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Construction Skill Development Council

Participant Handbook

Sector
Construction Skill Development Council of India

Sub-Sector
Real Estate and Infrastructure Construction

Occupation
Bar Bending and Fixing

Reference ID: **CON/Q0202, Version 4.0**
NSQF Level 3

Assistant Bar Bender and Steel Fixer

Published by

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"Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission."

Shri Narendra Modi
Prime Minister of India

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Certificate

COMPLIANCE TO

QUALIFICATION PACK- NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

CONSTRUCTION SKILL DEVELOPMENT COUNCIL OF INDIA

for

SKILLING CONTENT:PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/Qualification Pack:'Assistant Bar Bender and Steel Fixer'

QP No.'CON/Q0202, Version 4.0 NSQF Level 3'

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Authorised Signatory
(Construction Skill Development Council)

Acknowledgements

This participant's handbook meant for Assistant Bar Bender and Steel Fixer is a sincere attempt to ensure the availability of all the relevant information to the existing and prospective job holders in this job role. We have compiled the content with inputs from the relevant Subject Matter Experts (SMEs) and industry members to ensure it is the latest and authentic. We express our sincere gratitude to all the SMEs and industry members who have made invaluable contributions to the completion of this participant's handbook.

This handbook will help deliver skill-based training in the Bar Bending and Steel Fixing field. We hope that it will benefit all the stakeholders, such as participants, trainers, and evaluators. We have made all efforts to ensure the publication meets the current quality standards for the successful delivery of QP/NOS-based training programs. We welcome and appreciate any suggestions for future improvements to this handbook.

About this book

This participant handbook has been designed to serve as a guide for participants who aim to obtain the required knowledge and skills to undertake various activities in the role of an Assistant Bar Bender and Steel Fixer. Its content has been aligned with the latest Qualification Pack (QP) prepared for the job role. With a qualified trainer's guidance, the participants will be equipped with the following for working efficiently in the job role:

- **Knowledge and Understanding:** The relevant operational knowledge and understanding to perform the required tasks.
- **Performance Criteria:** The essential skills through hands-on training to perform the required operations to the applicable quality standards.
- **Professional Skills:** The Ability to make appropriate operational decisions about the field of work.

The handbook details the relevant activities to be carried out by an Assistant Bar Bender and Steel Fixer. After studying this handbook, job holders will be adequately skilled in carrying out their duties according to the applicable quality standards. The handbook is aligned with the following National Occupational Standards (NOS) detailed in the latest and approved version of Assistant Bar Bender and Steel Fixer QP:

- **CON/N0214:** Read and understand reinforcement bar detail from hand sketches
- **CON/N0215:** Use and maintain materials, tools and equipment relevant to reinforcement works
- **CON/N0216:** Perform cutting and manual bending of rebar for simple shapes
- **CON/N0217:** Assist in fabrication, placing and fixing of rebar for pre-fabricated and in-situ RCC structures
- **CON/N0101:** Erect and dismantle temporary scaffold up to 3.6 meter height
- **CON/N8001:** Work effectively in a team to deliver desired results at the workplace
- **CON/N9001:** Work according to personal health, safety and environment protocol at construction site
- **DGT/VSQ/ N0101:** Employability Skills (30 Hours)

The handbook has been divided into an appropriate number of units and sub-units based on the content of the relevant QP. We hope it will facilitate easy and structured learning for the participants, allowing them to obtain enhanced knowledge and skills.

Symbols Used


Key Learning Outcomes


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It is recommended that all trainings include the appropriate Employability skills Module. Content for the same can be accessed https://www.skillindiadigital.gov.in/content/list

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1. Introduction to Bar Bending and Steel Fixing Occupation

Construction Skill Development Council

Unit 1.1 – Introduction to Bar Bending and Steel Fixing
Unit 1.2 – Role and Responsibilities of an Assistant Bar Bender and Steel Fixer

Key Learning Outcomes

By the end of this module, participants will be able to:

- Define the role of an assistant bar bender and steel fixer
- Explain the personal attributes required to be an assistant bar bender and steel fixer
- Recall the basic terms used in the occupation of bar bending and steel fixing
- Discuss future possible progression and career options for assistant bar bender and steel fixer

Unit 1.1 Introduction to Bar Bending and Steel Fixing

Unit Objectives

By the end of this unit, participants will be able to:

- Give an overview of the construction industry.
- Recall the basic terms used in the occupation of bar bending and steel fixing.

1.1.1. Construction Industry

The construction industry is the oldest and one of the largest in the world, with a market size of over 10 trillion dollars. Construction has traditionally been a contracting sector, and the industry consists of a huge number of small businesses. Currently, the building industry is one of the main economic sectors. It contributes significantly to the national economy and employs a substantial number of people.

Construction Industry in India

During the forecast period, India's construction market is expected to grow at a CAGR greater than 10%. (2022–2027). As COVID-19 spread over the country in April 2020, the Indian construction sector, which was already struggling with poor management and a lack of labour force tracking, totally lost its central grip, bringing an end to the business. COVID-19 caused havoc on all levels and scales of the value chain.

- The availability of building supplies and the rate of price rise were major concerns. The lack of timely implementation due to lockdowns led to cost overruns, significant delays, and even the cancellation of projects.
- Many MSMEs were compelled to close their doors or restrict their activities as a direct result of the cancellation and postponement of projects. This was a major concern because the majority of construction firms and design studios are small and specialize in a certain style of structure.
- Despite the impact of COVID-19 restrictions and lockdowns on construction activity, India experienced 45 million square feet of new supply in 2020, with 36 million square feet coming from tier I cities and 8.9 million square feet from tier II and III cities.
- The 3PL and e-commerce sectors, which accounted for 62 percent of total absorption in 2020, continued to drive warehouse demand in 2021, with the manufacturing sector accounting for 14 percent. Delhi-NCR had the highest absorption rate among India's major cities in 2021, at 18%, followed by Pune at 15%. 14 percent and 11 percent absorption rates were recorded in Mumbai and Bangalore, respectively, with 20 percent in tier II and tier III cities.
- In 2021, industrial and logistics sector investments surpassed USD 1.5 billion, making it the second-largest receiver of such money after the office sector. This asset category has maintained its popularity due to its strong growth rate and regular returns.

The commercial real estate subsector is poised for growth as individuals return to the workplace and organizations adopt hybrid work arrangements. As more companies send their employees back to work, the demand for commercial office space gradually increases.

1.1.2. Types of Construction

The following are the types of construction:

a. Building construction:

Building construction is the act of adding a structure to undeveloped ground and adapting it for various uses, including residences, commercial buildings, garages, etc. The bulk of building construction projects involve minor improvements, such as adding a room, renovating a bathroom, enhancing a porch, etc.

There are differences between building construction projects, but there are some aspects and procedures that are universal. For example: design considerations, a budgetary estimate, and ethical and legal factors.

In the case of commercial building construction, multiple strategies are utilised. They consist of Design & Build, Cost Estimating, Competitive Bidding, Contract Management, Construction Management, and Design-Build Bridging.

The governments of all states and nations have enacted laws and regulations governing the construction of both commercial and residential buildings. During the designing and building processes, these norms and regulations must be properly adhered to. The materials required for the construction process should be readily accessible at the construction site. Brick construction is the most common technique of house construction in India.

b. Industrial Construction:

Industrial construction represents a minor portion of the construction sector. Even so, it is regarded as quite vital. Planning the layout of an industry, establishing industrial sectors, installing heavy machinery, and planning and constructing the size of an industry are the procedures involved in industrial construction.

Infrastructure, power transmission and distribution, metallurgy and material handling, medicine, petroleum, chemical, power generation, manufacturing, etc. are the primary aspects to be considered.

This form of building requires extremely specific knowledge of planning, cost estimation, design, and construction. When a large construction business launches a project, it typically assigns the task of ensuring the project's success and safety to a team. Architects and civil engineers are employed to assist in the planning of construction projects. In this instance, construction entails the construction or assembly of infrastructure.

Large-scale building projects necessitate the completion of several jobs by a large number of individuals. Different jobs are provided to different teams. For instance, a Project Manager is responsible for Project management,

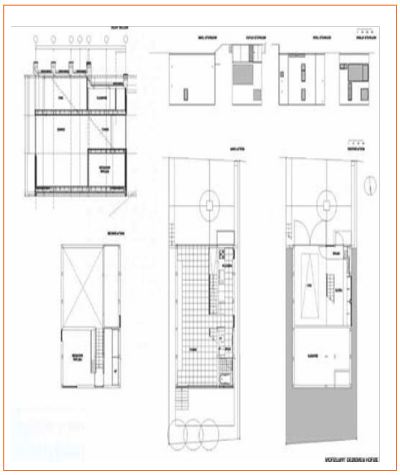

Fig. 1.1.1 Industrial Construction Site Plan

while a Construction Manager oversees Project construction. Additional examples include Design engineer, Project architect, and Financial Advisor. If a project is to be conducted successfully, the following must be ensured: Effective planning, successful scheduling, budgeting, construction site safety, availability of building materials, and logistics are essential for a successful construction project (that is transport of raw materials, etc).

c. Infrastructure Construction

Infrastructure, often known as heavy civil or heavy engineering, consists of massive public works, dams, bridges, highways, railroads, water or wastewater systems, and utility distribution. Civil engineering encompasses the design, building, and maintenance of the physical and naturally built environment, such as roads, bridges, canals, dams, tunnels, airports, water and sewage systems, pipelines, and railways.

Fig. 1.1.2 Under Construction Bridge

The infrastructure sector is an important economic driver in India. The sector is largely responsible for driving India's overall growth, and the government has placed a great deal of emphasis on implementing laws that will expedite the establishment of world-class infrastructure in the country. The infrastructure sector consists of power, bridges, dams, highways, and the development of urban infrastructure. In other words, the infrastructure sector functions as a catalyst for India's economic growth by driving the expansion of associated industries such as townships, housing, built-up infrastructure, and construction development projects.

1.1.3. Market Segment of Construction Industry

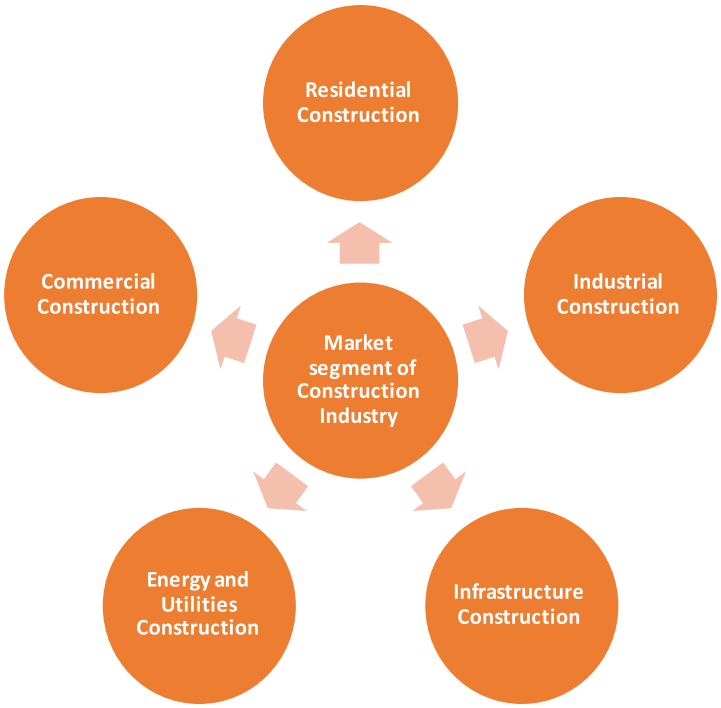

Fig. 1.1.3 Market segment of construction industry

1.1.4. Bar Bending and Steel Fixing

Bar bending and fixing, also known as reinforcement detailing, is an essential process in the construction industry that involves cutting and bending steel bars to specific shapes and sizes, and placing them in concrete to enhance its strength and durability. In India, bar bending and fixing is an integral part of the construction sector and plays a crucial role in the development of infrastructure and building projects.

Bar bending and fixing is also an area of continuous innovation, with new techniques and technologies being developed to improve the efficiency and accuracy of the process. The use of computer-aided design (CAD) software, for example, has made it possible to create precise 3D models of reinforced concrete structures, allowing engineers and construction professionals to optimize their designs and reduce the risk of errors and delays.

The global bar bending market is growing steadily, driven by the increasing demand for construction projects worldwide. According to a market research report published by MarketsandMarkets, the global rebar processing equipment market, which includes bar bending machines, is expected to reach USD 9.28 billion by 2022, growing at a CAGR of 5.2% between 2017 and 2022.

In India, the bar bending market is also expanding rapidly, primarily due to the country's focus on

infrastructure development and the growth of the construction industry. The scope of bar bending and fixing is vast and includes a wide range of projects such as bridges, dams, highways, tunnels, high-rise buildings, and residential complexes. The process of bar bending and fixing requires specialized skills and knowledge of the technical specifications and design requirements of each project.

According to a report by ResearchAndMarkets, the Indian rebar processing equipment market is expected to grow at a CAGR of 4.16% between 2019 and 2025. The report also highlights the increasing adoption of automated bar bending machines in the Indian construction sector, which is expected to drive the growth of the market in the coming years.

The demand for bar bending machines in India is also driven by the government's initiatives to promote affordable housing and infrastructure development projects such as the Bharatmala Pariyojana, Sagarmala, and Smart Cities Mission. The Indian government has allocated significant funds for these projects, which has led to an increase in construction activities and the demand for bar bending machines.

In addition to the construction sector, the bar bending market also has significant applications in other sectors such as manufacturing, automotive, and aerospace. The growing demand for infrastructure and industrial development is expected to continue to drive the growth of the global and Indian bar-bending market in the coming years.

1.1.5. Bar Bending and Steel Fixing Terminology

Some of the basic terms used in the occupation of bar bending and steel fixing:

1. **Rebar:** Short for "reinforcing bar," rebar is a steel bar used to reinforce concrete structures. Rebar is available in various sizes and grades, depending on the strength required for the application.
2. **Reinforcement:** Steel bars or wires used to reinforce concrete structures.
3. **Bend diameter:** The bend diameter is the minimum diameter around which a rebar can be bent without causing damage or compromising its strength.
4. **Lap length:** The lap length is the length of overlap between two pieces of rebar that are joined together to create a continuous length of reinforcement.
5. **Stirrups:** Stirrups are short pieces of rebar that are used to reinforce concrete columns and beams. They are bent into a U-shape and placed at regular intervals along the length of the column or beam.
6. **Tie wire:** Tie wire is used to secure rebar in place and to tie together overlapping pieces of rebar. Tie wire is typically made of steel or a steel alloy and is available in various gauges.
7. **Bar bending schedule:** A bar schedule is a document that details the quantity, size, and location of each piece of rebar required for a particular construction project.
8. **Bending machine:** A bending machine is a piece of equipment used to bend rebar to the required specifications. There are manual bending machines as well as electric or hydraulic ones that can handle larger diameter rebar and produce consistent bends.

9. **Bar chair:** A device used to support reinforcement bars at a specific height from the formwork.
10. **Bar spacing:** The distance between two parallel reinforcement bars.
11. **Bar mark:** A unique identification number given to each reinforcement bar.
12. **Dowel Bar:** Steel reinforcement bars used to transfer loads from one concrete section to another.
13. **Hook:** A bend at the end of a reinforcement bar used to anchor the bar in the concrete.
14. **Rebar coupler:** A device used to join two reinforcement bars together.
15. **Development length:** The length of reinforcement required to transfer the load from the bar to the concrete.
16. **Cover:** The distance between the surface of the reinforcement bar and the nearest surface of the concrete.

Notes

Scan the QR code to watch the video

https://youtu.be/nndLyZrGfWc

Construction Industry

https://youtu.be/1WVzo2UFyo8

Types of Construction

Unit 1.2 Role and Responsibilities of an Assistant Bar Bender and Steel Fixer

Unit Objectives

By the end of this unit, participants will be able to:

- Describe the role and responsibilities of an Assistant Bar Bender and Steel Fixer
- Discuss future possible progression and career options for an Assistant Bar Bender and Steel Fixer

1.2.1. Assistant Bar Bender and Steel Fixer

An assistant bar bender and steel fixer is a skilled labourer who works in the construction industry. Their primary role is to assist the bar bender and steel fixer in preparing and installing reinforcing steel bars or rebar, which are used to reinforce concrete structures. An assistant bar bender and steel fixer plays a crucial role in ensuring that the reinforcing steel bars are installed correctly and securely, helping to create safe and durable structures.

1.2.2. Role and Responsibilities of an Assistant Bar Bender and Steel Fixer

Some of the specific responsibilities of an assistant bar bender and steel fixer may include:

1. Cutting and bending rebar to the required specifications using cutting and bending machines or manual tools.
2. Transporting and positioning rebar in the appropriate locations within the construction site, based on the design drawings.
3. Securing and fastening rebar using wire or tie tools, and ensuring that they are properly placed and aligned.
4. Assisting with pouring concrete and ensuring that the rebar is embedded in the concrete at the correct depth and spacing.
5. Cleaning up the construction site and maintaining tools and equipment.

1.2.3. Personal Attributes required by an Assistant Bar Bender and Steel Fixer

To be an effective and successful assistant bar bender and steel fixer, there are several personal attributes that are important to possess. These include:

1. **Physical fitness and stamina:** The job of an assistant bar bender and steel fixer requires a lot of physical labor, including heavy lifting and standing for long periods of time. Therefore, it is essential to have good physical fitness and stamina to be able to perform these tasks effectively and safely.
2. **Attention to detail:** Installing reinforcing steel bars requires precision and accuracy. As such, it is essential to have a keen eye for detail to ensure that the rebar is cut, bent, and installed to the exact specifications required.
3. **Teamwork and collaboration:** Working as an assistant bar bender and steel fixer requires collaboration with other construction professionals, including engineers, architects, and other tradespeople. Therefore, being a team player and possessing strong communication and interpersonal skills is essential.
4. **Safety awareness:** Working in the construction industry can be dangerous, and there are many hazards that must be avoided. As such, it is essential to be safety conscious and follow all safety protocols and procedures.
5. **Willingness to learn:** The construction industry is constantly evolving, and new technologies and techniques are being introduced all the time. Therefore, it is essential to have a willingness to learn and a desire to continually improve one's skills and knowledge.

1.2.4. Career Progression of an Assistant Bar Bender and Steel Fixer

There are many opportunities for assistant bar benders and steel fixers to progress and advance in their careers, whether by moving up the ranks on a construction site or branching out into other areas of the industry. The key is to gain experience, develop skills, and continually seek out new opportunities for growth and development. There are several potential career paths for assistant bar benders and steel fixers who wish to progress and advance their careers. Here are a few possibilities:

1. **Senior Bar Bender and Steel Fixer:** With experience and training, an assistant bar bender and steel fixer can progress to become a senior bar bender and steel fixer, responsible for overseeing the work of other workers on the site and for ensuring that all rebar installation is completed to a high standard.
2. **Site Supervisor:** A site supervisor is responsible for managing the day-to-day operations of a construction site, including overseeing the work of various trades, including bar benders and steel fixers. Site supervisors are responsible for ensuring that the work is completed on time, to a high standard, and within budget.
3. **Estimator:** Estimators are responsible for preparing cost estimates for construction projects, including the cost of materials and labour. Assistant bar benders and steel fixers who are interested in moving into this role will need to develop their knowledge of construction materials and techniques, as well as gain experience in cost estimation.
4. **Project Manager:** A project manager is responsible for overseeing all aspects of a construction project, including planning, design, construction, and completion. Assistant bar benders and steel fixers who have gained experience in construction projects and have developed strong project management skills may be well-suited to this role.
5. **Entrepreneurship:** With experience and skills in bar bending and steel fixing, assistant bar benders and steel fixers can start their own business as subcontractors or work on their own as a self-employed person, taking on projects from clients.

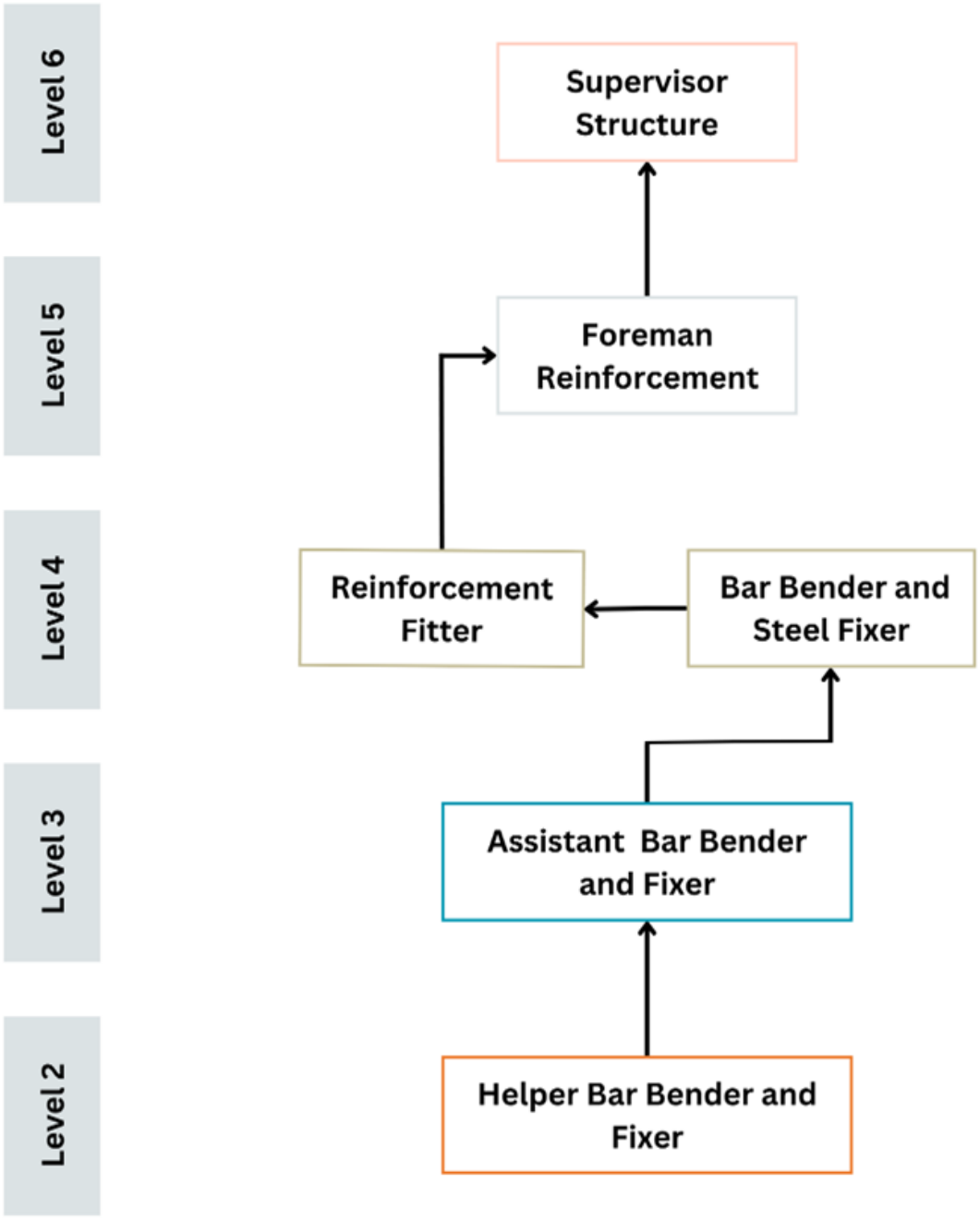

Fig. 1.2.1 Career Progression of an Assistant Bar Bender and Steel Fixer

Exercise

1. Explain the types of construction in brief.
2. What is Bar Bending and Fixing? Explain its scope.
3. What are the roles and responsibilities of an assistant bar bender and steel fixer?
4. List the career opportunities available for an assistant bar bender and steel fixer.
5. Fill in the blanks.

(Hint: bending machine, bar bending schedule, bar mark, reinforcing bar, u-shape)

a. Rebar is short form for _____.
b. Stirrups are bent into a _____ and placed at regular intervals along the length of the column or beam.
c. _____ is a document that details the quantity, size, and location of each piece of rebar required for a particular construction project.
d. _____ is a piece of equipment used to bend rebar to the required specifications.
e. _____ is unique identification number given to each reinforcement bar.

Notes

Scan the QR code to watch the video

https://youtu.be/H1qFaFQPZ-0
Assistant Bar Bender and Steel Fixer

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2. Interpret Reinforcement Bar Detail from Hand Sketches

Unit 2.1- Interpret Reinforcement Hand Sketches

CON/N0214

Key Learning Outcomes

By the end of this module, participants will be able to:

- List different systems of linear measurement
- Apply the basic knowledge of units, measurement and arithmetic calculation relevant to bar bending work
- Describe the different types of reinforcement bars, their grade and standard size
- Determine diameter, cutting length, cover, number and shape of reinforcement bars from hand sketch
- Determine spacing details for stirrups, chairs, space bars etc. by interpreting hand sketches relevant to bar bending works.

Unit 2.1 Interpret Reinforcement Hand Sketches

Unit Objectives

By the end of this unit, participants will be able to:

- List different systems of linear measurement
- Apply the basic knowledge of units, measurement and arithmetic calculation relevant to bar bending work
- Describe the different types of reinforcement bars, their grade and standard size
- Determine diameter, cutting length, cover, number and shape of reinforcement bars from hand sketch
- Determine spacing details for stirrups, chairs, space bars etc. by interpreting hand sketches relevant to bar bending works.

2.1.1. Reinforcement bar

A reinforced concrete structure is typically made up of several components namely, foundation, column, beams, slabs, walls, footings and reinforcing steel.

Fig. 2.1.1 Reinforcing Bar

Reinforcing steel, also known as rebar or reinforcing bar, is used to reinforce the concrete and provide additional strength and durability. Concrete has a high compression strength but a poor tensile strength. Rebar greatly boosts the structure's tensile strength. A continuous series of ribs, lugs, or indentations are present on the surface of rebar to improve concrete bonding and lessen the possibility of slippage. It is typically made of high-strength steel and is placed in the concrete according to a detailed plan called a rebar sketch.

Steel is exclusively used for rebar because its thermal expansion coefficient, which measures how much steel stretches when exposed to high temperatures, is almost identical to that of concrete. The standard length in which reinforcement bars are available in the market is 12 metres.

Types of Rebar

There are several types of rebar used in construction projects, each with its own unique properties and applications. The most common types of rebar include:

1. **Plain Mild Steel Bars:** In India, plain mild steel bar first appeared in the early 19th century. Around the year 1907, the first reinforced concrete construction project in India used Grade FE250 mild steel rebar to construct the hostel for the VJTI engineering college in Bombay.

Fig. 2.1.2 Plain Mild Steel Bar

These steel bars feature a smooth surface and circular sections with diameters ranging from 6 mm to 50 mm. Cutting these rebars is simple. The yield stress, which is indicated on the bar as "FE250," where FE stands for iron and 250 represents yield stress, is used to identify the grade of this rebar. The yield point is measured where the stress point on the tensile strength test is 0.2%, or 0.02. Steel with medium tensile strength ranges in grade from FE250 to FE330.

The following types of plain steel bar are listed in IS 432:1982(part I):

a. Mild steel
b. Medium tensile steel

2. **Plain Carbon/Back Steel Bar:** This is the most commonly used type of rebar, made from carbon steel and often referred to as black rebar. It has good strength and is suitable for most applications. It is used to hold the concrete in compression in reinforced concrete and reinforced masonry constructions as a tensioning device.

Fig. 2.1.3 Carbon Steel Rebar

According to American Society of Testing Materials, the grade for Deformed and Plain Carbon Steel Bars for concrete reinforcement is ASTM A615/M615.

3. **Deformed Steel Bar:** The surface of deformed steel bars has lugs, ribs, and other deformations that strengthen the interaction between steel and concrete. High yield, bond, and tensile strengths are seen in deformed bars. Deformed bars don't need hooks at the ends since they have a stronger connection than normal mild steel bars.

Deformed steel bars can be divided into two categories according to their rebar kinds.

Cold twisted bars: High-strength deformed bars (HSD) are converted into cold twisted bars (CTD) by a variety of cold working techniques (stretching and twisting).Compared to regular mild steel bars, CTD bars have a 50% higher major yield stress. These rebars range in size from 4 mm to 50 mm. These bars are referred to as TOR steel in India.

TMT bars: Thermo mechanical treatment, or TMT bar goes through a sophisticated procedure that creates a harder outer layer surface around a softer core by quenching red-hot rebars with a sequence of water jets. These kinds of rebar are frequently used as reinforcement for building, bridge, road, and other construction projects.

Fig. 2.1.4 Deformed Steel Rebar

4. **Epoxy-Coated Rebar:** This type of rebar has an epoxy coating that protects it from corrosion and rust, making it ideal for structures that are exposed to harsh weather conditions or saltwater environments. The corrosion resistance of the epoxy coating is 70 to 1,700 times greater than that of black bar.

   Unfortunately, it is extremely fragile and prone to breakage, which lowers the effectiveness of the epoxy coating.

   These green rebars may be utilised for a variety of purposes, including maritime constructions, bridges, infrastructure, buildings, and roads.

Fig. 2.1.5 Epoxy-Coated Rebar

5. **Galvanized Rebar:** This type of rebar is coated with a layer of zinc that provides excellent protection against corrosion and rust. It is ideal for use in structures that are exposed to saltwater or other corrosive environments. Rebars made of carbon steel are 40 times less resistant to corrosion than galvanised rebars.

   They are more expensive than black bars, though. These bars are appropriate for buildings that will be exposed to a lot of dampness and humidity.

Fig. 2.1.6 Galvanized Rebar

6. **Stainless Steel Rebar:** This type of rebar is made from stainless steel, which provides excellent corrosion resistance and is ideal for use in structures that require exceptional durability and strength. One of the best types of rebar to use where great corrosion resistance is desired or where expensive and complex repairs are required is stainless steel rebar.

Fig. 2.1.7 Stainless Steel Rebar

These rebars are, however, at least eight times more expensive than epoxy-coated rebars. The following are some benefits of using stainless steel rebars:

- Very robust and extended lifespan,
- More corrosion resistant by 1500 times than black bars.
- No upkeep is necessary.
- Are not harmed in transit or during installation.

7. **Glass-Fiber-Reinforced-Polymer (GFRP) Rebar:** These are fibreglass reinforcing bars, also known as fiberglass-reinforced polymer reinforcing bars. This type of rebar is made from a composite material that consists of glass fibers and polymer resin. It is non-corrosive and has a high strength-to-weight ratio, making it ideal for use in structures that require exceptional durability and lightweight design.

Fig. 2.1.8 GFRP Rebar

The advantages of GFRP are:

- It won't corrode under any circumstances, even salt exposure.
- Compared to steel, these bars have a higher tensile strength.
- Superior thermal insulator and non-conductive electrical qualities compared to steel rebar
- Saves money on shipping and material handling because of its lighter weight.

The choice of rebar type depends on the specific requirements of the project and the conditions in which the structure will be built. The local building codes and regulations may also specify which types of rebar are allowed for different types of structures.

2.1.2. Rebar Grades

Rebar comes in different grades and sizes, each with its own specific properties and applications. The most common rebar grades used in construction projects are:

Grade 40: This is the lowest grade of rebar and is typically used in smaller, non-load bearing structures such as sidewalks and driveways.

Grade 60: This is the most common grade of rebar used in construction projects and is suitable for most applications, including building foundations, retaining walls, and reinforced concrete beams.

Grade 75: This grade of rebar is used for more heavy-duty applications, such as large building structures and bridges.

Grade 80: This is the highest grade of rebar and is typically used in specialized construction projects, such as the construction of high-rise buildings or other structures that require exceptional strength and durability.

2.1.3. Rebar Sizes

Rebar comes in various sizes and diameters, with each size having its own specific properties and applications. The most common rebar sizes used in construction projects are:

#3 (3/8 inch diameter): This size of rebar is commonly used for lightweight and residential projects such as patio slabs and footings.

#4 (1/2 inch diameter): This size of rebar is commonly used for medium-duty and residential projects such as driveways and retaining walls.

#5 (5/8 inch diameter): This size of rebar is commonly used for medium to heavy-duty projects such as reinforced concrete walls and beams.

#6 (3/4 inch diameter): This size of rebar is commonly used for heavy-duty projects such as large-scale buildings and bridges.

#7 (7/8 inch diameter): This size of rebar is commonly used for heavy-duty projects such as large-scale buildings and bridges.

#8 (1 inch diameter): This size of rebar is commonly used for heavy-duty projects such as high-rise buildings and large-scale infrastructure projects.

Designation number of bar (Bar size)	Metric designation number	Nominal diameter in inches (excluding deformations)	Nominal Mass (kg/m)	Nominal Diameter (mm)
3	10	0.375	0.560	9.5
4	13	0.500	0.994	12.7
5	16	0.625	1.552	15.9
6	19	0.750	2.235	19.1
7	22	0.875	3.042	22.2
8	25	1.00	3.973	25.4
9	29	1.128	5.059	28.7
10	32	1.270	6.404	32.3
11	36	1.410	7.907	35.8
14	43	1.693	11.380	43.0
18	57	2.257	20.240	57.3

Table 2.1.1 Rebar Size

The type, size and grade of rebars may vary by country and region. Local building codes and regulations may specify which type, sizes and grades are allowed for different types of structures.

2.1.4 Rebar Marks

As all rebar kinds resemble one another in terms of appearance, it might be challenging to tell them apart. This can cause unneeded confusion, a likely rise in material prices, and a delay in finishing tasks. Rebar is marked in a variety of ways that make it easier to recognise the reinforcing bar specifically. ASTM reinforcement bar (rebar) markings are among the most used marking methods for revealing details about the materials used to make rebar and their production processes.

The American Society for Testing and Materials, formerly known as ASTM International, is a company that creates and publishes technical standards for a variety of materials, systems, goods, and services. Also, it has released specifications for reinforcing bars that are extensively used across the world.

A number of marks are etched onto each rebar while it is being made. The genuine nature of the bar is revealed by these distinctive insignia. Four primary marking symbols are used.

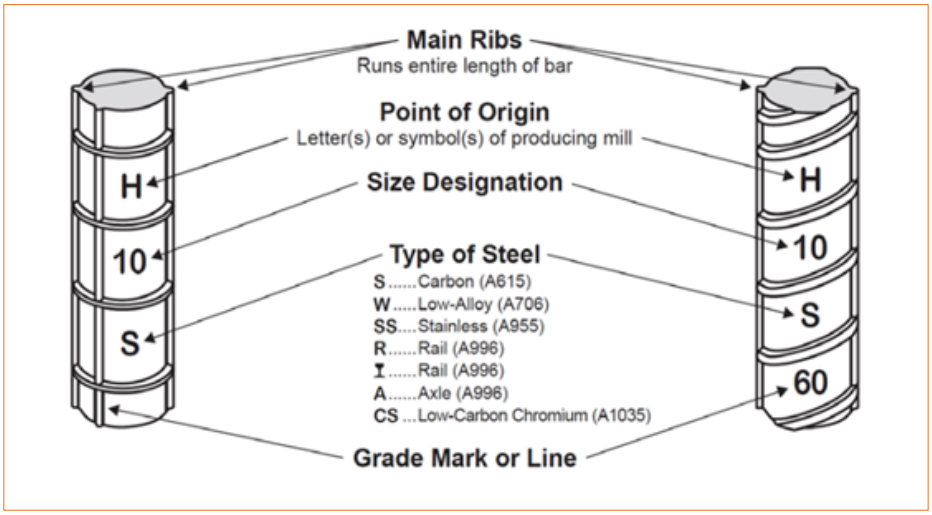


Fig. 2.1.9 Rebar Marks

1. **Manufacturer's code:** The first mark shows the reinforcing bar's manufacturing mill or manufacturer. It is either a pre-designated alphabet or a pre-designated symbol for the company.

2. **Numerical code indicating the bar's size:** The standard bar designation number expresses the numerical code identifying the bar's size. The nominal diameter of the bar up to size 8 is represented by the standard bar identification number as the number of eighths of an inch. As an illustration, a bar with identification number 4 has the same mass per foot as a plain bar with a diameter of 4/8 inch (0.500 inches).

3. **Letter code for the steel type:** The kind of steel is indicated by the third letter, an alphabet. Each of the five alphabets has an ASTM standard and represents one of five distinct grades of steel. It is as follows:

S: Billet steel is abbreviated as S. It has ASTM specification version known as A615-81 "Standard Specifications for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement"

I: I is abbreviated for rail steel. The ASTM specification version known as A616-79, "Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement."

A: Axial Steel A617-79, the "Standard Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement," is an ASTM specification version for axial steel.

W: W stands for low alloy steel. It has an ASTM specification version known as A706-80, "Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement."

4. **Grade of Steel:** The bar's steel grade is indicated by the fourth marking (or absence of a marking). The tensile strength of the bar is indicated by the grade in pounds per square inch.

   The number of lines taking up at least five spaces and indicating the grade. It is situated between the two major ribs and is smaller in size. Grades 40 through 60 are represented by one line, grades 70 by two lines, and grades 80 by no lines.

2.1.5. Rebar Sketch

A rebar sketch, also known as a reinforcement drawing, is a detailed plan that specifies the placement and dimensions of reinforcing bars in a reinforced concrete structure. The components of a rebar sketch typically include:

1. **Title block:** This section includes the title of the drawing, project name, date, sheet number, and other relevant information.
2. **General notes:** This section includes general information about the reinforcement work, such as the type of reinforcing steel to be used, the minimum concrete cover, and any special instructions.
3. **Plan view:** This section provides a bird's-eye view of the concrete structure and the reinforcing bars. It includes the location, size, and spacing of the reinforcing bars, as well as any bends or shapes.
4. **Section view:** This section provides a cross-sectional view of the concrete structure and the reinforcing bars. It includes the location and spacing of the reinforcing bars in relation to the concrete section.
5. **Bar schedule:** This section provides a list of all the reinforcing bars used in the concrete structure, including the diameter, length, shape, and placement.
6. **Bar bending details:** This section provides detailed information about the bending and shaping of the reinforcing bars, including the bending angle, radius, and length of straight sections.
7. **Details of connections:** This section provides details about the splices and connections between reinforcing bars, including lap lengths, mechanical couplers, and welding details.

2.1.6. Symbols in Rebar Sketch

Reinforcement hand sketches for bar bending typically use a set of standardized symbols to indicate the shape and orientation of the reinforcing bars. These symbols are used to communicate the required bending, cutting, and placement of the rebar. Here are some common symbols used in reinforcement hand sketches for bar bending:

S. No	Description	Symbol
1	Plain round bar or Diameter of Plain round bar	ϕ
2	Plain Square Bar or Side of Plain Square Bar	□
3	Deformed Bar or Side of Deformed Bar	#

Table 2.1.2 Structural rebar symbols

S. No	Description	Symbol
1	Alternate Bar	**Alt**
2	Bent Bar	**Bt**
3	Bottom Bar	**B**
4	Straight Bar	**St**
5	Stirrups	**Stp**
6	Spiral	**Sp**
7	Column Tie	**Ct**
8	Top Bar	**T**

Table 2.1.3 Shape of rebar

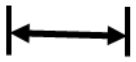
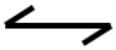
S. No	Description	Symbol
1	Each Way	EW
2	Centre to centre distance between rebars	c/c
3	Limit of area covered by bars	
4	Direction in which bars extend	

Table 2.1.4 Position and direction symbols

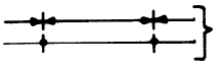
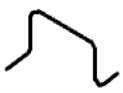
S. No	Description	Symbol
1	Concrete Line(Thin)	
2	Masonry Wall Line (Thin)	
3	Reinforcement (Thick)	
4	Dimension Line	
5	Right-angle-bent bar depicted in relation to the paper	
6	Bar with Hooks	
7	Bar with 90° Bends	
8	Chair Bar	

Table 2.1.5 Graphic symbols

These symbols are usually accompanied by dimensions and other notes to provide additional information on the required bending and placement of the reinforcing bars.

2.1.7 Reading a Rebar Sketch

Reading rebar hand sketches is an important skill for engineers, architects, and construction professionals involved in designing and constructing reinforced concrete structures. It involves understanding the dimensions, shapes, and placement of the reinforcing bars. Here are some steps to be followed:

Step 1: Identify the Drawing Scale

The first step in interpreting a rebar hand sketch is to identify the drawing scale. The scale indicates the proportion between the dimensions on the drawing and the actual dimensions of the structure. For example, a 1:50 scale means that every 1cm on the drawing represents 50cm in the actual structure.

Step 2: Identify the Key Plan

The key plan is a simplified diagram that shows the main structural elements of the structure, such as columns, beams, and slabs. Identify the key plan on the sketch, and use it to understand the overall layout of the structure.

Step 3: Identify the Reinforcement Details

The rebar hand sketch will show the dimensions, spacing, and placement of the reinforcement bars in the structure. Identify the details of the reinforcement bars, such as the bar diameter, number of bars, length, and spacing between bars.

Step 4: Identify the Bar Bending Shapes

The bar bending shapes indicate the shape and dimensions of each bar, including the angles of bends and the lengths of straight sections. These shapes are shown in plan and elevation views, and may also include details of hooks and bends.

Step 5: Determine the Bar Schedule

The bar schedule shows the exact location of each bar in the structure. Use the key plan to identify the location of each bar, and use the bar schedule to determine the reference point, spacing, and orientation of each bar.

Step 6: Calculate the Cutting Lengths

The cutting length is the length of each bar required to achieve the desired shape after bending. Calculate the cutting length using the dimensions and angles indicated on the bar bending shape.

Step 7: Verify Compliance with Design Standards

Verify that the reinforcement details and bar bending shapes comply with the design standards and codes, such as the ACI (American Concrete Institute) code. Check that the reinforcement provides

adequate strength and durability for the intended use of the structure.

Step 8: Prepare a Bar Bending Schedule

Based on the rebar hand sketch, prepare a bar bending schedule that provides a detailed list of the reinforcement details, bar bending shapes, bar schedule, cutting lengths, and fabrication details.

2.1.8. Reading Spacing Details

To read spacing details from a hand sketch, one should:

1. Look for the symbols or notes on the sketch that indicate the size, spacing, and placement of the rebar, stirrups, bar chairs, and spacer bars.

2. Identify the spacing requirements for the stirrups. The spacing will typically be indicated by notes or symbols such as “S1” or “S2”, and will specify the distance between each stirrup along the length of the rebar.

3. Determine the spacing requirements for the main and secondary rebar. The spacing for the main rebar will be indicated by notes or symbols such as “C/C” or “O.C.”, and will specify the distance between each bar along the length of the structure. The spacing for the secondary rebar will typically be indicated by symbols such as “X” or “XX”, and will specify the distance between each bar in the transverse direction.

4. Identify the required height of the bar chairs, as well as the spacing and placement of the chairs. Bar chairs are typically used to support the reinforcing bars at a specific height above the formwork or ground. The height and spacing of the bar chairs will typically be indicated by notes or symbols such as “H” or “CH”, and will specify the distance between each bar chair along the length of the structure.

5. Determine the required spacing and placement of the spacer bars. Spacer bars are typically used to maintain the proper spacing between the reinforcing bars, and will be indicated by symbols such as “SB”. The spacing and placement of the spacer bars will typically be indicated by notes or symbols such as “S1” or “S2”, and will specify the distance between each spacer bar along the length of the structure.

6. Double-check that all the spacing details comply with the design standards and codes for the specific structure.

2.1.9. Basic Mathematics in Bar Bending and Fixing

Bar bending and fixing in reinforcement work require basic mathematics to determine the length, size, and placement of the reinforcing bars. Here are some basic mathematical concepts used in bar bending and fixing:

1. **Measurement:** Measurement is the foundation of bar bending and fixing. Measurements are taken using a measuring tape, steel rule, or other measuring devices to determine the length, width, and height of the concrete structure, and to mark the positions of the reinforcing bars.

Systems of Linear Measurement

The most basic type of measuring is linear measurement. It is the process of calculating the separation between two points. The inch, which is the distance between two points at the end of a ruler, is the most typical sort of linear measurement. The foot, the yard, and the mile are more examples of linear units of measurement.

There are numerous linear measurement standards. The Imperial and Metric systems are the most widely used.

The English or Imperial System of linear measurement is used in the United States. Linear refers to a straight or in a line. Inches, feet, and yards are the three units of measurement used in Imperial System. The metric system is a measurement system that is used to measure distance, length, volume, weight, and temperature. It is built on three basic units that can be used to measure nearly anything in the world.

- M- metre, used to measure the length
- Kg- kilogram, used to measure the mass
- S- second, used to measure time

2. **Geometry:** Geometry is used to calculate the length and angles of the reinforcing bars, and to determine the bending and cutting points. Basic geometry concepts such as Pythagoras theorem, trigonometry, and basic angle relationships are used to calculate the lengths and angles of the reinforcing bars.

Determination of Geometric Areas:

a. Triangles
b. Quadrilaterals
c. Circles
d. Angles
e. Basic Trigonometry

6. **Algebra:** Algebra is used to calculate the quantities of reinforcing bars required, and to solve problems involving unknown quantities. Basic algebraic concepts such as equations, formulas, and solving for variables are used in reinforcement work.

7. **Unit conversion:** Unit conversion is used to convert measurements from one unit to another, such as from feet to meters or from inches to millimeters. Basic arithmetic and unit conversion formulas are used in reinforcement work.

8. **Estimation:** Estimation is used to estimate the quantities of reinforcing bars required based on the dimensions of the concrete structure and the required strength. Basic estimation techniques used in reinforcement work are rounding, approximation, and using standard sizes.

2.1.10. Bar Bending Schedule

A tabular depiction of reinforcing bar is known as a bar bending schedule or schedule of bars. The basic description of a bar bending schedule includes the specifics of the bars, the shape of the bending with illustrations, the overall length and weight of the bars, as well as their numbers.

Bars come in a variety of forms that are used for reinforcing. The load calculation affects the reinforcing design. Different bar sizes are estimated from bbs reinforcement, and then the bars are cut and bent suitably on site.

A bar bending schedule is typically created while estimating a R.C.C. job or construction.

The structural unit's reinforcing drawings contain the majority of the data in a BBS. By just looking at the drawings, which contain precise dimensioning, bar form, diameter, length, and spacing are directly put into the schedule.

Bar Bending Schedule

Project Name	ABC building				Engineer	XXXX			Revision	A					Doc.No:	XXXX	
Ref Dwg. No.	XX-XX-XX				Approver	Project Manager			Status	Tender					Date:	DD-MM-YY	
Bar no.	Bar Shape	a (m)	b (m)	c (m)	Dia (mm)	Spacing (mm)	Cutting Length (m)	no's	Length of Bar (m)								
									8	10	12	16	20	25	28	32	
1	b a	0.200	4.380	0.000	20	150	4.70	2					9.4				
2	b	0.000	4.380	0.000	10	150	4.38	2		8.8							
3	c a	0.140	0.000	0.285	8	180	1.04	24	25.0								
					Total Length (m)				25.0	8.8	0	0	9.4	0	0	0	
					Unit weight in kg/m				0.395	0.617	0.888	1.578	2.466	3.853	4.834	6.313	
					Weight in kg's				9.88	5.43	0.00	0.00	23.18	0.00	0.00	0.00	
					Total reinfocement Weight in kg's				38.5								

Fig. 2.1.10 Sample Bar Bending Schedule

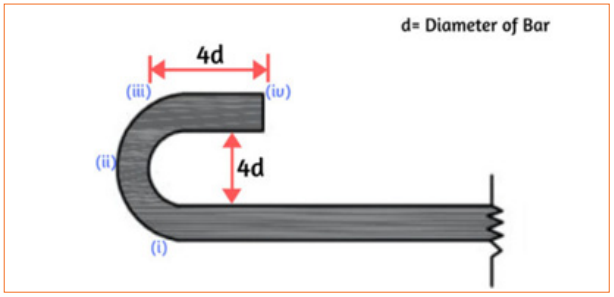
Components of a Bar Bending Schedule

A bar bending schedule (BBS) is a detailed document that provides information about the quantity and dimensions of reinforcing steel bars, their shapes, and placement in a reinforced concrete structure. The components of a bar bending schedule include:

1. **Identification:** This section includes details such as project name, drawing number, and date of preparation.
2. **Reinforcement details:** This section provides a list of all the reinforcement details, such as bar mark, diameter, number of bars, length, and weight.
3. **Bar bending shape:** This section illustrates the bending shape of each bar, which includes the angle of bend, bend length, and the length of the straight portions on each end of the bar.
4. **Bar schedule:** This section provides a detailed schedule of each bar's placement in the structure. It includes the location of the bar, the reference point, and the spacing between each bar.
5. **Bar summary:** This section provides a summary of all the reinforcement steel used in the structure, including the total number of bars, weight, and length.
6. **Cutting length:** This section provides the cutting length for each bar, which is the length of the bar required to achieve the desired shape after bending.
7. **Bar fabrication:** This section provides information about the fabrication process of the reinforcement steel bars, such as the fabrication yard, date of fabrication, and details of the fabricator.

2.1.11. Bar Bending Schedule Calculations

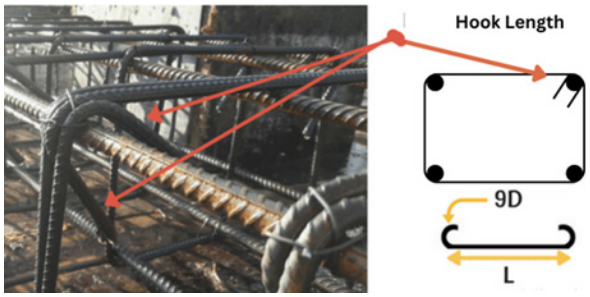
1. **Cutting length of stirrups:** Cutting length of stirrups or hook length is frequently specified for stirrups in beams and ties in columns. Often, stirrups or ties with hooks are placed to the two ends of the rebar.



Total hook length= (i)to(ii) + (ii)to(iii)+ (iii)to(iv)
= 4d+d+4d
= 9d

Hook Length= 9d

Calculation of the stirrup's overall length with the two hooks at the ends:

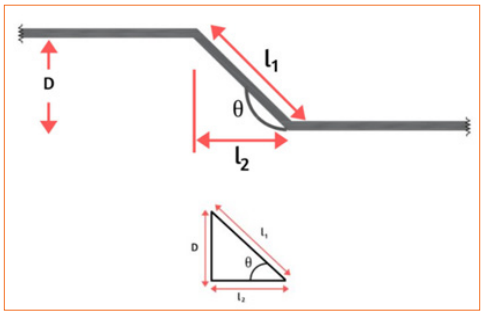


Total Cutting Length of stirrup or tie = Total length of Bar + 2 x Hook Length (Two hooks)
= L+2(9d)
= L+18d

Total Cutting length= L+18d

2. Bend Lengths: Cranked bars (bent up bars) and corners bent bars have distinct bend length calculations. The bars are cranked in slabs and are bent at the corners in stirrups or ties.

   i. **Cranked Bars:** The slab's supports experience the most shear stress. The bars are cranked at the ends of supports in the slab to withstand these stresses. The bent up bar in slab is seen in the figure below.



The steps listed below should be followed to calculate the bend length:

The additional length (la) is introduced as the bar is bent at an angle of θ°.

Where, la = l1 – l2 ……..(i)
Tanθ = D/l2;
Sinθ°= D/l1
Hence, l1 = /Sinθ and l2 = D/tanθ
Therefore, la= D/Sinθ – D/tanθ ……[from (i)]

$$l_a = D/\sin\theta - D/\tan\theta$$

Providing various values—such as 30°, 45°, and 60°—results in various extra length la values, as shown below.

θ^0	$D/\sin\theta$	$D/\tan\theta$	$l_a = D/\sin\theta - D/\tan\theta$
30^0	D/0.500	D/0.573	0.27D
45^0	D/0.707	D/1.000	0.42D
60^0	D/0.866	D/1.732	0.58D
90^0	D/1	0	1D
135^0	D/0.707	D/-1	2.42D

ii. Calculating the bend length of bent bars at corners: The key parameters considered while determining the bend length at corners:

45° Bend length = 1d
90° Bend length = 2d
135° Bend length = 3d
Here,'d' = Diameter of bar

3. Calculation of different types of bar shapes

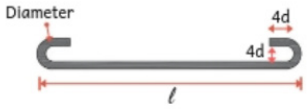
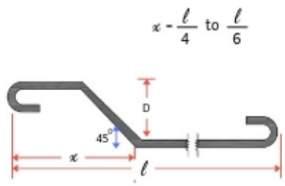
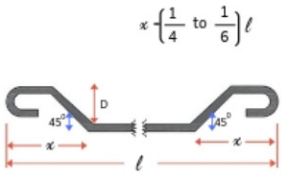
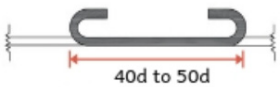
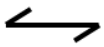
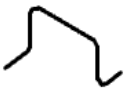
Bar Shape	Total length of the hooks	Total Bend Length	Total Length of the bar
Straight Bar 	Two Hooks = 9d + 9d = 18d	No bend	l + 18D
Only One Bent End 	Two Hooks = 9d + 9d = 18d	One bend bent at an angle 45° = 0.42D	l + 18D + 0.42D
Double Bent 	Two Hooks = 9d + 9d = 18d	Two bends bent at an angle 45°	l + 18D + 0.42D + 0.42D =l+18D+0.84D
Overlap Bars 	Two Hooks = 9d + 9d = 18d	No bend	(40d to 45d)+18d

Table 2.1.6 Total length of different bar shapes

Exercise

1. What are Reinforcement bars? List the different types of rebars.
2. Describe the primary marking symbols used on rebar.
3. What is a bar bending schedule?
4. Explain the process of reading rebar sketches in brief.
5. Match the following:

Description	Symbol
Chair Bar	
Direction in which bars extend	
Diameter of Plain round bar	
Right-angle-bent bar	
Bar with Hooks	

Notes

Scan the QR code to watch the video

https://youtu.be/Zecb8Wj5QHE

Reinforcement bar

https://youtu.be/debu3vUkF8E

Rebar Grades

https://youtu.be/H1j_Fb3OAJc

Rebar Sizes

https://youtu.be/4Ep9DU-g1zk

Rebar Sketch

https://youtu.be/4Ep9DU-g1zk

Symbols in Rebar Sketch

https://youtu.be/nGoTdkCxsuk

Bar Bending Schedule

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

3. Tools and Equipment relevant to Reinforcement Works

Construction Skill Development Council

Unit 3.1- Reinforcement Tools and Equipment

CON/N0215

Key Learning Outcomes

By the end of this module, participants will be able to:

- Classify the reinforcement bar with respect to their grade and size.
- Differentiate binding wires based on materials and thickness
- Identify the different types of hand tools and power tools used for steel reinforcement works.
- Demonstrate the use of hand tools for cutting rebars.
- Demonstrate the use of power tools like circular cutting machine (handheld and table mounted) and shearing machine for cutting rebar.
- Describe the process adopted for care and maintenance of hand and power tools used in bar bending works.
- Demonstrate the use of threading machine for marking threads on reinforcement bars.
- Demonstrate the use of bar bending machine
- Explain use of lifting gears and equipment used in reinforcement work
- Demonstrate the use of slings, shackles and lifting belts for lifting and shifting of rebar
- State the importance of maintaining proper body postures while using hand and power tools

Unit 3.1 Reinforcement Tools and Equipment

Unit Objectives

By the end of this unit, participants will be able to:

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- Demonstrate the use of bar bending machine
- Explain use of lifting gears and equipment used in reinforcement work
- Demonstrate the use of slings, shackles and lifting belts for lifting and shifting of rebar
- State the importance of maintaining proper body postures while using hand and power tools

3.1.1 Rebar Installation

Rebar, or reinforcing steel bar, is commonly used in reinforced concrete structures to increase their tensile strength. The process of installing rebars involves the following steps:

1. **Design and preparation:** The design of the reinforced concrete structure should be determined beforehand, including the required diameter, spacing, and location of the rebars. Proper planning and preparation are crucial to ensure that the rebars are installed correctly and the structure is durable and safe.
2. **Cutting and bending:** The rebars are cut and bent according to the design specifications using tools such as cutters, benders, and hydraulic shears.
3. **Placing the rebars:** Once the rebars are cut and bent, they are placed in the formwork or mould that will shape the concrete structure. The rebars should be secured and supported at the correct spacing and location, using ties or chairs.

4. **Checking alignment:** Before the concrete is poured, the alignment of the rebars should be checked to ensure that they are properly placed and spaced. Any misalignment should be corrected before the concrete is poured.

5. **Pouring the concrete:** Once the rebars are correctly placed and aligned, the concrete is poured into the formwork, covering the rebars. The concrete should be properly compacted and finished to ensure that it bonds well with the rebars.

6. **Curing:** After the concrete is poured, it should be cured for a specified period to allow it to gain strength and durability. The curing process may involve covering the concrete with a protective membrane, applying a curing compound, or keeping the concrete moist by watering it regularly.

7. **Inspection:** Finally, the completed reinforced concrete structure should be inspected to ensure that it meets the design specifications and safety standards. Any defects or problems should be corrected before the structure is used.

3.1.2 Cutting Rebar

Cutting rebar is a crucial step in steel reinforcement works, and it requires proper tools and techniques to ensure accuracy and safety. Here is a detailed process for cutting rebar:

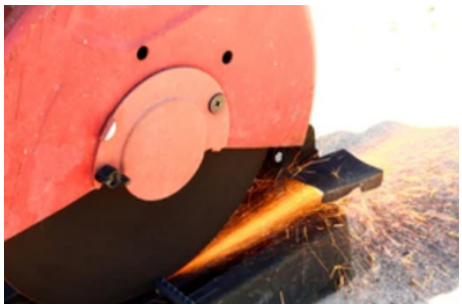

Fig. 3.1.1 Cutting of rebar

1. **Measure and mark the rebar:** Measure the length of the rebar to be cut using a tape measure and mark it with a chalk line or marker.

2. **Secure the rebar:** Secure the rebar in place using a vice or a rebar cutting machine. Make sure it is securely clamped to prevent it from moving during the cutting process.

3. **Choose the right tool:** Select the right cutting tool based on the diameter of the rebar. For thinner rebar, use bolt cutters, while thicker rebar may require a rebar cutter or a cutting wheel on an angle grinder.

4. **Position the cutting tool:** Position the cutting tool at the marked spot, making sure that the tool is perpendicular to the rebar.

5. **Cut the rebar:** Cut through the rebar using a firm and steady motion, applying pressure until the tool has cut through the bar.

6. **Inspect the cut:** Inspect the cut to ensure that it is straight, clean, and without any cracks or deformations.

7. **Remove burrs:** Use a grinder or a file to remove any burrs or rough edges on the cut ends of the rebar.
8. **Clean the work area**: Clear the work area of any debris or leftover rebar pieces to prevent any accidents or injuries.
9. **Repeat the process:** Repeat the process for any additional cuts required for the project.

It is essential to wear proper safety gear, including gloves, safety glasses, and protective clothing, when cutting rebar. Always ensure that the cutting tool is in good working condition and that the blade is sharp before cutting.

3.1.3 Bending Rebar

Bending rebar refers to the process of shaping steel reinforcement bars into a specific angle or curve to suit the design of a concrete structure. This is typically done using a bar bending machine or by hand using a manual rebar bender. Bending rebar is an essential step in steel reinforcement works as it allows the bars to be placed in the correct position and shape to reinforce the concrete structure and improve its strength and durability. The bending process can be done at the construction site or in a prefabrication facility before the bars are transported to the construction site.

Fig. 3.1.2 Bending of rebar

There are several types of bends that can be made in rebar to suit the design of the concrete structure. Here are some of the most common types of bends:

1. **Hook bend:** This is a U-shaped bend used to anchor the rebar to the concrete structure or to connect two pieces of rebar. It is commonly used in the construction of columns and beams.
2. **J bend:** This is an L-shaped bend used to create stirrups, which are used to reinforce concrete beams and columns. The J bend is also used to create vertical stirrups in reinforced concrete walls.
3. **Reverse bend:** This is a U-shaped bend that is made in the opposite direction of the hook bend. It is used to reinforce the end of a concrete structure, such as a beam or column.
4. **Crank bend:** This is a 90-degree bend that is made in the rebar to allow it to fit around obstacles or to create a specific shape in the concrete structure.
5. **Spiral bend**: This is a continuous bend that is made in the rebar to create a spiral shape. It is commonly used in the construction of reinforced concrete columns.

3.1.4 Tying Rebar

There are different methods of binding rebars, including:

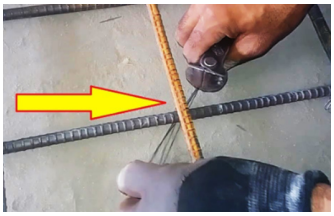

Fig. 3.1.3 Tying rebar

1. **Wire Tying:** This is the most commonly used method of binding rebars. It involves wrapping a wire around the intersection point of two rebars and twisting the ends together with pliers. The wire used for this purpose is usually annealed steel wire.
2. **Snap Ties:** This method involves using a snap tie to hold the rebars in place. A snap tie is a metal bar with hooks on either end that is inserted through a pre-drilled hole in the formwork and hooked onto the rebars. Once the concrete is poured and set, the snap tie is removed.
3. **Welding:** This method involves welding the rebars together using an electric arc welding process. It is a fast and efficient method of binding rebars but is generally not used for large scale projects due to safety concerns.
4. **Joints and Couplers:** Joints and couplers are mechanical devices used to connect two rebars. They are designed to transfer load between two rebars and maintain continuity in the reinforcement. These devices are either threaded or non-threaded.
5. **Looping and Tying:** This method involves looping the end of one rebar around the other rebar and then tying the loop together using wire. This method is particularly useful for vertical reinforcement in columns and walls.

Rebar binding wire is an essential component in the construction industry, used to tie reinforcing steel bars together for structural reinforcement. Based on materials and thickness, there are different types of binding wires used in rebar reinforcement, which are:

1. **Steel Binding Wire:** This is the most commonly used type of binding wire and is made from annealed steel. It is used for a wide range of applications, including rebar reinforcement, baling wire, and tying wire.
2. **Galvanized Steel Binding Wire:** This type of wire is coated with a layer of zinc to prevent corrosion and rusting. It is commonly used in areas with high humidity or in coastal regions where there is a higher risk of corrosion.
3. **Stainless Steel Binding Wire:** This wire is made of high-quality stainless steel and is highly resistant to corrosion and rusting. It is commonly used in areas where the wire may be exposed to chemicals or other corrosive substances.
4. **Copper Coated Binding Wire:** This type of wire is coated with a layer of copper to increase its resistance to corrosion. It is commonly used in areas where the wire may be exposed to high levels of humidity or where there is a high risk of corrosion.

Based on thickness, binding wires used in rebar reinforcement can be classified as follows:

1. **Light Binding Wire**: This wire is typically between 0.5 mm and 1 mm in diameter and is used for smaller diameter rebar reinforcement.
2. **Medium Binding Wire:** This wire is typically between 1 mm and 1.5 mm in diameter and is used for medium-sized diameter rebar reinforcement.
3. **Heavy Binding Wire:** This wire is typically between 1.5 mm and 2.5 mm in diameter and is used for larger diameter rebar reinforcement.

3.1.5 Hand and Power tools

Tools that aid construction workers, carpenters, and other manual labourers in their work are referred to as hand tools or power tools, depending on whether they are operated manually or electrically. While hand and power tools are very helpful, they also provide a number of physical risks that, if not avoided, can result in minor and serious accidents.

Hand tools in Reinforcement works

S.No	Tool Name and Description	Image
1	Measurement Tape: It is used to measure the length and size of steel reinforcement bars.	
2	Chisel: Chisels are cutting implements with metal blades that have been honed at the end. To suit various needs, they are available in a variety of sorts, shapes, designs, styles, and sizes	
3	Hammer: A hammer is used for driving nails or brads into wood. They come in different weights and sizes.	
4	Bar tying hook: A bar tying hook is a tool used in steel reinforcement works to tie together two or more steel bars or rebar to create a reinforcement structure. The hook is designed to grip the rebar tightly and pull it together, making it easier to tie the bars together using wire or other fastening materials.	

S.No	Tool Name and Description	Image
5	Bending lever: A bending lever is a manual tool used in steel reinforcement works to bend steel bars or rebar to the desired shape and size. It is also known as a rebar bender or manual bar bender.	
6	Gauge measure: A gauge measure is a tool used in steel reinforcement works to measure the thickness or diameter of steel bars or rebar. It is a precision measuring instrument that can provide accurate readings of the size of the steel bar, allowing the operator to select the appropriate bending or cutting tools.	
7	Podger Spanner: A podger spanner, also known as a podger wrench or simply a podger, is a type of hand tool commonly used in steel reinforcement works and construction sites. It is a versatile tool that can be used to tighten or loosen nuts and bolts of different sizes, as well as for aligning holes in steel members during assembly.	
8	Hack saw blade and frame: a hacksaw designed specifically for cutting metals that has a frame and a small, fine-toothed blade. The majority of hacksaws are hand saws with a walking frame in the shape of a C that keeps a blade under tension.	
9	Steel scale: A steel scale is a measuring tool used in steel reinforcement works to measure the length and thickness of steel bars or rebar. The scale is typically made of steel or other durable materials that can withstand the wear and tear of heavy use in construction sites.	
10	Try Square: A try square is a measuring tool used in steel reinforcement works to ensure that angles are square, meaning that they are at a 90-degree angle to each other. It is also known as a carpenter's square or framing square.	
11	Spirit level: A spirit level is a tool for measuring the level of surfaces. A spirit level is a bubble instrument. The Spirit Level is easy to calculate; simply monitor the movement of the bubbles.	

S.No	Tool Name and Description	Image
12	Plumb bob: Plumb bob is a basic tool used by bricklayers to build any vertical bricklaying task. It is typically available in mild steel with a coating weighing 30-40 gms. The plumb bob is a pointed weight connected to a line length enclosed within the bob and fixed in a slot in the lid	
13	Safety gear: Including hard hats, gloves, safety glasses, and safety boots, are also essential tools for workers involved in steel reinforcement works.	

Table 3.1.1 Hand tools used in reinforcement works

Power tools used in Reinforcement works

Fig. 3.1.4 Bar bending machine

1. **Bar bending machine:** A bar bending machine is a type of power tool used in steel reinforcement works to bend steel bars or rebar to the desired shape and size. Bar bending machines are commonly used in construction sites and prefabrication facilities to create precise bends in the rebar according to the design specifications.

   There are several types of bar bending machines available, including manual, semi-automatic, and fully automatic models. The manual model requires the operator to manually adjust the bending angle and direction using a lever or handle. The semi-automatic model is similar to the manual model, but it has an electric motor to power the bending operation, making it faster and more efficient. The fully automatic model is the most advanced type of bar bending machine, with a computer-controlled system that can bend rebar automatically according to pre-set angles and specifications.

2. **Circular cutting machine:** The circular cutting machine works by using a circular cutting blade that rotates at high speed to cut through the rebar. The blade is typically made of high-speed steel or diamond-coated steel to ensure a clean and accurate cut. The machine can be operated manually or automatically, depending on the model and the requirements of the job.

   Circular cutting machines are commonly used in prefabrication facilities and construction sites where large quantities of rebar need to be cut quickly and accurately. They are also useful for cutting curved or angled rebar, which can be difficult to cut using other types of tools.

a. Handheld circular cutting machines are designed for portability and ease of use. They typically consist of a circular saw blade mounted on a handheld motorized tool. The operator positions the saw blade over the steel bar or rebar to be cut and activates the motor, causing the blade to rotate and cut through the steel.

Fig. 3.1.5 Handheld circular cutting machine

b. Table-mounted circular cutting machines are designed for larger-scale production and more precise cuts. They typically consist of a circular saw blade mounted on a table, with a clamp to hold the steel bar or rebar in place. The operator positions the steel bar or rebar in the clamp, adjusts the saw blade to the desired length, and activates the motor, causing the blade to rotate and cut through the steel.

Fig. 3.1.6 Table-mounted circular cutting machine

3. **Shearing machines:** A shearing machine works by using a set of blades to apply a shearing force to the metal being cut, resulting in a clean and accurate cut. There are several types of shearing machines, including mechanical, hydraulic, and pneumatic models.

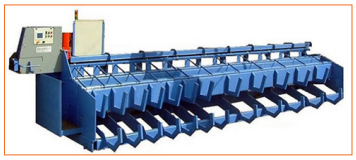

Fig. 3.1.7 Shearing machine

To use a shearing machine for cutting rebar, the operator must first secure the rebar in place using clamps or vices. The machine is then positioned over the rebar, and the blades are brought down onto the surface of the rebar with enough force to cut through it. The blades are then retracted, and the machine is moved to the next section of rebar to be cut.

4. **Reinforcement bar tying machine:** A reinforcement bar (rebar) tying machine, also known as a rebar tier or wire tying machine, is a power tool used in steel reinforcement works to quickly and efficiently tie rebar together using wire ties. The machine automates the process of tying rebar together, making the task faster and more efficient than manual tying.

Fig. 3.1.8 Reinforcement bar tying machine

The rebar tying machine consists of a handheld tool that is equipped with a wire feeding system and a wire tying mechanism. The operator places the tool over the rebar to be tied, and the machine automatically feeds the wire tie through the tool and around the rebar, twisting the wire to secure the rebar in place.

5. **Threading machine:** A threading machine is a power tool used in steel reinforcement works to cut threads on the end of steel bars or rebar. The machine automates the process of cutting threads, making it faster and more efficient than manual cutting.

   The threading machine typically consists of a motor-driven spindle, a cutting die, and a clamping system to hold the steel bar or rebar in place.

   Threading machines are commonly used in steel reinforcement works for applications such as the installation of threaded rebar couplers, which are used to join two steel bars or rebar together with a threaded connection.

Fig. 3.1.9 Threading machines

3.1.6. Lifting Gears and Equipment

1. **Slings:** Slings are made of strong, durable materials such as steel or synthetic fibers and are used to lift and move heavy loads of steel reinforcement.
2. **Shackles:** Shackles are metal fasteners used to connect lifting chains or slings to steel reinforcement. They are designed to resist bending, twisting, and crushing under heavy loads.
3. **Lifting belts:** Lifting belts are made of strong, durable materials such as nylon or polyester and are used to lift and move steel reinforcement. They are adjustable and can be used to securely wrap around the load.
4. **Chain hoists:** Chain hoists are motorized devices that use chains to lift and move heavy loads of steel reinforcement. They are typically used in industrial settings and can lift loads weighing up to several tons.
5. **Lever hoists:** Lever hoists are hand-operated devices used to lift and move heavy loads of steel reinforcement. They use a lever mechanism to lift the load and are typically smaller and more portable than chain hoists.
6. **Wire rope slings:** Wire rope slings are made of braided steel wires and are used to lift and move heavy loads of steel reinforcement. They are flexible and strong, and can be used to securely wrap around the load.
7. **Crane:** A crane is a machine equipped with a hoist, wire ropes or chains, and sheaves, which can be used to lift and move heavy loads of steel reinforcement. Cranes are commonly used in large construction sites to lift and move steel reinforcement to different locations.

3.1.7. Tool Safety

Without the aid of manual and power tools, no industry can prosper. However, employees and safety experts must make sure that the proper safety precautions are regularly used due to the inherent risks involved in their use. According to OSHA, the following are the five fundamental safety guidelines for avoiding risks related to the use of hand and power tools:

i. **Maintain all tools on a regular basis to keep them in good working order:** To maintain the equipment's dependability and safety throughout usage, regular maintenance is crucial. Regular tool inspections are necessary to reduce the risk of accidents caused by broken machinery and to avoid unplanned downtimes, which have a detrimental effect on operational effectiveness.

ii. **Use the right tool for the job:** Depending on their intended use, hand and power tools are constructed differently. It is important to select the right tool for the work in order to prevent accidents and injuries. For instance, employing a chisel in place of a screwdriver could result in the tip breaking and flying off, perhaps leading to eye damage.

iii. **Examine tools for any damage prior use and do not use damaged tools:** Before beginning work, hand and power tools need to be checked and inspected in order to find broken or malfunctioning equipment. Both minor and serious injuries, such as cuts, punctures, blindness, electrical shock, and skin infections as a result of scrapes and abrasions, can be brought on by damaged equipment.

   Making ensuring that employees never use instruments that are damaged is one of the employers' duties. Equipment should make it simple for workers to complete their tasks and shouldn't endanger them. Tools that are broken might be dangerous and could endanger your company.

iv. **Operate tools according to the manufacturers' instructions:** Employees can be guided by equipment manuals on how to handle and use tools properly. To prevent improper tool usage that results in otherwise avoidable mishaps, employees should read and follow the manufacturer's instructions.

v. **Provide proper personal protective equipment (PPE):** By lowering the overall physical risks brought on by power equipment, PPE aids in guaranteeing employee safety. To prevent physical contact with combustible materials that could result in burns, blindness, respiratory conditions, or other serious health issues, all personnel are required to wear the proper PPE when working around flammable gases, volatile liquids, or other explosive materials.

Maintaining proper body posture while using hand and power tools

1. **Prevents injuries:** Using hand and power tools can be physically demanding, and maintaining proper body posture can help prevent injuries such as back pain, muscle strain, and joint pain.
2. **Improves accuracy:** Maintaining proper body posture helps to maintain a stable position while using the tool, leading to greater accuracy and precision in the work being done.
3. **Increases efficiency:** Proper body posture can help reduce fatigue and increase endurance, which can lead to increased efficiency in completing the task.
4. **Reduces risk of accidents:** Using hand and power tools can be dangerous, and maintaining proper body posture can help reduce the risk of accidents by ensuring that the user has full control over the tool.
5. **Promotes good health:** Maintaining proper body posture can promote good health by improving circulation, reducing tension in the muscles, and increasing flexibility.

Exercise

1. Describe the process of installing rebar.
2. List the various hand tools used in reinforcement works.
3. Classify the binding wires on the basis of material and size.
4. Explain the importance of maintaining proper body posture while using hand and power tools.
5. Write a short note on following:
    a. Threading Machine
    b. Shearing Machine
    c. Bar bending Machine

Notes

Scan the QR code to watch the video

https://youtu.be/-Tp2mY4Gj0c

Rebar Installation

https://youtu.be/WnoqEfio9G8

Cutting Rebar

https://youtu.be/4c43B9S3CPo

Bending Rebar

https://youtu.be/H2J9uuLy1hg

Lifting Gears and Equipment

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4. Cutting and Bending of Rebar for Simple Shapes

Unit 4.1- Cutting and Bending of Rebar

CON/N0216

Key Learning Outcomes

By the end of this module, participants will be able to:

- Explain the procedure of measuring, marking and cutting of reinforcement bars into simple shapes.
- List the types of stirrups, chairs and hanger bar
- Describe tolerance limit for cutting and bending of the reinforcement bar
- Explain the importance of maintaining proper body posture while cutting and bending reinforcement bars
- Demonstrate marking and cutting of rebar to the specified length using appropriate hand cutting tools.
- Demonstrate marking and cutting of rebar to the specified length using appropriate power cutting tools.
- Demonstrate bending of reinforcement bar to the specified shape and angle using lever/ pipe.
- Apply basic ergonomic principles while cutting and bending of the reinforcement bars
- Demonstrate the procedure of making stirrups, chairs and hanger bars

Unit 4.1 Cutting and Bending of Rebar

Unit Objectives

By the end of this unit, participants will be able to:

- Explain the procedure of measuring, marking and cutting of reinforcement bars into simple shapes.
- List the types of stirrups, chairs and hanger bar
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- Demonstrate marking and cutting of rebar to the specified length using appropriate hand cutting tools.
- Demonstrate marking and cutting of rebar to the specified length using appropriate power cutting tools.
- Demonstrate bending of reinforcement bar to the specified shape and angle using lever/ pipe.
- Apply basic ergonomic principles while cutting and bending of the reinforcement bars
- Demonstrate the procedure of making stirrups, chairs and hanger bars

4.1.1. Rebar

Rebar is a term used to refer to reinforcing bars. Rebar is a metal bar (often steel) that is used like a frame inside the concrete construction. When it is bent into shape, rebar reinforces other materials by providing them with better stability and strength.

Slabs of concrete that brace large structures such as bridges and skyscrapers wouldn't be able to support their own weight without reinforcing bars.

The most common type of rebar are:

i. Plain Steel Bars
ii. Carbon Steel Bar
iii. Deformed Steel Bar
iv. Epoxy-Coated Rebar
v. Galvanized Rebar
vi. Stainless Steel Rebar
vii. Glass-Fiber-Reinforced-Polymer (GFRP) Rebar

Selection of the type of rebar

Reinforcement bars, or rebars, play a crucial role in the strength and durability of concrete structures, and selecting the right type of rebar is essential for ensuring the safety and longevity of a construction project. The following are the factors that affect the selection of the type of rebar:

1. **Size and Shape Requirements: T**he size and shape of the rebar are critical factors to consider when selecting the type of rebar for a construction project. The diameter and spacing of the rebar must be selected based on the load-bearing capacity, the span length of the concrete member, and the dimensions of the structure. For instance, thinner rebars may be used in lighter structures, while thicker ones may be necessary for larger structures. Similarly, the shape of the rebar, such as round or deformed, may depend on the requirements of the structure's design.

2. **Strength Requirements:** The strength of the rebar is measured by its yield strength, which is the amount of stress it can withstand without permanent deformation, and its ultimate tensile strength, which is the amount of stress it can withstand before breaking. The rebar must have sufficient strength to handle the expected loads and stresses in the structure, such as the weight of the building, the weight of people and equipment, wind loads, and seismic loads.

3. **Corrosion Resistance:** Corrosion is a significant problem that can lead to the weakening and eventual failure of concrete structures. The type of rebar selected for a construction project should have adequate corrosion resistance to ensure the longevity and safety of the structure. For instance, if the construction site is located near the sea or exposed to moisture, a corrosion-resistant rebar, such as epoxy-coated or stainless steel rebar, may be necessary to prevent rust and deterioration.

4. **Weldability:** Rebars are often joined by welding, so the rebar must have good weldability. Weldability refers to the ability of the rebar to form a strong and durable bond when welded to another rebar. Weldable rebar is essential to ensure the integrity and strength of the structure.

5. **Cost:** The cost of the rebar should be considered in relation to the project budget. Generally, the cost of the rebar will depend on the material, the size, and the supplier. The selection of the rebar should aim to achieve a balance between cost and quality.

6. **Availability:** The rebar should be readily available from local suppliers to avoid delays in the construction schedule. The selection of the rebar should aim to ensure that the required quantity of rebar is available when needed to keep the construction project on track.

7. **Sustainability:** Sustainability is a growing concern in the construction industry, and the use of sustainable materials can contribute to the environmental impact of the project. For example, recycled steel rebar is an eco-friendly option that can reduce the environmental impact of the project while maintaining the structural integrity of the building.

It is necessary to follow instructions while selecting the type of rebar because the safety and longevity of a construction project depend on it. The instructions provide guidance on how to select the appropriate type of rebar for the specific project requirements, and failure to follow these instructions can result in significant problems.

Here are some reasons why it is necessary to follow instructions while selecting the type of rebar:

1. **Safety:** The primary concern in any construction project is safety. The type of rebar selected for a construction project must be strong enough to withstand the expected loads and stresses in the structure. If the wrong type of rebar is selected, it may not be able to handle the loads, leading to a failure of the structure, which could be catastrophic.

2. **Structural Integrity:** The rebar is an essential component of a concrete structure, providing the necessary tensile strength to hold the structure together. If the wrong type of rebar is selected, it may not provide the required strength and stability, which can compromise the structural integrity of the building.

3. **Durability:** The type of rebar selected for a construction project must be able to withstand the environmental conditions of the construction site. If the wrong type of rebar is selected, it may corrode and deteriorate, leading to a decrease in the structure's durability and lifespan.

4. **Cost:** The selection of the wrong type of rebar can be costly in terms of both time and money. If the rebar needs to be replaced, it can result in project delays and additional expenses.

5. **Compliance:** Following instructions ensures compliance with building codes and regulations, which are in place to ensure the safety and quality of construction projects.

4.1.2. Marking Rebar

Marking of rebars is done to identify the size and length of each bar as well as any other relevant information such as the project number, job site, and the fabricator's name. Marking helps ensure that the rebars are installed in the correct location and orientation, and that the required length and number of rebars are used.

Fig. 4.1.1 Marking of rebar with a chalk

Here are the steps involved in marking rebars:

i. Determine the required length and size of the rebars based on the project specifications and drawings.

ii. Use a measuring tape or ruler to measure the length of each rebar, and mark the required length using a soapstone or chalk.

iii. Mark the size of each rebar by either using a rebar size stamp or by using a different color of paint or spray paint for each size.

iv. If required, mark any additional information such as the project number, job site, or fabricator's name on the rebar using a paint marker.

v. If the rebars need to be bent, mark the bending points using a soapstone or chalk.

vi. Once all the rebars have been marked, ensure that the markings are legible and easy to read.

vii. Finally, bundle the rebars together and secure them with wire or zip ties, making sure that the markings are visible.

4.1.3. Cutting Rebar

Cutting rebars is a common task in construction and involves cutting the rebars to the required length using appropriate tools. Here are the steps involved in cutting rebars:

i. Determine the required length of the rebar based on the project specifications and drawings.

ii. Measure the length of the rebar using a measuring tape or ruler, and mark the required length using a soapstone or chalk.

iii. Use a rebar cutter, which is a hand-held tool designed for cutting rebars. Rebar cutters are available in different sizes and types, including manual cutters, electric cutters, and hydraulic cutters. Select the appropriate cutter based on the size and number of rebars to be cut.

iv. Hold the rebar firmly in place using a rebar vise or clamps to prevent it from moving while cutting.

v. Position the rebar cutter jaws over the marked cutting point, making sure that the cutter is perpendicular to the rebar.

4.1.3. Cutting Rebar

vi. Operate the cutter, following the manufacturer's instructions. For manual cutters, use a cutting arm or lever to apply pressure to the rebar until it cuts. For electric or hydraulic cutters, activate the cutting mechanism by pressing a button or foot pedal.

vii. After cutting the rebar, remove any burrs or rough edges using a rebar bender or file. Burr removal is important to ensure that the rebars fit properly into the forms and to avoid any injuries during handling.

Tools for cutting rebar

A wide variety of tools are used for cutting rebar. One should select the appropriate hand or power tool for cutting rebar as per the requirement. Here are some of the most commonly used tool.

I. Angle Grinder for Rebar

Angle grinders are popular for cutting rebar on construction sites. It generally offers a quick solution, making a clean cut. However, Angle grinders are not very safe as these cause a large amount of sparks that fly in all directions. These sparks may cause severe damage and burn wounds to the exposed skin, and could also cause fire in flammable substances. Moreover, the dust and smoke produced during cutting, cause respiratory problems when inhaled.

Fig. 4.1.2 Angle Grinder

II. Rebar Cutting Saw (Circular Saw)

Circular saws are one of the most common tools for cutting rebar on construction sites. For the best results, one should use a circular saw blade appropriate for cutting metal. This means one either needs an abrasive disc or a metal cutting blade.

Fig. 4.1.3 Circular Saw

III. Portable Band Saw

The portable band saw is essentially a power saw. These are good at cutting rebar as they offer clean-cut edges with less vibration. These are safe also since they don't produce sparks.

Fig. 4.1.4 Portable Band Saw

IV. Metal Cutting Band Saw

A horizontal band saw is useful for the metalworking industry to cut metal bars and rods. The continuous loop of the blade dissipates heat with the help of coolant and lasts longer. This saw cuts rebar easily and is a good option for bulk cutting. However, horizontal band saws are large-sized shop floor tools that offer very little portability, therefore not suitable for construction sites.

Fig. 4.1.5 Metal Cutting Band Saw

V. Rebar Cutters

Bolt cutters may also be used to cut rebar manually. However, these are meant to cut bolts and chains, and they don't always make neat cuts. These shouldn't be used for cuts that require a smooth, flush end. Bolt cutters cut through the metal, often making a somewhat pointed cutting edge.

Fig. 4.1.6 Metal Cutting Band Saw

VI. Specialized Hydraulic Bar Cutters

Specialized hydraulic bar cutters are electrical tools designed specifically to cut rebar quickly and safely. Once plugged into a suitable power source, one just needs to place the rebar in the tool and press the cutting button. Bar cutters make even and clean cuts using a durable blade meant for cutting metal.

Fig. 4.1.7 Hydraulic Bar Cutters

4.1.4. Bending Rebar

There are different reasons for bending rebar. Most commonly, rebar is used in construction as columns to hold up brick buildings. One can bend rebar manually or use a bending machine.

a. Bending rebar manually

Fig. 4.1.8 Manual Bending

Follow the steps given below to bend rebar manually:

- Wear the appropriate PPE
- Straighten the rebar using appropriate tools and equipment before bending if required
- Avoid heating the rebar if it is a non-weld-able metal grade
- Ensure that bar is clamped tightly in a vise while setting up rebar for bending
- One should aim for the future bend to line up with the jaws of the vise
- Select the appropriate lever or pipe of suitable diameter for bending rebar
- Since accuracy is critical for perfect bends, one should use a set square to measure from one end of the rebar to find out how wide each section will be, ensuring it is perfectly straight.

- Mark on the bending bench to make stirrups, chairs, hanger bars
- One needs two tools to manually bend rebar - clamps and a bar bender. The clamps hold everything in place. The bar bender helps guide and secure the metal while it is hammered.
- The next step is to mark where one wants to bend the rebar. This can be done using chalk or a permanent marker. Make the appropriate calculations and mark on rebar.
- Place the rebar into a pipe of appropriate diameter
- Bend bars to the required shape and angle manually as per the criteria given in the code sheets
- One should use slow and even pressure to get the bend, avoiding to smack the rebar with a hammer or other tool.
- Check the bent rebar for the correct shape, angle and length

b. Bending Rebar using Hickey Bar

This method is similar to bending bars using hands. A hickey bar is essentially a metal bar with three

Fig. 4.1.9 Hickey Bar

fingers/studs. It's also known as a 3-pin bar bender.

These studs hold the rebar in position. It works on the principle of increasing torque for bending the rebar. It is preferred because of its small size and portability.

The handle of the hickey bar is designed in such a way as to give considerable pressure to bend the rebar. It is designed in such a way that one bar is not enough to bend the bar, requiring two of them.

- First one needs to place the rebar straight on the ground.
- Rebar should be held using one of the hickey bars, in such a way that the rebar passes through two of the studs. Then one needs to use another hickey bar and again the rebar using it.
- The distance between the two holding points is where the bar is bent. The shorter the distance, the more accurate the point of the bend will be. Then one needs to apply force to the second hickey bar. This creates torque, making bar bending very easy.
- Angle control is very important. It would be helpful if a second person uses a measuring square to check the angle of the bend during the process.

c. Bending Rebar using Bend & Cut Tool

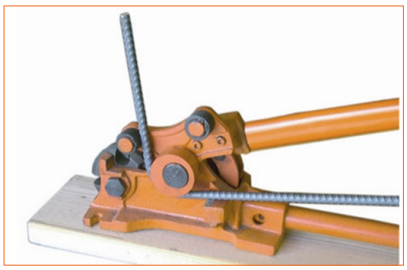

Fig. 4.1.10 Bend and cut tool

This also is a manual rebar bending process and is quite simple to follow. Bend & cut is an analogue tool that doesn't use electricity.

It follows the same principles for rebar bending as the hickey bar. It comes with a long lever and a CAM mechanism to generate optimum torque. It is portable and economic.

First, one has to select the correct setting for the rebar one is going to bend. One just has to pull the CAM towards oneself and rotate to the preferred setting. The numbers on the dials indicate the diameter of the bar one wants to bend in millimetres.

Once the settings are adjusted, the next step is to put the rebar in place and apply force on the lever until the bar is bent. Most of the tools only bend the bar up to 90 degrees.

If the force isn't enough to bend the bar then one shouldn't increase the lever size or apply more force, which may damage the tool. It only means that the rebar size is too much for the machine.

There are a lot of variations of this device. Every variation has its limits and drawbacks. Most of its variations can only cut bars up to 5/8 inches. Some of its variations only bend bars up to 90 degrees. It is a slow machine and can only bend one bar at a time. Most of the variations cannot bend bars of grade 60 and above.

One should always keep this device away from dirt, mud, water and dust which may damage its internal mechanism.

d. Bend Rebar using a Portable Rebar Bender

Fig. 4.1.11 Portable Rebar Bender

The portable rebar bending machine is commonly used at construction sites. It is also called a power bender.

This type of machine bends rebar easily and without damaging its strength. They are easy to operate and transport.
It works on both electricity and hydraulic power. Different variations can bend different sizes and grades of rebar. This device even allows one to bend rebar coming out of walls and columns. Its variations also come as a combination of rebar cutter and bender.

The process doesn't have a lot of steps. One has to place the rebar in the grip and turn the machine on. The hydraulic press bends the bar in 4 seconds. The machine can bend up to 180-degree. It can bend bars of up to 1-inch size. These may be a little expensive but are essential where one needs accuracy and speed.

e. Bending Rebar using Rebar Bending Machines

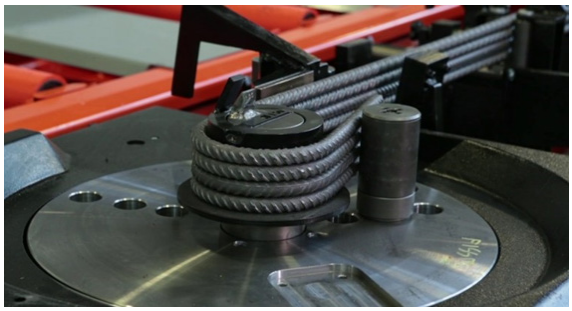

Fig. 4.1.12 Bending Machine

The rebar bending machine is an advanced machine used by companies in large construction projects. It is a large-sized machine with a big working platform. The machine is multi-purpose and one can use it for rebar of all shapes, sizes and types. One can even change the pillars or studs used to bend bars. Different sizes and types of bars require different pillars.

It works on pulleys and gears that allow it to bend strong bars. It also has different index pins to bend rebar at different angles.

The bending machine comes with appropriate safety features also. An emergency stop button in case something dangerous happens. The machine comes with a footswitch that lets one control the process as one wants.

To bend the rebar, first one needs to set up all the pillars according to the rebar to be bent. Then one needs to set up the indexing pieces according to the desired angle. Next, the bar should be placed between the solid bending disc and the square stick.

One then needs to press the footswitch and the bar will bend quickly. One can create a stirrup without taking the rebar out once.

4.1.5. Protection during cutting and bending

While working in different fields, one is required to use a variety of tools. It is important to follow the applicable safety rules and regulations for handling and storing reinforcement tools, materials and components. It includes the use of appropriate Personal Protection Equipment (PPE), such as face masks, gloves, goggles, etc.

For example, as stated earlier, during the cutting of rebar, a large amount of spark, smoke and dust is produced. These are health hazards and may cause skin damage and respiratory problems. One can mitigate these risks by wearing the correct Personal Protective Equipment (PPE) and working in a well-ventilated area away from flammable substances. Also, one could use carbide-tipped metal cutting blades, which helps reduce the amount of sparks generated.

4.1.6. Tagging Procedure for Rebar

Following cutting and bending, rebar of similar size and shape are grouped and tied. A tag specifying the location of steel in the structure is tied to each bundle. This location/ label corresponds with the member-numbering system given on structural drawings. If the structural drawings show insufficient detail to identify the reinforcement location, a marking drawing may be required.

Tagging of rebar basis its shape, size and location helps its easy identification.

4.1.7. Tolerance Limit

The tolerance limit in reinforcement works refers to the allowable deviation or variation from the specified dimensions or positions of the reinforcement bars during the construction process. It refers to the acceptable range of variation from the required dimensions or positions of the reinforcement bars that can still ensure the structural integrity and safety of the reinforced concrete structure.

Tolerance limits are usually specified by construction codes and standards, and they may vary depending on the specific requirements of the project. These limits are typically expressed as a percentage or a specific measurement, such as the allowable deviation from the required spacing, diameter, or position of the reinforcement bars.

The tolerance limit for cutting a rebar refers to the acceptable deviation or variation from the specified length of the rebar during the cutting process. The most commonly used tolerance limit for cutting a rebar is ±1/8 inch (or ±3mm) from the specified length of the rebar. This means that the length of the cut rebar can deviate by up to 1/8 inch or 3mm from the specified length without compromising the structural integrity and safety of the reinforced concrete structure.

The tolerance limit for bending a rebar refers to the acceptable deviation or variation from the specified angle of the bend during the bending process. The most commonly used tolerance limit for bending a rebar is ±5 degrees from the specified angle of the bend. This means that the angle of the bend can deviate by up to 5 degrees from the specified angle without compromising the structural integrity and safety of the reinforced concrete structure.

Tolerances for cutting and/or bending dimensions must follow the guidelines in the following table:

Tolerances	
Cutting and Bending processes	**Tolerances (mm)**
Cutting of straight lengths (including reinforcement for subsequent bending)	+25, -25
Bending: ≤ 1000mm > 1000mm to ≤ 2000mm > 2000mm	 +5, -5 +5, -10 +5, -25
Length of Bar in Fabric:	+25, -25, or 0.5% of the length (whichever is greater)

Table 4.1.1 Cutting and Bending Tolerances

4.1.8. Stirrup

A stirrup is a closed loop of rebar found in a reinforced concrete component that keeps the main rebar together. Stirrups can be found in various types depending on the design and shape of the structural members.

A stirrup consists of rebar wrapped around the top and bottom bars of beams (rectangular shape) or columns (may be rectangular or circular in shape).

These are often perpendicular to the longitudinal direction of rebar, they can be diagonally positioned also.

It's done to avoid shear failure that may occur in the case of beam cracks and is often diagonal. It's important for the stirrup designer to specify the stirrup spacing along the beam.

Types of Stirrup

Following are different types of stirrups based on shape:

i. Rectangular Stirrup
ii. Square Stirrup
iii. Circular or Round Stirrup
iv. Triangular Stirrup
v. Stirrups On a Spiral

Different types of stirrups based on the nature of construction:

i. **Single-legged Stirrups (Open Stirrup) -** These aren't commonly used, though they are useful when just two rods need to be tied. Single-legged stirrups have a flattened U-shaped form rather than a complete loop.

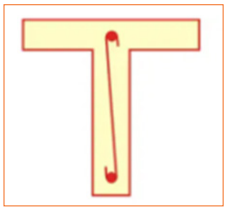

Fig. 4.1.13 Single-legged Stirrup

ii. **Two-legged or Double-legged Stirrups (Closed Stirrup) –** These are the most used type of stirrups in construction. As the name suggests, these have two legs and require at least four rods to be completed.

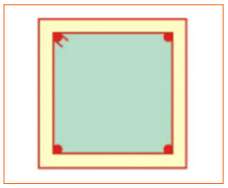

Fig. 4.1.14 Double-legged Stirrup

iii. **Four-legged Stirrups (Closed Stirrup) –** Such a stirrup is made up of two overlapping stirrups that do not surround all of the rods. If one has eight rods in two rows of four, the two overlapping stirrups will encircle six rods each, with the four in the middle wrapped by both.

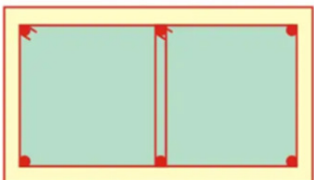

Fig. 4.1.15 Four-legged Stirrup

iv. **Six-legged Stirrups (Closed Stirrup) -** The identical eight-rod structure can be supported by a six-legged stirrup in place of eight rods. With this setup, the extra legs give additional support while a single stirrup surrounds all eight rods. Usually, these extra legs are positioned between two close rods.

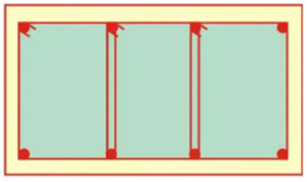

Fig. 4.1.16 Six-legged Stirrup

4.1.9. Chair Bar

Chair reinforcement also known as chair bars are small structural element that are used to place reinforcement bars in position and maintain the appropriate space between the top and bottom reinforcements.

Chair bars are primarily used in slab and footing. It's one of the most important parts of the raft foundations.

Importance of Chair Bars

Chair bars are used to:

- hold the reinforcement properly in position
- maintain the cover of the top and bottom bar
- maintain the distance between top reinforcement and bottom reinforcement
- provide strong support to the bars
- provide vertical support to the upper cage reinforcement and lower cage reinforcement in the footing and slab
- increase tension property of concrete, helping prevent the structure from collapsing due to the failure in the tension zone
- hold the reinforcement properly, so that the concrete may surround the reinforcement from all directions, including the bottom
- hold the upper cage bar from collapsing during vibration
- withstand the labour's and fresh concrete's weight

Parts of Chair Bar

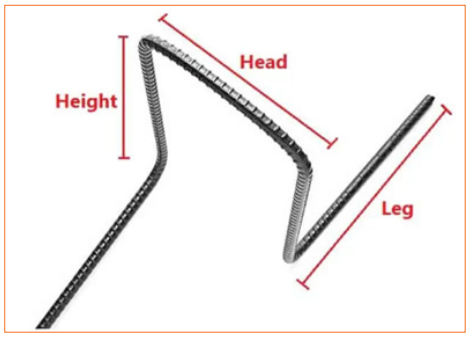

Fig. 4.1.17 Parts of Chair Bar

i. **Head of Chair:** The top horizontal part of the chair bar on which the upper cage reinforcement rests is called the head of the chair.
ii. **Height of Chair:** The vertical distance of the chair bar is called the height of the chair.
iii. **Leg of Chair:** The bottom vertical part of the chair bar is known as the leg of the chair.

Making Chair Bars

Generally, chair bars are made of 12mm and above diameter rebar. The most common diameter bars are 12mm, 16mm, and in some cases 20mm.

In rare cases, 10mm bars are used in slabs, when there is no extra external load other than the reinforcement cage load.

The reason for not using the smaller bars below 12mm is, they tend to bend or buckle due to overloading.

One should maintain the recommended spacing of chair bars which depends on several factors such as:

- Diameter of the bar used in making a chair. The larger the diameter of the bar, the more the spacing, and vice versa.
- The diameter of the rebar of the RCC structure.
- The type of structural member.
- External loads that act over the chair bar other than the rebar cage.

One should bend the rebar for making chair bars manually or using the bending machine, ensuring appropriate bending.

4.1.10. Hanger Bar

A hanger bar is a reinforcing bar which improves the load capacity of the anchor beyond the load at which the concrete would otherwise fail. A reinforcing bar is bent in an inverted V shape which is passed through a hole in the anchor.

Hanger bars are provided in concrete beams that support the secondary beams. Reinforcement is provided in the primary beam, and they are placed around the joint of two beams.

Design Technique

Generally, primary beams are provided to support the secondary beams. The reaction of the secondary beams is carried by the primary beam. The primary beams are designed for the reaction of the secondary beams. The joint should be designed to carry the reaction of the secondary beam. Engineers provide hanger reinforcement at the joint, in the primary beams in addition to the normal shear reinforcements.

Making of Hanger Bar

- Cut the required length of steel bar according to the design specifications.
- Use a bending machine or manual tools to shape the bar into a U-shaped or L-shaped configuration.
- Ensure that the hanger bar is shaped according to the design requirements, including the dimensions, angles, and spacing of the legs.
- Attach any necessary accessories, such as hooks or loops, to the ends of the hanger bar.
- Check the hanger bar for any defects or irregularities.

4.1.11. Safe use of cutting power tools in construction

Due to the potential dangers involved in using power tools, one must follow specific safety guidelines during their use. Electrical shock from power tools is one of the most severe workplace injuries involving power tools. Electrical shocks may cause severe burns and heart failure. One should follow the guidelines given below for the safe use of power tools and prevent electrical shocks.

- Use double-insulated tools with a three-pointed power cord which are plugged into a power source with a grounded receptacle.
- Use only approved electrical tools that have the required safety features, e.g. the ability to cut off power immediately and easily in case of an accident.
- Avoid using electric tools in wet conditions unless they are approved for use.
- Maintain the correct body posture and find good footing while using power tools to maintain balance and stay in control to avoid any accidents.
- Secure the workpieces (e.g. with clamps or a vise) to free both hands and use power tools safely.
- Use the appropriate PPE like face protection, leather work gloves, and steel-toe boots.
- Keep the work area clean and dry to avoid slipping while working around or with dangerous electric power tools.
- Never carry portable electric tools by their cords and also avoid pulling the cord from the power source.
- Keep fingers away from the switch button while carrying a power tool to prevent accidental starting.

4.1.12. Fundamental Principles of Ergonomics at Work

- **Use proper tools:** Use high-quality tools that are designed specifically for cutting and bending reinforcement bars. This can help reduce the amount of force required and minimize the risk of injury.
- **Work in neutral postures –** Maintain the proper posture, avoiding postures that may cause strain. Keep the neck, hands and wrists in proper alignment.
- **Keep everything in reach –** One should keep the necessary tools, equipment and materials within reach to avoid unnecessary stretch and strain while trying to reach items kept out of reach.
- **Use your body weight:** When cutting or bending bars, use your body weight to apply force rather than just your arms or hands. This can help reduce the strain on your muscles and joints
- **Reduce excessive motions –** It is important to avoid excessive repetitive motion which may cause disorder and numbness in long run. This can help prevent overuse injuries like tendonitis.
- **Work at the proper height –** One should work at the appropriate height which makes it easier to complete the relevant tasks. One should add appropriate extensions to maintain a proper while avoiding the use of chairs or tables as height extensions.
- **Maintain a comfortable environment -** The work area should have optimum conditions, e.g. appropriate lighting, temperature and spacing.
- **Move, exercise and stretch –** One should move and stretch following appropriate stretching techniques when possible.
- **Minimize fatigue and static load -** Fatigue is common in strenuous work. For example - having to hold things for a longer period is known as static load. One should take breaks at appropriate intervals between tasks to minimize fatigue.

Scan the QR code to watch the video

https://youtu.be/F1iVGU_1qD8

Cutting and Bending of Rebar

https://youtu.be/FTRENf1ptk0

Rebar

Exercise

1. Selecting the right type of rebar is essential for ensuring the safety and longevity of a construction project. List the factors that affect the selection of the type of rebar.
2. Identify two tools used for cutting rebar.
3. Name any two tools used for bending rebar.
4. What are stirrups? Name the different types of stirrup.
5. What is a chair bar? Mention the three parts of chair bar.

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5. Fabrication, Placing and Fixing of Rebar

Unit 5.1- Fabrication, Placing and Fixing of Rebar

CON/N0217

Key Learning Outcomes

By the end of this module, participants will be able to:

- List the different types of ties (Slash tie, ring slash tie, hair-pin tie, ring hair-pin tie, crown tie, lap tie) used in bar bending works
- Describe the sequence for tying of reinforcement bar in case of in-situ and pre-fabricated cages
- Explain the importance of lapping and staggering of reinforcement bars
- Describe the standard method of staggering of reinforcement bars.
- Explain use of chairs, hanger bar, spacer bar and cover blocks
- Demonstrate placing and fixing of chairs as per requirement for the slab reinforcement.
- Describe insertion and fixing sequence for footing, column, wall, beam and slab
- Demonstrate insertion and fixing of rebar for column, slab, beam and wall.
- Demonstrate fixing ties using hair pin tie, ring hair pin tie, slash tie, ring slash tie and crown tie.
- Demonstrate marking, placing, fixing and tying of stirrups for column, beam, wall & slab as per the specified spacing.

Unit 5.1 Fabrication, Placing and Fixing of Rebar

Unit Objectives

By the end of this unit, participants will be able to:

- List the different types of ties (Slash tie, ring slash tie, hair-pin tie, ring hair-pin tie, crown tie, lap tie) used in bar bending works
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- Demonstrate insertion and fixing of rebar for column, slab, beam and wall.
- Demonstrate fixing ties using hair pin tie, ring hair pin tie, slash tie, ring slash tie and crown tie.
- Demonstrate marking, placing, fixing and tying of stirrups for column, beam, wall & slab as per the specified spacing.

5.1.1. Pre-fabricated Cages

Pre-fabricated cages are reinforcement bar cages that are fabricated off-site and delivered to a construction site for use in reinforced concrete structures. These cages are pre-assembled, usually in a factory, and can be customized to meet a project's specific requirements.

Pre-fabricated cages can be made in different shapes and sizes, depending on the specific needs of a project. They can be cylindrical, rectangular, or square in shape, and can be used in a variety of applications, including building foundations, retaining walls, columns, and beams.

Using pre-fabricated cages has several advantages over on-site fabrication of reinforcement cages, such as:

- Increased productivity and efficiency as pre-fabricated cages can be manufactured in large quantities in a factory setting, reducing on-site fabrication time and labor.
- Better quality control as the pre-fabricated cages are manufactured in a controlled factory environment, ensuring consistent quality.
- Reduced waste as pre-fabricated cages are manufactured to the exact specifications required, minimizing scrap and waste.
- Safer construction sites as pre-fabricated cages reduce on-site fabrication and the associated safety risks.

5.1.2. In-situ Cages

In-situ cages refer to reinforcement bar cages that are fabricated on-site, at the construction site, in preparation for the pouring of concrete. The term "in-situ" means "on-site" or "in place," and therefore in-situ cages are fabricated in place at the location where the concrete structure will be constructed.

The process of fabricating in-situ cages involves the cutting and bending of reinforcement bars to the required sizes and shapes, which are specified in the project design drawings. The bars are then assembled and tied together using binding wire or other fastening materials to form a cage-like structure.

In-situ cages are used in a variety of applications, such as building foundations, retaining walls, columns, and beams. The advantages of in-situ cages include:

- **Flexibility:** In-situ cages can be customized and adjusted on-site to meet any design changes or modifications that may arise during construction.
- **Cost-effectiveness:** In-situ cages can be fabricated using less expensive reinforcement bars that can be easily sourced from local suppliers.
- **Reduced transportation costs:** Since in-situ cages are fabricated on-site, there is no need to transport them to the construction site, which can reduce transportation costs.
- **Control:** Fabricating in-situ cages on-site allows for greater control over the quality of the fabrication process, as well as the accuracy and precision of the final product.

5.1.3. Fabrication, Placing and Fixing

The process of fabricating, placing, and fixing rebar in a reinforced concrete structure requires careful attention to detail and strict adherence to quality control measures to ensure that the final product is of high quality and meets the required standards for safety and stability.

Fabrication Process

1. **Raw Material:** The first step in the fabrication of rebar is the selection of high-quality raw materials, typically steel billets or steel bars.
2. **Cutting:** The steel bars are cut to the required length using a mechanical or hydraulic cutting machine.
3. **Bending:** The steel bars are then bent to the required shape using a bending machine or manual bending tools.
4. **Quality Control:** The fabricated rebar is then subjected to a series of tests, including visual inspection, dimensional checks, and mechanical tests, to ensure that it meets the required quality standards.

Placing and Fixing Process

1. **Positioning:** The structural elements (column, beam, slab and wall) is then positioned in the formwork in the correct location and orientation, as per the design specifications.
2. **Tying:** Rebar ties, typically made of galvanized steel wire or plastic, are used to secure the reinforcement bars together at the intersection points, ensuring that they remain in place and are properly spaced and aligned during the concrete pour.
3. **Support:** Chairs, Hanger bars or spacers are used to hold the rebar in place and maintain the required spacing and alignment.
4. **Inspection:** The placement and fixing of rebar is then inspected by a qualified inspector to ensure that it meets the required standards and design specifications.

5.1.4. Fixing of Structural Elements

Insertion and fixing sequence for footing, column, wall, beam and slab may vary depending on the specific design and construction requirements, but a general sequence is as follows:

Footing:

- Excavate the soil to the required depth and width.
- Install reinforcement bars according to the design specifications.
- Pour concrete into the excavation and level it.
- Allow the concrete to cure.

Column:

- Place column formwork on top of the footing.
- Install reinforcement bars as per the design.
- Pour concrete into the formwork.
- Allow the concrete to cure.
- Remove the formwork.

Wall:

- Place wall formwork on top of the footing.
- Install reinforcement bars as per the design.
- Pour concrete into the formwork.
- Allow the concrete to cure.
- Remove the formwork.

Beam:

- Place beam formwork on top of the column and wall.
- Install reinforcement bars as per the design.
- Pour concrete into the formwork.
- Allow the concrete to cure.
- Remove the formwork.

Slab:

- Place slab formwork on top of the beams.
- Install reinforcement bars as per the design.
- Pour concrete into the formwork.
- Allow the concrete to cure.
- Remove the formwork.

After the completion of each of these steps, it is important to check the alignment and level of the structures before proceeding to the next step. In addition, any defects or issues should be fixed before proceeding to the next step to ensure the quality and stability of the overall structure.

5.1.5. Support and Spacing Elements

Chairs, hanger bars, spacer bars, and cover blocks are all components used in reinforced concrete structures to support and space reinforcement bars at the correct distance from each other and from the surface of the concrete. Here is a brief explanation of each of these components and their use in reinforced concrete structures:

Chairs: Chairs are small support structures that are placed on the formwork or subgrade and used to support reinforcement bars at the required height. They come in various shapes and sizes, such as circular or rectangular, and are typically made of plastic or metal. Chairs are important in ensuring that the reinforcement bars remain at the required height and distance from the formwork during concrete pouring and after the concrete has cured.

Hanger bars: Hanger bars are used to suspend reinforcement bars in a horizontal position. They are typically made of steel and are used in applications where it is not possible to place the reinforcement bars directly on the subgrade or formwork. Hanger bars can be attached to formwork or precast concrete elements to provide support to the reinforcement bars.

Spacer bars: Spacer bars are used to maintain a specific distance between two reinforcement bars. They come in various shapes and sizes, such as U-shaped or rectangular, and are typically made of plastic or metal. Spacer bars are used to ensure that the reinforcement bars remain in the correct position during concrete pouring and after the concrete has cured. They are also important in ensuring that the concrete cover over the reinforcement bars is maintained at the correct thickness, which is critical for protecting the reinforcement bars from corrosion.

Cover blocks: Cover blocks are used to keep the concrete cover over reinforcement bars at the right thicknes. They are typically made of concrete or plastic and are placed at regular intervals on the formwork or subgrade. Cover blocks are used to prevent the reinforcement bars from coming into direct contact with the environment, which can lead to corrosion, and to ensure that the concrete cover over the reinforcement bars is maintained at the required thickness.

5.1.6. Rebar Ties

Rebar ties are small pieces of wire or plastic that are used to secure reinforcement bars (rebar) together in a reinforced concrete structure. Rebar ties are typically made of galvanized steel wire or plastic, and are designed to withstand the tension and pressure of the concrete pour.

Rebar ties are used in both in-situ and pre-fabricated reinforcement cages to secure the bars together and maintain the required spacing and alignment. They are typically twisted around the intersecting points of the reinforcement bars, ensuring that they remain in place and are properly spaced and aligned during the concrete pour. The various types of ties used when securing reinforcing bars are:

i. **Slash tie:** Slash ties, sometimes referred to as simple or snap ties, are the most widely used infill ties. The wire ties are sometimes doubled for greater strength.

Fig 5.1.1 Slash Tie

ii. **Crown tie (Cross tie):** Crown tie, also known as cross tie or figure-eight tie, is a popular tie for setting up and fastening springy bars on main bars.

Fig 5.1.2 Crown Tie

iii. **Hair-pin tie (Saddle tie):** The hair-pin or saddle tie can be used as an alternative to the ring-slash tie. It works great for key bars.

Fig 5.1.3 Hair-pin Tie

iv. **Ring hair-pin tie:** The ring hair-pin is also known as a saddle tie with a turn. It is occasionally employed to secure major bars and avoid bar movement.

Fig 5.1.4 Ring Hair-pin Tie

v. **Ring slash tie (Wall tie):** Ring slash or wall ties are frequently used to secure smooth stirrups to major deformed bars in order to stop bar displacement.

Fig 5.1.5 Ring Slash Tie

vi. **Splice tie (Lap tie):** The splice tie is utilized when lapped lengths of rebar, etc. are being tied together.

Fig 5.1.6 Splice Tie

Economical use of Binding Wire

Using binding wire economically for tying of rebar is an important aspect of reinforcement works as it can help to reduce material waste, save time, and improve efficiency. Here are some tips for using binding wire economically:

- **Cut the wire to the right length:** When cutting binding wire, make sure to cut it to the right length so that you do not waste any excess wire. The length of the wire should be enough to wrap around the rebar at least twice and be secured tightly.

- **Use the right gauge of wire:** Using the right gauge of wire for the job can help to reduce waste and improve efficiency. If the wire is too thin, it may break easily, and if it is too thick, it may be difficult to wrap tightly around the rebar. It is best to use a gauge of wire that is appropriate for the size of the rebar being tied.

- **Don't overuse wire:** Using too much wire for tying the rebar can lead to wastage. Instead of wrapping the wire multiple times, try to wrap it only twice, but ensure that it is secured tightly. Overuse of wire can also lead to an increase in the weight of the structure, which can be undesirable.

- **Use the right tying technique:** Using the right technique for tying the rebar can help to reduce the amount of wire used. One common technique is the saddle tie, which involves wrapping the wire around the rebar and crossing it over the top to create a saddle shape. This method allows for efficient use of the wire while still ensuring a tight hold.

5.1.7. Stirrups

Stirrups are small reinforcement bars used in reinforced concrete structures to provide additional strength and stability to the structure. They are typically used to resist shear forces and prevent the longitudinal reinforcement bars from buckling under compression loads. Stirrups are commonly used in columns, beams, walls, and slabs and are an essential component of the reinforcement system in these structures.

Marking:

- Measure the spacing between the reinforcement bars where the stirrups are to be placed.
- Use a marker to mark the spacing on the reinforcement bars.

Placing:

- Cut the stirrup bars to the required length, allowing for the bends at the ends.
- Place the stirrup on the reinforcement bars at the marked spacing.
- Ensure that the stirrup is centered on the reinforcement bars.

Fixing:

- Bend the ends of the stirrup bars around the reinforcement bars using a bending tool.
- Ensure that the stirrup is securely fixed to the reinforcement bars.

Tying:

- Use binding wire to tie the stirrup to the reinforcement bars.
- Wrap the binding wire tightly around the stirrup and the reinforcement bars, ensuring that it is properly secured.
- Cut the excess binding wire using pliers.

Repeating:

- Repeat steps 1 to 4 for the remaining stirrups, ensuring that the spacing is consistent and the stirrups are properly fixed and tied.

5.1.8. Lapping of Reinforcement Bar

Lapping of rebar involves overlapping two or more pieces of rebar to create a continuous structural element. This is typically done to extend the length of a single bar, without having to use a longer, more expensive bar. The overlap length is calculated based on several factors, including the strength and size of the bars, the load they will be supporting, and the building codes and regulations governing the construction project.

Importance of Lapping

- **Cost-effective solution**: Lapping of rebars is a cost-effective way to extend the length of a single bar without having to use a longer, more expensive bar.
- **Simplifies construction:** Lapping can simplify the construction process by reducing the number of different lengths of rebars needed.
- **Improved strength and durability:** Lapping can also help in increasing the strength and durability of the structure by creating a continuous, unbroken length of reinforcement.

Process for lapping reinforcement bar

i. Determine the required overlap length and position on the rebar.
ii. Clean and prepare the surface of the bars to be overlapped, removing any rust, oil, or other contaminants that could weaken the joint.
iii. Place the first bar in position, making sure that it is properly aligned and supported.
iv. Position the second bar over the first bar, with the overlap length in the correct position.
v. Secure the two bars together with rebar ties or other fastening methods.
vi. Make sure the overlap joint is properly aligned, with the bars evenly spaced and parallel to each other.
vii. Use a straight edge or other measuring tool to ensure that the overlap length is correct and that the bars are straight and level.
viii. Once the joint is properly aligned and secured, continue placing additional bars as needed, following the same procedure.
ix. Inspect the completed rebar installation to ensure that it meets the required specifications and regulations for the construction project.

5.1.9. Staggering of Reinforcement Bar

Staggering of reinforcement bars is the process of spacing and positioning the bars in a reinforced concrete structure to optimize their strength and ensure proper load distribution. This is typically done to reduce the risk of cracking and to increase the overall durability and strength of the structure.
Staggering the reinforcement bars helps to distribute the load evenly throughout the structure, reducing the risk of cracking and other structural issues. It also helps to increase the overall strength and durability of the structure, making it more resistant to wear and tear and other environmental factors.

Importance of Staggering

Even load distribution: Staggering helps to distribute the load evenly throughout the structure, reducing the risk of cracking and other structural issues.

Improved strength and durability: Properly staggering the rebars helps to increase the overall strength and durability of the structure and makes it more resistant to wear and tear and other environmental factors.

Compliance with building codes and regulations: Building codes and regulations often specify the required spacing and positioning of rebars in reinforced concrete structures, and staggering is necessary to meet these requirements.

Process of Staggering

i. Determine the required spacing and positioning of the bars based on the structural and design requirements of the project.

ii. Lay out the bars in the correct position and orientation, making sure that they are spaced evenly and at the correct distance from each other.

iii. Stagger the bars by shifting the position of every other bar by half the spacing distance.

iv. Repeat the process for additional layers of bars as needed, ensuring that the bars are properly aligned and spaced.

v. Use rebar ties or other fastening methods to secure the bars in place and maintain the required spacing and alignment.

5.1.10. Splicing of Rebar

Splicing refers to the process of joining two or more reinforcing bars together to create a longer length. This is typically required in construction projects where long spans or lengths of reinforcing steel bars are needed, and the available lengths of the bars are insufficient to cover the required length. Splicing can be accomplished through a variety of methods, including mechanical splicing, welding, and overlapping.

Splicing should not be more than 50% of the total number of bars. This is done to avoid a concentration of stress in any one area. For example, if a column has 16 rebars and each rebar is 12 meters long, it may be necessary to splice two or more rebars together to achieve the desired length. If the maximum number of spliced rebars allowed in any one location is 50%, then no more than 8 rebars can be spliced together in any one location. This would require the splices to be staggered along the length of the column, to avoid creating a concentration of stress in any one area.

General steps involved in the splicing process include:

i. **Clean the rebars:** Before splicing, it is important to ensure that the ends of the rebars are clean and free of rust, scale, or other debris that could interfere with the splice. The ends of the bars may be cleaned using a wire brush, sandpaper, or a grinder.

ii. **Cut the rebars:** The rebars must be cut to the appropriate length to allow for the splice. The length of the overlap will depend on the specific splice method being used, as well as the size and grade of the rebars.

iii. **Position the rebars:** The rebars should be positioned according to the splice design, ensuring that they are aligned properly and spaced appropriately.

iv. **Prepare the splice:** The ends of the rebars must be prepared for the splice, which may involve the use of couplers, mechanical splices, or other devices to join the rebars together. The splice must be designed to ensure that it is strong and durable, and that it meets any applicable building codes or standards.

v. **Install the splice:** The splice is installed by connecting the prepared ends of the rebars together, using a coupler or other device to join them. The splice may be secured in place using wire ties or other fasteners, depending on the specific splice method being used.

vi. **Inspect the splice:** After the splice has been installed, it should be inspected to ensure that it meets all applicable building codes and standards, and that it is strong and durable. Any defects or issues should be addressed before the structure is put into service.

Scan the QR code to watch the video

https://youtu.be/yUlPEryeIMA
Pre-fabricated Cages

https://youtu.be/0mNUSewKGUk
Fabrication, Placing and Fixing

https://youtu.be/ZHVXWxEFqWI
Fixing of Structural Elements

Exercise

1. What are Rebar Tie? List the types of ties.
2. What is Lapping? Explain its importance.
3. What is Staggering? Explain its importance.
4. Write a short note on the following:
   a. Chairs
   b. Hanger bars
   c. Spacer bars
   d. Cover blocks
5. Match the following:

A	B
Slash tie	
Ring slash tie	
Hair-pin tie	
Ring hair-pin tie	
Crown tie	
Lap tie	

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6. Erect and Dismantle Temporary Scaffold

Unit 6.1- Erect and Dismantle a Scaffold

CON/N0101

Key Learning Outcomes

By the end of this module, participants will be able to:

- Identify different components of scaffold.
- List tools, materials components required for erection of 3.6 meter scaffold.
- Erect a temporary scaffold up to 3.6 metres height.
- Dismantle and stack a temporary scaffold up to 3.6 metres height.

Unit 6.1 Erect and dismantle a scaffold

Unit Objectives

By the end of this unit, participants will be able to:

- Explain scaffolding and its purpose
- List the common materials and tools used for erection of scaffolding (pipe, cup lock (vertical and ledgers), H- frames, bamboo and balli
- List the functions of different hand tools like hammer, spanner, pulleys, hooks, ropes, etc., used for erection/ dismantling of scaffolds
- List the visual checks to be carried out on the scaffolding components to ascertain their usability
- Identify different components of a temporary scaffolding such as base, toe board, guard rails, platform, walkways, ladder and so on
- Explain the functions of materials, components and accessories used in scaffolding
- Demonstrate preparation of scaffolding base
- Explain the methods adopted for the erection of the scaffold to ensure its safety
- Demonstrate erection of a scaffold up to 3.6 m height using pipes and couplers/ cup lock system/ H frame employing appropriate hand tools
- Explain various checks to be done on completion of erection of scaffolds, such as verticality check, stability check etc.
- Demonstrate the checks required for verticality, rigidity and stability during erection of scaffold.
- Explain the sequence and standard procedure of dismantling and stacking of scaffold
- Demonstrate the dismantling of the erected scaffold.
- Demonstrate the stacking of material, components, tools and accessories during erection and after dismantling.

6.1.1. Scaffolding

A scaffold, also known as scaffolding or staging, is a temporary construction that provides a sturdy platform for working at height or in difficult-to-access areas.

These temporary constructions are frequently used to support work crews and materials during the construction, maintenance, or repair of buildings, bridges, and other man-made structures.

Benefits of scaffolding

Scaffolding has been used for thousands of years for a reason: it works. Scaffolding continues to be one of the most useful and efficient means of working at height.

Here are the principal benefits of use scaffolding for work at height:

- **Access.** Scaffolding can provide unobstructed, stable access to virtually any region of a structure.
- **Balance.** Scaffolds provide workers with stable footing, allowing them to maintain balance in a variety of operating situations.
- **Construction ease.** Scaffolding is generally simple to assemble and remove, and may be erected and dismantled quickly.
- **Long-lasting.** Whether they're composed of wood or steel, most scaffolding may last for an extremely long time.
- **Safety.** Safety is one of the most essential benefits of scaffolding, as it provides a stable working platform for personnel. The best option for work at height, however, is to reduce or even eliminate the requirement for a person to be there; in the final portion of this guide, we will discuss how drones can assist inspectors lessen their need to work at height.
- **Functions as a bridge.** A variety of construction tasks necessitate that workers take circuitous paths to reach specific areas, which is a major time waster. By shortening the distance that employees must go, bridging points on scaffolding can aid in solving this issue.

6.1.2. Uses of Scaffold

Nowadays, scaffolding is utilized for a variety of purposes. Here are some of the most prevalent applications for scaffolding:

- **Cleaning:** Workers frequently use scaffolding to clean windows and other components of tall structures.
- **Construction**: Scaffolding is essential for construction because it allows employees to stand on a secure surface at heights. This is notably true for skyscrapers and other high-rise structures, but it is also a typical practise for ground-level construction projects.
- **Occupational inspections:** Scaffolding is commonly used for inspections because it enables inspectors to reach inaccessible regions to conduct visual inspections and other NDT testing. Inspectors frequently employ internal scaffolding or other temporary structures for both internal and external inspections, such as those performed inside enormous industrial boilers or pressure vessels. Regardless of the type of inspection, the scaffolding serves the same purpose: to enable inspectors to stand at height and conduct a variety of tests to satisfy inspection criteria.

- **Maintenance:** Typically, inspections are the initial stage in a maintenance procedure, as they identify areas that may require maintenance. After these faults are discovered by inspectors, maintenance personnel will address them while standing on scaffolding.
- **Other uses:** Different types of scaffolding are also employed for:
- Theatrical stages
- nstallations of art
- Exhibition displays
- Observation platforms
- Observation stand seating
- Shoring Ski ramps

6.1.3. Scaffolding Components

Here are all the scaffolding components:

- **Standards.** This structure comprises of vertical elements supported on the ground, on drums, or by ground anchors.
- **Ledgers.** The length of a scaffold bay is defined by tubes with a case wedge fixing device positioned horizontally between two standards and defining the length of the scaffold bay.
- **Braces.** The braces are attached to the standards diagonally.
- **Putlogs.** A putlog connects the wall under construction to the ledger. A putlog hole is drilled into the side of a structure to accommodate a putlog.
- **Transoms.** A transom is a sort of ledger putlog that both ledgers support.
- **Bridle.** Bridles are used to bridge an opening in a wall by supporting one end of the putlog that is used to build the wall.
- **Boarding.** Boarders function as horizontal platforms for supporting workers and materials throughout the construction process.
- **Guard railings.** A rail installed at the same height as the ledger.
- **Toeboard.** A parallel arrangement of boards supported by putlogs that provides protection at the level of the working platform.
- **Ladder scaffolding.** Using scaffolding ladders, employees can simply mount and descend the erected structure.
- **Scaffolding wheels.** Wheels at the base of the scaffold that facilitate its mobility from one location to another.

- **Cup-lock:** Cup-lock Scaffolding is a temporary framework utilized to support a slab, work crew, and materials during the construction, maintenance, and repair of buildings, bridges, and all other man-made structures. Cup-lock is a galvanized or painted, multipurpose steel scaffolding system that is excellent for giving general access and supporting vertical loads. All vertical standards and ledgers tubes are 48.3mm diameter with 3.00 or 3.20 mm thickness.

- **H Frames:** Due to its features, H-frame scaffolding guarantees significant labour and time savings. Essentially, the system consists of interconnected frames. One H frame is 2 metres high, whereas the length between two H frames is 2.5 metres. In addition, auxiliary factors are utilized in this system:

  - Metal plank
  - Stairs with or lacking a landing
  - Adjustable base jack
  - Adjustable support
  - Inclined floors are levelled with the aid of screws with a variable length. Steel work platforms improve the safety and durability of scaffolding. Passageways between floors are secure inside scaffolding with some applications such as staircase or access ladder. The use of a scaffolding clamp in jacketing operations improves scaffold safety and facilitates its deployment.

- **Pipes:** Galvanized scaffolding pipes are the most durable type of steel scaffold tubes. There are three distinct variations of galvanized steel scaffolding pipes. Include E-galvanized scaffolding pipes, GI pipes, and hot-dip galvanized steel pipes. HDG scaffold tubes are another term for hot-dip galvanized scaffolding pipe.

- **Bamboo:** In China and Hong Kong, bamboo scaffolding has replaced steel for numerous reasons. In reality, bamboo has a higher tensile strength than steel. It is also considerably less expensive and fully eco-friendly.

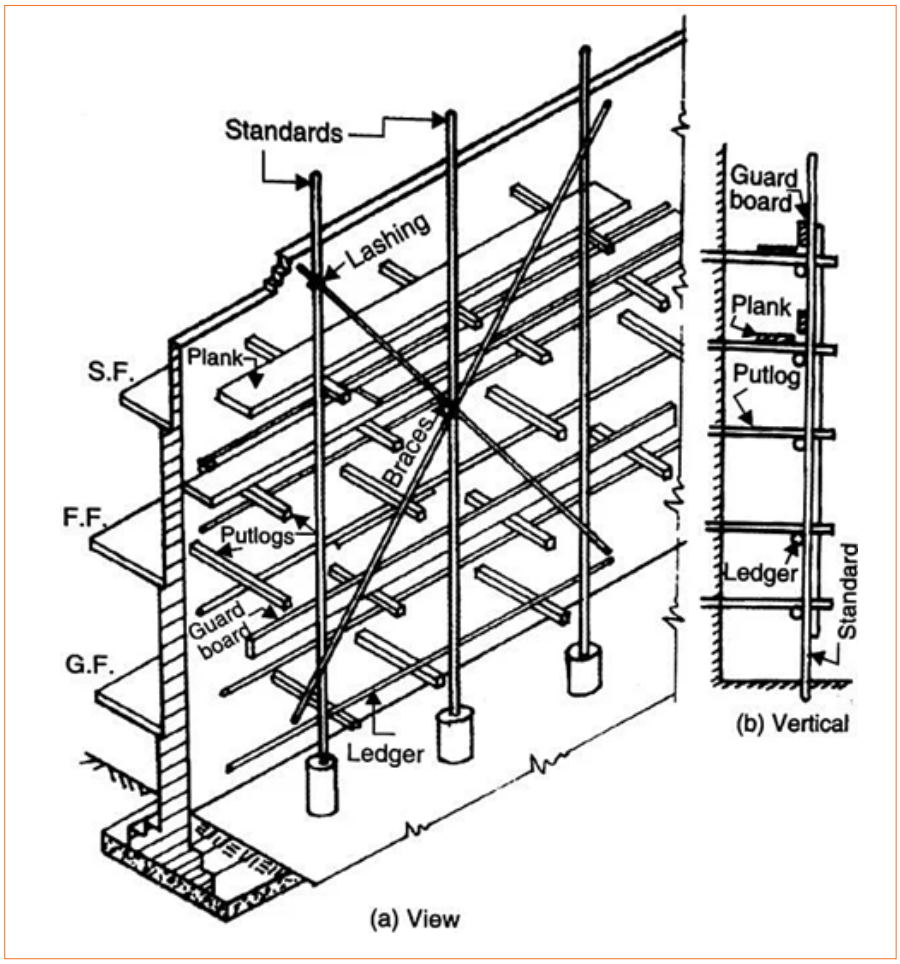

Fig. 6.1.1 Components of Scaffolding

6.1.4 Scaffolding Materials

Here are three of the most prevalent materials used to construct scaffolding:

- **Aluminium scaffolding.** Aluminium is commonly used for scaffolding because it is lightweight, sturdy, and highly corrosion-resistant.
- **Bamboo skeletons.** Since it is sturdy, flexible, lightweight, easy to work with, and abundant in certain places of the world, bamboo is an excellent alternative to steel. In Hong Kong, for example, bamboo is the most prevalent material used for scaffolding, and it is frequently repurposed from other applications to reduce waste.
- **Iron scaffolding.** Steel scaffolding is one of the most prevalent scaffolding materials. Although it is more expensive than bamboo or aluminium, it is quite sturdy and long-lasting, making it a perfect material for urban construction.

6.1.5. Scaffolding Erection and Dismantle

The erection and disassembly of scaffolding remains a hazardous task, not just for those performing the work, but also for other workers and the general public. The measures outlined in this guidance must be considered by everyone engaged in such activities. It is intended not only for scaffolding sector workers, but also for clients, planning supervisors, and general contractors. Listed below are a number of important considerations you must make to ensure the safety of scaffolding activities.

Scaffolds should always be built under the guidance of a skilled professional. Despite the fact that scaffold systems differ between manufacturers, all scaffold systems must meet a few basic specifications. A professional engineer must design frame scaffolds above 15 m (50 ft.) in height and tube-and-clamp and systems scaffolds over 10 m (33 ft.). The scaffolds must be built in accordance with the design, according to supervisors'

Scaffold Licenses

Before a scaffold can be placed on a public motorway, a permit from the local authority is required. Typically, an additional licence is required to instal a protective fan. A licence may stipulate lighting or painting requirements for a scaffold, or the maximum height at which a fan may be installed. For further guidance you should contact your local highway authority.

Protection of the public

During scaffolding activities, the public must be separated from both the work area and a suitable buffer zone.

- Obtaining a temporary pavement or street closure whilst operations are carried out;
- Carrying out operations during "quiet" hours, i.e. early morning, late evening, or weekends;
- Incorporating fans, crash decks, and "tunnels" as early as possible into a scaffold;
- Erecting barriers and signs and diverting the public away from operations;
- Storing scaffold clips and other loose material safely on the scaffold; and
- Not raising or lowering the scaffold during

Also remember that disabled individuals require proper access along scaffold-covered sidewalks.

6.1.6. Scaffolding Erection

Scaffolding is frequently required for building and home maintenance. Set up scaffolding correctly to ensure your safety and the safety of those utilizing the equipment. A lapse in scaffolding erection could result in a serious accident. The use of scaffolding is an alternative to ladders. In comparison to a ladder, scaffolding provides a bigger working space and greater manoeuvrability. It provides a walking surface and a place to set your tools. This significantly reduces work hours.

Here is a summary of the processes necessary to construct scaffolding:

- **Establish the foundation.** The scaffolding should be constructed on flat, stable ground. Attach the scaffolding to base plates or mud sills for stability; if you are on an uneven surface, you may need to dig down to level the soil.
- **Level it.** Ensure the scaffolding is level by adjusting the screws. If the terrain is steeply sloping, you may need leg extensions.
- **Consider casting devices.** If you intend to move the scaffolding from one location to another, it should incorporate wheels. Ensure that the casters are locked before installing the item.
- **Guarantee good assembly.** The scaffolding ends must be constructed correctly. First, raise one end portion, then connect the upper cross brace. To attach the upper cross brace of the second end piece, you must support the end by lifting the far end of this brace. Finally, secure the ends of the cross braces to the bottom of the opposing end frame.
- **Place the planks.** Place the planks over the scaffold bar and secure them in place using the provided hardware.
- **Identify access.** Consider accessibility when constructing a scaffold. If ladders are used for access, ensure that they are suited for the exact scaffold you are using and do not offer any other safety risks.
- **Mount guardrails.** Due to the height of the equipment and the risk of falling, guardrails must be installed on all scaffolds. Additionally, you should think about fall prevention measures, such as tie-offs.
- **Observe it**. Inspect the scaffolding thoroughly to ensure that it is safe for use. Ensure that all scaffolding components are secure by reviewing the setup properly. After leaving and returning to the site, always verify the scaffolding to ensure that it is still safe.

6.1.7. Hand Tools used in Erection/Dismantle

The following hand tools are used in erecting or dismantling the scaffold:

1. **Hammer:** A hammer is intended to deliver a large amount of force in a compact area. It is a long wooden stick connected to a metal block. The hammer is circular on one side and sharp on the other. The hammer is your closest friend whether you need to hammer something into place or smash something. However, ensure that the weight is appropriate for the user. When selecting a hammer, one must carefully consider the available sizes and weights.

Fig. 6.1.2 Hammer

2. **Spanner/Wrench:** A spanner is utilized to grasp and rotate items. Aside from plumbing, these instruments can also be used to assemble furniture or repair bicycles by loosening or tightening nuts and bolts. There are numerous types of spanners, including those with closed ends, open ends, and adjustable ends.

Fig. 6.1.3 Spanner/Wrench

3. **Pulleys:** A pulley is a simple machine composed of a rope and a wheel with grooves. The rope fits into the wheel's groove, and pulling on the rope causes the wheel to rotate. Generally, pulleys are used to raise objects, particularly heavy ones. The item lifted by a pulley is referred to as the load.

Fig. 6.1.4 Pulley

4. **Hooks:** A double-action aluminium scaffold hook typically used in conjunction with a fall arrest safety lanyard for rapid attachment to scaffolding or steel structures.

Fig. 6.1.5 Hooks

5. **Ropes:** Bundles of scaffolding rope coir yarn. In shapes such as bales, spools, dholls, and ropes. Cut to lengths suitable for both industrial and agricultural applications. Material used in the production of PVC-tufted pile carpets and mats, wall-to-wall carpets, and doormats. Support for hop plants and scaffolding erection for construction operations. Depending on the twist of the yam and the type of fibre used, a variety of characteristics suitable for various applications are available.

Fig. 6.1.6 Scaffolding rope

6.1.8. Safety Checks

1. Vertical Safety Check: Checking verticality would be required at various stages of building construction, such as when constructing vertical column formwork and transferring levels up consecutive floors of multi-story constructions. Several ways for controlling or inspecting verticality work in building construction are discussed.

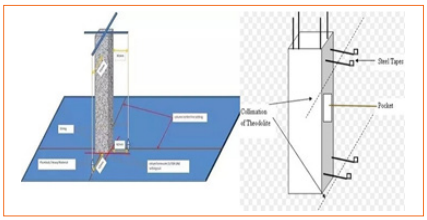

Fig. 6.1.7 Vertical Scaffolding Check

Methods used to check or control verticality works include:

a. Plumb-bob technique
b. Spirit level
c. Theodolite
d. Optical plummet

Fig. 6.1.8 Plum Bob Technique

a. Plumb-Bob Technique

As depicted in the illustration below, a plum-bob consists of a weight with a pointy tip attached to the end of a string. The heavy object will hang under the force of gravity and provide an exact vertical line, known as a plumb line.

This method is used for verifying or controlling the vertical alignment of structural elements, particularly inside, such as lift shafts. In addition, it controls the verticality of the foundation, walls, and columns.

The plumb line or vertical line of a plumb-bob will lose its accuracy and precision when subjected to wind force. Small to moderate lateral movement of the plumb-bob can be effectively minimized by soaking it in oil or water. If the height of the structural member is high, it is conceivable to replace the string with a long wire, but substantial precautions must be taken to avoid endangering the workers below.

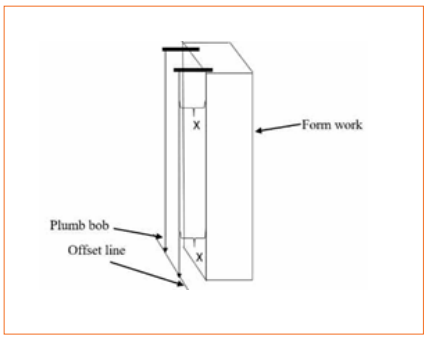

Fig. 6.1.9 Checking Verticality of Columns

b. Spirit Level Method

This device is suitable for managing the verticality of small-scale construction projects, such as examining door frames and formwork. If a spirit level is used for approximate inspections, then a more precise technique must be used to evaluate the verticality.

Fig. 6.1.10 Spirit Level

c. Theodolite Method

The theodolite is an extremely potent equipment that may be used to check the verticality of construction projects with high precision and accuracy. It is appropriate for verifying or managing the verticality of towers as depicted in Figure 4.1.9, walls, foundations, and columns as depicted in Figure 4.1.10, particularly a large number of columns along a single grid line. Using a Theodolite in conjunction with a tape, it is possible to measure the slope of the member's out-of-plumb line. The process for verifying column verticality comprises:

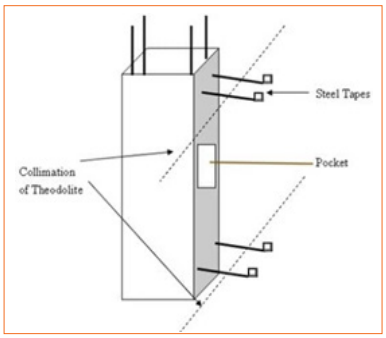

Fig. 6.1.11 Checking Verticality Using Theodolite

Install the digital Theodolite so that it is positioned on a peg that is 500 mm from the column grid.

After Theodolite has been precisely positioned, the laser beam will be activated and focused on the steel tape that is attached to the formwork.

Put the steel tape's reading via the telescope.

Take the readings of two spots at the same level on both the upper and lower formwork levels. By taking two measurements at the same level, any surface curvature can be determined. The figure below illustrates these steps.

d. Optical Plummet Method

It is a device that can look directly up or directly down. In comparison to previous methods utilized for managing verticality, the optical plummet's automatic compensator substantially improves its accuracy.

Fig. 6.1.12 Optical Plummet

2. Stability Check: Under each foot's contact with the ground, stabilise the scaffolding with solid, flat wood planks. This will prevent your scaffolding from becoming uneven and sinking into muck. Add weight and bracing to prevent the device from toppling.

Rule of Three to One

Unless the scaffold is one of the following, the height to least lateral dimension ratio cannot exceed 3:1.

- Linked to a structure, as described in the Tie-in Requirements section.
- Fitted with appropriate guy wires
- Provided with outrigger stabilisers to preserve the 3 to 1 ratio.

6.1.9. Safety Check before Dismantling

Safety must always come first in scaffolding and the construction business. Because disassembling a scaffold is just as tough as assembling one. Therefore, one must first devise a plan for disassembling your scaffold. Before dismantling a scaffold, one should always begin by doing a comprehensive inspection. One may continue as follows:

One may continue as follows:

Step 1: Check the stability and statics of the scaffolding. All scaffolding components should continue to be firmly attached to one another. If individual components have been removed or badly damaged throughout the scaffold's service life, they must be replaced for safe dismantlement.

Step 2: Check whether the scaffolding decks are still firmly in place.

Step 3: Verify the stability of all anchors and fasteners on the scaffold.

Step 4: Check the type of fall protection required during disassembly and install it.

Step 5: Ensure that no unsecured building materials or tools remain on the scaffolding. In the worst-case scenario, these could fall during disassembly and injure those below.

All of these stages are fundamental to a proper scaffold inspection.

6.1.10. Dismantling the Scaffold

Once the scaffold has passed all safety inspections, then can begin disassembling it. Again, one should continue methodically:

Step 1: Make space for the disassembled scaffolding components.

Create a nearby storage area for the disassembled scaffolding components. During disassembly, individual scaffold components should be taken off the scaffold and set away for subsequent inspection. In addition, there must be an access route for the vehicle that will transfer the scaffolding materials away from the construction site.

Step 2: Put safety equipment

Wear the appropriate protective clothes. This comprises PPE, such as safety shoes, a helmet, and gloves, as well as any other safety equipment necessary by the project.

Step 3: Remove scaffolding components from the top to the bottom

Logic dictates that disassembly should occur in the reverse sequence of assembly, from top to bottom. Before disassembling the scaffold decks, remove the tubes and safety railings first. During disassembly, scaffolding components should not be stored on the scaffold, but rather transferred immediately to the ground. This can be accomplished by reaching down to a colleague or by carefully lowering using a rope system or similar device.

Step 4. Remove scaffolding anchors

Stability must also be maintained at all times during scaffold disassembly. Therefore, remove the anchors only after disassembling the complete platform.

Step 5: Check the scaffolding components

After disassembling all scaffolding components, properly inspect them. Defective scaffolding components may cause injury, so any components that cannot be fixed must be set aside for disposal. All undamaged or reparable scaffolding components must be stored properly for transfer off-site.

Scan the QR code to watch the video

https://youtu.be/96shGh3rfXw

Scaffolding

https://youtu.be/5Vj-MosphpY

Uses of Scaffold

https://youtu.be/OKawvyUhUkA

Scaffolding Erection and Dismantle

https://youtu.be/AoDWOZE8Wb4

Safety Checks

Exercise

1. Explain scaffolding and its uses.
2. Name any 5 scaffolding components.
3. Explain the steps required for dismantling the scaffold.
4. Name the hand tools used in erection or dismantling of scaffold.

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7. Work Effectively in a Team

Unit 7.1- Work effectively in a team

CON/N8001

Key Learning Outcomes

By the end of this module, participants will be able to:

- Demonstrate effective communication with co-workers, superiors and sub-ordinates across different teams
- Provide support to co-workers, superiors and sub-ordinates within the team and across interfacing teams to ensure effective execution of assigned task.

Unit 7.1 Effective Interaction and Communication

Unit Objectives

By the end of this unit, participants will be able to:

- Demonstrate effective communication skills while interacting with co-workers, trade seniors and others during the assigned task.
- Interpret work sketches, formats, permits, protocols, checklists and other work-related requirements which are to be conveyed to other team members
- Demonstrate effective reporting to seniors as per applicable organisational norms.
- Explain effects and benefits of timely actions relevant to system scaffolding works with examples
- Explain importance of team work and its effects relevant to system scaffolding works with examples
- Demonstrate team work skills during assigned task.

7.1.1. Effective Communication

Effective communication is the process of sending and receiving messages from sender to receiver properly and successfully. The information is passed by signs and signals, speaking, writing or using some other medium and means. The objectives of effective communication are:

1. Sending, receiving and understanding the message or information.
2. Development of Interpersonal Skills.
3. To express effectively & with maximum efficiency.

Effective communication requires one to follow basic principles of communication, i.e., 7Cs:

- Clear: Be assertive about what needs to be communicated, whether verbally or in writing
- Concise: Use simple words and say only what's needed
- Concrete: Use exact words, phrases, Use facts and figures
- Correct: Use correct spellings, language and grammar
- Coherent: Words should make sense and should be related to the main topic
- Complete: A message should have all the needed information
- Courteous: Be respectful, friendly and honest

Communication Process

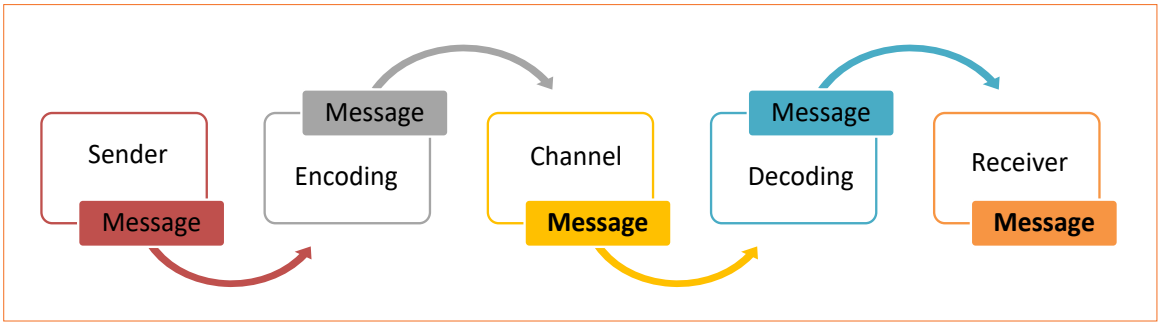

Fig 7.1.1 Effective Communication Process

- Sender: The person or entity starting the communication.
- Message: The information that the sender wishes to share.
- Encoding: Choosing the medium to send a message.
- Channel: The medium used to send a message.
- Receiver: The person or entity to whom the message is sent.
- Decoding: Understanding the message received.
- Feedback: The receiver's response to the message.

7.1.2. Workplace Communication

Every workplace organisation requires communication for day-to-day business, regardless of size, location, goals, etc. It forms a bridge between people to exchange ideas, inform, express their feelings, influence others, etc. Communication is required to communicate within the organisation with managers and employees, etc. and outside with suppliers, buyers, etc.

Effective Communication with Stakeholders

The key factors to establishing effective communication in the construction industry are:

1. Establish a Communication Chain of Command

Construction projects need a communication chain. The contract documents usually require the owner and general contractor to communicate through the architect.

The architect communicates with consultants and the general contractor with suppliers and subcontractors. The general contractor usually contacts the project superintendent.

Contract documents—drawings, specifications, change order forms, and requests for information—form the basis for construction communication. Any direct communication not in the contract documents must be authorised, and any scope or schedule modifications must be documented and reported.

2. Select an Appropriate Communication Method

We communicate vocally and nonverbally daily, and construction communication is no different. We text, talk on the phone and in person, send emails, and some of us still use fax machines inexplicably in this digital era. We communicate on the building site with signs, drawings, hand gestures, and meetings. We write daily reports, take photographs, generate information requests (RFIs), and examine modification orders.

There are benefits and drawbacks to each way of communication. Selecting the appropriate mode of communication can facilitate and expedite the transmission of information.

3. Be an Active Listener

One should be an active listener when engaging in oral communication, whether in person or by phone. At best, it is passive listening to sit there and absorb the information like a digital recorder. Try to comprehend what the speaker is trying to convey from their perspective.

Take notes on significant points, rather than transcribing every word they say, and jot down information that may require clarification. Maintain eye contact and use nonverbal cues such as head nods to demonstrate attentive listening.

4. Prevent Confusion, Be Clear and Concise

When communicating in the construction industry, you want your message to be understood the first time you convey it. Avoid jargon and unfamiliar phrases when interacting with others. Your communication should be concise and direct. Keep it as brief and clear as possible.

Focus on one project at a time if you are working on multiple projects with the same owner or architect to avoid misunderstanding. The real difficulty lies in attempting to be as descriptive as possible while using as few words as possible.

It takes practice to be concise yet comprehensive in your construction communications. Before sending any written communication, proofread it to determine if it may be shortened without affecting its meaning or omitting vital details.

5. Keep Written Communication Always Professional

Avoid using profanity and allowing your emotions to influence your message. If your feelings are running high, wait 24 hours before sending the email so that you can examine and make any necessary modifications. If a quick answer is required, read the message aloud or have another person review it for a second opinion.
Separate huge data pieces into smaller paragraphs. People tend to scan rather than read emails; thus, dividing the content into smaller bits facilitates processing. Use numbered or bulleted lists when delivering numerous details or posing innumerable questions.

6. Stick to the Facts

One should solely care about presenting or obtaining facts. In all communications, do not overcomplicate or provide irrelevant details. Keep the personal ideas and feelings about a project to yourself unless asked.

However, you must offer your professional thoughts on a project when you believe they could contribute to its practical completion. Your company's expertise contributed to its selection for the project, so don't be shy.

- Communicate effectively with the plant operator; Lower all ground engagement tools and/or implements to the ground.
- Disengage the plant controls so that they cannot be accidentally activated by the operator or by any other means;
- Visibly remove their hands from the controls of the powered mobile plant; and cease all movement of the plant.

7.1.3. Adverse Effects of Poor Communication

There is poor workplace communication when there is a disconnect between what is said and what is heard, whether between co-workers or between an employee and management. Specifically, there is a lack of mutual understanding between two parties when the recipient of your communication misunderstands it.

The following issues are faced due to poor communication:

Confusion

In building, a lack of communication is problematic. Miscommunications can also have a negative effect on a project by causing misunderstandings among significant stakeholders, construction professionals, and field personnel. Inconsistent reporting, incomplete reporting, inaccurate reporting, and delayed reporting can all contribute to errors that result in project delays and cost overruns on the construction site and the office.

Clear and straightforward messages prevent confusion. Keep messages brief, concise, and to the point.

Unnecessary Delays

Poor communication is a primary cause of project delays in the construction sector. It can manifest in various ways, including delays in the flow of information, communication directed to the wrong person or location, and confusing communication that leads to misunderstanding or incorrect interpretation. Any of these inefficient communication elements can result in errors and cause delays. Ordering unsuitable material, omitting a step in the construction process, or misallocating labour can all result in project delays.

Budget/Cost Overruns

According to the Project Management Institute (PMI), inefficient communications and improper time management of project communications account for more than half of all project budget risks. Poor or erroneous communication frequently results in greater expenditures. Adding a zero to a significant number can wreak havoc on a budget.

Injuries and Safety Issues

Poor safety communication is frequently attributable to three frequent causes:

- Workers lack familiarity with the safety training vocabulary. This is particularly true for trainees who are fresh to safety training. They can disconnect more quickly at this moment.
- Workers are scared to speak out when they find a safety hazard. They may fear judgement if they

alert a colleague or supervisor to a potential danger. It is simpler to avoid risk.

- Workers frequently regard safety communication as unfavourable. Typically, only negative situations are discussed or emphasised, while the positive aspects of their behaviour are neglected.

Issues with Stakeholders

Multiple parties are involved in every construction project, including owners, designers, investors, general contractors, project managers, subcontractors, and labourers. Effective and thorough communication among a project's stakeholders is essential to its success. It can lead to increased project expenses, delays, and stakeholder disputes. Poor project data and miscommunications between project stakeholders account for nearly 48% of all project rework.

7.1.4. Teamwork at Workplace

Teamwork is when people of an organisation collaborate to achieve a common objective or set of objectives. In the modern workplace, teamwork can take place in-person or (increasingly) online.

It is important to note that modern teams are vastly different from those of the past. Today's teams, for instance, are more varied and dynamic, with specialised skill sets that present new problems and opportunities. Consequently, any team-based initiative can also serve as an opportunity for personal and professional development.

As technology continues to dominate the workplace, digital literacy, or the ability to use information and communication technologies, has become increasingly vital in team settings.

Advantages of Teamwork

There is no stronger tool in a business' armoury than a strong staff. Effective teams can increase efficiency by tackling more complex tasks (think "two heads are better than one"), improve communication by fostering open discussion and cooperation among team members, maximise output by leveraging each team member's strengths, provide opportunities for personal growth, and serve as a support mechanism for staff.

Unsurprisingly, cooperation in the workplace has also been demonstrated to boost invention and creativity by allowing team members to contribute their own unique perspectives. Effective cooperation supports organisational growth and improves performance and success by capitalising on the unique talents and characteristics of each employee.

7.1.5. 5 C's of Teamwork

It is crucial for organisations and corporations to continuously seek ways to increase their productivity and competitiveness. It has been discovered how to make work teams more unified and effective. In other words, work as a team. For this reason, a great number of specialists have sought out the most efficient method for fostering teamwork.

Tom Peters, who is regarded by many as the "father" of modern management, investigated the variables necessary for teams to achieve high performance. His research established the five C's of teamwork, which are essential for achieving high performance.

Co-operation

Without cooperation between team members, no group will survive. Cooperation is intimately linked to effective communication and self-assurance. Better communication and a transparent and healthy work environment necessitate some degree of clarity and trust.

Compromise

Work relationships are not exempt from the necessity of reaching compromises on particular issues. If our peers' or managers' argument is valid and can contribute to greater performance, we may be required to concur. It is acceptable that not everyone can be on the same page at all times. To manage such circumstances, we must examine the situation and consider potential outcomes.

Communication

Considered vital for organising the individual and group efforts of the team. Communication is essential for conflict resolution and problem-solving, and companies must support healthy communication within and between teams. Communication must be open, honest, and timely so that every team member knows what to do and how to do it.

Confidence

Team members should have confidence in their skills. The leader must provide the team with a clear and simple explanation of the project, each member's responsibilities, and the final objective. It is essential to remember that confidence does not develop in the blink of an eye. It must be constructed step by step.

Commitment

The demands and interests of the team take precedence above individual concerns. Every action should contribute to the overall corporate objective.

7.1.6. Enhancing Teamwork in the Workplace

Working in a team can be complicated due to the fact that we are all unique individuals with varying mental states. Improving teamwork relies heavily on the role of the team's leader. Here are some recommendations that can assist them in achieving greater teamwork:

1. Concentrate more on "us" than "me"

A minor step is to begin speaking in the plural, so that all members feel as though they are a part of the effort. The greater our involvement, the harder we work to obtain the finest results.

2. Communicate Explicitly

Communication is the fundamental prerequisite. We must create an atmosphere in which team members are free to share their thoughts. It is advisable to make an effort to prevent such misunderstandings.

3. Delegate and believe

When working in a team, each assignment symbolises a problem that can be readily overcome via teamwork. Team leaders should be aware of the abilities and qualities of their team members and assign them jobs where they may demonstrate their value. For this, they must feel at ease while working and have confidence that their bosses have faith in them.

4. Establish shared aims and objectives

It is crucial to establish a unified business objective and effectively communicate it to team members.

5. Recognize and honour the achievements of others.

This attitude strengthens the team's trust and teamwork, which will inspire them to achieve the following objectives.

6. Conquer a conflict with success

Workplace conflicts are prevalent, and people with conflict management abilities are in high demand. Learn this talent if you still lack it.

7. Build a diverse group

People with varied origins, personalities, and experiences can be a source of innovative ideas. Through intelligent reading, we will recognise that we have the opportunity to maximise each individual's qualities.

8. Believe in Team Building

It's been said that teams that have fun remain together, thus establishing personal relationships in the workplace is a fantastic way to boost teamwork.

7.1.7. Importance of Teamwork in Bar Bending works

Teamwork is crucial in any construction project, and it is especially important in bar bending works. Assistant bar bending and steel fixing involves providing support and assistance to the supervisor team, and this work requires close coordination and communication with other team members. Here are some of the key reasons why teamwork is essential in bar bending systems:

Here are some reasons why teamwork is important in scaffolding erection and dismantle:

1. **Safety:** Working in bar bending can be hazardous, and teamwork is essential to ensure the safety of all workers. Team members can watch out for each other, spot potential hazards, and work together to implement safety measures.

2. **Efficiency:** When working in bar bending works, every member of the team has a specific role to play. By working together, team members can ensure that their tasks are completed efficiently and on time. This can help to avoid delays and keep the project on schedule.

3. **Quality:** The quality of the finished concrete structure depends on the accuracy of the bar bending and fixing work. Team members can work together to ensure that the formwork is correctly aligned and supported, leading to a high-quality finished product.

4. **Communication:** Communication: Effective communication is essential in bar bending works. Team members need to be able to communicate clearly and effectively to coordinate their work and avoid errors or miscommunications.

5. **Support:** Bar bending teams often work in challenging conditions, and teamwork can provide valuable support to workers. By working together, team members can share the workload, provide assistance when needed, and help each other stay motivated and focused.

7.1.8. Time Management

Time management is not about working harder; rather, it is about working smarter so that employees do not overburden themselves and create unnecessary strain. By effectively managing their time, employees will meet deadlines, increase their effectiveness, become more productive, and produce superior work.

By effectively managing their time, employees will meet deadlines, increase their effectiveness, become more productive, and produce superior work. They will also have a higher degree of job satisfaction because they will experience less stress, which will help them advance in their careers and reduce your company's staff turnover.

The benefits of time management skills to both for the person and the company are:

1. **Enhanced productivity and performance:** Poor time management causes employees to feel overwhelmed, whereas excellent time management leads to increased efficiency, which in turn improves performance.

2. **Providing work on schedule:** This is the most visible advantage of excellent time management, but it is also one of the most crucial. Time management enables workers to meet deadlines, which is essential for meeting client expectations.

3. **Less anxiety and stress:** When employees are stressed and anxious, not only do they miss deadlines and produce subpar work, but it also negatively affects their health. As an employer, you are responsible for ensuring that the mental health of your employees is a top priority. Stressed employees are more prone to take sick days and seek alternative jobs.

4. **Better-quality work:** With effective time management, employees have the necessary time to produce work that is not only completed on time but also of a superior quality.

5. **Boosts confidence:** When employees are on top of their responsibilities, it boosts their confidence and enables them to believe in their own talents. In turn, this reduces tension and anxiety because the body produces dopamine.

6. **Reduces procrastination and wasted time:** Knowing how to prioritise decreases procrastination and promotes a "eat the frog" mentality among staff. This saves downtime and increases productivity.

7. **Enhances the work-life balance:** An effective work-life balance When an employee is well-rested and has the opportunity to re-energize, they are in the best position possible to produce their finest work.

8. **Make better decisions:** When employees have time to concentrate and work thoroughly, they are not required to make decisions under duress. Instead, individuals can make selections based on all the necessary information to make the greatest choice.

Time Management in Bar bending Works

Effective time management is essential when working on a construction site, especially when it comes to bar bending system work. Here are some tips for managing your time efficiently:

1. **Plan the Day:** Before starting the work, take a few minutes to plan the day. Make a to-do list and prioritize the tasks based on their importance and urgency.

2. **Break down Large Tasks:** If one have a large task to complete, break it down into smaller, more manageable tasks. This will make it easier to focus on the individual steps and help to avoid feeling overwhelmed.

3. **Use a Calendar:** Use a calendar or scheduling software to keep track of deadlines, meetings, and other important events. This will help you stay organized and ensure that one don't miss anything important.

4. **Minimize Distractions:** Minimize distractions such as phone calls, emails, and social media during working hours. Set aside specific times to check your messages and notifications.

5. **Communicate with the Team:** Communication is key when working on a construction site. Make sure to communicate effectively with the team and that everyone is on the same page.

6. **Take Breaks:** Take regular breaks throughout the day to avoid burnout and stay focused. Use the breaks to stretch, take a walk, or have a healthy snack.

7. **Use the Time Wisely:** Use any downtime during the day to complete smaller tasks or catch up on paperwork. This will help you make the most of your time and avoid feeling overwhelmed.

7.1.9. Construction Reporting

Construction reporting is the preparation of official records that provide stakeholders with information on significant events, project phases, and processes. Typically, these reports are written documents containing data. They can also describe the condition of particular project components or the budget. Construction reports should be short and written in straightforward language. Additionally, they should be simple to navigate and contain only the essential information. Additionally, they should not be replicated in other reports. Reporting on construction gives the project team excellent visibility and comprehension of what should be done. Inaccurate reporting can have significant effects on project costs and deadlines.

Objective of Construction Reporting

Construction reports are a way to comprehend the activities occurring on construction sites. In order to provide an accurate depiction of the project's state, construction reporting utilises a number of methods to collect and combine project data.

Creating reports improves comprehension of current activities and minimises the likelihood of project delays and cost overruns. The information flow from construction reporting keeps stakeholders informed and provides psychological comfort as they enjoy a project's efficient operation. Construction reports can reduce safety concerns because problems are identified and documented before they escalate.

Types of Construction Reports

There are numerous types of construction reports that detail various project operations. The majority of construction reports fall under many categories, as illustrated below.

1. Materials Report

Technological advancements have produced new construction technologies that contractors can utilise. Consequently, material reports provide construction organisations with information regarding materials that offer greater cost savings and a longer lifespan. These construction material reports are provided by a variety of organisations, and construction enterprises must enlist in order to receive their services.

2. Trend Report

Standard in the building business, trend reports provide information on various construction styles and whether their market usage is expanding or diminishing. To have access to such information, contractors must subscribe to the websites that publish studies on building industry trends. The majority of these papers are published annually and provide excellent overviews of the most recent trends and industry dynamics.

3. Cost Report

These are construction reports that tell the client and other interested parties on the expected and actual expenditures of a project. Typically, cost consultants such as quantity surveyors or contractors produce cost reports. The project is then constructed in accordance with the client-presented cost estimate. These reports are periodically updated to monitor the project's expenses. Throughout the lifecycle of a project, cost reports are in a state of ongoing evolution. Consequently, the amount of detail and precision improves as the project progresses and more information becomes available.

4. Progress Report or Daily Report

Daily reports are an integral component of project management. A daily report describes the actions of a project on a daily basis. Daily reports augment a contract by recording and confirming project progress.

These reports describe the site's specifics and keep stakeholders updated. In the event of any delays, daily reports clarify the underlying causes, thereby eliminating the time wasted disputing over the surrounding minutiae. The daily report is typically prepared by the construction manager or foreman.

Exercise

1. What are the 7 Cs of effective communication?
2. State some Adverse Effects of Poor Communication.
3. What do you understand by Workplace Communication?
4. How to enhance teamwork in the workplace?
5. Explain the importance of time management.

Notes

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8. Work According to Personal Health, Safety and Environment Protocol

Construction Skill Development Council

Unit 8.1- Workplace Hazards

Unit 8.2- Fire Safety

Unit 8.3- Safety Measures at Workplace

CON/N9001

Key Learning Outcomes

By the end of this module, participants will be able to:

- Explain the types of hazards at the construction sites
- Identify the hazards specific to the bar bending and steel fixing work
- Recall the safety control measures and actions to be taken under emergency situation
- Explain the classes of fire and types of fire extinguishers
- Demonstrate the operation of fire extinguisher.
- Demonstrate different methods involved in providing First aid to the affected person.
- Explain the importance of worker participation in safety/mock drills
- Demonstrate the use of all Personal Protective Equipment (PPE) like helmet, safety shoe, safety belt, safe jackets and other safety equipment relevant to bar bending work
- Explain the reporting procedure to the concerned authority in case of emergency situations
- Describe the standard procedure for handling, storing and stacking of material, tools, equipment and accessories
- Explain different types of wastes produced at a construction site including their disposal method
- Explain the purpose and importance of vertigo test at construction site
- Demonstrate vertigo test
- List out basic medical tests required for working at construction site.
- Explain the types of ergonomic principles adopted while carrying out specific task at the construction
- Explain the types and benefits of basic ergonomic principles, which should be adopted while carrying out specific task at the construction sites.
- Explain the benefits of basic ergonomic principles used at construction sites.
- Explain the importance of housekeeping
- Demonstrate housekeeping practice followed after reinforcement works

Unit 8.1 Workplace Hazards

Unit Objectives

By the end of this unit, participants will be able to:

- Explain the types of hazards at the construction sites
- Identify the hazards specific to the bar bending and steel fixing work
- Recall the safety control measures and actions to be taken under emergency situation.
- Explain the reporting procedures adopted during emergency situations.
- Describe the standard procedure for handling, storing and stacking of material, tools, equipment and accessories.
- Explain the types of ergonomic principles adopted while carrying out specific task at the construction
- Explain the benefits of basic ergonomic principles used at construction sites
- Demonstrate the use of all Personal Protective Equipment (PPE) like helmet, safety shoe, safety belt, safe jackets and other safety equipment relevant to bar bending work.

8.1.1. Workplace Safety

Workplace safety is important to be established for creating a safe and secure working for the workers. The workplace has to be administered as per the rules of the Occupational Safety and Health Administration (OSHA). It refers to monitoring the working environment and all hazardous factors that impact employees' safety, health, and well-being. It is important to provide a safe working environment to the employees to increase their productivity, wellness, skills, etc.

The benefits of workplace safety are:

- Employee retention increases if they are provided with a safe working environment.
- Failure to follow OSHA's laws and guidelines can result in significant legal and financial consequences.
- A safe environment enables employees to stay invested in their work and increases productivity.
- Employer branding and company reputation can both benefit from a safe working environment.

Workplace Safety at Construction Site

To avoid injuries, accidents, and other health issues on a building site, the following safety guidelines must be followed:

1. Always wear PPE

All personnel and visitors on the construction site must wear the required PPE to reduce their exposure to potential hazards. Goggles, helmets, gloves, ear muffs or plugs, boots, and high visibility vests and suits are typical PPEs.

2. Pay attention and obey signs

Employees and visitors can be warned and made more aware of health and safety hazards through the use of safety signs. When necessary, strategically position them throughout the facility. Workers should be aware with construction site safety advice and various signs, including prohibition signs, required signs, warning signs, safe condition signs, and fire fighting equipment signs.

3. Provide precise directions

There should be a site induction or contractor induction on the job site. This will familiarise new employees with site operations. Additionally, toolbox presentations are an effective means of communicating health and safety instructions to the employees. On a daily or more frequent basis, a pre-work inspection is performed.

4. Keep site tidy

Ensure that excavation debris, dust, loose nails, and stagnant water are not lying about the site. For the prevention of slips and trips, the building site must be cleaned everyday and kept decluttered.

5. Organize and store equipment

Ensure that there are no tools laying around, and unplug all lights and power tools. The observance of building site regulations will prevent tools from becoming damaged or perhaps causing worker injury. Putting them in their proper location will help facilitate navigation.

6. Use the proper tools for the correct job

Frequently, accidents occur due to improper usage of a tool or piece of equipment. Avoid using homemade tools. Use the proper tool to complete the task more quickly and safely.

7. Have an emergency response plan

An emergency response plan instructs employees on what to do in the event of emergencies such as natural disasters, fire, hazardous material spills, and other catastrophes. Have a team committed to addressing emergency situations, answering queries, and reporting potential risks, quality issues, and near misses.

8. Set up protections

Installation of engineering controls, such as barriers, fences, and safeguards, is one method for ensuring site safety. These will aid in isolating individuals from hazardous places like high-voltage electricity or harmful chemicals.

9. Perform pre-inspection of tools and equipment.

Ensure that the tools and equipment to be utilised are free of defects or damage before beginning work.

10. Report problems immediately

Train employees to immediately report flaws and near-misses on the job site. Problems can only be resolved when management is made aware of them. The sooner problems are identified, the less likely they are to worsen and cause accidents or additional damage.

8.1.2. Workplace Hazards

A workplace is a situation that has the potential to cause harm or injury to the workers and damage the tools or property of the workplace. Hazards exist in every workplace and can come from a variety of sources. Finding and removing them is an important component of making a safe workplace.

Common Workplace Hazards

The common workplace hazards are:

- **Biological:** The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as biological hazards.
- **Chemical:** Chemical hazard is the hazard of inhaling various chemicals, liquids and solvents. Skin irritation, respiratory system irritation, blindness, corrosion, and explosions are all possible health and physical consequences of these dangers.
- **Mechanical:** Mechanical Hazards comprise the injuries that can be caused by the moving parts of machinery, plant or equipment.
- **Psychological:** Psychological hazards are occupational hazards caused by stress, harassment, and violence.
- **Physical:** The threats that can cause physical damage to people is called physical hazard. These include unsafe conditions that can cause injury, illness and death.
- **Ergonomic:** Ergonomic Hazards are the hazards of the workplace caused due to awkward posture, forceful motion, stationary position, direct pressure, vibration, extreme temperature, noise, work stress, etc.

Workplace Hazard at Construction Site

Working on a construction site entails working with or alongside massive, functioning plant machinery and tools and working at heights and in potentially hazardous settings.
The following are a few hazards of a construction site:

- **Working at Heights:** Working at heights is the leading cause of fatal workplace injuries. All personnel working at height must receive adequate training in operating on various equipment, and such work must be carefully organised.
- **Moving Objects:** A building site is a constantly-evolving environment with numerous objects in constant motion, frequently on uneven ground. Delivery vehicles, large plant gear, and overhead lifting equipment pose a threat to workers and operators on the job site. Sites should always be designed to manage plant-to-pedestrian contact when physical barriers and enough segregation are present.

- **Slips, Trips, and Falls:** Slips, trips, and falls can occur in practically any environment, but they occur less frequently in the construction industry than in other sectors. Unsurprisingly, slips, trips, and falls are major hazards on construction sites due to the often uneven ground and ever-changing typography.

- **Noise:** Exposure to loud, excessive, and repetitive noise can result in long-term hearing issues, including deafness. Noise can also be a risky distraction, diverting a worker's attention from the task at hand, which can lead to mishaps. A full noise risk assessment should be conducted if the risk assessment identifies a noise hazard associated with the proposed work.

- **Hand Arm Vibration Syndrome:** HAVS is a painful and debilitating condition affecting the blood vessels, nerves, and joints. It is often brought on by the repeated use of hand-held power tools, such as vibrating power tools and ground-working equipment. HAVS is avoided if construction projects are structured to minimise exposure to vibration during work and if personnel utilising vibrating tools and equipment are monitored and properly protected.

- **Material Handling - Manual and with Equipment:** On construction sites, materials and equipment are continuously lifted and transported, either manually or with equipment. Handling always carries a degree of danger.

- **Excavations:** On construction sites, incidents frequently occur within excavations, such as an unsupported excavation collapse with employees inside.

- **Electricity:** Contact with overhead or subsurface power cables and electrical equipment/ machinery accounts for most of these mishaps. The standard in the construction industry is service strikes. The strikes occur when excavation is performed without a sufficient search for existing utilities. Consequently, problems can be readily averted by employing technologies such as CAT and Genny scanning equipment to scan an area, anticipate prospective services, and prevent service interruptions.

Hazards Specific to Bar Bending and Steel Work

Bar bending and steel work involve working with metal rods and sheets, which can pose various hazards. Some of the specific hazards include:

Sharp edges and pointed ends: The metal rods used in bar bending and steel work often have sharp edges and pointed ends that can cause cuts, punctures, or lacerations.

Fire and explosion hazards: When working with steel, there is a risk of fire or explosion due to sparks, hot metal fragments, or combustible materials present in the area.
Heavy lifting: Steel bars and sheets are heavy and require proper lifting techniques to avoid back injuries or strain.

Noise pollution: The use of heavy equipment such as power saws, grinders, and drills can generate high levels of noise that can damage hearing if proper protection is not used.

Electrical hazards: The use of electric tools and equipment can pose an electrical hazard if not used correctly.

Chemical hazards: Steel work may involve the use of chemicals such as solvents, paints, and coatings, which can pose health risks if not handled correctly.

Falling hazards: Steel work involves working at heights or on elevated platforms, which can pose a risk of falling.

To mitigate these hazards, it is essential to use appropriate personal protective equipment, such as gloves, safety glasses, earplugs, and hard hats. Employers should also provide proper training and ensure that all equipment is in good working condition. Regular safety audits and inspections can help identify potential hazards and prevent accidents.

Workplace Hazards Analysis

A workplace hazard analysis is a method of identifying risks before they occur by focusing on occupational tasks. It focuses on the worker's relationship with the task, the tools, and the work environment. After identifying the hazards of the workplace, organisations shall try to eliminate or minimize them to an acceptable level of risk.

Control Measures of Workplace Hazards

Control measures are actions that can be taken to reduce the risk of being exposed to the hazard. Elimination, Substitution, Engineering Controls, Administrative Controls, and Personal Protective Equipment are the five general categories of control measures.

- **Elimination:** The most successful control technique is to eliminate a specific hazard or hazardous work procedure or prevent it from entering the workplace.
- **Substitution:** Substitution is the process of replacing something harmful with something less hazardous. While substituting the hazard may not eliminate all of the risks associated with the process or activity, it will reduce the overall harm or health impacts.
- **Engineering Controls:** Engineered controls protect workers by eliminating hazardous situations or creating a barrier between the worker and the hazard, or removing the hazard from the person.
- **Administrative Controls:** To reduce exposure to hazards, administrative controls limit the length of time spent working on a hazardous task that might be used in combination with other measures of control.
- **Personal Protective Equipment:** Personal protective equipment protects users from health and safety hazards at work. It includes items like safety helmets, gloves, eye protection, etc.

8.1.3. Hazard Identification and Risk Assessment (HIRA)

Hazard Identification and Risk Assessment (HIRA) is conducted to identify undesired events that can lead to a hazard, analyse the hazard of this undesirable event, and estimate its scope, magnitude, and possibility of detrimental effects. Within the industry, it is commonly acknowledged that the various risk assessment approaches contribute significantly to improving the safety of complex processes and equipment.

This analysis of hazards and risks aims to identify and assess hazards, the event sequences that lead to hazards, and the risk associated with hazardous occurrences. There are numerous strategies for identifying and analysing dangers, ranging from simple qualitative procedures to advanced quantitative methods. Multiple methodologies for hazard analysis are advised because each has its objective, strengths, and weaknesses.

To manage risk, risks must first be identified, and then the risk must be assessed and its acceptability established.

The earlier an effective risk analysis is conducted in the life cycle, the more cost-effective the future safe operation of the process or activity is expected to be. Most of the facility's other process safety management tasks are based on understanding the risk obtained via these studies. An inaccurate perception of risk at any time could result in inefficient use of scarce resources or the unwitting acceptance of hazards that exceed the genuine tolerance of the organisation or community.

Procedure for HIRA:

At each stage of the work life cycle, a review team questions process specialists about potential hazards and evaluates the risk of any detected hazards. There are numerous typical ways to evaluate a design, ranging from straightforward qualitative checklists to extensive quantitative fault tree analysis. Typically, the results of the review process are recorded on a worksheet whose level of information varies according to the stage of the job and the evaluation method employed. Typically, risk evaluations on operational processes are regularly updated or revalidated.

This work's objective is to detect hazards and risks by assessing each step involved in various building activities and to provide recommendations to remove or reduce the risk assessment (HIRA). The industry achieves success by satisfying production objectives and ensuring high employee satisfaction by meeting workplace safety criteria. Regularly, hazards and risk assessments should be performed, and steps should be taken to reduce the risk to an acceptable level.

HIRA Process it consist of four steps as follows:

i. Hazard identification
ii. Risk assessment
iii. Risk analysis
iv. Monitor and review

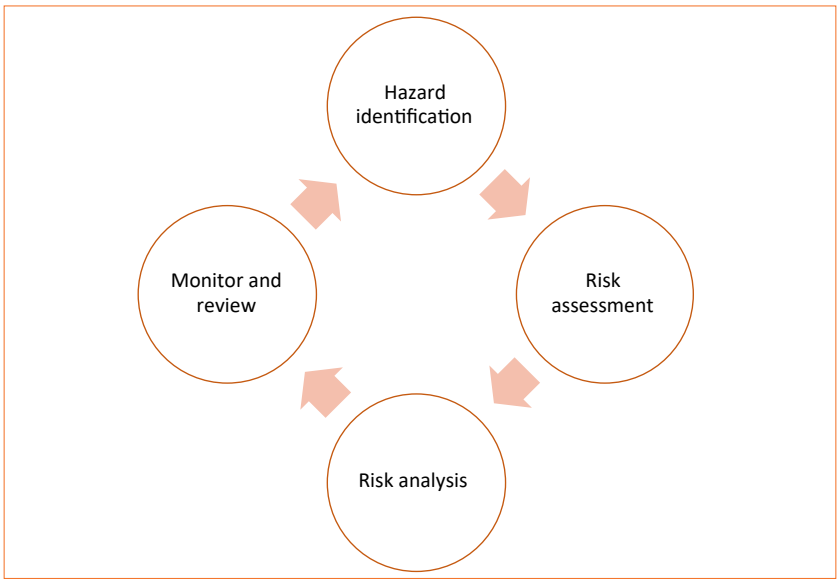

Fig. 8.1.1 HIRA Process

8.1.4. Workplace Warning Signs

A Hazard sign is defined as 'information or instruction about health and safety at work on a signboard, an illuminated sign or sound signal, a verbal communication or hand signal.'

There are four different types of safety signs:

- Prohibition / Danger Alarm Signs
- Mandatory Signs
- Warning Signs
- And Emergency

1. **Prohibition Signs:** A "prohibition sign" is a safety sign that prohibits behaviour that is likely to endanger one's health or safety. The colour red is necessary for these health and safety signs. Only what or who is forbidden should be displayed on a restriction sign

Fig. 8.1.2 Prohibition Warning Signs

2. **Mandatory Signs:** Mandatory signs give clear directions that must be followed. The icons are white circles that have been reversed out of a blue circle. On a white background, the text is black.

Fig. 8.1.3 Mandatory Signs

3. **Warning Signs:** Warning signs are the safety information communication signs. They are shown as a 'yellow colour triangle'.

Fig. 8.1.4 Warning Signs

4. **Emergency Signs:** The location or routes to emergency facilities are indicated by emergency signs. These signs have a green backdrop with a white emblem or writing. These signs convey basic information and frequently refer to housekeeping, company procedures, or logistics.

Fig. 8.1.5 Emergency Signs

8.1.5. Personal Protective Equipment

Personal protective equipment, or "PPE," is equipment worn to reduce exposure to risks that might result in significant occupational injuries or illnesses. Chemical, radiological, physical, electrical, mechanical, and other job dangers may cause these injuries and diseases.

The right PPE is essential in scaffolding work to ensure the safety of workers. Employers should ensure that all workers are trained on how to properly use and maintain their PPE.

Here are the different types of PPE that are commonly used in scaffolding:

Injury Protection	Protection	PPE
Helmet	This protects the worker's head from falling objects or bumps. It should fit snugly and be adjusted properly.	
Safety Shoes	This protects the worker's feet from falling objects, sharp objects, and slips. It should have a nonslip sole and be made of sturdy material.	
Safety Belt	This protects the worker from falls. It should be properly anchored and adjusted to fit snugly.	
Safe Jackets	This provides visibility and protection from the weather. It should be made of reflective material and be adjustable to fit properly.	
Safety Glasses	This protects the worker's eyes from dust, debris, and other hazardous materials. It should be made of shatterproof material and fit snugly.	
Gloves	This protects the worker's hands from cuts, abrasions, and other injuries. It should be made of durable material and fit snugly.	

Table 8.1.1 Commonly Used PPE in bar bending and fixing

8.1.6. Basic Ergonomic Principles

The basic ergonomic principles for construction are:

1. Work in neutral space.

Whether working seated or standing and moving throughout the day, it is essential to maintain a neutral posture. Several parts of the body are typically affected by this principle. The foremost is the rear. A healthy spine has an S-curve, and it is essential to maintain this curve when working to prevent back pain. When working in a seated position, lumbar support is essential. When standing stationary, it can be advantageous for those who stand or move around a facility to rest one foot on a footrest, and when lifting, it is important to lift using your legs rather than your back.

Neck, elbows, and wrists are additional parts of the body that may be misaligned. To lessen tension on these areas and maintain their alignment, try modifying your equipment or work position so that your muscles remain in a relaxed state.

2. Reduce the necessity for excessive force.

Imagine a time when you had to move an object using your entire body weight. This is what the principle refers to. Heavy pushing, pulling, and lifting can strain your joints, potentially leading to weariness or injury. Instead of employing unnecessary force, look for equipment or methods that can lighten the load you must move. It may be as easy as using a cart or hoist to transport heavy objects, or you may need to modify your workflow to reduce the distance you must go or the number of objects you must transport.

3. Keep materials easily accessible.

Try extending your arms in front of you and drawing a half-circle with them. This is your reach envelope, and you should keep goods you use regularly within this semicircle at your desk. To accommodate your reach envelope, you may need to rearrange your space so that you no longer have to reach for often used goods. Adjusting your seat and armrests can help alleviate fatigue by bringing machine controls within reach.
Also applies while reaching into boxes or containers. Before reaching into a box, tilt it or lay it on a lower surface instead than straining your shoulders to reach higher.

4. Work at the appropriate height.

A work surface that is either too high or too low might cause back, neck, and shoulder strain. Standing or sitting, the majority of normal tasks should be performed at elbow height. Nonetheless, if you work with heavy instruments, you may need to change your position to work below elbow height. On the other hand, precision work may necessitate working at heights above the elbow.

5. Reduce needless movements.

Manual repetition can result in overuse injuries, thus it is essential to consider the motions you repeat throughout the day and identify solutions to prevent excessive motion. Is it conceivable, for instance, to replace a screwdriver with a drill, so eliminating the need for manual motion? Additionally, you might seek for possibilities to alter your position or the arrangement of your workspace in order to operate in a more ergonomic manner.

6. Reduce fatigue resulting from static stress.

There may be tasks at work that need you to maintain the same position for a lengthy period of time. This is known as static load. Static load can impact various regions of the body, including the legs while standing for an extended period of time and the shoulders when holding the arms overhead for more than a few seconds. These types of tasks might create muscle fatigue and discomfort that persists long after the work is completed. You may be able to prevent the weariness generated by static load by altering the orientation of your work area, repositioning your body, or using tool extenders.

7. Minimize contact stress.

When a tool or surface repeatedly comes into contact with the same part of your body, contact stress occurs. Sometimes referred to as pressure points, these places of contact can be painful. When you habitually squeeze a tool, such as pliers, or hold a heavy object, such as a nail gun, that exerts pressure on a portion of your hand, this is an example of contact stress. Adding padding, wearing gloves, or selecting equipment with a padded grip can be beneficial. Consider adding anti-fatigue mats to standing surfaces to reduce heel contact stress.

8. Leave adequate clearance.

This idea is straightforward: you must have adequate space for your head, knees, and feet. Adjust your seat to allow sufficient legroom if you perform your duties while seated. Remove above obstacles to avoid head injuries. Visibility also plays a role in this scenario. It is essential to have a clear perspective of your surroundings regardless of where you are working or what equipment you are employing.

9. Stay active and flexible throughout the day.

Sitting or standing in one posture for too long is unhealthy for the human body. Take time to stretch and exercise your muscles. If you are sedentary for an extended amount of time, take frequent breaks to walk around. If you are on your feet all day, wear supportive shoes and rest during your breaks. And if your profession is physically demanding on specific sections of your body, it may be beneficial to stretch before to undertaking tough duties.

10. Keep your atmosphere comfortable.

Depending on your sector and position, work conditions vary widely, but lighting, temperature, vibration, and noise are a few common factors you may want to consider. Consider strategies to reduce glare or improve lighting in dimly lit places. Whenever feasible, maintain a pleasant temperature in the workplace, and when working outside, dress appropriately for the weather. And if the tools produce excessive noise or vibration, give hearing protection and seek methods to attenuate the vibrations.

8.1.7. Emergency Response Plan for Construction Site

Construction projects are commonly recognised as one of the most accident-prone activities. It must be realised that the size and complexity of a project determines the associated dangers and risks. In the majority of cases, poor response, a lack of resources, or the absence of trained staff on a building site will result in chaos. In order to reduce human suffering and financial losses, it is strongly suggested that the emergency response plan be developed prior to project launch.

The Emergency Response Plan must address the following factors:

1. Statutory Obligations

The entity must comply with all applicable Central and State Rules and Regulations, such as The Building and Other Construction Workers' Act of 1996, the Environment (Protection) Act of 1986, the Factories Act of 1948, the Inflammable Substances Act of 1952, the Motor Vehicles Act of 1988, the Public Liability Insurance Act of 1991, the Petroleum Act of 1934, the National Environment Tribunal Act of 1995, and the Explosives Act of 1874, etc.

Incorporate applicability and compliance status into the Emergency Response Plan.

2. Emergency Preparedness

a. The process of hazard identification and risk assessment entails a thorough review of construction activities such as Excavation, Scaffolding, Platforms & Ladders, Structural Work, Laying of Reinforcement & Concreting, Road Work, Cutting /Welding, Working in Confined Space, Proof/Pressure Testing, Working at Heights, Handling & Lifting Equipment, Vehicle Movement, Electrical, Demolition, Radiography, Shot blasting

b. Listing On-Site (Level I & II) and Off-Site (Level III) Emergency Scenarios in accordance with their effects and available resources.

3. Measures for Emergency Mitigation

To ensure safety during construction activities, the business must have an appropriate Health, Safety, and Environment Management System in place.

a. Health, Safety, and Environment (HSE) Policy;
b. Duties and Responsibilities of Contractor/Executing Agency;
c. Site planning and layout;
d. Deployment of Safety Officer/Supervision;
e. Safety committees with fair participation of workers;
f. Safety audits and inspections shall be conducted using prescribed checklists.
g. Work permit system h) PPE I Safety awareness and training, etc.

4. Measures for Emergency Preparedness

a. Emergency Drill and Exercise on Identified Scenarios and Evaluations b) Emergency Response Training
b. Mutual Aid

5. Disaster Recovery Procedures

The entity must develop well-planned and documented response procedures. The action plan may be documented for both On-site and Off-site disaster scenarios.

6. Organization and Responsibilities during Emergencies

The entity must create an organisation chart (emergency action flowchart) and specify the roles and duties of key individuals in order to properly handle an emergency scenario on the project site. Clause 14.0 of the PNGRB (ERDMP) Regulations may be consulted in order to establish the emergency organisation and responsibilities.

7. Resources for Emergency Management

1. The following emergency control systems and facilities must be provided on the project/ construction site: -

    a. Fire and gas detection system
    b. Fire protection and firefighting system (Active and Passive)
    c. Ambulance facility on-site; if not, on urgent call basis.
    d. Rescue facilities and personal protective equipment (PPEs)
    e. First aid stations.
    f. Medical facility on-site or affiliation with a local hospital or medical centre

g. Internal and External Communication Facilities as well as a Notification System

h. Gathering places

i. Escape route and evacuation zones

2. Internal and External Emergency contact information for police, fire, hospitals, mutual assistance industry, factory inspectors, Board, State Pollution Control Board, Petroleum and Explosive Safety Organization (PESO), etc.

3. Addresses and Telephone Directory of Technical Support Services and Professional Emergency Responders

8. Emergency Recovery Method

Following the emergency, the following tasks must be completed in detail.

a. Information to legal authorities (Refer to Clause 23.0 for Incident Reporting to PNGRB).

b. Incident examination.

c. Damage evaluation.

d. Product salvage, decontamination, clean-up, and restoration.

e. A comprehensive report shall be compiled based on the complete incident experience, including restorations, restrictions, and lessons learned.

Notes

Unit 8.2 Fire Safety

Unit Objectives

By the end of this unit, participants will be able to:

- Explain the classes of fire and types of fire extinguishers.
- Demonstrate the operating procedure of the fire extinguishers.

8.2.1. Fire and its Classes

Fires can be catastrophic. Burning, hurting, and even murdering people. causing property and equipment damage. Disrupting corporate operations. Fire may take lives and destroy businesses.

Fire prevention is the most effective technique to prevent fire from affecting you or your organisation. In addition to preventing fires from starting, you should also have a plan in place for responding to flames if they occur.

There are five distinct classes of fire:

Class A: Ordinary solid combustibles, including paper, wood, fabric, and certain polymers.

Class B: Flammable liquids such as alcohol, ether, oil, gasoline, and grease that should be smothered.

Class C: Electrical equipment, appliances, and wiring where applying a nonconductive extinguishing chemical minimise electrical shock-related injuries. Don't use water.

Class D: Certain combustible metals, including sodium and potassium. These items are not often found at the Medical Center.

Class K: Flames caused especially by cooking fat or oil.

8.2.2. Fire Safety

Fire safety is a set of actions aimed at reducing the amount of damage caused by fire. Fire safety procedures include both those that are used to prevent an uncontrolled fire from starting and those that are used to minimise the spread and impact of a fire after it has started. Developing and implementing fire safety measures in the workplace is not only mandated by law but is also essential for the protection of everyone who may be present in the building during a fire emergency.

The basic Fire Safety Responsibilities are:

- To identify risks on the premises, a fire risk assessment must be carried out.
- Ascertain that fire safety measures are properly installed.
- Prepare for unexpected events.
- Fire safety instructions and training should be provided to the employees.

Prevention of a Workplace Fire

- Workplace fire drills should be conducted regularly.
- If one has a manual alarm, one should raise it.
- Close the doors and leave the fire-stricken area as soon as possible. Ensure that the evacuation is quick and painless.
- Turn off dangerous machines, and don't stop to get personal items.
- Assemble at a central location. Ascertain that the assembly point is easily accessible to the employees.
- If one's clothing catches fire, one shouldn't rush about it. They should stop, descend on the ground, and roll to smother the flames if their clothes catch fire.

8.2.3. Fire Extinguisher

Fire extinguishers are portable devices used to put out small flames or minimise their damage until fire-fighters arrive. These are maintained on hand in locations such as fire stations, buildings, workplaces, public transit, and so on. The types and quantity of extinguishers that are legally necessary for a given region are determined by the applicable safety standards.

Types of fire extinguishers are:

There are five main types of fire extinguishers:

1. Water.
2. Powder.
3. Foam.
4. Carbon Dioxide (CO2).
5. Wet chemical.

1. **Water:** Water fire extinguishers are one of the most common commercial and residential fire extinguishers on the market. They're meant to be used on class-A flames.

2. **Powder:** The L2 powder fire extinguisher is the most commonly recommended fire extinguisher in the Class D Specialist Powder category, and is designed to put out burning lithium metal fires.

3. **Foam:** Foam extinguishers are identified by a cream rectangle with the word "foam" printed on it. They're mostly water-based, but they also contain a foaming component that provides a quick knock-down and blanketing effect on flames. It suffocates the flames and seals the vapours, preventing re-ignition.

4. **Carbon Dioxide (CO2):** Class B and electrical fires are extinguished with carbon dioxide extinguishers, which suffocate the flames by removing oxygen from the air. They are particularly beneficial for workplaces and workshops where electrical fires may occur since, unlike conventional extinguishers, they do not leave any toxins behind and hence minimize equipment damage.

5. **Wet Chemical:** Wet chemical extinguishers are designed to put out fires that are classified as class F. They are successful because they can put out extremely high-temperature fires, such as those caused by cooking oils and fats.

Notes

Unit 8.3 Safety Measures at Workplace

Unit Objectives

By the end of this unit, participants will be able to:

- Explain the importance of housekeeping practice followed after system scaffold works.
- Demonstrate safe housekeeping practices.
- Explain the importance of participation of workers in safety drills.
- Explain the purpose and importance of vertigo test at construction site.
- List out basic medical tests required for working at construction site.
- Demonstrate vertigo test.
- Demonstrate different methods involved in providing First aid to the affected person
- Demonstrate safe waste disposal practices followed at construction site.
- Explain different types of waste at construction sites and their disposal method.

8.3.1. Safety, Health and Environment at Work Place

The Indian Constitution gives explicit standards for people's rights and the Directive Principles of State Policy, which offer a framework for the acts of the government. The government is dedicated to regulating all economic activities for the management of safety and health risks at workplaces and to implementing steps to provide safe and healthy working conditions for every man and woman in the country. This commitment is supported by both these Directive Principles and international instruments. The government recognises that worker health and safety contribute to both economic growth and worker output.

8.3.2. Good Housekeeping

Good housekeeping on construction sites refers to the practice of keeping your site clean and tidy. After all, construction work is messy, and cleaning up now will only result in more mess later.

A clean work environment reduces the likelihood of accidents and improves fire safety. There are fewer things to trip you up if there are no materials, waste, or discarded tools.

10 housekeeping rules for a clean site. Implement these, and you should see a decrease in slip and fall accidents and near misses among your employees.

1. Make a separate area for trash and waste.

Make a waste disposal area. After all, if you want your workspace to be free of waste materials, you'll need a place to store them. Depending on the amount of waste, this could be a skip or another waste disposal bin. Segregating waste types for reuse, recycling, or landfill is a best practice solution.

2. Safely stack and store materials.

Poorly stacked materials can obstruct access routes or topple over, resulting in crushing injuries or property damage. You will need materials and tools throughout your project; store them safely to avoid them becoming hazardous.

3. Maintain a safe working environment.

On a construction site, your job will almost certainly generate daily waste. Whether it's packaging, demolition, or leftovers. Check and clean up your work area regularly throughout the day. If trip hazards and clutter are beginning to accumulate, address them as soon as possible.

4. Maintain clear access routes.

A safe working environment includes access and egress. It is how you arrive at work and how you leave. Leave no materials/tools/benches in gangways/corridors where they could obstruct someone's escape or cause a trip hazard (it might be you or a colleague who needs to get out in a hurry).

5. Place tools at designated place after use.

Put away tools and equipment after you've finished using them. It's easy to leave items lying around, but if you won't need them again soon, store them. If it's not in use, it should be out of sight, or at the very least out of your way!

It is not your responsibility simply because it is not yours. If you see anything lying on the floor, stairwell, or passageway that could cause people to trip and fall, pick it up and put it somewhere safe - don't wait for someone else to move it; the next person could be the one who gets hurt.

6. If something is broken, fix it.

Fix it or get rid of it. Good housekeeping also entails keeping things in working order on-site. Damaged tools or equipment must be removed from service so that they can be repaired or replaced.

7. Avoid tripping over cables.

Equipment trailing leads and cables are common trip hazards, especially when using portable equipment. You may not have a socket nearby, but make sure the lead is routed away from walkways or access routes. Cables should be routed so that they do not present a tripping hazard to you or others.

8. Avoid fire hazards.

Make sure that waste or material storage does not accumulate in fire escapes, as you may need to use these escapes at some point. Clearing up and removing waste is also a good way to keep fires at bay on the job site. Because fire requires fuel, do not store waste materials near sources of ignition. If all garbage is collected on a regular basis and placed in a skip, the danger is contained and more easily dealt with in the event of a fire.

9. Inform others.

Everyone must work together to keep the workplace clean. Use our free good housekeeping toolbox talk to raise awareness on your site. If everyone follows the same good housekeeping routines, you will be well on your way to a clean and safe site for everyone.

8.3.3 Importance of Housekeeping Practice followed after Reinforcement Works

Housekeeping is an essential practice that should be followed after reinforcement works on a construction site. Here are some of the importance of maintaining good housekeeping practices:

1. **Improved Safety:** A clean and organized worksite is a safer worksite. By removing clutter and debris, workers are less likely to trip, slip or fall, and this helps to reduce the risk of accidents and injuries.
2. **Increased Productivity:** A well-organized worksite allows workers to move around freely and quickly, without obstacles getting in the way. This improves productivity and efficiency, allowing work to be completed more quickly.
3. **Compliance with Regulations:** Many regulatory bodies require construction sites to maintain a high standard of housekeeping. By adhering to these regulations, contractors can avoid fines and penalties and maintain a positive reputation with regulatory agencies.
4. **Enhanced Reputation:** Maintaining a clean and organized worksite is a reflection of the contractor's professionalism and commitment to quality. A well-kept site can help to enhance the contractor's reputation with clients, suppliers, and other stakeholders.
5. **Better Equipment Maintenance:** Cleaning and maintaining equipment after use is essential to ensure it continues to operate safely and efficiently. This can help to extend the life of the equipment and avoid costly repairs.
6. **Improved Morale:** A clean and organized worksite can have a positive impact on worker morale. When the work environment is tidy and well-maintained, workers tend to feel more valued and appreciated, which can lead to increased job satisfaction and lower turnover rates.

Maintaining good housekeeping practices after reinforcement works is crucial for the safety, productivity, and reputation of the construction site. By keeping the site clean and organized, contractors can avoid accidents and injuries, comply with regulations, and enhance their reputation with stakeholders.

8.3.4. Safety Drills at Construction Site

Construction is a hazardous field in which employees must become proficient. Fortunately, safety training can reduce workplace injuries while informing employees of necessary precautions to take.

Here are five types of construction industry safety training one should be aware of.

Safety in Excavation and Trenching

Training on excavation and trenching safety emphasises the dangers associated with working in excavation sites and confined spaces. The training enables workers to navigate these areas safely in order to prevent falls and fatalities. In addition, the programme emphasises preplanning and protective systems (which fall under OSHA-compliant safety material). Workers will be educated on the various excavation methods and techniques in order to perform their duties safely.

Fall Prevention and Safety Measures

Fall prevention and protection training is another type of safety training that all construction workers must receive. Falls are one of the leading causes of death in the industry; therefore, it is essential that workers protect themselves. Fall prevention programmes illustrate fall protection principles, fall arrest system components, and fall hazard recognition. Moreover, demonstrations familiarise workers with fall protection equipment.

Hazard Communication

On a daily basis, construction workers are exposed to hazardous materials and chemicals at their work sites. A worker's health and safety may be compromised by repeated exposure to such substances. Training on hazard communication includes the numerous types of chemicals used in the workplace as well as methods for minimising worker exposure. In addition, employees are taught how to read material safety data sheets and identify product labels.

Crane Hazards Management

Cranes pose a distinct hazard in the construction industry because of the diverse causes of these injuries. For instance, improper placement of loads, contact with overhead electricity lines, and structural failures can result in injuries and fatalities. Nevertheless, crane hazard management develops a grasp of OSHA compliance rules, which enhances job site safety and decreases the likelihood of employee accident.

Construction Industry OSHA Course

OSHA courses for the construction sector equip novice and seasoned workers with a general understanding of diverse construction sites. In addition to an introduction to OSHA, employees will receive training on issues including material handling, ergonomics, access into restricted spaces, and site-specific policies. This course is designed to cover industry-wide themes and handle safety issues.

8.3.5. Medical Examination for Construction Workers

The government has mandated that industrial enterprises undertake annual health checkups on their employees. In accordance with the Factories Act of India from 1948, both contractual and permanent employees in manufacturing businesses are required to undergo periodic health examinations. These examinations aim to protect the health and safety of factory workers.

The type of medical examination varies according to an employee's job description or the nature of the industrial process in which he is involved. For instance, if an employee works in the food business, their hands are routinely inspected for skin disorders. If someone is involved in a hazardous manufacturing process, chest X-rays may be part of the medical checkup.

Consequently, depending on the nature of the production process and the job profile, an employee may be subjected to all standard and specific tests.

In addition, the frequency of medical examinations varies. According to the Maharashtra Plant Rules, for instance, if the factory is involved in the production of lead, workers are inspected once every month.

Medical Check-up Prior to Employment: A young person must have a pre-employment medical examination by a Certifying Surgeon to determine and confirm his fitness to work in a factory, according the Factories Act of 1948. The certificate of fitness is only valid for one year from the date it was issued.

Medical Examinations for Workers in Hazardous Occupations: According to the Factories Act, a plant that engages in hazardous procedures is required to have its employees examined by a competent medical professional prior to employment and on a recurrent basis thereafter. Workers employed in a "hazardous process" are medically tested once before to employment by a Factory Medical Officer to determine their physical fitness and appropriateness for employment in a hazardous process.
Once every six months, the health status of all workers exposed to occupational health hazards must be determined.

Form 7 is completed, and if the medical findings reveal any abnormality or unsuitability of a person employed in the hazardous process, or if the worker or employee has manifested signs and symptoms of a notifiable disease (as specified in the Third Schedule of the Factories Act), the worker must be removed from the process for health protection and cannot be employed in the same process. Alternatively, if the worker is totally handicapped, he or she will receive appropriate rehabilitation. Only after obtaining a Fitness Certificate from the Certifying Surgeon and Form 7 in accordance with the Factories Act may a withdrawn employee be rehired for the same process.

List of Recommended Medical Tests under the Factories Act:

1. Complete Physical Examination
2. Blood Group, Rh factor
3. Blood CBC, ESR, RBS
4. Urine Test (Routine & Microscopic)
5. Creatinine
6. Electrocardiogram (Computerised ECG)
7. Chest X-Ray (Standard Size)
8. Lung Function Test
9. Vision Test (Screening)
10. Audiometric Test
11. HIV & HBS Tests

8.3.6. Vertigo Test

Vertigo is a symptom, not a condition in and of itself. Vertigo is a sort of dizziness that is frequently described as the sensation that one is spinning or that the world is spinning around them, especially when they alter their position. Vertigo affects people of all ages. Middle ear pathology is typically the culprit in younger patients. The danger of falls and associated sequelae necessitates a specialised assessment of the elderly. The key to arriving at a diagnosis is distinguishing vertigo from other causes of dizziness or imbalance, as well as distinguishing central causes of vertigo from peripheral causes.

Vertigo is a symptom that is associated with numerous medical disorders. Your doctor may require one or more tests or procedures to better understand your underlying issue. Numerous of these tests require specialised equipment and experienced personnel.

Some exams are brief and painless, while others are lengthy and unpleasant. Your doctor can recommend the relevant tests for your condition.

Diagnostic Procedures Typically Employed for Vertigo

Following a discussion of your symptoms, a review of your medical history, and a general physical examination, your physician may recommend one or more of the following tests:

Dix-Hallpike Maneuver

If your doctor suspects you have benign paroxysmal positional vertigo (BPPV), the most frequent type of vertigo, he or she may employ the Dix-Hallpike manoeuvre. This procedure can also assist your doctor in determining if your vertigo is caused by an inner ear disorder or something in your head.

The physician will rotate your head 45 degrees to one side. Then, you will immediately lie on your back with your head off the edge of the table for at least 30 seconds. Your physician will examine your eyes and inquire whether you feel dizzy. The process is repeated on the opposite side.

You should be aware that this examination could induce vertigo. If you experience symptoms during this examination, your physician will conclude that you have vertigo.

Head Impulse Test

The head impulse test examines the coordination between your eyes and inner ears. It is frequently utilised when vestibular neuritis is suspected. Your doctor will quickly twist your head to search for rapid eye movements and reflexes that may indicate a problem with the semicircular canals of the inner ear.

Romberg Test

The Romberg test requires that you stand with your feet together. You will then close your eyes. Your doctor will evaluate the degree to which you wobble or fall to establish the cause of your vertigo.

Fukuda-Unterberger Test

The Fukuda-Unterberger test consists of a blindfolded march. To determine which side of your body is afflicted by vertigo, your doctor will evaluate how your body deviates from the midline.

Electronystagmography (ENG) or Videonystagmography (VNG) Electronystagmography (ENG) and Videonystagmography (VNG) are used to identify aberrant eye movements and assess if vertigo symptoms are caused by an inner ear condition.

ENG employs electrodes and VNG uses small cameras to monitor eye movements while the head is put in various postures or while the subject is requested to track specific visual targets. Air or water may also be utilised to regulate the temperature of the ear canal. Typically administered in a dark setting, these examinations may induce jerking eye movements.

Rotation Test

To determine how well the eyes and inner ear work together, rotation tests are administered. Eye movements are analysed while the head is slowly moved from side to side. Different types of rotation tests exist. You may be required to sit in a chair that swivels or to look at a stationary target while moving your head back and forth or up and down.

8.3.7. First Aid

First aid is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.

The aim of first aid is to:

- Preserve life
- Prevent the worsening of a sickness or injury
- If at all possible, relieve pain
- Encourage recovery
- Keep the unconscious safe.

First aid can help to lessen the severity of an injury or disease, and in some situations, it can even save a person's life.

Need for First Aid at the Workplace

In the workplace, first aid refers to providing immediate care and life support to persons who have been injured or become unwell at work.

Many times, first aid can help to lessen the severity of an accident or disease.

It can also help an injured or sick person relax. In life-or-death situations, prompt and appropriate first aid can make all the difference.

Treating Minor Cuts and Scrapes

Steps to keep cuts clean and prevent infections and scars:

- **Wash Hands:** Wash hands first with soap and water to avoid introducing bacteria into the cut and causing an infection. One should use the hand sanitiser if one is on the go.

- **Stop the bleeding:** Using a gauze pad or a clean towel, apply pressure to the wound. For a few minutes, keep the pressure on.

- **Clean Wounds:** Once the bleeding has stopped, clean the wound by rinsing it under cool running water or using a saline wound wash. Use soap and a moist washcloth to clean the area around the wound. Soap should not be used on the cut since it may irritate the skin. Also, avoid using hydrogen peroxide or iodine, as these may aggravate the wound.

- **Remove Dirt:** Remove any dirt or debris from the area. Pick out any dirt, gravel, glass, or other material in the cut with a pair of tweezers cleaned with alcohol.

8.3.8. Waste Management

The disorderly nature of construction sites can make it difficult for workers to remain productive. By applying waste management methods from the outset of the project, one will aid in maintaining order and keeping everyone focused on their jobs.

- **Avoid Accidents:** To prevent accidents, the workers must ensure that waste and debris are properly disposed of. Ensure that they are aware of which objects are hazardous in the event of a fire or an object being thrown into machinery.

- **Reduce Cost:** Managing garbage on-site can assist decrease costs by minimising the cost of removal, in addition to improving safety.

- **Maintain a wholesome working atmosphere:** To maintain a healthy building site, workers will need a variety of equipment and supplies, such as wheelbarrows for transporting dirt and pallets for storing bricks and other heavy items. Ensure that there are always sufficient rubbish bins available so that the workers may dispose of the trash without difficulty.

- **Keeping Material Records:** All building materials must be accounted for at all times to prevent their accidental disposal. This contributes to cost control and time management. If using Reo mesh for wall stability, one would not want to waste such a valuable resource. This occurs frequently on construction sites and may be controlled with simple procedures. This can be as easy as choosing various colours for waste piles or maintaining a log. Materials that are no longer required should never be discarded until they have reached the end of their functional life on the site; in other words, until nothing can be salvaged from them.

- **Environmentally Responsible:** Waste management is also essential since it ensures the environmental friendliness of a project. If garbage is not disposed of in an environmentally responsible manner, it can negatively impact the local ecology and nearby places by contaminating streams and contributing to air pollution.

Waste and Debris Management on the Construction Site

On the construction site, one must be mindful of how they handle waste and garbage. Having a plan for managing these goods is necessary to protect the safety of both workers and the general public. Here are some waste management strategies:

- Before disposing of them in the dumpster, place any hand tools in containers with lids.
- Place empty paint cans in the trash instead than spilling them down drains or onto pavements.
- Rinse disposable cups and other food containers before placing them in a recycling bin. This will help prevent litter from being blown onto the property during windy or rainy weather.
- Recycle equipment and other metal objects by utilising a magnet or air compressor to remove all non-metal components, such as nails, screws, nuts, bolts, electrical wiring, etc. These are then segregated by category prior to proper recycling.

- Insulation should be disposed of in the garbage as opposed to being poured down drains or onto pavements, as it can clog sewer systems.
- Use a tarp to pile dirt, rocks, bricks, and other heavy things into the bed of a truck before hauling them away when the work is complete. This will make future clean-up easier.
- Instead of discarding excess lumber, wrap it in plastic to prevent it from becoming wet and infected with termites.
- Use a leak-proof container or urn to transfer hazardous liquids away for proper disposal; this will keep the workers and others on-site dry and healthy.
- Regularly cleaning up will reduce the amount of debris.
- Using trash cans with lids to prevent rubbish from falling to the ground.
- On your site, provide workers with safety vests for simple identification and protection from concealed threats such as electrical cables and sharp instruments.
- Ensure that there is a designated space for recyclable materials such as glass, plastic, cardboard, and metal containers so that they may be sorted later.

It is essential to have a plan for waste management on construction sites, which are typically untidy places.

Exercise

1. Name the types of fire extinguishers.
2. Explain PPE in brief.
3. Explain the importance of workplace safety at construction site.
4. What do you understand by good housekeeping?
5. Why are safety drills at construction site important?

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9.Employability Skills (30 Hours)

It is recommended that all trainings include the appropriate Employability skills Module. Content for the same can be accessed https://www.skillindiadigital.gov.in/content/list

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Employability skills can be defined as those soft skills which employers look for in a potential employee. These skills equip the employees to carry out their role to the best of their ability and client satisfaction. For example, the ability to explain what you mean in a clear and concise way through written and spoken means, helps to build a better relationship with the client or the customer. Similarly, handling stress that comes with deadlines for finishing work and ensuring that you meet the deadlines can be done through effective self-management training. It can also be done by working well with other people from different disciplines, backgrounds, and expertise to accomplish a task or goal. In today's digital age, employers expect that the employees should be able to make use of elementary functions of information and communication technology to retrieve, access, store, produce, present and exchange information in collaborative networks via the Internet. Students need to develop entrepreneurial skills, so that they can develop necessary knowledge and skills to start their own business, thus becoming job creators rather than job seekers. Potential employees need to develop green skills, which are the technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community. Thus, students are expected to acquire a range of skills so that you can meet the skill demands of the organisation that you would work for or to set up and run your own business.

This chapter is about employability skills, Constitutional values, becoming a professional in the 21st Century, digital, financial, and legal literacy, diversity and Inclusion, English and communication skills, customer service, entrepreneurship, and apprenticeship, getting ready for jobs and career development.

The scope covers the following :

- Introduction to Employability Skills
- Constitutional values – Citizenship
- Becoming a Professional in the 21st Century
- Basic English Skills
- Career Development & Goal Se ng
- Communication Skills
- Diversity & Inclusion
- Financial and Legal Literacy
- Essential Digital Skills
- Entrepreneurship
- Customer Service
- Gettng ready for Apprenticeship & Jobs

The details of Employability module is available on eskill India. Please find below the link.

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Annexure-1

Annexure of QR Codes for Assistant Bar Bender and Steel Fixer

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code
Chapter 1: Introduction to Bar Bending and Steel Fixing Occupation	Unit 1.1: Introduction to Bar Bending and Steel Fixing	Construction Industry	https://youtu.be/nndLyZrGfWc	9	Construction Industry
		Types of Construction	https://youtu.be/1WVzo2UFyo8		Types of Construction
	Unit 1.2: Role and Responsibilities of an Assistant Bar Bender and Steel Fixer	Assistant Bar Bender and Steel Fixer	https://youtu.be/H1qFaFQPZ-0	15	Assistant Bar Bender and Steel Fixer
Chapter 2: Interpret Reinforcement Bar Detail from Hand Sketches	Unit 2.1: Interpret Reinforcement Hand Sketches	Reinforcement bar	https://youtu.be/Zecb8Wj5QHE	39	Reinforcement bar
		Rebar Grades	https://youtu.be/debu3vUkF8E		Rebar Grades
		Rebar Sizes	https://youtu.be/H1j_Fb3OAJc		Rebar Sizes

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code
		Rebar Sketch	https://youtu.be/4Ep9DU-g1zk	39	Rebar Sketch
		Symbols in Rebar Sketch			Symbols in Rebar Sketch
		Bar Bending Schedule	https://youtu.be/nGoTdkCxsuk		Bar Bending Schedule
Chapter 3: Tools and Equipment relevant to Reinforcement Works	Unit 3.1: Reinforcement Tools and Equipment	Rebar Installation	https://youtu.be/-Tp2mY4Gj0c	55	Rebar Installation
		Cutting Rebar	https://youtu.be/WnoqEfio9G8		Cutting Rebar
		Bending Rebar	https://youtu.be/4c43B9S3CPo		Bending Rebar
		Lifting Gears and Equipment	https://youtu.be/H2J9uuLy1hg		Lifting Gears and Equipment

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code
Chapter 4 : Cutting and Bending of Rebar for Simple Shapesp	Unit 4.1: Cutting and Bending of Rebar	Cutting and Bending of Rebar	https://youtu.be/F1iVGU_1qD8	74	Cutting and Bending of Rebar
		Rebar	https://youtu.be/FTRENf1ptk0		Rebar
Chapter 5: Fabrication, Placing and Fixing of Rebar	Unit 5.1: Fabrication, Placing and Fixing of Rebar	Pre-fabricated Cages	https://youtu.be/yUlPEryelMA	88	Pre-fabricated Cage
		Fabrication, Placing and Fixing	https://youtu.be/0mNUSewKGUk		Fabrication, Placing and Fixing
		Fixing of Structural Elements	https://youtu.be/ZHVXWxEFqWI		Fixing of Structural Elements

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code
Chapter 6: Erect and Dismantle Temporary Scaffold	Unit 6.1: Erect and dismantle a scaffold	Scaffolding	https://youtu.be/96shGh3rfXw	104	Scaffolding
		Uses of Scaffold	https://youtu.be/5Vj-MosphpY		Uses of Scaffold
		Scaffolding Erection and Dismantle	https://youtu.be/OKawvyUhUkA		Scaffolding Erection and Dismantle
		Safety Checks	https://youtu.be/AoDWOZE8Wb4		Safety Checks

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