Hazard Identification and Evaluation in Construction Industry

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Abstract— The word construction comes in light then we can say that it is a way of assembling, altering or building anything. In Construction several types of material are used like bricks, sand, cement, wood, steel and so on. Construction industry is a kind of process industry that manufactures the buildings, bridges, roads, hospital, commercial buildings, cinema hall, etc. Construction industry plays a big role in the development of a country. If we want to check the development of any country we can find this out very easily by its construction & development, because the level of country's development is reflected by its infrastructure. The infrastructure is in the form of roads, airports, buildings, commercial buildings, offices etc. As we know that construction industry is the most hazardous industry, almost daily an accident occurs on site. Hazards in construction industry are fall from height, falling of material, failure of lifting appliance, scaffolding collapse, soil collapse, vehicle struck, electric fire, unwanted material stacking at height, ergonomic effect and temporary structure failure. In this project we are using job safety analysis (JSA) methodology to control risk factor in construction industry mainly we are using JSA for this high risk activity. In JSA methodology three main components are there Job steps : in job steps the risky activity steps are splits in to parts and we dictating every steps of an activity due to this steps we split the risk and after that, Hazard identified : in job steps how to do that work activity and in this activity hazard is identified just because of their nature and we calculate the hazard, Control measures: after that we control the hazard by the control technic and control activity to reduce the hazard. In these project can apply JSA in different type of construction activities like tower crane erection, height work (form work), slab concreting, manual material handling due to job safety analysis methodology we control the high risk in construction industry. after that from this activity we are implemented them on construction site and calculate data from last five years than the accident ratio decreases and implemented the high risk activity covers by edge protection and fall protection system (ex. edge protection hard barricading, life line, floor opening close for fall protection system we are using full body harness, fall arrestor, safety net).

Key words: Planning, Process, Standard Operating Procedure, Safety Policy, Hazard: Construction activity, Mechanical Activity, Installation Process Safety: Methodology, Job Safety Analysis (J.S.A), Safety Task Assessment, Induction, Training Program, Job Specific Training

I. INTRODUCTION

India is a development country the construction is the back bone of our country, for the improvement and success of our country we need import and export system for this National highway , road is construct and main tend to them Airport , Ports , Dam , Tunnel , Over Bridge , Metro Line , Metro Bridge pass through Sea , High Rise Building , now the days due to construction system of India our country become very strong nation behalf of our advance technology and quick construction system due to large construction work in India economy growth is very help full for our Indian system due to Tata Projects , Hindustan Construction Company, Larson & Turbo ,Leighton, MW Group , DLF. This company works in India and Abroad and the main reason of boost of the construction industry is due to increase of Purchas power of middle class and improved living standard. Only Construction industry would provide the basic physical infrastructure for the nation.

Construction work is based on temporary structure and scaffolding is main temporary structure, for quick work Using Mechanical System (Tower Crane) & Machineries. In Construction apart from other industry High Risk Work and Hazard, Unsafe Work & Unsafe Condition.

A. Safety Codes and Standards:

Every Construction Company follows government rules and regulations with standards codes:
Standards and Codes should be followed in following order:

1) Statutory Standards.
2) Indians Standards (IS) and Codes.
3) International Standards like ISO 9001 & 14001 and OHSAS 18001.
4) Building and other improvement Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCWA)
5) Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Central Rules, 1998 (BOCWR)
6) Gas Cylinder Rules, 1981 (GCR)
7) Electricity Act, 2003 (EA)
8) Indian Electricity Rules, 1956 (ER)
9) Motor Vehicles Act, 1988 (MVA)
10) Central Motor Vehicles Rules, 1989 (CMVR)

II. ANALYSIS & METHODOLOGY

A. Job Safety Analysis

Job safety analysis is that methodology in which we can reduce the hazard through this technique in Job Safety Analysis Methodology 3 main Components are there:
In JSA Method we applied three steps of JSA just because of this three steps we can protect the hazard and their effect just because of control measures we can control the hazard

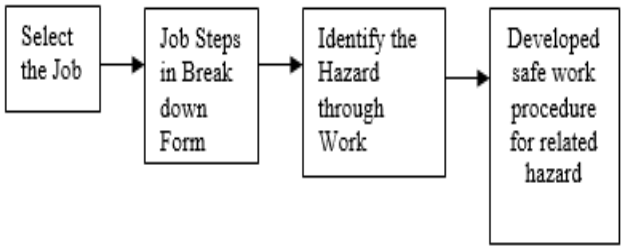
1) Job Steps:

This is show the steps of that job and how to work in that job in this every activity
is in that step's - That may have been overlooked at the design or planning stage of plant layout, building, machinery, equipment, tool, workstations, processes etc.

2) Hazard Identification:
In this hazard identification we can see every part of that job steps after that we can identify the hazard and their effect so just because of this hazard identification we can calculate very less severity rate hazard and after that control method is applied on them -That were noticed subsequently

3) Control Method:
this control method is main part in this we can show how to control by high risk work to safe and controlled form and this method can show very small –small activity of job and easy way to control them.- That were resulted from changes in work procedure or personnel. It is the first step in hazard or accident analysis and safety training.

III. JOB SAFETY ANALYSIS PROCESS CHART



The safely solution to the hazards noticed may be worked out by:

1) Provide new methodology and new process to do that job.
2) Analysis that point node of hazard and change their physical condition.
3) After analysis of Hazard Eliminate them change the work procedure and trained to other for follow safe process
4) Reducing that Job activity which is hazard and stop frequency also.
5) Give Proper P.P.E Related to that Job If Present and also Provide Why P.P.E Is Helpful for us.

After Completion of JOB SAFETY ANALYSIS also give one copy to read and understanding the safe process to relate with that supervisor & Practical knowledge of that job because it very help full to Analyses safety officer and that supervisor.

IV. HIRARICE CONTROL

A. Elimination Process

Remove items from the area or select different area for employees and volunteers to utilise.

B. Substitution Process

Guards on entry points
Use effective barriers and edge protection.
Enclose noisy machinery.

C. Engineering Control

Use a machine to lift heavy objects.
Use barrier controls to assist patron movement.

D. Admiration Control

Chang Training in lifting techniques.
Training in dealing with patrons

E. Provide Personal Protective Equipment (PPE)

In all cases, this must be seen as the last line of defence in the effective control of workplace hazards and the least preferred option.

High visibility jackets in car-park areas

F. Job Safety Analysis Table of Tower Crane Erraction of 60 by 40 (60Meter Boom Length 40 Meter Height)

Job steps	Hazard identified	Control measures
Pre - Inspection & Assembly of Crane	Fall of Structure or loose components	– Advise the loading post to get segregation of loose components transportation, – Plant Manager must check the pre-deliveries at reaching in store yard and conduct pre-delivery inspection before to assign unloading. – Competent riggers to handle the rigging operation with safe mode. "
	Fall of personnel	– Use proper ladder or work platform to reach the structures on trailer. – Three point contact on ladder
	Oil Spillage or slippery surface	– Check any leakage on hydraulic parts and fix before to start any operation." – All maintenance or work involving use of oils must be performed by using spill tray below.
	Oil Spillage or slippery surface	– Any chemical or substance used i.e. paint stripper or paint must be procured through proper channel with MSDS communications. – Store manager must authorize usage at site – Operatives must use eye, hand and nose protection prior and during usage of any chemical or paints.
	Contact with chemicals or substance hazardous to health	– No working of crane or trailer stoppage below any OHPL or Electrical service. – Find and select only safe place to park trailer and unloading operation.

		– All the Electrical points checked by competent & authorized electrician.
	Electrocution	– Check drivers for valid driving licensee and alcohol consumption at entry
	Operational errors	– Check drivers for valid driving licensee and alcohol consumption at entry
	Contact with other site vehicles	– Traffic management plan and demarcate Traffic routes – Provide Flag men at key points – Speed limit restriction 20KM/Hr to be followed
	Contact with workers /Employees	– Segregation of vehicles and pedestrian access
	Oil & Fuel Spillage	– Spill kit / Training and awareness
	Dust/Noise	– Use dust mask along with the mandatory PPE – Spray water for dust suppression
Crane mast & other structures assembling	Personal Injury	– Tower cranes shall be erected, operated and dismantled under the immediate supervision of competent person. – Tower cranes shall be erected, maintained and used in accordance with the manufacturer's specifications, recommendations and procedures. – Tower cranes shall be positioned whereby they can swing 360° without either the counterweight or jib striking any building, structure or other object. – Full body harness with double lanyard shall be used while working at height more than 1.8 meter. – If possible assembly of JIB light fixing can be made on ground for safe as after erection this will be critical activity. – The crew will not work under suspended load. Tag lines shall be used to position the load.
Erection of Boom after assembling of crane	Improper fixing of pins lock pins to booms & pendants. Wedge sockets/clamps to rope ,pendants	– All joints shall be checked by competent or authorized person. – Ensuring no loose material on booms – Ensuring of checks as per 'crane check list' (after assembly and before erection of boom) – No unauthorized allow to enter in area.
Erection of Crane / Extending and dismantling	Collapse of foundation	– Provide proper P.C.C and R.C.C at the base tower crane foundation mast. – (Follow draw and design spec as per manufacturer instructions) – Properly plumb the foundation mast provides proper support.
	Failure of lifting machinery	– Pre inspection of Mobile crane and lifting tools and tackle before using by authorized / competent person. Confirm legal compliance on test certificate and others – Pre inspection of mobile crane, lifting tools and tackles and its SWL capacity w.r.t checklist. Lift evaluation plan to be completed by competent person with operator. Conduct PSB before start of work
	Fall counter jib and counter loads.	– Barricading the lifting area with signage – Ensure that competent & adequate supervision available at work place. Clear or move unwanted to safe zone
	Fall of person	– Ensure Only authorized persons are accessing the crane – Ensure PPE like Helmet, High visibility reflective Vest, goggles, safety shoes and full sleeve shirt are worn while accessing Tower Crane – Ensure access ladder is attached with fall protection devises like ‘rope attached with sliding fall arrester’

	Failure of electrical System	Proper inspection of electrical equipment and cables by competent & experienced person prior to give supply. Lighting arrestor and Anemometer must be installed and operational
	Hit with nearby Building	– Ensure competent person is guiding and supervising the erection process – Ensure Break is applied to arrest the rotation movement of main jib during erection activities – Ensure Taglines(20MM Ropes) are used to tie Jib with permanent structure as an additional safety measure during erection process to avoid unexpected rotation – Stop erection during adverse weather condition/wind speed exceeding 55 KM /HR – 3rd Party inspection and certificate prior to operation
Movement of Trolley Cage	Personal Injury	– Only trained person shall be allowed to operate. – All necessary PPE's shall be used. – Check whether the rollers of trolley cage are in excellent condition. – Ensure all Hand tools are in healthy condition. – The maintenance person should compulsory wear the safety belt with hooking in the jib at maintenance area i.e... in trolley cage. – When the person is travelling in trolley cage he should maintain limit 1st speed – Check whether the rope of trolley is in good condition both long and short
Fixing of Hook block/ Ball hook and riving as per required configuration	Person getting injured while riving on the hook block	– Ensure use of mandatory PPEs including suitable hand gloves. – Proper care taken for hands should not caught between the rope and pulley. – Use proper platform and full body safety harness while working at height.
	Fall of material or loose objects	– Ensure lifting is as per the load chart of the crane – Make sure all nuts, bolts and swivel coupler are in safe and secure condition. – Signage on English / Hindi to stop unauthorized movement or entry or risk of falling materials. – Daily visual inspection of lifting gear.
	Electrocution	– Ensure cables are not running on floor – Ensure no joints on cables – Ensure electrical connections are done by electricians – Ensure power supply DB is equipped with ELCB – • Ensure that Earthling/ safety device should working properly
	Dark area / poor illumination	– Proper illumination on work area. – Random inspection of illumination using LUX meter
	Weather condition or adverse scenario	– STOP operation on adverse weather or wind blow exceeding 55 KM /HR or 12 meter per second" – "Monitoring and communication on weather condition
	Mechanical failure	– Third party examination before start and on periodic basis on lifting appliance and gear" – The crane shall not be used to pull vehicles of any type, remove piling, loosen formwork, pull away loads attached to the ground or walls, or for any operation. – Daily visual inspection by operator and monthly formal inspection
	Human failure resulting into serious injury / property damage	– operator competency assessment & Medical examination – Only authorized rigger to work on with signal man with communication device.

Operation of Tower crane	Loose bolting of Metal Halide lights	– Periodically inspection of all installed lights should be done by the electricians and operators as per inspection checklist.
	Hit with nearby Building/ Structure	– Ensure Tower Crane Trolley is not Extending out side the site boundary, the maximum permitted limit is as mentioned below:- 1) North side 24M 2) South side 33M 3) East side 50M 4) West Side 33M – "Ensure that competent & experienced rigger/ signalman Detail for signaling.
	Fire or burn injury	– Never start hot work without obtaining and complying Hot work permit – Ensure fire extinguisher is available in the operator's cabin
	Fall of men or materials	– No person should stand or move outside platform or access ladder. – Use safety harness while climbing with fall arrestor tied to life line. No loose materials to be left or handled without proper tie on elevated platform.

Job Breakdown Sheet			
Operation Step	Description	Hazards	Precautions / controls
1.	Start the Ply Cutting Machine (JOB)	1) Breakage of ply cutting wheel 2) Contact with ply cutting wheel 3) Flying particles	1) Check and adjust the Guard 2) Adjust tool rest 3) Get wheel dressed if necessary. 4) Use goggles/ shield
2.	Pick up the Ply Cutting Machine (JOB)	1) Cutting wheel sharp edges 2) Unsafe gripping or lifting	1) Use Cut Resistance hand gloves 2) Use Safety shoes 3) Proper method of storing 4) Proper training in lifting 5) Proper operating technique
3.	Grind	1) Wheel Flying particles 2) Dust-Silicosis, nuisance 3) Sound of Cutting Machine	1) Use Face Shield 2) Nose Mask 3) Ear Plug
4.	Replace the job.	1) Sharp edges 2) Fall of casting 3) Strain and sprain	1) Cut Resistance hand gloves 2) Use safety shoes 3) Proper method of storing 4) Proper training of operating

G. Application of 5x5 Risk Matrix Methodology

Risk Level Severity of harm	Likelihood Score				
	1= Rare	2= Unlikely	3= Possible	4= Likely	5= Almost Certain
Catastrophic Level 5	5	10	15	20	25
Major Level 4	4	8	12	16	20
Moderate Level 3	3	6	9	12	15
Minor Level 2	2	4	6	8	10
Negligible Level 1	1	2	3	4	5

This construction Risk matrix shows the risk level of that job and likelihood score rate just because of that matrix we can compare the high risk level of that job.

Risk Level in Likelihood	Risk Level in Severity	Colour Code	Rating
Very likely	Extremely harmful		4
Likely	Harmful		3
Unlikely	Slightly harmful		2
Very unlikely	Very slightly harmful		1

This table show about the matrix components and their nature of severity and likelihood rating show harm and colour code shows the nature.

H. Analysis of Construction Site Data Last 5 Years

Year	Reportable accidents	no of workers Full time/contractor	Total man days lost (average	IR	SR	FR	Frequency severity Index
2011	17	70+ 310=380	51	44.73	536.46	31.95	4.13
2012	15	68+ 302=370	44	40.54	84.94	28.95	1.56
2013	13	65+ 290 = 355	37	36.31	74.44	26.15	1.3952
2014	09	60+ 280=340	27	26.47	68.877	22.95	1.257
2015	06	65 + 265 =330	17	18.181	36.79	12.987	0.0691

I. Analysis of Construction Site accident Data Last 5 Years.

Year / Incident Type	2011	2012	2013	2014	2015
Fall from height	8	6	5	5	3
Falling of object	1	2	2	1	1
Caught in or between	2	1	1	0	1
Electric shock	0	1	2	0	0
Fall through opening	0	0	2	0	0
Incident due to Improper swing of crane	0	0	0	0	1
Incident due to excavation loss soil collapse	1	1	0	0	0
Cut Lacerations	2	1	1	2	0
Injury to eye in cutting & welding	1	1	0	0	0
Slip from platform / Stairs	2	1	0	0	0
Collapse of temporary structure	0	1	0	1	0
No. of Accidents/Incident	17	15	13	09	06
No. of Workers Involved	380	370	355	340	330
Total Man-Days Lost	51	44	37	27	17

1) Year 2011

Calculation of frequency rate, severity rate, incident rate and frequency–severity index. From the accident data sheet we can obtain the accident reading in a work with safety management

Total No workers: 380
Full time workers: 70
Contract workers: 310
Working hrs for year 2011
Full time workers: 40 hrs/week× 35weeks/Year
Contract workers: 40 hrs/week× 35weeks/Year
Man-hours worked-(70 X40X 35) + (310X40X35) = 98000 + 434000 = 532,000hrs.

1) Frequency Rate= (17x 1000000)/ 532,000=31.95
2) Severity Rate= (285.4x 1000000)/ 532,000=536.46
3) Incident Rate= (17x 1000)/380=44.73
4) 4. Frequency Severity Index = FSI = √SR X FR/ 1000 √536.46 X 31.95 /1000 =4.13

2) Year 2012

Calculation of frequency rate, severity rate, incident rate and frequency–severity index. From the accident data sheet we can obtain the accident reading work with safety management

TotalNo.workers:370
Full time workers: 68
Contract workers: 302
Working hrs:
Full time workers: 40 hrs./week× 35weeks/Year
Contract workers: 40 hrs./week× 35weeks/Year
Man-hours worked-(68 x 40x 35) + (302 x 40 x 35) = 95200 + 422800 =518000hrs.

1) Frequency Rate= (15x 1000000)/518000=28.95
2) Severity Rate= (44x 1000000)/518000=84.94
3) Incident Rate= (15x 1000)/370=40.54
4) Frequency Severity Index = FSI = √SR X FR/ 1000 √28.95 X 84.94 /1000 =1.56

3) Year 2013

Calculation of frequency rate, severity rate, incident rate and frequency–severity index .From the accident data sheet we can obtain the accident reading a work with safety management

Total No.workers:355
Full time workers: 65
Contract workers: 290
Working hrs:
Full time workers: 40 hrs/week× 35weeks/Year
Contract workers: 40 hrs/week× 35weeks/Year
Man-hours worked-(65 x 40 x35) + (290 x 40 x35)= 91000 + 406000 = 497000 hrs.

1) Frequency Rate= (13x 1000000)/497000=26.15
2) Severity Rate= (37 x 1000000)/ 497000=74.44
3) Incident Rate= (13x 1000)/355=36.31
4) Frequency Severity Index = FSI = √SR×FR/1000 SQRT √74.44 X 26.15/1000 = 1.3952

4) Year 2014

Calculation of frequency rate, severity rate, incident rate and frequency– severity index .From the accident data sheet we can obtain the accident reading in a work with safety management

Total No.workers:340
Full time workers: 60
Contract workers: 280
Working hrs:
Full time workers: 40 hrs/week× 35weeks/Year
Contract workers: 40 hrs./week× 35weeks/Year
Man-hours worked-(60 x 40 x35) + (280 x 40 x35) = 84,000 + = 392000hrs.

1) Frequency Rate= (09 x 1000000)/ 392000=22.95
2) Severity Rate= (27x1000000)/ 392000=68.877
3) Incident Rate= (09x 1000)/340=26.47
4) 4. Frequency Severity Index = FSI = √SR ×FR/1000 SQRT √68.877 X 22.95/1000 = 1.257

5) Year 2015

Calculation of frequency rate, severity rate, incident rate and frequency–severity index .From the accident data sheet we can obtain the acid entre ading in a work with safety management

Total No.workers:330
Full time workers: 65
Contract workers: 265
Working hrs:
Full time workers: 40 hrs/week× 35weeks/Year
Contract workers: 40 hrs./week× 35weeks/Year
Man-hours worked-(65*40*35) + (265*40*35) = 91000 + 371000 = 462000

1) Frequency Rate= (06 x 1000000)/ 462000=12.987
2) Severity Rate= (17 x 1000000)/ 462000=36.79
3) Incident Rate= (06 x 1000)/330=18.181
4) 4. Frequency Severity Index = √FSI =SR ×FR/1000 √36.79 X 12.98 /1000 = 0.6910

This Year 2015 Data is calculated in construction industry with the help of analysis at site related people so we can calculate and this data is decrees in 2015 this shown in Frequency Severity index .

In data calculation data is decrees year by year.

Frequency Severity Index = √FSI =SR ×FR/1000

Year	Frequency severity Index
2011	4.13
2012	1.56
2013	1.3952
2014	1.257
2015	0.0691

V. CONCLUSION

This project is based on construction activity. In construction there are several activities are going we can dictating many phase of construction, and we can implementing the work activity by advanced technology and this technology are very high and fast due to this activities some time its very harm full for construction work and also for worker's so controlling for this harm we can prepare hazard identification technique so just because of that technique controlled on injury haram & accident.

In our project we use JSA (Job Safety Analysis) to control the construction high risk activities and we apply it on tower crane erection, slab concreting, material handling, height work. In this project we can show high risk activity and to control this we work on JSA after that using JSA control to them by control measure and in our project we have data from last 5 years the incident is decrees so we can control accident by this JSA in project.

We can see at site safety culture and practices should start at the top management. Make safety committees and safety managers a part of the job. Recognize success of safety performance but hold everyone accountable. Prequalify subcontractors for safety before assignment is offered. Train workers for safety Focus on fall management & Combat substance abuse. Evaluate each project phase for safety & site specific practices. Make safety an everyday topic and Review accidents and near misses incidents. Work with your insurer and risk management experts with objective toward zero injuries

Develop Site specific EHS Plan along with Analyze potential site safety hazards in pre-construction phase. Appoint/assign/authorize site safety personnel. Strong safety leadership with abilities in supervisors will deliver success. Always include jobsite workers in safety process. It is very good practices to Conduct regular project safety audits with foreman/workers. Establish measurable EHS goals and objectives & Track leading safety metrics. Always utilize effective job safety and hazard analysis findings for implementation. Design Site specific training programs and Implementing safety mitigation in to design process.

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