

Case Study of Accidents Related to Fall from Height in Indian Coal Mining Industry: An Analysis

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Abstract-The accident rate of the Indian mining industry has been declining in recent years in number only. However, the fatality and injury rate in mining is also unacceptable like other safety critical industries. Taking 2014 as an example, there were 84, 30 and 5 fatal accidents involving 87, 32 and 5 fatalities in coal, metal and oil mines, respectively. Similarly in the year 2013 there were 82, 57 and 3 fatal accidents in coal, metal and oil mines respectively. Fatality due to fall from height is less, it's about 9% during the period 1973-2014. But when cause of serious accidents were considered its percentage increased to 45% during the same period. Invariably such falls of person from height results in serious injury or some time tragic death. In this paper, 41 years' fatal and serious accident data from Indian coal mines were analyzed from 1973. The rate of serious accident shows a random trend from 1993 to 2014. Though all the serious accidents were reported, investigated and recommendation were made for preventing recurrence, there is no further reduction in the total serious accident rate as well as serious accident due to fall from height in last 21 years which reveals the gaps in our safety management system, working procedure, investigation procedure etc. An effort has been made in this paper to highlight the gaps through accident data analysis and a real case study. Lessons were learnt and suitable control measures are taken to ensure that similar accidents will not recur.

Index Term- Accident, Coal mine, Fall from height, Fatal accident, Fatality, Injury, Serious accident.

1. Introduction

THE Health, Safety, and the Environment (HSE) defines an accident as "an unplanned event that resulted in injury or ill health of people, or damage or loss to property, plant, materials or the environment or a loss of business opportunity" [9,10]. Mining industry and related energy resource industries are associated with high rates of occupational injuries and fatalities. Mining is one of the hazardous work environments in most of the countries around the globe [7, 21].

In Indian mines, accidents are still continuing at some disturbing rate as on date. Failed defences, human factors, environmental / workplace conditions and organisational failure results into most of the accidents.

Identification of such factors responsible for some direct failure may play an important role in accident prevention. Mining is one of the highest accident rated industry [5, 6]. Fatality rates in the coal mining sector were much higher in India. In the year 2014, there were 84, 30 and 5 fatal accidents involving 87, 32 and 5 fatalities in coal, metal and oil mines, respectively. The number of fatal accidents during the previous year 2013 were 82, 57 and 3 for coal, metal and oil mines respectively. The trend in 10-yearly average number of fatal accidents and that of fatality rates per thousand persons employed from 1901 to 2014 for coal and non-coal mines are shown in Figure 1. A consistent decline is observed for coal mines, in the 10-yearly average number of accidents and fatalities per year since the 1930s. In the last ten yearly average during the period 2001-10 have slightly decreased in number of accidents and fatalities and the last four-yearly average have fallen significantly during the period 2014. In case of non-coal mines the trend of average number of accidents and fatalities have remained nearly same during the period from 1950 to 1990 after that it slight increased and from 2010s it started decrease. As compare to non-coal mines, the coal mining industry is associated with high rates of occupational injuries and fatalities [5, 6].

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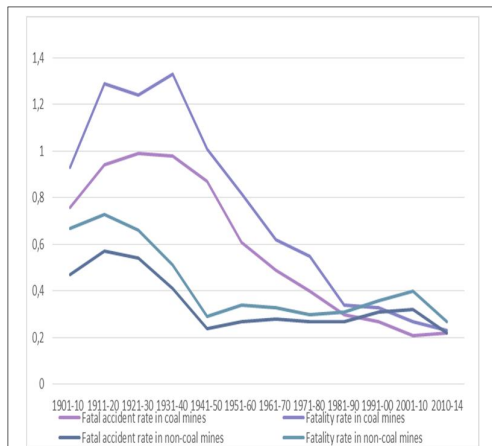


Fig. 1. Trend in fatal accidents and fatality rates per 1000 persons employed (Ten yearly averages) in Indian Coal and Non-Coal mines

2. Causes of coal mine fatal accident and its analysis

The causes of coal mines fatal accident were analysed for the last 41 years (since nationalization of Indian coal mines), and it is clearly observed that there are five major causes, such as Ground movement, Fall other than fall of ground, Transportation machinery (other than winding), machinery other than transportation machinery and explosives which contribute to almost 90% of the total accident. That is why we divided the cause of the accident into five groups and rests of causes are in one group.

Accidents due to ground movement contributed 40%, transportation of machinery (other than winding in shaft) contributing 31% along with Machinery Other than Transportation Machinery, Explosive and Fall (other than the fall of Ground) which contributed 7%, 3% and 9% respectively.

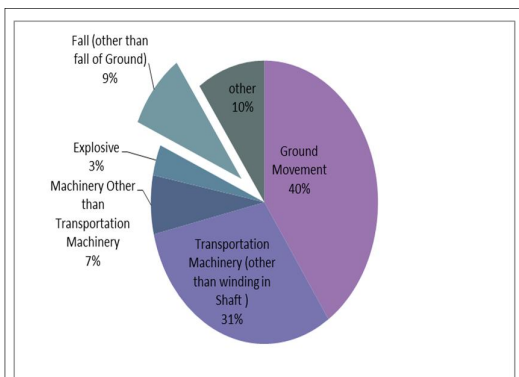


Fig. 2. Cause wise fatal accident in Indian coal mines from 1973-2014

2.1. Observations

The accident due to ground movement accounted for about 40% of all fatal accidents during the 1973-2014. The numbers of fatal accidents due to ground movement involving roof fall and side fall accidents are 2295 during this period.

Transportation Machinery (other than winding in Shaft) caused 1753 number of accidents which resulted in 31% of total accident during the same period.

Machinery Other than Transportation Machinery, Explosive, the fall (other than fall of Ground) and other resulted into 380, 199, 495 and 550 numbers of accidents which is equivalent to 7%, 3%, 9% and 10 of the total accidents respectively during this period.

3. Causes of coal mine serious accident and its analysis

When cause of serious accidents were analysed for the same period (1973-2014), the result was shocking and thought-provoking, that is the cause fall other than fall of ground which contribute 9% in fatal accident and 45% in case of serious accident. That is why we divided the cause of the accident into two groups, one is fall other than fall of ground and rests of causes are in one group.

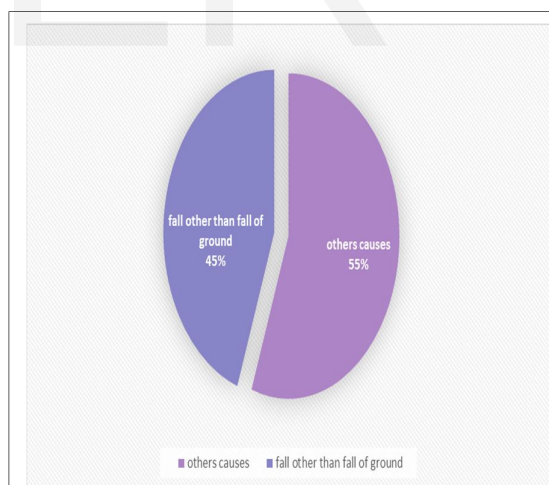


Fig. 3. Cause wise serious accident in Indian coal mines from 1973-2014

Fall other than fall of ground includes fall of person, fall of object and other fall among these three sub causes the fall of person is the most dominant cause. Fall of persons, the dominant cause of serious accidents, accounted for about 33% during the year 2014 as shown in figure 4.

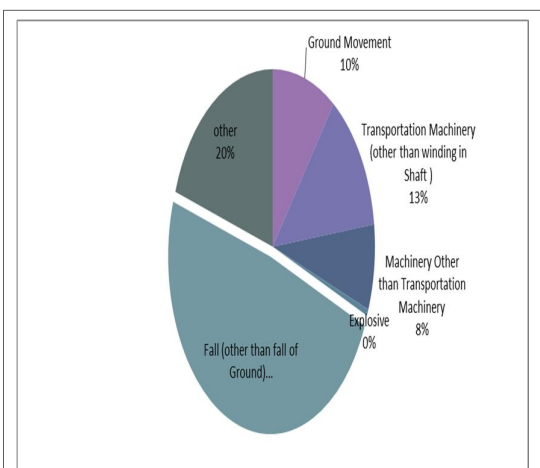


Fig. 4. Cause-wise distribution of serious accidents in coal mines during 2014

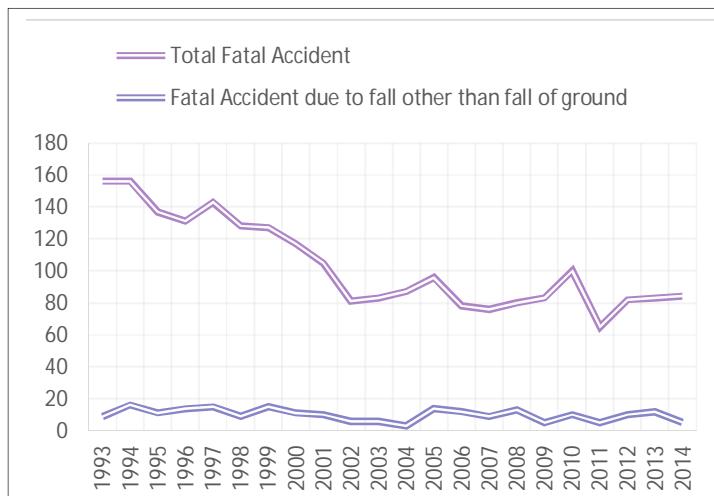


Fig. 5. Trend in total fatal accidents and fatal accidents due to fall (other than fall of ground) in Indian Coal mines

3.1. Observations

From the figure 2, 3 and 4 we observed that

The numbers of fatal accidents due to fall other than fall of ground involving fall of person, fall of object and other fall accidents are 495 during the year 1973-2014. Fall of person and fall of object accounted for about 9% of all fatal accidents during this period.

But the same cause contributed 45% in case of serious accident during the same period. There are 6577 number of accidents due to fall other than fall of ground which is a matter of serious concern.

During 2014, highest percentage of serious accidents was due to fall other than fall of ground and it was about 49% in which fall of person caused 33.23% and fall of object accounted 15.13%. It was followed by other causes about 20%, transportation machinery (other than winding in Shaft) about 13%, ground movement about 10 and machinery other than transportation machinery caused 8%.

4. Analysis of accidents due to fall other than fall of ground

Last twenty one years of fatal accident data due to fall other than fall of ground of Indian coal mining industry have been further analyzed. The rate of accidents per year due to fall other than fall of ground since 1993 have been plotted in figure 5.

4.1. Observations

- There was a reduction in the total number of accidents in the period from 1993 to 2002 (156 to 81)
- The trend was almost flat for the next three years, then graph slight decrease in year 2006 and again increased to 100 in the year 2010.
- But in case of fatal accident due to fall other than fall of ground is almost flat throughout the period from 1993 to 2014.

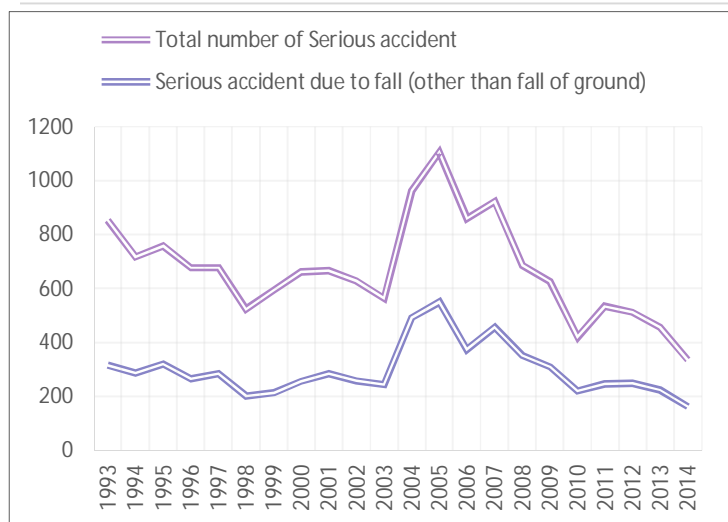


Fig. 6. Trend in total serious accidents and serious accidents due to fall (other than fall of ground) in Indian Coal mines

In figure 6, both serious accident and injury number are in a random trend starting from 1993 to 2014.

5. Case studies

In this section a real case study accident (Fatal accident due to fall of person from height) has been reviewed to examine the nature of causes identified leading to the accident. Brief description of the accidents and the identified causes including responsibilities are described.

5.1. Brief description of the accident

In an open cast mine, two workmen of a contractor were working on a screen assembly at a height of 9.5m from ground level without being secured by safety belt during replacement of the screen assembly, one workman lost balance due to slight jerk in the screen assembly, fell down over classifier on ground level, received serious injuries to which he succumbed at the end, and another person escaped unhurt.

5.2. Identified Causes

The screen assembly replacement work was not being properly supervised and proper safety belt was not used by the worker.

5.3. Responsibility

The investigator held the Contractor, Sr. officer-mechanical and shift In-charge, Sr. Manager-Mech. & Shift In-charge and the Supervisor responsible for the accident.

5.4. Gaps

The investigation didn't reveal the following and raised a few questions

- Whether there was any documented procedure for working at height?
- Why the person failed to use fall protection device?
- Whether the contractor workers were trained and competent to undertake such work at height?
- Whether a suitable Personal Protective Equipment (PPE) for protection against fall from height (safety belt) were provided?
- Whether the mine had a culture of using fall protection devices while undertaking such work?
- Why the supervisor failed to ensure the contractor worker to use the safety belt?

- Whether adequate supervision was provided in the shift?
- Whether there was any system of proper communication to the supervisor about the job of the contractor's worker in the shift?
- Whether the role and responsibility of senior officer mechanical, senior manager mechanical, supervisor was examined during the investigation before fixing responsibility?

In absence of proper investigation into such issues as mentioned above, the underlying causes against the direct causes of lack of supervision and not using PPE, could not be unearthed.

6. Finding of the gap analysis

The summary of the findings on the gap analysis of the case study are as follows:

- Serious accidents due to fall from height are of very common and repetitive in nature.
- In most of the cases, human behavior or unsafe act was identified as main cause and persons who were directly involved in the accidents, including the deceased, were held responsible for the accidents.
- The direct causes were identified to be the causes for accidents and no efforts were made to identify the latent, indirect or underlying causes
- The organizational factors like task condition, supervision, risk assessment and development of safe work procedure, ensuring competency for performing a job etc. were not examined while identifying causes of the accidents.
- The basic theory of causation of any accident as unplanned and uncontrolled energy was overlooked.
- Risk assessment was not carried out before all the routine or non-routine type of activities and adequate controls were not identified or in place before undertaking such job.
- Lack of skill, competency and fitness for duty of the operators or work persons was not examined.
- Human error or non-compliance of statutory provisions was identified as causes of accidents in most of the cases. But what led to human error or non-compliance were not examined.

- The real objective of accident investigation through identification of root causes and implementation of corrective measures could not be achieved through such superficial accident investigation.
- There is not only a strong need to identify the root causes of this type of accidents but also need to review the effectiveness of existing procedure for working at height and introduce the new technology and concept of reducing the probability and consequences of the accidents.

7. Discussion

From the analysis, injury rates in the mining sector due to fall from height were much higher than those in other causes in India. In 2014, 49% of serious injury was due to fall from height in the coal mining industry. A primary reason for these kinds of serious injury is an increased level of workplace exposures to hazards. These significant rate could be related to organisational failure like Less than adequate (LTA) working procedures, LTA hazard identification, LTA training etc. and their relative lack of experience in working at height which is unique to the mining industry.

One important finding in this study is the opposite relationship between rate of fatality and injury rate due to fall other than fall of ground. There are a number of probable reasons why the injury rates increase due to fall from height in mining industry. First, the trends might be related to differences in job tasks and hazard exposure. Workers may be more likely to work in a job task that exposes them to the kind of hazards that result in injury / fatalities.

Most of these serious and fatal accidents are directly caused by the few common causes as given below:

- LTA working procedure
- LTA risk assessment procedure
- LTA training program
- Workers failed to use personal fall protection equipment
- LTA Competency of the worker
- Poor culture (like normalization of abnormal condition, risk taking behavior, ignorance etc.)
- In-effective learning system.

Furthermore, a standard procedure for a safer system of work for working at height in mines must be developed and implemented by the Mine safety management system. This includes a comprehensive risk assessment before and after

the work, planning a suitable work method, setting out the required safety measures and safe working processes, as well as providing all necessary safety instruction, information, training and equipment. The work should be supervised to ensure compliance with the relevant safety procedures.

8. Conclusion

From the analysis of limited statistic of accidents due to fall from height and the case study accident, it is revealed that the rate of serious accident due to fall from height is a major contributing factor. More alarming is the fact that the rate of accidents due to this cause is follow an uncontrolled trend over the period. In spite of all the actions deriving from the investigations, things have not been improved. Complete elimination of working at height is an ideal strategy, rather it may increase in the future. It is essential to learn from the past accidents [4, 23, 1, 8, 11, 12, 13, 14, 15, 20, 22]. In most of the cases serious accidents are not even investigated and if investigated, it is an in-effective one. But through the case study, it is revealed that accident investigation in Indian mines is mainly focused at human error or non-compliance of statutory provisions [2, 3]. In most of the cases only the direct causes have been identified to fix responsibilities and making recommendations [2, 3, 4] that is why similar accidents are repeated [10, 16] over the years.

The following recommendations are proposed to prevent re-occurrences of such accidents in the future:

- All accident must be investigated properly to identify the root causes and develop suitable and effective recommendation and prepare a comprehensive incident report in each case of accident. The report must cover the background information, scenario, the possible cause(s) and the recommendation(s). Wherever suitable, lesson should also be prepared to improve safety training and awareness in order to prevent from recurrence of similar type of accidents.
- The system must work more safely with standard working procedure at height which includes some major issues like work permits, risk assessment, falling objects, work on roofs, fall-arrest devices, scaffolding, design of scaffolding etc.
- A safety environment must be established in order to "correct" the safety attitude, risk taking behavior, of the workers such

that safety performance of working at height can be improved.

- Supervisors must provide supervision for the un-routine works, critical works etc.
- Workers must be provided with adequate and appropriate safety equipment such as safety harness with fall arrestor and an independent lifeline.
- Clearly written and updated working procedures and guidelines must be provided.
- An initial training must be given to all new employees regarding the working procedures and guidelines, propose use of PPE, proper use of ladders and others safety equipment.

This will fill the gaps in the existing system resulting into the prevention of similar accident or incident. Thus these will continual and sustainable improvement in the health and safety management system of the mining industry.

Conflicts of interest

All authors have no conflicts of interest to declare.

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