Original research paper

Improving safety conditions for pedestrian/bicyclists at pathway rail grade crossing

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Abstract

Safety treatments for non-motorized users at railway grade crossings have been a growing issue. Every year, pedestrians/bicyclists die or get injured due to collision with trains at highway rail grade crossings and pathway rail grade crossings. Although, the number of fatalities due to collisions between trains and vehicles has reduced, the number of pedestrians/bicyclists fatalities and injuries at highway and pathway rail grade crossings has remained consistent in the last decade. Very recently, two accidents happened between bicyclist and light rail within the inner loop of Houston, Texas. There is a growing importance being directed towards enhancing the safety measures for non-motorized users at rail grade crossings to prevent injuries and fatalities of pedestrians/bicyclists. The objective of this study is to propose safety treatment at pathway rail grade crossing to enhance the security and invulnerability of non-motorized users by conducting a survey. Two pathway rail grade crossing locations, namely Fannin at Sunset Boulevard and Fannin at Holly Hall Street were

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selected as two accidents happened there recently for conducting survey on people around those locations. A questionnaire was prepared and the survey was executed on 102 people. After the survey, various factors were analyzed from the survey data. Some of those are mode of crossing, frequency of using crossing, warning sign and device awareness and addition to improve safety at crossing. After investigating the results from the survey, safety treatment is proposed for those two locations and recommendation is also made to the METRORail for augmenting safety for pedestrians/bicyclists along rail grade crossings.

Keywords:

Pedestrian/bicyclists; accidents; crossing; safety; survey.

1 Introduction

In United States, though there was a reduction in rail crossing accidents from 1978 to 1994, many accidents still happen every year (Metaxatos and Sriraj, 2015). In opposite to the reducing number of fatalities between train-vehicle collisions at rail grade crossing, the number of non-motorist fatalities at rail grade crossing is relatively unchanged still. Between 1994 and 2007, incidents at highway rail grade crossings reduced by 44%. Although, between 2003 and 2007 the number of incidents between non-motorists and trains remained the same (Horton,2010). The number of domestic and international research on train-related accidents is many, though the number of studies related to non-motorist safety at rail grade crossings is limited (Lobb, 2006). There is a natural relationship between pedestrians and public transit rail services. Rail services provide high capacity travel option for pedestrians allowing them to travel many places otherwise not possible. Augmenting the pedestrian safety at rail crossings benefits the pedestrians as well as the transit services resulting in an attractive service and better consistency at crossings (TCRP Report 175, 2015).

Pedestrian safety at rail crossing is an imposing issue due to a number of reasons. Incidents occurring between pedestrian/bicyclists and rails occur in various settings requiring context sensitive solutions. For instance, accidents involving violations at rail grade crossings are different from trespassing accidents away from crossings. A difficulty for implementing proper safety treatment for pedestrian is that in addition to pedestrian, pedestrian crossing serves other types of non-motorized users as well such as skateboards, rollerblades and equestrians (Metaxatos and Sriraj, 2016).

A good number of treatments for pedestrian/bicyclists have been applied at various highway rail and pathway rail grade crossings but hardly any work has been done to assess their effectiveness. The purpose of this study is to conduct a survey on pedestrians at two distinct locations within the inner loop of Houston. Based on the survey results, safety treatment is proposed for those two locations and recommendations are made to the METRORail for augmenting the safety measures for pedestrian/bicyclists at those two locations.

2 Background

2.1 Light rail

Light rail is a kind of rail service that is provided by short trains or single vehicles on dedicated ROW or on roads and streets. Light-rail vehicles (LRV) are generally driven electrically by power being drawn from and overhead electric line via a pantograph or trolley. Transit users typically board LRVs from stations or from trackside stops in streets (TCRP Report 175, 2015).

2.2 METRORail

METRORail *is* 23.8 mile (38.3 km) LRT system in Houston, Texas. By 2015, METRORail had an average weekday ridership of 60,600 and total annual ridership of 16,500,400. After Dallas' DART Light Rail, METRORail is ranked as the second most traveled light rail system in the Southern United States and the 13th most traveled light rail system in the United States. METRORail is operated by the Metropolitan Transit Authority of Harris County (Wikipedia). Figure 1 shows the map of METRORail, Houston.

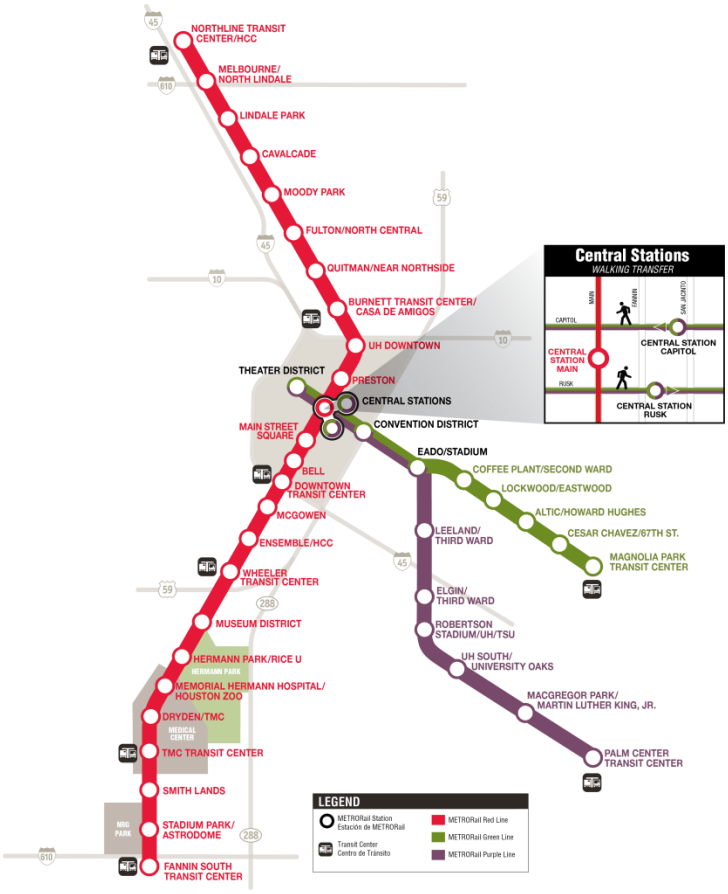


Fig. 1 Map of METRORail, Houston (ridemtro.org)

The 13-mile Red Line consists of 25 stations from Northline Transit Center to Fannin South. It opened in 2004 and carries 48,000 passengers daily. It is the nation's most traveled lines based on boarding per track mile. It was expanded in December 2013. Featured stops include downtown, the Museum District, the Texas Medical Center and NRG park. The Green Line (East End) consists of 9 station which travels along Harrisburg from the Magnolia Park Transit Center and through the historic East End to a variety of downtown entertainment and business locations. The 6.6-mile Purple Line (Southeast) consists of 10 stations beginning at downtown and travels southeast along Capitol and Rusk to the Palm Center near MLK and Griggs. It runs through one of Houston's oldest African-American communities and connects to both Texas Southern University and the University of Houston. The final section of the trackway is shared with the Green Line (East End), which enables riders to transfer at the EaDO/Stadium to travel through the East End (METRORail-Houston).

2.3 Pedestrian-Rail Crossing Types

The highway-railroad crossing design guide published by the Southern California Regional Rail Authority (SCRRA) states that pedestrian-railroad grade crossings can be characterized as one of four types that are:

- Pedestrian-rail grade crossings adjacent to a motor vehicle crossing.
- Pedestrian-rail grade crossings at stations adjacent to a motor vehicle crossing.
- Pedestrian-rail grade crossings at stations.
- Pedestrian-rail grade crossings not adjacent to motor vehicle crossing or in a station.

2.3.1 Pedestrian-Rail Crossings Adjacent to a Motor Vehicle Crossing

Pedestrian-rail grade crossings adjacent to a motor vehicle travel lane involve a crossing which is parallel to roadways crossing the tracks. For this type of crossing, road and adjacent pedestrian route cross the train tracks. Another type is pedestrian-rail grade crossings adjacent to a motor vehicle crossing where the street and pedestrian crosswalk cross both the train tracks and vehicle lanes where light-rail services operate in mixed traffic along a roadway.

2.3.2 Pedestrian-Rail Grade Crossings at Stations Adjacent to a Motor Vehicle Crossing

This type of crossing is a special case of pedestrian-rail grade crossing. These crossings, along with pedestrian-rail grade crossings at stations are used to provide access to rail transit station platforms for pedestrian.

2.3.3 Pedestrian-Rail Grade Crossings at Stations

For this third type of crossing, station is located in the median of a street, requiring the passenger to cross one or more tracks as well as one or more highway lanes to access adjacent land use.

2.3.4 Pedestrian-Rail Grade Crossings Not Adjacent to Motor Vehicle Crossing or in a Station

The fourth type of pedestrian rail grade crossing is when the crossing is not adjacent to a motor vehicle crossing or in a station. These types of crossings are generally used on multi-use paths adjacent to rail transit lines or to maintain established pedestrian traffic paths which are interrupted by the construction of a new rail transit line.

2.3.4 Findings from the Literature Review

The major findings from the literature review include the following:

- A wide number of Manual on Uniform Traffic Control Devices (MUTCD) signs and warning devices are used at rail grade crossings to warn pedestrian/bicyclists of incoming trains. A good number of non-compliant MUTCD signs and devices are also used as well.
- The signs and warning devices consist of active and passive signs, pavement markings, channeling devices such as fencing, zigzag, swing gates, automatic pedestrian gates and second train coming warning devices.
- The measurement of forcefulness of a particular sign or warning device at rail grade crossing is unidentified.
- There is a lack of method for quantifying the risk of pedestrian/bicyclists incidents with trains at grade crossing.

- There is a necessity to address the requirements of users with disabilities at grade crossing.
- A wide number of criteria are used for the selection of signs and warning devices at grade crossings such as: pedestrian/bicyclists collision experience at the crossing, inclement weather, train speed, frequency of trains, pedestrian volume at peak and non-peak hour, railroad traffic pattern, surrounding land use pattern, sight distance for pedestrian approaching crossing, presence of multiple tracks and installation and maintenance cost.

3 Survey Methodology and Site Location

A survey was conducted on two locations that are Fannin @ Sunset Boulevard which is near Hermann Park/Rice University transit station and Fannin @ Holly Hall Street which is near Reliant Park transit station. A questionnaire was developed to conduct the survey on people using those two crossings. The questionnaire was influenced by the questionnaire which was developed by Urban Transportation Center (UTC) research team and the Survey Research Laboratory (SRL) project coordinator for an earlier survey of Chicago region non-CTA grade crossings (Metaxatos and Sriraj, 2013). Figure 2 and figure 3 shows the site locations where the survey was conducted.

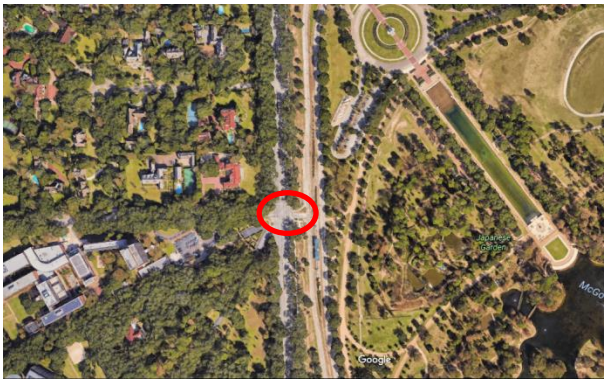


Fig. 2 Fannin @ Susnet Boulevard (Google Earth)

Fig. 3 Fannin @ Holly Hall Street (Google Earth)

4 Survey Analysis and Results

4.1 Crossing Mode

Among the 102 survey respondents, about 43% walked, more than 16% were texting while they were walking, less than 12 percent were riding bicycles, about 8% were talking on phone as well as listening to music on earphones, less than 6% people were with some kind of walking aid, about 4% were on skateboard and less than 3% people were with young children. The following figure 4 shows the crossing mode of survey respondents.

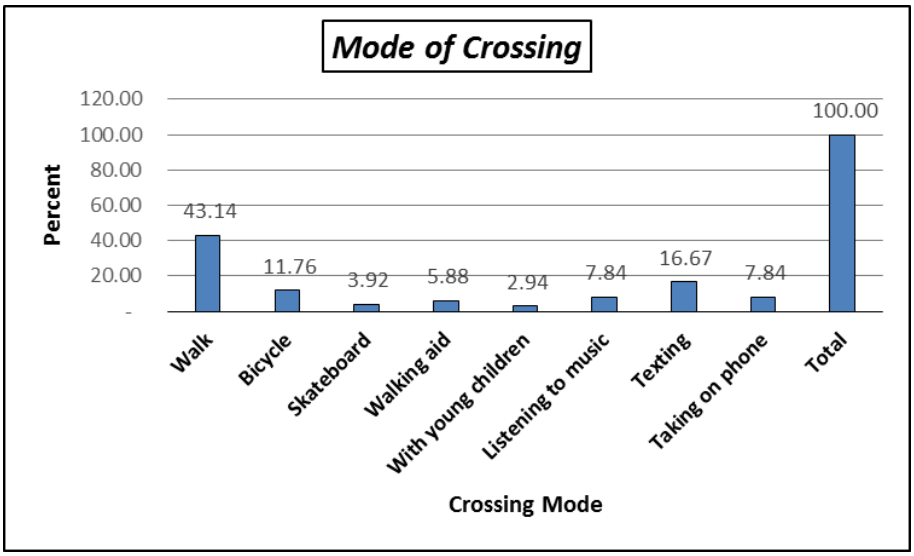


Fig. 4 Crossing Mode of Survey Respondents.

4.2 Age & Gender Distribution

Overall, male respondents were more present in the survey than the female respondents. 65 of the 102 respondents were male and 37 were female. Almost 30% of the respondents aged between 31-40 years among which, 19 were male and 11 were female. 29% respondents aged between 21-30 years among which, 15 were male and 14 were female. Almost 15% respondents aged between 41-50 years among which, 10 were male and 5 were female. The percent of respondents aged less than 21 years and aged between 51-60 is same which is just under 11% among which 8 were male and 3 were female for both of the group. Finally, almost 6% percent respondents aged between 61-70 years old among which, 5 were male and 1 was female. Figure 5 shows age and gender distribution of survey respondents.

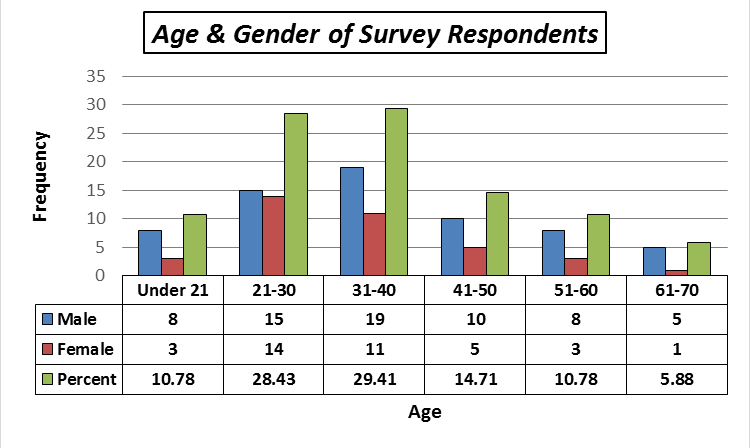


Fig. 5 Age & Gender of Survey Respondents.

4.3 Pedestrian/Bicyclists Rushing Behavior at Survey Locations

Pedestrian/Bicyclists crossing behavior was observed at both the survey locations for a period of 1 hour from 9 30 A.M to 10 30 A.M in the morning. Pedestrian/Bicyclists are considered rushing at rail crossings if the gates are down or the lights are flashing or the bells are ringing or the pedestrian crossing sign is not active. During the 1 hour period, 221 people were seen crossing both the crossing locations. 196 of them were walking and the rest 25 were bicyclists. 88 of the 196 people walking were male and 108 were female. Among the 25 bicyclists, 14 were male and 11 were female. Among all the male walkers, 43% were seen to be rushing to cross the pedestrian crossing. Among the female walkers, 39% were seen rushing. Among the male cyclists, 57% were seen rushing and among the female cyclists, 27% were seen rushing. Overall among the walkers, male were seen rushing more than the female by 4%. Among

the bicyclists, male were seen rushing more than female by 30%. The following figure 6 shows rushing behavior of pedestrian/bicyclists at rail grade crossing.

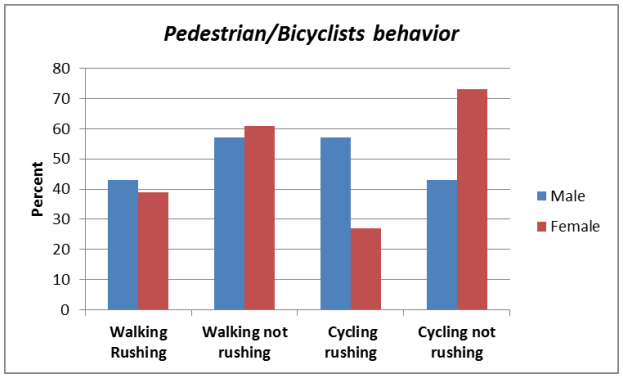


Fig. 6 Pedestrian/Bicyclists Rushing Behavior

4.4 Crossing Frequency of Respondents

Among all of the 102 survey respondents, 32 were irregular users. So, almost 70% (70 of 102) were regular users. More than 8 out of 10 people of regular users used the crossings at which they were interviewed were using the crossings daily or weekly. 60% of the regular users used crossings daily, 25% people used crossings weekly and almost 15% people used crossings on a monthly basis. The most frequency of using crossings for daily, weekly and monthly basis was 1. Table 1 shows the crossing frequency of survey respondents.

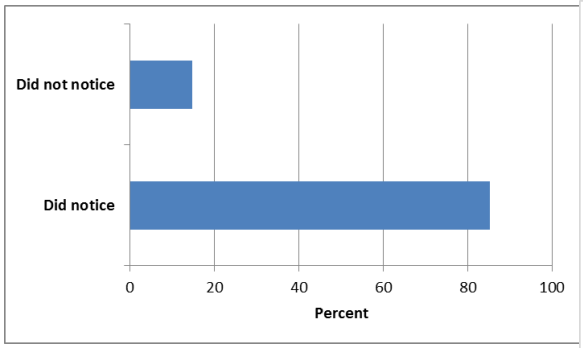
Table 1 Crossing Frequency of Respondents

Number of Times	**Daily**	**Weekly**	**Monthly**	**Total**	**Percent**
1	18	5	**3**	26	37.14286
2	12	4	2	18	25.71429
3	5	4	1	10	14.28571
4	3	1	1	5	7.142857
5	4	4	3	11	15.71429
Total	42	18	10	70	100
Percent	60	25.71429	14.28571	100	
Irregular Users				32	

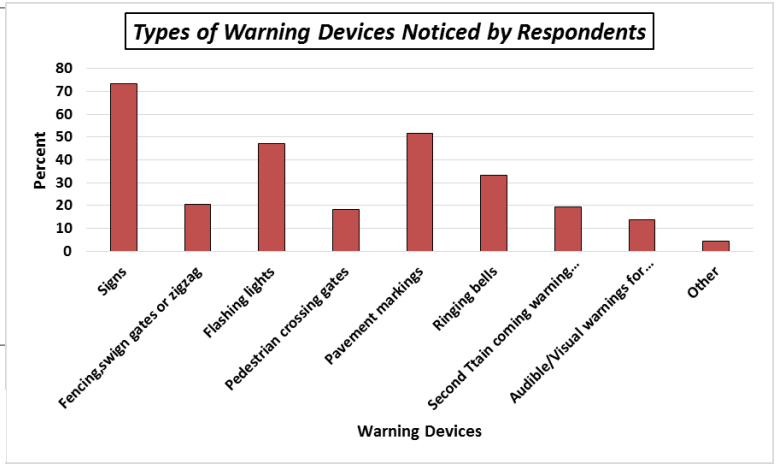
Total	**102**

4.5 Signs/Warning Devices Noticed by Respondents

Of all the 102 respondents, more than 85% people did notice warning devices/signs installed while crossing the pedestrian crossing. The warning device most noticed by users was signs which is more than 73% followed by pavement markings which is almost 52 percent. Flashing lights was the third most noticed warning device that is about 47 percent. Fencing, swing gates or zigzag were noticed by approximately 20% users. 19% users noticed second train coming warning signs. Pedestrian crossing gate was noticed by 18% respondents. Finally, little less than 14% users noticed audible/visual warnings for people with disabilities. Figure 7 shows the signs/warning devices noticed by survey respondents.



(a) Percent of users noticed or did not notice warning devices



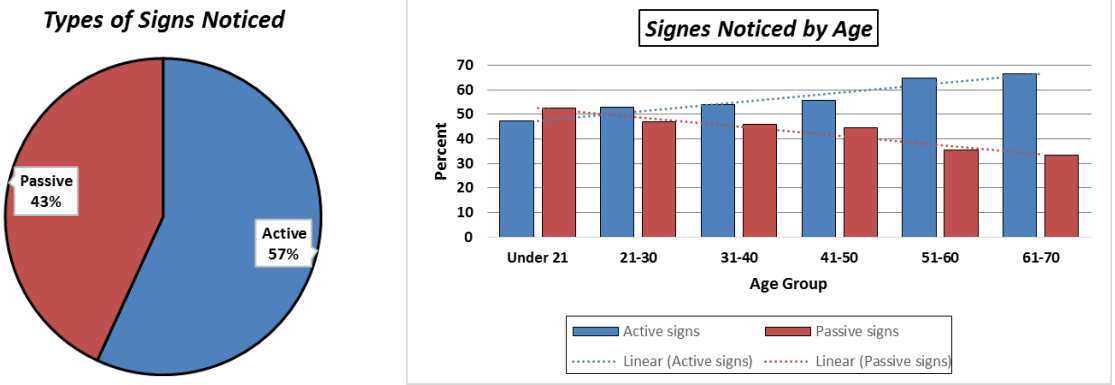
(b) Different warning devices noticed by survey

Fig. 7 Signs/warning devices noticed by survey respondents

4.6 Active/Passive Sign Detection

The warning devices/signs shown in figure 4 were further categorized in two categories that are active and passive in order to investigate visibility differences. In age group under 21, 47% users noticed active signs. Users in age group 21-30 noticed 52% active signs. Among age groups 31-40, 41-50, 51-60 and 61-70, the percent of noticing active signs is 53, 55, 64 and 66 respectively. It is interesting to note that the percent of noticing passive signs decrease as the age increases and the percent of noticing active

signs increases as the age increases. Figure 8 shows active/passive sign detection by survey respondents.



(a) Types of Signs Noticed

(b) Type of signs noticed by different age group

Fig. 8 Active/Passive Sign Detection

4.7 Attitudes of Respondents at Crossing

A good number of respondents said that they would not cross the tracks if the gates were down or the lights were flashing or the bells were ringing. However, 40% users said that they would cross the track if they were in a hurry, 52% users said they would cross if other people were crossing, 21% users said they would cross if they were annoyed for the train to pass, 38% users would cross if they could not see a train coming and lastly, 49% people would cross if they felt they had enough time. The following figure 9 shows the attitudes of survey respondents at crossing.

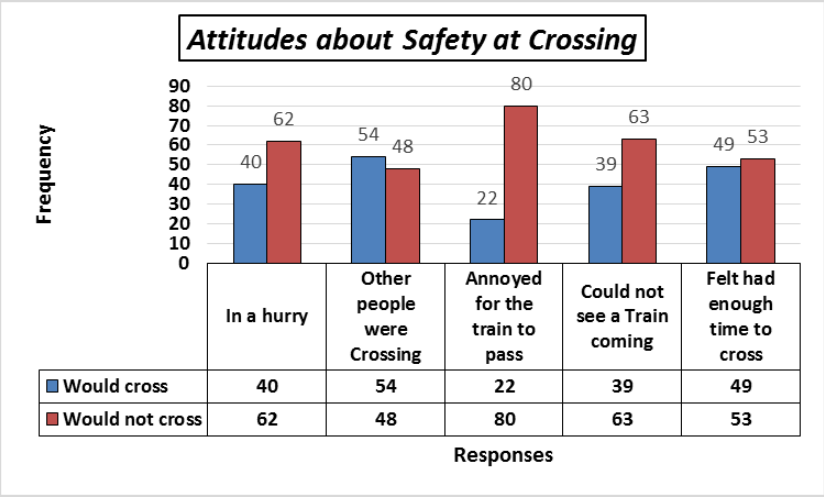


Fig. 9 Attitudes about Safety of Survey Respondents at Crossing

Overall, female respondents were more safety cautious than the male respondents. Moreover, users of younger age were seen to be crossing the tracks against activated signals/warning devices. Furthermore, regular users were more concerned about safety than the irregular users as well.

4.8 Frequency of Seeing Others Cross Tracks

Most of the users participating in the survey (87%) said they saw other people crossing tracks against activated warning signs/devices. Female respondents were more active in recognizing such activities. Only 13% users said that they never saw others crossing the track against activated signals/devices. Figure 10 shows the frequency of seeing others crossing track at locations other than the designated pedestrian crossing

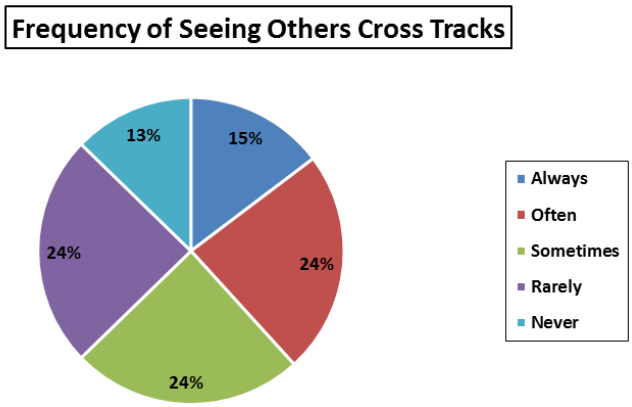


Fig. 10 Frequency of Seeing Others Crossing Tracks Against Activated Signals

4.9 Frequency of Crossing Tracks at locations other than Pedestrian Crossing

Among all the respondents, 24% users said that they never cross the track at locations other than the pedestrian crossing. About 8% users always, 16% users often and 24% users sometimes cross the tracks from locations other than the designated pedestrian crossing. Figure 11 shows percent distribution of survey respondents crossing tracks at locations other than designated pedestrian crossing.

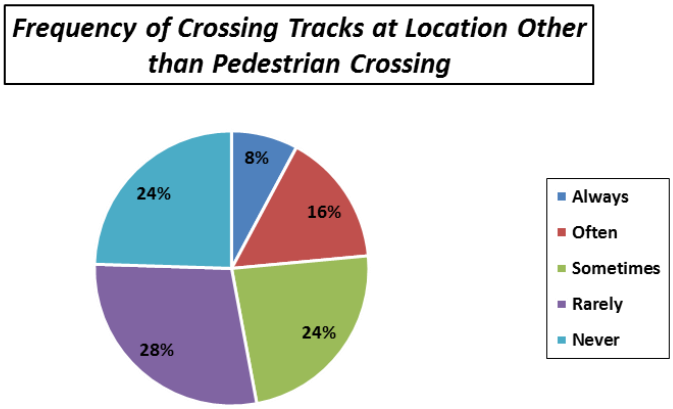


Fig. 11 Frequency of Crossing Tracks at Locations Other that Pedestrian Crossing

4.10 Reasons for Crossing Tracks at Other Locations

20% of the respondents said that they do not cross the tracks at locations other than the designated pedestrian crossing. 39% users responded that they cross the tracks at other locations because they saw other people were crossing, 44% users said they felt they had enough time and 25% respondents said they previously did it and they were not hurt. Figure 12 shows different reasons for survey respondents crossing tracks at other locations.

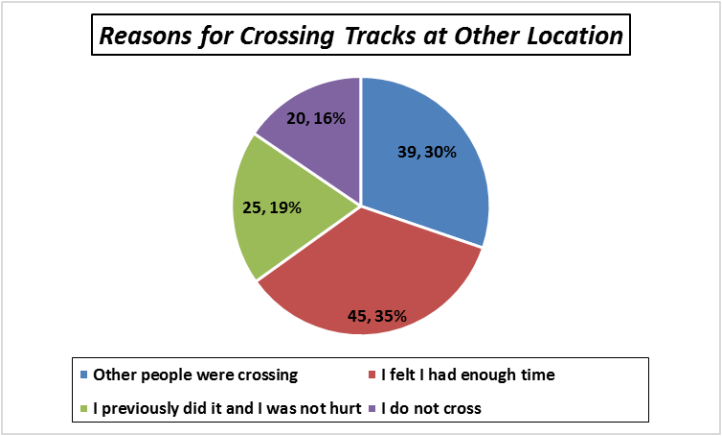
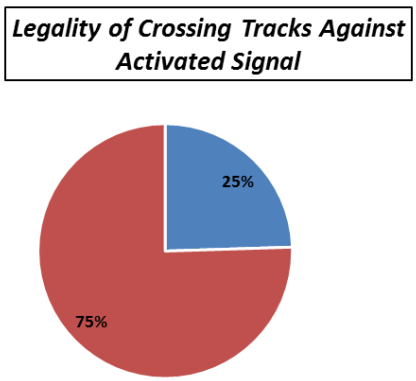


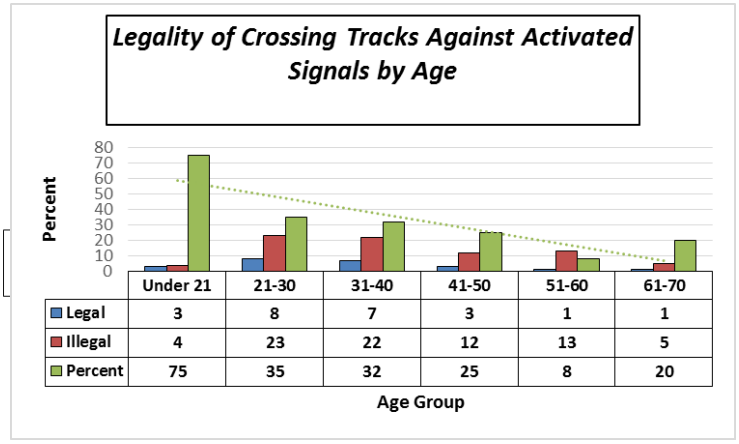
Fig. 12 Reasons for Crossing Tracks at Other Location

4.11 Legality of Crossing Tracks against Activated Signals

77% of all the respondents said that it is illegal to cross the tracks against activated signals. However, it is interesting to note that, the number of percent of users who feel that it is allowed to cross signals against activated signals increase as the age decreases. 75% of the users in the age group under 21 feel it is allowed to cross tracks against activated signals whereas only 20% people in the age group 61-70 feel the same. It is observed that the sense of safety increases in the users as their age increases.



(a) Legality of Crossing Tracks



(b) Legality of Crossing Tracks by age

Fig. 13 Legality of Crossing Tracks against Activated Signals

4.12 Notion of Safety at Pedestrian Crossing

Only 26% of all the users felt extremely safe or very safe about using the pedestrian crossing. 34% users felt moderately safe, 27% users felt unsafe and 12% users felt extremely unsafe about using the pedestrian crossing. This notion is shared evenly between male and female respondents. Most of the users who felt extremely safe were above 50 years old which can be seen in the following figure 14

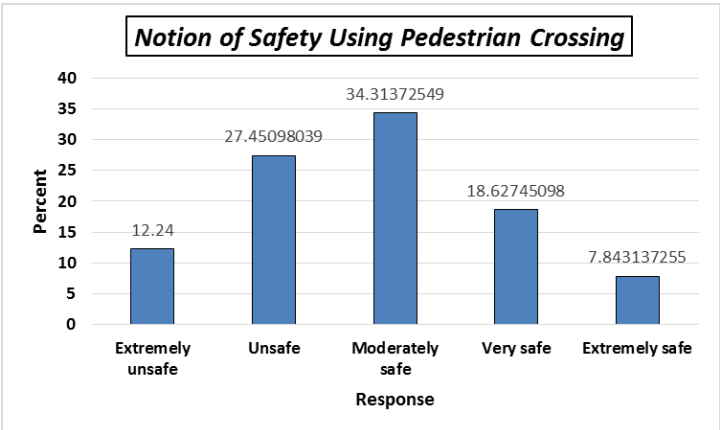


Fig. 14 Perception of Safety using Pedestrian Crossing

4.13 Predicament in Crossing Tracks

32% of the respondents said it was moderately easy for them to cross the tracks. For about 40% of the users, it was very easy or easy to cross the tracks.19% users found it difficult and 9% percent users found it extremely difficult to cross the tracks. A relationship is observed between notion of safety and difficulty in crossing tracks which is shown in figure 15.

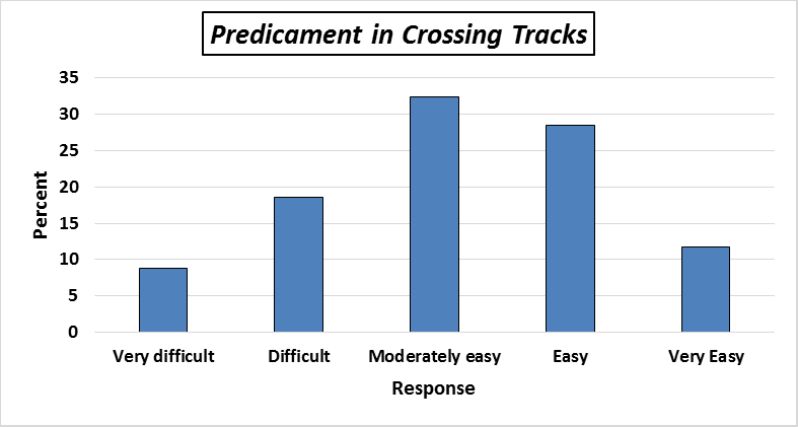


Fig. 15 Difficulty in Crossing Tracks

4.14 Reasons for Difficulty in Crossing Tracks

Almost all the respondents stated that they had some kinds of difficulties in crossing the pedestrian tracks. 16% respondents mentioned visually unclear signs as the reason of difficulty. 15% users said the direction of the sidewalk was not clear. It is noted that the percent of respondents is evenly distributed among the various reasons stated in the figure ranging from 10% to 16% which is shown in the following figure 16.

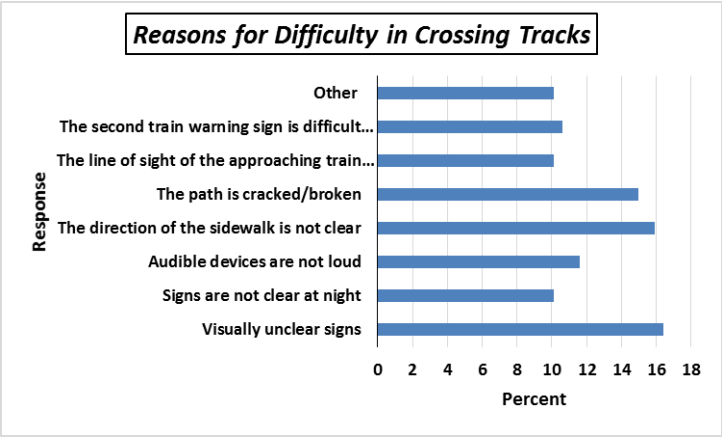


Fig. 16 Different reasons for Difficulty in Crossing Tracks

21 respondents stated other reason as the reasons for difficulty in crossing tracks which can be seen in the following table. 4 out of the 21 people who stated other reasons for difficulty in crossing tracks stated that traffic was too heavy and 3 users stated too many cars which can be seen in the following table 2.

Table 2 Other Reason for Difficulty in Crossing Tracks

Response	**Frequency**
From out of town not sure	2
Not often enough	1
Traffic is too heavy	4
Not difficult	2
Too many cars	3
None of the above	2
It is okay	1
I don't think so	1
Don't know	2
None	2
Traffic	1
Total	21

4.15 Disability Status

Among the 102 respondents, 6 people reported to have some kind of disability. Among these 6 people, 4 were male and 2 were female.

4.16 Inclusions for Improving Safety at Pedestrian Crossing

All the 102 survey respondents were asked for suggestions/comments to enhance the safety condition at pedestrian crossing. Almost all the respondents irrespective of gender or age made suggestions on additions to improve the safety of pedestrian crossing. Pedestrian crossing gate clearly stands out among the other options as more than 17% users felt that adding a pedestrian crossing gate would enhance the safety measure of pedestrian crossing. 14% users made suggestions to include signs, 12% respondents commented to introduce ringing bells as well as audible/visual warnings for people with disabilities. The distribution of different inclusions to improve safety suggested by survey respondents is shown in figure 17.

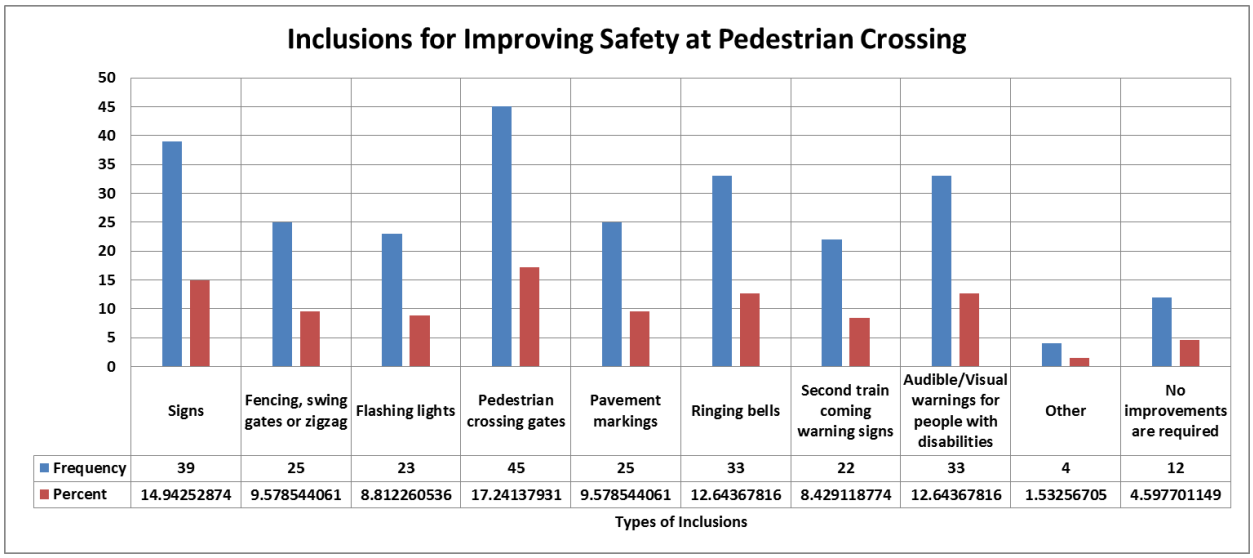


Fig. 17 Additions to Improve Safety at Pedestrian Crossing

Less than 2% users suggested other additions to include which is shown in the following table 3. Only 5% respondents suggested that no improvements were required to enhance the safety of pedestrian crossing.

Table 3 Other suggestions for improving safety

Response	Frequency
More advanced warning prior to regular warnings	1
Fix blind spot	3

5 Conclusion

After an analysis of literature review and the survey results, the study concludes the following:

- A number of activities such as: texting, talking on phone and listening to music create disturbance among the pedestrian/bicyclists while they are travelling across a grade crossing.
- Female users tend to be more safety conscious than male users both in terms of walking and cycling while travelling across a grade crossing. The propensity of rushing is found more in male users than female users.

- Most of the pedestrian/bicyclists irrespective of their gender and age notice warning signs and devices while crossing at grade crossing. Signs and pavement markings are the two most noticeable warning devices.
- Active signs are more noticed than passive signs among all users while crossing. The percentage of noticing active signs more than passive signs gets higher as the age increases among both male and female users.
- A good number of people do cross the pedestrian crossing when it is not allowed to cross (e.g., if the gates are down or the lights are flashing or the bells are ringing).
- Trespassing by crossing the tracks at locations other than the designated pedestrian crossing is a common habit of most users.
- A small number of people think it is legal to cross tracks against activated signals. However, this notion is found most among the younger people irrespective of their gender.
- A small percentage of people feel that it is moderately safe to cross tracks. On the other hand, most of the users feel it is not safe to cross tracks at rail grade crossings.
- A variety of reasons were found among pedestrian/bicyclists when they were asked about the reasons for difficulty when crossing tracks and the percentage of views were almost equally distributed between the reasons that are: visually unclear signs, the direction of sidewalk, not loud audible devices, broken path, the line of sight of the incoming train, second train coming warning signs and visibility of signs at night.
- Safety treatments for pedestrian/bicyclists should incorporate special treatment for people with disabilities.
- Most of the users believe that inclusion of pedestrian crossing gates should improve the safety condition for pedestrian/bicyclists at grade crossing.

6 Recommendation

The study recommends the following to METRORail, Houston for enhancing safety treatments for pedestrian/bicyclists at rail grade crossings:

- Install pedestrian crossing gates at the two locations on where the survey was conducted to improve the safety condition of pedestrian/bicyclists.
- Establish method to measure performance of signs and warning devices used at rail grade crossings.
- Establish method to calculate the risk of incidents between pedestrian/bicyclists and trains.
- Promote awareness on safety at rail crossings among all people specially young users.
- Promote treatments which consider the needs of people with disabilities at rail crossings.

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