil upon which the tree grew and also by the changes in nature to which it was subjected while growing. As far as possible these defects should be avoided or removed during conversion for use.

8.2 Defects due to Natural Forces/Fungi/Insects

The life of sound and well-seasoned timber in a well ventilated position entirely immerged in water for several years. Various causes or situation which favor early decay of timber are:

1. Attack by insects and wood borers
2. Attack by fungi
3. Vegetable growth
4. Bad storage or staking of timber
5. Moisture

Defects Caused by Nature

a) Star Shakes

These are radial splits wider on the surface of tree and becoming narrower as they move towards the center. They are caused by severe frost or by severe heat of the sun.

b) Heart Shakes

These are wide splits running right through the heart wood of the tree. This splits, radiate from the pitch running towards the sap wood. These are caused by the shrinkage of interior parts or by decay because of accumulated mixture.

c) Cup Shakes or Ring Shake

These are curved splits separating one annual ring from the adjacent one either wholly or partly. These are caused by strong winds swaying the tree and by excessive

frost action on the moisture present in the tree, specially while it is still young.

d) Twisted Fibers

Fibers are twisted by strong winds turning the tree constantly in one direction. Trees in exposed positions or on hill tops are the most affected.

e) Rind Galls

These are peculiar swellings caused generally by the growth of layers of sap wood over wounds remaining after a branch of tree has been imperfectly cut off or broken.

f) Upsets

In these defects, during the growth of tree, fibers are sometimes injured due to crushing resulting in the breakage of continuity of fibers.

g) Knots

A knot is either the root of branch that is embedded in the stem with the formation of annual rings at right angle to those of the stem or the tissues set in elliptical or concentric circles.

h) Foxiness

Presence of radish or yellowish strains shows the beginning of decay in timber because of bad ventilation during storage.

Reasons of Environmental Process (Dry and Wet)

a) Dry Rot: It is an attack of timber by a fungus. The fungus reduces timbers to a dry powder. On seasoned timbers become an easy prey to the fungus. To prevent dry rot only well-seasoned timber should be used. Also, it should be ensured that the timber is used in such a manner that there is free access to fresh air to all parts of the timber.

b) Wet Rot: It is decay of timber due to alternate wetting and drying. In it there is no attack of any fungus. To prevent wet rot timber should be protected against alternate wetting and drying. It should be so used that either it is wholly submerged under water or it is always dry.

The decay of wood is caused by fungi colonies of plants of microscopic size which feed upon some of materials in the wood and form thread like filaments which spread through wood in all directions.

In general, the same means that protect against decay by fungi also protects against

destruction by animal or organism. The following conditions must be present simultaneously in order that fungi may be alive:

a. Adequate food
b. Proper temperature
c. Oxygen enough to support the life process
d. Proper amount of moisture

If any of those above four factors are rendered too unfavorably, decay of wood cannot take place.

8.3 Shrinkage of Wood

As wood dries below its fiber saturation point, it shrinks. Shrinkage is the reduction in timber dimensions caused by the lose of moisture from the wood's cell walls. Below the fiber saturation point, all of the moisture remaining is bound water and is an integral part of cell walls. Removing this water makes small changes to the thickness of cell wall. Aggregation of this reduction over thousands of cell causes in the thickness of timber.

Defects Caused by Shrinkage

The followings are the common defects caused by shrinkage:

- Defects caused by cross-sectional dimensions
- Reduction in strength
- Reduction in stiffness
- Reduction in durability
- Shrinkage in coatings

8.4 Definition and Purpose of Wood Preservation

Timber has to be protected from the attack of insects e.g. white ants, etc. and from internal decay due to dry and wet roots. Preservation of timber refers to the art of treating the timber with some chemical so as to increase its life.

The purpose of preservation of timber are:

- To make the timber structure durable.
- To lengthen the life of timber structure.
- To protect the timber structure from attack of destroying agencies such as fungi,

insects, etc.

8.5 Oil Soluble and Water-soluble Preservatives

Oil Preservatives

Coal tar creosote with or without admixture or soluble oils is used to protect timber as oil preservatives.

Water Soluble Preservatives

These are toxic chemicals in water, such as zinc chloride, boric acid, copper chrome, arsenic composition (ascue). Ascue is a chemical used as preservative. For use six parts by weight of the powder is dissolved in 100 parts by weight of water.

8.6 Hot and Cold Bath Method

In this process timber is stacked in the tank and cold preservative (usually creosote) is then run into the tank, till the timber is completely submerged. The preservative is then heated to about 95◦C and maintained at that temperature for a suitable period. After that it is allowed to cool until the required absorption of preventatives is obtained. By this process, a penetration up to 5 cm is obtained.

8.7 Pressure Method of Preservation

Injecting preservative under into the timber is the most effective method of treating timber with preservative. This method proves to be essential for treating nondurable timbers which are to be used at places where there is danger of attack by fungi and insects. Various pressure processes are enumerated below:

i. Fuel cell or bethel process

ii. Empty cell or reaping process

8.8 Preservation from Termite in a Building

Control Termites and White ants/insects by Providing Proper Ventilation

This method requires much less preservative to give the desired absorption and protect from the white ants/insects and termite and also used for preserving mixed species.

Periodical Carefulness of Termites in Building

Termites are commonly known as home owner worst nightmare and have the ability to go undetected for long periods of time while silently attacking houses one bite at a

time from the inside out. Due to the hot and humid climate in many parts of country, termite is most likely to attack. For periodical carefulness of termites, we generally inspect the timber product for the period of 1-2 yrs.

8.9 Different Types of Paints and their Application

Introduction and Purpose

Paints and varnishes are used to protect metals, timber or plastered surfaces from the corrosive effect of weather, heat, moisture or gases etc. and also to improve their appearance.Finishing refers to the process of embellishing and/or protecting the surface of wooden materials. This process starts with surface preparation, either by sanding, scarping, or planning.

Cleaning Work Piece

To clean wood furniture, start by dusting it with a soft, lint-free cloth. Then, mix 1 gallon of warm water with half a cup of liquid dish detergent, making it as a sudsy as possible. Next dampen a cloth in the mixture, and try cleaning just a small area on piece.

Sanding Work Piece

To remove those last bits of finish, palm sand with medium sand paper (150grit) until we see the bare wood. Then switch to fine sand paper (200+grit) until the entire piece is uniform. Some of the wood dust from sanding will become air borne, it is wise to wear a particle mask while working.

Putty Applying

Wood putty is just what you need to fill a crack, hole, or open joints in wood projects. To apply wood putty, first, mix it up in its container with a putty knife (putty can separate after it sits for a while). It's tempting to load the putty knife with tones of putty and slather it on-we can always sand it off. Wood putty is sandable. But after drying, petroleum-based putty type hardens rock-solid. In fact, if you are filling a soft wood (such as pine), the wood putty becomes stronger than the wood itself.

Priming

After knotting, the surface is rubbed smooth using abrasive paper. Priming consists of applying the first coat of paint to fill all the pores. Priming coat creates a layer or film which provides adhesion of the paint with the surface.

Drying

Generally, if we are using paint, expect it to be dry to touch in six- eight hrs. and ready to recoat in 24 hours. A latex paint is usually dry to touch in about an hour, and we can safely

Enameling

Enamel paint is general term applied to paints that dry to a hard, durable finish.

Working with enamel paint is a matter of knowing when it is best suited for project.

Generally, we should follow the following steps for enameling:

- Decide if an enamel paint is right for project
- Choose the right type of paint
- Use high quality brushes
- Start with primer
- Wait until the primer to dry
- Use sprayer
- Apply two coats of enamel

Varnishing

Varnish is a solution of resins or resinous substances (such as common resin, amber, copal, shellac, etc.) in alcohol, turpentine, or oil. It is applied on wood surfaces with the following objectives.

- To intensify or brighten the appearance of natural grain in wood
- To render brilliancy to the painted surface
- To protect painted surface from atmospheric action
- To protect unpainted wooden surfaces of doors, windows, floors, roof trusses, etc. from atmospheric action

Chapra Polishing (Shellac)

Shellac is a resin secreted by the female lac bug, on trees in the forests. It is processed and sold as dry flakes and dissolved in alcohol to make a liquid shellac, which is used as a brush-on colorant, food glaze and wood finish. Shellac functions as a tough natural primer, sanding sealant, tannin-blocker, odor-blocker, stain, and high- gloss varnish.

Uses

- In the tying of artificial flies for trout and salmon where the shellac was used to seal all trimmed materials at the head of fly
- For fixing pads to the key- cups of wood wind instruments
- For luthier applications, to bind a wood fiber down and prevent tear out on the soft spruce sound boards

Thinners

A paint thinner is a solvent used to thin oil-based paints or cleanup after their use. Commercially, solvents labelled “paint thinner” are usually minerals spirits having a flash point at about 400C, the same as some popular brands of charcoal, starter.

Thinner are added to the paint to make it thin so that it can be easily applied on surfaces.

It also helps the paint in penetrating through the porous surface of the background.

The thinning agent commonly used in the spirit of turpentine. Other solvents contain some part of spirit of turpentine, and therefore inferior. Thinner reduces the gloss of the paints. Normally linseed oil, turpentine oil, and spirit are used as thinner.

Exercise

Choose the correct answer from the given alternatives.

1. Dry rot is a defect caused in timber in which wood is converted into dry powder form by fungi. Which of the following statements about dry rot is not correct?
   a. Unseasoned softwoods cannot be easily attacked by dry rot
   b. It usually occurs at places where there is no free circulation of air
   c. If the storage of timber after its felling is not done properly, it is liable for the attack of dry rot
   d. It is not essential to have damp conditions for the development of dry rot

2 . Which of the following is not a variety of industrial timber?
   a. Veneers b. Plywood
   c. Fiberboard d. Baulk

3. Which of the below is a natural defect occurring in timber?
   a. Twist b. Split
   c. Shakes d. Bow

4. How many types of shakes are there?
   a. 3 b. 2 c. 6 d. 5

5. _____ defects is indicated by red/yellow tinge in wood.
   a. Froxiness b. Druxiness c. Callus d. Burls

6. Which of the following is not a cause of the decay of timber?
   a. Lack of ventilation b. Alternate dry and wet conditions
   c. Absence of moisture d. Moisture accompanied by heat

7. What causes dry rot in timber?
   a. Bacteria b. Beetle
   c. White ants d. Fungus

8. Ascue is a.....
   a. Defect by insects b. Preservative
   c. Natural defect d. Type of marine bore

9. Which method of application of preservative is suitable for moist timber?

a. Pressure application
b. Brushing and spraying
c. Soaking
d. Hot and cold tank treatment

10. The defect indicated by curvature formed in a transverse direction is.....

a. Bow
b. Spring
c. Twist
d. Cup

11. A good preservative should.....

a. Be poisonous
b. Be unaffected by heat and moisture
c. Have pleasant odour
d. Have white color

Write short answer to the following questions.

1. Define and explain the defects in timber/wood?
2. How can we remove defects caused by shrinkage?
3. Define timber decay and explain how it can be prevented from fungal attack?
4. Define preservation. Write about oil preservation.
5. Define Painting and varnishing.
6. Briefly explain the steps for painting a building in points.

Write long answer to the following questions.

1. Explain in detail the defects caused by nature.
2. Describe how of environment as factors contribute to the decay of timber.
3. Explain about pressure methods of preservation.
4. Explain about oil and water-soluble preservatives. Explain hot and cold bath method. Write short notes on chopra polishing and thinners.
5. Explain the detail process of painting a building structure.
6. What are the defects caused by shrinkage? How to you control termites/white ants/ insects in wood. Explain.

Project Work

1. Demonstration of different types of defects in timber and explanation in classroom/ laboratory in group of 4-5 students.
2. Demonstration of materials and tools for formworks and reinforcements with

explanations in classroom/laboratory in group of 4-5 students.

3. Cutting the section of defects seen in timber in workshop and analyzing them.
4. Analyzing the decays in timber and check whether is dry rot or wet rot in workshop.
5. Performing test of timber whether it is caused due to natural causes by checking the properties like (Heart, star, cup) shake, twisted fibers, upsets, knots, foxiness in workshop.
6. Introducing different kinds of paints and its application in wood structures.

Unit 9 : Construction Joint

9.1 Definition and Purpose of Construction Joints

The term joinery may be define of construction joints as the trade in wood work in which skilled labour is required to render the wooden members capable of framing together. It is the art of preparing internal fitting and finishing of timbers. Construction joint is the craft of connecting and securing the separate members of the wooden construction to one another by means of specific cuts on the ends or sides of the members. It is the spot where the two pieces of wooden construction are joint together to form a rigid self-supporting and permanent construction. The main purpose of wood construction joint is to join the two or more pieces of wood to give rigid connection. The followings are the general wood construction joints.

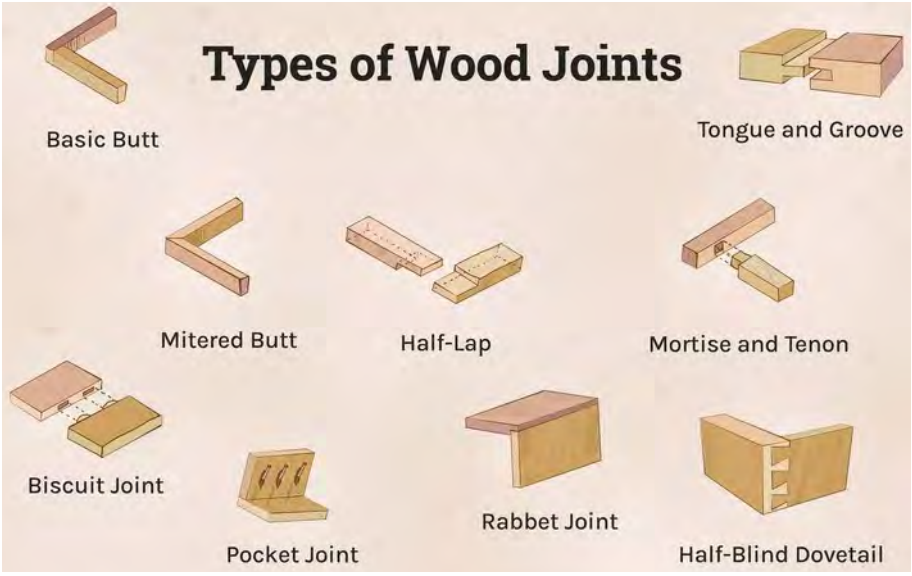


Fig: Types of Joints

9.2 Types of Joints and Their Use

Joints, where two or more bones meet, are classified based on their structure and function, primarily into fibrous, cartilaginous, and synovial types. Synovial joints, the most common, are further categorized into six types: hinge, pivot, saddle, condyloid, ball-and-socket, and gliding, each with distinct movement capabilities.

These classifications allow for a range of motion, from the rigid structure of the skull (fibrous) to the free movement of the shoulder (synovial)

9.3 Cross Half-Lap Joint

The half-lap joint is where half of each of the two boards being joined is removed so that the two boards join together Flush with one another. This type of wood joinery can obviously weaken the strength of the two adjoining boards, but also is a stronger joint than butt joints. There are a number of projects where this type of wood joint is quite desirable, in spite of its drawbacks.

9.4 Mortise and Tenon Joint

The mortise and tenon is a classic wood joinery method. These joints have been used since the early times of woodworking, and are still among the strongest and most elegant methods for joining wood. Learn methods for creating tight, beautiful mortise and tenon joints.

9.5 Half-Blind Dovetail Joint

There are situations where a dovetail joint is the connection of choice, but both edges of the dovetails should not be visible. A perfect example is a drawer front, where you don't want to see the end of the through dovetail on the face of the drawer. For this type of joint, the best choice is a half-blind dovetail. Learn how to build a clean, strong and beautiful half-blind dovetail joint and when to use this type of wood joinery.

9.6 Through Dovetail Joint

Of all wood joinery methods, the through dovetail may be the most revered. A classic through dovetail is beautiful and very strong and adds a touch of class to any piece. There are a few methods for creating through dovetails, from hand cutting to machining with a jig. Learn the keys to a quality through dovetail joint and how to create them.

9.7 Dado

A dado is nothing more than a square-grooved slot on one board where another board will fit. Similar to tongue and groove joinery, this is a commonly-used wood joint for connecting plywood, such as building cabinetry. Learn how to properly cutba dado, and when to use one.

9.8 Mitred Butt Joint

A mitred butt joint is nearly the same as a basic butt joint, except that the two boards are joined at an angle (instead of square to one another). The advantage is that the mitred butt joint will not show any end grain, and as such is a bit more aesthetically pleasing. However, the mitred butt joint isn't all that strong.

9.9 Butt Joint

There is no more basic wood joinery than the butt joint. A butt joint is nothing more than when one piece of wood butts into another (most often at a right angle, or square to the other board) and is fastened using mechanical fasteners. This type of joint is often used in wall framing on construction sites. Learn tips for using a butt joint, as well as when to choose another wood joinery type.

Other Types

- **Tongue and Groove Joint**

  When joining two boards square to one another along a long edge, one can simply butt the joint together and hold it with fasteners. However, the tongue and groove joint is much stronger and provides more adjoining surface areas, which is particularly useful if you're going to glue the joint.

- **Biscuit Joint**

  Another method for joining boards along the edges (like the tongue and groove joint) is to cut slots and use beech wood wafers (known as a biscuit) to hold the boards in place. This is a very useful modern woodworking joint, particularly for creating table tops, relying on glue and the swelling of the beech wood biscuit to hold the boards in place. Learn how to cut consistent slots and get reliable results from biscuit joinery.

- **Bottom of Form**

a. Pocket Joint

The Pocket Joint is a type of wood joinery that involves cutting a slot and predrilling a pilot hole at an angle between two boards before connecting the two with a screw. This pre-drilling needs to be very accurate, so it is typically accomplished by use of a commercial jig. Pocket joints work great for cabinet face frames and other similar applications where a lot of strength is not needed. Learn the steps to creating pocket joints in your woodworking projects.

b. Rabbet

Another common wood joint used in cabinetry is the Rabbet. A rabbet is essentially a dado cut along the edge of a board. Rabbets are often used at the back of cabinets and other similar assemblies for attaching the back to the sides of the box, adding a considerable amount of strength to the assembly. Learn how to cut clean rabbets and when to use them.

c. Sliding Dovetail

A sliding dovetail is a versatile joint with a lot of possible uses. A good way to think of it is as a locking dado. Learn the keys to building a clean sliding dovetail joint, and when to use one.

d. Box Joint

Dovetail joints are beautiful and strong, but not always practical. A box joint is a simpler alternative to the dovetail joint. Learn how to build consistent and strong box joints in your woodworking projects.

Exercise

Choose the correct answer from the given alternatives.

1. _____ joints are employed to extend the length of a member by joining two pieces of timber.

   a. Lapped b. Angle

   c. Lengthening d. Bearing

2. _____ is the simplest form of joint.

   a. Lapped joint b. Framing joint

   c. Oblique joint d. Widening joint

3. _____ joints are employed to connect the members at an angle other than a right angle.

   a. Angle b. Lapped

   c. Oblique d. Bearing

4. The two members meeting at an angle can be joined by a _____

   a. Bridle joint b. Oblique tenon joint

   c. Mitre joint d. Birds mouth joint

5. _____ joint is used to connect members of bigger sizes.

   a. Lapped joint b. Oblique tenon joint

   c. Mitre joint d. Birdsmouth joint

Write short answer to the following questions.

1. Define and explain the use of construction joints.
2. How can we make a butt joint ?
3. Define mortise and tenon joints.
4. Define cross half-lap joints. Write about dado joint.
5. Define biscuit joint.
6. Briefly explain four types of joints points.

Write long answer to the following questions.

1. Explain in detail about construction joints and their uses with figures and elaboration.

Project Work

1. Demonstration of different types joints and explanation in classroom in group of 4-5 students.
2. Demonstration of materials and tools for joints with explanation in Workshop in group of 4-5 students.
3. Cutting the section of wood for making joints in workshop and analyzing them.
4. Introducing different kinds of Joints and its application in wood structures like chair, tables, doors, windows.

Unit 10 : Introduction to Electricity and House Wiring System

10.1 Electricity and Sources of Electricity

Concept of Electricity

The definition of electricity is the flow of charge. Usually our charges will be carried by free-flowing electrons. Negatively–charged electrons are loosely held to atoms of conductive materials. With a little push we can free electrons from atoms and gate them to flow in a generally uniform direction.

Atomic Theory

"Atomic model" redirects here. For the unrelated term in mathematical logic, see Atomic model (mathematical logic for a history of the study of how atoms combine to form molecules, see History of molecular theory. The current theoretical model of the atom involves a dense nucleus surrounded by a probabilistic "cloud" of electrons in chemistry and physics, atomic theory is a scientific theory of the nature of matter, which states that matter is composed of discrete units called atoms.

Electric Charge

Electric charge is the physical property of matter that causes it to experience a force when placed in an electro-magnetic field. There are two types of electric charges; positive and negative (commonly carried by protons and electrons respectively).

Electron Theory

Electron theory states all matter is comprised of molecules, which in turn are comprised of atoms, which are again comprised of protons, neutrons and electrons. A molecule is the smallest part of matter which can exist by itself and contains one or more atoms.

Conductor and Insulator

Conductor is object or type of material that allows the flow of electrical current in one or more directions. Materials made of metals are common electrical conductor. An electrical insulator is a material that does not easily conduct an electric current. Materials typically used to insulate include rubber, plastic and glass.

10.2 Sources of Electricity

Electricity cannot be mined from the ground like coal. It is called secondary source of energy, meaning i.e. derived from primary sources, including coal, natural gas, nuclear fission reactions, sunlight, wind and hydropower. Electricity generation is the production of a current, normally caused by charged **Particles** moving through a material. In most cases, this material is a wire of some sort.

Sources and Methods of Electricity Generation

Electrical energy can be generated by multiple different sources, such as oil, gas, nuclear, or solar energy. Some of these are raw **materials**, some are other **forms of energy** that are then converted into electrical energy. The next thing we want to look at is the different forms of electricity generation. On Earth, there are two main categories that methods for generating electricity fall into, and you may have heard these terms before. One category is renewable and the other is non-renewable, and both categories have a series of sources or generation methods.

Wind Energy

Electricity can be generated via wind power through the use of wind turbines. Turbines are made to rotate by the wind, which is produced as a result of convection currents in the atmosphere. The motion of the wind pushes drive blades on the wind turbine, where the rotation of the blades connects to a system of gears that are linked to a generator. This generator is the part of the turbine that generates electricity. Wind power is a clean form of electricity generation. This method essentially converts the kinetic energy of air into kinetic energy of the blades which is finally converted into electrical energy.

Water Energy

Electricity generated by water comes in several forms, mainly because there are several different ways to convert kinetic energy into electricity via a generator. The three forms of electricity generation via water energy are wave power, tidal power and hydroelectric power. All power generation that uses water is a clean form of electricity generation.

- Wave power generates electricity thanks to the rise and fall of waves on the surface of the ocean. This upwards and downwards motion is a form of kinetic energy, and is used by buoys or pontoons to generate electricity via kinetic movement.

- Tidal power generates electricity from the extremely large amounts of water that move in and out of the mouth of a river during high and low tides. To harness this electricity, a structure called a tidal barrage is built across an estuary, which forces water between small gaps to make use of the kinetic energy of a tidal movement. These gaps in the tidal barrage contain electrical generators, and so they generate electricity.
- Finally, hydroelectric power is where a large damn is built to block the water in a higher up location. Hydroelectric dams take advantage of the gravitational potential energy of the water.
- Buoys or pontoons to generate electricity via kinetic movement.
- Tidal power generates electricity from the extremely large amounts of water that move in and out of the mouth of a river during high and low tides. To harness this electricity, a structure called a tidal barrage is built across an estuary, which forces water between small gaps to make use of the kinetic energy of a tidal movement. These gaps in the tidal barrage contain electrical generators, and so they generate electricity.
- Finally, hydroelectric power is where a large damn is built to block the water in a higher up location. hydroelectric dams take advantage of the gravitational potential energy of the water

Solar Energy

Electricity generated by solar power is caused directly by the sun shining on solar cells, or photovoltaic cells. Photovoltaic cells convert energy from light waves into electrical energy. Solar power is a renewable source, which means we can continue to generate electricity for as long as the sun is shining. It is also a clean source of electricity.

Biofuel

The final source of renewable electricity that we need to talk about is biofuel. Biofuel requires burning biological matter such as tree trunks to generate electricity. Burning biofuel is still a dirty process, however, unlike the other three energy sources we have discussed above.

The term biofuel is used as a catchall for any method of generating energy that has a biological material as its fuel source. Therefore, biofuel can be used for transportation as well as for generating electricity within a power plant and that electricity can be exported to the grid.

10.3 Importance and Purpose of symbols

An electrical symbol is a visual symbol that represents a particular type of electrical component in electronic devices such as wires, Batteries, etc. The electrical symbols are very important especially when fixing electrical appliances because it tells you where the wire of neutral and live go.

Table of Electrical Symbols

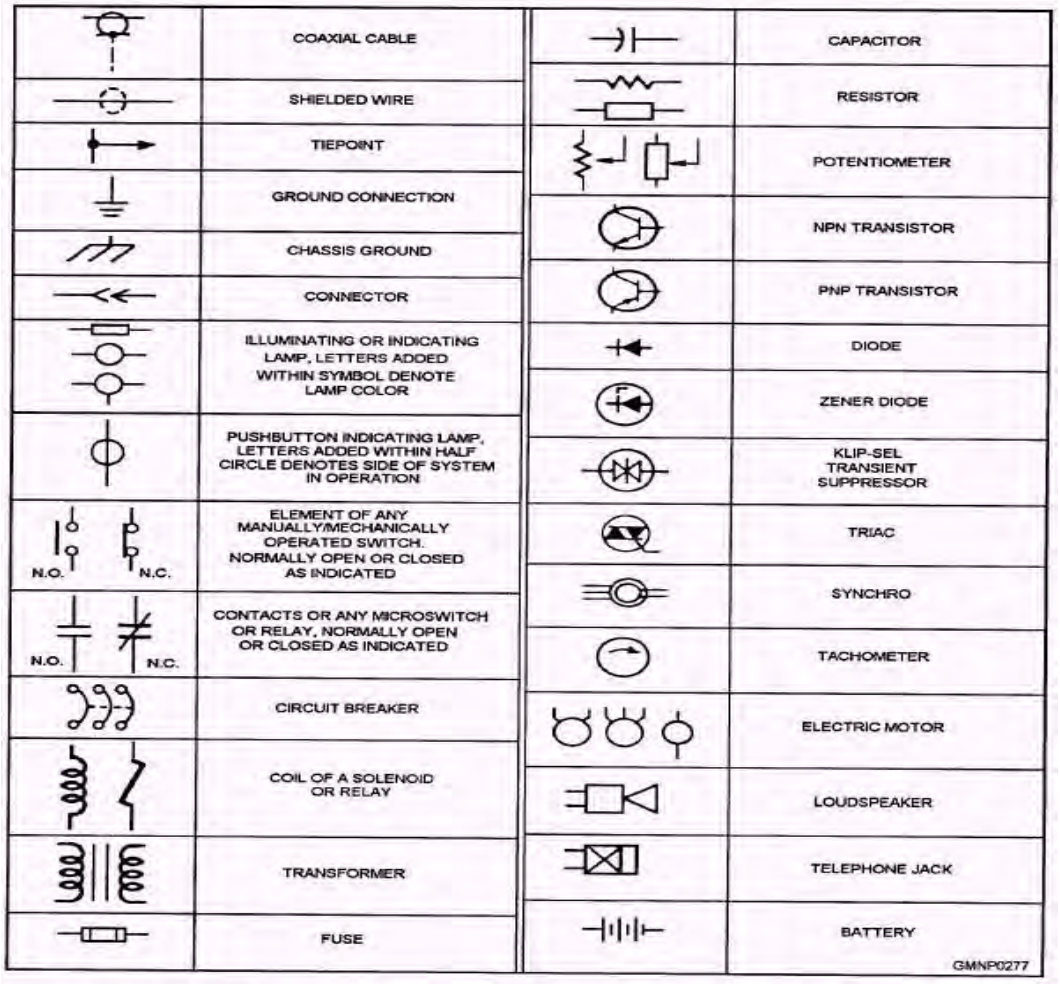


Fig: Electric Symbols

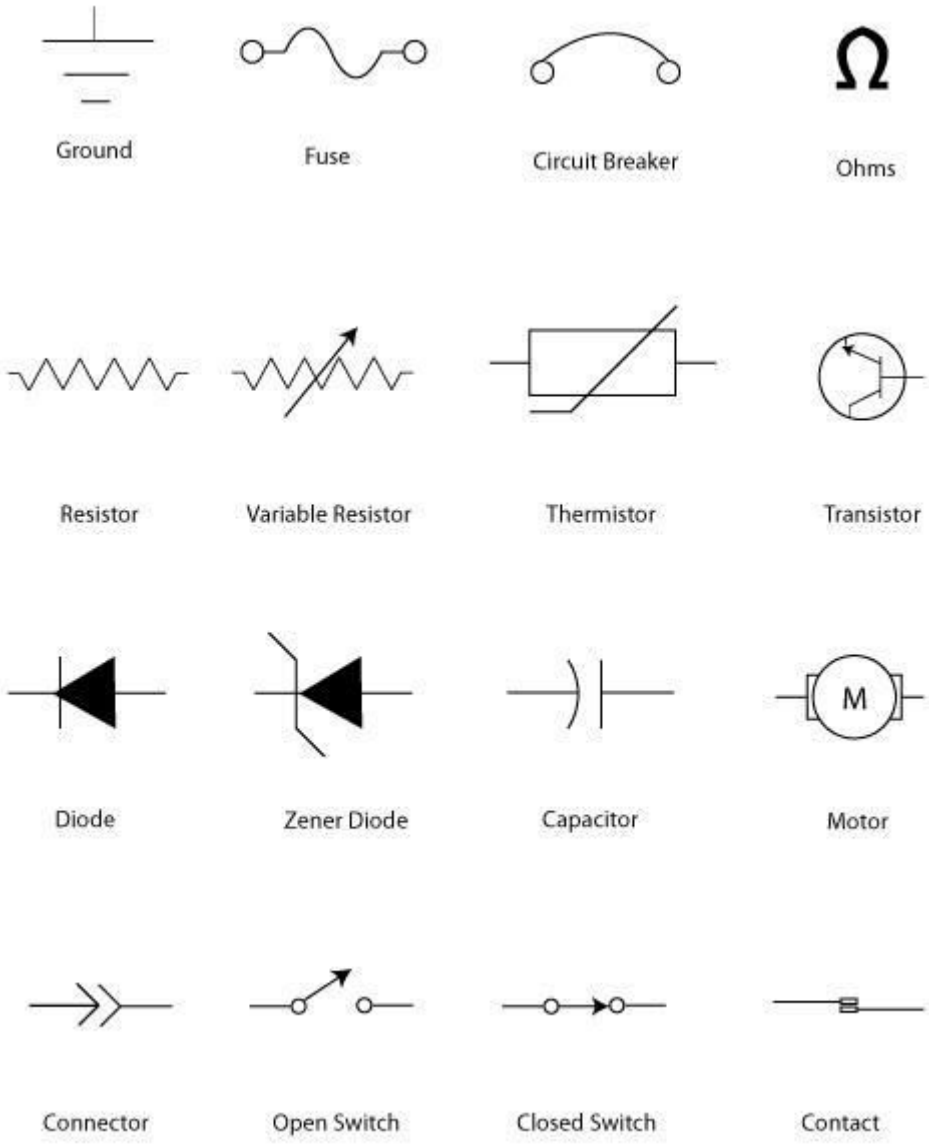


Fig : Electric symbols

10.4 House Wiring Process

Types of Electrical House Wiring Systems

1. Cleat Wiring

This wiring comprises of PVC insulated wires or ordinary VIR that are braided and compounded. They are held on walls and ceilings using porcelain cleats with groves, wood or plastic. It is a temporary wiring system, therefore making it

unsuitable for domestic premises. Moreover, cleat wiring system is rarely being used these days.

2. **Casing and Capping Wiring**

   It was quite popular in the past but it is considered obsolete these days due to the popularity of the conduit and sheathed wiring system. The cables used in this electric wiring were PVC, VIR or any other approved insulated cables. The cables were carried through the wooden casing enclosures, where the casing was made of a strip of wood with parallel grooves cut lengthwise for accommodating the cables.

3. **Batten Wiring**

   This is when a single electrical wire or a group of wires are laid over a wooden batten. The wires are held to the batten using a brass clip and spaced at an interval of 10 cm for horizontal runs and 15 cm for vertical runs.

4. **Lead Sheathed Wiring**

   Lead sheathed wiring uses conductors which are insulated with VIR and are covered with an outer sheath of lead aluminum alloy which contains about 95% lead. The metal sheath gives protection to cables from mechanical damage, moisture and atmospheric corrosion.

5. **Conduit Wiring**

   There are two types of conduit wiring according to pipe installation:

   - Surface Conduit Wiring When GI or PVC conduits are installed on walls or roof, it is known as surface conduit wiring. The conduits are attached to the walls with a 2-hole strap and base clip at regular distances. Electrical wires are laid inside the conduits.

     Concealed Conduit Wiring When the conduits are hidden inside the wall slots or chiseled brick wall, it is called **concealed conduit wiring**. Electrical wires are laid inside the conduits. This is popular since it is stronger and more aesthetically appealing.

Here are some Advantages and Disadvantages of Concealed Conduit Wiring System

Advantages

- It is a safe wiring system

- Safe from chemical effects, humidity and other external factors
- No risk of shock
- It is aesthetically appealing
- No risk of wear and tear, fire or damaged cable insulation
- Quite reliable
- Renovations can be easily performed as you can replace old wires easily

Disadvantages

- Expensive as compared to surface conduit wiring
- Changing the location of switches or appliances is difficult
- Installation is complex
- Hard to find defects in the wiring
- Adding additional conduit in future is a tedious task

When the wiring is not done properly or isn't maintained well, it may lead to dangerous situations such as electrical fires. Therefore, it is important that you take a lot of care while installing electrical wires and cables.

Step by Step House Wiring Process

Tools Required to Wire a House

It's a mostly straightforward process to wire a house, but there are some tools for the process:

Wire Strippers

This is one of the most essential tools you can have when working with wires and cables. Electricians depend on wire strippers, and you'll need to have a quality pair if it's your first time.

Cable Tester

Testing a cable is an essential step in wiring because it provides information about how the wire has been connected at either end or if there are any problems with the connections themselves.

Cables and Cable Boxes

You will need enough cables, wires, and cable boxes to wire your space. First, measure the length of cables you'll need, plus how many cable boxes you require to house everything.

Keep in mind, certain sized cable boxes only recommend housing a few cables in one to not overload the socket.

Wire Connectors

Wire connectors will go over the ends of your hot wires for safety until the outlets and wiring are complete.

Cordless Drill (Flexible)

You're going to want a quality drill that is electric and battery-powered—we don't recommend using a drill you have to plugin, as it will make things much more difficult. If you can, use a cordless drill that bends to reach odd angles. This will come in incredibly helpful when drilling through your studs in the corners.

Hammer

This is a tool you'll need to drive your wires into place. It's essential for installing cable staples. It can also act as a nail puller if you need it.

Tape Measure

This is one of the most important tools you'll need. You're going to want a quality tape measure that measures distances up to 30 feet with accuracy. A quality tape measure should be sturdy, accurate, and hold in place while marking your lengths with a pencil.

Masking Tape+Sharpie

Marking your cables is going to be essential to ensuring you label them correctly after they're threaded through the walls in your room. You can use masking tape or write directly on the cable with which wire it's for.

How to Wire a House: Step by Step

We're going to walk you through wiring a standard room in your home that would have outlets, light switches, and at least one light fixture in the ceiling. This can be applied to just about any room you wire and other standard electrical jobs around the house.

Step 1: Locate and Mark Box Locations

Before you begin to wire your room, it's essential that you first locate and mark the spots for any cable boxes or electrical outlets. You're going to want a pencil so that you can mark these locations on either side of the open wall space where they will go in with masking tape. You can also write directly on the wall if you haven't installed

your drywall yet. You will mark each box as either a duplex receptacle (dual outlet), single switch, three-way switch, or light fixture. You can summarize using initials or use the electrician symbols found **here.**

Step 2: Place Box on Your Frame

It's important to place the box on your frame to know where it will go and how high or low. You can either measure each wall with your tape measure and mark it with a pencil or use a level to ensure everything is flush. Standard heights for outlets are 12 inches, and light switches will be 48 inches. Next, drill your box into the exposed wood frame in the spot you want it, making sure to place a 2×4 behind it to make room for drywall and window frames.

Step 3: Drill Bore Holes for Running Your Cables

Next, you'll need to drill holes through the wall studs so you can run your electrical cables through them around the room. This ensures they don't sit on the ground behind the wall and stay nice and organized. The holes should be at least 3/4 inch in size and be at least 1 1/4 inch away from the wall or back of the stud. This ensures the cables are run right through the middle and don't touch any surrounding walls.

Step 4: Thread the Cable through the Holes

Now, thread the cable through the holes in each stud. This may take some time to do depending on how many cables you have going through it. You'll want to make sure they're threaded as smoothly and evenly as possible so that there are no bulges or kinks. Threading a single wire can be done by hand, but if you have more, you might need to use needle-nose pliers to push and pull them through.

Step 5: Cut the Cable to Length at the Box

Once you reach your cable to the intended circuit or switch box, cut it to size, leaving at least 12 inches of extra at first. The last thing you want is to cut it too short. Strip this last section of all but 1 to inches of sheathing to expose the wires.

Step 6: Run Cables to Your Main Circuit Panel

Now, take your exposed wires and run them to the main **circuit panel** in your home. These will be either at ground level or on a low shelf in an unfinished basement, utility room, or garage. You'll want to clearly label each cable to the room or circuit it's leading to. Using a sharpie to mark these before you run them to the service panel is a fail-proof way of doing so.

We highly recommend hiring a professional electrician to do this last part—connecting your newly wired cables to their corresponding circuits in the service panel. To make their jobs easy, make sure to leave 4 to 5 feet of cable extra for them to work with.

Step 7: Run and Strip the Wires and Cover The Ends

Each box will have pre-cut holes that you'll punch out using a screwdriver. These holes are where your cables go through to enter the box housing. Once you get the cables threaded through, you can staple them 8 to 10 inches from the box against the wall studs. This will keep them tight and secure with no extra hanging anywhere.

You will then strip the wires, so they are separate and ready to connect to your circuit or switch. Use a wire cover to cover each end to keep them safe until installation can be complete.

Step 8: Group and Label Your Wires

At this point, you'll need to group and label your wires. There are many ways of doing so—the best way is with a marker and electrical tape. You can also use zip ties if they're available or have wire labels for more specific grouping purposes. Then, when your remodel is completely done, you'll know which groups go to your **overhead lighting**, the outlets, or your light switch, etc.

Step 9: Finish Your Drywall

Complete your remodel! Make sure every bit of wiring is done before you finish the drywall. It's much easier to do this now than open the wall back up to make critical repairs.

Safety and Precaution

a) **Turn Off Power:** Always turn off the power at the circuit breaker or fuse box before starting any electrical work. Confirm that the power is off using a voltage tester.

b) **Use Proper Tools and Equipment:** Use insulated tools and equipment specifically designed for electrical work to prevent shocks and short circuits.

c) **Inspect Wires and Cables:** Before installation, inspect wires and cables for any damage or wear. Replace any compromised wiring to prevent electrical hazards.

d) **Follow Local Codes and Regulations:** Adhere to local building codes and regulations when planning and executing wiring projects to ensure safety and compliance.

e) **Use Correct Wire Sizes and Ratings:** Use wires with the correct gauge and insulation ratings for the intended purpose and load capacity to avoid overheating and electrical fires.

f) **Install Ground Fault Circuit Interrupters (GFCIs):** Install GFCIs in areas where water and electricity may come into contact, such as kitchens, bathrooms, and outdoor outlets, to protect against electrical shock.

g) **Avoid Overloading Circuits:** Distribute loads evenly across circuits and avoid overloading them to prevent overheating, tripped breakers, and potential fires.

h) **Securely Fasten and Protect Wires:** Securely fasten wires with staples or clamps and protect them from damage with conduit or tubing where necessary, especially in high-traffic areas.

i) **Label and Document:** Label circuit breakers clearly and document the wiring layout for future reference and troubleshooting to ensure safe maintenance and repairs.

j) **Test and Inspect after Installation:** After completing the wiring, test all outlets, switches, and fixtures with appropriate tools to ensure they are functioning correctly and safely before restoring power.

Step 10: Install Outlets, Switches, and Fixtures

Installing outlets, switches, and fixtures, involves connecting the wiring, securing the devices within the electrical boxes, and attaching the covers or faceplates. This step follows the previous steps of running wiring and installing boxes. It's crucial to ensure the power is turned off before starting any electrical work and to double-check the wiring before securing the devices.

Exercises

Choose the correct answer from the given alternatives.

1. The commercial sources of energy are.....
   a. Fossil fuels, water and radioactive substances
   b. Solar, wind, biomass
   c. Wood, animal wastes and agricultural wastes
   d. None of the above

2. Which of the following power plants is the least reliable?
   a. Wind
   b. Tidal
   c. Geothermal
   d. Solar

Write short answer to the following questions.

1. What do you mean by electricity? What are the sources of electricity? Explain in brief
2. Differentiate renewable and non –renewable sources of electricity.
3. Write down the steps of house wiring process.

Write long answer to the following questions.

1. Explain in detail six sources of electricity generation in detail
2. Explain the process of house wiring system in detail.

Project Work

1. Demonstration of different types wiring systems and explanation in classroom in group of 4-5 students.
2. Demonstration of materials and tools electrical circuit with explanation in Workshop in group of 4-5 students.
3. Cutting the section of ply and make domestic wiring circuit board for series and parallel connections in workshop and analyzing the result.
4. Introducing connections of different kinds switch, bulbs, sockets and connect them in workshop.

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