15Journal of Civil Engineering (IEB), 35 (1) (2007) 17-27

Journal of
Civil Engineering
IEB

Involvement of vehicle factors in road accidents

Md. Shamsul Hoque and Md. Rafiqul Hasan[1]

Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh

Received on 05 August 2006

Abstract

The Road-Traffic system is a complex interaction among three components e.g. road and road environment, vehicles and road users. Like roadway fault and human error, defective and road unworthy vehicles contribute to road accidents. Vehicles may have defect in the brake system, the steering system, the lighting system along with smooth tyres etc. Studies carried out in developed countries have indicated that between 2 to 8.5 percent of accidents are directly caused by faulty vehicles. In developing countries, it is likely that vehicle defects are more often a pronounced factor in accidents as vehicle maintenance practices as well as vehicle conditions are generally much worse. The vehicle fleets consist usually of old reconditioned imported vehicles and vehicles locally modified with little or no consideration at all to passenger safety. In order to ensure overall road safety, it is important to know the involvement of vehicle factors in road accidents. In this regard an extensive study is carried out in an attempt to identify the common vehicular defects and their influence in road accidents on a typical national highway of Bangladesh. This paper presents the results and discussions of the research work along with remedial measures.

Keywords: Vehicle Factors, Tyre Burst, Brake Failure, Passenger fell down, Wheel Jam.

1. Introduction

Defective vehicles are not only unsafe but also cause more noise and air pollution. Vehicles may have defects in the vehicle control system viz. brake, clutch, steering etc., in the communication system viz. indicator lights, other signaling devices, exhaust system etc. along with worn out tyres, metal fatigue etc. Studies carried out in the United Kingdom (UK) have identified that between 5.0 and 8.5 percent of accidents are directly caused by faulty vehicle condition (ADB, 1996). In other studies it is reported that 25 percent of freight carrying and 11 percent of passengers carrying vehicles involved in

[1] Graduate student

accidents have defects which contributed to road accidents. Based on a comprehensive accident research study conducted on several European countries, the European Commission Report (Rompe, K. and Seul, E., 1985) concluded that between 3 and 5 percent of all accidents are caused primarily by vehicle defects. Australian (FORS, 1999) studies indicated that vehicle defects contributed between 2 to 6 percent of reported crashes. In developing countries like Bangladesh, it is very likely that vehicle defects are major contributors in accidents as vehicle conditions are generally much poor with vehicular fleet consisting mainly of reconditioned vehicles. Besides, buses are often constructed on truck chassis using materials and designs that offer little or no protection to passengers in the event of an accident. Leg space between seats is often exceptionally narrow and the seat frames and other in vehicle furniture are usually made of steel angles, frequently needing amputation of victims' limbs in the event of an accident. Emergency exit, even when provided, is often blocked by a row of seats, making their use difficult. Modification of vehicle specification such as laden weight, overhang, seating arrangement, fixing additional features with the vehicle like strong bumpers, rooftop railing, tendency of using worn out tyres by rubber lining, etc. also pose a great safety hazard. It is important to comprehend the extent of overall involvement of defective vehicles in the occurrence of road accidents, in order to device effective and appropriate countermeasures, to justify appropriate share of investment in improving vehicle conditions as well as to examine the effectiveness of existing vehicle fitness certificate issuance and enforcement practices.

2. Data collection

Investigation related to involvement of vehicle factors in accidents, demands a comprehensive, reliable and importantly very detailed accident database. As accidents are complex events that rarely have a single cause, a well trained, qualified and dedicated accident data unit (ADU) team equipped with necessary logistics to respond to an incident promptly, is a must to identify the most probable cause of an accident. This is very scarce in Bangladesh, particularly with the police department. In this investigation, accident data collected from the Jamuna Multi-purpose Bridge (JMB) approach roads (39 km) by the ADU of JOMAC (the toll collection and bridge maintenance agency) is used. In addition to a well trained, dedicated and full fledged rapid action ADU team, the JOMAC's accident record keeping and documentation system is very comprehensive comprising of six pages of accident data collection form including collision diagram and vital photographs of the event.

3. Data analysis

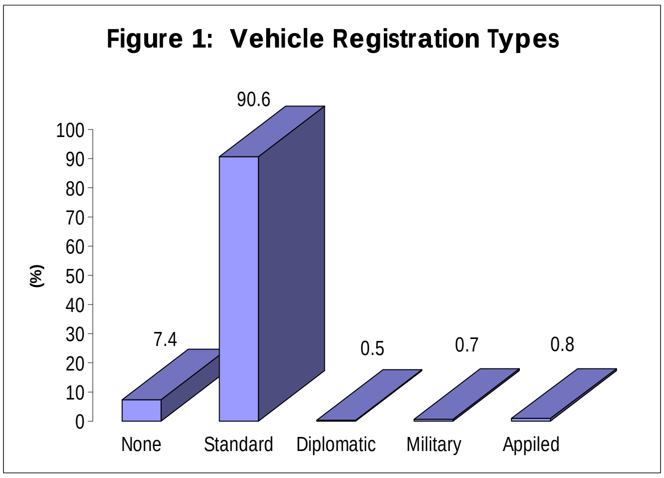
3.1 General analysis

Analysis of accident database shows that during 01-Jan-99 to 31-Apr-04 a total of 1011 accidents occurred on about 39 km section of roadway which includes 14.76 km east approach road, 16.54 km west approach road and 4.8 km length of the bridge itself. These accidents resulted in 314 fatalities, 1841 injuries and involved 1410 vehicles. The registration information of these involved vehicles, as shown in Figure 1, reveals that 7.4% had no registration and fitness related documents. It seems, in Bangladesh a large number of vehicles in the traffic stream operate without registration and fitness certificates which is a manifestation of sheer slackness in prevailing vehicle field inspection and deficiencies in enforcement practices. This is definitely very alarming from the overall vintage of road safety.

Table 1
Major Accident Records between 01-01-99 to 30-04-04

Sl No.	Acc Ref	Date	Time	Description	Casualty	Fatality
1	00/0371	28-Apr-00	15:00	One bus(1) was moving from E to W and the driver lost control of the vehicle when front right side wheel was burst and the vehicle turned to the right. Another bus(2) which was coming from the opposite direction collided with the former bus(1) and both overturned	163	45
2	00/0297	18-Jan-00	12:30	A bus had suffered from left front wheel burst and the driver lost control and finally left the carriageway.	71	16
3	01/0536	5-Mar-01	09:00	One large bus lost control while trying to save a by-cycle.	53	1
4	00/0378	20-May-00	11:35	A large bus moving from E to W swerved and overturned on the south side of the road while it tried to avoid collision with two overtaking vehicles from the opposite direction.	50	5
5	01/0500	15-Jan-01	15:30	One Large Bus moving from W to E collided with another Truck moving from opposite direction and driver lost control and ran down through the road side slope to water pond on the south side of the road.	49	0
6	02/0810	2-Sep-02	10:40	While a motorcycle with a flat tyre became uncontrolled, a bus along the same direction tried to save the motorcycle as a result the bus driver lost control and it went off the road.	35	1
7	00/0339	16-Mar-00	04:08	Two buses collided head on at about 400m east of the JMBA E18.	35	4
8	02/0809	1-Sep-02	04:30	A W bound truck had a front flat tyre & driver lost control and the truck went off the road on the N side	32	1
9	99/0234	6-Oct-99	14:40	A eastbound bus became uncontrolled when its front tyre burst	32	1
10	00/0399	13-Jul-00	02:00	A medium truck moving from the E to W was collided with large bus moving from the opposite direction. Thereafter, both the vehicles left the carriageway and overturned.	32	7
11	99/0224	17-Sep-99	13:55	A westbound bus driver lost control of the vehicle while overtaking another bus and collied with bridge E10 and fallen down by the side of the road.	31	1
12	01/0599	26-Jun-01	03:45	One truck hit a bus from the front.	31	11
13	99/0114	14-Feb-99	23:45	While a bus was moving at high speed, driver could not control veh. due to brake failure & it went off rd	30	1
14	00/0459	30-Oct-00	13:20	One large bus moving from W to E, the driver lost control of his vehicle because of flat front tyre and the bus went off the road.	28	3
15	03/0927	24-Apr-03	02:45	A westbound truck was hit by a eastbound bus, as such the truck driver lost control and went off the road.	28	1
16	99/0236	13-Oct-99	01:45	A eastbound bus lost control and hit the central island.	27	0
17	99/0271	20-Dec-99	10:50	Bus traveling east attempts to overtake truck of same direction. 3 rickshaw vans travelling west hit by bus.	26	1
18	99/0208	16-Aug-99	10:10	A westbound bus driver lost the control of the vehicle and overturned.	25	0
19	01/0577	21-May-01	18:30	One bus driver lost the control of the vehicle due front left tyre burst	25	7
20	01/0547	24-Mar-01	11:50	One bus got uncontrolled and went to the ditch while its front right wheel burst	24	7

Source: JOMAC Accident Data Unit



Note: Analysis excluded NMV and Non-standards Vehicles.

In an attempt to discern the most severe incidences among 1011 accidents on the selected road-bridge section, the entire accident database was sorted out in ascending order of casualty numbers. Table 1 shows the sorted out most severe 20 accidents. From the Table it can be seen that the very first accident occurred due to tyre burst. It is observed that on 28th April 2000 *"One bus (1) was moving from E to W and* ***the driver lost control*** *of the vehicle* ***when the front right side wheel was bursted*** *and the vehicle turned to the right. Another bus(2) coming from the opposite direction collided with the out-of-controlled bus(1) and both overturned."* In this tragic incident 45 persons died on the spot and in total 118 persons were severely injured. This larger number (163 nos.) of casualties occurred mainly due to the facts that the collision was head-on type; taken place between two buses and most importantly, the incident was triggered by sudden busting of tyre. Table 1 also shows that the 2nd top ranked accident also occurred due to tyre burst resulting a total of 71 casualties including 16 fatalities. This is a single-vehicle lost-control type accident which was triggered by the front left-side tyre burst. The vehicle involved in the incident is also a bus. Table 1 further reveals that out of 20 major accidents, nine are occurred due to vehicular defects of which eight accident occurred by tyre burst while only one was caused by brake failure. It implies that 45% of top 20 accidents ranked in order of severity have occurred due to vehicular defects.

3.2 Vehicle defect-wise analysis

Tyre burst

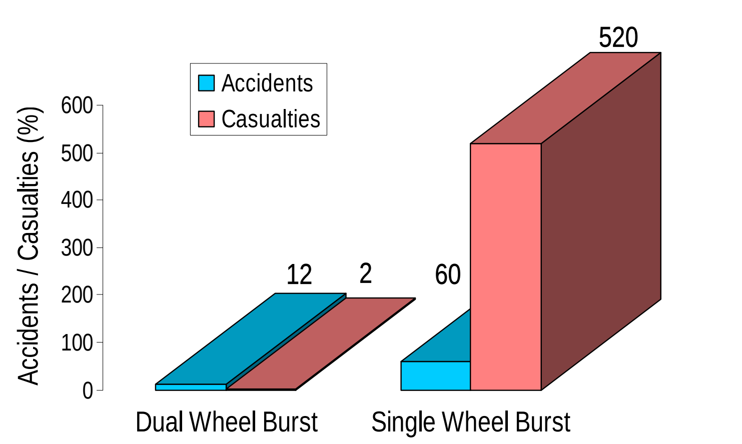
From Table 2 it is observed tyre burst or flat tyre accounts for 72 incidents out of a total 1011 accidents. Close observation of Table 2 reveals that the highest incidence of tyre burst involved trucks (61.1%) that is followed by light vehicles (22.2%) and buses (16.7%). Based on casualty figures, buses are found to be the most vulnerable vehicle which constituted about 85% of total casualties.

Buses and trucks together account for 78% of tyre burst related accidents and resulted in 98% of casualties, which essentially shows the over-involvement of heavy vehicles in tyre burst type of accidents. Table 2 also reveals that among 72 incidences, 60 are of the single tyre burst type and the remaining 12 are of the dual tyre burst type. From Figure 2 it can be seen that the single tyre burst incidences inflicted much more casualties than that of the bursting of two tyres at a time. This may be due to the fact that among 12 dual wheel burst cases all were involved with the trucks.

Table 2
Summary of Tyre Burst Type Accidents

Vehicle Involved	Tyre Burst		Burst Type		Casualties	
	No.	%	Single	Dual	No.	%
Bus	12	16.7	12	0	444	85.1
Truck	44	61.1	32	12	70	13.4
Car, Jeep, Pickup, Taxi, Microbus etc.	14	19.4	14	0	5	1.0
Motor Cycle	2	2.8	2	0	3	0.6
Total	72	100.0	60	12	522	100.0

Figure 2: Types of Tyre Burst Involved in Accidents



The positions of burst tyre in axle wheels are shown in Table 3. It is found that between front and rear axle wheels, relatively the occurrences of rear axle wheel bursts are more frequent (54.4%) than that of front axle wheels (45.6%). A close look at Table 3 reveals that vehicle-wise, trucks and light vehicles cause more rear wheel bursts (65.7%, 70%) as compared to front wheel bursts. Though in case of buses, the incidences of front wheel bursts are more frequent (91.7%) than that of rear wheel bursts. This opposite nature of bursting incidences particularly between buses and trucks may be associated with rampant overloading tendency of trucks (Rahman, S. M., 2002). Further analysis of rear wheel burst reveals that among 31 recorded incidents, 12 are of dual tyre bursts and 19 are of single tyre bursts. All the dual-tyre rear-wheel burst incidences involved trucks. No incidence of burst involving two tyres could be found with buses. In consideration of tyre side-position, left hand side tyre burst is distinctively found to be more common with all types of vehicles as compared to the right hand side tyre burst which are 84.0%, 62.5% and 66.7% for trucks, buses and light vehicles respectively. This essentially indicates that sidewise the left-hand side tyres are more prone to bursting than that of the right-hand side tyres of all vehicles.

Table 4 is prepared according to four possible combinations of tyre positions in two axles viz. front-left, rear-left, front-right and rear-right in order to assess the vulnerability of tyre position based on occurrence of tyre burst incidences and resulting casualties. From Table 4 it is clear that in terms of casualty, the front wheel combinations viz. front-left and front-right are more vulnerable (together inflicted 95.5% casualties) as compared to rear wheel combinations viz. rear-left and rear right. It may be because of the fact that the front axle comprises only one tyre at each side and any of the front tyres burst can easily make the moving vehicle totally unstable and make it out of control. Further, the front-right tyre is identified as the most casualty (60.8%) inflicting tyre. In terms of total 2155 casualties in 1011 accidents it tantamount to about 10.0%. This may be due to over involvement of buses with this combination of tyre burst incident as well as most importantly may be because of the fact that front-right tyre burst usually tend to cause most severe head-on type collision, whereas the other three tyre burst combinations mostly caused rear-end, hit-pedestrian/object, overturn, left carriageway etc. types of collisions as presented in Table 5. Further analysis of accident database confirms that out of eight front-right tyre burst incidences five were head-on type collisions and all were involved with buses. It is also found that out of 26 left carriageway type accidents 20 were caused by front-left tyre burst. Table 5 shows that 90% casualties are caused by head-on and left carriageway type accidents and most of them were initiated either by front-right or front-left tyre burst incidences.

Table 3
Wheel positions in tyre burst incidences

Type of Tyre Burst	Incidences *		Truck		Bus		Light Vehicles**	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Front Wheel Burst	26	45.6	12	34.3	11	91.7	3	30
Rear Wheel Burst	31	54.4	23	65.7	1	8.3	7	70
Total =	57	100.0	35	100.0	12	100.0	10	100.0
Dual-tyre Rear Wheel Burst	*12*	*38.7*	*12*	*52.2*	*0*	*0*	*0*	*0*
Single-tyre Rear Wheel Burst	*19*	*61.3*	*11*	*47.8*	*1*	*100*	*7*	*100*
Total =	*31*	*100.0*	*23*	*100.0*	*1*	*100.0*	*7*	*100.0*
Left Wheel Burst	32	76.2	21	84.0	5	62.5	6	66.7
Right Wheel Burst	10	23.8	4	16.0	3	37.5	3	33.3
Total =	42	100.0	25	100.0	8	100.0	9	100.0

*Note: * Known cases only; ** Car, Jeep, Pickup, Taxi, Micro-bus, Motorcycles etc.*

Table 4
Various Combinations of Defective Tyre

Tyre Combination	Incidences		Casualties	
	No.	%	No.	%
Front-Left Wheel	10	26.3	122	34.7
Front-Right Wheel	8	21.1	214	60.8
Rear-Left Wheel	19	50.0	16	4.5
Rear-Right Wheel	1	2.6	0	0.0
Total	38	100	352	100

Table 5
Consequences of Tyre Burst Incidences

Accident Types	Accidents Nos.	Casualties Nos.	%
Head on	5	208	40
Rear end	3	8	2
Hit Objects	8	0	0
Overturn	17	45	9
Fell on carriageway	2	0	0
Tilted on carriageway	11	0	0
Left carriageway	26	261	50
Total	72	522	100

According to occurrences of tyre burst incidences it is observed from Table 4 that among 38 known cases, the most burst prone tyre is the rear-left combination which causes 50% of the incidences. Both in terms of occurrence and casualty figure, the rear-right tyre is found to be the least burst prone (with only 2.6% incidences and no casualty). In addition to faulty tyre, the plausible reason behind the occurrences of unusually high percentage of rear-left burst incidences may be due to the fact that rear axle wheels of buses/trucks carry most of the vehicle weight, which is about 80% of total gross weight. Theoretically, though load should be evenly distributed on both sides of the axle, due to 2-3% camber provided in carriageway, the centre of gravity of vehicle-weight tilted towards left wheels. As a result, the left wheels are forced to carry more weight than that on the right wheels. Moreover, the load distribution become more eccentric when left wheels of vehicle occupy roadway shoulder and become more tilted due to steeper slope of shoulder (more than 5%) and most importantly due to pavement edge-drop which is often found to be as high as 25 mm. In consequence more weight is shifted to the rear left wheels and induces high internal tyre pressure. This situation becomes more aggravated when rear-left wheels make impact with embedded solid objects and potholes of shoulder and induces further 10-20% dynamic weight to the rear left wheels. The extra weights, which thus produced on the rear left-side wheels along with general poor tyre condition and overloading tendency cause extreme high tyre pressure as well as temperature and become the main catalyst of frequent rear left tyre bursting incidences.

Brake Failure

Brake failure type accidents as tabulated in Table 6 shows that the vehicular defect in the form of brake failure initiated a total of 16 accidents and caused 38 casualties of which two were fatalities. Fewer numbers of casualties and fatalities imply that in case of brake failure, drivers could somehow manage to stop the vehicles without very serious consequences. Table 6 reveals that the highest number (56.3%) of brake failure incidences is associated with trucks and the next 31.3%, 12.5% are contributed by buses and light vehicles respectively. Among all types of vehicles, expectedly bus is found to be the most casualty (86.8%) inflicting vehicle with a staggeringly high 6.6 casualty index.

Table 6
Summary of Brake Failure Type Incidences

Vehicle Involved	Incidences No.	%	Casualties No.	%	Casualty Index
Bus	5	31.3	33	86.8	6.6
Truck	9	56.3	2	5.3	0.2
Other	2	12.5	3	7.9	1.5
Total	16	100	38	100	

Table 7
Locations of Brake Failure Incidences

Just ahead of	Incidences No.	%
Roundabouts	5	31.3
Toll Plazas	3	18.8
Speed Breakers	1	6.3
Other roadway elements	7	43.8
Total	16	100

The spatial distribution analysis of brake failure cases, as presented in Table 7, reveals that 31.3% accidents took place just in the near vicinity of the East and the West roundabouts, 18.8% occurred just before the Toll plazas and 6.3% occurred before the speed breakers. It is to be worth mentioning that once speed breakers were installed at a few black spot areas of this road section, eventually were withdrawn in consideration of safety hazard posed by these speed breakers themselves. In total, the occurrence of 56.2% incidences just ahead of the roundabouts, toll plazas and speed breakers, essentially suggests that in addition to faulty brakes, the application of hard brake supposedly with excessive approach speed might have triggered these brake failure incidences. Excessive overloading could be another catalyst for the occurrence of these brake failure incidences particularly those associated with trucks.

Wheel Jam & Drum-off from Axle and *Axle & Tie Rod Fault*

Table 8
Incidences caused by Wheel Jam, Wheel-off, Axle and Tie Rod Fault

Vehicle Involved	Wheel Jam & Wheel-off		Axle & Tie Rod Fault	
	No.	%	No.	%
Bus	2	16.7	0	0.0
Truck	9	75.0	6	85.7
Other	1	8.3	1	14.3
Total	12	100	7	100

Thorough observation of accident database reveals that a total of 12 incidents are reported involving wheel jam and wheel going-off the axle etc. and 7 incidents involving broken or fall down axle, broken tierod etc. The data is summarized in Table 8. From the

Table it is evident that in both types of vehicular faults, trucks appear as the most defective vehicles involved in 75.0% and 85.7% incidents respectively. Excessive overloading of trucks could be a reason for wheel jams, wheel drum-offs from axles and material fatigue type failures viz. axle and tie rod broken down etc.

Defective Vehicular Light System

Accident database shows that there were only two accidents from defective vehicle light; one serious casualty was reported due to this type of failure. From detail description of these two accidents it is found that in one incident “A JOMAC patrol vehicle hit a standing truck on the back side. The truck **had no parking light** and occupied about half the carriageway” and in other incident “A motorcycle rider failed to identify the east roundabout due to **defective head light**. As such, he lost control and fell down from the bike”. Though it is evident from the field survey (Hoque, M.S., 2003 and Hasan, M.R. 2006) that nearly two-third vehicles that are plying along this corridor contain defective lights including indicators and headlights, reporting of only two incidents related to this particular type of defect may be due to difficulties in identifying this factor as a cause of accident by the field crew. In an attempt to investigate further on this vehicular defect, in consideration of the fact that accidents caused by defective indicator lights are often associated with overtaking maneuver and turning operation at junctions, the database was scanned objectively. It was observed that 21 accidents were found to be associated with turning operations, though no definite cause of accident is reported except type of collision. Presumably, few of these accidents might have been caused by defective vehicular light system.

Passenger Fall-down from Rooftop

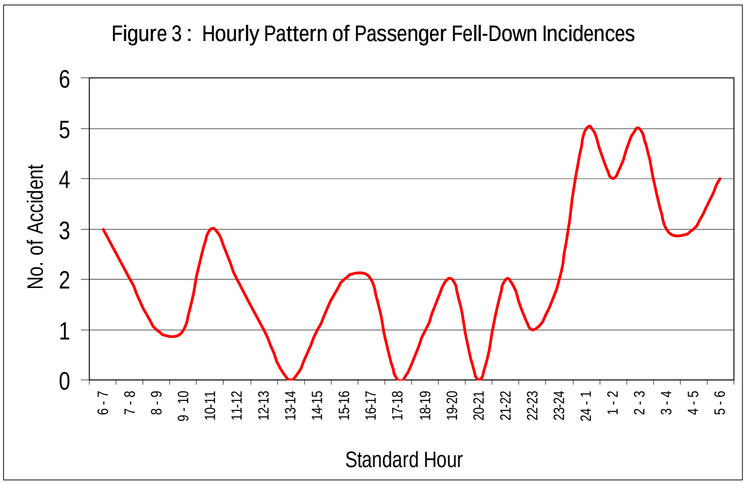
In the analysis, passenger fall down are considered as vehicle factor related accidents due to the fact that these incidences are the inevitable consequences of either vehicle modification in the form of attaching rooftop railing or associated with unsafe freight top passenger loading pattern. Table 9 shows that during the study periods, out of total 1011 accidents 50 passengers’ fall-down incidents had happened and most were recorded as fatal or severely injured. Though Table 9 shows that the maximum number of incidences (68.0%) as well as casualties (61.8%) are associated with buses, casualty index reveals that passengers who fell down from the

freight top of trucks are more prone and more likely to inflict severe consequences than that of falling down from roofs of buses. Perhaps, these may be due to the fact that rooftop bus passengers have railing facilities at least to hold on as well as get extra side protections to prevent themselves from falling down which is not the case with the freight top truck passengers. As a result, the truck passengers become more prone to fall down. Moreover, due to relatively greater falling height of overloaded freight top truck passengers as compared to rooftop bus passengers, they are more likely to inflict severe injuries.

It is also evident from the database that among 50 of these incidents, 14 occurred at the two roundabouts where high speed of vehicles was reported as the cause of these incidents. This essentially suggests that while drivers were negotiating the roundabouts’ weaving section with high speed, the rooftop or freight top passengers, particularly the drowsy and sleepy ones, were fell down due to high centrifugal force induced by excessive radial motion of vehicle. From the temporal distribution of

Table 9
Incidences of Passenger Fell Down

Passenger fell down from	Incidences No.	Incidences %	Casualties No.	Casualties %	Casualty Index
Bus	34	68.0	34	61.8	1.0
Truck	9	18.0	14	25.5	1.6
Other	1	2.0	1	1.8	1.0
Unknown	6	12.0	6	10.9	1.0
Total	50	100	55	100	



passenger fell down incidents, as shown in Figure 3, it is revealed that many incidents had occurred between late night and early morning when the passengers tend to fall asleep. It is also evident from the detailed description of incidences that the passengers who fell down particularly at these times often run over by the following vehicles.

3.3 Overall contribution of vehicular defects

Table 10
Summary of accidents caused by vehicular defects

Vehicle Factors	Accident	Casualty
Tyre Burst	72	518
Brake Failure	16	38
Wheel Jam & Wheel/ Drum-off from Axle	12	19
Axle Fallen, Axle, Tierod Broken etc.	7	1
Defective Light	2	1
Passenger fallen from Roof & Freight Top	50	47
Total accidents caused by veh. factors =	159	624
Total accidents caused by road, vehicle, users, environmental factors etc. =	1011	2155

Table 10 shows a summary of accidents that are caused by various vehicular factors. From Table it can be seen that due to different types of vehicular faults a total of 159 accidents occurred involving 624 casualties. Among various vehicular defects, the highest numbers (72) of accidents as well as casualties (518) were contributed by tyre bursting.

Figure 4: Vehicle Factors in Road Accidents

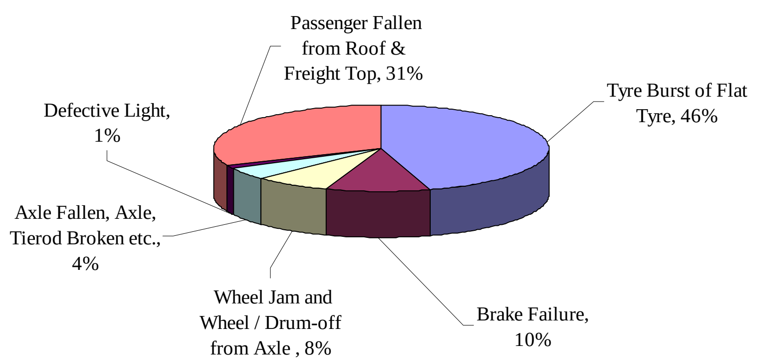
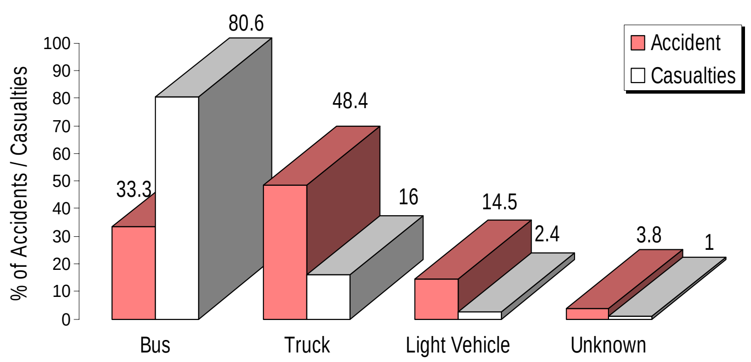


Figure 4 shows that tyre bursts constituted about 46% of the pie followed by passenger fall down (31%), defective brakes (10%), defective wheels (8%), axle and tierod fault (4%), and defective light (1%).

Vehicle involvement in various vehicular defects related accidents, as shown in Figure 5 reveals that by and large the truck is the most defective and accident-prone vehicle which accounts for a total of 48.4% accidents followed by bus and light vehicles with 33.3% and 14.5 accidents respectively. From Figure 5, bus is found to be the most dangerous and high casualty (80.6%) inflicting vehicle followed by trucks (16%) and light vehicles (2.4%).

Figure 5: Vehicle Involvement in Accidents



In terms of total accidents and casualties that are caused by road, vehicle and road users, the analysis of various defects as shown in Figure 6, it is found that the tyre burst is the most dangerous type of reported vehicular defect. The contribution of tyre burst tantamount to about 7.1% and 24.0% respectively. The passenger fell-down is also found to be alarmingly high particularly in terms of accident occurrence. Finally, in terms of percentage of total accidents, the contribution of all reported vehicular defects, as shown in Figure 6, is found to be 15.7% and in terms of total casualties caused by the same factor is 29.0%.

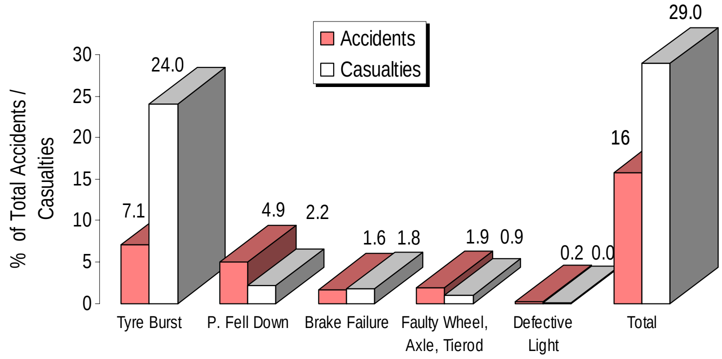
4. Conclusion

It is found that during the period of 01-01-99 to 30-04-04, a total of 1011 accidents involving 2155 casualties occurred on about 39 km section of roadway. Among these accidents, due to different vehicular faults a total of 159 accidents had occurred involving 624 casualties. In terms of the percentage of total accidents the contribution of vehicular defects is calculated to be 16.0% and in terms of total casualties caused by the same factor is 29.0%. By any comparison these findings are dreadfully higher than those in developed countries. The common vehicular faults are identified as tyre bursting, brake failure, axle failure, wheel jam and wheel-off from axle, passenger fall-down from rooftop etc. It is revealed that the most serious vehicular fault is the tyre bursting which accounts for 45.3% accidents and 83.0% casualty of all vehicular defect related accidents. It is tantamount to about 7.0% and 24.0% respectively in the context of the total accidents and casualties. Based on the frequency of accidents, the rear-left tyre is found to be the most prone to bursting. Trucks are identified as most defective and accident prone which accounts for a total of 77 accidents followed by bus and light vehicles with 53 and 23 accidents respectively. Further, analysis shows between front-left and front-right tyres, the front-right is found to the most hazardous which inflicted the highest 60.8% of casualties that are caused by various vehicular defects.

5. Remedial Measures

Presence of 7.4% vehicles on roads without registration and roadworthiness fitness certification indicates the level of slackness in vehicles' inspection and most importantly deficiencies in prevailing enforcement practice. In this regard strict enforcement and random vehicle inspection system need to be introduced involving highway police and vehicle inspectors. Evidence of rampant tyre burst incidences and resulting staggering casualty figures essentially suggests that vehicles owners and drivers should make aware about the causes and dreadful consequence of tyre bursting. They should be persuaded not to use of worn out tyres, reuse tyres by rubber lining and, most importantly, not to delay in the change of tyres as tyre burst emerges as a cause of many dangerous accidents. Field investigation (Hasan, M.R., 2006) reveals that both drivers and owners have little knowledge on safe method of tyre interchanging within different positions of axle wheels and they are also not aware of unsafe mixing of radial-ply and cross-ply tyres. On these very vital issues they should be given proper education and training. It is also been learned from the field investigation that heavy vehicle owners are facing serious problem in selecting a good quality tyre in the midst of large scale faking and dumping of branded tyres. They seriously complained that though tyre inscription shows 14/16/18-ply tyre but after premature burst it is often found that total ply is as low as six layers. In this regard due to lack of necessary quality confirming test equipment, the importers are also bit helpless. Considering the urgency of quality control of all types of domestic and imported tyres, this issue needs to be dealt with seriously. The Bangladesh Standards and Testing Institute (BSTI) should be immediately equiped with prerequisite non-destructive testing (NDT) facilities and mandatory quality assurance certification should be introduced in tyre trading. Moreover, realizing the consequences of defective tyres, the Bangladesh Road Transport Authority (BRTA) should take sincere initiatives to make the vehicle fitness checking more effective and must include checking if radial and non-radial tyres are used in the same axle, if 'rib and lug' tread patterns are wrongly dual together in an axle and most importantly need to check the overall condition of tyres with due importance.

Figure 6: Contribution of Various Vehicular Defects



In consideration of poor vehicle maintenance practices, aged vehicular fleet conditions and most importantly short life of heavy vehicles' tyre (3 to 4 months), introduction of six-monthly fitness checking could be most appropriate than the current yearly fitness practice. Accordingly, fitness checking centers need be increased throughout the whole country. Singapore, with its highly productive and sophisticated test system, specifies inspections every six months for public service vehicles (PSVs), heavy goods vehicles (HGVs) and taxis (ADB, 1996). In addition to that there is a need for introducing computer based vehicle fitness checking system to make the service more reliable, quicker and most importantly to eliminate subjective judgment of vehicle inspectors and thereby reduce the scope of illicit financial practice in vehicle fitness issues. Moreover, contactless inspection system needs to be introduced so that vehicle owners do not get the chance of managing vehicle inspectors and get preferential treatment. Besides, privatization of the fitness issuing system could be a better alternative in order to provide the service more effectively and competitively. This type of system has been adopted by Singapore where three main contractors (all qualified to International Quality Assurance Standard ISO 9002) have been licensed (ADB, 1996). There is, in addition, an enforcement regime operated by the Registrar of vehicles and the police. A testing station is available for testing suspect vehicles by government examiners. Testing of light vehicles in the UK is also carried out by the private sector with appropriate control and enforcement by the government.

The frequent passenger fall down from roof and freight tops and of run over by following vehicles prompted to enact strict enforcement policy on banning of rooftop railing and carrying passengers both on freight and roof tops. In consideration of alleged connection of incorrect tyre pressure, overloading and overspeeding with tyre burst, axle broken, brake fail etc. these violations should be strictly controlled by deploying adequate number of highway petrol police and equipping them with radar speed guns, handy tyre pressure checking devices, portable wheel load scales as well as by installing permanent weigh-bridges at key locations along the highways. In order to make drivers and owners of vehicles self-motivated in good maintenance practice, safety awareness campaign focusing on specifying their responsibilities could be a better approach in the long run. To encourage owners to keep their vehicles fit and roadworthy, duty and sales tax on tyre, brake system and essential spares be eased so that owners feel encouraged to replace worn out tyres, defective brake etc. without delay.

Last but not the least, existing police accident data reporting form needs to be updated to include vehicular defect related information more specifically and the traffic and highway petrol police should be given training to make them qualified enough to identify the most probable cause of an accident so that the similar type of investigation can be undertaken comprehensively taking into account of the total accident database of Bangladesh.

References

ADB (1996). *"Road Safety Guidelines for the Asian and Pacific Region"*, Vehicle Safety and Standards, Draft Report (RETA 5620), Asian Development Bank.

FORS (1999). *"Cost Effectiveness of Periodic Motor Vehicle Inspection"*, A Report by Federal Office of Road Safety, Keatsdale Ply Ltd., Australia, p39, p43,47.

GAO (2003). *"Research Continues on a Variety of Factors that Contributes to Motor Vehicle Crashes"*, Report for the Congressional Requesters, Highway Safety, United States General Accounting Office USA.

Hasan, T. (2003). *"The Human Component: Human Factors, Safety of Road Users"*, Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hasan, M.R. (2006). *"Involvement of Vehicle Factors in Road Accidents"*, M.Engineering Thesis (unpublished), Department of Civil Engineering, BUET, Dhaka.

Hoque, M.M. (2003). *"The Road Component: Road Factor and Element of Safer Road"* Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hoque, M.S. (2003). *"The Vehicle Component: Vehicle Factor and Vehicle Safety"*, Paper presented on Road Safety Training Course organized by Accident Research Center (ARC), BUET, Dhaka.

Islam M.N. (2004). *"An Investigation of Road Accidents on the Jamuna Bridge and Its Approach Roads"*, M.Sc. Engineering Thesis, Department of Civil Engineering, BUET, Dhaka.

Rahman, S. M. (2002). *"Study of Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road"*, B.Sc. Engineering Thesis, Military Institute of Science and Technology (MIST), Mirpur Cantonment, In association with Department of Civil Engineering, BUET, Dhaka.

Rompe, K. and Seul, E. (1985). Commissioned Report for the Director General of Transport of the Commission of the European Committee.