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Preventing Incidents in Construction Projects with Help of Risk Management and Risk Assessment

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Abstract: *The construction industry is growing all over the world and considered as a labor-intensive industry. It is associated with significant safety risks and losses resulting from major accidents. These critical safety risks are largely due to ignorance or lack of awareness, which causes poor performance in building construction activities. Furthermore, it is difficult to estimate the safety risks because of the incomplete quantitative safety risk database and uncertainty within construction projects. In industrial arena, if any industry to be successful, it has to be safe, reliable, and sustainable in its operations. The industry has to identify the hazards and assess the associated risks and to bring the risks to tolerable level. Hazard Identification and Risk Assessment (HIRA) is carried for identification of undesirable events that can lead to a hazard, the analysis of hazard of this undesirable event, that could occur and usually the estimation of its extent, magnitude and likelihood of harmful effects. It is widely accepted within industry in general that the various techniques of risk assessment contribute greatly toward improvements in the safety of complex operations and equipment. The objective of this work of hazards and risk analysis is to identify and analyze hazards, the event sequences leading to hazards and the risk associated with hazardous events. Many techniques ranging from the simple qualitative methods to the advanced quantitative methods are available to help identify and analyze hazards. The use of multiple hazard analysis techniques is recommended because each has its own purpose, strengths, and weaknesses..*

Keywords: Safety Risks

I. INTRODUCTION

For any industry to be successful, it has to be safe, reliable and sustainable in its operations. the industry has to identify the hazards and assess the associated risks and to bring the risks to tolerable level.

Hazard Identification and Risk Assessment (HIRA) is carried for identification of undesirable events that can lead to a hazard, the analysis of hazard of this undesirable event, that could occur and usually the estimation of its extent, magnitude and likelihood of harmful effects. It is widely accepted within industry in general that the various techniques of risk assessment contribute greatly toward improvements in the safety of complex operations and equipment.

The objective of this work of hazards and risk analysis is to identify and analyze hazards, the event sequences leading to hazards and the risk associated with hazardous events. Many techniques ranging from the simple qualitative methods to the advanced quantitative methods are available to help identify and analyze hazards. The use of multiple hazard analysis techniques is recommended because each has its own purpose, strengths, and weaknesses. Recently, Indian construction industry has been experiencing widespread growth in construction sites, state that India's economy and infrastructure development has increased considerably and rapidly. Furthermore, the construction industry continues to play a significant role in the continued development, and construction activities have been implemented to fulfil the high demand for market expansion. With the rise in construction sites, however, the number of construction accidents has also increased. On many building constructions sites there are too many unsafe conditions and ill-advised activities are performed. Most employees currently employed in the construction industry are originally from the agricultural sector. Moreover, both construction and agricultural work are characterized by temporary workers who are more likely to split their time between these seasonal jobs during agricultural production and construction (Aksorn and Hadikusumo, 2008). Regarding construction sites in India, found that an accident do not just happen; they are caused

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by the workers' carelessness, failure of workers to follow safety procedure, working at high elevation, using equipment without safety devices, harsh job operation, unskilled workers and workers' lack of knowledge, poor attitude of workers, unusual nature of the industry, working site conditions, misuse of equipment, improper loading or placement of equipment, lack of warning for co-workers, failure to secure equipment, failure to use personal protective equipment (PPE), unsafe operations, human elements, and poor site management.

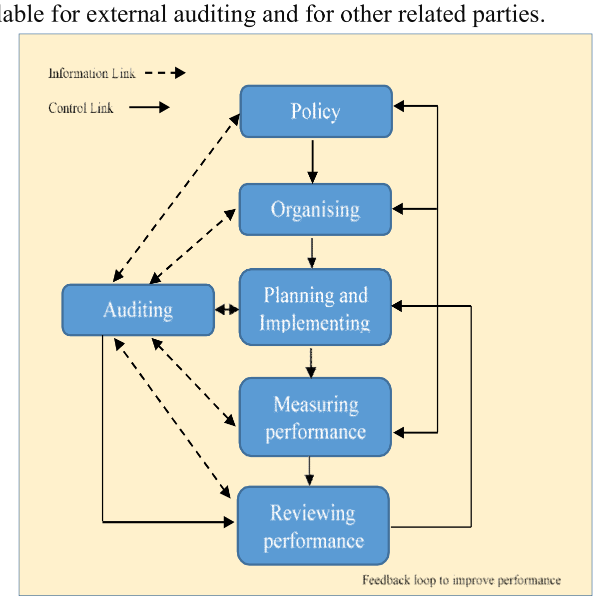
Safety risk management programmes are a key to eliminate occupational accidents and injuries. implemented and enforced, Indian construction safety measures, such as guardrails, safety nets, harness, and safety line systems, are still insufficient. Moreover, the involved parties, namely, construction engineers and supervisors, have not given much attention to the unsafe conditions, which may be due to ignorance and lack of awareness of the personnel's safety concerning hazards and risks. As the part of the work. Hazard identification and risk analysis was carried out for construction activities and the hazards were identified and risk analysis was carried out. The different segments of activities were divided in to high, medium and low depending upon their consequences and likelihood. The high risks activities have been marked in red color are un-accepted and must be reduced. The risks which are marked in yellow color are tolerable but efforts must be made to reduce risk without expenditure that is grossly disproportionate to the benefit gained. The risks which are marked in green have the risk level so low that it is not required for taking actions to reduce its magnitude any further.

II. LITERATURE REVIEW

The safety management framework consists of a set of measures relating to safety management which are operated and implemented continually. Most of the key elements required for safety management are similar to those for construction management, business financial management, and total quality management. Hughes and Ferrett (2012) identified five key elements in a successful safety management framework, as shown in Figure

organizations should have a well-prepared documented policy regarding the ILO Guidelines on occupational safety and health management systems (ILO-OSH, 2001) provides general guidelines for a safety policy application as:

1. The policy should be suitable with scales and types of organizations.
2. It should be clearly and simply written and approved by the head of the organization so that it can be simply applied by employees.
3. It should be circulated by different means of communication and followed by employees, who should be familiar with its instructions.
4. It should be editable for continuous updating.
5. It should be available for external auditing and for other related parties.



Hazard identification and risk analysis (HIRA) is a collective term that encompasses all activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public or the environment are consistently controlled within the organizations risk tolerance level. These studies typically address three main risk questions to a level of detail commensurate with analysis, objective, life cycle stage, available information, and resources.

Tools for simple hazard identification or qualitative risk analysis include hazard and operability analysis (HAZOP), what –if/checklist analysis, and failure modes and effect analysis (FMEA)

Tools for simple risk analysis include failure modes, effects and critically analysis (FMECA) and layer of protection analysis (LOPA), and

Tools for detailed quantitative risk analysis include fault trees and event trees. For example, some companies may judge the mere existence of an explosion hazard to be an unacceptable risk, regardless of its likelihood. Others may be willing to tolerate an explosion risk if proper codes and standards are followed. Still there could be some those may be unwilling to accept an explosion risk unless it can be shown that the expected frequency of explosion is less than 10-6/yr. HIRA encompasses the entire spectrum of risk analysis, from qualitative to quantitative. A process hazard analysis (PHA) is a HIRA that meets specific regulatory requirement in the U.S.

Construction is the process of constructing a building or infrastructure. Construction differs from manufacturing typically involves mass production of similar items without a designated purchaser, while construction typically takes place on location for a known client. Construction as an industry comprises 6 to 9 percentage of the Gross Domestic Product (GDP) of developed countries. Construction starts with planning, design and financing and continues until the work is built and ready for use.

III. RISK ASSESSMENT TECHNIQUE

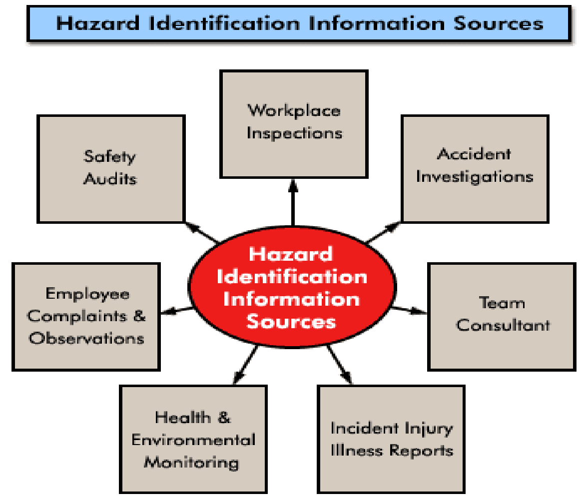
3.1 HIRA

To manage risk, hazards must first be identified, and then the risk should be evaluated and determined to be tolerate or not. The earlier in the life cycle that effective risk analysis is performed, the more cost effective the future safe operation of the process or activity is likely to be. The risk understanding developed from these studies forms the basis for establishing most of the other process safety management activities undertaken by the facility. An incorrect perception of risk at any point could lead to either inefficient use of limited resources or unknowing acceptance of risks exceeding the true tolerance of the company or the community.

3.2 HIRA Operation

HIRA reviews may be performed at any stage in a works life cycle-conceptual design, detailed design, construction, Commissioning, on-going operation, decommissioning or demolition. In general, the earlier that a hazard is identified (eg during conceptual design). The more cost-effectively it can be eliminated or managed. studies performed during the early design stages are typically done at corporate or engineering offices. Studies performed once a process is near start-up, during operation or before decommissioning are typically done in a plant environment.

A HIRA study is typically performed by a team of qualified experts on the process, the materials , and the work activities- personnel who have formal training on risk analysis methods usually lead these teams, applying the selected analysis technique with subject matter experts from engineering, operations, maintenance and disciplines as needed. A simple early-in-life hazard identification study may be performed by a single experts: However, a multidiscipline team typically conducts more hazardous or complex process risk studies, especially during later life cycle stages involving operating and maintenance personnel early in the review process will help to identify hazards when they can be eliminated or controlled most cost- effectively. When the study is complete, management must then decide whether to implement any recommended risk reduction measures to achieve its risk goals.



3.3 Procedure for HIRA

At each stage in the work life cycle, a review team questions process experts about possible hazards and judges the risk of any hazards that are identified. Several common methods exist for questioning a design, ranging from simple qualitative checklists to complex quantitative fault tree analysis. The result of the review process are typically documented in a worksheet form, which varies detail, depending on the stage of the work and the evaluation method used. Risk studies on operating processes are typically updated or revalidated on a regular basis.

The purpose of this work is to identify the hazards and risk by analyzing each steps involved in various activity in the construction, and to give suggestion in order to eliminate or reduce the risk assessment (HIRA). Industry becomes successful by not only meeting the production requirements but also should have high employee satisfaction by providing the safety requirements in the workplace. The Hazards and risk assessment should be done and actions to be taken to convert the risk to a tolerable level on regular basis.

3.4 HIRA Process

HIRA Process it consist of four steps as follows:

1. Hazard identification
2. Risk assessment
3. Risk analysis
4. Monitor and review

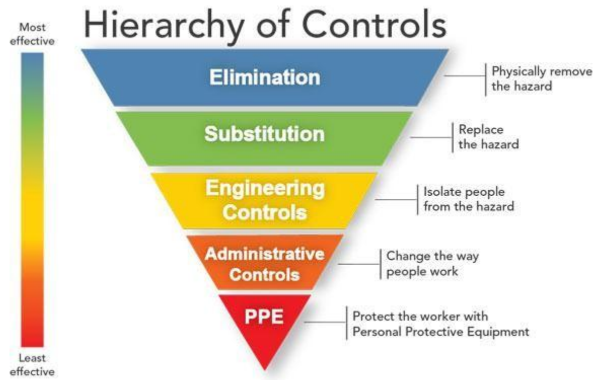
A. Hazard Identification

Workplace hazards can be identified in a number of ways. Inspections provide a system of recognizing hazardous conditions so that those conditions can be corrected. The data collected while performing inspections will be used to identify hazards and barriers to working safely and in an environmentally protective manner so that they can be addressed such as procedure changes or purchasing different PPE. The data also will be tracked as a protective measure of acceptable HSE behavior on the site. reports and safe work observation information will be shared with employees at toolbox safety meetings

B. Assessment

Once the hazard have been identified, it is necessary to assess what risk they pose to employees in the workplace. In this way we can establish a measure of the risk and determine what priority they should have for corrective actions. The risk assessment step is that part of the process that assesses the probability (likelihood) and consequences (severity) of hazard that have been identified. Once we have estimated the probability and consequences for each hazard then we can allocate it a priority for corrective action. Generally, risk assessment is estimating: what are the chances (probability) of an accident happening, and if it does happen, what are the chances that someone will be hurt? What will be the extent of equipment or environmental damage, and how bad will it be (severity)? The level of risk is dependent on the exposure to the hazard and the probability and consequences of an event occurring.

C. Risk Control



IV. RISK ASSESSEMENT PROCEDURES

4.1 Hazard and Operability Analysis (HAZOP)

A HAZOP is an organized examination of all possibilities to identify and processes that can malfunction or be improperly operated.

HAZOP analyses are planned to identify potential process hazards resulting from system interactions or exceptional operating conditions.

Features of HAZOP study are:

- It gives an idea of priorities basis for thorough risk analysis,
- It provides main information on the potential hazards, their causes and consequences,
- It indicates some ways to mitigate the hazards,
- It can be executed at the design stage as well as the operational stage,
- It provides a foundation for subsequent steps in the total risk management program.

Advantages:

- Offers a creative approach for identifying hazards, predominantly those involving reactive chemicals.
- Thoroughly evaluates potential consequences of process failure to follow procedures.
- Recognizes engineering and administrative controls, and consequences of their failures.
- Provides a decent understanding of the system to team members.

Disadvantages

- Requires a distinct system of engineering documentation and procedures. HAZOP is time consuming.
- Requires trained engineers to conduct the study. HAZOP emphases on one event causes of deviations or failures.

List possible causes of deviation

Select a process or operating step peat for all guide words Apply guide word to process variable or task to develop meaningful deviation Repeat for all process variables or tasks

Repeat for all process sections or operating steps Select a process variable or task Examine consequences associated with deviation Explain design intention of the process section or operating step Develop action items Identify existing safeguards to prevent deviation Access acceptability of risk based on consequences, cause and protection

Failure Mode and Effect Analysis (FMEA)
An FMEA is a systematic method for examining the impacts of component failures on system performance. Basically FMEA focuses on failures of systems and individual components and examines how those failures can impact facility and processes. FMEA is most effective when a system is well defined and includes the followings key steps:

Listing of all system components;
Identification of failure modes (and mechanisms) of these components;
Description of the effects of each component failure mode;
Identification of controls (i.e., safeguards, preventive) to protect against the causes and/or consequence of each component failure mode;
If the risks are high or the single failure criterion is not met.

Fault Tree Analysis (FTA)
A fault tree is a detailed analysis using a deductive logic model in describing the combinations of failures that can produce a specific system failure or an undesirable event. An FTA can model the failure of a single event or multiple failures that lead to a single system failure.
FTA is often used to generate:
Qualitative description of potential problems Quantitative estimates of failure frequencies/ likelihoods and relative importance of various failure sequences/contributing events
Suggested actions to reduce risks Quantitative evaluations of recommendation effectiveness The FTA is a top-down analysis versus the bottom-up approach for the event tree analysis. The method identifies an undesirable event and the contributing elements (faults/conditions) that would initiate it.
The following basic steps are used to conduct a fault tree analysis:
Define the system of interest.
Define the top event/system failure of interest. Define the physical and analytical boundaries. Define the tree-top structure.
Develop the path of failures for every branch to the logical initiating failure.
Perform quantitative analysis.
Use the results in decision making.
Once the fault tree has been developed to the desired degree of detail, the various paths can be evaluated to arrive at a probability of occurrence.

Advantages
- It directs the analyst to ferret out failures deductively;
- It points out the aspects of the system which is appropriate for an understanding of the mechanism of likely failure; define the system or operation identify the initiating events identify controls and physical phenomena define accident scenarios analyze accident sequence outcome summarize results use result in decision making
- It provides a graphical assistance enabling those responsible for system management to visualize the hazard; such persons are otherwise not associated with system design changes;
- Providing a line of approach for system reliability analysis (qualitative, quantitative);
- Allowing the analyst to give attention to one particular system failure at a time;
- Providing the analyst with genuine understandings into system behavior.

Disadvantages
- Requires a skilled analyst. It is an art and also a science
- Focuses only on one particular type of problem in a system, and multiple fault trees are required to address the multiple modes of failure
- Graphical model can get complex in multiple failures

Event Tree Analysis (ETA)

An ETA is an inductive analysis that graphically models, with the help of decision trees, the possible outcomes of an initiating event capable of producing a consequence.

Procedure of Event Tree Analysis

An analyst can develop the event tree by inductively reasoning chronologically forward from an initiating event through intermediate controls and conditions to the ultimate consequences.

An ETA can identify range of potential outcomes for specific initiating event and allows an analyst to account for timing, dependence, and domino effects that are cumbersome to model in fault trees. 49

An ETA is applicable for almost any type of analysis application but most effectively is used to address possible outcomes of initiating events for which multiple controls are in place as protective features.

Advantages

- Accounts for timing of events Models domino effects that are cumbersome to model in fault trees analysis Events can be quantified in terms of consequences (success and failure) Initiating event, line of assurance, branch point, and accident sequence can be graphically traced

Disadvantages

- Limited to one initiating event Requires special treatment to account for system dependencies Quality of the evaluation depends on good documentations Requires a skilled and experienced analyst The above techniques provide appropriate methods for performing analyses of a wide range of hazards during the design phase of the process and during routine operation. A combination of two or three methods is more useful than individual methods as each method has some advantages and disadvantages.

Failure Mode Effect and Critical Analysis (FMECA)

The FMECA is composed of two separate investigations, the FMEA and the Criticality Analysis (CA). The FMEA must be completed prior to performing the CA. It will provide the added benefit of showing the analysts a quantitative ranking of system and/or subsystem failure modes. The Criticality Analysis allows the analysts to identify reliability and severity related concerns with particular components or systems.

V. EXPERIMENTS

To carry out safety risk assessment and management, the safety risk management team of the barmer 82 mtr stack construction project with help of Task based Risk Assessment, verified to contain all the hazard groups and hazardous events by brainstorming and discussions. The construction safety system is divided into 14 hazard groups: falls from height; falling objects; manual handling; equipment machinery and tools; electricity; slips and trips; traffic hazards; vehicle overturn; fire and explosions; exposure to hazardous substances; collapse of site structure; confined space; ergonomic/ human factors; and noise and vibration. Each hazard group includes several identified and codified risk events, which are described below.

Purpose

This Procedure describes a risk assessment technique that shall be used as an integral part of approach to the identification and assessment of the risks from all day to day activities. After the assessment of the risk, control measures are implemented to reduce the risk to acceptable or tolerable levels.

SCOPE

This procedure covers all Critical activities being undertaken in the approved premises. This includes the activities of all the persons having access to the operational area like contractors and visitors and the facilities at work place. The procedure covers Task based risk assessment for all critical activities.

DEFINITION

Hazard	Source, situation, or act with a potential for harm in terms of human injury or ill health, or a combination of these.
Health Hazard	The potential to cause harm to health. Health hazards may be biological, chemical, physical, ergonomic or psychological in nature. 'Health hazards' are also known as 'agents hazardous to health' and 'hazardous agents. These terms are interchangeable.
Risk	combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s)
HSE Critical Task	A task with potential to cause major injury or health effects to people, local damage to assets, localized effects to the environment or considerable impact on reputation .
Task	A discrete work activity.
TBRA	Task Based Risk Assessment - an accident prevention tool that works by identifying hazards and eliminating or minimizing them before a job is performed, and before they have a chance to become accidents.
Residual Risk	An assessment of the worst case risk associated with the hazard or effect (no defences) and an assessment of the risk carried by people and the facility once this risk is defended against is called the residual risk
ALARP	To reduce the risk to a level which is as low as is reasonably practicable involves balancing reduction in risk against the time, trouble, difficulty, and cost of achieving it. This level represents the point, objectively assessed, at which time, trouble, difficulty and cost of further risk reduction measures become unreasonably disproportionate to the additional risk reduction obtained.

Critical Jobs (High risk Job)

1. Hot works producing naked flame / spark such as welding, grinding, gas cutting. Other hot work like vehicle entry permit, photography, chipping etc. shall not be included in these criteria.
2. All Confined Space Entries
3. Radiography
4. Cold work activities on line/equipments containing toxic gases such as H2S etc.
5. Jobs carried out while equipments/lines are in service.
6. Work at Height.
7. Activities involving use of lifting equipments / Appliances.
8. Any work other than above considered critical by permit issuer.
9. All clamping job on leaking lines

Procedure

Selection of Task for TBRA

Task Based Risk Assessment is done compulsorily for Critical Jobs & optional for routine jobs. The format shall be jointly filled up by issuer, receiver & safety persons (if required) and shall be attached to the permit. Additionally, the job with possibility of harmful exposure, potential of injury / illness or equipment / facility damage shall have priority for TBRA. The task selected shall be divided into basic job steps in order to determine the risk involved and precautionary measures required to mitigate the risk.

Basic Job Steps

- Each job consists of a set of movements or steps, which has to be completed for accomplishing the task.
- The primary part of TBRA is to identify each task required in order to complete the job. Record this on the TBRA worksheet form. Tasks should be recorded in sequential order.
- Conduct Site visit The members of the TBRA team must have visited the site before filling TBRA.
- **Potential Hazards**
- For each task being assessed, the team must identify and record the associated hazards, on the TBRA worksheet form.
- Using information from the initial identification from the job site visit, the TBRA leader should use the experience of team member to identify possible additional hazards and their range of consequence.
- Using the Risk Assessment Guide of this procedure, identify signification hazards associated with each of the documented tasks. Significant hazards are those hazard types (high energy potentials such as electrical,

mechanical, hydraulic, pneumatic), which are most likely to cause significant consequences if not adequately controlled. When determining hazards associated with a particular task, consideration must also be given to the exposure of people, the environment and assets external to the task at hand. Record these on the TBRA form. Ensure hazards identified match up with the task being considered (examples of hazards can include- electricity, working at height, unguarded machinery, hot pipes, etc.).

Identify consequences for each hazard

- When all the hazards associated with the task are listed, the 'reasonably credible' consequences for each hazard will be agreed and recorded. Consequences may be to people (those performing the task and/or others), plant, environment and business impact, as detailed in the Risk Matrix
- Each hazard may have a range of possible consequences. For example, electrical energy may cause: ignition; burns; shock; a large fuel spill may result in fire; environmental damage; public outrage. Consequences can be to people, plant and environment or have business impact, as in the Consequences Severity Table.
- Judgment is required to agree how severe the worst 'reasonably credible' consequences could be in each of these categories for each hazard. The qualitative descriptions should be used to aid consistency, and also to discriminate between higher and lower residual risks.

Identify suitable controls for each hazard and consequence

- For each hazard and consequence, suitable control measures must be identified using the hierarchy of controls (see Risk Assessment Guide). It is important to try to eliminate the hazard completely. If this is not possible, prevent or minimize exposure to the hazard by one of a combination of; substitution, engineering and isolating the hazards. As a last resort, when exposure to the hazard is not (or cannot be) minimized by other means, include administrative controls and the use of Personal Protective Equipment (PPE).
- The TBRA team should give particular emphasis to physical and procedural controls that prevent or limit consequences, or reduce probability of occurrence, including task specific contingency/emergency arrangements.

The controls selected must always consider the other measures before PPE is selected. The hazards of the task should be controlled to a level As Low as Reasonably Practicable (ALARP). Controls should consider - specialist contractors, emergency requirements, equipment, permit requirements, procedures, training and competency, PPE.

Control & Distribution of TBRA sheets

Once TBRA is prepared, it is to be attached to the original copy of work permit available at site. On completion of the job, the TBRA Sheet shall be returned to Permit Issuer for further use. Signed off photo copy/Original TBRA shall be attached with permit. Torn or faded TBRA shall not be attached with permit.

CONSEQUENCES (EFFECT ON...)						SEVERITY RATING (S)	LIKELIHOOD OF EVENT HAPPENING (L)				
Probable Personal Safety Consequence	Probable chance of Leak/ Pollution	Chance of Asset Damage/ Loss of Financial Credit	Downtime	Production Loss	REPUTATION (R)		Never Heard of in Industry	Heard of Incident in Industry	Incident has occurred in Our Company (Essar Group)	Happens Several Times a Year in Co. (Essar Group)	Happens Several Times at our Location
PEOPLE (P)	ENVIRONMENT (E)	ASSET (A)					A	B	C	D	E
Minor injury (First Aid Case) or Health Effect	Slight Effect. 100% Cleanup possible	Slight Damage	Less than 12 hour outage for single section (within 1 plant)	< Rs. 1.0 Lakh	Slight Impact. Public Awareness exists. No Public concern	1 Low					
Major Injury (MTC or LTI) or Health Effect for One Person	Minor Effect. Has Impact on Environment but no permanent effect	Minor Damage	12 hrs to 48 hrs outage for single section	< Rs. 5.0 Lakh	Limited Impact. Public concern in neighbourhood. Few columns in Local newspaper	2 Minor					
Major Injury (more than one MTC or LTI) or Health Effect	Localized Effect. Has significant Impact on Environment but no permanent effect	Local Damage. Plant Shutdown	48 hrs to 1week outage for single section; or less than 48 hrs for plant	< Rs. 10.0 Lakh	Considerable Impact. Major concern in National Press/ Local TV	3 Moderate					
Single Fatality or Permanent Total Disability to One Person	Major Effect. Extended breaches of Regulatory Limits	Major Damage. Disruption to Operations	Less than 1 week outage for 1 section; or 48 hrs to 1 week for the plant	< Rs. 1.0 Crore	Major Impact. On National TV/ National Press	4 Critical					
Multiple Fatalities	Massive Effect. Over a Large area or constant breach of Regulatory Limits	Extensive Damage. Prolonged Loss of Production	Plant outage more than 1 week	> Rs. 1.0 Crore	International Impact. Adverse Attention in International Media	5 Major					

Use of RAM is optional. This guideline may be used to identify whether risk is reduced to low/ALARP level (Risk Level in green zone) after identified control measures in TBRA sheet as per example given below

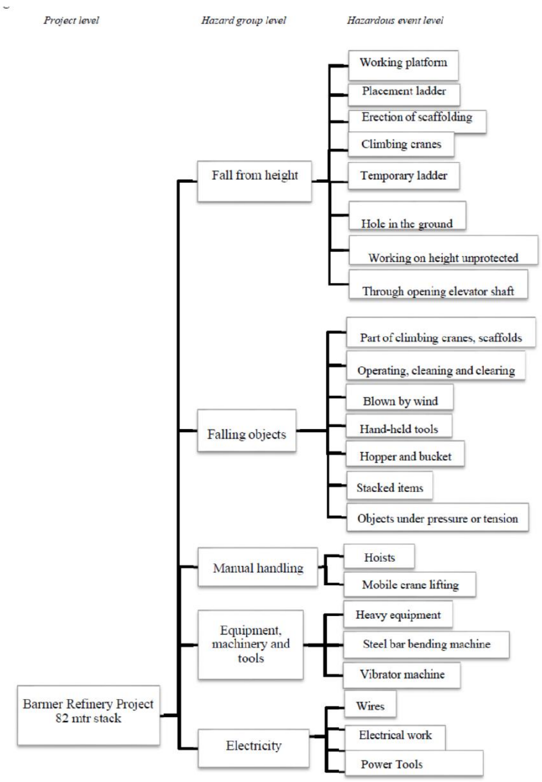
Residual risk is any risk that remains once the control measures are in place. The Risk Matrix may be used to determine the residual risk level for each listed hazards, task or task-step, as follows:

- First take the hazards listed on the TBRA form and agree the worst, reasonable credible consequence level assuming the control measures listed are in place.
- Review the probability on the Risk Matrix. Identify which level of probability best matches the probability of this hazard being realized, resulting in the specified consequence.
- Using the Matrix, determine the residual risk for that identified hazard. The combination of the consequence and the probability will result in a residual risk level in green zone.
- If the residual risk is in other zone apart from green zone, review whether further controls are practical, if so document them and reassess the residual risk.

Repeat steps for each identified hazard, task or task-step

TASK BASED RISK ASSESSMENT SHEET FOR STACK

The most important part of web-based applications is security, where there are different types of attacks such as users' data stealing, password hacking, session hijacking, etc. As the growth of building a web application began at the same time breaching of application started. The popularity of web-based



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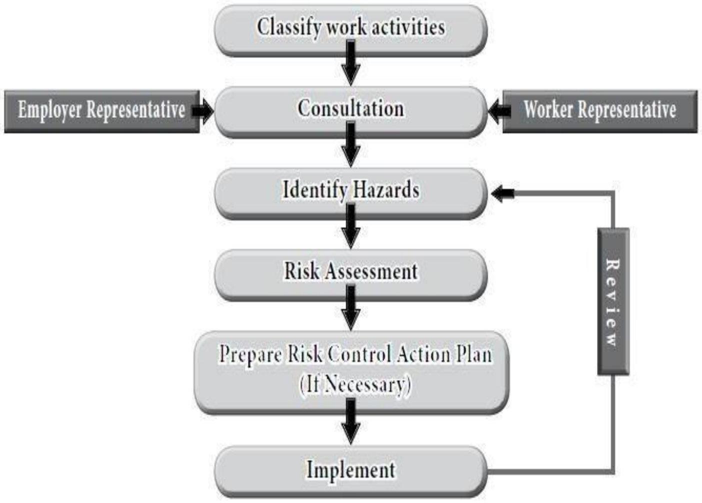

TASK BASED RISK ASSESSMENT SHEET

Activity: Erection of 82 mtr SRU Stack.

Sub activity	Hazards identified	Consequences	Control measures required
Scaffolding Scaffolding Erection and Dismantling Lifting & Shifting of Scaffolding Material	Lack of awareness, Fall of material, Scaffolding collapse Omission guard rail and toe rail	Fall injury, hit injury by moving objects, cut injury.	• Ensure base plate and bracing is provided for stability of scaffolding. • Ensure application of mandatory as well as job for use specific PPE's. • Ensure material should be lowering and hoisting by rope and pulley. • Ensure no any loose materials should be kept on scaffold. • Ensure that return path is directly connected to the job. • Scaffolding pipes will be tied /secured at two locations before lift by rope and pulley. • Spanner will be kept tied with Strigor or rope. • Scaffolding will be prepared as per sequence. • Double lanyard safety harness shall be provided, used and anchoring the at height. • While using ladder for small job proper anchorage arrangement will be provided • should be provided at toe rail. • Provide guard rail (1200mm), mid rail(600mm) Toe guard (100mm). on all open sides and end of the platform above 2m height. Toe guards are generally applicable to working platform and not for landing platform.in case of provision of toe rail,at least two pipes • Use 6X6inch and 6mm thinness baseplate. • During erection of scaffolding tag with the wording "DO NOT USE SCAFFOLD" • Overlapping of two platforms/grating should be done at least 12 inch over grating supports. • The footing of scaffolding shall be placed on leveled & sound ground, capable enogh of carrying maximum intended load without settling of displacement. • Cross bracing area provided for all side of scaffolding structure.
	Fall of person form the height	Fall injury, Fatal injury to personnel	• Ensure use of full body harness and its anchoring properly. Visual inspection of full body harness shall be done prior to use. • Ensure proper access and egress to be provided on scaffold. • Ensure adequate railing (top rail 1200mm, mid rail 600mmm and toe guard 100mm to 150mm) is provided on working platform. • Ensure that return path is directly connected to the job. • No workers are allowed to stand under suspended load. • All the working personnel shall be free from height phobia. • Training shall be given to working personnel daily prior to job. • Personnel shall not be allowed to work at the inside bottom of Scaffolding while the work is in progress. • No worker should be expected to expose himself to an unprotected fall while getting to the work location or while working.
Corbel & beam casting, brick lining. Use of Winch machine Lifting and Shifting of Material	Fall of materials & person, injury to personnel, Mechanical Hazard to moving part Overload/ Defective due to mechanical failure Hazards by contact	Fall injury, cut & crush injury. Trapping (crushing, pressing, drawing in and shearing injuries) Crushing, Fall of object, Damage to equipment, Injury to person, back injury Cuts, abrasions	• Proper planning and supervision should be done by engineer before starting job. • All lifting tools and tackles should be kept in safe place. • Ensuring for safe rigging arrangement for loading -unloading as per the approved rigging plan • Ensure that portable hand tools are tied with a lacing rope at the end and fixed to support or tied to body to prevent. • No loose material should be on working platform. • Sufficient illumination will be required during work. • Bricks are stag properly when brick lining work has been done. • Third party inspection of all lifting, tools & tackles shall be made available. • All the lifting tools & tackles shall be visually inspected prior to use and free from damage/corrosion etc. • Only trained and experienced personnel (specific team) in stack corbel and beam casting and brick lining should be deployed. • Work areas shall be barricaded with hard scaffold pipes with suitable warning sign boards. • One stand by person shall be deployed outside stack to prevent unauthorized entry. • Use only certified scaffold. • Suitable means of communications (Wakie talkie) should be used.
			• Alarm bell should be provided and in working condition and the personnel shall be aware about the usage. • Winch machine operator shall be always present at the job location. • Winch machine, ropes, connected accessories and man basket shall have a valid third-party certificate and shall be inspected visually prior to use. • Once the scaffold is ready, access to scaffold shall be only through lifts. • Conflicting activities shall not be performed. • Personnel shall not be allowed to work at the inside bottom of stack while the work is in progress. • All the winch machine and rope movement area shall be hard barricaded. • Job sequence shall be as per method statement given by COMPANY engineer (every 6 meters). All the jobs including refractory (bricks work, corbel, painting etc.) should be completed together before proceeding to next level. • Maximum No. of 5 personnel movement on the lift shall be and followed SWL 800KG. • Awareness shall be given to working personnel on usage of lifts not to touch any moving parts and take care while going in the lifts and SIGNAGE boards indicating "DO NOT TOUCH ANY MOVING PARTS" shall be displayed on the lift door. • Training shall be given to working personnel daily prior to job. • Lift gate shall always be closed and locked when the person and material is inside the lift. • Material shifting and manpower movement in lift shall not be done together. (To be done separately). • Entry/Exit register shall be maintained by standby person and the register shall cover checking of workers health by asking them. • All the working personnel shall be free from height phobia. • Continuous monitoring shall be done for working hours of the personnel (No person shall work for more than one shift). • One person inside stack shall always have one personal H2S detectors. • Job shall be stopped immediately in case of any emergency. • Sufficient illumination shall be provided inside stack for the job.

	Failure of load and Improper Signaling	Fatal injury, cut & crush injury, hit by object	• Ensure lifting tackles are validated and TPI Certificate available at work location. • Weekly inspection shall be done as par checklist of winch machine and also connected accessories / lifting tools and tackles. • Area to be cordon off. • Check the all tools and tackles before starting the job. • Ensure signal man deployment & appropriate signaling • Suitable means of communications (Wacky talkie) should be used.
	Electrical Hazards &Un-authorized operation of electrical equipment	Burn injury, shock injury.	• Electric supply should be taken through ELCB. • ELCB shall be tested by COMPANY electrical Dept. • All power cables should be protected from damage by proper laying • All panel board should be protected against rain. • Proper Earthing/grounding shall be provided. • Power cables shall not overlap with welding cables. • Weekly inspection shall be done as par checklist of associated work power tools. • Only trained and validate(authorized) person shall be operate power tools • All power tools shall be use only company electrical certified. • Ensure application of mandatory as well as job for specific PPE's • TBT/Training shall be given prior job start

Sub Task	Activity	Hazard / Risk	Initial Risk Factor				Existing Control Measures	Actual Risk Factor				Priority	Responsibility	
			E	S	P	R		E	S	P	R		By Whom	By When
1.	Shifting of structural materials from yard to blasting / painting area and back to fabrication yard (By using of hydra, crane & trailer)	1.Unathorized Operation of Vehicle. 2.Carrying Unauthorized Passengers 3. Intoxicated Driving	6	4	3	72	1.Area Survey to be done before moving the crane 2. Designated persons are only allowed to travel in the cabin of trailer / truck.	6	4	0.5	12	4	Execution Team	Before / During Job
2.	Manual Material Handling / Material`	1.Hazards during manual materials handling. 2. Pinching of leg/hands while handing of materials. 3. Improper stacking of Material.	6	4	3	72	1.Don't allow the person to lift more than 30 kg for materials shifting from one place to other. Provide Trolley for materials shifting. Person handing the material should be physically fit to do work. 2.Use hand gloves during material handling. All mandatory PPE's shall be use at site.	6	4	0.5	12	4	Execution Team	Before / During Job
3.	Mechanical Lifting	1.Unauthorized Operation of crane. 2.Inadequate space for access/ egress. 3.Improper illumination.	6	7	3	126	1.medical Fitness of Crane operators shall be check . 2.The space for access &egress should be proper, clear & adequate.	6	7	0.5	21	3	Execution Team	Before / During Job
4.	Gas cutting Activity Storage, Handing & use of Gas Cylinders at site.	1.Improper unloading process- damage of cylinder resulting fire & explosion, injury while handling. 2.Improper Storage – Un tied cylinders. 3.Fire, burn injury while using at site.	6	7	3	126	1.Cylinders should keeping at upright direction only. 2.Providing Flash back arrestor each side of gas cutting set.	6	7	0.5	21	3	Execution Team	Before / During Job
5.	Grinding Work	1.Struck by grinding wheel. 2.breaking of wheel. 3.Poor electrical connection.	6	7	3	126	1.All the grinding m /c's shall be used with wheel guard. 2.Check expire date of grinding wheel and use approved product of wheel.	6	7	0.5	21	3	Execution Team	Before / During Job
6.	Welding Work	1.Electricution due to improper electric connection. 2.Welding fumes / Health hazard. 3.Fire hazard due to welding spark.	6	7	3	126	1.Welding goggles shall be provided to welder's helper for eye protection. 2.Area shall be cleared of Flammables and combustibles before commencing welding.	6	7	0.5	21	3	Execution Team	Before / During Job

The frequency of exposure indicates how often a dangerous situation can arise. It could be an exposure to a toxic chemical or working and handing of a dangerous machine.

Factor	Description
0.5	Very Rarely (less than one per year)
1	Rarely (few times per year)

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2	Sometimes (12 times per year)	
3	Now and then (one per week)	
6	Frequently (daily)	
10	Continuous (more than two times per day)	
Severity Rating		
The apparent effect indicates the seriousness of the arising situation		
Factor	**Description**	
1	Minor (injury without time / work restriction FAC)	
4	Major (injury with time /work restriction MTC/RWC)	
7	Serious (irreversible effect handicap LWC)	
15	Critical (single fatality immediately or afterwards)	
40	Disaster (multiple fatality immediately or afterwards)	
Probability Rating		
Factor	**Description**	
0.2	Virtually impossible (>20 years, one in a life time, only theoretical case)	
0.5	Conceivable but improbable (once in a career (1/20 years)	
1	Improbable / borderline case, (1/10 years)	
3	Unusual (one can think of a (unusual) scenario (1/3 years)	
6	Possible (once every 6 months)	
10	To be expected (one per week)	
Risk Rating		
Risk = Exposure x Severity x Probability		
Risk Score	**Priority**	**INTERPRETATION**
>20	4	Very limited risk – acceptable
20-69	3	Take additional measure to mitigate the risk level close to priority 4
70-199	2	Immediate measures required
>=200	1	Stop work until measures are taken

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

The construction industry has characteristics that sharply distinguish it from other sectors of the economy. It is fragmented, very sensitive to economic cycles, and highly competitive because of the large number of firms and relative ease of entry. It is basically due to these unique characteristics considered a risky business.

This study was carried out to identify the construction industry risk factors, their importance and their allocation. Moreover, risk management actions, risk analysis techniques and their effectiveness and usage were settled on. The above topics were examined from contractors and owners' perspectives. These objectives were brought out, some tendencies were concluded and some actions that may improve risk management practices were recommended.

In this study, identifying the risk factors faced by construction industry is based on collecting information about construction risks, their consequences and corrective actions that may be done to prevent or mitigate the risk effects. Risk analysis techniques were investigated too. The research has shown that the proposed model can assist project managers, safety officers and engineers with decision-making to enable them to manipulate and control safety risks in their safety risk management and improve SOP during their construction projects. The main achievements of this research are summarized below according to the specific objectives.

The first step for emergency preparedness and maintaining a safe workplace is defining and analyzing hazards. Although all hazards should be addressed, resource limitations usually do not allow this to happen at one time. Hazard identification and risk assessment can be used to establish priorities so that the most dangerous situations are addressed first and those least likely to occur and least likely to cause major problems can be considered later. (5) Electricity includes four hazardous events: wires (EL-21), electrical work (EL-22), overhead power lines (EL-23), and arc welding machine (EL-24). The study also revealed that systematic methods were used and risk was assessed by brainstorming, checklist and health and safety regulations. Working at height, and manual handling observed to be most critical hazards in indian Industry construction site.

Based on methods used to communicate risk at construction sites, it was revealed that toolbox meetings, site meetings, posters and informal verbal communication are used to communicate risk. It was also revealed that safety committees and gang supervisors play a major role in communicating health and safety risks. However, the issue of power relations and conflicts was observed when there is a clear separation between health and safety communication and quality and productivity. The study also reveals that PPE is the main item used for risk control. However, there was enough PPE on the sites. Based on factors influencing risk management, the study reveals that legal system plays a major role in risk assessment, communication and control. The regulations provide for some hazards such as falling from a height and control mechanisms. They also require that health and safety risk to be communicated to workers and that PPE be provided for worker.

Regular inspections, penalties and compliance certificates issued by regulatory institutions influence risk management more. Furthermore, the organizational culture of safety is another factor influencing risk management. It is observed that construction firms with a safety culture considered health and safety when employing the site manager, the safety coordinator and safety officer. Knowledge of health and safety is a criterion for employment. Meanwhile firms with a safety culture provide resources for site workers, such as PPE and training. Additionally, individual characteristics such as experience of those working on construction sites, their educational background and knowledge of health and safety matters also influence health and safety risk management. It was observed that risks were assessed based on experience and educational background. Furthermore, the study revealed that the work environment such as site layout and location, the nature and the size of the work, working methods and working team influence health and safety risk management.

The study also provides factors hindering health and safety risk management in construction sites. The factors include the low level of public awareness of regulations, lack of resources such as personnel and funds, coverage of the regulations, complexity of design, the procurement system, and the low level of education, site configuration, and location. Thus, the main 'mantra' is that every job on the construction site must be carried out with at-most activity.

6.2 Recommendations

The developed construction safety risk management model and safety risk assessment methodologies are not restricted to the construction industry, but can also apply to multidisciplinary areas, such as warehouse safety, office safety, health risk assessment, maintenance safety, and manufacturing safety. It will be beneficial if future researchers can apply the combination of TBRA methods and the involvement of more than six experts' judgements in testing how sound the developed model.

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