

Development of a proper method for identifying hazardous locations by assessing the track safety

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Abstract:

Railway traffic can be considered as a system that consists of three basic components that interact with each other, namely, the railway user (train drivers, operators in stations ,...), the vehicle and the track and its environment. An accident occurs when one or a combination of these components fails. The risk of a crash is not uniform throughout the railway network. At certain locations, the level of risk will be higher than the general level of risk in surrounding areas. Accident will tend to be concentrated at these relatively high-risk locations. Locations that have an abnormally high number of accidents are described as accident concentrated, high hazard, hazardous or black spot sites.

Track safety engineering plays a vital role in influencing driver behavior as engineering measures. In this sequence, the track and its environment should assist the driver in making a series of correct decisions and, if not correct, provide a forgiving track environment to reduce the severity of the accident. Track safety engineering can create such an environment by:

- Controlling the rate of decision-making to a level that a driver is able to accommodate
- Providing information to the driver in such a manner that it facilitates quick and correct decisions.

Track Safety Assessments forms part of a railway safety management plan. By assessing the track safety of the railway network, hazardous locations can be identified and prioritized, enabling a railway authority to spend funding in a focused way on railway safety audits and remedial measures at the hazardous locations.

According to existing statistics in Iran, 21% of accidents are related to track and substructure factors. Therefore, there is high potential for decreasing the number and severity of accidents by assessing the track safety of the Iranian railway network. In this paper, we analyzed the rail accidents in Iran and presented a suitable method according to track safety engineering, by comparing existing methods of other countries to detect high risk accident locations. Finally, we tried to adopt these methods to Iranian railway network.

Introduction

According to the researches made, the cause of accidents can be attributed to the complex interference of various factors including vehicle, manpower, route and environment. Each of these factors has got its specific features, which make related researches somewhat difficult and discreet. Some experts emphasize that implementing safeguarding plans which attempt to change people's performance and habits are problematic. They believe that safety improvement through engineering case operation (such as curves modification and determining optimized super elevation) shall be more efficient.

Safety engineering

Before studying specific safety issues, the fundamental concepts and definitions of safety engineering shall be taken into account. It should be noted that this issue can also be referred to for other systems dealing with human beings.

Risk and incident

The consequences of an incident may be the damage incurred to an individual, assets and environment or something like an incident. Therefore an incident is defined as an unexpected event that may or even may not incur injury or damage. But risk is described as the conditions having the possibility of incurring an incident or event. Figure 1 show the risk and incident consequences.

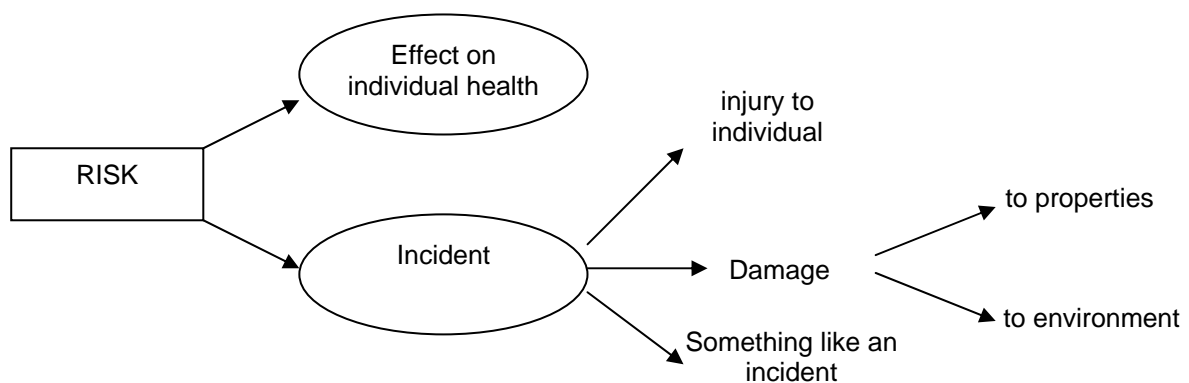


Fig 1- consequences of risk and incident

Danger is created by unsafe conditions and/or actions. Danger can last for a long time, without leading to an incident. It seems that passing through a threshold or border may give rise to the occurrence of an incident. For example there may be a pit on the street for a long time which causes no danger, but the sudden fall of the wheel of a car may lead to the lack of control by the driver and bringing about of an unpleasant accident. Unsafe conditions and actions are named as risk factors. According to figure 2, unsafe conditions are created due to imperperness of the situation and/or working system structure, whereas unsafe actions are individual defects which endanger safety and health of people. Therefore danger identification operation is the process of recognizing risk factors.

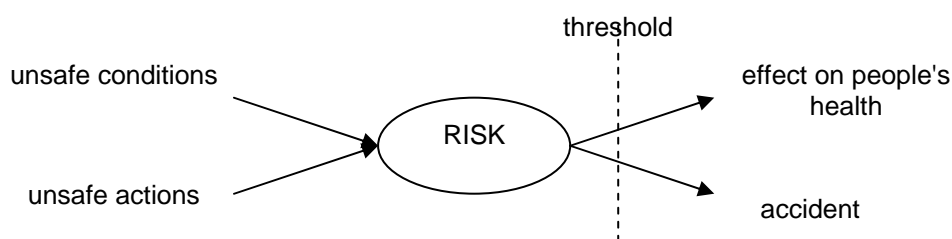


Fig2- Actions and unsafe conditions

Risk evaluation

Risk evaluation is the calculation of risks related to safety and health of the operation which is followed by taking necessary measures to remove and/or control the risk. If the evaluation shows that no risk threatens health and safety of the operation, its process has been complete and imposing cautious conditions may not be essential. Otherwise it is necessary to adopt some decisions to remove or control the risk. If it is logically reasonable, confrontation of people with any dangerous material or condition should be prevented. When it is not possible to prevent them, it seems necessary that the people's confrontation be discreetly controlled. In such cases the following items should be observed:

- Measures to be taken that create sufficient control
- Measures to be taken to implement considered measures correctly and continue this trend regularly
- It should be ensured that human factors involved have got enough education.

In order to perform risk evaluation, it is better to apply a group comprising of design and operation engineers, safety specialists and if required maintenance personnel, except for very simple evaluations.

Selecting method of safety evaluation

Decision making tree diagram (Fig 3) can be used to choose a proper safety evaluation method according to the type of the process and risk criteria.

When using the above diagram, the following definitions should be taken into consideration:

Hazard: the ability to cause damage to people, assets or environment

Frequency/probability: probability of occurrence of an event. The probability may be expressed in terms of frequency (number of events taken place in a specified time) and/or chance (chance of occurrence of an event in a specified time).

Population: number of people or units exposed to danger

Exposure: population * frequency

Consequence: the intensity of a damage and/or injury due to a danger which probability is high

Risk: exposure * consequence

Population and frequency of an event is generally classified from low to high and multiplication of these two factors specifies the degree of exposure.

The consequence of an event is also classified from low to high and the multiplication of consequence in exposure specifies the risk amount.

Traffic black spots

There is no assured definition about black spots. After evaluating the risk level and the probability of occurrence of an incident in specified areas, some are classified as black spots. The accident occurrence risk is not equal all over a network. In some specific areas, there is a higher risk than its adjacent places and accidents are usually concentrated at these high risk spots. Such points with several accidents are defined as black spots. Although a black spot points to a specific and exact area, it is often referred to a part of a route too. The exact identification of these points is difficult, because a lot of factors are

related to them. These factors include degree and type of risk, route specification, amount of traffic and intensity of accidents. The points which have potentially dangerous features are described as accident prone spots.

Classification of identification methods according to type of reaction

In a general classification, the identification of accident prone areas can be made either by reactive or proactive methods. Reactive method develops according to statistical data of the traffic amount, number and type of accidents. The accuracy of reactive method relies on a great extent to the accuracy of data collection and storage. This method can identify black spots. Proactive method is based on physical properties and operational conditions. In fact, safety of the operation in a route can be evaluated by means of key factors and the way of operations and hence the safety indicator can be identified. These methods require a lot of time, precision and also making use of safety experts. The result of these methods is a prioritized list of accident prone areas.

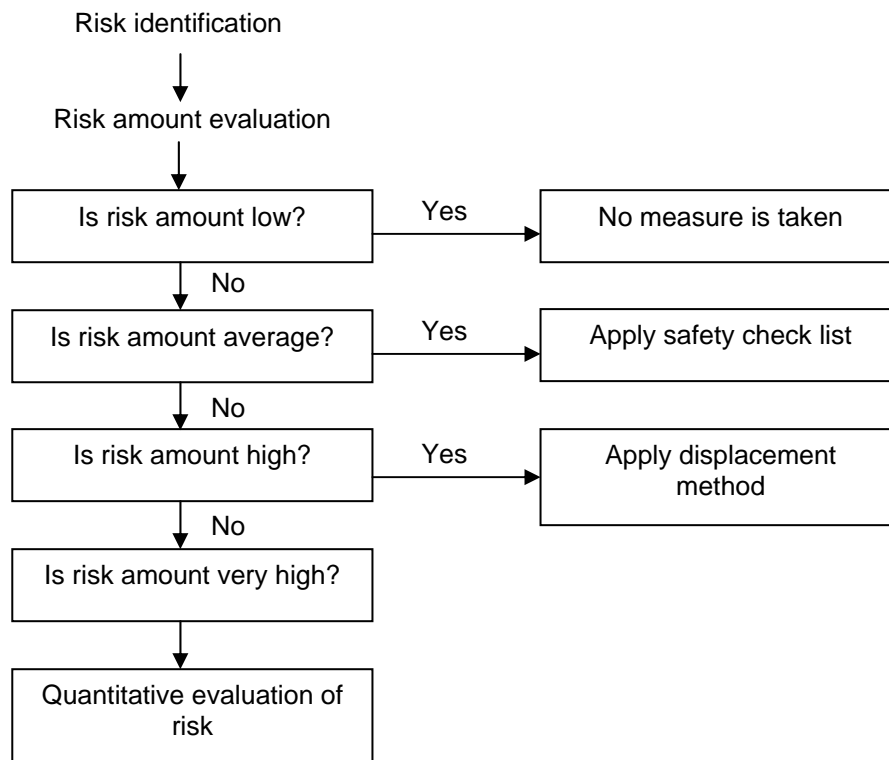


Fig 3- Selection of evaluation method

Targeting and grading of black spots

The activities pertaining to safeguarding black spots can be described as the activities carried out to improve safety through changing in environmental and geometrical properties of problematic areas in the existing network.

Such activities include identification and improving areas in the route with unusual and visible number of accidents. For example Visitsen (2002) explains that non-rail routes can be divided into three phases:

1. identification and determining black spots in the route
2. prioritization of these spots in order to improve them through safety corrective actions

3. Pre and post studies in order to survey the measures taken

Generally some parts of the route are graded according to the number of reported accidents. Those areas with more than a specified amount of accident are recognized as black spots. With regard that accidents are considered as rare and accidental phenomena that are related to other factors, it seems necessary to compare them in a specified place considering a constant duration of time (eg. one year). A 3 year period seems reasonable as the least necessary time to obtain the annual average rate of accidents.

Moreover there may be some accidents in a section of a route without any specific distribution. In such a case, it is necessary to refer to accident density, i.e. the number of accidents in km for that section of the route.

The spots or sections can be rated according to the accidents background by means of these indicators. The average amount of accidents in a year can be applied for a section, while the average accidents in kilometer in a year can be used for a specified length of the route.

If there is sufficient information about the cost of different accidents (fatal, injuring, damaging), they can be measured according to the costs incurred. In this case a fatal accident costs n times more than a damaging accident, n units can be used instead.

If information about costs cannot be obtained, quality weighting can be applied. For example in South Korea, the *Equivalent Accident Numbers* is applied for primary grading; coefficient 12 for fatal accidents, 3 for injuring and 1 for damaging accidents. Then according to the EAN amounts, a comparison is made between different places and then the grading can be made. In Belgium the following equation is used to determine accident prone spots that can be extended to rail routes according to type of train, passenger and freight traffic.

$$(1) \quad P = x + (3*y) + (5*z)$$

Where:

P: priority indicator

x: number of less important injuring accidents

y: number of severe injuring accidents

z: number of fatal accidents

Prioritization of black spots

Virtise (2002) explained that identification of hazardous areas aims at enhancing safety level of the network through performing corrective actions. Any positive effect due to safety actions in black spots indicate the advantages of such actions. Accomplishing safety measures is costly, but theoretically every action that creates positive net profit shall be executed. However the limited budget for safeguarding affairs of black spots is within the responsibility of the authorities, which restricts the areas to be modified. Therefore it is necessary that a prioritization be made between areas and safety actions so that the limited budgets be consumed more effectively. The general target of prioritization can be described as following:

$$(2) \quad \text{Max}_y \frac{B(y)}{C(y)}$$

Where:

y: safety measure

B(y) and C(y) : total costs and benefits related to y

This approach has been made reasonable and practical as a principle.

When talking about profit and costs rising from related measures such as decreasing the number of accidents and costs, there seems to be two main problems. The first is the problem to determine the price of injuring accidents, since there is no definite commercial price for human being live. Generally there are 3 ways to estimate fatality costs and/or costs related to damages incurred to society. These methods are implicit values, human capital and willingness to pay. The real cost of injuring accidents practically relates to the number of people involved. However since the number of people is independent from the location of the accident, the average cost of accident is usually referred to.

The amount an accident is decreased due to applying a safety measure is indistinguishable other than problems existing in order to recognize the accidents costs. This unclearness can be summarized as below:

- unclearness of accidents decrease rate due to the costs consumed for modification
- obscurity about whether that the kind of accidents already happened at location
- unclearness about whether the specified place has been really a black spot or not

The last two ones are related to the place, whereas the former is associated with the safety measure. It is assumed that places recognized as black spots, have got a relatively high potential for decreasing the accidents. Also a safety measure which concentrates over specific types of accidents, shall have a relatively high effect on places where such types are dominant. In order to increase the information about unclearness of the safety measure, pre and post complementary studies are required.

Conclusion and selection of a suitable method to apply in IRAN

As it was described beforehand, there are various methods to identify and prioritize accident prone areas. The efficiency of these methods corresponds to type and accuracy of primary data used. Since the amount of data and its collection method in railway is not at an acceptable level, therefore setting up identification methods require further studies and researches, performing short-term projects and pre and post studies that should be made parallel to the structural modification of accident data and statistics collection and storage. Anyway, in Iran the following methods can be used for short and long term periods:

1. Short term period: For short term periods (eg. 3 years) reactive methods can be used such as "using cumulative frequency of accidents in sections", to identify and prioritize black spots. Then by concentrating over these spots and offering corrective strategies, its effect on the number of accidents can be evaluated.

2. Long term period: Despite type of existing data, the best method to identify black spots can be named as "safety engineering assessment". The usage of this method gives rise to a more exact identification of dangerous sections. Imposing this method requires efficient manpower, long term planning and cooperation of related organizations such as the ministry of roads, municipalities, police, etc. based on studies about Iranian Railway Network, It is suggested that this method be evaluated and implemented in the framework of a 10-year safety strategy. Since there are still some faults exist in structure, grouping and statistics of accidents information and there is a need to access the position location of accident as a important field for system design. It is better to design a GIS based system simultaneously. Because of important role of infrastructure in rail safety it is suggested that in Iranian Railway these special measurement about impaired track, building ,... etc simultaneously be done with engineering assessment method and checklist and modules be prepared based on that.

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