Estimation of Risk to pedestrians on rail tracks on Mumbai Suburban

1. INTRODUCTION

As per National Crime Bureau Report(NCRB, 2016), Government of India, Railway accidents form a small percentage of total traffic accidents reported. During 2015, out of 4,96,762 Traffic Accident cases reported in India, 4,64,674 (93.5%) are Road accident and 29,419 (5.9%) are Railway accident causing 1,48,707 and 26,066 deaths respectively. Railway Accidents include, track pedestrian collision during trespassing, falling from train and other injuries to passengers' due to passenger accidents with train. Trespassing on Railway tracks is one of the leading railway safety challenges worldwide(Lobb, 2006) causing most fatalities from collisions between trains and pedestrians. Trespassing can be defined as violation of the Railway Train's right of way, i.e. a person walking along or across the functional Railway Track voluntarily with full knowledge of the risk involved. Railway Track pedestrian is a commuter/passenger trespassing on railway track.

A comparative study of railway accidents and particularly track pedestrian collisions in other countries, can help to relate the extent of problem in India. European Union Railway accidents caused 964 deaths and 778 injuries in 2016(Eurostat, 2017) . Suicide outnumber the trespassing accidents and reported 2870 fatalities, due to suicides, on the European rail network in 2016. US Railroads reported 575 fatalities and 505 non-fatalities during 2017 (FRA report, USA) Railroad trespassing incidents. Canada reported 81 incidents causing 53 fatalities in 2017. Great Britain reported 43 fatalities, other than suicide cases during 2014-15(ORR, 2017).

In India, as per NCRB reports, 31,236 incidents in 2013 caused 27,765 deaths, 28,360 incidents in 2014 caused 25,006 deaths vis-a΄-vis 29419 incidents in 2015 caused 26,066 deaths. High level Safety Review Committee(Kakodkar *et al.*, 2012) had been critical of Mumbai Suburban for such massacre on Railway System.

Approximately 70 deaths are reported on an average every day on Indian Railway System, including track pedestrian collisions with train, fallen from train, suicide cases etc. Of the total deaths reported, 70 % of fatalities on Indian Railways (NCRB, 2016) is due to Railway Track Pedestrian incidents and thus is a very important area of study in Transportation Safety Area.

1.1 Mumbai Suburban Culture and Pedestrian risk:

The Mumbai suburban culture has evolved over a century now, since the first suburban trains inducted in 1890. Historically, Central Business District (CBD) is situated in the lower peninsular part of the mainland Mumbai city comprising of Parel, Dadar and Fort area. The commuters arrive to the Mumbai city from suburbs in the morning and leave back for home in the evening. There has been a phenomenal increase in the Mumbai suburban population over the years and consequently tremendous increase in commuter traffic is observed. To keep pace with the mobility demand of these commuters, approximately 3000 suburban trains (with enhanced capacity) with additional coaches (12 to 15 coach train) are in operation for 21 hours in a day. However, the availability of suburban trains to commuters is still considered inadequate, due to rising population of city expanding to farther areas and adjoining districts up-to 100 km from main city hub.

In such scenario of inadequate infrastructure and the rational commuter's intent to maximize returns (on saving time and cost of commute), results into a situation of trains being overpacked to a super dense crush load of 16 passengers per square meter of coach floor space. And further amplified with the indifferent Mumbai suburban commuter culture wherein people tend to rush towards the train, keep pushing themselves into the train and try to locate any possible hold-on to train, with least consideration to fellow commuters and gross neglect of safety considerations. The huge population propelled development of the Mumbai city and its suburbs on either sides of the suburban railway track and consequently generated the need of people moving across the unfenced railway track to cater to daily needs of shopping, schooling, entertainment etc. Also, frequently people walk along the suburban railway track as a shortcut route to their destination, and feel convenient by avoiding the circuitous road or pedestrian path approach.

Track pedestrians trespass the railway track, according to their convenience duly glancing the non-availability of a running train. These pedestrian's cross railway track in the time gap available in between the trains departure and before arrival of next train at that spot on that railway track, hence are exposed to risk due to high traffic density of trains in the suburban area. At railway stations the commuters avoid the Foot over Bridges available on the railway platforms and resort to trespassing preferably at the end of the platform, at ground level. The commuters also cross the railway track to reach to required platform or exit gate, during a short time-gap, when train halts at a station as a scheduled stop for few seconds. Track Pedestrian tend to either crossover or walk along the railway track. Pedestrians

walking along the track move out of path to make way for the train, on hearing approaching train.

The possible reason for such high fatalities may be inadequate infrastructure facilities, e.g. narrow station platforms, insufficient and narrow Foot-Over Bridge (FOB) etc. The high rush of commuters and trespassers on the railway station vicinity supplement the exiting problems of space crunch, forcing people to move on railway track wherever and whenever possible in unsafe manner. The trespassing occurs to save egress time and distance, as soon the train stops at a scheduled halt and more often after the train leaves the platform. The FOBs at these suburban stations though available, are generally inaccessible for use due to its location and high rush at the platforms. Pedestrians prefer to cross the railway tracks on surface level, generally at either end of platform, rather use the overpass or underpass. These trespassing behaviour of track pedestrians is highly risky and may result in severe injuries and fatalities.

The track pedestrian accidents or passengers falling off the running train account for maximum fatalities on Mumbai Suburban system but are not considered as railway accidents as per the extant Railway Act, but are treated as 'untoward incidents'. Due to non-consideration of these fatalities on railway premises as railway accidents, the safety culture is influenced. Prima-facie inadequacy of the requisite infrastructure augmented with deliberate violations of safety norms by commuters may be contributing to high rate of fatalities. There is a need to understand high rate of these incidents over the years through the concept of epidemiology as used on public health system to arrive at inclusive safety solutions for pedestrians and commuters on Mumbai Suburban system.

In this paper, the accidents due to collision with train and cases of fallen from train, on Mumbai Suburban system is analysed in details to evolve the cause-wise risk assessment figure for each of these Suburban stations. Relevant review on risk, track pedestrian behaviour and remedial measures adopted by different railway systems around the world is discussed.

2. Pedestrian Risk and Behaviour

The safety consciousness of an individual is an inbuilt psychological trait. Understanding the risk perception and human behavioural response to the risk, is very important in the study on track pedestrian collisions. 'Risk as feeling' discuss the fast, instinctive and intuitive reactions to danger(Slovic *et al.*, 2004). Perceived risk is closely tied to cultural adherence and social learning, is an

important concept to understand cultural theory of risk(Sigve Oltedal, Bjørg-Elin Moen, Hroar Klempe, 2004). People choose what to fear and how much to fear. Culture has a major role to play in the way human psychology is shaped towards risk. The major theory of decision making under risk is the expected utility model. Rational decision (Tversky and Kahneman, 1981) makers will prefer the prospect that offers the highest expected utility. Mumbai Culture propagates risky behaviour of the suburban commuters on overcrowded suburban trains to optimize the available time and cost of commuting.

2.1 Pedestrian Risk

Pedestrian Risk, defined in terms of expected loss (Haight, 1986; Elvik, 2004) is, Risk =Probability of an unwanted event X Consequence of the unwanted event. Railway track pedestrian collision with train is an unwanted event, the consequences are the associated losses of injury and life. The accident may be very fatal as the accident severity is very high compared to road accidents. The accident severity, defined as 'number of persons killed per 100 accidents' is 88.6 for railway accident compared to 29.1 for road Accidents in 2015(MoRTH, 2017). The risk is undertaken by the habitual trespassers /pedestrian, presuming the probability of unwanted event of a collision with train, to be low The risk though very high, but is not apparent to pedestrian due to 1) low noise levels of an incoming suburban train because of improved technology adopted in manufacturing suburban trains coaches and track maintenance, 2) trespassers failure to perceive the precise distance and speed of the moving train 3) Poor visibility of incoming train due to curve or other obstructions in suburban area.

Theory of planned behaviour(Ajzen, 1991) predicts that individual behaviour is a direct function of the intention to perform that behaviour and perceived behavioural control accounting for internal and external constraints. Mumbai suburban system compels unsafe behaviour of trespassing railway track due to the available situation.

2.2 Modelling the engineering effect of track pedestrian safety measures:

A conceptual framework was developed to explain the findings of road safety evaluation studies and identified nine risk factors(Elvik, 2004). The same model can be extended to understand risk factors that are associated to track pedestrian accidents. The safety measures to be undertaken must influence these 6 basic risk factors, one or more of which may cause accidents or injuries of the track pedestrians or trespassers.

1. Kinetic Energy
2. Visibility

3. Compatibility
4. Complexity
5. Predictability
6. Individual Rationality

The movement of suburban train and people produces kinetic energy. The Kinetic energy produced is a function of mass of the body and its velocity, which is considerably high for a suburban train consisting of 12- 15 coaches with an average speed of 60-80 kmph and is a big hazard for the trespassers on railway track. Visibility of the suburban train is an apt risk factor for railway track pedestrians due to the inherent geometry of the railway track and the sight obstruction caused by buildings and vegetation. Hence the trespasser may not be able to see the train to respond effectively. The compatibility refers to the difference between the Kinetic energy produced by the moving train and the pedestrian, which is very high and hence is a serious risk factor. Speed, vehicle mass, visibility and compatibility are risk factors closely related to physical laws governing movement of bodies on railway track.

Complexity is a property of the existing traffic system and traffic. Mumbai suburban system is highly complex traffic system, with high frequency of suburban trains running in either direction consisting of fast and slow trains. The amount of information per unit time, required to be processed by the trespassers to cross the railway track at any instant, is tremendous and can be erroneous, causing risky situations. Predictability denotes the reliability with which the occurrence of the risky event can be predicted in any given situation. The suburban trains operate at high speed as per schedule, on the railway track and has right of way, without any expectation of pedestrian crossing track. The trains have a long braking distance to come to a stop on application of emergency brakes. Hence the track pedestrian face severe risk due to trespassing the railway area. Individual rationality is the extent to which a track pedestrian maximises the utility vis-à-vis risk. Mumbai being a busy commercial capital, to maximize the utility of time and money tend to take proportionately higher risk. Track pedestrians violate the railways right of way and perpetuate unsafe culture of crossing railway track wherever feasible to save time and effort.

2.3 Railway Track Pedestrian literature review:

Train-pedestrian collisions are the leading cause of fatality in train-related accidents worldwide(Lobb, 2006). A review of research on the railway pedestrian safety, reflects Train-pedestrian collisions are less common than other forms of pedestrian accident such as collisions between motor vehicles and pedestrians on the roads, but are more likely to result in death or irreparable damage, such

as amputation or paralysis. Pedestrians faced with the choice between crossing a potentially dangerous railway track, will frequently choose the risky option. The saving of time and effort by unsafe crossing of Railway tracks outweigh the risk of being hit by a train. A study into the origins of rule breaking at pedestrian train crossings(Freeman and Rakotonirainy, 2015) inferred pedestrians are more likely to deliberately violate rules (rather than make errors) at crossings. Violations of trespassing are observed more frequently after the train has passed, rather than arrival of train.

Complex interplay of environmental and social factors affects pedestrian choice of route. Trespasser accidents represent a major proportion of deaths and injuries on New Zealand's railway corridor causing 10 to 20 trespassers fatalities per year(Patterson, 2004). The study evaluated a multifaceted programme of public education and access prevention, to reduce illegal and unsafe crossing of the railway tracks by pedestrians in New Zealand(Lobb, Harre and Suddendorf, 2001). Trespassing had decreased substantially due to the programme of educational and access prevention interventions and has generated awareness of the illegality of walking across the tracks.

A study on Czech Railways had identified the typology of risk localities where trespassing on railway property frequently cause train-person crashes(Skládaná *et al.*, 2016). With increasing speed of trains and decreasing noisiness of trains, trespassing has become more dangerous. Project 'AMELIA' is aimed to contain the trespassing in the localities of such occurrences/behaviour. The illegal paths over railway tracks are main cause of train-pedestrian collision especially at train stops and stations, shortcuts for everyday use in proximity of level crossings, touristic paths, recreational localities, places of meeting especially abandoned goods shed, bridges closer to railway track.

A study of trespassing on the US Railroads provides a statistical analysis of the demographics of trespassers casualties on mainline and commuter railroads (Savage, 2007). The number of trespassers are of very high order of magnitude than the people who are caught for illegal crossing and a very few of that suffer fatalities or injuries. People in early twenties, males and Afro-Americans are at high risk. The trespassing phenomenon is urban and almost three quarters of fatalities occurred within city due to railroads being un-fenced and passing through the residential areas.

Train–pedestrian fatalities on Finnish railroads during 2005-2009 shows, 311 pedestrians killed in train–pedestrian collisions, including 264 suicides(Silla and Luoma, 2012a). The effect on frequency of illegal crossing of Railway Track or

trespassing railway tracks in un-authorized places(Silla and Luoma, 2011) by introduction of countermeasures on Finnish Railways was studied. Physical barriers reduce the incidences of trespassing from fencing (94.6%) and by landscaping (91.3%) as compared to prohibitive signs (30.7%) so put up at vulnerable locations/identified trespassing locations. A model of suicide and trespassing process was developed to analyse the decision process involved in suicide and trespassing to suggest suitable countermeasures(Burkhardt *et al.*, 2014). The chain of events causing the casualty is same due to the accessibility into railway track area and consequently leading to train pedestrian collision. European project RESTRAIL (Reduction of Suicides and Trespassers on RAIL property) started in 2012 with aim of reducing the occurrence of suicides and trespassing on railway property.

To establish the "Opinion on Railway Trespassing of people living close to a railway line" on Finnish railroads an anonymous survey was conducted from 1500 household in city of Eastern Finland(Silla and Luoma, 2012b). The data concluded (i) Specific time of trespassing cannot be defined, but most frequently happen during normal commuting time between 11AM and 7 PM, (ii) Adults form the largest trespassers group, (iii) Most effective countermeasures to prevent trespassing includes building an underpass or fencing off the tracks, (iv) Information campaign can also prevent trespassing.

3. Method

3.1 Data

This paper may be the first comprehensive review on track pedestrian fatalities on Indian Railways to assess the risk to pedestrians on Railway Track on Mumbai Railway Suburban system. The aggregate data about railway incidents including trespassing incidents on Indian Railways, is available from National Crime Record Bureau (NCRB), Government of India, which forms the basis to understand the extent of problem. The Data is discussed broadly to conclude about the issue on pan India basis. In these Government reports, the trespassing casualties are categorized under 'railway accidents'. All Railway Accidents which happen due to the collision of a person with the train, including suicide is classified as "untoward incidents" by Indian Railways as per the extant provisions of Railway Act.

This paper discusses the data about injuries and fatalities from railway accidents including collision between pedestrian on track and the suburban train in Mumbai Suburban network for the year 2015 and 2016. The study area comprises

of Mumbai city and its suburbs on which the Mumbai suburban train services are operational. The Mumbai Suburban network is spread over five Districts and falls under Mumbai Metropolitan Region(MMR), and is home to 21.3 million (2016) people, and have dense and busy passenger and freight traffic. This excludes data of short stretch of 11.4 km of Mumbai Metro between Andheri and Ghatkopar.

The Station wise and cause-wise injuries and fatalities data for the year 2015 and 2016 is collected from two Mumbai Railway Divisions of both Central Railways (C Rly) and Western Railways (W Rly) zones operating these commuter trains. The suburban station-wise footfall data of W Rly is aggregate of number of originating passengers recorded at these stations for two years 2015 and 2016. For the C Rly Footfall data is for the Year 2017 (Average per day since January to August)

3.1 Railway Accidents- All India Scenario

29,419 cases of Railway Accidents(NCRB, 2016) are reported in 2015, contributing to 26,066 deaths and 4,055 injuries. Maximum Railway Accidents were reported by State of Maharashtra accounting for 26.5% followed by Uttar Pradesh (15.1%). The state of Maharashtra is highest among all States/UTs. Maharashtra and Uttar Pradesh have also reported highest fatalities in Railway accidents, 18.1% (4,719 out of 26,066 deaths) and 17.2% (4,472 deaths) respectively. Also 76.3 % persons injured (3,095 out of 4,055 persons) in railway accidents were reported from Maharashtra.

During 2015, a total of **27,794 out of 29,419** cases of Railway accidents were furnished under "Other Causes", 'fall of persons from trains' or 'persons run-over by train' are furnished under this category.

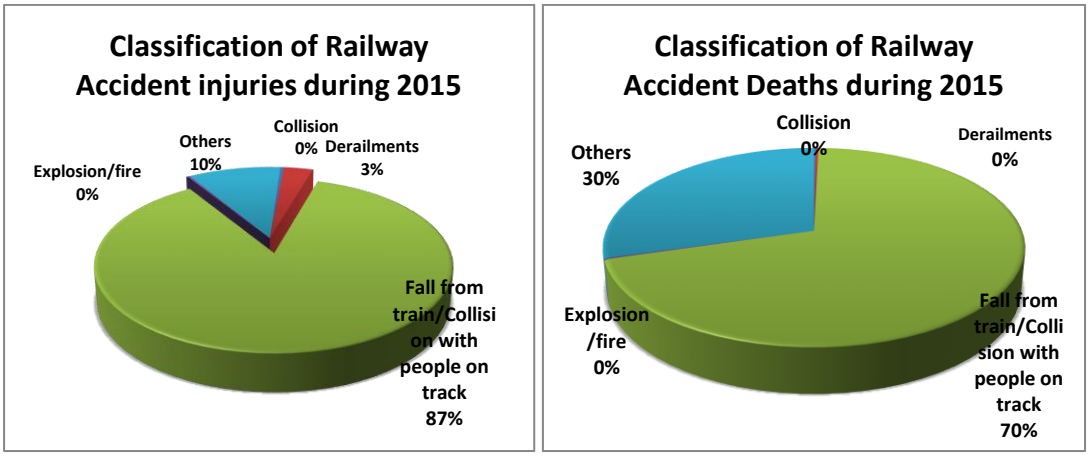


Fig 3.1: Cause wise analysis of injuries and deaths in Railway Accidents in the year 2015(NCRB report 2016)

72.5% of Railway accidents cases (21,339 out of 29,419) were due to 'fall from trains' or 'collision with people at track'. Analysis of cause-wise Railway accidents as per Fig 3.1 show that both fatalities and injuries are highest for the accidents due to 'fall from train' and 'collision with people on track'.

State of Maharashtra has reported the maximum cases, accounting for 33.4 % of the total cases (21,335) of 'fall from train' or 'collision of trains with people at track'. During the year 2015, a total of 18,259 persons died due to either fall from train or collision with people on track (Track pedestrians' collisions), which account for a total of 70% of total deaths in Railway accidents (26,066). Mumbai with vast suburban network is the major contributor of Track pedestrian collision fatalities and injuries, with average of **10 deaths per day.**

During 2015, on Indian Railways, a total of 859 cases of Railway accidents occurred due to equipment failures (like poor design, track faults, bridges/tunnel issues) causing 913 deaths and 150 injured persons. A total of 5 accident cases are reported with 67 deaths and 125 injuries due to Derailments of trains. The collision of trains (2 cases) accounted for 38 deaths and 14 injuries in 2015. All these accidents due to mechanical failures, sabotage, derailments and collisions etc., are investigated/analysed in-depth by the Railways, and some critical cases by Commissioner of Railway Safety, an autonomous body independent of Ministry of Railways for unbiased and impartial inquiry into such cases. The findings of these in-depth inquiry reports are generally arrived at, in form of fixing responsibility and suggestions for appropriate changes in maintenance schedules of Railway assets, technology upgradation and means to fill the observed gaps in knowledge base or skill upgradation of Railway staff.

3.2 Untoward Incidents and Railway Act provisions.

The accidents caused due to 'fall from train' or 'collision of trains with people on track' are classified as "**untoward incidents**" under section 124A in the Railway Act' 1989, which define the "passenger" and the compensation eligibility because of such incidents. These accidents are considered as Medico-Legal Case (MLC) and are governed by section 174 in the code of Criminal Procedure(CrPC) 1973, which empowers police to enquire and report cases of a person killed by machinery or by accident. The cases are registered at respective police stations jurisdiction by Government Railway Police(GRP), an arm of the State Government Police responsible for law and order issues on Railway Premise.

Due to the high toll of human lives in Mumbai Suburban Railway Network and the concern expressed in various public litigations, Parliamentary Committees

etc., Central Railway and Western Railway zones are regularly updating the data of such untoward incidents on their official website and the same is available in Public Domain.

As per Railway Act, penalties are defined for the violations of trains right of way-trespassing and unsafe travelling on suburban coaches by public, which need stricter enforcement. Travelling of roof as per section 156 of Railway Act calls for punishment of 3 months jail or a fine of Rs 500/- or both. Trespassing as per section 147 of Railway Act calls for punishment of 6 months jail or a fine of Rs 1000/- or both.

4. Mumbai Suburban Railway System

On Indian Railways, of the 22.21 million passengers transported per day, 12.21 million passengers per day are suburban commuters. Mumbai suburban commuters alone account for 7.6 million passengers per day, i.e. about 34 % of total passenger traffic and more than 62% of all suburban commuter traffic on Indian Railways. Of the 115,000 km of route length of railway track on Indian Railways, Mumbai suburban network is mere 465 km (0.4%) spread over 135 stations. Of the 12,617 trains run per day on Indian Railways, Mumbai Suburban system operates 2896 (23% of total trains) suburban trains per day.

The Suburban Railway System in Mumbai is the most complex, densely loaded and intensively utilized system in the world, operated by Western Railway (W Rly) and Central Railway (C Rly) zones of Indian Railways. The Railway Suburban network consist of four corridors 1) from Churchgate, the city's business centre to Dahanu Road covering 123 Kms. and 36 stations on W Rly , 2)Main line from Mumbai Chatrapati Shivaji Maharaj Terminus(CSTM) to Karjat/Kasara (100/120km), 3) Harbour line from CSTM to Mankhurd (22km) and 4)Trans Harbour Line from Thane to Vashi (20 km) on C Rly.

The Suburban trains are Electric Multiple Units (EMUs) operated on 25 KV AC power supply from overhead catenary. Train sets of 9-car, 12-car & 15-car composition are utilized to run approximately 3000 train services for almost 21 hours in a day, including weekends and public holidays. The passenger density during peak hours is very high with an average of 5000 to 6000 passengers per rake of 12 coaches/cars against 2400 capacity, resulting super dense crush load of 12 to 15 passengers per sqm. of floor space of the suburban coach.

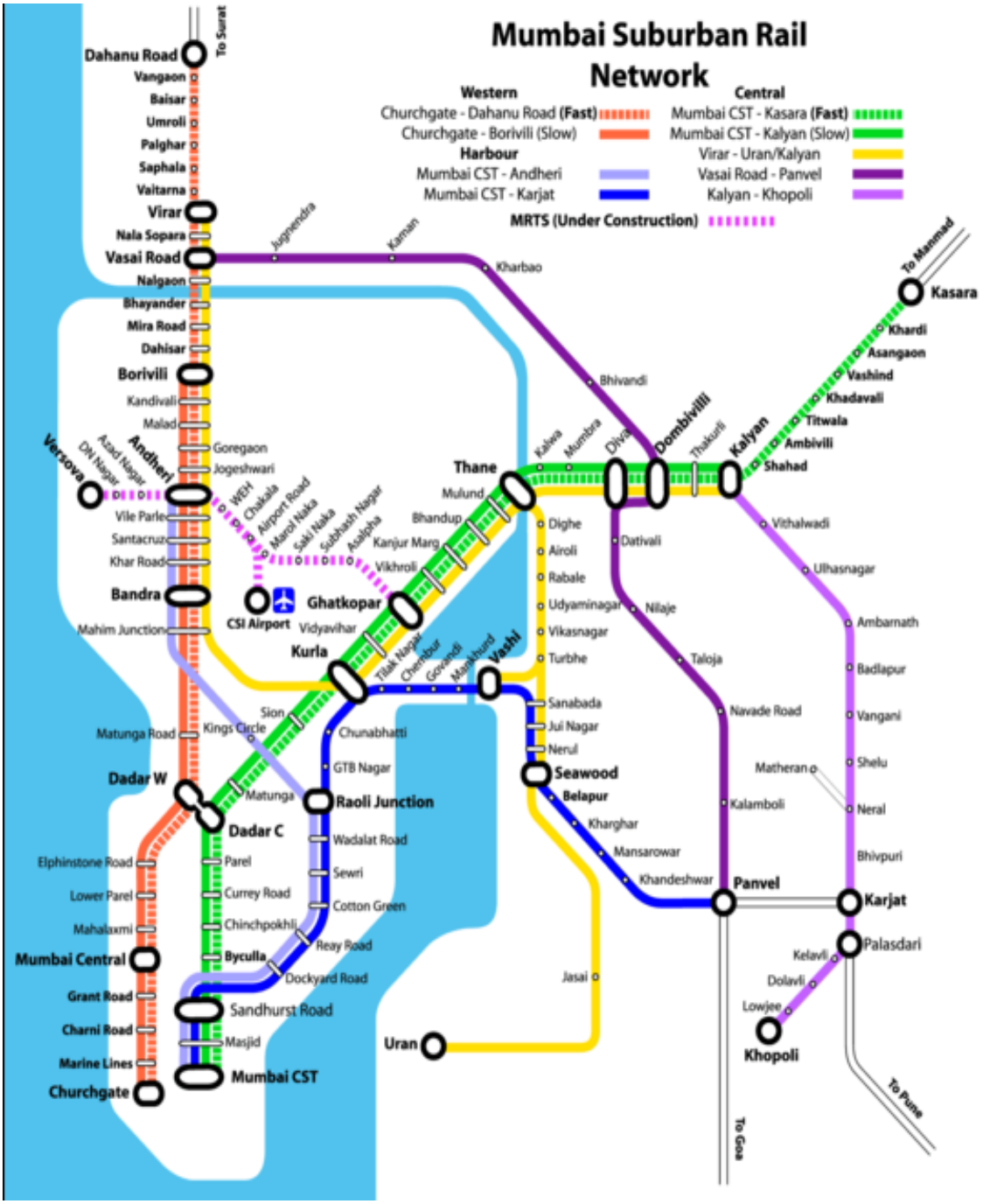


Fig 4.1 Mumbai Suburban Railway Map

4.1 Mumbai Suburban System accidents

Mumbai suburban network railway accidents data, including track pedestrian incidents is compiled from different sources. The station wise statistics about 81 Suburban stations on Central Railway and 35 Suburban stations on Western Railway for two years 2015 and 2016 was analysed. the complete data including

natural deaths, suicides and due to some other cause are not considered for analysis of fatalities cases, although these figures were studied for analysis of total incidents. The main causes for the untoward incidents leading to fatalities on railway tracks on suburban network are:

(i) **collision of persons with train while crossing tracks:** The people moving along the railway track, or people crisscrossing railway tracks randomly while moving across the railway track, are hit by a moving train, resulting into grievous injuries and death.

(ii) **fallen from train:** Due to overcrowding of the suburban trains and no provision of auto-door closure in suburban coaches, there is possibility of people falling off from coach when train moves due to in-appropriate grip or a small push/nudge from densely packed suburban coach.

(iii) **Dash-to or knock down by pole/Overhead Traction Equipment mast:** The commuters who are hanging out of these suburban coaches due to heavy rush can get hit by the Overhead Electrical Mast/pole, fixed quite close to railway track.

(iv) **falling between the gap of platform and footboard of the coach**. Due to a difference in level of coach and the platform, short halt time at suburban stations and heavy rush on trains and platforms, there is a possibility of a passenger falling in-between the gap of platform and the footboard of the suburban coach in process of boarding the train, causing grievous injury.

(v) **Electric Shock**: There is a possibility of passengers climbing up the coach due to heavy rush and get electrocuted due to overhead electric mast as these Suburban trains are powered by 25 kV AC electric traction system.

Cause wise analysis for total incidents, injuries cases and fatalities cases is carried out for each of the Mumbai suburban stations.

4.1.1 Total Cases: Total untoward incidents (fatalities and injuries) reported by C Rly during 2015 & 2016 are 4288 & 3958 and for W Rly are 2364 & 2594 respectively. Cause wise analysis of injuries and deaths due to suburban train incidents in 2015 & 2016 on Mumbai Suburban are given in Fig 4.2.

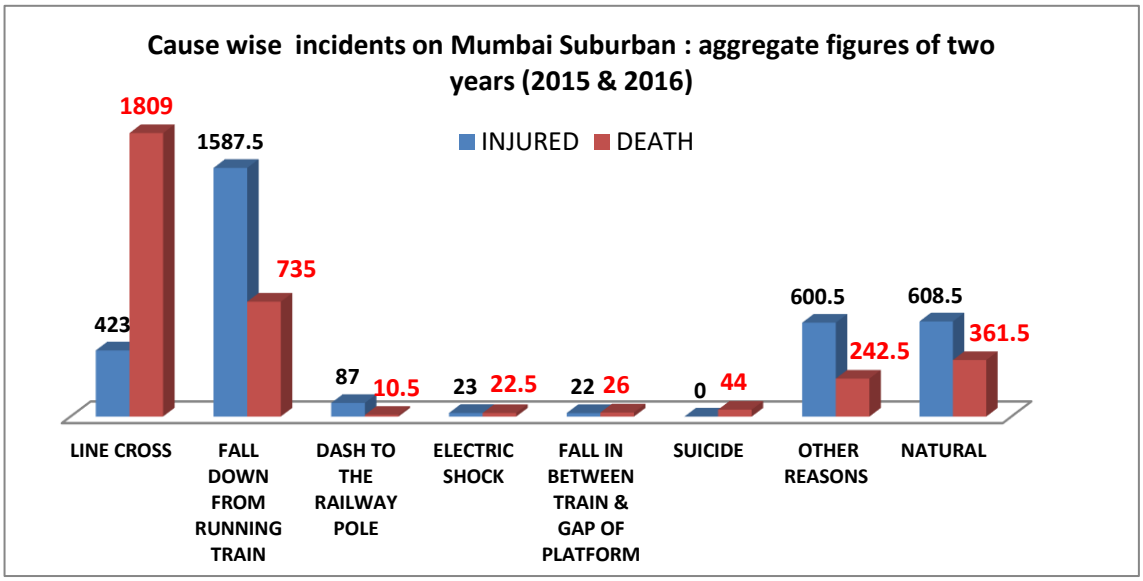


Fig 4.2: Cause wise analysis of railway incidents on Mumbai Suburban (WRly and CRly) in 2 years-2015 & 2016

Cases of 'Fallen from train' is the highest contributor followed by 'collision with train while crossing tracks' in these years.

4.1.2 Injuries cases: Total injury case reported during 2015 & 2016 by C Rly are 2103 & 1844 and W Rly are 1249 & 1507 respectively. Fig 4.3 shows that most injuries (47%) happen in cases of fall down from running train (47%) followed by track trespassing (line cross).

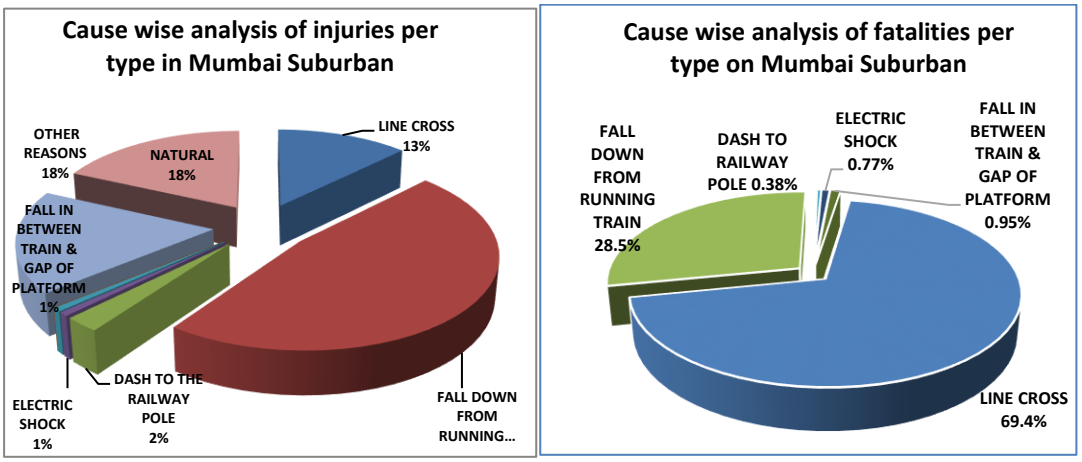


Fig 4.3: Cause-wise aggregate analysis of injuries and fatalities in Mumbai suburban (2015 & 2016).

4.1.3 Fatalities cases: Total fatalities reported during 2015 & 2016 by C Rly are 1653 & 1765 and W Rly are 890 & 856 respectively. Fig 4.3 shows that most cases of 'track pedestrians' fatalities occur due to collision with trains while crossing track (69.4 %) and persons fallen from train (28.5 %).

5. Discussion and Results

5.1 Risk assessment for Mumbai Suburban Commuter

Based on the analysis of railway track pedestrian incidents on Mumbai suburban (on WRly and CRly system) and the footfalls generated at these suburban stations, we can work out associated risk to commuters and pedestrians to classify Mumbai suburban stations on risk propensity. The risk assessment for the Mumbai suburban commuter on stations for different causes of track pedestrian accidents, may also help the Railways to plan and prioritise the efforts towards safe travel of suburban commuters.

5.2 Risk analysis on Mumbai Suburban Stations (Western Railway)

Total untoward incidents over 35 Suburban stations on Mumbai Railway Division (Western railway) were compiled along with the station footfall data for 2 years during 2015 & 2016.

'Risk of a track pedestrian' on a suburban station can be defined as 'total unusual incidents observed' to 'number of pedestrians exposed (footfalls)' in a suburban station. The cause wise un-usual incidents along with the average footfalls observed on these 35 suburban stations were compiled. From the data, the cause–wise risk of a person while trespassing the railway track etc. is derived.

Total average annual un-usual incidents during 2015 & 2016, on the Mumbai division of W Rly, spread over 35 suburban stations, are 2419 (Annexure I).

The average number of track pedestrian incidents per year are very high at Andheri (147.5), Borivali (153.5), Vasai (124), Virar (126), Vileparle (119.5) and Nalasopara (117). Average annual Footfall (in millions) is very high at Borivali (107.03m), Andheri (93.23m), Nalasopara (74.55m), Virar (68.18m), Dadar (56.42m), Bandra (52.49m), Vasai (48.11m) and Churchgate (44.20m).

The risk to a commuter or track pedestrian is measured as '**number of incidents per 10 million footfalls'** is calculated cause-wise, i.e risk of a person due to fall from train, line cross etc., for each station on WRly Suburban network.

a. According to **total incidents per 10 milllion footfalls**, Vangaon (89.72), followed by Dahanu (68.66) and Vaitarna (64.45) are most risky stations on WRly (Annexure I). Though the footfalls at these stations are comparatively much lower, but the reported incidents are very high. None of the high-density suburban stations figure in these high-risk station list.

b. The other two causes i.e., 'knock down by Pole' and 'Fallen between platform(PF) gap and train footboard' are very low and 'nil' at many stations. The maximum risk stations with regards to incidents due to falling between **gap of PF and footboard** are Dahanu, Palghar and Boisar, although the average footfalls (in millions) at these stations is comparatively very low, 6.19m, 9.37 m and 9.69m respectively.

c. The maximum risk stations for injuries due to **knock down by pole** are Marine lines, Churni Road, Grant Road and Churchgate stations.

d. The maximum risk stations for incidents due to Track trespassing (**Line cross)** are Vangaon (53.02), Boisar (34.06), Vaitarna (37.59), Dahanu (28.27) and Kelva (26.91), although the footfalls (in millions) at these stations is comparatively low; 2.45m, 9.69 m, 0.93m, 6.19m and 2.04m respectively.

e. The maximum risk stations for incidents due to **Fallen down from train** are Vangaon(30.59), Vaitarna (26.85), Kelva (22.02) and Dahanu (19.39), although the footfalls (in millions) at these stations is comparatively low; 2.45m, 0.93m, 2.04m and 6.19m respectively. Details are at Annexure I.

f. The maximum risk stations **for fatalities per 10 million footfalls** on Mumbai suburban (including all types of incidents) are Vangaon (59.3), Vaiterna (48.34), Kelve (46.48) and Dahanu Road (42.81). Details are at Annexure II.

To understand the risk for high traffic stations, we can list the suburban stations reporting above average incidents and footfalls.

The average yearly incidents for these 35 stations are 69.11 and Average footfall is 36.69 million/year. There are 13 suburban stations with average yearly incidents above 70 and average foofalls above 36 million/year. These stations contribute to almost 65% of total footfalls and 61 % of total incidents over Mumbai Suburban on WRly. The risk to commuters/pedestrians in these high-density stations with classification of accidents is given in Fig 5.1.

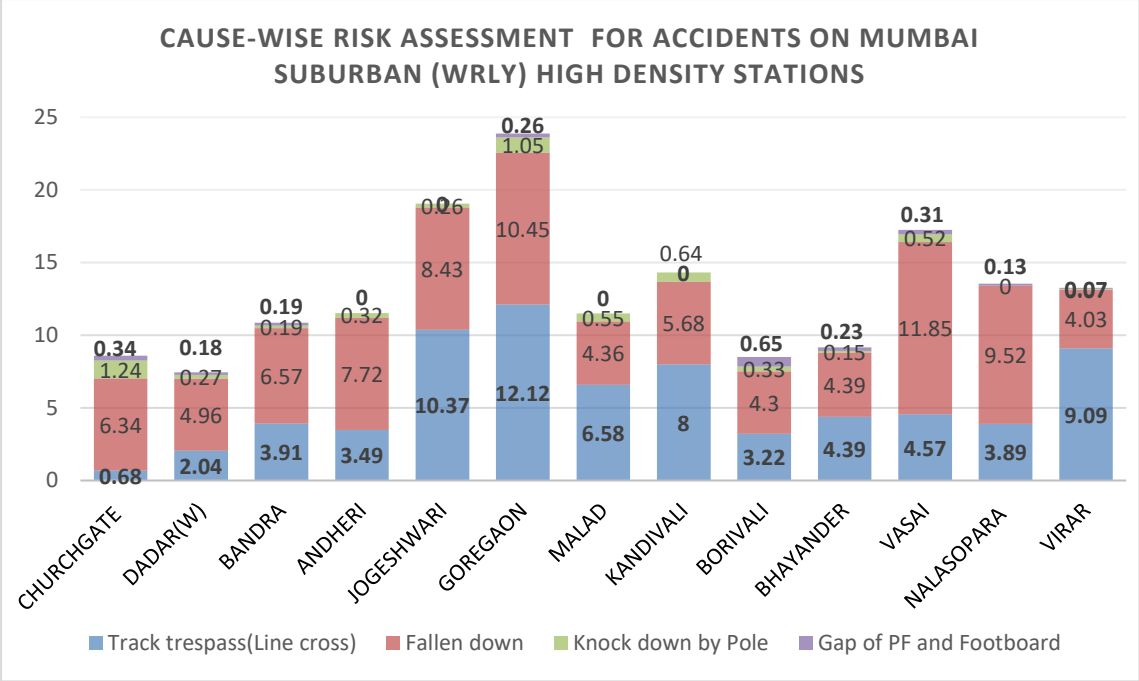


Fig 5.1: Cause wise risk for railway incidents on Mumbai Suburban(WRly) selected high traffic density stations for the year 2015 & 2016

Goregaon, Jogeshwari and Vasai are the riskiest high-density stations for suburban incidents.

5.3 Risk Factor analysis on Mumbai Suburban Stations (Central Railway)

Total average annual untoward incidents during 2015 & 2016, on the Mumbai division of C Rly, spread over 80 suburban stations, are 4054 (Annexure III).

The number of track pedestrian incidents per year are very high at Thane (319.5), Kalyan (263.5), CSTM (207.5), Kurla (203.5), Diva (138.5), Ghatkopar (113.5) and Mulund (110). Average daily Footfalls (in 10,000) is very high at Thane (25.6), Dombivali (24.7), Kalyan (20.8), Ghatkopar (18.9), Kurla (15.5) and CSTM (14.5).

The risk to a commuter or track pedestrian is measured as '**number of incidents per 10 million footfalls'** is calculated for number of incidents reported and cause-wise (classification of different cause of pedestrian fatalities) also, duly indicating the risk due to fall from train, line cross etc., for each station. This analysis indicates the risk to commuter or track pedestrian for each station for such classification of accidents.

a. According to **total incidents per 10 milllion footfalls**, Palsdari (1198.6) followwd by Juchandar (484.9) and Atagaon (380) are most risky stations on

CRly. Though the footfalls of these stations are comparatively much lower but the incidents are very high.

b. The other two causes i.e., 'knock down by Pole' and 'Fallen between platform gap and train footboard' are very low and nil at many stations. The maximum risk stations for injuries due to **knock down by pole** are Chunabhati (3.4), Bhivpuri (3.6) and Kopar (1.2).

c. The maximum risk stations for incidents due to **Line cross** are Juchander (303.1), Kharbhav (250.8), Atagaon (226.2) and Palsdari (171.2), although the daily footfalls at these stations is comparatively low 226, 437, 1514 and 80 respectively (Annexure III).

d. The maximum risk stations for incidents due to **Fallen down from train** are Palsdari (684.9), Lojee (207.6), Kelvali (200.5) and Juchandr (181.8), although the footfalls per day at these stations is comparatively low 80, 396, 146 and 226 respectively.

e. The maximum risk stations for **fatalities per 10million footfalls** on Mumbai suburban on CRly (including all types of incidents) are Juchandr (484.9), Kamnroad (347.1), Atagaon (280.5) and Kharbhav (282.1). Details are at Annexure IV.

To understand the risk of railway accident for these high traffic stations, we can reclassify the suburban stations based on the incidents and footfall observed which are above average of these 80 stations. Average yearly incidents for these 80 stations on Mumbai suburban area of Central Railway is 50.7 and the average figure of daily footfalls are 51367.

These suburban stations with above average footfalls and incidents, can be further classified for better appreciation of risk. The following 22 stations show the average incidents to be more than 50 and footfalls are more than 51366. The risk at these high-density stations with classification of accidents is given in Fig 5.2.

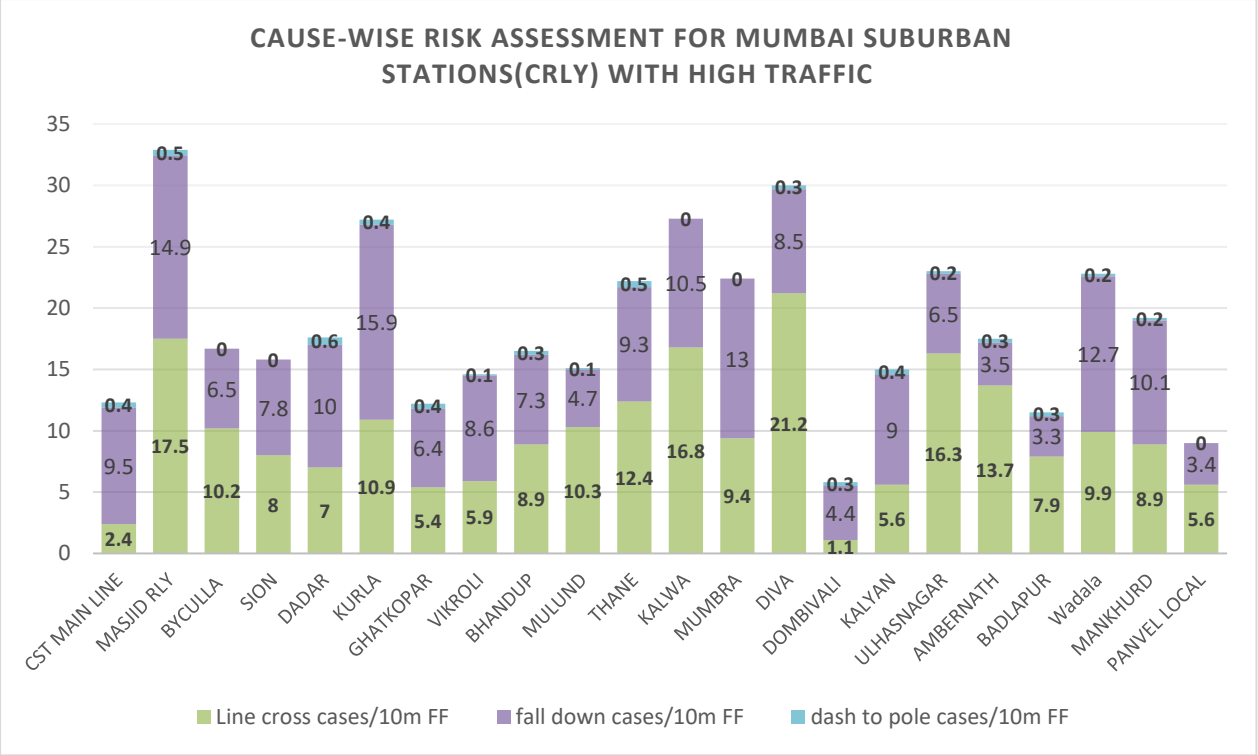


Fig 5.2: Cause wise risk of railway incidents on Mumbai Suburban(CRly) selected high traffic density stations for the year 2015 & 2016

On these high traffic density stations, the risk is highest at Dadar followed by Masjid, CSTM and Diva station.

Number of fatalities are relatively low but the death figures at CSTM is high due to higher number of reported incidents of natural death etc., and other Misc. cases (Miscellaneous cases being 157 out of 217). CSTM is the terminus station, possibly all the natural death cases may get recorded at this terminal station, when the train is finally evacuated before the scheduled maintenance at the end of the daily trips.

Risk of a track pedestrian for line cross cases/10m footfall is highest at Diva followed by Masjid and Kalwa suburban station. Similarly risk for a commuter fall down from train cases/10million footfall is highest at Kurla followed by Masjid suburban station.

Central Railways in its report(PHOD-Committee, 2016) has analysed the reasons for these trespassing incidents and suggested remedial actions to reduce these incidents. Incidents of trespassing occur at stations and at midsections between stations. At stations commuters are in a hurry and hence avoid climbing up the foot-over Bridge(FOB) and cross the railway tracks. In mid-sections the people are crossing tracks from one side to other due to non-availability of roads or FOBs, to connect settlement across the tracks. Non-availability of fencing/boundary wall

and porous fences encourage the trespassing. More than 80% incidents are taking place between stations and at locations where either the road is far away or FOBs are not available.

Falling down incidents account for 35% of total incidents. There are six stations - Kurla, Ghatkopar, Mulund, Thane, Kalwa and Mumbra accounting for nearly 50% incidents of falling down. Most of the cases are due to footboard travel, rooftop travels and few cases are due to fall in between the gap between station platform and Train.

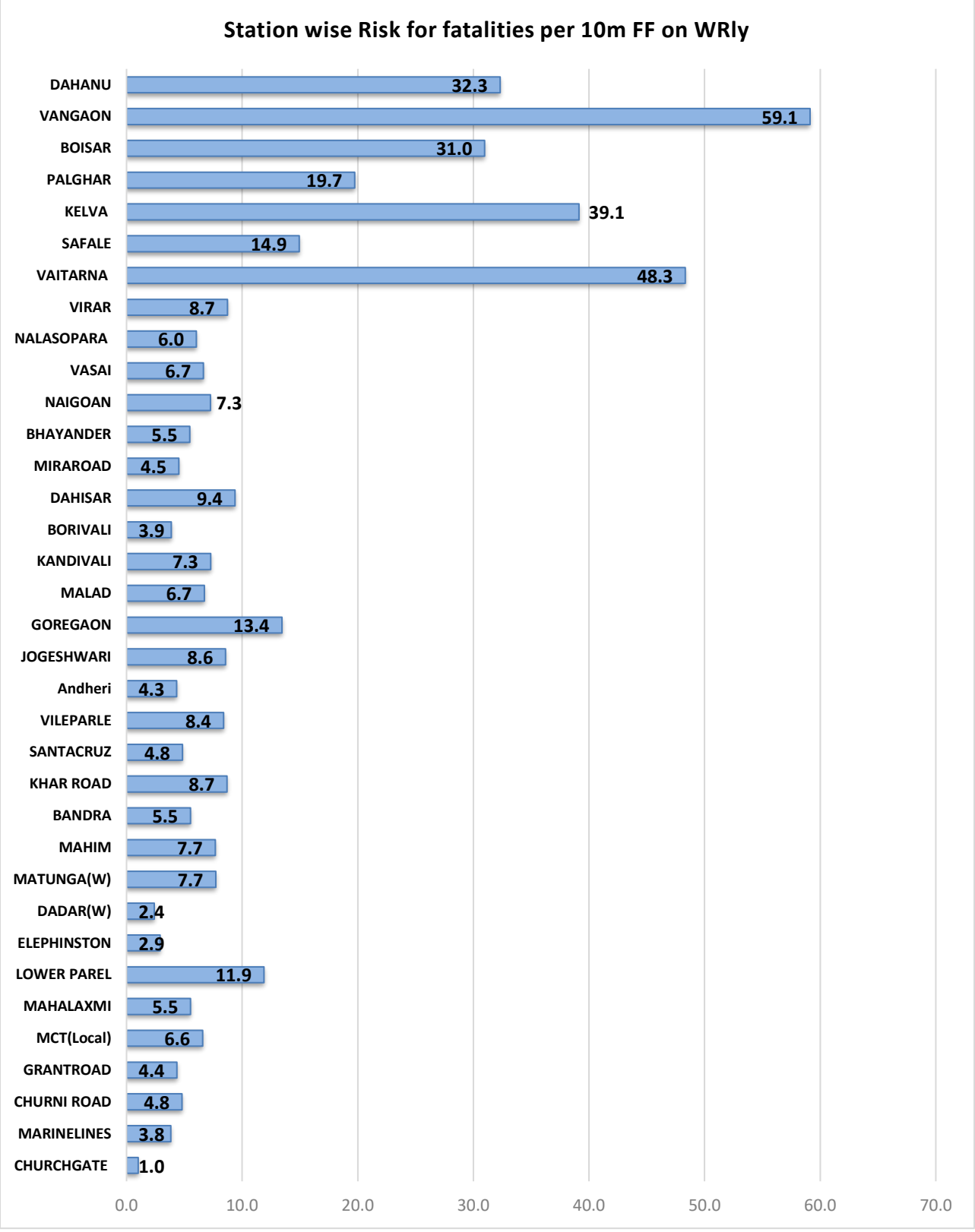
The report(PHOD-Committee, 2016) has suggestive measures of augmenting the infrastructure at suburban stations, especially building more FOBs, skywalks, Escalators and introducing rakes of more coaches to cater to the high-density traffic.

A detailed report(Empowered-Committee, 2016) on review of rising trend of accidental deaths on Mumbai suburban has comprehensively examined the existing infrastructure and has given futuristic innovative solutions for augmentation of suburban services with introduction of more trains and re-development of many suburban stations for increased throughput and elimination of the existing operational bottlenecks. The committee had Honourable Members of Parliament from Mumbai Area, Mumbai Municipal Commissioner and General Manager, Central Railway.

Annexure I: Cause-wise Risk for a commuter or track pedestrian **for all type of incidents** on Mumbai Suburban (Western Railway) stations

S.No	Railway Stations	Avg Yearly footfall (in Million)	Avg yearly Incidents	Line cross/10m FF	Fallen down / 10 m FF	Knock down by Pole /10m FF	Gap of PF and Footboard	Other incidents / 10mFF (including suicide)	Total incidents/10m FF
1	CHURCHGATE	44.2	88	0.68	6.34	1.24	0.34	11.31	19.91
2	MARINELINES	16.96	39.5	1.77	11.2	2.95	0.88	6.49	23.29
3	CHURNI ROAD	23.96	38	3.76	6.47	1.25	0	4.38	15.86
4	GRANTROAD	30.98	41.5	2.74	5.43	1.25	0.65	6.26	13.4
5	MCT (LOCAL)	24.32	65	4.73	11.72	0.82	0.21	9.25	26.73
6	MAHALAXMI	17.18	23	4.66	6.4	0.29	0.29	1.75	13.39
7	LOWER PAREL	25.24	64.5	4.36	17.63	0.2	0	3.37	25.55
8	ELEPHINSTON	29.29	28	2.05	3.93	0.68	0	2.9	9.56
9	DADAR(W)	56.42	102	2.04	4.96	0.27	0.18	10.63	18.08
10	MATUNGA(W)	11.02	25.5	7.26	8.62	0	0	7.26	23.15
11	MAHIM	31.91	46.5	8.62	3.6	0	0	2.35	14.57
12	BANDRA	52.49	84	3.91	6.57	0.19	0.19	5.14	16
13	KHAR ROAD	30.51	45.5	6.88	6.56	0.16	0	1.31	14.91
14	SANTACRUZ	52.6	44	4.37	3.42	0	0.1	0.48	8.37
15	VILEPARLE	32.75	119.5	9.92	17.86	0.76	0	7.94	36.49
16	ANDHERI	93.23	147.5	3.49	7.72	0.32	0	4.29	15.82
17	JOGESHWARI	38.56	90	10.37	8.43	0.26	0	4.28	23.34
18	GOREGAON	56.94	160	12.12	10.45	1.05	0.26	4.22	28.1
19	MALAD	63.1	89.5	6.58	4.36	0.55	0	2.69	14.18
20	KANDIVALI	62.52	125	8	5.68	0.64	0	5.68	19.99
21	BORIVALI	107.03	153.5	3.22	4.3	0.33	0.65	5.84	14.34
22	DAHISAR	30.92	58.5	7.6	7.28	0.16	0	3.88	18.92
23	MIRAROAD	41.93	51.5	3.34	6.56	0.24	0.12	2.03	12.28
24	BHAYANDER	64.86	77.5	4.39	4.39	0.15	0.23	2.78	11.95
25	NAIGOAN	15.85	27.5	4.1	9.15	0.32	0	3.78	17.35
26	VASAI	48.11	124	4.57	11.85	0.52	0.31	8.52	25.77
27	NALASOPARA	74.55	117	3.89	9.52	0	0.13	2.15	15.69
28	VIRAR	68.18	126	9.09	4.03	0.07	0.07	5.21	18.48
29	VAITARNA	0.93	6	37.59	26.85	0	0	0	64.45
30	SAFALE	7.7	20	12.34	9.09	0	0	4.55	25.98
31	KELVA	2.04	12	26.91	22.02	0	0	9.79	58.71
32	PALGHAR	9.37	49.5	23.48	8	0	1.6	19.74	52.83
33	BOISAR	9.69	65	34.06	17.03	0	1.55	14.45	67.09
34	VANGAON	2.45	22	53.02	30.59	0	0	6.12	89.72
35	DAHANU	6.19	42.5	28.27	19.39	0	1.62	19.39	68.66
	TOTAL	36.69	2419	5.93	7.24	0.42	0.2	5.05	18.84

Annexure II: Risk of railway accident fatalities per 10 million footfalls on Mumbai Suburban stations (Western Railway)

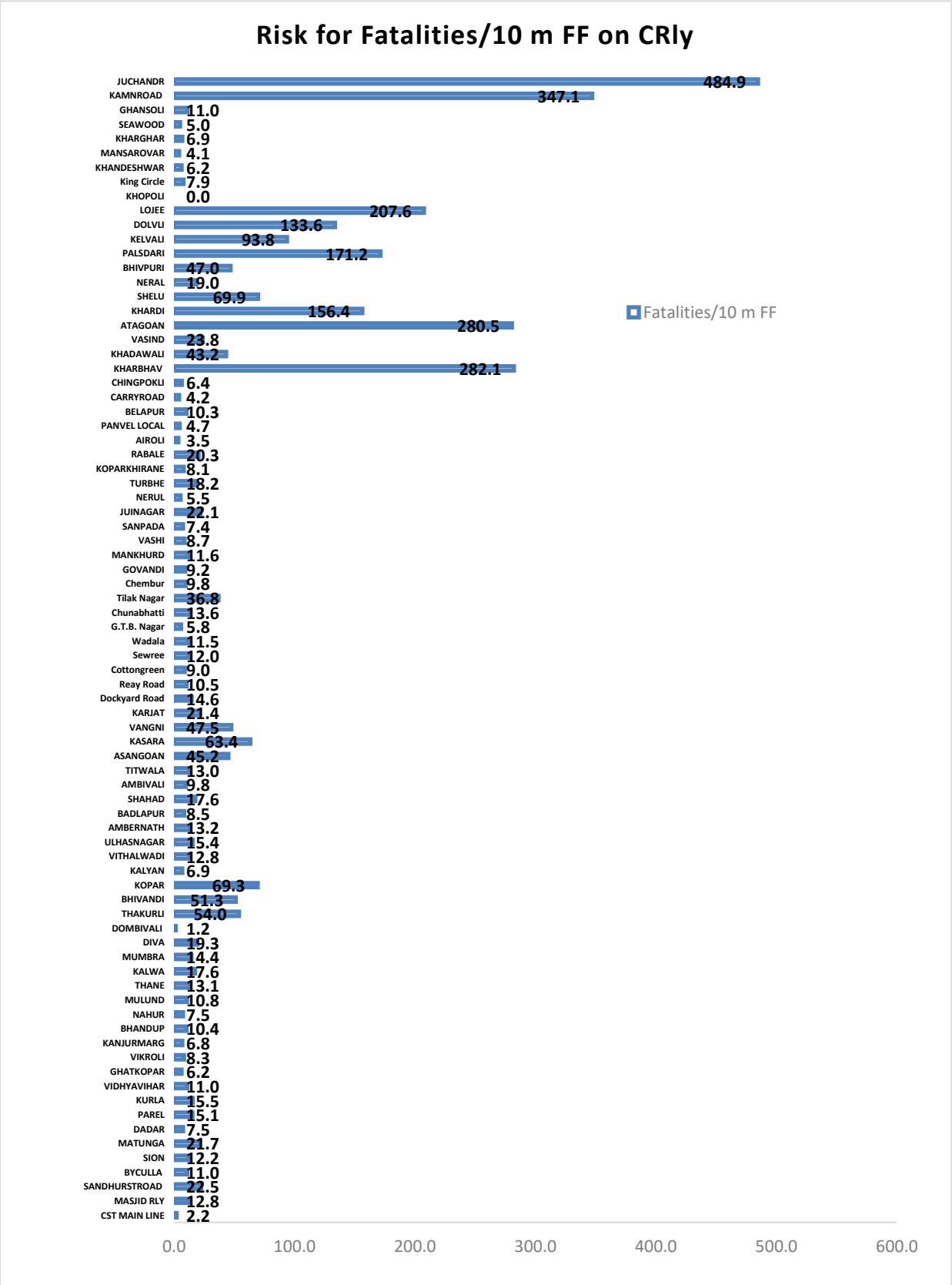


Annexure III: Cause wise Risk for all types of incidents on Mumbai Suburban stations(C Rly)

S no	NAME OF RLY STATION	Footfall (Avg/ day)	Avg incidents	Line cross cases/10m FF	fall down cases/10m FF	dash to pole cases/10m FF	Total cases/10m FF
1	CST MAIN LINE	145268	207.5	2.4	9.5	0.4	39.1
2	MASJID RLY	52362	75	17.5	14.9	0.5	39.2
3	SANDHURST ROAD	42531	77	16.7	22.9	0.3	49.6
4	BYCULLA	69808	62	10.2	6.5	0	24.3
5	SION	84029	65	8	7.8	0	21.2
6	MATUNGA	28459	38.5	19.3	14	0.5	37.1
7	DADAR	72902	109.5	7	10	0.6	41.2
8	PAREL	25354	26.5	15.1	7	0.5	28.6
9	KURLA	155238	203.5	10.9	15.9	0.4	35.9
10	VIDHYAVIHAR	52516	43	7.3	11.5	0.3	22.4
11	GHATKOPAR	188841	113.5	5.4	6.4	0.4	16.5
12	VIKROLI	92543	62.5	5.9	8.6	0.1	18.5
13	KANJURMARG	72808	32	5.1	4.3	0	12
14	BHANDUP	104460	75.5	8.9	7.3	0.3	19.8
15	NAHUR	34556	14.5	6.3	3.2	0.8	11.5
16	MULUND	151573	110	10.3	4.7	0.1	19.9
17	THANE	256034	319.5	12.4	9.3	0.5	34.2
18	KALWA	74050	84.5	16.8	10.5	0	31.3
19	MUMBRA	83021	78	9.4	13	0	25.7
20	DIVA	100237	138.5	21.2	8.5	0.3	37.9
21	DOMBIVALI	246694	106	1.1	4.4	0.3	11.8
22	THAKURLI	27676	106	47.5	40.1	3	104.9
23	BHIVANDI	7474	22	51.3	11	0	80.6
24	KOPAR	23706	100	52.6	52	1.2	115.6
25	KALYAN	207902	263.5	5.6	9	0.4	34.7
26	VITHALWADI	37419	32.5	12.4	8.4	0.4	23.8
27	ULHASNAGAR	61204	63.5	16.3	6.5	0.2	28.4
28	AMBERNATH	81090	76	13.7	3.5	0.3	25.7
29	BADLAPUR	96573	55.5	7.9	3.3	0.3	15.7
30	SHAHAD	39619	42.5	18.3	4.8	0.7	29.4
31	AMBIVALI	29449	26	10.2	5.6	0.5	24.2
32	TITWALA	48571	50	11.8	9	0.3	28.2
33	ASANGOAN	14866	39	37.8	20.3	0.9	71.9
34	KASARA	6917	68	41.6	87.1	0	269.3
35	VANGNI	9219	22.5	34.2	22.3	0	66.9
36	KARJAT	13440	51.5	22.4	25.5	0	105
37	Dockyard Road	24454	26.5	5.6	20.7	0.6	29.7
38	Reay Road	23502	25.5	6.4	17.5	0	29.7
39	Cottongreen	30477	23.5	4	13.5	0.9	21.1

40	Sewree	43355	35	11.4	8.2	0	22.1
41	Wadala	69196	72	9.9	12.7	0.2	28.5
42	G.T.B. Nagar	53918	32	3.3	6.9	0	16.3
43	Chunabhatti	24235	29	9	13	3.4	32.8
44	Tilak Nagar	8924	25.5	26.1	33.8	0	78.3
45	Chembur	56008	43.5	8.6	8.1	0	21.3
46	GOVANDI	65317	47	5.9	8.8	0.2	19.7
47	MANKHURD	86510	68.5	8.9	10.1	0.2	21.7
48	VASHI	50307	46.5	6	12.5	0	25.3
49	SANPADA	35128	23	6.2	8.6	0	17.9
50	JUINAGAR	34144	36	16	10.4	0.4	28.9
51	NERUL	70332	30	4.9	3.7	0	11.7
52	TURBHE	18103	22	17.4	9.1	0	33.3
53	KOPARKHIRANE	38945	21	8.1	5.6	0	14.8
54	RABALE	25616	23.5	6.4	16.6	0.5	25.1
55	AIROLI	50693	16.5	3.5	3.2	0	8.9
56	PANVEL LOCAL	88212	55.5	5.6	3.4	0	17.2
57	BELAPUR	39872	30.5	11	5.8	0	21
58	CURRYROAD	35803	13	3.1	4.2	0	9.9
59	CHINCHPOKLI	36268	15.5	7.2	3	0	11.7
60	KHARBHAV	437	4.5	250.8	31.3	0	282.1
61	KHADAWALI	6345	18.5	36.7	28.1	0	79.9
62	VASIND	10929	20	11.3	23.8	0	50.1
63	ATAGOAN	1514	21	226.2	108.6	0	380
64	KHARDI	1664	15.5	123.5	74.1	0	255.2
65	SHELU	2352	10	34.9	81.5	0	116.5
66	NERAL	13716	18.5	13	11	1	37
67	BHIVPURI	3792	16	28.9	36.1	3.6	115.6
68	PALSDARI	80	3.5	171.2	684.9	0	1198.6
69	KELVALI	146	0.5	93.8	0	0	93.8
70	DOLVLI	205	2.5	66.8	200.5	0	334.1
71	LOJEE	396	4.5	103.8	207.6	0	311.3
72	KHOPOLI	5045	3	0	2.7	0	16.3
73	King Circle	29313	19.5	5.6	9.3	0	18.2
74	KHANDESHWAR	39541	13	6.2	1.7	0	9
75	MANSAROVAR	36335	10	3	3.4	0	7.5
76	KHARGHAR	45695	19.5	5.7	4.5	0	11.7
77	SEAWOOD	29889	8.5	4.6	1.4	0	7.8
78	GHANSOLI	33473	15	5.3	4.9	0	12.3
79	KAMNROAD	513	5	160.2	106.8	0	267
80	JUCHANDR	226	4	303.1	181.8	0	484.9
	Average	51366.7	50.7	30.6	31.9	0.3	78

Annexure IV: Cause wise Risk of fatalities on Mumbai Suburban Stations on Central Railway (considering all incidents)



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