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Capital University of Science and Technology, Islamabad Pakistan

MANHOLE RELATED ROAD ACCIDENT PREVENTION USING SUSTAINABLE METHODS

[a] Ashar Ahmed*, [b] Muhammad Abeer Shaikh, [c] Bushra Aijaz

a: Department of Urban and Infrastructure Engineering, NED UET, Pakistan, aahmed@cloud.neduet.edu.pk
b: Department of Urban and Infrastructure Engineering, NED UET, Pakistan, shaikh4306588@cloud.neduet.edu.pk
c: No current Affiliation, bushra.aijaz.37@gmail.com
* Corresponding author: Email ID: aahmed@cloud.neduet.edu.pk

Abstract- Road accidents are the major cause of fatalities, injuries and property damage worldwide. The implementation of sustainable road accident prevention methods is essential to reduce the risk of accidents, promote safety and protect the environment. This research paper investigates road accidents in Karachi, particularly the impact of open manholes. Focusing on the disruptive effect of open manholes on road safety, the study addresses the issue and its implications. The paper analyzed onsite data on traffic volume and accidents, providing insights into vehicle flow rates during peak hours. The effect of open manholes on accident frequency is examined. The traffic mix at the study location comprised of 57.9% motorcycles, 28% cars and 12.4% rickshaws, while buses, tankers and trucks constituted the rest. It was found that there have been approximately 105 road accidents due to open manhole at the study location. After the recycled rubber tire has been placed, no accident occurred. This is a remarkable finding. The placement of recycled rubber tires over open manholes is a sustainable solution that is cost-effective, durable, easy to install, slip proof, more theft-proof then conventional reinforced concrete manhole covers and eco-friendly.

Keywords- Manhole, Rubber Tire, Traffic Volume, Peak Hour Factor.

1 Introduction

Road networks serve as fundamental channels, facilitating the seamless movement of numerous individuals engaged in diverse activities such as commuting, traveling, studying, and running errands. However, due to increase in exposure as a result of daily mobility, road accidents also increase. Ahmed and Aijaz [1] has indicated 28,170 fatal injuries in Pakistan in 2020 in its literature and identified major reasons for road accidents. According to the survey report published by Khurshid et al [2], 50.4% of fatalities in Karachi city; are due to the road accidents, out of which 12.9% were happened during 6:00pm till 11:59pm in 2019, which was increased in 2020 to 22%. Muhammad et al [3] have reported that 22.1% of traffic accidents have had happened in evening from 5:00pm till 9:00pm. They collected the data of 426 injured patients and recorded that 36.2% accidents were due to the vehicle slippage and 16.8% were occurred at Link Road and 75.3% on Main Road. We have identified one such region consisted of an exposed or uncovered manhole located near SSGC on the Abul Hassan Isphahani Road connecting to Main University Road, Karachi. The study area manhole is 2 ft wide and have been a reason of many vehicular accidents, especially during peak hours.

The occurrence of accidents is influenced by multifarious factors, encompassing peak traffic volumes during specific time periods, intricate traffic patterns, the quality of infrastructure, and driver conduct, including the presence of manholes along roadways. The manhole covers provides preventions to fall hazards. Manhole covers are made up of steel reinforced concrete and weighs about hundred or more kilograms to sustain the load of traffic passing over it. The

presence of numerous addicts and beggars seeking financial gain in the city has resulted in the theft and removal of manhole covers, leading to exposed manholes. Exposed manholes have become prominent contributors to road accidents. A significant number of manholes exists throughout the city, necessitating urgent attention and the implementation of a sustainable solution. There has been a lot of work towards sustainable solutions for road repairments. Abrar and Shah [4] have suggested non-woven fabric and ultra-thin asphalt overlay for repairing potholes during rehabilitation phase. Khan eta al [5] has also suggested the use of rubber tires' strips in the manufacturing of manholes covers instead of conventional reinforcement. This study is one of a kind that addresses the problem pertinent to the city of Karachi. It aims to explore the various sustainable methods of mitigating road accidents due to open manholes. The installation of manhole covers that are cost-effective, environmentally friendly, and theft-resistant becomes an ideal approach. To address this challenge, rubber tires have been utilized as part of manhole covers. The placement of rubber tires as manhole covers provides visual indicator to alert drivers about manhole presence. It brings out a sustainable solution, as they can be recycled into various products such as road surfacing, and even synthetic oil. Waste rubber tire can also be used in pervious concrete, as mentioned in Bonicelli et al [6], and hence can help to minimize the need for new materials.

By deploying the recycled rubber tire on the exposed manholes, it not only warns drivers and pedestrians about the fall hazard but also a positive and low-cost solution to economy. To achieve this, an onsite survey was conducted, and responses were collected from nearby shopkeepers along the route from Abul Hasan Isphahani Road to University Road of Karachi, Pakistan. The survey included traffic volume count conducted from 5:15 pm to 7:15 pm, enabling the calculation of traffic flow rate and peak hour factors. The method adopted for traffic data collection was on-site manual count. For accident data collection, on-site interviews were conducted from the nearby shopkeepers, before and after the intervention. The subsequent sections consist of results obtained after traffic analysis results along with its discussion, followed by conclusions drawn out of this investigation.

2 Methodology

The methodology employed in this study consisted of three integral parts. The first section describes the study area followed by traffic and accident data collection and the last section explains the analysis method.

2.1 Study Area

The selected study area for this research encompassed the stretch of road from Abul Hassan Isphahani Road to Main University Road, specifically near the SSGC building. The Abul Hassan Isphahani Road facilitates around 12 educational institutes, predominantly schools. Consequently, a substantial volume of vehicles traversed this road on a regular basis. Notably, numerous manholes were present along this road, with two significant ones situated in close proximity to the UIT University and at the junction connecting Abul Hassan Isphahani Road and University Road. Our study area is the later one.

a) 

b) 

Figure 1: Study Area, a. Location of the study area (Source: Google Maps), and b. Physical condition of the road as of 01st June 2023.

Figure 1 depicts the location and geometry of the study area. The manhole is measured to be 2ft wide. It is situated at the curve where Abul Hassan Isphahani Road is about to join the Main University Road (Figure 1a). The curve is also connecting the service road, a U-turn and a triangular round-about. The potential dimensions of traffic movement making the study area more sensitive specially for motorcyclists, Qingqi and auto-rikshaws (Figure 1b). The presence of hawkers, baggers and pedestrians increases the chances of sudden application of brakes and turnings by the drivers, which results in greater chances of vehicle/pedestrian crashes or their fall/slippage into manhole.

2.2 Data Collection.

Data collection is the process of gathering information about the transportation system, its users, and its environment [7]. Two types of data were collected for this study; which are traffic volume and accident frequency. On-site manual count method was used to collect volume data while interview method was used to collect accident data. The authors conducted manual count of traffic moving on Abul Hasan Ispahani Road towards University Road. The two-hour traffic volume was counted from 5:15 pm to 7:15pm. The classified count was obtained through manual counting of each type of vehicle on site. The data was divided into intervals of 15 minutes for further analysis. The authors also interviewed the nearby shopkeepers to gain insights into the type and frequency of road accident at the location of study.

2.3 Traffic Analysis.

The collected traffic data was analysed for various traffic macroscopic parameters. First the distribution of traffic with respect to each mode, that is traffic mix, was analysed. It was followed by the calculations of Rate of flow and Peak Hour Factor [8]. Rate of flow represents the vehicular flow that exist for periods of time less than one hour. It is represented in units of "vehicles per hour" and can be calculated using equation (1) described as follows,

$$Rate\ of\ flow = \frac{No.of\ vehicles}{time\ interval\ in\ min} X\ 60 \qquad (1)$$

The Peak Hour Factor (PHF) can be collected using equation (2). PHF explains the variation of traffic occurring within an hour. It helps understand the flow of traffic on a particular location and examine the situation on site. It provides insightful information on traffic patterns and the potential influence of volume changes on the occurrence of road accidents.

$$PHF = \frac{V}{4 \times V_{m15}} \qquad (2)$$

Whereas,

PHF = Peak Hour Factor
V = Hourly Volume (vehicles)
V_{m15} = Maximum 15-minute volume within the hour

3 Results and Discussion

3.1 Traffic Mix

The traffic mix, that is, the distribution of traffic with respect to each mode was surveyed on-site for traffic moving from Abul Hasan Isphahani Road towards University Road. The corresponding percentage for each mode of transport was calculated. The survey revealed that motorcycles made up 57.9% of all traffic passing through the location as shown in Figure 2. Cars with a share of 28.0% constituted the second largest portion, followed by rickshaws at 12.4%, while the trucks and small trucks collectively represented a minimal proportion of 0.11%.

The findings indicated that rickshaws were particularly vulnerable to accidents occurring as a result of open manholes. This observation underscores the need for effective measures to address the safety risks faced by drivers and passengers passing by the location of study.

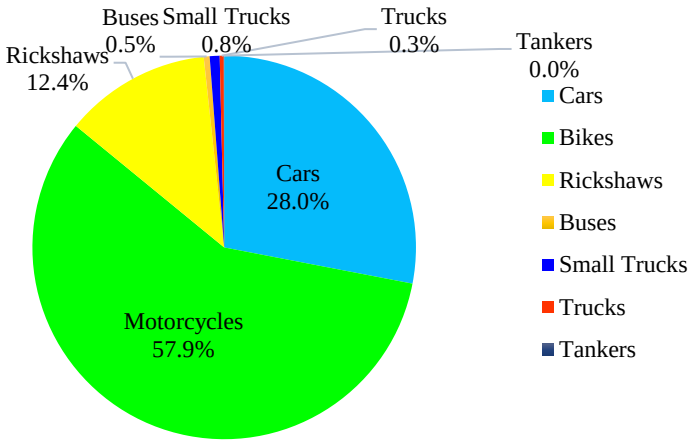

Figure 2: Traffic mix at the location of the study.

3.2 Flow Rate

Flow rate is the equivalent hourly rate at which vehicles pass through a given point or segment of a lane or roadway within a given time interval of less than one hour, usually 15 min [9]. The analysis of the flow rate at the study area indicated an upward trend. Figure 3 shows that as the time of the day is increasing the flow rate is also increasing. This is conformal with the behavior of traffic flow in the city. Since, Abul Hassan Isphahani road connects its surrounding residential areas with the University Road, this serves as the likely route for students going for evening classes at NED University and University of Karachi. The variation in the flow rate is likely due to the movement of students with respect to their evening class timings.

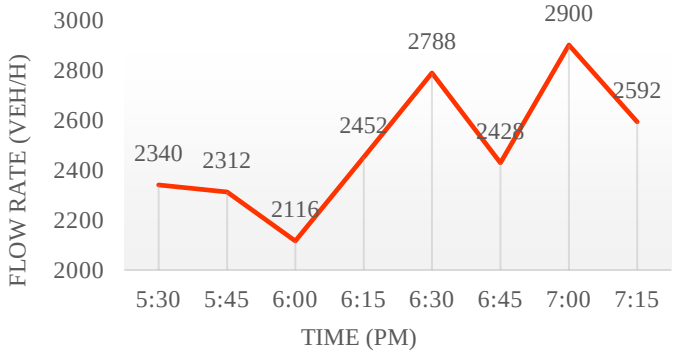

Figure 3: Traffic flow from 5:15 pm to 7:15 pm on 1 June 2023 at the location of the study.

3.3 Peak Hour Factor

The Peak Hour Factor (PHF) is one of the basic parameters used by traffic engineers to examine the macroscopic behaviour of traffic at a particular location. It is calculated on the basis of dividing an hour into four quarters, each consisting of 15-min. The total volume during a particular hour is divided by the maximum 15-min volume multiplied by 4 to obtain the PHF. The values of PHF cannot be less than 0.25 and greater than 1. The more the value is near to 1, the lesser the variation in traffic flow. The calculated PHFs are shown in Table 1.

Table 1: Peak Hour Factor

Time	PHF
Volume 5:15-6:15	0.94
Volume 6:15-7:15	0.92

The examination revealed that as the evening is approaching the variation in traffic flow is decreasing. This finding is mathematically conformal with the traffic flow behavior, as the value of PHF greater than 0.9 is an indicative of the uniformity in traffic flow.

3.4 Traffic Accidents at Study Area

According to the survey, the eyewitness at the location claimed that an average of four rickshaws and one car fell into this manhole every day as recorded in Table 2. Some of the accidents involved considerable property damage in which the front part of the rickshaw collapsed completely. No human loss or injury accident has been reported yet but it is common to have slight, sever, or even fatal accidents due open manhole if it is located on a straight segment. As per the survey, approximately 105 accidents have occurred on the site till 31st May 2023. These numbers are from the date the manhole cover was stolen, that is, 5th May 2023.

Table2: Average accidents per day of each type of vehicle

Vehicle Type	Motorcycle	Rickshaw	Car	Bus	Small Truck	Truck	Tanker
Average accident per day	0	4	1	0	0	0	0

3.5 Sustainable Accident Prevention Methods

Road accidents involving open manhole could easily be prevented by simple methods. Conventional manhole covers contain steel reinforcements which are of high value to addicts. These conventional covers are sabotaged and stolen by addicts to extract the steel in them, in order to fulfill their needs. Unconventional manhole covers, that do not contain steel, will be of no use to them and hence will be safe from being sabotaged or stolen. One such manhole was developed at NED University in 2020 using recycled rubber tire [5]. Instead of conventional steel reinforcements, rubber tire strips were used. The load bearing capacity of the resultant tire was found to be in the range of 12.75 to 17 kN, which is higher than the conventional manhole covers available in the market. But it had some limitation like durability; since heavy traffic will be moving upon it whole day and this particular manhole cover may not support it.

To address the issue of uncovered manholes, a recycled rubber tire is proposed to be deployed as a cover. The choice of using a rubber tire cover was based on its durability, cost-effectiveness, and environmental suitability. It costs approximately PKR 1650 cheaper than sustainable manhole tires, along with they offer moderate durability in contrast to sustainable manhole cover's high durability. They do make high effectiveness and impact. Suiting them to an overall rank of 1 as presented in Table 3. Another most readily available material and the urgent solution; is the bamboo stick. In case of missing or damaged manhole cover, the first object that is used by the nearby residents or passersby is the bamboo stick as an alarming notification to the drivers. Although bamboo sticks are available at a cheaper rate than the two but they offer less durability and moderate level of effectiveness in preventing accidents.

Table 3: Sustainable Accident Prevention Methods

	Cost (PKR)	Durability	Effectiveness	Impact	Overall Rank
Sustainable Manhole Cover	2,000	High	High	High	2
Recycled Rubber Tire	350	Moderate	High	High	1
Bamboo Stick	200	Low	Moderate	Moderate	3

The onsite survey also revealed a notable decline in the number of road accidents following the implementation of rubber tire covers to secure the manholes. The rickshaws try to utilize the extra space available at the junction (curve) during peak hours, which otherwise remain empty, causing more rickshaw related accidents. The interviewers claimed that the accidents reduced to zero after the placement of rubber tires as manhole cover. The utilization of rubber tires also served as a visual indicator for drivers, alerting them about the presence of open manhole and prompting them to exercise caution. Figure 3a shows the manhole before the placement of the rubber tire. In the existing scenario speedy drivers will

get little to no chance to swerve away from its path. After intervention, as shown in Figure 3b, the manhole is noticeable to the drivers. The application of paint further improves its conspicuity specially during dark.

It is to be noted that the manhole addressed in this study does not lie in the middle of the road. It is at the corner of the road where the curve intersects the straight segment. The traffic flow and geometry of the study area indicates that vehicles do not move exactly over this manhole during off-peak hours. During peak hours only, when the traffic is near jam, the rickshaw drivers try to overtake other vehicles by utilizing the extra space available near the curve junction where this manhole is located. Placement of tire serves as an indication for potential hazard suggesting drivers to follow their usual path. This tire does not create any obstruction in the flow of traffic.

Figure 3: a) before the installation of rubber tire, b) after the installation of rubber tire.

4 Conclusions

Following conclusions can be drawn from this study:

1 The study location indicates that the manhole is located at a space just besides the median of the curve junction. This space is more often occupied by vehicles when the flow rate increases and the PHF is high (> 0.9).
2 The study findings demonstrate that there have been no accidents at the location, after the placement of the recycled rubber tire over the manhole.
3 The placement of rubber tire as manhole cover has deterred addicts and beggars from removing them, thus improving the safety at this specific point.
4 It is to be noted that mere deployment of tire over an open manhole is a temporary solution. Sustainable covers made with rubber tire strips instead of conventional steel reinforcements, is a long-term and more feasible solution.

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