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A step towards accident prevention: a pre-warning signals analysis

Although, there are a number of safety management systems available but the near-misses, dangerous occurrences, incident and accidents occur every day and it became worst and known to be a major concerned in mining industry. In this paper, a coal mine accident has been analysed which showed reoccurring disturbances during routine operation were present in the contributory path of the accident. The reoccurring disturbances were the warning from the system toward the organisation and could be seen as pre-warning signals. It is necessary to investigate all the pre-warning which are unknown, as well as to identify all the underlying causes. As a result suitable action can be taken against them for the prevention of accidents in future.

Keywords: Accident investigation, pre-warning signals, safety indicators, risk assessment

1. Introduction

In this day and age, workplace accident occur every day and it became worst and known to be a major concerned in almost all types of industry (Rahman et. al, 2014). Mining is a hazardous profession and considered as war against the unpredictable forces of nature. As a result, the mining industry continues to be associated with a high level of accidents, injuries, and illness (Maiti et al., 2004). Accidents in mines are still continuing at some disturbing rate. The failure of people, equipment, or surroundings to behave or react as expected, results in most of the accidents. Identification of different factors responsible for such failure may play an important role in accident mitigation (Paul and Maiti, 2001). Even if several safety measures applied in mining industries, accidents cannot be prevented. We should learn from past accidents and incidents. From the past accidents investigation data knowledge was gained in finding better ways to control risk. Every industry demands that they offer their first priority to safety that is "Safety first". If so, then why do accidents still occur despite the numerous methodologies? Normal accident theory (Perrow, 1984) suggest that accidents keep occurring because the learning process is handicapped (Lagadec, 1997). Multi-level failure leads to an accident. Before any accident there must be some pre-warning that were normalized and ignored by workers/management which latter on leads to the accident. Warning (indicator) should be treated as pre-warning signals for likely accidents and mitigating action must be taken in time to prevent possible accident.

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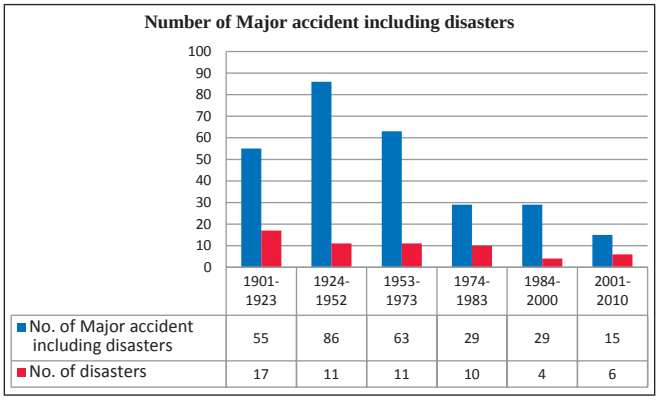
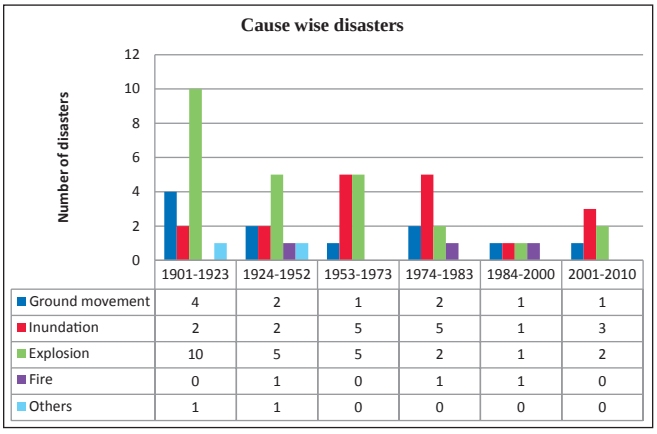
2. Brief overview of mining safety statistics of Indian coal mines

This section provides an overview of the safety record of the mining industry. The focus is on the Indian coal mining industry for which the following data have been collected from the Directorate General of Mines Safety (DGMS report).



	1901-1923	1924-1952	1953-1973	1974-1983	1984-2000	2001-2010
No. of Major accident including disasters	55	86	63	29	29	15
No. of disasters	17	11	11	10	4	6

Fig. 1: Number of major accidents including disaster from 1901-2010



	1901-1923	1924-1952	1953-1973	1974-1983	1984-2000	2001-2010
Ground movement	4	2	1	2	1	1
Inundation	2	2	5	5	1	3
Explosion	10	5	5	2	1	2
Fire	0	1	0	1	1	0
Others	1	1	0	0	0	0

Fig. 2: Cause wise disasters in Indian coal mines from 1901-2010

3. Observation

- In coal mines, major concern is the occurrence of disasters at regular intervals, mostly in the underground mines.
- Disasters due to explosion have been controlled in the last two decades.
- The frequency of disasters due to inundation has been alarmingly increased in the recent past.

4. Case study: The Bagdigi mine disaster

In this section, we analysed one underground coal mine disaster due to inundation. It is observed from the Bagdigi mine disaster that there were certain per-warning signals before incident. If those per-warning signals would have been identified in time and action could have been taken then we could able to avoid that incident.

Brief description

The 1st shift workers were engaged in working of the VII seam of the mines along with the manager and assistant manager. The plan of the VII seam before and after the accident is presented in the Fig. 3. There was a sound of loud explosion followed by gushing of water. The workers were taken by surprise. Some of them were able to escape through cage but other could not. Within the moments, the level was completely submerged with water and those workers who could not escape, were trapped inside. The workers who were able to come out from the mines alerted the management. The rescue and recovery operation continued. Dead body of 29 people could be recovered.

Pre-warning signals

Pre-warning signals were defined as measurable disturbances in the working process that permit an organisation to counter in time and take corrective measures to prevent a likely accident from happening (Korvers, and Sonnemans, 2008).

The followings are the causes of the Bagdigi mine disaster including few pre-warning signals as observed by the court of inquiry of GOI (Court of Inquiry Report).

1. There was an abnormal seepage of water. Increase in the seepage of water indicates the decrease in the thickness of the barrier between the water resolver and the underground working.
2. There was a regular complain about increase in the seepage of water.
3. The workers met the manager, demanded gum-boots on account of inconvenience faced during the work due to accumulation of water.
4. Similar type of accident (inundation) happened 6 years before the disaster (i.e. 1995).
5. The surveyors' team used to complain about the defective survey machine.
6. Ignoring the caution from DGMS withdrawing permission to work in that area.
7. Ignoring the fact of reducing gradient of the seam along dip direction.

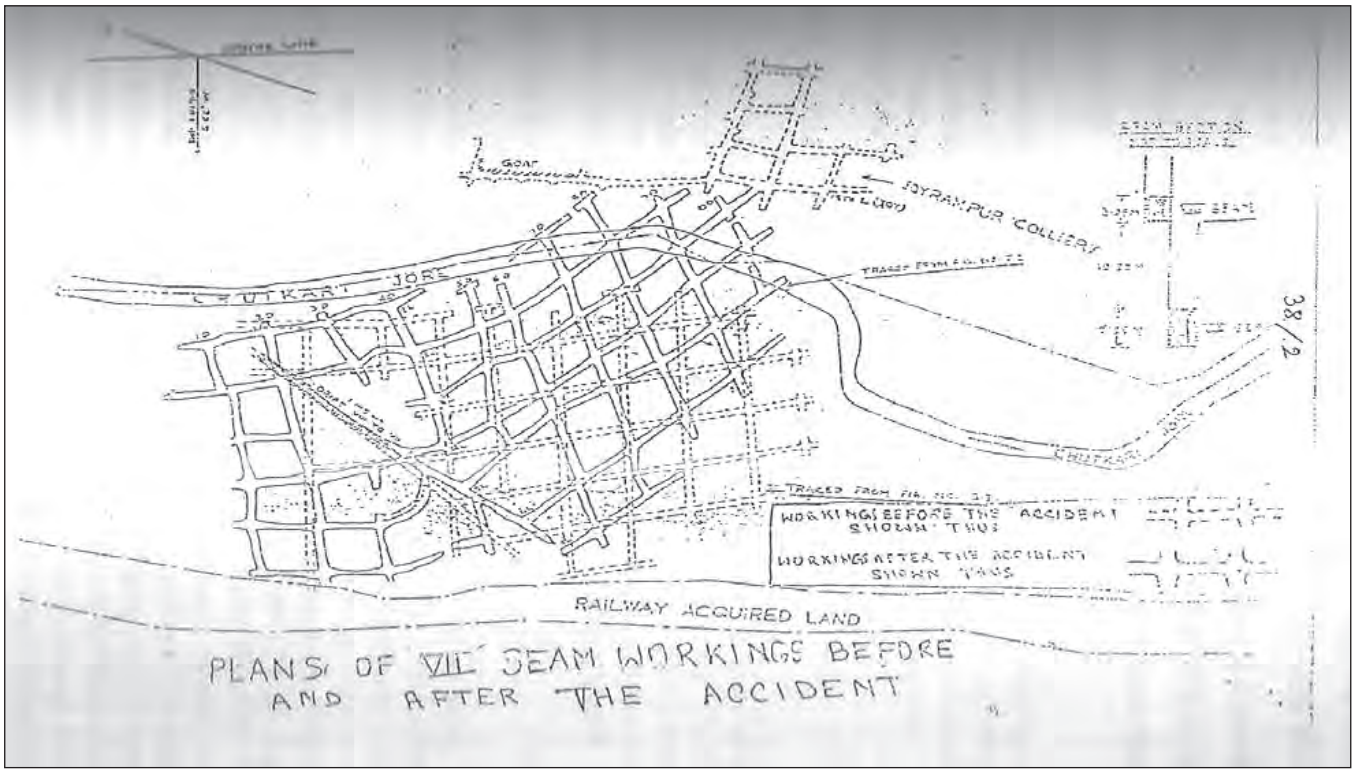


Fig. 3: Plan of working of VII seam before and after the accident (Nath, 2008)

Analysis of the pre-warning signals

From the case study accident report, several pre-warning signals were ignored to normalise the conditions due to which the accident happened. According to Heinrich (1959) and Turner (1978), failures or disruptions in normal operations are present prior to an accident. It is necessary to take care of all the pre-warning signals of the accidents, in order to react in time and space to prevent a possible accident. We can avoid all the possible accident by removing the latent causes in time and space at the sharp end of the accident (Korvers, and Sonnemans, 2008).

In 2001, one level of the mine was submerged due to inundation. It is clear from the court of inquiry report that the inundation occur through a causal path as depicted in Fig. 4.

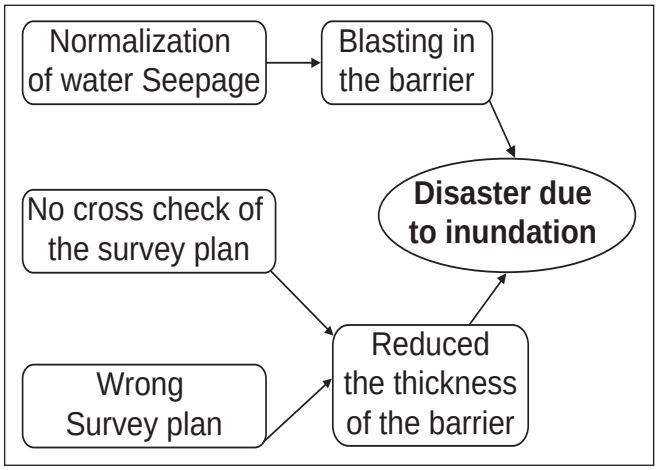


Fig. 4: accident causation diagram

Fig. 4 reveals that the disaster occurred due to two different routes:

a. Poor work culture like ignorance and normalization regarding seepage of water led to normalize the abnormal seepage of water to continue the production by allowing the blasting in the face without any risk assessment. The continuous blasting decrease the thickness of the barrier that ultimately resulted in the inundation.

b. The other latent causes like no cross check of the survey plan and wrong survey plan led to reduce the thickness of the barrier which at last caused the disaster in the mine.

As per the court of inquiry of the disaster the survey plan of that mine was incorrect and the surveyors' team complained about the defective survey instrument several times prior to this accident. But not even once the management responded to these problems. Mines management did not verify the accuracy of the plan. If the management could have taken care of the problems then the disaster might be avoided.

The abnormal seepage of water was ignored by the higher authority and management to normalise the working condition. Six years before a similar accident took place in the same mines. It indicates that the management did not learn from their past accident. If a risk analysis was done by the management about the seepage of water, then accident could be prevented. Hence all the workers would have been rescued from the underground workings prior to the accident. Therefore, disaster could have been turned to a not fatal dangerous occurrence.

During the analysis of investigation report, it clearly observed that focus was centralized on the known "safety related" events, like inaccurate survey plan. But the routine operations in which (indirect safety) these normalisation of the abnormal conditions, ignoring behaviour or risk taking behaviour had not been identified possibly might have been relevant regarding safety. Finally, these pre-occurred events caused a similar accident (repetitive) only this time with huge consequences.

The fact that the past accident was not analysed thoroughly. Here indirect safety related event that reoccurred were normalisation of the seepage, violation of the rule etc. even if this information was not used in the construction of proactive safety indicators, but it was clearly pre-warning signals for the serious accident that finally took 29 workers' life. The events like abnormal seepage of water, accumulation of water, complain about defective survey instruments, etc. were the safety indicators. But how the management failed to receive these indicators?

5. Practical considerations

In practise, a lot of data are available from routine operations, like failure of equipment, maintenance backlogs, rep orts about seepage, reports about scarcity of resources, etc. However, it is a challenging task to acknowledge the pre-warning signals properly in the routine working process. The major problem is that these events may arise in many different ways among many other reoccurring disturbances that really have no impact on safety at all. It would be practically very difficult to identify the proper warning and predict the accident among all the disruptions from daily operation. As the risk of a re-occurring event was unknown, its cause was neither identified and analysed further, nor eliminated. So the event could happen over and over again, finally leading to the accident. To predict the possible accident from the pre-warning signals required additional knowledge, skill and experience in the safety assessment of the information.

6. Discussion

According to Kletz (1993), some events keep occurring

again and again. Sometimes that leads to an accident. It is not only sufficient to identify these events but also equally important to address all the underlying root causes properly to prevent the possible accident. As per accident reports, the investigation is centralised around the rules and regulation (rule based investigation) which the management or workers violated. According to Rasmussen (1997) the absence of accident investigation reports not going into underlying causes of an accident by saying; ''there is a tendency to see what you expect to find'', as it was also stated in Bourrier (1998). Accident investigators are often carried out by safety experts and people from justice departments. They mainly focus on safety procedures and activities that have been violated. Rasmussen (1997) stated; ''when rules, laws, and instructions, which are practically speaking never followed by the letter, are judged by these investigators, focus will be on blame fixing and not on the events happening during normal operation''. Where focus should actually be (Korvers, and Sonnemans, 2008), accidents are the result of multiple causes or defects in the system (OSHA, 2013). Generally there are some pre-warning signal prior every accident. If the system itself can be able to identify the pre-warning signals properly then it can be avoided in time.

In this study the pre-warning signals analysis has been done from a hindsight perspective only. From the case study report, it is clear that disruptions are often present in accident trajectories. Subsequently, it is striking to see that the disruptions are not used for constructing pro-active signal indicators neither are they highlighted in accident investigation reports as pre-warning signals. The pre-warning signals are intended to point out likely safety risks during or before any operation and they are constructed in numerous ways like from historical data, abnormal conditions, knowledge, etc.

In this paper authors made an effect to prevent the possible accident by picking up the pre-warning signals. It can be concluded that the attention should be given on reoccurring disruptions which are present in daily operations, as they include indicators of potential accidents. Risk assessment must be done before normalizing the abnormal condition. Additionally, to effectively pre-warn organisations of prominent accidents, one should extend the body of knowledge involved in assessing these reoccurring events, to identify the safety vital ones among them.

Acknowledgments

The authors would like to express their sincere gratitude to the Department of Mining Engineering, IIT (ISM), Dhanbad for its help and support, and also to Directorate General of Mines Safety (DGMS) for their kind co-operation during the course of the study.

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