SAFETY ON RAILWAY LEVEL CROSSINGS IN KURUNEGALA DISTRICT, SRI LANKA

Kumudu Vidana Gamage[1,2]

[1]*Department of Civil Engineering, University of Peradeniya, Sri Lanka*

[2] *Postgraduate Student of Master of Philosophy, Department of Civil Engineering, Curtin University, Australia*

Abstract *A majority of railway accidents happens at level-crossings and the human and material losses caused by these accidents are enormous. Although the importance of the protection measures is difficult to overestimate, the variety of protection systems available and lack of experience confuse policy-makers.*

Accidents at level-crossings cause not only the injury and death of people, but also economic losses due to disruption of train operations, destruction of goods and shutdown of road traffic. Such negative economic effects, coupled with the reduced reliability, attractiveness and other performance indicators of railway transport also affect users' choice of transport mode.

In this study, accidents happened on railway level crossings were considered. On an average Sri Lanka Railways (SLR) spend about Rs. 25000 a month as wages for each level crossing. SLR which is running with a subsidy from the Central Government should not be burdened financially any more. If parallel roads are constructed by the Provincial Governments, level crossings can be avoided. Level crossing collisions are usually caused by inattention or by drivers becoming impatient or ignoring warning signs and signals.

The objectives of this study were to collect accident records on railway level crossings in Kurunegala District, Sri Lanka investigate; reasons for those accidents and find possible ways of improving the safety at each location. With the collection of data from police stations, railway stations, including gate operators the reasons for accidents at railway level crossings were identified.

Number of level crossings in Kurunegala district on A, B and minor class roads were fifty nine. According to the details collected from gate operators, main accident type was crashing on the gate. The data collected so far indicates average two fatal accidents (train-vehicle) occur in a five year period. Types of data collected were accident records, gate types, availability of road signs and markings, traffic flow, dimensions of the level crossing and dimensions of the median barrier if available.

Key Words : Level crossings, Collisions

1 INTRODUCTION

The escalating trend of railway accidents over the past few years has caused much concern among the train travellers as well as the public. Most of these accidents have caused great damage not only to the life and property of others, but also to the passengers, notwithstanding the rolling-stock of the Sri Lanka Railway including the track. The railway track is generally unfenced and accidents involving pedestrians, passengers and animals are frequent. Many Sri Lankan pedestrians seem to regard the railway track as a footpath and the trains as intruders; on some of the crowded commuter trains. Under such conditions, accidents are inevitable.

Several types of accidents can happen in railways.

- Accidents at railway level crossings
- Accidents in railway stations
- Collisions on railways
- Derailments

The intention of this study was to investigate the accidents, which are occurring at railway level crossings because that is where the majority of accidents have occurred.

1.1 Accidents at Railway Level Crossings

The term level crossing (also called a railroad crossing, railway crossing, train crossing or grade crossing) is a crossing on one level (at grade intersection) without resource to a bridge or tunnel of a railway line by a road, path or another railroad. Railway level crossings are dangerous places because trains are unable to stop suddenly or swerve to avoid colliding with motorists, cyclists or pedestrians. Therefore, this represents a significant danger for both road and rail users.

Protection for road users varies from passive signage to active protection, which is a combination of bells, lights or boom gates. Hence, an extreme care must be taken when crossing.
Several types of accidents can happen in railway level crossings.

- Train-vehicle collision
- Crossing induced accidents
- Collision into barriers, gateposts
- Rear end collision

Yangalmodara railway level crossing accident is a remarkable accident in railway history in Sri Lanka, which happened on 27th April 2005. Because of this accident 35 people died on the spot and it also caused a great damage to properties. Although such serious cases have happened, the responsible authorities have not implemented any practicable remedy to prevent those impending disasters.

1.2 Railway Network in Kurunegala District

Out of eight railway lines in Sri Lanka, three of them are going through the Kurunegala district. Those are,

- Main line
- Northern line
- Trincomalee line

Main Line : The Main Line leaves the Colombo fort to Badulla. The section within the Kurunegala district is from Bujjomuwa to Yatagama. The length of that section is about 21 km. From Bujjomuwa to Polgahawela, the railway line is a double track and from Polgahawela to Yatagama, it is a single track.

Northern Line: The Northern Line leaves the Main Line at Polgahawela to Kankasanturai. The section within the Kurunegala district is from Polgahawela to Senarathgama and its length is about 98 km. This is a single track throughout.

Trincomalee Line: The Trincomalee Line leaves the Northern Line at Maho (junction for the Batticaloa and Trincomalee Lines) to Trincomalee. The section within the Kurunegala district is from Maho to Agbopura. The length of that section is about 113 km. This is also a single track.

There are 62 railway level crossings and 10 major stations in Kurunegala district. Polgahawela and Maho are the main stations in the district.
Based on these facts, this study aimed to prepare a safety index for each railway level crossing in Kurunegala district. The main objectives of this study were to collect accident records on railway level crossing in Kurunagala district, to investigate the reasons for those accidents and to find possible ways of improving the safety at each location.

To achieve these objectives, study cope has been formatted. The operational area of the Sri Lanka Railway in Kurunegala district is divided into three divisions; Kurunegala, Maho and Kuliyapitiya. The study area covered the railway network of the Kurunegala district within the above three divisions. The route length covered under the study is about 232 km, which is of about 16% of the total route length of Sri Lanka.

2. MATERIALS AND METHODS

2.1 Data Collection

The data collection was a major part in the project. Since it was required to get past accident records, measurements and photographs at level crossings, the permission from the Deputy Inspector General of Police of North Western Region, the Provincial Director of Road Development Authority in North Western Province and Station Masters of each railway station was taken.
Records of railway level crossing accidents, which were happening during last five years, were taken from police stations at Ambanpola, Pothuhera, Alawwa, Polgahawela, Kurunegala, Wellawa, Galgamuwa, Maho and Polpithigama. Since public opinions also have to be considered for a successful technical solution, railway gatekeepers were interviewed to get records of past accidents and near misses and to get their suggestions to improve the safety at those level crossings. Types of roads, which intersect the railway level crossings and traffic volume data were taken from RDA. Each and every railway level crossing in Kurunegala district was observed to identify the important details of them such as the type of gate, availability of road signs and markings, visibility, geometry, dimensions of the level crossing, availability of median barriers. To fulfill this objective, photographs of each railway level crossing were taken with important details.

2.1.1 Data Collection from Maps

The types of level crossings present in the area were identified and the required information about the railway network in Sri Lanka and in Kurunegala district was collected using the following maps.
Road Map of Sri Lanka (Scale 1: 50,000)

Map of North Western Province (Scale 1:250,000)

Table 1 gives a detailed description of level crossings in Kurunegala district.

Table -1: Description of Level Crossings

Line	Road Type			Total
	A-Class	B-Class	Minor	
Main	1	1	6	8
Northern	4	13	31	48
Trincomalee	0	1	2	3
Total	5	15	39	59

2.1.2 Data Collection from Questionnaire

Railway gate keepers, people who live near railway level crossings and some of the public were given a questionnaire and gathered their opinions regarding the railway level crossing accidents.

2.1.3 Details Collected From Literatur

The information, which related to the railway lines which lie in Kurunegala district and other information related to the railway level crossings were gathered using various publications.

2.2 Numbering System

Using the Road Map of Sri Lanka and the Map of North Western Province, the locations of the railway level crossings were identified. For the convenience of carrying out the project, a numbering system was introduced to each railway level crossing.

The three railway lines in the Kurunegala district were numbered as follows. These are standard codes for the railway lines and the line digits are based on Hyatt D., " Railway of Sri Lanka ", Comrac, London and Colombo, 2000.

Main line = 1

Northern line = 4

Trincomalee line = 7

Road types were categorized as A-class (A), B-class (B) and minor roads (M). Numbers were given to each railway level crossing, according to the type of road, which the railway line intersects. The numbering starts with Main line at Bujjomuwa, Northern line at Polgahawela and Trincomalee line at Maho.

E.g. 4A03

Digit **'4'** indicates the Northern line. **'A'** indicates that the railway level crossing intersects an A-class road. **'03'** indicates that the particular railway level crossing is the third one, which intersects the A-class road.

2.3 Safety Index Preparation

The aim of the project was to prepare a safety index for each railway level crossing in Kurunegala district. Then, an observer can get an idea that how much the railway level crossing is safe. Further, it is also important to improve the safety of each railway level crossing.

The following requirements were considered when giving marks to each railway level crossing.

- Type of gate
- Signalling system
- Alarm
- Communication system
- Signs and markings
- Visibility
- Median barrier
- Geometry

Assumption : All the requirements were considered as equally important.

1) If there is no gate, then particular level crossing was considered as unprotected and zero marks were given.
2) Ten marks were allocated for above each requirement. According to the field observations, the amount of marks for each requirement depended on their conditions.
3) Since the type of gate was a main factor which was affected for most of the accidents, the marks given for the type of gate was multiplied by two(factorized).
4) Accident rate per one million vehicles of each railway level crossing was calculated using Equation 1.
   This accident rate was considered as negative marks and it was added to the total marks of the relative level crossing.
5) No. of fatal accidents was multiplied by ten and it was also considered as negative marks.
6) Then, total marks of each railway level crossing were calculated.
7) According to the total marks, all fifty nine level crossings were classified under following three ranges and a colour code was assigned to each range.

Range of Total Marks	Colour Code
0 -35	Red
36-60	Yellow
61<	Green

8) According above colour system, if a level crossing has obtained

"Red" colour - Dangerous

"Yellow" colour - Risky

"Green" colour - Safe

$$\text{Accident rate} = \frac{\text{No.of Accidents Occurred within 5 years} * 1{,}000{,}000}{\text{Average Annual Daily Traffic Flow} * 365 * 5} \quad \text{..... Eqn. (1)}$$

3. RESULTS AND DISCUSSION

3.1 Types of Level Crossings

3.1.1 Active Crossings : In an Active crossing, the level crossing user is made aware of the presence of a train.

1. Manually controlled gates
2. Manually controlled barriers
3. Automatic half-barriers

3.1.2 Passive Crossings : In a Passive crossing, the level crossing user is responsible for detecting the presence of an approaching train. (NSW government, 2015).

1. Open crossings
2. Footpath crossings

Table-2: Types of Gates

Line	Gate Type				Total
	Gates Interlocked with Signals	Gates with Padlock	Bamboo Gates	Unprotected	
Northern	8	9	17	15	49
Main	2	2	-	3	7
Trincomalee	-	1	2	-	3
Total	10	12	19	18	59

3.2 Types of Gates

1) Gates interlocked with the signals
2) Gates with padlock
3) Bamboo gates
4) Unprotected

The Table 2 gives the types of gates in each railway line.

3.2.1 Gates Interlocked with Signals

This is the common protected gate type at Kurunegala district. There is an interrelationship between the station and the level crossing. There were three gate operators assigned to protect this type of level crossings with eight hour shifts. When the railway track crosses the major roads, these gates are used.

The following requirements are essential to keep the safety at the level crossing.

- Mechanically operated gates
- Median barrier for the road
- Alarm
- Signals to the road users
- Approaching signs and markings
- Signals for the train
- Communication system with stations either side
- Lights

3.2.1.1 Function of the Level Crossing

1. The gate operator is received the message from the station master through the communication system.
2. Yellow lever is pulled to close the barrier. Once it starts to close, the alarm also starts to ring and the warning signals for road users start to light until the gates are opened.
3. Red lever is pulled to give the signal to the train. The left one is pulled when the train comes from upper station and the right one is pulled when the train comes from down station.
4. Red lever is released after train passes the level crossing.
5. Finally, yellow lever is released and the gates are opened.

The following safety precautions are taken in these level crossings.

i. Until the yellow lever pulls, the red levers cannot be pulled. So, the signal for the train cannot be given until the gate is closed.
ii. In a single track, if one red lever is being engaged, the other one cannot be pulled. So, two trains cannot be moved in opposite directions at the same time.
iii. The Red lever should be released before yellow lever. So, the gate can be opened only after disengaging the signal to the train.

3.2.2 Gates with Padlock

This type of gates closes the entire width of the road. There were three gate operators for each level crossing. The major problem of this type of gate is that the gate operator has to close both gates after seeing the approaching train. Because, there is no communication system with the station. Since, the time required to close both gates before the train approaches the level crossing is not sufficient, this type of gates are not suitable for double track crossings. When a private property requires access across the rail track, the approval is given by the railway department after considering the requirement according to the railway rules and regulations.

3.2.3 Bamboo Gates

Bamboo gates are used when rail track crosses a minor road. There were three gate operators assigned to protect the level crossing with an eight hour shifts. There was no communication system between the gate operator and the station master. The gates are closed after the gate operator sees the approaching train. Bamboo gates are not suitable for double tracks as the time required to close the gates is not sufficient. Another problem is these gates have to be replaced from time to time.

3.2.4 Unprotected

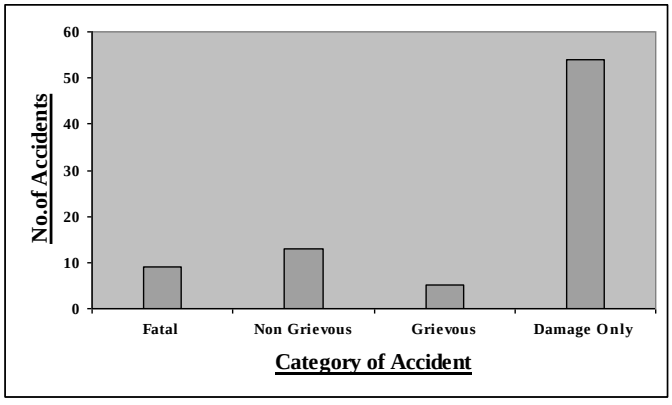
These level crossings are protected only by warning boards and signs. So, those are in dangerous position. Therefore, the road users have to take extra care to avoid accidents. A clear visibility of the rail track is essential for this type of level crossings.

3.3 Railway Accidents in Kurunegala District

According to police records of the past five years, 81 accidents were happened in Kurunegala district. Most of them were railway induced accidents such as gate-vehicle collision, vehicle-vehicle collision. Out of those 81 accidents, 9 were fatal accidents. Several reasons were affected for those accidents such as the geometry of the level crossing, driver discipline, and defects at level crossings. Compared to other two lines, the number of accidents happened in main line is high. The following table illustrates the accident description in the Kurunegala district within last five years.

Table- 3: Accident Description in Last Five Years

Level Crossing	No. of Accidents		Total
	Fatal	Non Fatal	
Alawwa	0	5	5
Gorokgasdeniya	1	1	2
Kapuarala	0	1	1
Walakumbura	1	1	2
Yangalmodara	4	21	25
Polgahawela	0	7	7
Godawela	1	7	8
Kohilapitiya	0	1	1
Girambe	0	1	1
Amunugama	1	13	14
Thalawattegedara	0	1	1
Dambokka	0	1	1
Muttettugala	0	7	7
Wellawa	1	2	3
Ganewatta	0	2	2
Kasikote	0	1	1
Total	9	72	81



There are 59 level crossings in Kurunegala district. But accidents were occurred only at 16 level crossings. Out of these 16 level crossings, only 5 level crossings are unprotected.

Fig – 3: Variation of No. of Accidents with the Category of Accident

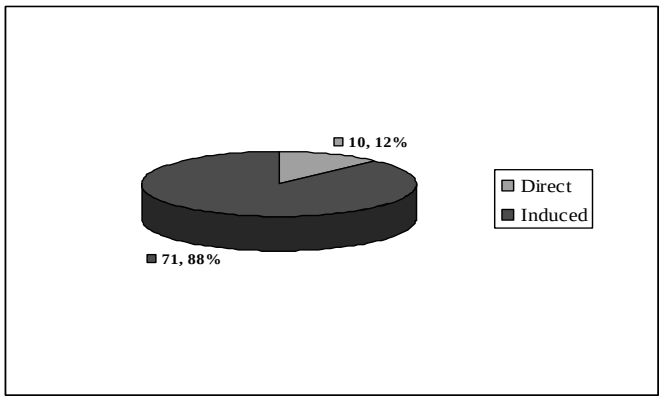


Fig – 4: No. of Direct and Induced Accidents and their Percentage

According to Fig. 3, number of damage only accidents are at a high level with respect to other accidents and according to Fig. 4, number of railway induced accidents is comparatively high. Most of the damage only accidents are of collision with the rail gate. Drivers' negligence and poor visibility of the rail gate at night were affected for those accidents. Nine fatal accidents were occurred during last six year period. Most of them were happened by collision with the train. According to the collected data, out of those nine accidents only two accidents were happened at unprotected level crossings. Therefore, the driver negligence was seriously affected for those accidents.

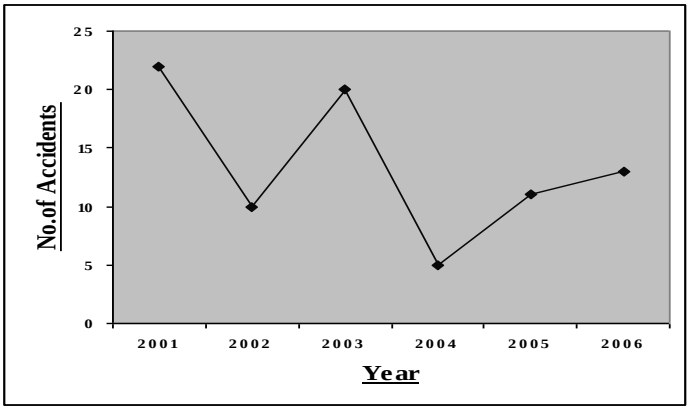


Fig -5: Variation of No. of Accidents with the Year

When the number of accidents is considered annually, according to Fig. 5, the number of accidents happened in the first three years are comparatively higher than the number of accidents happened in the latter three years. The reason for the reduction of accidents is not because of safety precautions. Because, an increase of the number of accidents can be seen again in last three years. There is no uniform variation of accidents during this period.

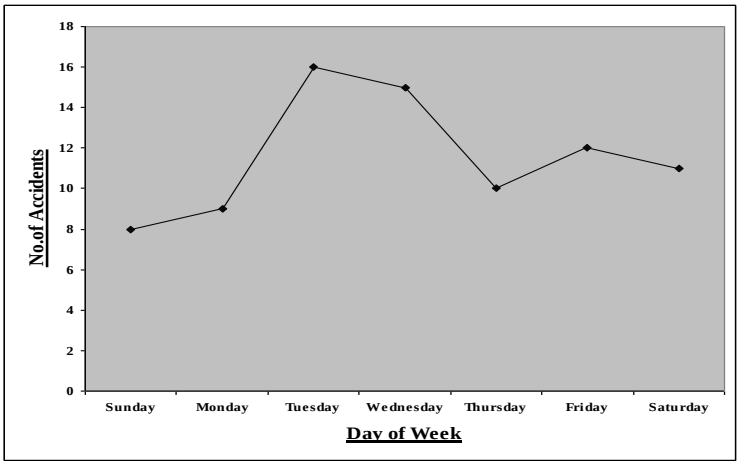


Fig – 6: Variation of No. of Accidents with the Day of Week

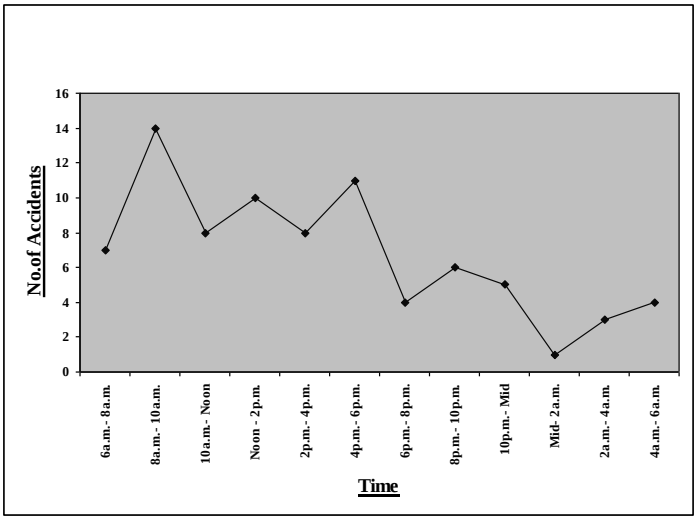


Fig – 7:Variation of No. of Accidents with Time

According to Fig. 6, most of the accidents were happened on Tuesdays and Wednesdays. The minimum number of accidents was happened on Sundays. Since Sunday is a holiday, the traffic volume is at a low level. Accordingly a reduction of accidents can be seen on Sundays. When considering the time duration, according to Fig. 7, most of the accidents have happened during office hours, i.e. 8 a.m.-10 a.m. and 4 p.m. - 6 p.m. An increase of accidents can be seen again during noon – 2 p.m. time period. This may be due to the traffic congestion occurs in the school time. The number of accidents happened in the midnight is at a minimum level because of the less traffic volume.

Table 4 gives a summary of the conditions of the railway level crossings.

Table- 4: Summary of Railway Level Crossings

Se. No	Location	Type of Railway	Gate Type	Signaling System	Alarm Signal	Availability of Communication System	No of Tracks	Visibility	Road Bend	Vegetation Cover	Constructions	Median Barrier
1A01	Yangalmodara-Main	Protected	Manual	Yes	Yes	Yes	2	Good	Yes	No	No	Yes
1B01	Alawwa	Protected	Manual	Yes	Yes	Yes	3	Normal	Yes	No	Illegal	No
1M01	Gorokgasdeniya	Unprotected	No	No	No	No	2	Good	No	No	No	No
1M02	Kapuarala	Protected	Manual	No	No	No	2	Good	No	Yes	No	No
1M03	Walakumbura	Protected	No	Yes	Yes	No	2	Normal	No	No	No	No
1M04	Balagalla	Unprotected	No	No	No	No	2	Good	No	Yes	No	No
1M05	Yangalmodara	Protected	Manual	No	No	No	2	Normal	No	No	No	No
1M06	Morugama	Protected	Manual	No	No	No	2	Poor	No	No	No	Yes
4A01	Polgahawela	Protected	Manual	Yes	Yes	Yes	6	Normal	Yes	No	Legal	Yes
4A02	Godawela	Protected	Manual	Yes	Yes	Yes	1	Good	No	No	No	Yes
4A04	Pothuhera	Protected	Manual	No	No	Yes	1	Poor	Yes	No	Legal	Yes
4A05	Muttettugala	Protected	Manual	No	No	Yes	1	Good	No	No	Legal	Yes
4B01	Girambe	Protected	Manual	No	No	Yes	1	Good	No	No	No	No
4B02	Thalawattegedara	Protected	Manual	No	No	No	1	Good	Yes	No	Legal	No

4B03	Wadakada	Protected	Manual	No	No	No	2	Good	No	No	Legal	No
4B04	Dambokka Junction	Protected	Manual	No	No	Yes	1	Normal	Yes	No	No	No
4B05	Maraluwawa-3	Unprotected	No	No	No	No	1	Poor	No	Yes	No	No
4B06	Wellawa	Protected	Bamboo	No	No	No	2	Good	No	No	Legal	No
4B07	Wellawa	Protected	Manual	No	No	No	1	Good	No	No	No	Yes
4B08	Ganewatta	Protected	Manual	No	Yes	No	2	Good	No	No	Illegal	No
4B09	Maho	Protected	Automatic	Yes	Yes	Yes	6	Good	No	No	Legal	No
4B10	Ambanpola	Protected	Manual	No	Yes	Yes	2	Good	No	No	No	No
4B11	Galgamuwa	Protected	Manual	No	No	No	1	Good	No	No	Both	No
4B12	Amunukole	Protected	Bamboo	No	No	No	1	Poor	No	No	No	No
4B13	Bandawa	Protected	Manual	No	No	No	1	Poor	Yes	No	Illegal	No
4M01	Polgahawela	Unprotected	No	No	No	No	1	Poor	Yes	No	No	No
4M02	Boyagane	Unprotected	No	No	No	No	1	Poor	Yes	Yes	No	No
4M03	Nailiya	Protected	Manual	No	No	No	1	Normal	Yes	No	Illegal	No
4M04	Muttettugala-1	Unprotected	No	No	No	No	1	Poor	Yes	Yes	No	No
4M05	Maraluwawa	Unprotected	No	No	No	No	1	Normal	Yes	Yes	No	No

4M06	Maraluwawa-2	Unprotected	No	No	No	No	1	Normal	No	No	Legal	No
4M07	Meddegama	Unprotected	No	No	No	No	1	Good	No	No	No	No
4M08	Thuruliyagama	Unprotected	No	No	No	No	1	Normal	Yes	No	Legal	No
4M09	Hadirawalana	Unprotected	No	No	No	No	1	Good	No	No	Legal	No
4M10	Wellawa	Unprotected	No	No	No	No	2	Poor	Yes	Yes	No	No
4M11	Wellawa	Unprotected	No	No	No	No	1	Good	Yes	No	No	No
4M12	Pahala Waraddana	Protected	Bamboo	No	No	No	1	Poor	No	No	No	No
4M13	Porapola	Protected	Bamboo	No	No	No	1	Normal	No	No	Legal	No
4M14	Porapola Junction	Protected	Bamboo	No	No	No	1	Normal	Yes	No	No	No
4M15	Ganewatta-Tambagalla	Protected	Bamboo	No	No	No	1	Good	N	No	No	No
4M16	Nagollagama	Protected	Manual	No	No	No	1	Poor	Yes	No	Legal	No
4M17	Rolawa	Unprotected	No	No	No	No	1	Poor	No	No	No	No
4M18	Dethawa	Protected	Bamboo	No	No	No	1	Good	No	No	No	No
4M19	Kirimatiyawa	Protected	Bamboo	No	No	No	1	Normal	No	No	No	No
4M20	Belumgala	Protected	Bamboo	No	No	No	1	Normal	No	No	No	No
4M21	Kasikote	Unprotected	No	No	No	No	1	Normal	Yes	No	N	No

4M22	Getadiwula	Unprotected	No	No	No	No	1	Poor	Yes	Yes	No	No
4M23	Palukadawala	Protected	Bamboo	No	No	No	1	Good	No	No	Legal	No
4M24	Devagiripura	Protected	Bamboo	No	No	No	1	Poor	No	No	No	No
4M25	Galgamuwa	Protected	Bamboo	No	No	No	1	Poor	Yes	Yes	Illegal	No
4M26	Galgamuwa fair	Protected	Bamboo	No	No	No	2	Good	No	No	No	No
4M27	Galgamuwa	Protected	Bamboo	No	No	No	1	Good	No	No	Legal	No
4M28	Diwulwewa	Protected	Bamboo	No	No	No	1	Good	No	No	Legal	No
4M29	Kurundankulama	Protected	Manual	No	No	No	1	Good	No	No	No	No
4M30	Kelegama	Protected	Bamboo	No	No	No	1	Good	No	No	No	No
4M31	Mahagalkadawala	Unprotected	No	No	No	No	1	Poor	No	No	No	No
7B01	Yapahuwa	Protected	Manual	No	No	No	1	Good	No	No	No	No
7M01	Madurugama	Protected	Bamboo	No	No	No	1	Normal	Yes	Yes	No	No
7M02	Kaikawala	Protected	Bamboo	No	No	No	1	Normal	Yes	No	No	No

3.4 Safety Index

Table -5 : Safety Index

Location	Gate Type	Signal	Alarm	Communication	Signs & Markings	Visibility	Median Barrier	Geometry	Accident Rate	Fatal Accidents	Total	Index
1B01	10	10	10	10	6	4	0	9	0.178	0	67	
1M01	-	-	-	-	-	-	-	-	-	-	-	
1M02	4	0	0	0	2	6	0	5	0	0	31	
1M03	-	-	-	-	-	-	-	-	-	-	-	
1M04	-	-	-	-	-	-	-	-	-	-	-	
1M05	9	0	0	0	0	8	0	7	0	0	33	
1A01	8	10	10	10	6	10	10	8	1.5	4	25	
1M06	4	0	0	0	2	7	10	8	0	0	35	
4A01	8	10	10	10	8	6	5	8	1.79	0	55	
4M01	-	-	-	-	-	-	-	-	-	-	-	
4A02	8	10	10	10	8	10	5	7	0.48	1	61	
4A03	7	0	0	0	4	2	0	3	0	0	33	
4B01	8	0	0	10	2	10	0	8	0.731	0	49	
4B02	7	0	0	0	4	6	0	6	0.736	0	33	
4B03	10	0	0	0	4	9	0	6	0	0	49	
4A04	8	0	10	10	8	10	6	7	0.84	1	49	

4B04	10	0	10	10	6	5	0	9	0.567	0	64	
4M02	-	-	-	-	-	-	-	-	-	-	-	
4M03	7	0	0	0	6	8	0	4	0	0	52	
4A05	8	0	10	10	0	10	1	2	0.397	0	45	
4M04	-	-	-	-	-	-	-	-	-	-	-	
4M05	-	-	-	-	-	-	-	-	-	-	-	
4M06	-	-	-	-	-	-	-	-	-	-	-	
4B05	-	-	-	-	-	-	-	-	-	-	-	
4M07	-	-	-	-	-	-	-	-	-	-	-	
4M08	-	-	-	-	-	-	-	-	-	-	-	
4M09	-	-	-	-	-	-	-	-	-	-	-	
4B06	7	0	0	0	8	10	0	10	0	0	52	
4M10	-	-	-	-	-	-	-	-	-	-	-	
4B07	9	0	10	0	8	10	7	10	0.271	0	60	
4M11	-	-	-	-	-	-	-	-	-	-	-	
4M12	7	0	0	0	4	7	0	8	0	0	53	
4M13	7	0	0	0	8	10	0	8	0	0	60	
4M14	7	0	0	0	6	6	0	6	0	0	52	
4B08	8	0	10	0	9	8	0	6	1.71	0	42	

4M15	7	0	0	0	6	8	0	6	0	0	52	
7B01	7	0	0	0	6	10	0	7	0	0	57	
7M02	7	0	0	0	7	8	0	3	0	0	52	
7M01	7	0	0	0	6	4	0	6	0	0	50	
4B10	8	0	10	10	7	6	0	7	0	0	73	
4M20	7	0	0	0	10	8	0	8	0	0	60	
4M21	-	-	-	-	-	-	-	-	-	-	-	
4M22	-	-	-	-	-	-	-	-	-	-	-	
4M23	7	0	0	0	9	9	3	6	0	0	58	
4M24	7	0	0	0	10	10	0	8	0	0	62	
4M25	6	0	0	0	8	4	0	8	0	0	52	
4B11	8	10	0	0	10	10	0	9	0	0	65	
4M26	-	-	-	-	-	-	-	-	-	-	-	
4M27	7	0	0	0	7	8	0	8	0	0	57	
4M28	6	0	0	0	6	7	0	3	0	0	48	
4M29	7	0	0	0	7	8	0	8	0	0	57	
4M30	6	0	0	0	6	9	0	8	0	0	55	
4B12	7	0	0	0	6	6	0	9	0	0	45	
4M31	-	-	-	-	-	-	-	-	-	-	-	

4M19	6	0	0	0	8	9	0	9	0	0	58	
4M18	7	0	0	0	10	9	0	6	0	0	59	
4M17	-	-	-	-	-	-	-	-	-	-	-	
4B09	8	10	10	10	9	8	0	7	0	0	70	
4M16	7	0	0	0	7	6	0	4	0	0	51	

0 - 35 - Dangerous

36 - 60 - Risky

>60 - Safe

3.5 Reasons for Accidents

1. Lack of Driver Discipline
   The behaviour of the main road drivers is the main reason which affected for the most of the accidents. Yangalmodara railway level crossing accident which was happened on the 27th of April 2005 is the best example of that. Although the level crossings have all the safety arrangements, if the illegal movements are occurring there, then probably an accident can be happened. Most of these illegal movements can be seen in level crossings with half barriers. Sometimes, gates are closed for more than twenty minutes due to improper communication with the station. It also may cause the drivers to make illegal movements.

2. Poor Geometry and Visibility
   The geometry of the level crossing has affected to the accidents in some cases. At some level crossings there is a huge elevation difference between the railway line and the road. Because of this, a vehicle cannot cross the line smoothly, which causes of railway induced accidents. One of the other reasons is the poor visibility of the train. If there is a huge bend at the railway line or the if the approaching road is with a bend, then the drivers cannot see the approaching train and the level crossing clearly.

   Some level crossings are covered by vegetation. The reason for the accidents which were happening in night times is the poor visibility of the level crossing. So, the level crossings should be lighted at night

3. Poor Maintenance
   In some places, the road surface has not been properly maintained, which makes the vehicles to move with difficulty. This causes for railway induced accidents. The approaching signs for road belong to the Road Development Authority (RDA) and warning signs belong to the Sri Lanka Railway (SLR). Most of these signs are poorly maintained and because of that people are not aware about the presence of a level crossing which directly grounds for accidents.

4. CONCLUSION

According to the safety index, only nine level crossings are safe. Also, 25 level crossings are dangerous. The main two reasons for those railway level crossings become unsafe are driver behavior and improper management of Sri Lanka Railway.

Most of the level crossings are protected by bamboo gates. Although, they have been introduced 17 years ago, there is no any improvement of these level crossings. Some of them have already become unprotected due to the lack of support from the SLR to maintain them. Gate operators are not given sufficient funds to renovate the gates. Since they have no facilities such as lights, flags, huts, watch they tend to escape from the job. Then the level crossings become unprotected automatically. So, the best solution for the bamboo gates is to implement a magnetic alarm system near the level crossing. Also, the approaching signs have to be renovated. Then, unless there is a gate operator at the crossing, the driver can identify the approaching train. Bamboo gates are never suitable for double track crossings. Because, the gate operator is not able to close the gates before the train is coming. Those crossings need at least gates with a lever system.

A basic requirement to approve a level crossing is that the train driver should be able to see the both sides of the railway to a distance of 7 feet from a distance of 660 feet before the level crossing. But, the above requirement could not be seen at some of the level crossings. Also, a minimum 30 feet reserved area should be appeared at the both sides of the rail track. But, there were many illegal constructions within that area. Those are indirectly affected to the accidents.

Although some level crossings have all the requirements, accidents are occurring. The main reason is driver discipline. Many illegal movements can be seen at A class level crossings such as Yangalmodara, Muttettugala, Maho. If the drivers behave by understanding their responsibilities, further improvements are not needed. Otherwise, security points have to be established at each and every A type level crossings. If the road is fully closed by barriers, then those illegal movements can be stopped.

Finally, if the SLR and road users realize their responsibilities and do their duties properly, safety on railway level crossings can be improved without much outflow.

ACKNOWLEDGEMENTS

First of all, I would like to make my gratitude to my project supervisor Dr.Jayalath Edirisinghe for giving me the

opportunity to carry out a research project under his supervision and also for the trustiness that I can do this type of research project.

Next my heartily gratitude goes to Dr. R.M.S.Sathyaprasad who's a senior lecturer in the Civil Engineering Department, helped me as the co-advisor on the project. And also I would like to memorize Dr.Gemunu Gurusinghe , a senior lecturer in the Civil Engineering Department.

Then I would like to express my gratitude to Deputy Inspector General, Wayamba Region, Traffic O,I,Cs of all the police stations in Kurunegala District, Chief Engineer of Road Development Authority of Kurunegala, all the people in SLR who helped me.

Finally, I would like to thank all the organizations and personals that helped me in various ways to make this project a success.

REFERENCES

1) Road Map of Sri Lanka (Scale 1: 50,000)

2) Map of North Western Province (Scale 1:250,000)

3) Hyatt D., Railways of Sri Lanka , Comrac, London and Colombo, 2000, pp12,13,4065,66,159,163

4) Rail 2000, Sri Lanka Railways, Comrac, London, 2000, pp14

5) www.levelcrossings.nsw.gov.au

BIOGRAPHIES

Kumudu Vidana Gamage is presently pursuing her Master of Philosophy degree in Civil Engineering at Curtin University, Western Australia. She has earned her bachelor of Engineering degree from University of Peradeniya, Sri Lanka and carried out this project as a fulfillment of her degree.