

# Evaluating Cost-Effective Railway Level Crossing Protection Systems

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**Abstract** - Improving safety at railway level crossings (RLX) is costly and funds are always limited, it is important to search for cost-effective alternative solutions. There are low-cost innovative RLX-protection systems available worldwide with opportunities for application in Australia, subject to their effectiveness and appropriateness. To date, there is no systematic approach available in Australia to evaluating those systems. This paper sets out a methodology to identify and evaluate suitable technologies in relation to their adoption and adaptation to conditions.

## 1. INTRODUCTION

Railway safety is a crucial aspect of rail operation the world over. Malfunctions resulting in accidents usually get wide media coverage even when the railway is not at fault and give to rail transport, among the uninformed public, an undeserved image of inefficiency often fuelling calls for immediate reforms. Rail/road intersections are very unique, special, potentially dangerous and yet unavoidable in the world. Here two different entities with entirely different responsibilities, domains, performances come together and converge for a single cause of providing a facility to the road user. During the normal operation also, there is every possibility of accidents occurring even with very little negligence in procedure and the result is of very high risk. The potential for accidents is made higher as the railways control only half the problem. The other half, meanwhile, cannot really be said to be controlled by one entity, as even though traffic rules and road design standards supposedly exist, the movements of road users are not organized and monitored by one specific entity as rigidly as rail movements. A very high number of these collisions are caused by the negligence, incompetence or incapacity of road vehicle drivers, who by and large operate their vehicles in environments in which safety consciousness is practically non-existent.

Since it is the railway, which must bear the responsibility for ensuring that road users protect it from the transgressions (despite the fact that in many countries the law gives it priority of passage over road users), it is the railway which also has to shoulder most of the financial burden of providing this protection.

Similarly, it is the railway, which has most of the responsibility for educating road users on the safe use of its cost effective system for railway level crossing protection appears that in many regions, railways are ill-equipped to be in a position to monitor level crossing safety effectively and to take both corrective and pro-active measures to improve the safety of their level crossing installations. Railway is an eco-friendly and popular mode of transport in major cities of the world. Train accidents occur normally due to safety violations resulting from human errors or limitations and equipment failures losing precious lives. The Ministry of Railways (Railway Board), Govt. of India has referred many collisions in the past few years and therefore need for research is very important in this field.

## 2. LITERATURE REVIEW

### 2.1 A.J. Powderham and G. J. Tamaro [1995],

Settlements occurring during the first phase of tunnelling for the extension of the Docklands Light Railway in London caused concern for damage to the Mansion House during subsequent phases of the work. The building is a landmark structure and no further damage could be accepted. Tunnelling was halted until a satisfactory protection program was in place. Various means of protecting the structure were investigated, ranging from full structural underpinning to a least-risk methodology based on the observational method. This paper describes the background to the development and implementation of the observational method to successfully protect the building and complete construction. This required appropriate contingency measures to be identified and planned. Of the contingencies involving preventive or strengthening works, a system of structural ties through the building was selected as most appropriate, least risky, and most economical. Trigger levels for building response were established. Extensive instrumentation was installed and the building was fully monitored during the subsequent phases of tunneling.

## 2.2 Yeboah Gyasi-Agyei [2004],

An advanced technology cost-effective drip irrigation system design and setup on environmentally sensitive elevated steep slopes ~batters! Of a coal train derailment site in Central Queensland, Australia, are presented. The final profile of the coal burial site consists of six batters and associated berms with a drop in elevation of about 35 m. A small dam constructed downstream of the confluence of the two main drainage channels at the site supplied water for irrigation of the batters to aid the establishment of grass to control erosion. Water was periodically pumped from the small dam to three storage tanks using a petrol (gas) pump. Three solar pumps drew water from the storage tanks and dam to irrigate the top four batters. Contactors, pressure switches and irrigation control valves in turn shared a single solar power source between the solar pumps. Level balls (floating switches) placed in the storage tanks cut the solar power supply to the pumps when the storage tanks were nearly empty. On the whole, the irrigation system worked very well and excellent grass cover was established within 12 weeks. Given the environmental risks associated with the on-site burying of coal and the estimated cost of about AU \$11.73/m<sup>2</sup> (every 10 years) in maintenance if the railway batters are not treated, the estimated total cost of AU\$4.61/m<sup>2</sup> of batter area treated with irrigation, including AU\$3.08/m<sup>2</sup> in irrigation cost, is justified.

## 2.3 Alfred E. Fazio [2004],

Light rail transit (LRT) offers the widest range of opportunities to the design community in applications engineering. There are certainly more varied possibilities in the design and configuration of LRT than in that of rail rapid transit or commuter rail. Consequently, it is particularly important to understand the relationship between applications design and railway operations when deploying light rail. The development of a new rail system should begin with a clearly stated operational requirements document and then evolve to a comprehensive, systems-level design. This evolution must be supported by an active systems integration process. Examples of this approach are taken from the deployment of the Hudson-Bergen Light Rail, a high-performance light rail transit system located in northern New Jersey that is currently in deployment through a design, build, operate, and maintain contract.

## 3. LEVEL CROSSING SAFETY IN INDIA

The Indian Railway network with a route length of 62,495 km has a total of 40,445 level crossings, or an average of one every 1.5 kilometre. Of this total, 16,132 crossings are some form of barrier protection facing road users, 20,528 are open crossings with fixed road warning signs, 948 are road crossings adjacent to canals without barrier protection, and with the warning of road warning signs, and 2,837.

In 1997/98, level crossing accidents constituted 65 out of 420 the accidents (or 15 percent) of all types in the Indian railway network. However, in the same year, level crossing accidents accounted for 42 percent (134 individuals) of all fatalities and 18 percent (179 persons) accidents on the network. In one year surveyed, 80 percent of all level crossing accidents occurred crossings which were unmanned Indian Railways has recently crossing to the effect that the decision has taken Number of unmanned gates with a high level of usage by road and / or rail and not to Unmanned operation.

## 4. LEVEL CROSSING SAFETY INITIATIVES

### a) Manning Of Unprotected Level Crossings

The current five-year plan (covering the period 1999/2000 to 2003/2004) provides for the progressive conversion of unmanned &unprotected crossings to manned &protected status. Depending upon the assigned category of each crossing, this will involve installation of warning signs or lights and boom barriers of various types as well as construction of a crossing attendant's workstation at prioritized locations.

### b) Other Level Crossing Upgrading Measures

In addition to conversion of unprotected level crossings to manned status, the Indian Railways has a plan to grade separate or to relay interlock some of the more densely trafficked crossings on its network.

### c) Road User Education

The Indian Railways has only a very small budget for road user education but does make use of the mass media (mainly television and newspapers) to promote public awareness of the need for caution when using level crossings. One effective means of disseminating this message is the use of notice boards in punjayat (or local village) offices to display safety posters. Since residents of rural areas tend to regularly visit their punjayat offices, this initiative has the potential to reach a wide section of the community. One such poster used to promote caution by the public when using level crossing is shown hereafter.

#### d) Level Crossing Safety Impediments

Apart from a lack of adequate capital funds to upgrade level crossings, the main factors considered to be working against an improvement in level crossing safety in India are:

- The lack of priority
- The lack of funding priority
- Increasing disposable incomes and motorization
- The predominance of Absolute Block and Tablet systems of safe working

### 5. ADVANCED SYSTEMS FOR LEVEL CROSSING PROTECTION

Systems likely to be available in future for the protection of level crossings are of types:

#### 5.1 Advanced Radio-Based Train Control System – General Features

The American and Canadian Railway Associations began to study Advanced Train Control Systems (ATCS) in 1984. The systems then investigated involved the use of radio, satellite and radar communications. Following the lengthy appraisal of this technology, it will at last enter operational service with San Francisco's Bay Area Rapid Transit System (BART) in 2001.

Application of ATCS will allow elimination of track circuits and signals and in future will facilitate high density and unmanned train operations.

#### 5.2 ATCS - Level Crossing Safety Features

Existing level crossing systems represent a weak point of safety management and control on railways. Adequate warning time is needed for safe level crossing operation. Existing systems having electronic train detectors work on the basis of short track circuits installed in the track approaches on either side of level crossings. These systems control the beginning and end of the warning indication. The disadvantage of this system is that the warning interval becomes disproportionately long with slow trains, because maximum train speeds normally determine the interval between the beginning and end points of track circuited sections, and thus a train operating at slow speed will take significantly longer to pass between these two points.

#### 5.3 ATCS – Financial Benefits

The functions of CTC and ATC are added easily to the system for a relatively low additional cost. Indeed, the addition of CTC or ATC is estimated to comprise less than 50 per cent of the total system installation cost.

An automatic level crossing warning/protection system based on conventional track circuiting is estimated to cost US\$ 45,000 per level crossing in Japan. By contrast, the cost of a BART-style ATCS 23 is estimated to cost only about US\$22,000 per level crossing.

#### 5.4 GPS-based Advanced Train Control System

Global Positioning Satellite (GPS) communications systems are now in common use for sea, air and land transport navigation applications. GPS uses communications links with number of satellites to establish the navigation coordinates of aircraft or surface transport receivers. GPS systems are on the whole very inexpensive – a receiver for an automobile now costing as little as US\$ 500

### 6. ALTERNATIVES SYSTEM

**O' Conner System** - This system uses solar powered microwave radar sensors to detect the location, speed and direction of approaching trains up to 3 km away and activate the warning device when the train is 25 seconds away. A solar-powered LED "X" sign would be located near the crossing and interfaced to the level crossing protection system.

**Solar Powered Railway Level Crossing Radio Warning System (SOLAGARDTM)** - This system allows both audio and visual warning at a crossing. An electro-magnetic track device detects an approaching train (2-5 kms from the crossing) and actuates a solar powered VHF transmitter located about 3-4 kms from the level crossing. Through VHF Radio Communication Link, the transmitter sends a coded radio signal towards the level crossing.

**Low-Cost Highway-Rail Intersection Active Warning System (HRI System)** - This system provides active advanced warning in addition to traditional flashers at the crossings. A typical crossing includes four sub-systems, one on each cross-buck (Master and Slave) and one on each advance warning sign.

**EV-Alert** - In Australia, an example of a system used by the sugar industry at RLX in Queensland is called the EV-Alert. A radio transmitting device is fitted to all locomotives, and constantly sends out a coded signal.

**Minnesota In-Vehicle Warning** - In this Minnesota project, the system used wireless vehicle and roadside communication antennas that could be built into the familiar cross buck, "RXR" sign and front vehicle license plate. The trackside unit picked up a signal from the railroad's train detection electronics and transmitted that signal to antenna-signs.

## 7. RESULT AND DISCUSSION

### a) Percentage of Accident

Level crossing accidents include a small but growing proportion of all railway accidents in India In the last year for which data were available (1990-2016) the total number of railway accidents in India and the number of recorded accidents at level crossings are given in table. The trends in level crossings as a proportion of all railway accidents are shown in Table 1.

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**Table - 1:** Significance Of and Trend In Level Crossing Accidents in India

| Year | Total railway accidents (No) | Accidents at level crossing (No) | Level crossing accident % |
|------|------------------------------|----------------------------------|---------------------------|
| 1990 | 532                          | 36                               | 6.77                      |
| 1991 | 530                          | 47                               | 8.87                      |
| 1992 | 524                          | 51                               | 9.73                      |
| 1993 | 520                          | 66                               | 12.69                     |
| 1994 | 501                          | 73                               | 14.57                     |
| 1995 | 398                          | 68                               | 17.09                     |
| 1996 | 381                          | 65                               | 17.06                     |
| 1997 | 396                          | 66                               | 16.67                     |
| 1998 | 397                          | 67                               | 16.88                     |
| 1999 | 463                          | 93                               | 20.09                     |
| 2000 | 473                          | 84                               | 17.76                     |
| 2001 | 415                          | 88                               | 21.2                      |
| 2002 | 351                          | 96                               | 27.35                     |
| 2003 | 325                          | 95                               | 29.23                     |
| 2004 | 234                          | 70                               | 29.91                     |
| 2005 | 234                          | 75                               | 32.05                     |
| 2006 | 195                          | 79                               | 40.51                     |
| Year | Total railway accidents (No) | Accidents at level crossing (No) | Level crossing accident % |
| 2007 | 194                          | 77                               | 39.69                     |
| 2008 | 177                          | 69                               | 38.98                     |
| 2009 | 165                          | 70                               | 42.42                     |

|      |     |    |       |
|------|-----|----|-------|
| 2010 | 141 | 53 | 37.59 |
| 2011 | 131 | 61 | 46.56 |
| 2012 | 121 | 58 | 47.93 |
| 2013 | 117 | 59 | 50.43 |
| 2014 | 135 | 56 | 41.48 |
| 2015 | 107 | 35 | 32.71 |
| 2016 | 90  | 16 | 17.78 |

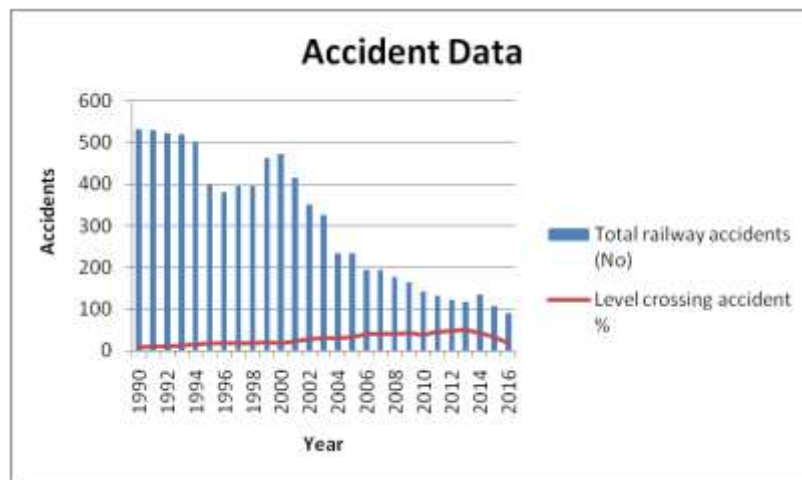


Chart - 1: Level Crossing Accidents in India, By Type of Crossing

Nearly two-thirds of the total number of crossings unmanned level crossings and this proportion has been increased over the past decade as is shown in chart 1. Total no of accident are more 1990 & its decreases in early years but, in level crossing accident continuously increases up to 2016 as per the figure.

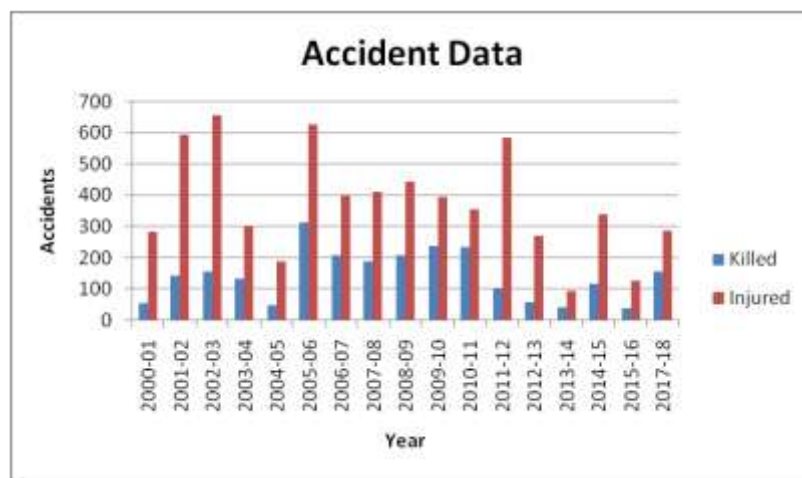
**b) Percentage of fatalities**

In 2000-2001, fatalities in level crossing accidents, all fatalities in railway accidents in India, as shown in Table 2. Although the share of level crossings deaths in all railway facilities declined significantly in the following year (2013-014), over the decade it has shown a rising trend which is Explained in part by increasing train speeds and in part by increasing motorization of rural communities.

Table - 2: Significance Of and Trend in Level Crossing Injuries in India

| Year    | Number of Passengers |         | Total Casualties per million passengers carried |
|---------|----------------------|---------|---|
|         | Killed               | Injured |   |
| 2000-01 | 55                   | 286     | 0.01  |
| 2001-02 | 144                  | 595     | 0.02  |
| 2002-03 | 157                  | 658     | 0.03  |
| 2003-04 | 135                  | 302     | 0.03  |
| 2004-05 | 50                   | 191     | 0.04  |
| 2005-06 | 315                  | 627     | 0.165   |
| 2006-07 | 208                  | 402     | 0.098   |
| 2007-08 | 191                  | 412     | 0.092   |

|         |     |     |       |
|---------|-----|-----|-------|
| 2008-09 | 209 | 444 | 0.094 |
| 2009-10 | 238 | 397 | 0.088 |
| 2010-11 | 235 | 358 | 0.078 |
| 2011-12 | 100 | 586 | 0.083 |
| 2012-13 | 60  | 270 | 0.039 |
| 2013-14 | 42  | 94  | 0.02  |
| 2014-15 | 118 | 340 | 0.05  |
| 2015-16 | 40  | 126 | 0.02  |
| 2017-18 | 156 | 289 | 0     |



**Chart - 2:** Significance Of and Trend In Level Crossing Injuries in India

Figure shows the significance & trend in crossing injuries in India, in which total no of killed and injured passenger per year. The highest injured in 2002-03 & lowest in 2013-14. Killed passenger are heights in 2005-06 & its decreases now a day.

**c) Hazard Index of Crossings**

Table shows the Hazard index of crossing year wise 2002 to 2013 ,in which hazard index of crossing calculated by multiplying Average annual daily traffic, Average annual daily train traffic & Pf factor. The highest hazard index at 2013 is 1244346 & lowest hazard index at 2002 is 706550.

**Table - 3:** Hazard index of crossing

| Sr.No | Item | Annual traffic | Annual train traffic | Average annual daily traffic | Average annual daily train traffic | Tf  | Hazard index of crossing |
|-------|------|----------------|----------------------|------------------------------|------------------------------------|-----|--------------------------|
| 1     | 2002 | 4970803        | 63122                | 13618.6                      | 172.937                            | 0.3 | 706550                   |
| 2     | 2003 | 5112361        | 63221                | 14006.5                      | 173.208                            | 0.3 | 727811                   |
| 3     | 2004 | 5377937        | 63465                | 14734.1                      | 173.877                            | 0.3 | 768574                   |
| 4     | 2005 | 5724516        | 63332                | 15683.6                      | 173.512                            | 0.3 | 816390                   |
| 5     | 2006 | 6218881        | 63327                | 17038                        | 173.499                            | 0.3 | 886822                   |
| 6     | 2007 | 6524377        | 63273                | 17875                        | 173.351                            | 0.3 | 929593                   |
| 7     | 2008 | 6920369        | 64015                | 18959.9                      | 175.384                            | 0.3 | 997577                   |

|    |      |         |       |         |         |     |         |
|----|------|---------|-------|---------|---------|-----|---------|
| 8  | 2009 | 7245805 | 63974 | 19851.5 | 175.271 | 0.3 | 1043820 |
| 9  | 2010 | 7651090 | 64460 | 20961.9 | 176.603 | 0.3 | 1110578 |
| 10 | 2011 | 8224384 | 64600 | 22532.6 | 176.986 | 0.3 | 1196386 |
| 11 | 2012 | 8420659 | 65436 | 23070.3 | 179.277 | 0.3 | 1240790 |
| 12 | 2013 | 8397057 | 65808 | 23005.6 | 180.296 | 0.3 | 1244346 |

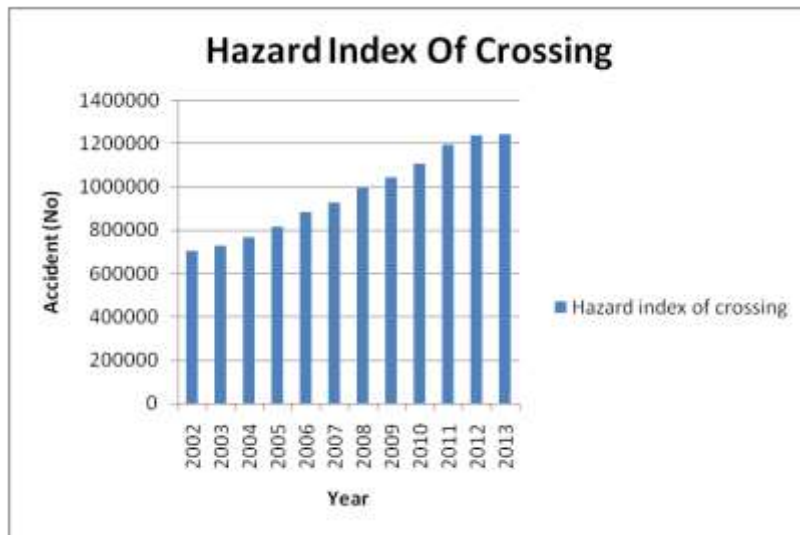


Chart - 3: Index Of Crossing

Figure shows the Hazard index of crossing, in which per year hazard crossing is given, the highest hazard index at 2013 is 1244346 & lowest hazard index at 2002 is 706550.

### 8. CONCLUSIONS

Safety is accorded the highest priority by Indian Railways and all possible steps are undertaken on a continual basis including up gradation of technology to prevent accidents and to enhance safety.

- Level crossing accident in India in recent year is more percentage as compared to past record, so advance protection system to be used for safety.
- Level crossing injuries in India the rate of crossing injuries are less now a day
- Hazard index of crossing are continuously increase per year therefore more safety required for it.
- Expected no of accident or no of crashes increasing rate per year more so present & advance protection system use for decreeing the rate of accident.
- Initial crash prediction is increases high in last few years.
- Alternative system, the Enhanced safety gives more safety there for RLX protection systems are used in Indian railway.

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