Executive Summary

Globally, 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 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 control is recognized as one of the most important options to alleviate 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 in implementation etc Hence mitigation efforts are mostly channelized through alternate lower level, easy-to-do, 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 To address such ever existing challenges, which looms over large as well as small construction sites, various suitable and sustainable avenues were explored As mentioned above, as well as in each chapter in this work, various engineering control measures were reviewed and some of such engineering control measures were adopted for implementation after applying Pareto principles All these engineering control measures were basically low-cost, easy to implement solutions, with freely available resources In this research work six such engineering solutions are presented as a part of this study

Problem statement: Limited availability of engineering solutions for mitigation of various risks associated with construction work

Objectives: To examine the effectiveness of existing risk control measures at construction sites and to find out solutions to improve the

same with focus on enhancement in engineering control measures at construction sites for prevention of accidents and injuries

From the analyses available incident databases as well as of risk potential assessments of safety surveys at construction works and making use of Pareto principle, appropriate engineering control measures for the identified engineering challenges were systematically developed and tested on-site This study documents the process of analysis, risk assessment, development of engineering control measures and establishment of the improved safer system at work High risk areas were identified through analysis of accidents and injuries as well as potential risk assessment of large construction projects, the following areas were short-listed for engineering interventions, to promote safe working conditions and prevent accident and injuries These areas are:

i) Making table mounted circular saw operations safer in construction industry – a practical approach
ii) Preventing ladder related incidents in construction industry – Engineering controls
iii) Safe handling of gas cylinders at construction sites
iv) Pulmonary health hazards in manual welding operation in construction: A study on engineering control measures
v) Head protection while carrying head load
vi) Working safely near over-head energized power line

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

Circular saw is one of the most commonly used power tool in civil engineering related construction work Circular saw is mainly used for cutting wood materials, including plywood for shuttering work, used for in-situ casting of concrete 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 Wooden shuttering is also extensively used for architectural building requiring intricate shuttering works

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, hence frequently removed from the equipment by the operator

Engineering challenges:

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

This improved design of circular saw guard found to be more operator friendly which can be operated with safety features

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

Falls from height are major contributor for highest number of 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

Many construction activities involve working at height Though ladder is basically an access equipment, it is sometimes used to perform short-time work such changing of lamps, nailing etc

Ladders also used to provide access to scaffolds (temporary work platforms) and connect various working levels till permanent stairs are built

Engineering challenges:

Safe fixing of ladder, considering the right slope and suitability of the structure – Due to the temporary nature of construction activities, ladders often get shifted from one place to the other In absence of a standard and quick-to-fix arrangement with the structures on which it leans, ladders may fall sidewise, causing injury to the person who is using it or even standing nearby

iii) Safe handling f gas cylinder at c nstructi n site:

Compressed gas cylinders are heavy (40 kg+) especially when full Compressed gas cylinders generally come at a pressure of 250 psi (DA Cylinder) and 2200 psi (Oxygen Cylinder) contains the kinetic energy equivalent to a small weapon In case of breakage of main valve due to sudden fall, gas cylinder could fly more than 500 m and even penetrate reinforced concrete walls There is a need for safe handling of all gas cylinders including loading and unloading Due to the nature of the construction site, gas cylinders are required to be used at various locations where permanent arrangements of unloading and loading back empty cylinder do not exist

Engineering challenges: In most cases gas cylinders are transported in conventional carriage, manually handled, loaded and unloaded from the motorized vehicles Such loading and unloading of cylinders are not standardized and varies from project to project Risk assessments conducted on various such conventional handling methods of gas cylinders, depicts at probable serious consequences, in case these gas cylinders get dropped to ground or hit by objects during handling Even then, a number of cylinders loading / unloading is manually done handling process and a huge scope of engineering interventions is a scope of improvement in determining an effective control

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

Studies indicate that exposure to welding fumes can cause numerous health problems When inhaled, welding fumes can enter the lungs, bloodstream, brain nerve cells, spinal cord and other organs and can cause both short- and long-term health effects Many welders who work in factories or in the construction, ironworks, manufacturing, mining, metallurgy, petrochemical, railroad, shipbuilding or steel industries, mostly suffer from some sort of respiratory illness or pulmonary infection In construction industry such welding operations are carried in a covered booth like set ups which results in buildup of welding smoke in the working zone

Engineering challenge: There are no proven effective methods to ensure a proper ventilation system which could be incorporated on the work areas Owing to the dynamic nature of the task and magnitude of welding for the mechanical jobs in industrial construction work this requirement gets overlooked Hence there is a scope for a study in this area to arrive at an effective engineering intervention for reducing adverse health impacts

v) Head pr tecti n while carrying head-l ad

Efficient handling and storing of materials is vital to construction industry Though mechanization at construction site has increased enormously, still the industry depends on many manual activities, which include manual load carrying The most common materials that are being carried manually may vary with the activities and may include a wide range of materials including cement bags, bricks, lumber, ply woods, steel rods, pipes etc Some of these materials that are normally carried on head while handling it across the workplace

Since at construction sites there is always a potential risk of fall of materials / hit by objects it is very important to have an adequate head protection for all workers and hence Safety helmets is considered to be one of the mandatory PPEs

Those who carry head load, find it difficult to use safety helmets as it hinders proper setting of the load on the head Due to this they are unable to wear protective headgear which further intensifies the risk of head injuries

Engineering challenge: It is necessary to find a solution so that head protection can be worn when head load is being carried The existing standard helmets are not designed for carrying any head loads Firstly, the load cannot sit on a circular smooth surface of a helmet Secondly, specified clearance between the helmet shell and the anti-concussion tapes provided inside the helmet, to be maintained for effective impact dissipation If these internals are not suitably designed, the gap between the shell and the head may get reduced due to head load carrying and thereby nullifying the benefit of helmet usage This may require changes in the existing design of the helmet

vi) W rking safely near energized verhead p wer line

Workers who are engaged in erection and maintenance of electric networks including railway traction lines work are exposed to the hazards of electric shock

Any work in the proximity of energized overhead bare conductor power line is hazardous Hence "shut-down" is obtained for safe working Shutdown is obtained by the Engineer-in-charge responsible for construction/maintenance work and given by the nominated officer (Engineer in charge of Transmission /Distribution) of the respective authority

However, for the working crew it is not possible to know whether the line is really switched off, discharged and rendered safe to work in the vicinity They also remain unaware if the line gets suddenly energized due to operational or administrative failures Sometimes lines could also get charged due to back feeding of electricity from other downstream sources, such as Diesel Generator/ UPS at any consumer's end, resulting serious consequences

Since contact with energized conductor or even in the induction zone may cause grievous injuries including death due to short-circuit or 'flashover' The risk of flashover increases as the line voltage increases

Engineering challenge: Lack of provision of automatic indication/alarm for sudden energization of the circuit where work is in progress

Lack of dynamic monitoring system of nearby installations with could be hazardous in case the crew comes within induction zone

It would be worthwhile to have a system of alarm to help the workforce to manage work near electric overhead power lines so that risks from accidental contact or close proximity to the lines are adequately controlled