iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52667

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Safety Cost Analysis for Building in Construction Industry

Mr. Sudarshan S. Mangave[1], Mr. Amit S. Sajane[2], Dr. D. B. Desai[3], Mr. S. K. Patil[4], Mr. Vinod R. Nejkar[5]
[1]*P. G. Student,* [2]*Assistant Professor,* [3]*Associate Professor, Department of Civil Engineering, Dr. J. J. Magdum College of Engineering Jaysingpur*
[4, 5]*Assistant Professor, Department of Civil Engineering, DKTE Society's Textile and Engineering Institute, Ichalkaranji, Maharashtra, India*

Abstract: ***The construction industry provides shelter for a variety of societies and for a variety of purposes. A security culture is concerned with ensuring safety and avoiding risks. A questionnaire is used to collect information for this project. The study's questionnaire included questions with fixed response categories as well as open-ended questions. Three ratios were calculated, and a graph was plotted for analysis. The Accident Loss Ratio (ALR), Safety Investment Ratio (SIR), and Accident Occurrence Index (AOI) are the three ratios calculated. An estimation of 0.672% of the contract amount was found to be the optimum safety investment for a construction project. It was found that the overall cost to the contractor (accident loss plus safety investment) was 1.148% of the total contract amount. It isn't intended to suggest the scary assumption that 0.672% is the optimum value and that a safety investment higher than 0.672% is not necessary. In actuality, 0.672% needs to be thought of as the very minimal amount to invest in safety in a construction project. The purpose of the graphical representation is to demonstrate the effect of safety investment in a project on the severity of accidents and accident loss occurrences on site, which ultimately reduces the contractor's profit margin. The main goal of the graphical representation is to understand the importance of safety investment in terms of both tangible and intangible benefits such as greater peace of mind for workers, a better image of the organisation in the market, and greater job satisfaction for employers and employees, as well as monetary benefits such as increased profit margins.***

Keywords: Safety, Accidental causes, Safety investment, Safety parameters, Minimum safety investment.

I. INTRODUCTION

The construction industry provides shelter for a variety of societies and for a variety of purposes. It provides employment for people. Construction is a more dangerous and risky sector than others, but it has lots of accidents. The sector is one that is competitive, complex, dynamic, and scattered. Accidents in the construction industry are more common than in any other industry. Major accidents, minor accidents, first aid cases, deaths, and so on are all examples of accidents. Aside from the loss of life, injuries, and occupational illnesses, workplace accidents incur significant economic costs. Accidents caused losses in the construction project, which impacted net income. As a result, it is critical to provide the budget for the construction site during the design phase. Otherwise, future losses in construction projects will be higher. A security culture is concerned with ensuring safety and avoiding risks. There is general agreement that construction contract workers should increase their security interest in their programming advancement. The greater the level of security supposition, the better the execution for well-being. When an injury or adverse event occurs, all parties must deal with the consequences, which also hindered project execution. The use of safety on a construction site includes cost, and risks that cause errors also include cost. The expenses that arise because of errors are classified as either immediate or irregular. Direct and indirect expenses can take the form of remuneration and loss of reputation, respectively. Generally, it is critical to allocate an appropriate sum for the occupation's wellbeing and security during the construction phase of a development venture.

A. Causes of Accidents

On the job site, there are many possible causes of accidents, and it is the site manager's or supervisor's duty to find these causes and effective solutions. As a result, we must identify these causes and implement control measures for them. In that, we find specific causes and, based on this, provide ranks for all causes as well as safety measures. Construction workers' mistakes, poor judgment, lack of focus, awareness of the risks involved with the task, and lack of safety regulations are other factors that contribute to accidents.

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Every construction and building site employee needs to receive adequate safety training in order to increase their level of safety awareness.

B. Safety Cost

The cost of providing a safe environment on a construction site is known as the safety cost. This price includes safety nets, seat belts, PPE kits, and other safety equipment. This type of cost is provided during the construction site's planning phase. If this cost is not included in the planning phase, the project's cost will rise and the timeline will be pushed back.

The salaries of the safety officer, safety leader, safety supervisor, and other employees who will assist in the safety process are also included in the safety costs.

C. Accident Cost

An accident is a condition or circumstance that gets out of hand, causing injuries and damage. Accidents and dangers that occur frequently in the construction industry include injury, death, and damage to hardware and building materials. Accidents are defined as any unexpected event that results in injuries or harm that occurs immediately after the event. As a result, it is critical to investigate the consequences of an accident that could create serious failure at the groups in inquiry. The loss suffered by any of the parties involved in the development project is referred to as the accident cost.

Accident costs can be classified as either direct or indirect. Direct costs are the contractor's actual cash flows that are mainly related to deaths and injuries. Compensation paid to the injured person, medical services and expenses, fines and legal expenses, damage to materials or finished work, and equipment or plant loss are all examples of these costs. The indirect cost of accidents includes lost time for other employees who were present on site at the time of the accident, decreased productivity of other labourers and employees due to fear, and losses from mobilised resources remaining inactive on site.

II. LITERATURE STUDY

S.L. Tang of the Hong Kong Polytechnic University's Department of Civil and Structural Engineering, located in Hunghom, Kowloon, Hong Kong, researched and created a system for estimating the minimal safety investment for a construction project. It states that the ideal level of safety investment must be determined and that safety investments cannot be made indefinitely. ALR is the ratio of the overall cost of accidents to the contract price for a project. The level of safety expenditure in the project affects how safely a construction site operates. A dimensionless number called the Safety Investment Ratio can be used to compare safety investments on projects of various sizes and at various timeframes with respect to the ALR. SIR is described as the proportion of the project's overall safety investment to the contract amount. The AOI is measure of safety performance and determined by dividing the total number of man-days needed to finish the project by the total number of comparable days lost. Plotting the SIR and ALR curves results in a minimal point on the combined total cost curve (SIR+ALR).

Eugenio Pellicer, Gloria I, and Joaqun Catalá studied a paper that reveals the results of an assessment adventure conducted in Spain and wishes to develop a procedure that allows administrators to assess the associated security and economic costs of a specific improvement adventure during the structure stage. This strategy divides costs into four categories: security costs, expected costs, disaster costs, and recovery costs. Work incident data for the entire Spanish construction industry was obtained from 1990 to 2007, and these data were similarly mixed thoroughly and misused. Each cost item was listed using a numerical model.

This methodology gives organisations and adventure managers the ability to check the cost achieved due to work-related success and safety during the assignment, taking into account both unquestionable characteristics, for example, the improvement of the adventure's financial framework or the work standard, as well as quantifiable data. An application of this methodology for a case study revealed that the associated well-being and safety costs for that advancement adventure came to around 5% of the total budget cost.

Lopez Alonsoa, M.P., Ibarrondo Davilab, and M.C. Rubioa investigated this paper, which inspects a few investigations of word-related wellbeing and security costs across the board and proposes a method for distributing wellbeing expenses. Evaluating wellbeing and security costs in the development industry presents a number of challenges, including the complexity of cost designation, a lack of information available to directors, and the absence of a record-keeping model designed specifically for security costs. Frequently, the expenses resulting from workplace mistakes are not completely identifiable due to the enveloped costs included.

Mohd Saidin Misnan, Zakaria Mohd Yusof, Sarajul Fikri Mohamed, and Norazam Othman investigated the three development projects chosen for the study.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

The findings demonstrated the basic security equipment used on the construction site as well as five types of health costs that should be considered for building development projects. A security cost breakdown structure is used to fill in the total cost of security in a construction project. As previously stated, there are five major costs associated with wellbeing: the cost of security across the board, the cost of wellbeing methodology, the cost of building wellbeing, the cost of site wellbeing, and the cost of labourers wellbeing. According to an examination of three building destinations, the total number of assessed security costs for each undertaking is around 1% to 1.5%. This is influenced by the project. The greater the venture's estimation, the greater the overall expense distributed for wellbeing things, and the lower the level of the thing.

Bima Abubakar Muhammad and Ismaila Abdulateef Baba Dorothy Ladi of the Department of Project Management at the Federal University of Technology Minna, Nigeria, conducted a study that examined the cost effects of wellbeing and security across the board in the development industry and identified the effect of cost directly on ventures. In this study, a field overview was provided using the example of fifty contractual workers chosen in a specific geological location with a high density of development work. Information was gathered through organised surveys and investigated through an even introduction to identify rates of given reactions. The findings show that temporary workers understand that their safety and well-being are dependent on the extent of their activities. The findings also show that the rate of mistakes and injuries in the Nigerian construction industry is high. The findings demonstrate the need for successful wellbeing and security that executives, guidelines, and the exercise of control in the Nigerian development industry have all the more authoritatively.

III. SCOPE OF PROJECT

In this project, you will investigate the most likely cause of a construction site accident. It was also recommended to take accident prevention measures. First, the construction industry's need for optimal safety investment is identified. The study's overall goal was to demonstrate the significance of the safety investment required for a construction project. The study also supported determining the minimum necessary safety investment for a residential building project. It also aimed to demonstrate the significance of implementing a safety management system in organisations. Furthermore, the study of safety cost analysis was limited to residential buildings only. The impact of the accident on project completion time.

IV. METHODOLOGY

A. Data Collected with the Help of Questionnaire

A questionnaire is used to collect information for this project. The study's questionnaire included questions with fixed response categories as well as open-ended questions. Data is gathered using two questionnaires, the first of which is designed to identify the most likely causes. The second question concerns the project's safety and accident costs. We also use this questionnaire to determine the project's minimum safety investment.

B. Calculating Safety Investment and Accident Cost

The majority of the safety investment is made up of costs for safety administration personnel and safety equipment. Safety administration personnel include stewards, supervisors, officers, and managers from the safety department. There are various safety devices that could be used during the construction process. Other areas where safety investment is required and costs are incurred are safety promotion and safety training. All of these items were calculated as a safety investment. Accidents result in significant financial losses for those involved. It is critical to investigate the effects of accidents that may result in losses to the parties involved. A loss of money is one of the significant losses that must be calculated. The financial loss caused to any of the parties involved in the construction project was referred to as the accident cost in the analysis.

C. Analysis of Safety Investment and Accident Cost

Three ratios were calculated, and a graph was plotted for analysis. The Accident Loss Ratio (ALR), Safety Investment Ratio (SIR), and Accident Occurrence Index (AOI) are the three ratios calculated. The Accident Loss Ratio (ALR) is a dimensionless quantity used to compare the site accident costs of projects with varying contract amounts and completion dates. ALR is the percentage ratio of a project's total cost of accidents to the contract sum.

In terms of ALR, safety investments on projects of various sizes and at various times can be compared using a dimensionless quantity known as the Safety Investment Ratio (SIR). SIR is defined as a percentage ratio of the total safety investment in a project to the contract sum. The ratio of the total equivalent day loss to the total man-days required to complete the project is defined as the AOI. Curves for SIR and ALR were plotted and a minimum point was obtained from the combined total cost curve (SIR+ALR).

V. ANALYSIS AND FINDINGS

A. Data Collection

The information for project work was obtained using two questionnaires. The questionnaire is used to find different causes of accidents. In this questionnaire, we find thirteen different causes of accidents and obtain responses from experts and from this questionnaire about which cause is more responsible for an accident.

The second questionnaire is used for finding safety costs and other factors related to safety. The questionnaire was divided into three parts:

1) Part - Basic Information of the project
2) Part B - Safety investment of the project
3) Part C - Cost items arising from accidents

The questionnaire responses were obtained through various methods, including conducting a field survey, using printed questionnaires, obtaining responses online via email,. The raw data is compiled into a single format. The calculations are then performed in order to obtain the required information. The three factors: accident occurrence index (AOI), safety investment ratio (SIR), and accident loss ratio (ALR) are calculated based on the information obtained.

B. Data Analysis

The information obtained from the survey is used to find the causes of accidents. In this survey, we obtained a total of 42 responses from safety officers. On the basis of these 42 responses, we find different causes according to the number of accidents. The following table shows the number of accidents and their causes:

Table 4.1 Number of accidents and their causes

Sr. No.	Causes	No. of Accidents
1	Slips, trips or falls	600
2	Use of unsafe equipment	550
3	Using broken or defective tools	410
4	Falling from height	400
5	Injured while handling	370
6	Struck by falling objects	360
7	Contact with moving	340
8	Trapped by something collapse	320
9	Removing form work	270
10	Electric shock	220
11	Collapse of structure	210
12	Exposure to an explosion	40
13	Gas explosion	20

The information obtained from the survey work is used to calculate the safety investment and total cost of an accident. With the help of total man-days lost, safety investment, and accident cost, the three ratios AOI, SIR, and ALR are calculated. The detailed illustration is explained below for response number 1. The results obtained after doing calculations for all the responses are given in a table on the next page.

Table 4.2 Summary of investments on the safety

Sr. No.	Contract Period (in months)	Contract Sum (in crore)	Cost of work Completed Till Date (in crore)	Total Man Days Employed (in no.)	Safety Investment (in Rs.)	Accident Cost (in Rs.)	Total Man Days lost due to Accidents
1	25	99	45	175522	5490000	283400	160
2	16	80	58	165421	5916000	4065800	420
3	35	85	60	151420	9144000	211200	120
4	24	54	29	101220	2639000	1380400	77

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

5	25	115	75	162500	5587500	3285000	273
6	24	160	85	182400	3102500	6451500	257
7	15	98	77	92500	8547000	669900	70
8	24	50	20	29950	2020200	148000	23

Table 4.3 Summary of AOI, SIR and ALR ratios

Accident Occurrence Index (AOI)	Safety Investment Ratio (SIR)	Accident Loss Ratio (ALR)	SIR + ALR
0.00091	1.22	0.063	1.283
0.00254	1.02	0.701	1.721
0.000793	1.524	0.0352	1.5592
0.000757	0.91	0.476	1.386
0.00168	0.745	0.438	1.183
0.00141	0.365	0.759	1.124
0.000757	1.11	0.087	1.197
0.000768	1.01	0.074	1.084

1) Calculation for Safety Investment

Safety investment consists of the following three main components;

a) Investment on Safety Administration Personnel

The total investment on safety administration personnel is calculated as given below;

Table 4.4 Investment on Safety Administration Personnel

Sr. No.	Particular	No.s	Monthly Salary (Rs)	Monthly Expenses (Rs)
1	Safety Site Engineer	2	20000	40000
2	Safety officer	1	30000	30000
3	Safety Manager	1	40000	40000
4	Others	0	0	0

Total monthly expenditure = Rs. 1, 10,000/-
Numbers of working months till date = 25 months
Total expenditure on safety staff till date = 1, 10,000 * 25 = Rs. 27, 50,000/- ……. (A)

b) Investment on Safety Equipment's

Investment on safety equipment's is calculated as given below;
1. Cost of PPE's given to labours at induction -
a. Total number of labourers inducted on site till date = 540
b. Cost of PPE's given to each labour at induction = Rs. 1000 per labour
Total Cost of PPE's given to each labourers at induction = a*b = Rs. 540,000/-
2. Cost of PPE's given to labours other than at induction = Rs.1,85, 000/-
3. Cost of safety net = Rs. 2, 75,000/-
4. Cost of safety harness = Rs. 1,78,000/-
Total expenditure on safety equipment's till date = Rs.11, 78,000/- ……. (B)
Note - For most of the responses direct value for the parameters B, C and D is obtained (i.e. 2+3+4).

c) Investment on Safety Training and Safety Promotion

1. Safety promotion cost = Rs. 13, 00,000/-

2. Safety training cost = Nil
Total expenditure on safety promotion and safety training = Rs. 13, 00,000/- ……. (C)
Note - For most of the projects safety training is in-house with help of safety administration personnel and hence no separate expenditure is incurred for safety training.

d) Other Costs
1. Cost of medical check-up -
a. Total number of laborers inducted on site till date = 540
b. Cost of medical check-up of laborers at induction = Rs. 200 per labor
Total Cost of medical check-up = a*b = Rs. 1, 08,000/-
2. Environmental Reporting cost = Rs. 1, 54,000/-
Total other costs = Rs. 2, 62,000/- ……. (D)
Total safety investment on project till date = A + B + C + D = Rs 54, 90,000/-

2) Calculation for Accident Cost
The compensation paid to injured labourers is as per 'The Workman's Compensation Act, 1923, with the latest amendment of 2017. According to the Workman's Compensation Act, the compensation paid to an injured worker resulting in permanent disablement or death depends on monthly wages and the age of the injured person. To account for age, relevant factors are given in Schedule IV of the act. In cases of partial permanent disability, the percentage of disability is given in Schedule I of the act. But due to data insufficiency about the percentage of disability assigned to each individual worker, the categories of partial permanent disablement and total permanent disablement are considered as only one, i.e., total permanent disablement. The compensation for temporary disablement is paid on the basis of the laborer's monthly wagesr. No compensation is paid for first-aid cases.

a) Assumptions in Calculation of Accident Cost
Following are the assumptions made for the calculation of accident costs and the compensation to be paid to the labourers and employees:

- The cost of an accident for first aid cases and non-reportable accidents occurring on site is considered to be Rs. 200 for each injury.
- In cases of temporary disablement, whether total or partial, resulting from injury, the compensation for the injured person is assumed to be paid for an average period of three months.
- Due to data insufficiency about the percentage of disability assigned to each individual workerr, the categories of partial permanent disablement and total permanent disablement are considered to be one, i.e., total permanent disability.
- The monthly wages of labourers are assumed to be Rs. 12000 per month, whereas the monthly wages of employees are assumed to be Rs. 30000 per month.
- The relevant factors for partial disablement and fatal accidents are age-dependent and vary as per the age of the injured person. But due to data insufficiency, it is assumed that the average age of labour is forty-four years, whereas the average age of an employee is forty-one years.
- The cost of insurance paid by the contractor is ignored in safety investment, and hence it is assumed that all the compensation to injured personnel is paid by the contractor. (If the project is insured, the same amount of compensation is paid by the insurance company.)

b) Compensation to be paid as per the Workmen's Compensation Act
The amount of compensation to be paid to injured labourers as per provisions of 'The Workman's Compensation Act, 1923' with the latest amendment of 2017 is as follows:

- The amount of compensation that must be provided in the case of a deadly accident or death is equal to 50% of the injured person's monthly wages times the appropriate age factor.
- When an injury results in entire or partial permanent disability, compensation is payable in an amount equal to 60% of the injured person's monthly salary times the corresponding age factor.

- If an injury results in temporary whole or partial disablement, compensation is to be paid every six weeks in an amount equal to 25% of the monthly pay.
- Relevant factors to account for age are given in Schedule IV of the act. As per the assumption, the average age of labour is considered to be forty-four years, whereas the average age of a construction employee is considered to be forty-one years. The relevant factors of age for a labourer and an employee are 172.52 and 181.37, respectively.

c) Calculation of Compensation

Following are the records of accidents for response no. 1;

- Accident record of laborer's -

First Aid Cases = 142

Temporary Disablement = 17

Permanent Disablement = 0

Fetal (Death) = 0

- Accident record of employees –

First Aid Cases = 6

Temporary Disablement = 0

Permanent Disablement = 0

Fetal (Death) = 0

For all the above cases the amount of compensation to be paid is calculated as follows;

➢ Compensation paid to labourers -

a) The amount of compensation to be paid for first aid cases;

= No. of cases * Rs. 200/- = 142 * 200 = Rs. 28,400/- …….. (1a)

b) The amount of compensation to be paid for temporary disablement cases;

= 25% * No. of cases * Monthly wages * No. of months of disablement

= 0.25 * 17 * 12000 * 5 = Rs. 2, 55,000/- ……..…….. (1b)

c) The amount of compensation to be paid for permanent disablement cases;

= 60% * No. of cases * Monthly wages * Relevant age factor

= 0.60 * 0 * 12000 * 172.52 = Rs. 0/- ……. ……..…….. (1c)

d) The amount of compensation to be paid for fatal accidents (death);

= 50% * No. of cases * Monthly wages * Relevant age = Nil.

Table 4.5 Amount of Compensation

Sr. No.	Accident Case	No. of Cases	Amount of compensation
1.	First aid cases	142	28,400
2.	Temporary disablement	7	2,55,000
3.	Permanent disablement	0	00
4.	Fatal accidents (death)	0	00
		Total	Rs. 2,83,400

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

➢ Compensation paid to employees -

There are zero accidents in case of employees. So only the formulas are listed down.

❖ The amount of compensation to be paid for first aid cases;

= No. of cases * Rs. 200/- =6 * 200 = Rs. 1,200/- ...…….…….. (2a)

❖ The amount of compensation to be paid for temporary disablement cases;

= 25% * No. of cases * Monthly wages * No. of months of disablement = Nil…. (2b)

❖ The amount of compensation to be paid for permanent disablement cases;

= 60% * No. of cases * Monthly wages * Relevant age factor = Nil ....…….... (2c)

❖ The amount of compensation to be paid for fatal accidents (death);

= 50% * No. of cases * Monthly wages * Relevant age factor = Nil.....…. (2d)

Note - In case of compensation to be paid for employees the monthly wages to be considered are rupees thirty thousand and the relevant age factor is 181.37.

Total amount of compensation paid for all the accidents;

= 1a + 1b + 1c + 1d + 2a + 2b + 2c + 2d = Rs. 25, 49,888/- ….……. (A)

d) Other Accident Costs

- Cost of damaged equipment's due to accidents = Rs. 0 /- …….
- Cost of damaged materials due to accidents = Rs. 0 /- …….
- Total cost of accidents on project till date = A + B + C = Rs. 2, 83,400/-

3) Calculation of AOI, SIR and ALR

a) Calculation of Accident Occurrence Index

The accident occurrence index (AOI) is defined as follows;

$$AOI = \frac{\text{Total equivalent days lost}}{\text{Total man days worked till date}}$$

$$AOI = \frac{160}{175522}$$

$$AOI = 0.00091$$

The accident occurrence index (AOI) for response no. 1 is 0.00091.

b) Calculation of Safety Investment Ratio

The safety investment ratio (SIR) is defined as follows;

$$SIR = \frac{\text{Safety investment on site till date}}{\text{Actual cost of work completed till date}} * 100$$

$$SIR = \frac{5490000}{45,00,00,000} * 100$$

$$SIR = 1.22\%$$

The safety investment ratio (SIR) for response no. 1 is 1.22 %.

c) Calculation of Accident Loss Ratio

The accident loss ratio (ALR) is defined as follows;

$$ALR = \frac{\text{Cost of accident}}{\text{Actual cost of work completed till date}} * 100$$

$$ALR = \frac{283400}{45,00,00,000} * 100$$

$$ALR = 0.063\%$$

The accident loss ratio (ALR) for response no. 1 is 0.063%.

C. Graphical Representation

The graph is drawn using the three ratios Safety Investment Ratio (SIR), Accident Loss Ratio (ALR) and Accident Occurrence Index (AOI) with help of Microsoft Excel. Scatter plot is used for plotting the graph. The lines shown on the graph are trend lines of SIR, ALR and SIR+ ALR

D. Findings from Graph

The graph shows equations of trend line for safety investment ratio (SIR), accident loss ratio (ALR) and total cost curve (SIR+ALR). The equations of trend line obtained from Microsoft Excel are as follows;

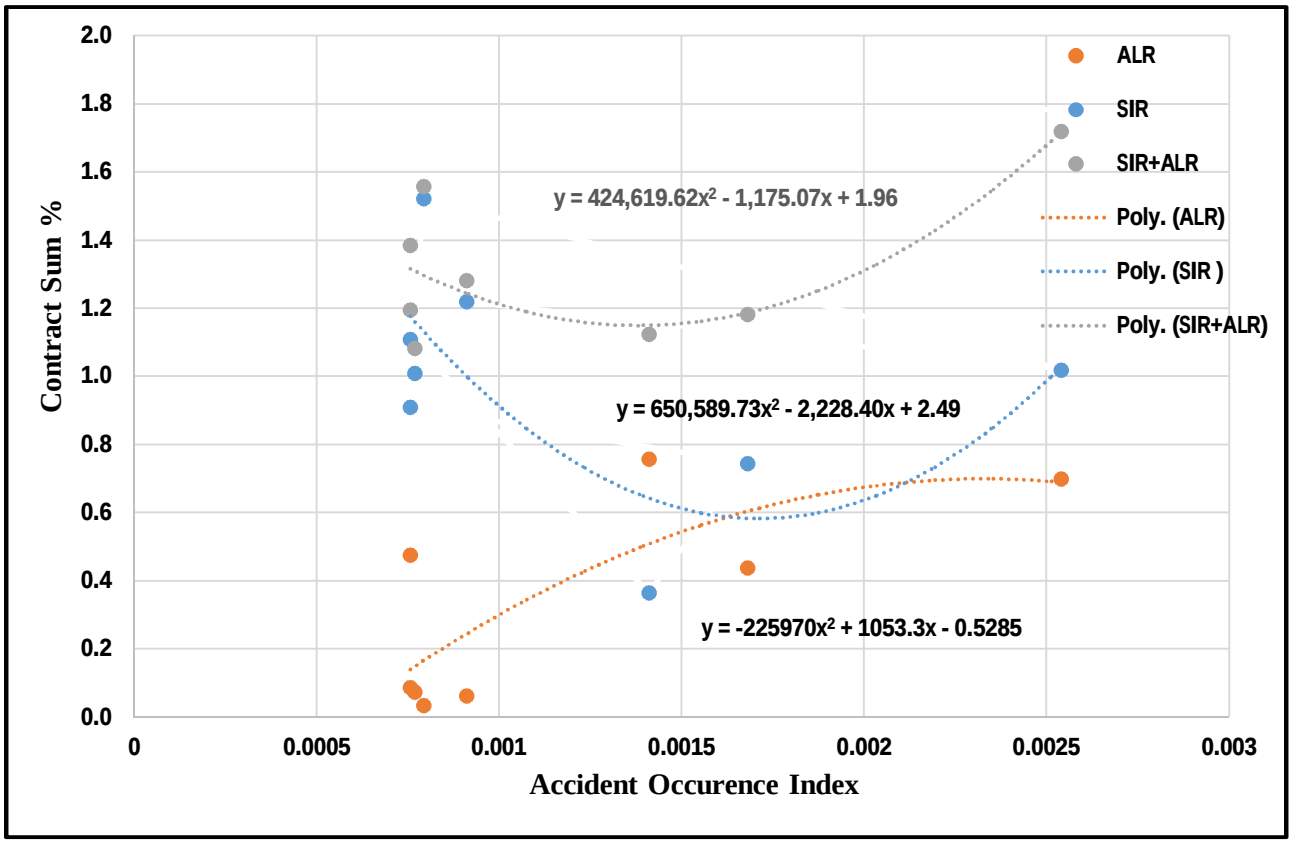


Figure 4.1. Graphical representation of SIR, ALR & SIR+ALR

1) For SIR $y_1 = f(x) = 650589.7x^2 - 2228.4x + 2.49$

2) For ALR $y_2 = f(x) = -225970x^2 + 1053.3x - 0.5285$

3) For SIR+ALR $y = f(x) = 424619.6x^2 - 1175.07x + 1.96$

To know about minimum point on total cost curve we have to find out derivative of total cost curve equation y = f(x) with respective to x.

Equation of trend line for SIR+ALR;

$y = f(x) = 424619.6x^2 - 1175.07x + 1.96$

Taking Derivatives of y = f(x) w.r.t "x";

We get; $dy / dx = 849239.2x - 1175.07$

Now equating the first order derivative of y with zero;

$dy / dx = 0$

$849239.2x - 1175.07 = 0$

$x = 0.00134$

i.e. Accident Occurrence Index (x) = 0.00134

Now, Put value of x in equation of trend line for SIR+ALR;

We get;

$y = 1.148$

i.e. Value of minimum point on total cost curve is 1.148%.

The minimum value of y (i.e. total costs ratio) was found to occur at x (i.e. accident occurrence index) = 0.00134. For this the minimum total cost is 1.148% of contract sum.

To know the component of safety investment in the total cost,
Put value of AOI (i.e. x coordinate) in trend line equation of SIR.
Equation of trend line for SIR;
$y_1 = 650589.7x^2 - 2228.4x + 2.49$
Put value of x = 0.00134
We get;
$y_1 = 0.672\%$
i.e. the component of safety investment is 0.672% of contract sum.
To know the component of accident loss in the total cost,
Put value of AOI (i.e. x coordinate) in trend line equation of ALR.
Equation of trend line for ALR;
$y_2 = -225970x^2 + 1053.3x - 0.5285$
Put value of x = 0.00134
We get; $y_2 = 0.48\%$
i.e. the component of accident loss 0.48% of contract sum.
From the above analysis the minimum safety investment on a building project is found to be 1.09% of the contract sum whereas the cost of accident loss is found to be 0.48%.

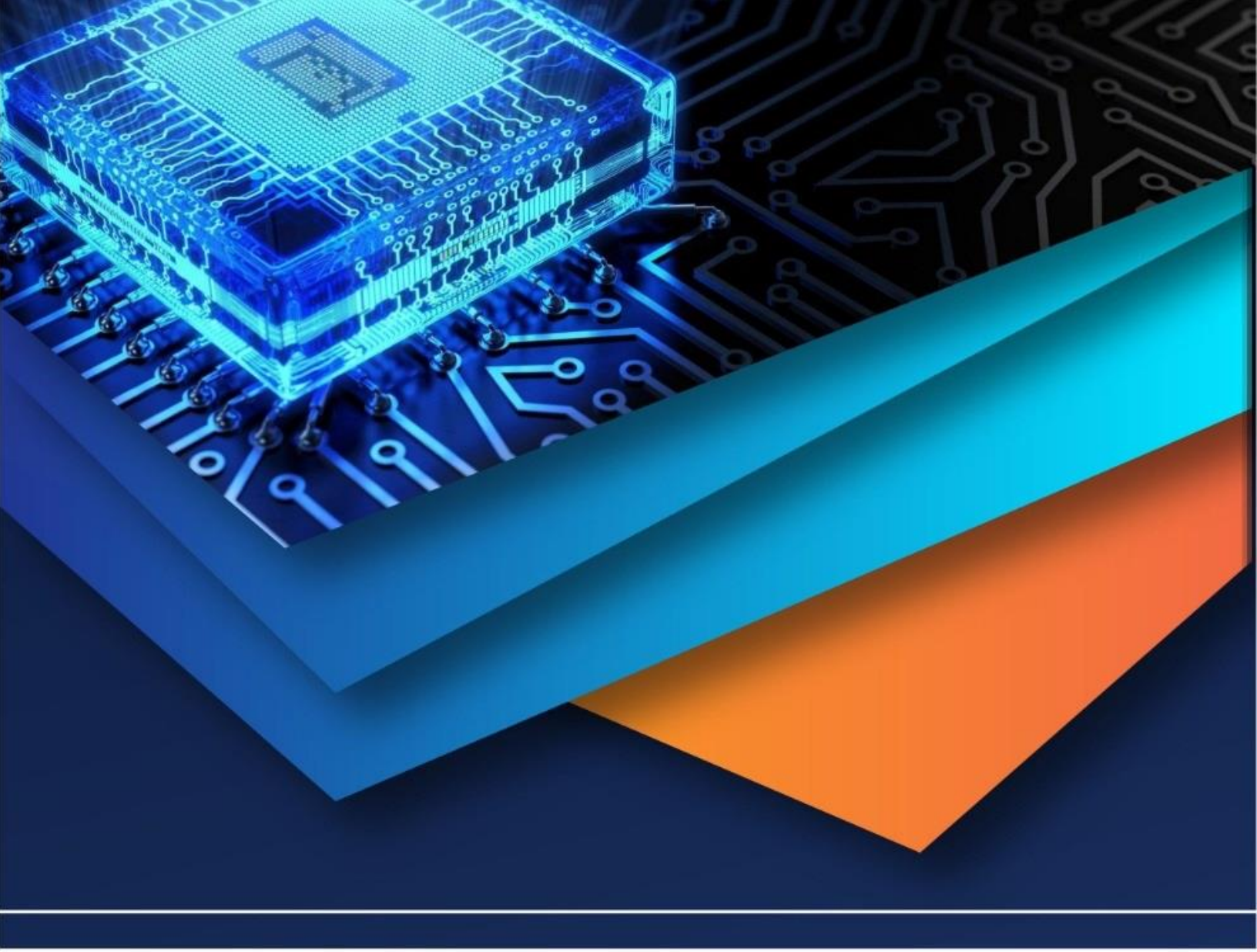
VI. CONCLUSION

An estimation of 0.672% of the contract amount was found to be the optimum safety investment for a construction project. It was found that the overall cost to the contractor (accident loss plus safety investment) was 1.148% of the total contract amount. It isn't intended to suggest the scary assumption that 0.672% is the optimum value and that a safety investment higher than 0.672% is not necessary. In actuality, 0.672% needs to be thought of as the very minimal amount to invest in safety in a construction project. Even though they are not taken into account in this mathematical model, abstract benefits like increased worker confidence, a better company reputation, increased job satisfaction, and so forth will result from a safety investment greater than 0.672% and will undoubtedly be valuable assets to the contractor.
The purpose of the graphical representation is to demonstrate the effect of safety investment in a project on the severity of accidents and accident loss occurrences on site, which ultimately reduces the contractor's profit margin. The main goal of the graphical representation is to understand the importance of safety investment in terms of both tangible and intangible benefits such as greater peace of mind for workers, a better image of the organisation in the market, and greater job satisfaction for employers and employees, as well as monetary benefits such as increased profit margins.

REFERENCES

[1] Aibinu, A.A. and Odeyinka, H.A. (2006), “Construction delays and their causative factors in Nigeria”, Journal of Construction Engineering and Management, 132 (7), 667-77.
[2] A. V. Praveen Kumar, C. K. Vishnuvardhanm.Eii Year M.E., (CEM), “A Study on Construction Jobsite Safety Management,“International Journal of Innovative Research in Science, Engineering and Technology An ISO 3297: 2007 Certified Organization, Volume 3, Special Issue 1, February 2014.
[3] Bima Abubakar Muhammad, Ismaila Abdulateef, Baba Dorothy Ladi “Assessment of Cost Impact in Health and Safety on Construction Projects”, American Journal of Engineering Research, Volume-4, Issue-3, pp-25-30.
[4] Dheeraj Benny Assistant Professor, Department of Civil Engineering, SRM University, Chennai, India , D. Jaishree Assistant Professor, “Construction Safety Management And Accident Control Measures’’ International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 4, April 2017, pp. 611–617 Article ID: IJCIET_08_04_069.
[5] Eugenio Pellicer, Gloria I. Carvajal, M. Carmen Rubio, and Joaquín Catalá, "A Method to Estimate Occupational Health and Safety Costs In Construction Projects", KSCE Journal of Civil Engineering, July 2014. Evelyn Ai-Lin & Yingbing fen(2013).“Effect of Safety Investment on Safety Performance for Building Projects” ,Safety Science 59(2013),28-45.
[6] G.Emre Gurcanli (2016). “Activity based risk assessment and safety cost estimation for residential building construction projects”, Journal of safety science, 80(2015),1-12
[7] M. Lopez-Alonsoa,, M.P. Ibarrondo-D´avilab and M.C. Rubioa,' Safety cost management in construction companies: A proposal classification' IOS Press and the authors, Work 54, (2016), pp-617–630.
[8] Mohd Saidin Misnan, Zakaria Mohd Yusof, Sarajul Fikri Mohamed, Norazam. Othman, "Safety Cost in Construction Projects", 3rd International Conference on Construction Industry, April 2012.
[9] Nicholas Chileshe (2012), “Benefits barriers of construction health and safety management (HSM)”,Journal of Engineering ,Design and Technology,10(2),276298.

[10] Peckitt, Steven J, Glendon, A.I, Booth, R.T., "A Comparative Study of Safety in Culture the Construction Industry of Britain and the Caribbean: Summary of the Findings", Aston University and the Health and Safety Executive, 2001.
[11] Riza Yosia Sunindijo, "Improving Safety among Small Organisations in the Construction Industry: Key Barriers and Improvement Strategies", the 5th International Conference of Euro Asia Civil Engineering Forum, Procedia Engineering, 2015.
[12] Tang S.L., "Financial and Social Costs of Construction Accidents" Civil and Structural Engineering Department, The Hong Kong Polytechnic University, Hong Kong.
[13] W.A.Asanka1* and M. Ranasinghe2 1AMIE(SL), ICE(grad), "Study On The Impact Of Accidents On Construction Projects. 6th international conference on structural Engineering and construction Management 2015,Kandy Sri lanka.11th -13th December 2015.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)