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Effects of the construction for the tunnel metro line on the surrounding traffic environment

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ABSTRACT :

Construction operations will begin when metro rail projects are performed, and there will unavoidably be long-term construction zones during this period. Extended construction zones on city highways cause fuel consumption, traffic accidents that cause unexplained financial losses, reduced capacity, longer travel times, long waits, and forced merges, among other difficulties. If we want to know how much money will go out the window due to metro rail construction zones, we need to study and measure the effects on traffic. In light of the existing state of affairs, this study aimed to analyse and, ultimately, quantify the traffic-related impacts of metro rail construction zones. The software was used to investigate the consequences of intersections in a work zone. We measured the wait times in both the work and non-work zones. Building an elevated metro on that site is projected to result in a total economic loss of around 20 crores per km, per year. Considering the significant financial losses, control measures are necessary to lessen the impact of metro rail construction work zones.

Keywords*:* capacity loss, speed reduction, travel time delays.

Introduction

there is construction or maintenance taking place on a highway, it will be marked as a work zone. This is because drivers may experience changes to their operating characteristics or the number of lanes available to them. The rapid growth of the city's population, the proliferation of automobiles on the road, and the rise in private vehicle usage have all contributed to a significant worsening of urban traffic congestion. Potential solutions to this problem in emerging countries like India include constructing mass rapid rail systems and enhancing road infrastructure. Upon completion of these projects and clearance for construction, cities will inevitably transform into perpetual construction zones. Many issues arise as a result of the projects' inadequate design and execution of these long-term urban work zones, even though the projects' stated objective is to reduce traffic. Among these include decreased capacity, increased travel times and queues, fuel consumption, the frequency of forced merges, and the extent to which traffic accidents result in unrecognised monetary losses. Hence, the first step is to investigate and measure.

The Indian Roads Congress has recommended safety requirements for these locations, and the Highway Capacity Manual (2000) specifies the maximum loads that can be accommodated in both temporary and permanent work zones [1]. The impacts of work zones caused by highway and metro rail construction projects are distinct due to the vast differences in the types of projects and the construction activities involved in each. Economic loss due to metro rail construction can only be estimated through research and measurement of the consequences of work zones on the traffic environment.

Objectives of the present study:

- To investigate, recognize, and evaluate the many features of an elevated metro construction work zone inside the research area.
- To examine the features of traffic flow in the work zone and contrast them with non-work environments.
- To research the features of fuel use in a work area.
- To calculate the financial loss resulting from longer commutes and higher fuel usage in a work zone.
- To use VisSim software to model different scenarios and investigate how shifting work zone conditions affect the features of traffic flow.

Literature Review

The full-section approach, step methodology, and CRD method are considered necessary in urban junction tunnel engineering according to the NATM core construction protocols. For the full-section approach, as shown in Figure 2a, the tunnel design is created using a single blast, and then the lining and support are added. This system's construction method is simple and consists of three primary parts. The first step is to use a big drill to drill holes in the component. The next step is to insert the explosives and connect the fuses. Secondly, the tunnel segment is shaped by detonating explosives after the big drill has left. The last step before moving on to the next cycle is to remove the slag and add section support. Due to the reduced number of tasks and interactions between processes, the full-section technique simplifies construction management and organisation. Stabilising the surrounding rock is another benefit of excavating the tunnel segment at the same time. However, because of the extensive excavation section, the method requires a

high rock strata grade. Evidence from the field suggests that the full-section approach is effective for strata ranging from grade I to grade III [27, 28]. Additionally, the full-section approach requires a large amount of space due to its dependence on bulky equipment. The Xi′an metro tunnel project [29] and the Georgia No. 3 tunnel [30] are two examples of urban tunnel engineering projects that benefit from this method. These projects feature advantageous construction circumstances and high surrounding rock grades. In order to divide the tunnel length into upper and lower levels, the NATM frequently uses the step method of construction. Both processes require a specific amount of time to complete. After supporting and digging the top step a specific distance, the bottom step must be removed. Figure 2b shows that the top and bottom stages can be drilled simultaneously on distinct work sides. Based on how long each phase of the process takes, it is labelled as long, short, or extremely brief. With the step technique, there is no barrier between the two sides of the excavation, which allows for quick building development. Furthermore, a tiny excavation region stabilises the palm surface. This means that the step approach works well with developed joints and weak rock layers of classes I–III. Building on both sides of the excavation causes further disturbance, which weakens the surrounding rock. Urban tunnel engineering projects that can benefit from the step technique include the Eling tunnel [31] and the Feng'an tunnel of the Zihui road project [32]. Weak surrounding rock and short building deadlines are the characteristics of these projects. Inadequate research has led to an inadequate urban transportation environment. But numerous researchers from other nations have examined and recorded the effects of work zones on rural roadways. Work zones on rural roads were the primary focus of the referenced literature, which served as a rich source of information for the present investigation. The transition zones in Stages I and II caused several vehicle types to slow down, whereas the newly constructed route in Stage III caused speeds to climb. As the car gets closer to the work zone, its speed drops drastically. According to the studies, cars drive
faster in the advance warning zone. Its velocity drops when it approaches the transition zone. Even more so in the action zone, its speed decreases. Its speed increases once more at the terminal phase. The construction site's transition zone had a 60% slower traffic speed compared to in Because of construction-related activities and traffic patterns, the site is constantly changing. By simulating traffic in pre-construction regions without road width restrictions, the study aimed to assess the scenarios' performance in relation to travel time and delays. The study's parts had a 25-30% decrease in speed due to the road's initial six- lane width being narrowed to four lanes during work zone development. When making decisions on the kind of building and how long it will last, quantification might be useful. It was also shown that microscopic traffic simulation is the best technique to establish a controlled environment to exhibit and evaluate different scenarios without disrupting traffic. Regardless of lane closure patterns, the Highway Capacity Manual (2000) states that short-term highway work zones should have a capacity of 1600 PCU/h/ln. [5]. When traffic switches to lanes normally used by the opposite direction of travel, long-term construction work zones can accommodate as many as 1,550 autos per hour per lane. If a merge down to one lane is necessary instead of a crossover, the speed is typically higher and might average around 1,750 vehicles per hour. found out what causes drivers to incur more expenses due to delays. [6].

A research was conducted to evaluate the consequences of applying the. In order to assess
the effects of ATCS on fuel usage before and after its implementation, we employ equations that were constructed as part of IIT Bombay's 2000 Traffic and Transportation Study for Bandra-Worli Sea Link Project. The ATCS Pune impact assessment report from 2006 [7] details the results of the impact analysis. This study used these equations to calculate the monetary losses caused by buses, vehicles, and two-wheelers.

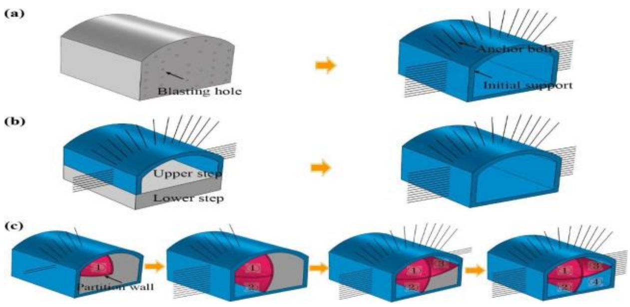


Fig. 1. construction methods in urban tunnel engineering.

Study area profile and data collection

The site is situated on, an East Bali road six-lane divided carriageway that links Boring Road. It is located in the urban ward of Krishna Nagar in the East Patna district of Bihar. Business enterprises are dotted across the site's surrounding region, which is primarily residential. The location and description of the study region are displayed in Figure 1.

Fig.2. Study area location.

Because the drain only follows one side of the road, there isn't a lot of traffic going left-in and left-out, which is why we choose this position. We choose this spot for the project since it gets the greatest traffic and has the fewest conflicts with other crossroads in the area. Assuming that bends have no effect on traffic speeds, most construction occurs on straight sections, and through traffic accounts for 80% of all traffic. When analysing the traffic flow data, a 1-kilometer section of the study length is selected to compensate for the two small crossings.

Fig.3. Survey areas, data collection area.

the three sites that were chosen. Figure 2 shows every possible location for video recording. Location 1's traffic flow parameter analysis used a site free of work zones, Location 2's used a limited set of parameters, and Location 3's used a station location. We compared the non-work zone and work zone circumstances during peak and off-peak hours by collecting footage of cars, buses, two-wheelers, and other vehicles over the course of 12 hours. The morning hours of 07:45 to 08:45 were off-peak, the hours of 09:30 to 10:30 were peak, and the hours of 12:30 to 13:30 were off-peak. From 17:30 to 18:00, it reaches its climax in the evening. At 200-meter intervals along the length, statistics on delays and speeds were recorded for both work zone and non-work zone conditions. A petrol flow detector was used to assist in conducting a fuel usage survey. Vehicles equipped with the device were designed to operate in both work and non-work zones, with two simultaneous runs per hour for speed and delay tests. Data on fuel consumption was recorded every 300 meters in both the work zone and non-work zone environments. A user feedback poll was carried out at several points throughout the day. To determine monetary loss, the following data were retrieved from the poll of public opinion: regular monthly salary.

Data Analysis

According to the site specifics description, all traffic going towards Boring Road. Because the station area for the work zone has a road width that is closer to boring road. there are discernible differences in the traffic flow metrics when compared to normal conditions. The following study was conducted in order to understand the traffic flow parameters in the three locations: The composition of traffic • Traffic flow during peak and off-peak hours; • Work zone effects on speed profiles; • Work zone effects on road capacity; • Comparison of speed, fuel consumption, and trip time

Conclusions are drawn after analyzing the effects of the previously given parameters, which measure their impact on the traffic environment. In the next sections, the economic losses arising from the work zone are calculated using these conclusions as a basis.

Composition of vehicular traffic

Fast-moving vehicles make up the majority of the daily traffic mix, with two-wheelers accounting for the biggest percentage. The second most common mode is the car. Cars and two-wheelers make up over 60% of the traffic. About sixteen percent of traffic is made up of cars and buses. depicts the traffic composition. Although it is not very substantial, the non-motorized traffic composition has a major impact on speed reductions in work zones when road widths are reduced.

Traffic flow variation

We studied the changes in peak morning, evening, and afternoon traffic flows. Throughout these hours, every five minutes, we assess the traffic movement in both directions at each place for each mode. Within the span of three hours, traffic patterns show minimal change between morning and evening rush hours, as well as off-peak periods in the afternoon. Morning and evening peak hours encompass work travels and business job journeys in the afternoon as a result of the commercial sector surrounding the study stretch.

Effect of work zone on speed profile

In order to evaluate the impact of the work zone, non-work zone, and station area work zone scenarios on the speed profile, the three sites were analysed for mode-wise speed variations. Computing the 15th, 50th, and 85th percentile speeds of different modes required the use of software to create cumulative graphs for the speed profile. Transferring from the work zone to the non-work zone conditions at the station area requires varied travel speeds for the various modes of transportation. Various motorised modes of transportation can rapidly achieve varying speeds. The road width is reduced in the work zone, which makes a visible effect is within a five-meter radius for automobiles to reach. The typical speed increase while transitioning from a work zone to a non-work zone is 40%, and when transitioning from a station work zone to a non-work zone is 174%. In the parts that follow, we'll talk about how fuel usage, longer lineups, and more delays are all consequences of drastically reduced traffic. An example of this would be a typical 15% speed reduction from the non-work zone to the work zone while traffic is approaching, and a 33% reduction from the non-work zone to the station work zone.

Looking at the average spot speed profile data for the different settings reveals a distinct
disparity in speeds that drop in a linear fashion. The speed decreases marginally for selections that do not utilise motors. Vehicles are required to travel at a speed ranging from 0 to 15 km/h in the station work zone and 25 to 30 km/h in the work zone. The flow of traffic is suddenly improving.

Effect of work zone on capacity

The road's capacity decreases when a work zone is established. the capacity continuously decreases from non-work zone to work zone to station area work zone. This has a big
impact since a sharp drop in capacity causes a bottleneck, which in turn causes shock waves to form. These waves affect not just the route in question but also traffic moving on the nearby network. Speed and flow graphs created from the data taken from the video graphic survey are used to calculate capacity.

Combined speed vs flow graph

The road's capacity gradually decreases from the non-work zone to the work zone to the station area work zone, as shown in figures 4 and 5.

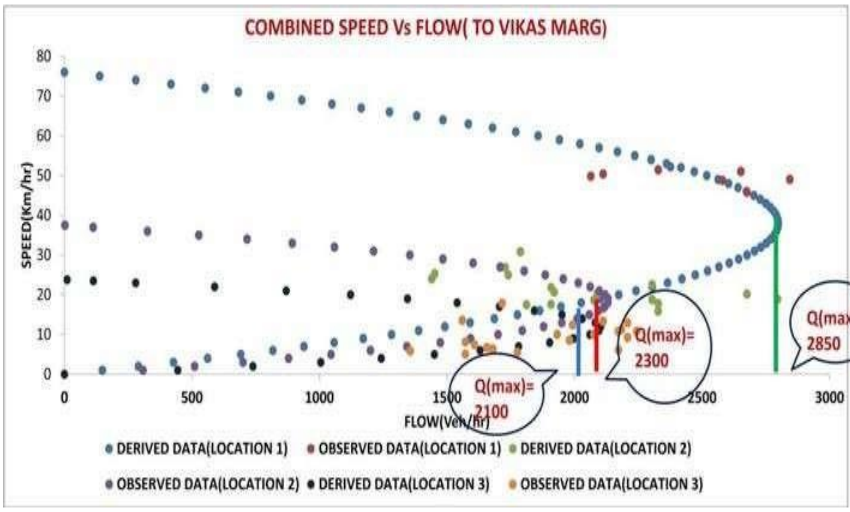


Fig.4. Combined speed flow graph

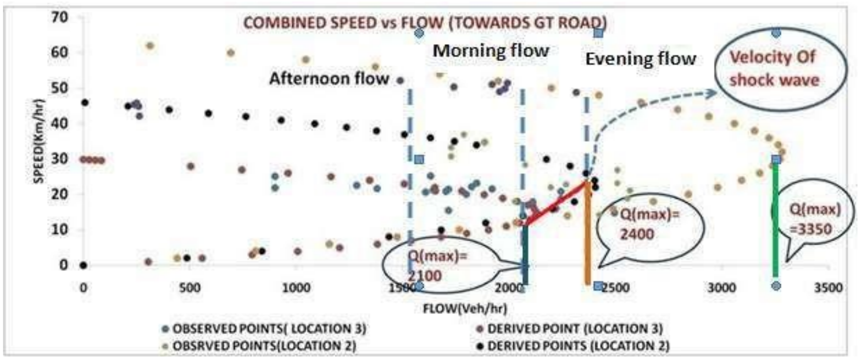
The speed flow graph for traffic moving toward The optimal capacity is 2300 automobiles for the work zone, 2500 cars for the station area work zone, and 2900 cars for the non-work zone. A 31% increase.

The speed flow graph for traffic moving toward in the graphic at three distinct locations. The non-work zone can accommodate up to 4500 automobiles, the work zone can accommodate up to 3500 cars, and the station area work zone can accommodate up to 3200 cars. From the non-work zone to the work zone region, there is a 78.3% reduction in capacity; following the metro station work zone area, there is an additional 15.5% reduction. Consequently, there is an effective 57% reduction.

Development of shock waves

In the given case study, shock waves are created when the evening peak traffic volume exceeds the bottleneck's capacity. The traffic flow towards is less than the bottleneck capacity in the morning and afternoon. The shock wave velocity shown in figure 6 represents the difference between the velocity at the maximum capacity, or bottleneck capacity, at site 3 and the velocity at flow equivalent to evening flow. Given that the nighttime flow velocity is 24 km/h and the bottleneck capacity velocity is 18 km/h, the shock wave velocity is calculated to be 6 km/h.

Fig.6. Combined speed flow graph



According to shock wave velocity, traffic shock waves spread at a speed of 6 km/h, which means that if traffic is not managed, a 6 km jam might develop. Shock waves do not, however, spread in the case study because traffic is managed by traffic signals at the intersection before to the construction zone. Due to a lack of traffic data for distances greater than one kilometre, it was not able to investigate rearward moving shock waves for traffic headed towards.

Calculation of economic loss

As was seen in the last chapter, traffic congestion in the work zone area causes slower speeds, longer travel times, and increased fuel consumption. Finding the monetary losses brought on by these characteristics is crucial. It is crucial to determine the loss of fuel consumption and journey time since fuel loss affects the economy directly and trips wasted by travellers take time away from other activities. Unfortunately, this case study only takes into account fuel and passenger travel time losses from four different modes: vehicle, two-wheeler, bus, and auto. There are many additional forms of direct and indirect economic losses that may be included.

Estimating the value of wasted time in the workspace

First, find out how many people will be riding during peak and off-peak hours by multiplying the total number of vehicles by the average occupancy after choosing each mode of transportation. The number of persons travelling for business and leisure is determined. From the user opinion survey that was carried out during the study period, we were able to get the average occupancy rate as well as the percentage of passengers who were on work journeys and those who were not.

Second Step: To find the passenger income per minute, you must labour eight hours each day for twenty-five days in a month. While user opinion surveys are used to establish income for work trips, price indexing based on the complete selling price index is used to consider revenue for non-work travels by various modes, according to the CRRI-Road user cost research, 2001[8].

Third, deduct the time spent outside the work zone from the time spent inside it to get the total time lost to cover per km.

Fourth, to find the total amount of time lost, we multiplied the number of passengers on work and non-work travels using different modes by the respective income levels. We also include the amount of time lost by the mode when entering and leaving work zones. According to the Road User Cost (8) Study, automobiles, autos, two-wheelers, and buses generate an estimated 24046, 18247, 13406, and 14630 rupees, respectively, in revenue

from non-work journeys. The steps taken are identical to those described in IRC-SP-30 2009[9].

- The calculations take into account the peak traffic times of the day. We run the numbers for 12 hours assuming that during off-peak hours there is 15% less traffic than during peak hours.

Calculating the fuel loss value in the work area

Subtract the fuel consumption per kilometre inside and outside of a work zone to get the amount of gas wasted by an automobile. One way to calculate overall fuel usage is to multiply the number of automobiles using a specific fuel by the number of vehicles leaking gasoline, and then to multiply the result by one vehicle per km. The sum of all fuel losses multiplied by the cost of fuel per unit yields the overall value of fuel loss. The fuel consumption for different modes is determined using the equations used for the Bandra-Worli sea connection transportation and traffic research by the Indian Institute of Technology (IIT) Bombay [7]. The equations are as follows:

Every year, the following amounts are lost per kilometre: 60,69,600 rupees for two- wheelers, 1,63,8300 rupees for cars, 52,54,800 rupees for buses, and 96,57,300 rupees for automobiles. The construction zone delayed four modes of transportation—autos, two- wheelers, buses, and cars—and cost an estimated 2,26,20,000 rupees. Total economic losses per kilometre after fuel and time lost amount to Rs 19,92,93, 011 per annum.

1. How a construction zone crossing affects the length of time vehicles must wait in queue In regions where metro rail development is taking place, intersections have a significant impact on queue length. The building work zones significantly increase the waiting time at the crossing. We used the program to build a simulation model both before and after setting up the work zone so we could measure how long the queue was. Once the simulation model had ran for an hour, it started to generate findings every 600 seconds. The data show that the crossing causes a 66.2% increase in the average line length heading towards Road within the work zone. When a construction zone crosses a crossroads, the average traffic wait time increases by 460%.

Consolation:

The study set out to do two things: first, find out how traffic is affected by metro rail construction work zones; and second, measure the unreported direct and indirect economic losses. Given the significant financial losses, it is imperative to implement systematic work zone scheduling and traffic control techniques in order to minimise the impact of the metro rail construction work zone. This is why traffic control and systematic work zone scheduling are necessary to lessen the impact of the work zone. Shockwaves can be monitored and controlled by changing the timing of traffic signals. The majority of financial losses are caused by bus passengers' lost time, hence public transport should be prioritised in work zones. In work zones, one method of traffic control is to limit one or more vehicle categories during peak hours.

REFERENCES

1. Zhang, S.; He, S.; Qiu, J.; Xu, W.; Garnes, R.S.; Wang, L. Displacement Characteristics of an Urban Tunnel in Silty Soil by the Shallow Tunnelling Method. *Adv. Civ. Eng.* **2020**, *2020*, 3975745.
2. Jiang, C.; He, J.; Zhu, S.; Zhang, W.; Li, G.; Xu, W. Injury-Based Surrogate Resilience Measure: Assessing the Post-Crash Traffic Resilience of the Urban Roadway Tunnels. *Sustainability* **2023**, *15*, 6615.
3. Xu, F.; Du, Z.; Chen, C. Distribution and Development Characteristics of Urban Road Tunnels in China. *Mod. Tunn. Technol.* **2022**,
4. *59*, 35–41+69.
5. Li, Y.; Jin, X.; Lv, Z.; Dong, J.; Guo, J. Deformation and Mechanical Characteristics of Tunnellining in Tunnel Intersection Between Subway Station Tunnel and Construction Tunnel. *Tunn. Undergr. Space Technol.* **2016**, *56*, 22–33.
6. Zhou, Z.; Zhou, X.; Li, L.; Liu, X.; Wang, L.; Wang, Z. The Construction Methods and Control Mechanisms for Subway Station Undercrossing an Existing Tunnel at Zero Distance. *Appl. Sci.* **2023**, *13*, 8826.
7. Zhang, P.; Ma, B.; Zeng, C.; Xie, H.; Li, X.; Wang, D. Key Techniques for the Largest Curved Pipe Jacking Roof to Date: A Case Study of Gongbei Tunnel. *Tunn. Undergr. Space Technol.* **2016**, *59*, 134–145.
8. He, Y.; Chen, Q. Construction and Application of LSTM-Based Prediction Model for Tunnel Surrounding Rock Deformation.
9. *Sustainability* **2023**, *15*, 6877.
10. Chen, C.; Zou, W.; Geng, P.; Gu, W.; Yuan, F.; He, C. Study on Seismic Damage Risk Assessment of Mountain Tunnel Based on the Extension Theory. *Sustainability* **2023**, *15*, 5294.
11. Song, G.; Wu, S. Site Monitoring Data Analysis of Tunnels with Small Clear Spacing Close Cross Soft Rock. *J. Water Resour. Archit. Eng.* **2017**, *15*, 188– 191.
12. Chen, W.; Zheng, D.; Yu, J.; Yuan, J.; Liu, H.; Tian, H. Study on Stability of Close Cross Tunnel on Existing Tunnel. *Chin. J. Rock Mech. Eng.* **2015**, *34*, 3097–3105.
13. Li, G.; He, M.; Zhang, G.; Tao, Z. Deformation Mechanism and Excavation Process of Large Span Intersection within Deep Soft Rock Roadway. *Min. Sci. Technol.* **2010**, *20*, 28
14. Nonomura, S.; Kimura, H.; Nakamura, J.; Tamura, S. Design and Construction of a Tunnel Intersection Area with Special Structure.
15. *Tunn. Undergr. Space Technol.* **2004**, *19*, 490.
16. Sharifzadeh, M.; Kolivand, F.; Ghorbani, M.; Yasrobi, S. Design of Sequential Excavation Method for Large Span Urban Tunnels in Soft Ground—Niayesh Tunnel. *Tunn. Undergr. Space Technol.* **2013**, *35*, 178–188.
17. Gong, F.; Maekawa, K. Proposal of Poro-mechanical Coupling among ASR, Corrosion and Frost Action for Damage Assessment of Structural Concrete with Water. *Eng. Struct.* **2019**, *188*, 418–429.
18. Gao, F.; Zhao, T.; Zhu, X.; Zheng, L.; Wang, W.; Zheng, X. Land Subsidence Characteristics and Numerical Analysis of the Impact on Major Infrastructure in Ningbo, China. *Sustainability* **2023**, *15*, 543.
19. Tang, L.; Zhou, Q.; Wang, S.; Yao, W.; Zhang, B.; Xiang, K.; Satyanaga, A.; Tao, J. Evaluation of the Ground Settlement in an Urban Area Resulting from a Small Curvature Tunneling Construction. *Sustainability* **2022**, *14*, 16230.
20. Shi, C.; Peng, L.; Liu, B. Influence of Shallow Tunnel Excavation on Ground Surface Buildings. *Chin. J. Rock Mech. Eng.* **2004**, *23*,