Chapter 1

Intr ducti n

1.1 C nstructi n industry

Construction projects involve multiple and complex activities Execution, including coordination, monitoring, controlling as well as delivery, poses various challenges due to several interwoven factors as well as simultaneous activities Complexities of diverse operation, inherent multilayer hazardous processes, conflicting priorities within various sub-groups of operating agencies, casual nature of employment etc creates safety challenge due to which projects remain prone to incidents leading to life and property losses

According to ILO, every 15 seconds, a worker dies from a work-related accident or disease Also the economic burden of occupational safety and health practices is given as 4 per cent of global Gross Domestic Product yearly Protection of the health and safety of workmen is the primary responsibility of an employer Accidents or incidents which occur in a construction site/work place will affect the lives of people badly The persons affected can be those in the work place, friends, family etc Moreover there will be major impacts on the organisation too, which can be in the form of loss of skilled labour, financial loss, decline in the production etc Also an incident occurring in the site will bring bad reputation to the company

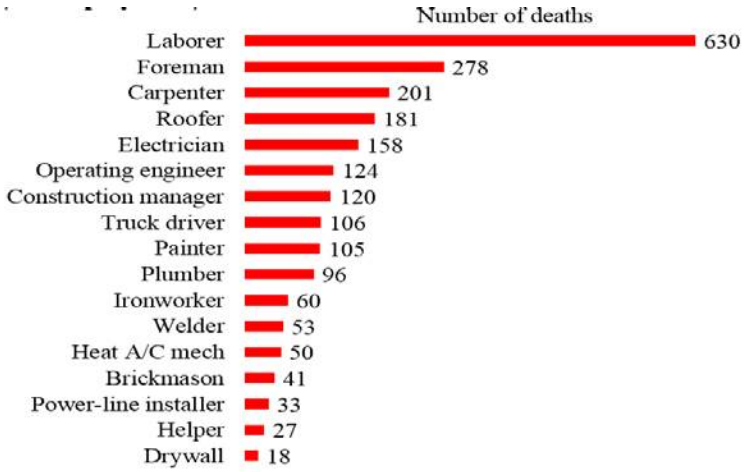


Fig 1.1. Number f fatalities, selected c nstructi n ccupati ns, 2008-2010 (as per CPWR c nstructi n chart)

By nature, construction industry is thoroughly heterogeneous and tremendously complex There are several classifications of construction that varies markedly from one another: factories, housing, non-residential building, heavy, highway, utility etc Scope of construction projects are large, including new construction, renovation, and demolition for all sorts of projects

Construction projects in many ways could be unpredictable Managing risks in construction projects has been recognized as a very important process in order to achieve project objectives in terms of time, cost, quality, safety and environmental sustainability Project risk management is an iterative process: the process is beneficial when is implemented in a systematic manner throughout the lifecycle of a construction project, from the planning stage to completion

Risk management in the construction project management context is a comprehensive and systematic way of identifying, analysing and responding to risks to achieve the project objectives The use of risk management from the early stages of a project, where major decisions such as choice of alignment and selection of construction methods can be influenced, is essential The benefits of the risk management process include identifying and analysing risks, and improvement of construction project management processes and effective use of resources

1 Applicati n f Paret principle

The Paret principle, well kn wn as rule f 80/20, in ther w rds, the law f the vital few and trivial many, states that f r many events, r ughly 80% f the effects c me fr m 20% f the causes Indicating the need f f cus n vita issues This als indicates that 20% f eff rts can be en ugh t address 80% f pr blem This leads t the need f selecting and addressing the imp rtant issues and dispersing the eff rts with trivial matters As an extensi n f this principle, it can be said that 20% of the hazards leads to 80% of the injuries, and by suitable categorizing of the hazards, those 20% of the hazards can be targeted so that that cause 80% of the injuries or accidents can be prevented On the other hand, if hazards are addressed in random, it is likely that one of the 80%

of hazards will get addressed which account only for some fraction of the remaining 20% of injuries In fact, application of Pareto principle also ensures hazards prioritized with overall impact, including economical contexts, as the principle ensures the resources deployed are best used to prevent the most incidents and adverse outcomes

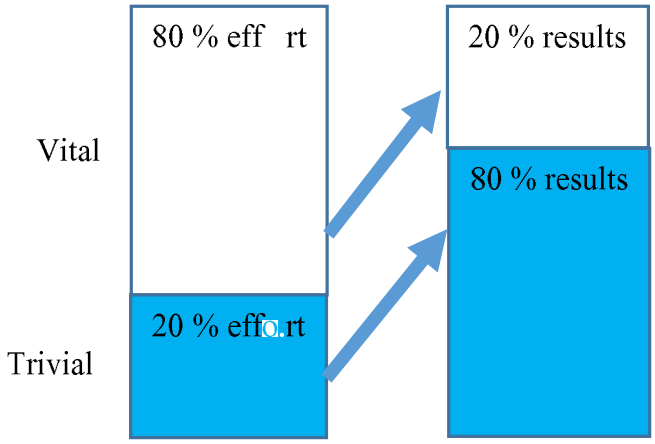
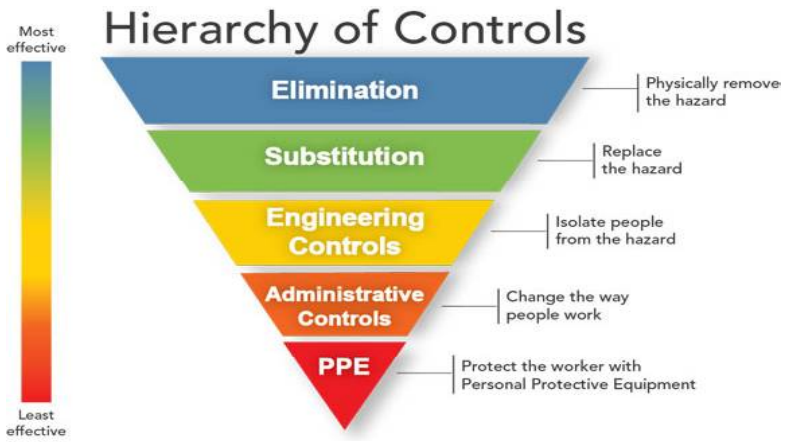


Fig 1.2 Paret principle

As we bring the perspectives f Paret principle in this c ntext, the importance and need of selecting appropriate focus areas through scientific analysis and hazard prioritization, becomes evident As a part of the process, a survey on construction safety risk leads to the following distribution of mitigation measure:



. Hierarchy f c ntr l

1 Various mitigation methods and their implications

Meth d	**Implicati n**	**Applicability in C nstructi n (in %) Survey result**
Elimination	Availability of alternative option Feasibility Financial viability 100% effectiveness	5
Substitution	Same as above Very high effectiveness	12
Engineering Control	Integration through design Sustainable solution High effectiveness	55
Administrative Control	Limited effectiveness	13
PPE	Low effectiveness Recurring expenses	15

2 Risk c ntr l in c nstructi n w

Risk c ntr l in c nstructi n sites, plays an imp rtant r le in verall management f the safety and health f the perati ns This requires in depth analysis f the activities and ass ciated risk in the dynamic situati n, n a regular basis T achieve this, fact rs which c uld harm the pe ple sh uld be clearly identified and checked whether suitable steps are already integrated t prevent adverse c nsequences This is kn wn as risk assessment and sh uld be regularly carried ut f r best results Identifying the appr priate mitigati n measure and implementing the same t c ntr l risks is als a significant part f risk assessment This c uld be based n past experience and emerging safety bservati ns, f ll wed by risk rating and risk categ rizati n

1 Steps t assess risks

- Identify potential hazards
- Decide how it can harm people and who will be harmed
- Evaluate the identified risks and decide on mitigation measures
- Note the major findings
- Review the assessment and update if necessary

Risk can be quantified and as a product of probability and consequence Any activity beyond acceptable risk level need to be treated with suitable mitigation measure to bring the risk to within as low as reasonably practicable limit

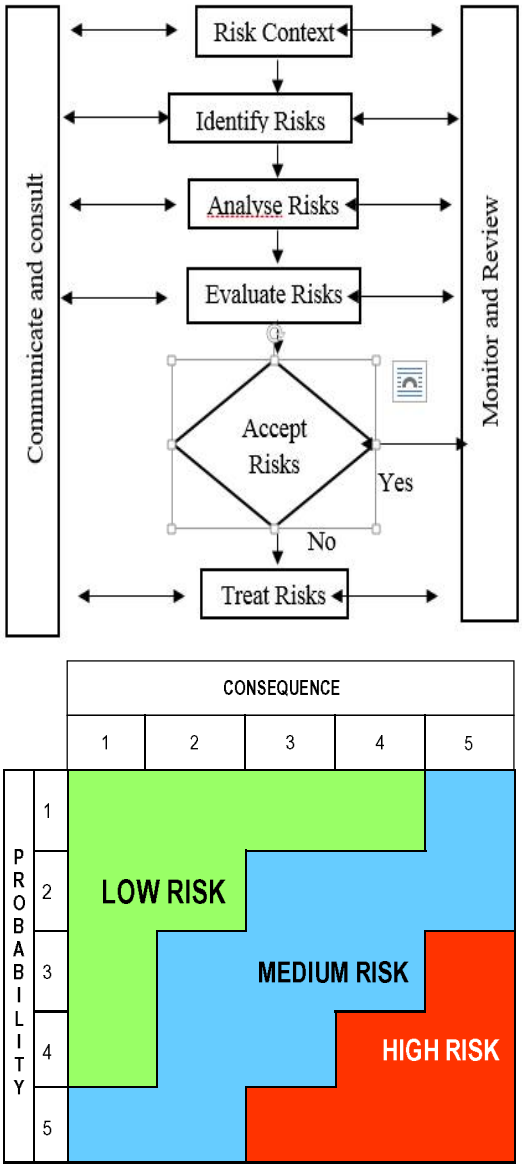


Fig Risk Management Process and Risk Matrix

Elimination of risk can be the best option to handle the risks If this is not possible, we should try for "substitution" When that is not possible, we need to look at the next level, ie, third option, which is "engineering control" In fact, risk treatment begins here This is followed by lower level of controls, such as administrative control and PPE, evidently with reducing level of effectiveness

2 Engineering c ntr l

The first and best strategy is to control the hazard at its source Engineering controls do this, unlike other controls that generally focus on the employee exposed to the hazard The basic concept behind engineering controls is that, to the extent feasible, the work environment and the job itself should be designed to eliminate hazards or reduce exposure to hazards

Engineering controls can be simple in some cases They are based on the following principles If feasible, design the facility, equipment, or process to remove the hazard or substitute something that is not hazardous If removal is not feasible, enclose the hazard to prevent exposure in normal operations Where complete enclosure is not feasible, establish barriers or local ventilation to reduce exposure to the hazard in normal operations

3 Administrative c ntr ls

While safe work practices can be considered forms of administrative controls, OSHA uses the term administrative controls to mean other measures aimed at reducing employee exposure to hazards These measures include:

- Additional relief workers
- Exercise breaks
- Rotation of workers

These types of controls are normally used in conjunction with other controls that more directly prevent or control exposure to the hazard

4 PPE

When exposure to hazards cannot be engineered completely out of normal operations or maintenance work, and when safe work practices and management controls cannot provide sufficient additional protection from exposure, personal protective clothing and/or equipment may be required

A supplementary method of control is the use of protective clothing or equipment This is collectively called personal protective equipment, or PPE PPE may also be appropriate for controlling hazards while engineering and work practice controls are being installed For specific OSHA requirements on personal protective equipment, see OSHA's standard, 1910 Subpart I

3 C nstructi n Industry in India

Out of nearly 41 million people are employed in this sector, less than 6 per cent has structured training and skill building, which influences safety at work This Industry needs infusion of at least 6 million persons per year Since the total training capacity is woefully inadequate, against a requirement of over 35 million trained tested and certified workers, the capacity available is about 05 million per annum This leads to enhance the risk at work as the workers employed at the job lacks the basic skills and vulnerable to accidents Various associated factors such as temporary relationships between employer and employee, uncertain working hours, lack of basic amenities and inadequacy of welfare facilities enhances the safety and health risks at work

As per the report of the working group on occupational safety and health for the twelfth five year plan (2012 to 2017), accidents in construction industry are mainly due to the factors such as,

- Large number of small firms and self-employed workers
- Shorter duration of construction activities at sites
- High-turnover of workers
- Large number of seasonal and migrant workers not familiar with construction activities
- Many different trades and occupations involved in construction activity

In India construction sites draw workmen from various parts the country Due to the transient and casual nature of occupation, they continue to move from one project to the other and hardly get any long-term career development and growth opportunities This sector is the second largest industrial sector next to agriculture

Statutory provisions under Building and Other Construction Workers' (Regulation of Employment and Conditions of Service Act (BOCW) 1996 and Rules made thereunder as well as Indian Standards specifications requires implementation of suitable control measures to mitigate the risk, which is covered under this study at the following specific areas:

- Working Safely Near Energized Overhead line under BOCW Central Rules, Electrical Hazard - Rule 47
- IS 14956 Live working - Minimum approach distances - Method of calculation
- Circular Saw guard under BOCW Central Rules, Fencing of Motors - Rule 37
- Head protection, under BOCW Central Rules, Head Protection and other protective apparel- Rule 46
- IS 2925 Specification of Industrial Safety Helmets
- Fall protection, edge protection, ladder under BOCW Central Rules, Floor opening Rule- 115, Guardrail Rule 196, Opening Rule 195
- IS 3696 Safety code for scaffolds and ladders Part 1 and 2 – Scaffolds and Ladders
- IS 4014 Code of practice for steel tubular scaffolding Part 1 Definitions and materials,
- IS 4014 Code of practice for steel tubular scaffolding Part 2 safety regulation for scaffoldings
- Gas Cylinder Rules 2004, Rule 18 - Handling and use

2 Pr blem statement: Limited availability f engineering s luti ns f r vari us risks ass ciated with c nstructi n w

India is one of the world's fastest growing economies, with estimated annual GDP growth of 8%, driven by huge expansion in industries such as chemicals, manufacturing and textiles However, while India has had legislation on occupational health and safety for many years, large sections of the estimated 465 million-strong workforce are not covered by health and safety law, and safety inspection and enforcement remain small-scale and piecemeal As a result, work-related injury and ill health remain enormous problems For instance, in a 2008 report, the International Labour Organization (ILO) estimated that in 2003, around 47,000 people were killed in workplace accidents in India and 356,000 others died as a result of occupational illness

As per the planning commission estimates 7 % of the total workforce is engaged in construction, work It also shows that construction is ranked among the most dangerous occupations, in industrial sectors The frequency and severity rate of injury and occupational diseases is notably higher than other industries

Study has shown that for a full-life time of employment in construction sector, an average workman would get exposed to various safety and health risks leading to harm It is the job of the management to mitigate these risks and provide a safer workplace to all concerned

As per widely accepted model of "hierarchy of control", engineering controls is recognized as one of the primary option to mitigate the risks associated with above mentioned areas However, this is not an easy option in practice due to various reasons, including perceived high cost implications, time and efforts involved etc Hence mitigation efforts are mostly channelized through alternate lower level hazard control avenues, which are not the best options for risk mitigation As a result, those lower level hazard control measures show limited and short-lived success and won't sustain over long period

3 Research M tivati n / need and verview - h w imp rtant this is gl bally

Construction is among the most dangerous occupations, in industrial sectors

Various studies have shown that for a lifetime of employment in construction sector, each workman would get exposed to various safety and health risks leading to serious harm

Globally construction industry is among the most hazardous industries, in terms of occupational injuries and illnesses As per one study, 20 -30% of workers meet with occupational deaths due to injuries and illnesses In India out of around 41 million workers in construction where 96% are small firms employing less than 200 workers

In view of the large impact to the workers as well as their families and society at large, it is necessary to conduct in-depth research on possible preventive measures and facilitate protection of the construction workers from various occupational hazards This can be achieved through enhancement of engineering control measures and prevent occupational accidents and illnesses in construction work, on a long term basis

As per ILO estimates, cost of occupational accidents and diseases results 4% of global GDP loss, which by any means, is a substantial amount Just in India though nearly 7 to 8% of the working population is engaged in construction work, they in fact share over 10 to 12% burden of the occupational safety and health injury Hence nearly 05% GDP of the country, USD 1877 trillion is lost, which may rise to USD 2384 USD in 2016

In view of the enormity of the occupational safety and health challenges in the construction sector and it its various consequences, including economic, environmental, humanitarian and social, the need of suitable corrective steps are strongly felt This work aims to address this need, in a humble way, focusing the correctives actions on the basis of engineering control

4 bjectives

1. To examine the effectiveness of existing risk control measures at construction sites
2. Find out solutions to improve the same with focus on enhancement in engineering control measures at construction sites for prevention of accident and injuries

5 Research Meth d l gy

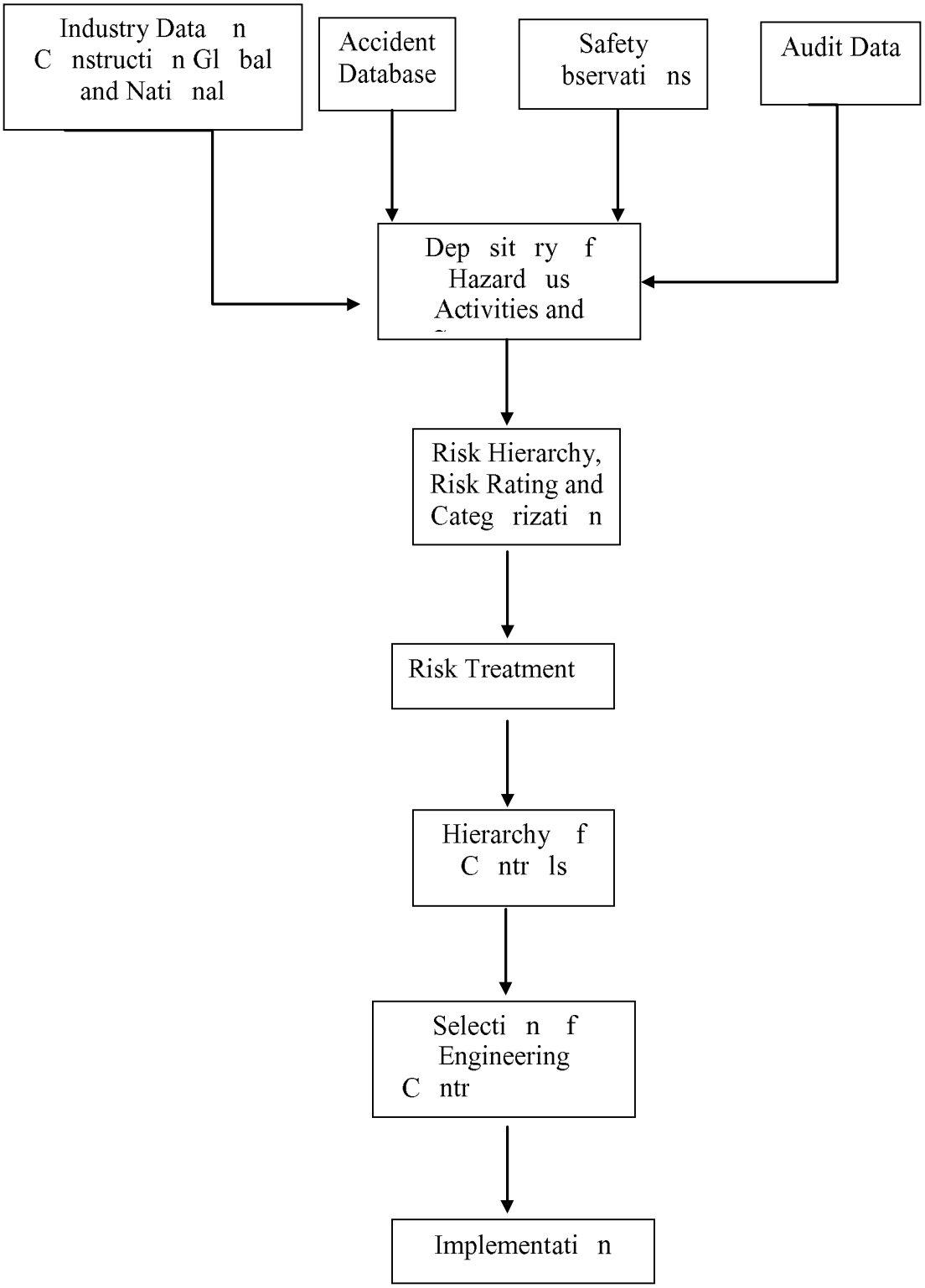
This research initiated with analysis of specific occupational safety and health concerns, with reference to the high-risk construction related activities at large project sites

From the incident database and inspection records of a large construction company as well as available literature, various existing "engineering controls" measures for the above risk areas were evaluated The methodology is aimed to explore, develop and adopt sustainable safety improvement with focus on engineering improvements The process flow is given belo :

Steps:

- Analysis of accident pattern in major construction projects
- Sampling study of prevailing engineering interventions on the subject area
- Cause and effect analysis of accidents and identifying the need and significance of engineering intervention programs
- Identification of deficiencies through collated inspection data of related activities
- Design engineering solutions at selected construction sites with specific focus on engineering intervention
- Analyze the result of engineering controls and formulate proposal for implementation

6 Pr cess Fl wchart



7 C ntributi n f research

This research is aimed to bring low-cost, easy to implement engineering interventions at construction sites in India for prevention of high potential accidents and injuries This might also encourage future research in the same area to find out various possibilities of engineering interventions for improving work safety and accident prevention at construction sites

8 utline f thesis chapters

Outline of next chapters containing details of six engineering control measures

1 Making table m unted circular saw perati ns safer in c nstructi n industry – a practical appr ach

In civil construction work, circular saw is a commonly used power tool Circular saw is mainly used for cutting wood materials, including plywood for shuttering work Naturally this involves cutting of various types of woods, with high level of precision such as crosscut, rip, and bevel cut etc where electrically operated circular saw is used

As per various studies, severe cuts and even amputations of upper extremities may occur in case the operator accidentally contacts the saw blade, moving at a very high speed Chances of injuries occurring are high when any blade is fully exposed during cutting operation Existing guards are not really effective due to technical limitations and not operator friendly, and get frequently removed from the equipment by the operator

Engineering challenges:

Restricted visibility – Existing design of guards restrict the vision of the operator – he may not be able to see the cutting points clearly in most situations

Restriction to versatile operations – While cutting various types of wooden material such as full length ply wood or long logs, the basic fixtures of the guards may create hindrance, requiring removal of the same, which eventually never gets re-fitted

Engineering interventions need to be effective in terms of versatility; while visibility of the object to the operator is an important factor which is essential not only for precision in the job, but also helpful in monitoring the cutting operations to prevent kickbacks Kickback takes place when separated ends on the wood meet on the other side of the saw and pushes the object backwards (towards the operator), causing serious injuries

The new design of the guard should be effective and come with more operator friendly and safety features

Since unguarded moving parts in a machine can cause severe workplace injuries, such as crushed fingers or hands, amputations etc Naturally, safeguards are essential for protecting workers from these injuries which are mostly preventable When operating a circular saw, accidental contact with rotating circular saw blade must be safeguarded Consequently, providing a suitable enclosure/guard to such machines is also part of legal requirements globally

In this study hazards associated with operation of table mounted circular saw for construction activities are studied In construction work, for RCC (Reinforced Cement Concrete) structures, solid wood and plywood are extensively used for holding the concrete it its shape, while it is being cast in a pre-determined shape Circular saw is extensively used for making various types of formwork It is generally mounted on a bench/table

Studies also point that table mounted circular saw machines are responsible for most wood working accidents Many of these result in severe injuries Analysis of accidents investigated by HSE-UK has found that most were caused by inadequate or missing guards Many of these accidents could have been avoided by having a correctly adjusted saw guard and using a push-stick

Circular saw is one of the most commonly used power tool in civil construction work Circular saw is mainly used for cutting wood materials, including plywood for shuttering work Various types of wood cutting operations some of which involves high level of precision such as crosscut, rip, and bevel cut etc are done by circular saw

The most dangerous part of the Circular Saw is its blade Severe cuts and even amputations of upper extremities could occur, when the operator accidentally

come in contact with the blade moving at a high speed Chances of injuries occurring increases when the blade is kept fully exposed during cutting operation Existing circular saw blade guards are not really effective due to technical limitations and not operator friendly; hence these are frequently removed from the equipment

2 Preventing ladder related incidents in c nstructi n industry – Engineering c ntr ls

Construction Work is mostly related to work at height, at various levels Several activities are required to be performed at elevations which are more than 18 m higher from the ground level

Ladders are also used to provide access to scaffolds (temporary work platforms) and connect various working levels till permanent stairs are built However it is sometimes used to perform short-time work such changing of lamps, nailing etc

Various activities such as brick work, concreting, grinding, insulation painting, welding, as well as enabling work such as erection of scaffolds, material handling rigging etc often requires working at height

In most of the cases the preferred conventional method of access is usage of scaffolds aided with ladders The factor of utilizing the ladder in an effective way is the key ingredient in completing the work safely

Fall from height is the major contributor for serious and fatal injuries at construction sites While any fall, including fall on the same level could be dangerous, fall from two meters or more, could lead to serious consequences which may lead to death

3 Pulm nary health hazards in manual welding perati n in c nstructi n: A study n engineering c ntr l measures

During manual metal arc welding, the welder gets exposed to fumes and gases generated during the process He also get exposed to heat, Ultra-violate as well as Infra-red radiations However, harm to the health depends on various factors, including the job size, location, duration of exposure, other environmental factors etc

4 Safe handling f gas cylinder at c nstructi n site

Gas cylinder poses potential risk due to two reasons Content, which could be explosive, for example, Acetylene and Acetone in DA Cylinder and also due to the state of the gas It is necessary to handle gas cylinders with care Due to dynamic nature of construction of construction sites and other factors including lack of knowledge about the risk potential as well as suitable resources such as "cylinder trolley" etc, the cylinders are dropped, rolled and pulled at construction sites In view of the inherent hazards of the cylinders, adequate corrective measures must be taken focusing on engineering control measures

5 Head pr tecti n while carrying head-l ad

Usage of helmet at construction site is a statutory requirement, due to high risk of fall of material from height While all care must be taken to prevent fall of material, as a standard requirement, usage of helmet at construction site is mandatory In India, still a large amount of construction work is done manually Women workers who are engaged for various supportive roles at site, including shifting of brick and pan of concrete/mortar etc, find it difficult to use the conventional industrial safety helmet due to contour on the top of the helmet To overcome this problem, a small plastic pipe of 200 mm diameter and 77 mm long pipe was and attached with the helmet After the same was successful, it was molded as an integral part of the industrial helmet (IS 2925)

6 W rking safely near energized verhead p

Construction of high, medium and low voltage transmission line, Accelerated Power Development and Reform Programme (APDRP), Railway Electrification are some of the work where construction workers come in the vicinity of energy sources, mostly with bare conductors Permit to Work (PTW) and shutdown of supply is a basic administrative requirements In practice, after obtaining PTW and with shut-down of supply, workers are deployed at work However, due to various factors sometimes workers get exposed to the possibility of contacting a live wire without their knowledge or due to in effective PTW/shutdown owing to administrative/ technical reasons