Industrial Safety Engineering

Module 3

SAFETY ISSUES IN CONSTRUCTION INDUSTRY

Prepared by
Kasmeera K S

Syllabus

- Introduction to construction industry and safety issues in construction Safety in various construction operations
  - Excavation and filling
  - Under-water works
  - Under-pinning & Shoring
  - Ladders & Scaffolds
  - Tunneling
  - Blasting
  - Demolition
  - Confined space
  - Temporary Structures.
- Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety.
- Relevance of ergonomics in construction safety.
- Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders

INTRODUCTION TO CONSTRUCTION INDUSTRY

- Construction is an industry that includes the erection, the maintenance, and repair of buildings and other immobile structures, and the building of roads and service facilities.
- Construction covers the processes involved in delivering buildings, infrastructure and industrial facilities, and associated activities through to the end of their life.
- Construction includes structural additions and alterations but excludes the building of mobile structures such as trailers and ships.
- It typically starts with planning, financing, design, execution, builds, and also covers repairs and maintenance and improvement work.

SAFETY ISSUES IN CONSTRUCTION

The major areas considered for safety considerations at the Construction site are:

1. Excavation work at Construction
2. Housekeeping works
3. Scaffolding Issues
4. Working at Heights

Safety Issues with Housekeeping at Construction Site

- Housekeeping practice in a construction site means keeping the work area neat, orderly and avoid slip and trip hazards.
- Poor housekeeping can result in
  - Slipping wet or dirty surface
  - Accidents from falling objects
  - Presence of loose objects on floors, platforms and stairs

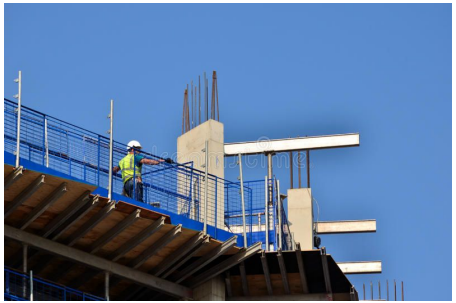
Good Housekeeping practices in Construction site

- Proper maintenance of the building area and the working equipment is the primary safety practice. This ensures that the building, equipment and the machinery are efficiently working
- Regular cleaning during the work shifts
- Proper waste disposal
- Unused materials can be removed and
- Proper inspection of the work area by a competent person
- The access and exit for the construction site must be safe and clear
- General safety signs must be erected and placed in order
- There must be safe and neat storage spaces for the materials and the plant
- Maintain a neat and orderly workplace environment.

Safety Issues in Working at Heights

- The major safety practice that is to be provided when the workers are at heights are to provide sufficient fall protection.
- Greatest fatalities in the construction industry are caused due to falls.
- The major reasons involved in falling are:
    - Unstable working surfaces
    - Failure to use fall protection equipment and accessories
    - Human errors

Safety Practice when Working at Heights



- Use of aerial lifts or elevated platforms to provide safer working surface
- The holes in the floors must be covered
- Personal fall arrest systems or safety net systems must be used
- Provide guard rails
- Warning lines or control lines can be installed
- Proper training of the workers regarding safety working practice
- Make workers aware about the use and maintenance of Personal protective equipment(PPE)
- Check the working condition of the equipment working at heights

SAFETY ISSUES FOR EXCAVATION AND TRENCHING WORKS

- Serious hazards can be provided to the workers involved in the trenching and excavation works.
- The major risk is during the cave-ins which is severe than any excavation issues.
- Before entering the trench, it must be assured that adequate protections are provided to prevent the cave-in hazards.
- Other issues associated with the same are hazardous atmosphere, falling loads and safety issues from the mobile equipment.

Safety Practices in Excavation and Trenching Works

- The sides of excavation work must be sloped and benched for easy movement. This avoids further collapse. A slope not steeper than 1 and half to 1 is safe for any form of soil
- The sides of excavation must be supported.
- The side of the excavation and the working area must be separated by means of a shield.
- Protective barricades can be used to avoid falling of soil rock over the workers. Any other equivalent form of protection can be provided.
- When the mobile equipment or machines are working adjacent or near the edge of excavation, proper warning have to be provided.
- Keep the workers away during the loading and unloading of the heavy materials. This protects the life from falling materials or any spillage.
- As the trenching progress, OSHA recommends the professionals to check the air quality levels. Presence of depleted oxygen levels will ask the workers to wear respiratory protection equipment depending on the severity of hazardous atmosphere.

SAFETY ISSUES WITH SCAFFOLDING WORKS

- Scaffolding is a temporary frame used to support people and material in the construction or repair of building° and other large structures.
- Improper scaffolding will result in hazards. Fall hazards are occurred if scaffolds are not properly erected or used.
- As per OSHA about 2.4 million construction workers work over scaffolding.
- Following the safety practices during scaffolding works helps to prevent injuries
- Every scaffolding must be erected on a solid footing

Safety Practices in Scaffolding Works

- The scaffolding must be erected on a solid footing with proper foot bearing plates
- The scaffolding used must be strong and rigid
- The scaffolding must carry its dead weight and almost 4 times the maximum load coming over it. This must be carried without any form of displacement or settlement.
- Scaffolding must not be supported by means of boxes, loose bricks or any other unstable objects
- Any repair or damage to the scaffolding accessories like braces, screw legs, ladders or trusses have to be repaired and replaced.
- Access to the scaffolding is provided through ladders and stairwells
- The natural and synthetic ropes used in suspension scaffolding must not interrupt with heat or electricity producing sources.
- A minimum of 10 feet have to be maintained between the scaffolding and the electric lines.
- Scaffolding construction must be inspected by a competent person. The unit must be erected, moved or dismantled with the guidance and supervision of this competent person.

SAFETY ISSUES IN UNDER-WATER WORKS

- Underwater construction work is an area which requires extensive training.
- Not only does the worker need to worry about the regular dangers that come with working with tools, now he is working in a different medium, water, which has an effect on the work actually being done, plus he needs to use special breathing equipment.
- Some of the work can be on bridges, power stations, ships, submarines, marines, etc. And each type of job will have it’s own special requirements.
- Diving poses a unique risk, because if a problem arises the diver's life could be in immediate danger.

Safety precautions

- Extreme familiarity with their diving equipment.
- Check working condition of equipment.
- Plan the dive: time, depth, work to be done and stick to the plan.
- Never dive alone. Always have at least one partner that we will stay close to.
- Have a rescue plan in place.
- Know where the nearest decompression chamber is located and how to get help.
- Descend slowly.
- Ascend slowly with the scheduled breaks.
- Monitor air supply regularly during the entire dive.

SAFETY ISSUES IN UNDER-PINNING SHORING

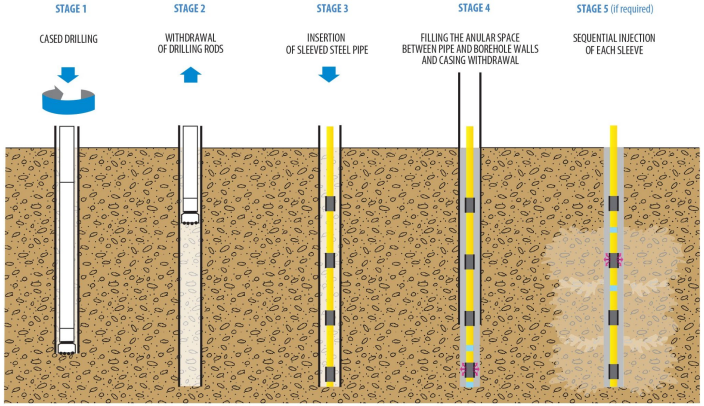
Underpinning

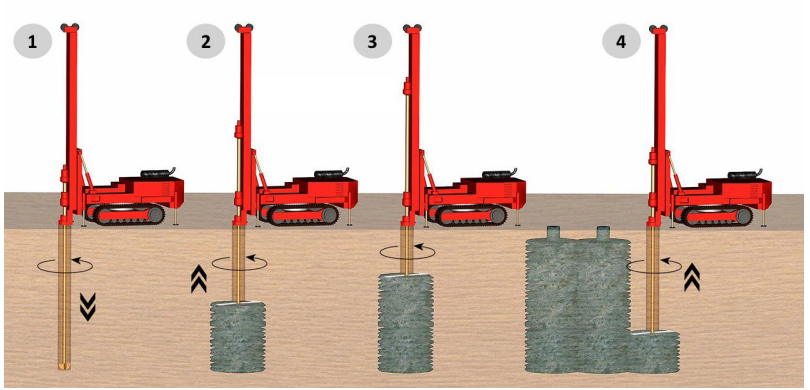
- It is the process of strengthening and stabilizing the foundation of an existing building or other structure.

Underpinning may be necessary for a variety of reasons:

- The original foundation is simply not strong or stable enough, e.g. due to decay of wooden piles the foundation.
- The usage of the structure has changed.
- The properties of the soil supporting the foundation may have changed (possibly through subsidence) or were mischaracterized during planning.
- The construction of nearby structures necessitates the excavation of soil supporting existing foundations.
- It is more economical, due to land price or otherwise, to work on the present structure's foundation than to build a new one.

- Underpinning is accomplished by extending the foundation in depth or in breadth so it either rests on a stronger soil stratum or distributes its load across a greater area.
- Use of micropiles and jet grouting are common methods in underpinning.
- An alternative to underpinning is the strengthening of the soil by the introduction of a grout.





General Precautions:

Before any form of underpinning work is commenced, the following precautions should be taken:

1. Notify adjoining owners of proposed works giving full details and temporary shoring or tying.
2. Carry out a detailed survey of the site, the building to be underpinned and of any other adjoining or adjacent building or structures. A careful record of any defects found should be made and where possible agreed with the adjoining owner(s) before being lodged in a safe place.
3. Indicators or 'tell tales' should be fixed over existing cracks so that any subsequent movements can be noted and monitored
4. If settlement is the reason for the underpinning works, a thorough investigation should be carried out to establish the cause and any necessary remedial work put in hand before any underpinning works are started.
5. Before any underpinning work is started the loads on the building to be underpinned should be reduced as much as possible by removing the imposed loads from the floors and installing any props and/or shoring which is required.
6. Any services which are in the vicinity of the proposed underpinning works should be identified, traced, carefully exposed, supported and protected as necessary.

Shoring

- It is a general term used in construction to describe the process of supporting a structure in order to prevent collapse so that construction can proceed. The phrase can also be used as a noun to refer to the materials used in the process.
- Shoring is used to support the beams and floors in a building while a column or wall is removed.
- In this situation vertical supports are used as a temporary replacement for the building columns or walls.
- Trenches - During excavation, shoring systems provide safety for workers in a trench and speed excavation. In this case, shoring should not be confused with shielding.
- Shoring is designed to prevent collapse where shielding is only designed to protect workers when collapse occur.
- Concrete structures shoring, in this case also referred as falsework, provides temporary support until the concrete becomes hard and achieves the desired strength to support loads.

Safety precautions for Shoring

- A qualified person should survey the jobsite for hazards that could cause issues with the shoring system. If hazards are uncovered, they should be corrected as needed
- Plan the shoring's installation in advance. This includes ensuring that the right equipment is available to safely finish the work.
- Inspect all equipment before use. If a defect is found, the affected item should be removed and repaired. Defective equipment should never be used.
- Obtain a shoring drawing from a qualified professional. The drawing should be used onsite at all times.
- Handle the shoring equipment with care, and only use the equipment as it was intended.
- Don't erect, dismantle or alter the shoring equipment without the approval of a qualified supervisor.
- Inspect the shoring system through the duration of a project. If there's any doubt about the safety of the shoring, stop use immediately and contact a qualified supervisor.
- Shoring systems should not be used for fall protection.
- Furthermore, workers should not use shoring systems if they feel dizzy or lightheaded.
- Do not climb on the cross braces.
- Periodically adjust uneven grade conditions, and plumb and level shoring frames as the erection proceeds. Do not force braces on frames; level the shoring towers for the proper fit.
- Follow proper safety practices during dismantling. Nothing should be removed from the shoring system until a qualified supervisor has given their approval.

SAFETY ISSUES WHILE USING LADDERS IN CONSTRUCTION

- People who work at a construction site often overlook ladder safety
- Ladder is a common piece of equipment used in construction site
- A fall from a ladder can result in permanent disabilities, and may even lead to death.
- In fact,numerous people get injured every day due to not following proper ladder safety.

Safety precautions

A. Choose the Right Ladder

a. TypeI-Industrial: heavy-duty with a load capacity of not more than 250 lbs.
b. Type II- Commercial: medium-duty with a load capacity not more than 225 lbs.
c. Type III - Household: light-duty with a load capacity not more than 200 lbs.

B. Correctly Use the Ladder

a. Secure the ladder: An extension ladder should be tied at the top, middle and bottom to prevent ladder movement or slipping.
b. The structure that we tie the ladder to must be capable of supporting the ladder.
c. A second person should act as a spotter and hold the ladder at the bottom. Tie off at the bottom of the overlap section to prevent slippage.
d. The top must extend 3 feet beyond the roof line if we are climbing onto the structure.
e. If climbing from the ladder to another surface, make sure the ladder extends 3 feet past the platform being climbed to.
f. Always face the ladder when climbing or descending. Do not climb higher than the second rung on step ladders or the third rung on straight or extension ladders
g. Personnel should have their hands free of material while climbing ladders.
h. Hand lines and/or tool pouches will be used to raise or lower material.
i. Utilize the 4-1 ratio: The 4-to-1 Ratio applies to the distance the ladder's base must be from the foundation. This is figured by dividing the length of the structure from the ground to the top support point (where the ladder resist against the building) by four. The 4-to-1 Ratio is important because the angle it creates utilizes the ladder's strength and gives optimum balance when climbing.

C. Properly Maintain the Ladder

- The final part of ladder safety is proper maintenance. Ladders should be inspected before and after each use.
- Inspect step ladders and extension ladders for broken or frozen joints or latches.
- Inspect aluminum ladders for cracks, broken welds,rough spots and burrs.
- Inspect wood ladders for cracked wood, splinters, and rot. Look for broken or loose hardware. Protect wood ladders with linseed oil or clear sealant.
- Fiberglass ladders are protected with a clear sealant. If the fiberglass is damaged through the sealant, sand lightly before applying another coat of lacquer.
- With all ladders frequently oil metal bearings of locks, wheels, pulleys and other moving parts.

LEFT: Professional Swingback Aluminium Step Ladder
RIGHT: Super-Trade Swingback Fibreglass Step Ladder

SAFETY IN TUNNELING

- In simple terms, tunneling is the physical process of constructing an underground passageway beneath the earth's surface, tunnels can also be created underwater.
- To be precise, a tunnel is a more or less a horizontal underground passageway constructed via excavation processes.

Safety Precautions in Tunneling

1. The floor of the tunnel should be kept dry and clean.
2. Open flames, electric short-circuiting should be avoided by providing proper covering over the power line and light.
3. Medical equipment and doctors should always be available at the site.
4. Fire fighting equipment with an excellent operator and sufficient water supply should be available at the site at all times.
5. Light and electric lines need to be entirely secured and insulated.
6. Unnecessary machines, tools, and construction materials should be avoided to store in the tunnel.
7. All the machines and tools should be maintained in usable condition.
8. Working platforms should be checked periodically.
9. The communication system (like; a telephone) should be installed inside the tunnels for receiving and sending important information about tunnel conditions.
10. All the internal systems like communication systems, power systems, safety devices, and lighting should be checked periodically

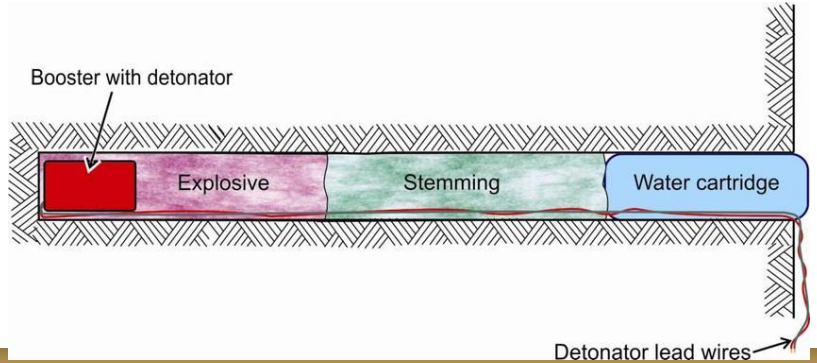
11. The double power supply should be provided so that the power from the standby unit can be restored during the power failure of one power supply.
12. Removal of rock protrusions by immediate hammering in the wake of blasting is known as scaling. The hammer stroke sound must be hard, not hollow. The hollow sound means loose rock.
13. Every worker must be aware of their safety
14. Protective clothing, steel helmet, rubber gloves, goggles etc, should be put on by every worker during their work.
15. The proper ventilation system should be provided in the tunnel as required.
16. Proper drainage must be provided.
17. Safety sign boards should be provided at various Pla along the tunnel.
18. Without permission, no unauthorized person should be permitted to enter the tunnel.

SAFETY IN BLASTING OPERATION

- Blasting is a process of reduction of rocks or hard soil into fragments with the help of explosives
- The blasting operation involves drilling of holes, installation of a detonator and charge, detonating the charge, and removal of debris.

Safety Precautions before Blasting

- The blasting operations shall be carried out under the supervision of a responsible authorized blasting engineer.
- In case of blasting with dynamite, the position of all the boreholes to be drilled shall be marked in circles with white paint.
- The boreholes shall be of a size that facilitates the easy passage of cartridge.
- After the drilling operation, the engineer shall inspect the holes to ensure that only the marked locations have been drilled, and no extra hole has been drilled.
- The engineer shall then prepare the necessary charge separately for each borehole.
- The boreholes shall be cleaned thoroughly before the insertion of the cartridge.
- For tamping, only cylindrical wooden tamping rods shall be used. Metal rods with pointed ends shall never be used for tamping.
- Each cartridge shall be placed in the borehole and gently pressed but not rammed down.



- Cartridges shall be added as required to make up the necessary charge for the borehole.
- The topmost cartridges shall be connected to the detonator, which shall, in turn, be connected to the safety fuses of the required length.
- The fuses of the required length shall be cut and inserted into the holes.
- The fuses shall be free of joints but if found unavoidable, a semi-circular notch shall be cut off from one piece of fuse from end and inserted into the notch of the other fuse.The joint pieces of the fuse shall then be wrapped together with string. All joints of the fuses exposed to dampness shall be wrapped with rubber tape.
- The maximum of eight boreholes shall be loaded and fired at one go
- The charges shall not be fired simultaneously but successively.
- Immediately before firing, a warning shall be given, and the engineer shall see that all the workers have retired to a place of safety.
- The safety fuses of the charged holes shall only be ignited in the presence of the engineer.
- The required count before each blast shall be set by the engineer and others.
- After all the charged boreholes have exploded, the engineer shall inspect the site for anomalies.

Safety Precautions while Blasting

- For the safety of workers, red flags shall be prominently displayed around the area where blasting operations are to be carried out.
- All the workers at the site shall withdraw to a safe distance of at least 200 meters from the blasting site.
- An audio warning by blowing whistle shall be given before igniting the fuse.
- The blasting operation shall be carried out under the supervision of trained personnel.
- The blasting shall not be done within 200m of an existing structure unless permitted explicitly by the engineer in writing.
- All procedures and safety precautions for the use of explosives, drilling, and loading of explosives before and after shot firing and disposal of explosives shall be carried out corresponding to the region and country code.

SAFETY IN DEMOLITION WORK

- Demolition or dismantling refers to breaking up of buildings, structures either fully or partially.
- Utmost consideration is to be given to demolition or dismantling of structures than to erection, construction and maintenance.
- The problems, hazards and uncertainties can be much greater in demolition if it is also carried out by the unskilled workers.
- The design engineers have responsibility for safety for not only for design and construction but also for the demolition of the structures at the end of its usual life.

Precautions during demolition has three goals.

1. Specifically aimed at safeguarding the personnel on the site.
2. Safeguarding of persons not connected with demolition including the general public and
3. The protection of the property likely to be affected by demolition operation.

- The causes of accidents to workers involved with demolition are fall from heights, falling materials, inadequate access, over-fragile materials etc.
- Premature collapses due to incorrect dismantling, over loading or excessive pre- weakening feature particularly during demolition.

Safety measures in demolition of the buildings:

1. Workers should not be deployed at different levels unless adequate precautions are taken to ensure safety of them
2. Demolition work should begin at the top of the structure and proceed downwards. .
3. Masonry concrete and other dismantled materials should not be allowed to accumulate in quantities which may endanger the stability of any floor or structural support.
4. Part of the structures, where necessary should be adequately shored, braced or otherwise supported.
5. If the structure is to be demolished by explosives, all safety measures pertaining to explosives such as transport, storage, handling, loading firing etc. should be strictly adhered to.
6. Foundation walls serving as retaining walls to support of adjoining structures should not be demolish until the adjoining structure have been under pinned or braced or earth supported by sheet pilling.
7. Stairs with hand railing should be kept in place as long as practicable to provide access and egress.
8. If the work of demolition is continued in night, all passageways, stairs and other parts of the structure where the workers have to pass and also to work should be adequately lit.

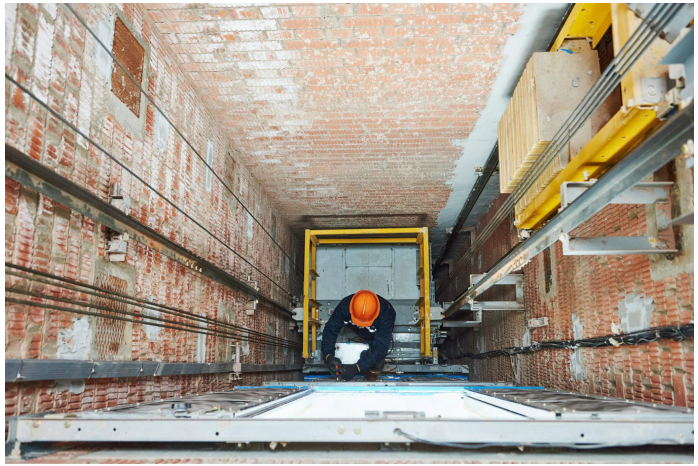
9. Workers should wear strictly safety belts, safety helmets and hand glove.
10. If the demolition is carried out by machines such as power shovels, bulldozers etc. the safety measures relevant to operation and use of such machines should be adhered to.
11. If swinging weight such as ball is used for demolition, a safety zone having a width of at least 1.50 times the height of the building or structure should be maintained.
12. Scaffolds used for demolition operations should be independent of the structure to be demolished.
13. If ladders are used for demolition, only travelling mechanical ladders should be used.
14. The hoists or chutes, whenever it is practicable, should be used to lower the materials. Materials chutes should have a gate at the bottom with suitable means for regulating the flow of materials

Safety measures in demolition of structural steel works:

1. The steel structures should be demolished from top, tier by tier.
2. Removing the various members of the steel structures should be done in a planned manner.
3. All precautions should be taken to prevent danger from any sudden twist, spring or collapse of steel parts/work when it is cut or released.
4. Structural steel parts should be carefully lowered and not dropped from a height.
5. Safety precautions of gas cutting of the steel members should be adhered to.

SAFETY IN CONFINED SPACE

- A confined space is one which is both enclosed, or largely enclosed, and which also has a reasonably foreseeable risk of fire, explosion, loss of consciousness, asphyxiation or drowning to workers.
- It may be small and restrictive for the worker or it could be far larger such as a grain storage silo with hundreds of cubic meter capacity.



Safety precautions before entering a confined space

Before workers enter a confined space the following precautions should be carefully considered and put in place before work is allowed to commence:

- **Avoid entry if practically possible:** It's that simple, if the job can reasonably be done externally or remotely then it should be. As reflected in the hierarchy of controls elimination should be the first course of action considered before actual entry
- **Carry out a risk assessment of the space:** Determining what hazards are present and the threat severity they pose is essential to the safety of workers within the space. If we don't know about it, we can't protect against it.
- **Get a work permit for the space:** A confined space entry permit must be in place prior to work commencing and needs to be signed off on by all involved; namely the issuing authority, performing authority and the workers due to carry out the task in question.

- **Safe access and escape arrangements:** The most obvious example of this would be a fixed ladder arrangement with means of emergency escape also being ready as required e.g. an emergency winch rescue device for retrieval of operatives via a safety harness in the event of an accident or other dangerous development.
- **Monitoring the atmosphere within the space:** Checks need to be made with a four-way gas detection monitoring device for the presence of gas such as Carbon Monoxide (CO), Hydrogen Sulphide or combustibles hazards such as high oxygen levels.
- **Providing appropriate breathing apparatus:** These must be safe to use within the space's conditions, accounting for risks such as electrocution with power tools in water or sparks which may ignite flammable gases
- **Space ventilation:** This will most likely be a fan assisted system implemented inside the confined space to maintain airflow and keep temperatures down to safe levels

- **Capable operatives:** Considering if we or our operatives are in suitable physical condition and appropriately trained for the work is a fairly straightforward though easily overlooked point. If there is concern that the physical condition of a worker may endanger an operation or the conditions within a space may aggravate a health complaint, then they should not enter to begin with.
- **Edge protection:** Hazards aren't necessarily limited to operatives entering the space having high visibility fixed barriers, flashing lights, signage and/or traffic cones positioned around entries such as manholes may be necessary to warn others of a fall.
- **An emergency rescue team:** Hopefully we won't need it, but regardless an emergency response rescue team must be kept on standby to be ready in the event of an incident. There should be a team member in place on top of or just outside the entry point, a clear method of communication (eg. radio), mechanical aids such as an emergency winch/ tripod attached to an operator's safety harness and sign in/out logs for commencement and completion of work.

SAFETY IN TEMPORARY STRUCTURES

- Temporary works are constructions that will not be a permanent structure, but instead are necessary either to create the infrastructure of the site (e.g. bridges, tunnels ete.) or as part of the construction of the permanent feature such as scaffolding or a necessary support structure.
- Temporary works usually fall under the category of earthworks, structures or the foundations for equipment such as cranes.
- Temporary works can also include structures which are only needed to be in place for a short period of time. Examples of this includes temporary seating stands which are only needed for a one-off event and then will need to be dismantled and removed once the event has taken place.

Safety Guideline for Construction of Temporary Structures.

- Build the structure on a stable ground.
- Use non-flammable fabrics
- Make sure there is sufficient time and resources available to build and dismantle the structure safely.
- Build the structure to the agreed design in accordance with a safe system of work.

NATIONAL BUILDING CODE OF INDIA

- The National Building Code (NBC) is a document that provides guidelines for construction of structures- residential, mercantile, institutional, educational, commercial, assembly, storage spaces or even hazardous buildings.
- It is important to follow these guidelines that are meant to protect the overall health of the construction and ensure the health and safety of the public and the residents.

Types of Residential Buildings

- As per the National Building Code of India, residential buildings include any building that is equipped with sleeping accommodation for normal residential purposes, with or without cooking and dining facilities.
- Residential buildings are classified into the following categories:
    - Lodging or rooming houses.
    - One or two-family private dwellings.
    - Dormitories.
    - Apartment houses or flats.
    - Hotels

Guidelines related to building exits

The NBC has guidelines for the entry, as well as exit points in buildings.

- An exit must be provided in every building, so as to permit safe escape of residents in times of fire or earthquakes, etc.
- Exits are compulsory and these should be clearly visible to all and must be illuminated. These cannot be reduced in number, width or by any other means. The requisite number is dependent on occupancy load, capacity, travel distance, etc.
- Alarms are necessary to ensure those in danger are evacuated promptly.
- Exits should be continuous, leading to the exterior or building.
- Exits can be horizontal or vertical.
- Lifts and revolving doors are not exits.

Guidelines for staircases in residential buildings

- For group housing, where the floor area does not exceed 300 sq metres and the height of the building is not over 24 metres, a single staircase may be acceptable.
- In buildings that are identified in Bye-Laws No 1.13 VI (a) to (m), a minimum of two staircases are compulsory.
- In a residential low-rise building, the minimum width for the stairways is 0.9 metres.
- For flats, hostels, group housing, guest houses, it is 1.25 metres.

NBC guidelines regarding fire safety

- In large-sized buildings where accidents due to fire may not be easily noticed, automatic fire detection and alarm facilities are a must and should be provided. Not just this, such buildings should be provided with and protected by fire extinguishers, wet risers, automatic sprinkler installations, etc. These shall be in accordance with the set standards.
- The guidelines for fire drills and evacuations for high-rise buildings are also specified in NBC Part 4. It mandates the appointment of a qualified fire officer and trained staff for significant occupancies.
- NBC Part 4 Fire and Life safety specifies the demarcation of fire zones, restrictions on construction of buildings in each fire zone, classification of buildings based on occupancy, types of building construction according to the fire resistance of the structural and non-structural components and other restrictions.
- According to the Part 4 of the NBC, "Every building shall be constructed, equipped, maintained and operated as to avoid undue danger to the life and safety ot the occupants from fire, smoke, fumes or panic during the time necessary for escape."

RELEVANCE OF ERGONOMICS IN CONSTRUCTION INDUSTRY

- Ergonomics is a science that focuses on designing spaces, workplaces, tasks, and processes to improve well-being and prevent strain and muscular injury.
- In the context of construction, we can simplify the concept down to fitting the job to the employee rather than forcing the employee to fit to the job.
- That means avoiding unnecessary uses of force, reducing stress on the body, and eliminating task performed in awkward positions.
- Proper ergonomic design and solutions can prevent and reduce the risk of musculoskeletal disorders (MSDs).
- While these disorders are generally short-term, they can develop into long term, disabling conditions that will severely impact an employee's ability to perform their work and enjoy their life

MAJOR ERGONOMIC RISKS

- When a task isn't fit to an employee's capabilities and limitations, it can result in two types of ergonomic injury:
  - cumulative trauma disorders (CTDs) and
  - sprains or strains.

Cumulative Trauma Disorders

- CTDs, or repetitive strain injuries, are soft tissue injuries caused by repeated exposure to an ergonomic stressors .
- Many workplace tasks become risky when they are overdone.
- They can be performed safely for a limited amount of time and with adequate rest periods at regular intervals.
- However, when they are performed too often or for too long without allowing the body to recover, these tasks can result in a repetitive strain injury.
- These injuries generally develop in smaller parts of the body, such as the fingers, wrists, elbows, or neck.
- In the construction industry, the three most common types of CTD are tendon disorders, nerve disorders, and neuro-vascular disorders.

Tendon Disorders

- These injuries are caused by the inflammation of the tendon or the tendon sheathing due to repetitive rubbing against ligaments or bone.
- The most commonly known tendon disorder is called Lateral Epicondylitis, but we probably know it as tennis elbow.
- In this condition, the outer part of the elbow becomes painful and tender.
- The pain from tennis elbow can extend to the back of the forearm and affect grip strength.

Nerve Disorders

- When nerves are compressed repeatedly against bones, ligaments, and tendons, it can make moving the affected part of the body extremely painful.
- One of the most well-known nerve disorders is carpal tunnel syndrome.
- With carpal tunnel, the median nerve that travels through the wrist is compressed, resulting in pain, numbness and a tingling sensation in the thumb, index finger, and wrist.

Neuro-Vascular Disorders

- These disorders occur when the blood vessels or nerves are constantly compressed due to exposure to vibration or temperatures cold enough to reduce blood flow to the extremities.
- This condition is commonly known as Raynaud's disease.
- In the construction industry, the fingers are most affected by this
- When a worker is affected with it, the fingers turn white and then blue if the exposure continues for too long.
- When the stressor is removed and the blood returns to the area, the fingers then turn red and the affected worker experiences a painful burning sensation.

Sprains and Strains

- Unlike CTDs, sprains and strains are caused by a single, forceful event and develop instantly.
- Sprains and strains occur when a worker performs an activity that surpasses their physical limitation, like suddenly lifting a heavy or awkward object.
- Sprains and strains typically affect larger segments of the body, such as the back, legs, and shoulders.
- And the risk of injury increases with every additional ergonomic risk factor that present, such as static loading, repetition, force, contact stress awkward posture, and vibration.
- While we tend to use the terms interchangeably, sprains and strains are actually different.
- Both are stretches or tears in body tissue, but sprains refer to injuries to the ligaments while strains refer to those that happen in a muscle or tendon.

Ergonomic Hazard Controls in Construction

- We know what kind of injuries we're dealing with and how costly they can be. We need to discuss solutions
- Every organization should assess the ergonomic hazards on its sites, based on the scope of work, injury history, and the best business practices.
- This hazard assessment should be the foundation of the ergonomics program.
- Moreover, it is important to note that there is no silver bullet for all ergonomic hazards.
- Employers must consider and implement multiple control methods, often in combination, to keep workers safe.
- The following are a few simple and cost-effective solutions that construction operations can implement to solve common ergonomic problems in their industry.

a) Stooping, Bending, and Kneeling

- Construction work can involve a surprising amount of stooping, bending, kneeling, and squatting, often for extended periods of time.
- Workers who are tasked with fastening or connecting construction materials are especially likely to spend a lot of time in these awkward positions.
- One great solution to this problem is to ensure workers are provided with tools that allow them to perform their work in an upright position.
- Here are some examples of these:
    - Auto-feed screw guns with an extension to assist workers in securing subflooring, false floors, and decking and roofing materials.
    - Powder-actuated fastening tools with a stand-up handle allows employees to make steel-to-steel connections, fasten metal tracks to concrete, or install plywood on concrete without needing to constantly kneel and rise while doing the job.
    - Manual or battery-operated rebar tying tools allow employees to tie rebar while standing and eliminate need for the rapid and forceful hand motions used when performing the same task with pliers.
    - Motorized screeds (or vibratory screeds) eliminate kneeling, reduce repetitive movement, and substantially reduce the force needed to level concrete.
    - Kneeling creepers with cushioned knee support and chest support reduces stress on the knees and back when installing tiles or deck membranes - and does it without velcro or leather straps that can interfere with blood circulation
    - Split-level adjustable scaffolding keeps the bricks at waist level when doing masonry work, which reduces the need for stooping.

b)Overhead Work

- Overhead work creates substantial stress on the shoulders and arms.
- Working with the arms up is never comfortable- add repetitive motion, forceful grip on tools, and twisting the body and we've got significant potential for an MSD.

Some solutions include:

- Mechanical lifts reduce the need to reach overhead while holding and positioning objects. The lift will hold the object to be installed, leaving the worker's hands free to do the work under substantially less tension.
- Elevated work platforms provide a stable working surface that reduces the need for awkward postures while also eliminating the risks associated with ladders scaffolding.
- Extension shafts tor drills and screw guns allow workers hands at waist level. The employee can push with their biceps instead of their shoulder, which is a less strenuous position.
- Extension poles for powder actuated tools avoids the exhausting work performed with hands above the head. The extension pole might also eliminate the need to work from a ladder, which is also strenuous.
- Spring-assisted drywall finishing tools might not reduce the force reduce the pressure required, to push the compound onto the wall by 75%
- Pneumatic drywall finishing tools might not reduce the repetitive motion or eliminate all of the awkward positions involved in finishing drywall, but they do reduce the pressure required, thus decreasing the risk of ergonomic injuries.

c) Lifting and Handling Materials

- Lifting and handling heavy and large materials puts a lot of pressure on the back, shoulders, and nerk.
- Heavy objects can dig into a worker's hands and impede circulation.
- Holding them for extended periods of time can lead to conditions such as tendonitis or carpal tunnel syndrome.

Options to decrease these risks

- Reduce the weight of the materials being handled. This Can be achieved by buying smaller cement bags, packaging materials in several smaller boxes instead of a large one, or using lightweight concrete masonry blocks (which are 30-40% lighter than regular concrete boxes).
- Provide mechanical, hydraulic, or vacuum litts t handle window panes or drywall panels
- Provide mechanical lifts or carta when handling large and heavy objects, such as barrels.
- Special handles for handling large drywall panel reduce the grip force required to hold them as well as the effect that the sharp edges have on blood circulation
- Powered and non-powered carts reduce the need to transport heavy objects by hand, such as sheet materials or pipes
- Using pre-blended mortar and grout mixes instead of making them on site eliminates the need for lifting cement bags and mixing them by hand. Cement baps around 100 pounds and the employees might need to handle hundreds of them each day on large jobs.
- Use skid plates to move concrete-filled hoses. Concrete filled hoses are heavy and awkward to handle, so that employees have to make jerking movements to drag them and they often get caught in re-bars. A skid plate makes the hose slide on the re-bar, reducing the amount of force required to move them as well as the sudden movements required when the hoses get caught.

d) Hand Intensive Work

- Employees in construction spend a lot of time gripping tools and materials, which places a lot of stress on the hand, wrist and elbow.
- In time, this can lead to serious muscle or joint injury.

Solutions that will reduce these risks

- Easy hold gloves for mud pans are a great way to reduce the hand force required to hold a drywall mud pan. The glove attaches to the pan and holds it to the employee's hand without needing a forceful grip. Considering that the pan often weights up to 5 pounds and the employee does the task all day long, this eliminates a significant amount of strain.
- Power caulking guns require a lot less force than the trigger on traditional caulking guns. Using them reduces the risk of carpal tunnel.
- Opt for low vibration power tools or provide workers with anti-vibration gloves. High vibration power tools can lead to reduced blood circulation, which is exacerbated by a forceful grip. This can lead to conditions such as "white finger" or "hand and arm vibration syndrome."
- Use power brushes instead of hand wire brushes when clearing rust or other materials. Power tools reduce the need for a forceful grip, as well as repetitive motions.
- Quick threading lock nuts can be positioned or slide on the rod to the desired location. This reduces the installation time and eliminates a lot of repetitive movements.

Ergonomic tools can also help. While these are not always clearly defined or certified, here are some basic rules:

- Tools should conform to the geometry of the hand.
- Pistol grip and inline tools should have a handle about 5 inches long, and a handle diameter of 1 to 1.5 inches.
- Handles that end in the palm of the hand (too short) are not recommended.
- Pliers and crimping tools should have a handle length of 4 inches minimum and a recommended handle span of 2.5 inches.

ERGONOMICS HAZARDS

- Ergonomic hazards are physical conditions that may pose a risk of injury to the musculoskeletal system.
- Ergonomic hazards include awkward postures, static postures, high forces, repetitive motion, or short intervals between activities.
- The risk of injury is often magnified when multiple factors are present.
- Factors such as whole-body or hand/arm vibration, poor lighting, poorly designed tools, equipment, or workstations all contribute to negative interactions with the worker/user
- Some of the common body regions where injuries may occur include but are not limited to:
    - Muscles or ligaments of the lower back.
    - Muscles or ligaments of the neck.
    - Muscles, tendons, or nerves of the hands/wrists.
    - Bones and muscles surrounding the knees and legs.

- Injuries in these and other parts of the body could result in Musculoskeletal Disorders (MSDs), which may be called Cumulative Trauma Disorders (CTDs) or Repetitive Strain Injuries (RSIs), and are estimated to account for about a third of all non-fatal injuries and illnesses and their associated costs.
- Construction work can involve floor and ground-level work overhead work, lifting, holding, and handling materials, and hand-intensive work.
- Construction workers often experience backaches and pain in the shoulders, neck, arms, and hands, these symptoms often lead to musculoskeletal disorders and can cause health complications in the employees experiencing these symptoms.
- Employees have an increased risk of these injuries and health conditions if they often carry heavy loads, work on their knees, twist their hands and/or wrists, stretch to work overhead, u use certain types of tools, use vibrating tools or equipment.
- Ergonomic hazards occur in both occupational and non-occupational settings such as in workshops, building sites, offices, homes, schools, or public spaces and facilities.
- Finding ways to eliminate or reduce ergonomic hazards in any setting will ultimately reduce the risk of injury.

Causes of ergonomic hazards in construction work

Awkward posture

- For some construction jobs, stooping or kneeling is required for tasks like finishing slabs, decks, or floor coverings.
- Bending, stooping, kneeling, or squatting can cause pain or discomfort in the employee's back or knees.
- Not only can these activities cause pain and discomfort, but these physical positions can limit other job activities such as lifting pushing, or pullings weights without substantial body stress. Some potential solutions for these kinds of tasks and ergonomic hazards include raising the work on a work surface so it is no longer needed to be done on the floor, but on a surface closer to the worker.
- Using tools with extension handles that allow the employee to work standing up could help eliminate the need to stoop and kneel.
- A device called a kneeling creeper could be used for tasks in which kneeling is required. This device offers chest support during the task to offer more body support during tasks.

- Working overhead is often required of construction employees.
- Drilling, driving fasteners, or finishing drywall are all tasks that would entail overhead work. This positioning could put stress on the neck, shoulders, and could reduce the ability for the employee to work safely.
- Using lifts or hoists would help the employee become closer to the work surface to reduce the frequency and intensity of lifting materials overhead.
- Attaching extension shafts for drills can help eliminate the need to reach overhead at all, and could help protect the employee from overhead ergonomic complications. Another solution could be to use an extension pole for tools.
- An extension pole is a fixed height pole attached to a powder-actuated tool, meaning the tool is out of the employee's hands, but they are still able to operate it.

Static posture

- Static posture is a posture that workers hold over period of time while performing a job or a work.
- Static posture in construction is a rare thing to see because of the amount of movement needed to complete all the construction process except in the office setting where planning is done

Contact stress

- Many tasks on construction sites involve lifting, holding and handling materials.
- This lifting and holding can strain the lower back, shoulders, neck, arms, hands, and wrists.
- Many tools are used today that are mechanical, but some tasks still need to be done manually.
- Using a power vacuum to lift large, lighter items such as a pane of glass can remove the need to lift items manually and can take most, if not all, of the strain off of the employee's body.
- Receiving proper lifting training can also help prevent complications from lifting materials.
- Best lifting practices include; not reaching 10-inch. away from the body when lifting or setting items down, not twisting the body, lift with the legs and not the back, lift items with two hands, instead of one.
- Using substitution can help with lifting materials as well. Some construction materials are very dense and heavy, substituting these materials for lighter weight materials (such as lightweight concrete blocks) can help reduce body strain during work and lifting tasks. Using skid plates under a concrete-filled hose cat help move the hose easily, and can prevent the need ro bending and awkward postured on the employee's part.

Repetitive motion

- There are also more fine motor skills that are needed on construction site and project, and these tasks can cause injuries such as tendinitis, carpal tunnel syndrome, trigger finger, epicondylitis, and Hand-arm Vibration Syndrome (HAVS)
- Substituting tools that do not fit the employee, with more ergonomic tools.
- Take into consideration the handle, wrist position, handle diameter, and if the tool is spring-loaded.
- Automated tools such as power caulking guns can help when completing tasks where caulking is needed.
- Vibrations from power tools can also cause injuries and long-term health effects.
- Using reduced vibration power tools, or issuing employees ant-vibration gloves can help reduce health effects from tool vibrations

High forces

- High forces are forces that workers put to lift objects during construction.
- In Construction, most of the work requires a certain amount of high force required to lift a heavy object. High forces in Construction is not only focused on heavy lifting but can be seen in the pushing, pulling, and gripping of tools.
- All these can lead to some ergonomic issues that might affect the work

MUSCULOSKELETAL DISORDERS

- Musculoskeletal disorders (MSDs) are injuries or pain in the human musculoskeletal system, including the joints, ligaments, muscles, nerves, tendons, and structures that support limbs, neck and back.
- MSDs can arise from a sudden exertion (e.g., lifting a heavy object), or they can arise from making the same motions repeatedly repetitive strain, or from repeated exposure to force, vibration, or awkward posture.
- MSDs can affect many different parts of the body including upper and lower back, neck, shoulders and extremities (arms, legs, feet, and hands).
- Examples of MSDs include carpal tunnel syndrome, epicondylitis, tendinitis, back pain, tension neck syndrome, and hand-arm vibration syndrome.
- Workers maintain the same posture over long work days and often several years, even natural postures like standing can lead to MSDs like low back pain.

- Postures which are less natural, such as twisting of or tension in the upper body are typically contributors to the development of MSDs due to the unnatural biomechanical load of these postures.
- There is evidence that posture contributes to MSDs of the neck, shoulder, and back.
- Repeated motion is another risk factor for MSDs of occupational origin because workers can perform the same movements repeatedly over long periods of time (e.g typing leading to carpal tunnel syndrome, lifting heavy objects leading to herniated discs/slipped discs), which can wear on the joints and muscles involved in the motion in question.
- Workers doing repetitive motions at a high pace of work with little recovery time and workers with little to no control over the timing of motions (e.g. workers on assembly lines) are also prone to MSDs due to the motion of their work.
- Force needed to perform actions on the job can also be associated with higher MSD risk in workers, because movements which require more force can fatigue muscles quicker which can lead to injury and/or pain.

- Additionally, exposure to vibration (experienced by truck drivers or construction workers, for example) and extreme hot or cold temperatures can affect a worker's ability to judge force and strength, which can lead to development of MSDS
- Vibration exposure is also associated with hand-arm vibration syndrome, which has symptoms of lack of blood circulation to the fingers, nerve compression, tingling, and/or numbness.

Thank You