Application of Pareto Principle and Hartman's Principle for the safety issues in construction industries

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ABSTRACT

The Pareto principle says that the for many events the 80% of the consequence is due to the 20% of the cause if we apply this to the safety and Identify the 20% of the causes we can reduce the potential accidents by 80% and this will automatically allow us to improve the safety performance in this way we used Pareto's Principle. The problems identified must be solved but according to the effectiveness and the compatibility so now we use the Hartman's principle of the Pareto's priority index and find which safety issues must be addressed and solved with the immediate effect so that there increase in the quality of the safety in the industry. We selected the construction industries for the application of this principles as they are industries where we have many safety issues, ill-organized sector and the 11% of employment in India is in construction industry followed by the agriculture which is 53%. As India is the developing country and pushing toward the urbanization the employees in the agriculture sector are moving towards the construction or the manufacturing industries. In the last decade, there is a prominent increase in employees in the construction industries.

Keywords— Pareto's Principle, Hartman's Principle, Pareto priority index, 80 /20 rule safety, Prioritization, Construction industry, Employees

1. INTRODUCTION

The urbanization has led to the growth of the employment in the cities and the unskilled and untrained labour form the rural are started settling the construction Industry this increased the number of employees in the construction industry reason[1]. This also made many people to be exposed to hazards that are present in the Construction Industries. This paper mainly speaks about the quality of the safety that means they merely don't only speak about the hazards in the industry and their control measure this also focuses on which must give more priority to achieve maximum safety and this is applicable only to the starting stages of the construction latter all the safety measures are to be implemented. Here we identify the different hazards and which worker is more exposed to the hazards and priority is given in order of the Pareto Priority Index. Pareto's Principle says that if the top 20% issues are given importance then 80% of the problem is solved.[2].Here this can be used as a tool for loss prevention

2. STATISTICS

The hazard in the construction industries are mainly due to poor safety management like
- Safety manual and procedures
- Provision of personal protection equipment
- Safety meeting and training
- Impact of site accidents
- The perceived probability of serious accidents on site.[3]

The accidents are caused due to many other factors besides the management they are firstly not able to identify the unsafe conditions before the start of the project or while the project is being performed then come to a worker neglecting the identified unsafe conditions and proceed to do the work. finally, after all, conditions are made safe the worker acting unsafely will cause the accident.[1]

The following are the statistic of a construction site for a period of 15days on which we will performing the Pareto priority index and the given control accordingly.

Table 1: Reasons for accidents and Number of accidents happened

Causes of Injury	No. of accidents	Percentage
Falls from Height	3	6
Slip, Trip and Fall	4	8
Electrical power lines	3	6
Building power cables	3	6
faulty facility wiring	3	6
faulty tool/wiring	4	8
Struck by Vehicle	4	8
Material falling from Height	6	12
Struck by material swing materials	3	6

Trapped in between equipment parts	4	8
Caught in between the materials stacked	3	6
Excavation (Cave In)	5	10
Explosion	1	2
Fire	4	8
Total	50	100

The causes of injury were taken from reference.[1]

The loss time injuries in the construction industry have the incident rate of 10.1 which is 2.5 times the incident rate of all the other industries and every 100,000 employees 25.6 are being dead in the accidents occurred in the construction site.[4]

3. COST OF ACCIDENT
There are mainly two types of cost that will affect the company after the accident they are:

3.1 Direct Costs: These costs can be directly measured in currency and this will show what is the effect of the accident at that point of time this includes costs like Compensation costs, Material loss, legal cost Etc.[5]

3.2 Indirect Costs: The indirect costs are which cannot be measured in terms of currency but in a long time may show negativity in the production this includes loss of time, loss of reputation Etc.[5]

The cost that is required for the different events and Hazards in the Construction Industry are as follows. Here are some assumptions according to the local conditions,
- Average Wage = Rs 7,000/- per month
- Average Age of employee = 35-40 years
- Compensation for death = Rs 6,89,500/-
- Funeral Expenses = Rs 5,000/-
- Compensation for permanent Disablement =Rs 8,27,400/-
- Indirect Cost = 110% of Direct cost

These calculations are according to works men compensation act[6] besides this the company may have to bear more losses if proved that organization hasn't provided any safety measure for the accident that happened and we also have other costs like loss of time and reputation. So, form the above stats we can say that cost for death will be around 15lakhs and the Permanent Disablement will be 20lakhs per injury as per local conditions after including the indirect costs

4. CONTROL MEASURES AND THEIR COSTS
Controls are required in any case to avoid the reoccurrence or to prevent the occurrence of the accidents. For knowing the controls for the various hazards to which the workers are being exposed we must know the source of the hazards then suggest the control measure in such a way that the risk is brought to the acceptable level and will not have any huge effects on the people health and safety.

Table 2: Control measure and their application costs for various types of accidents

Causes of Injury	Source of Injury	Control measure	Cost of Control Measures (Rupees)
Falls from Height	• Working on ladder • Working on scaffolding • Working on unguarded floors	• Medical surveillance of employees for vertigo • Proper PPE • Inspection of Ladders and Scaffolds as per IS 3696	• 1,20,000 • 50,000
Slip, Trip and Fall	• Cables on ground • Poor Housekeeping	• Increasing employees for Housekeeping • Caution Boards on the premises near where there are trailing wires and Pipes	• 5000 per person per month • 200 for board
Electrical power lines	• Not marking overhead electric facilities • Not marking underground electrical cables	• Underground cable locators • Request for switching off the overhead power cables	• 80,000 • Compensation of 5000 for 1 hour
Building power cables	• Uninsulated cables • Using it no proper earth connection	• Insulating the wire while construction • Earthing is compulsory before working	• 10,000
faulty tool/wiring	• Instruments like Welding, drilling with no ground connection	• Weekly inspection of all equipment • Replacing all ungrounded Instrument	• 30,000
Struck by Vehicle	• Forklifts • Debris Trolley • Other material handling equipment	• Horns • Separate paths for vehicles and pedestrians • Insite signalling System	• 2000 • 10,000 • 15,000
Material falling from Height	• Improper Cranes Usage • Working on height	• Competent crane operator • Having toe boards to all scaffolds • Inspection of ropes • Banksmen	• 1000 per person per day • 200 for board • 500 per person per day
Struck by material swing materials	• Swinging material from cranes • Materials on the material handling equipment	• Swing resistors • Ropes to bind the material on the handling equipment	• 18,000 • 150 per rope
Trapped in between equipment parts	• Cement mixing machinery	• Guarding	• 10,000
Caught in between the materials stacked	• Improper stacking of material	• Guarding	• 10,000
Excavation (Cave In)	• In excavations	• Shoring • Shielding	• 15,000 • 20,000
Explosion	• Welding cylinders	• Replacing them with electrical welding • Flashback arrestor	• 12,000 • 8,000
Fire	• Poor housekeeping near the welding area	• Increasing workforce for housekeeping • Gas testing near working premises	• 500 per worker per day • 1,50,000

*Cost that is given as per the present local conditions
*Control Measure have some cost if it is an engineering control

5. APPLICATION OF PARETO'S PRINCIPLE

The Pareto's principle will give us an idea what are the problems that are in the top 20% by solving which we can achieve 80% of safety in the construction industry this is done from the data collected from the construction site in table 1.

The data in the table is arranged in the order of the decreasing order of the percentage and the graph is plotted between the accidents and the percentage and cumulative percentage to get the Pareto Graph and to know the top 20% hazards and to solve them get 80% safety.
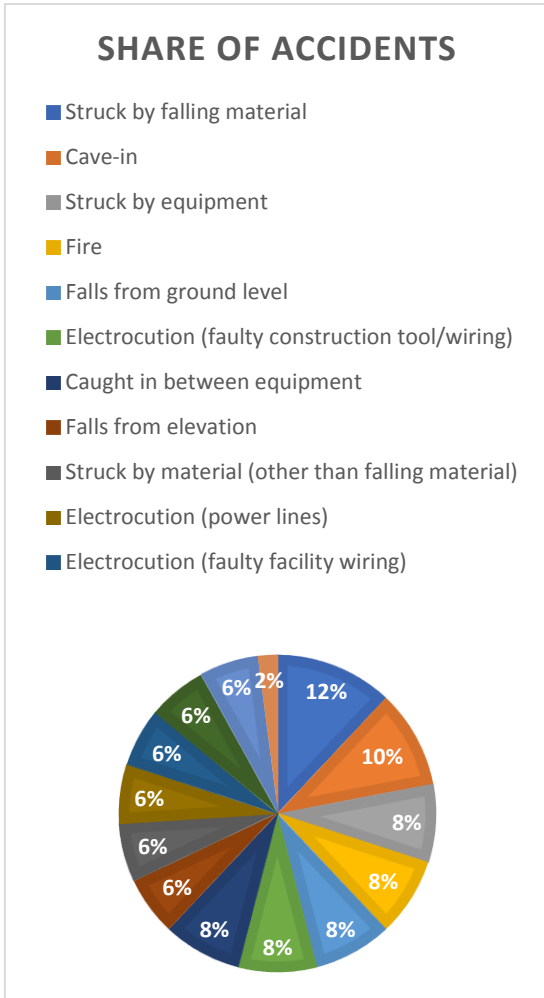

Fig. 1: Pie chart showing the share of the different accidents
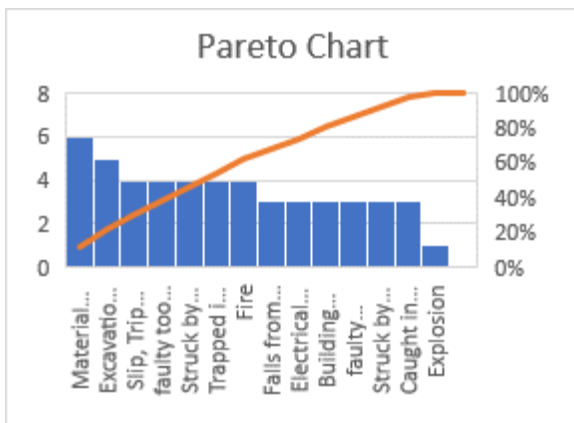

Fig. 2: Bar graph interpreting the data of accident which are in the top 20%

So, from the data we collected we got the above-plotted Pareto curve which has clearly shown the top 20% of hazards by applying controls to these identified top 20% hazards now we

can get 80% of the safety but here which must give priority because there are many hazards that can cumulatively give rise to top 20% now we use pareto priority index prioritization of hazards and control to achieve maximum safety with the lowest time and lowest investment.

The results that we got after the plotting the graph from the data that which we have collected for the construction site the we arrive to the conclusion that these hazards like struck by falling material form height, Cave in in Excavations, Struck by Vehicles moving in the site, fire due to the welding activities, slip trip and falls, usage of the faulty equipment and getting trapped between the equipment's parts any of these two can fall into the top 20% hazards now by using Hartman's Principle of Pareto Priority Index and know to solve which hazard will give more effective progress towards safety

6. APPLICATION OF HARTMAN'S PRINCIPLE

Hartman's Principle is the extension of the Pareto's Principle after finding out the top 20% problems the prioritization of these problems is to be done as based on the formulae and this gives us by solving which problem first will give a maximum improvement in safety

The data of the only top 20% of problems are taken in consideration as they will give the maximum output of safety if solved according to the prioritization the data is needed to evaluate the Priority Index is Savings, Probability of success, Cost of Project and time to complete the project.

- **Savings:** The amount of money that is estimated to be saved after application of the control measures this saving is reflected in the decrease of fines, Compensation, Increase in productivity. Measured in Rupees
- **Probability of Success:** This is the parameter that shows how successful the project is and its efficiency in solving the problem we took up
- **Cost of Project:** This is the amount of money that is required for the proceeding on the control measure and to apply and bring it to working. Measured in Rupees

Time to complete Project: this the time required to apply the control measure. Measured in Years

$$\text{Pareto's Priority Index} = \frac{\text{savings} * \text{Probability of Sucess}}{\text{Cost} * \text{Time of completion}}$$

Table 3: Data of savings, probability, cost and time of various controls

Project	Saving (in lakh Rs)	Probability	Cost (in lakh Rs)	Time (years)	PPI
Crane safety equipment	90	.8	1.5	1	48
Toe boards	60	.8	.4	.5	240
Shielding and shoring	75	.9	.6	.5	225
Horns	60	.7	.5	.5	168
Banksmen deployment	60	.8	6	.5	16
Traffic Signaling system	60	.8	1.2	1.5	26.67
Housekeeping	95	.6	6	.2	47.5
Flash Back arrestor	60	.9	1.5	.5	72
Grounding and Earthing of equipment	80	.95	1.5	1.5	33.78
Guarding	80	.7	.3	1.5	124.44

Savings in the money that is saved from the compensation and another legal fine because of the accident is a mixture of compensation of both deaths and Permanent Disablement. Probability is shown how efficiently it will work and Cost is as specified above for the local conditions and time to apply the control measure

Now from the Pareto's Priority Index (PPI), we can prioritize the controls that are too applied first in the construction site to increase the efficiency of safety with the lowest investment are found by arranging the Control measures in the descending order of their respective PPI.

7. RESULTS AND DISCUSSION

The controls that are to give more priority as per PPI and Hartman's Index are providing the Shielding and shoring in the excavation activities will reduce the no. of accident and fines to the organization. Fixing of the boards to all the scaffolds will reduce the danger of material fall on the work that can cause the death or severe injury. The construction is more prone to vehicular accidents so we must take care that all vehicles are provided with horns to warn the worker about approaching vehicle and finally guarding of machinery is one of the most important as the hazards due to the unguarded machinery will cause a permanent disablement which is more dangerous and costlier to organization by applying these controls to hazards that are in top 20% we are able to make the organization 80% safer than it is.

Table 4: Control measures in order of Priority

Control Measures	PPI
Toeboards	240
Shielding and shoring	225
Horns	168
Guarding	124.4
Flash Back arrestor	72
Crane safety equipment	48
Housekeeping	47.5
Grounding and earthing of equipment	33.78
Traffic Signaling system	26.67
Banksmen deployment	16

8. CONCLUSION

- Construction Industry all over the world is the ill-organized sector it 2.5-time number of incidents compared to all other industries
- The main reason for the failure of the construction Industry is an improper management system
- To improve the safety the issues are to be identified and controls are to be applied
- The organization cannot implement all the controls at once so for the identification of the top 20% hazards we use the Pareto's Principle
- The top 20% are identified as Pareto's principal said that the solving top20% hazard will give 80% efficiency
- After identifying the top 20% we must prioritize the hazard that is to solve first
- This prioritization is done by the using Pareto's Priority Index given by Hartman
- Form this we identified in this construction site if we apply controls like providing toe board to all the scaffolds, Shielding and Shoring while excavation Horns to all the vehicle and the guarding to machinery are to be given more priority
- After applying these controls we can achieve 80% safer construction site

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