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Evaluating the impact of new overpass bridge of a roundabout Compared to Previous Roundabout: The Case of Imperial-Gerji

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ADDIS ABABA UNIVERSITY,

EIABC

Addis Ababa, Ethiopia

Date: November, 2023

Declaration

I hereby declare that the thesis entitled “*Evaluating the impact of new overpass bridge of a roundabout Compared to Previous Roundabout: The Case of Imperial-Gerji.*” has been carried out by me under the guidance and supervision of DR. Dipl- Ing. Berhanu Woldetensae. The thesis is original and has not been submitted for the award of any degree or diploma to any university or institution.

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November 2023, ADDIS ABABA, ETHIOPIA

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Certificate

This is to certify that the thesis entities “*Evaluation the Impact of New Overpass Bridge of a Roundabout: A Case Study of Imperial-Gerji Roundabout.*”, submitted to Ethiopian Institute of Architecture, Building construction and City Development (EIABC) for the award of degree in Master of urban planning. Therefore, I hereby declare that no part of this thesis has been submitted to any other university or institution for the award of any degree or diploma.

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ABSTRACT

Roundabout is a form of crossroads that provides traffic control indirectly without the use of traffic signals. When compared to stop-controlled and signal-controlled intersections, roundabouts can improve both safety and traffic flow. Congestion is the biggest issue with roundabouts, and levels fluctuate throughout time, with a visible surge during the commute to work. Because the majority of pedestrians are wounded in automotive accidents, efforts to improve their safety have focused on reducing pedestrian traffic. Poor road design and a lack of physical roundabout elements have a substantial impact on roundabout capacity and traffic congestion. The objective of this research is to address the critical aspect and effect of a new overpass bridge operational performance, level of service, and capacity analysis of the Imperial-Gerji roundabout. This study used quantitative research methodology, which makes use of numerical data. Geometric data and a traffic volume survey A field survey was conducted to assess the general geometric condition of roundabouts for this study. Traffic volume studies were also carried out to determine the number, movement, and classifications of vehicles at the chosen roundabout approaches. For this study, skilled people manually collected traffic data using a vehicle statistic. According to the findings of SIDRA intersection 9.1 software programs, the degree of congestion at the roundabout is 1.721, which is significantly beyond the recommended criteria for providing a sufficient level of service. As a result, the delay resulted in an overall fuel consumption of 1095.3L/H, a CO₂ emission of 2573.9Kg/h, a hydro carbonate emission of 0.288Kg/h, and nitrogen oxides (NOX) emission of 0.589, indicating that the congestion had an effect on the environment According to the analysis, the level of service provided by the Imperial-Gerji intersection prior to the construction of the overpass bridge was F it mean that more traffic is coming and indicating inadequate comfort and increased accident risk, whereas the level of service provided by the intersection after the construction of the overpass bridge was LOS B it mean that continuous traffic flow, and. also indicating continuous traffic flow with substantial control over operational conditions. The following recommendations have been forwarded to important stakeholders for consideration. Imperial-gerji roundabout geometric components should be updated and built in accordance with modern roundabout design rules since they are quite valuable in terms of capability and traffic safety. Proposed building an additional overpass bridge from Hayahulete to Gerji, comparable to the one built from Megenagna to Bole, to improve the capability of a crossroads during peak hours.

Keywords: Roundabout, Overpass Bridge, Capacity Analysis, Sidra intersection 9.1, Congestion

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LIST OF ACRONYMS/ABBREVIATION

AA	Addis Ababa
AACRA	Addis Ababa City Road Authority
AASHTO	American Association of State Highway and Transportation Officials' publication
CBD	Central Business District
HCM	Highway Capacity Manual
HCV	Heavy Compact Vehicle
FHWA	Federal Highway Administration
ITS	Intelligent transportation systems
LOS	Level of service.
NCHRP	National Cooperative Highway Research Program
PCU	Passenger car unit
SIDRA	Signalized and Un-signalized Intersection Design and Research Aid
UN	United Nation

CHAPTER ONE: INTRODUCTION

1.1 Introduction

The Imperial Gerji roundabout overpass bridge has been under construction since September 2021 and is scheduled to be completed in 2023. Before to the construction of the overpass, the states of this roundabout were operating at below capacity. Before the overpass bridge was built, the Imperial-Gerji intersection service level was F, which indicates that a large number of vehicles were using the roundabout and it indicates that the intersection provided inadequate assistance. There is an increase in traffic volume. A site with more traffic than it can handle, forcing traffic to flow in a manner that is inappropriate. Stop-and-go traffic, lengthy travel times, a lack of comfort and convenience, and a higher chance of an accident are characteristics of level of service Traffic congestion at Addis Ababa crossroads is now common during the morning and afternoon As a result; traffic officers must intervene to control traffic flow by bypassing traffic control systems. Roundabout capacity and traffic congestion are significantly impacted by poor road layout and subpar roundabout geometry characteristics. Some of the issues concerning roundabout capacity are as follows Roundabout There are no such things as curves or aprons in geometry. Plants high stonework causes visibility issues at some roundabouts. This requires the entering car to pause before entering the circulating traffic, reducing the Roundabout effectiveness center islands, which are accessed by pedestrians there, is no road marking signs or lighting.

To be able to address the problems, the following questions were put forth: How does the mitigation measure implemented contribute to enhanced road capacity? Which factors contribute most frequently to vehicle delays? What is the existing degree of operation (LOS) at the roundabout? How do you study intersection congestion while increasing road capacity? What steps can be implemented to reduce fuel energy use around intersections?

1.2. Statement of problems

Traffic congestion is one of the main social and economic problems in urban areas related to transportation industries, both in developed and developing countries. Prevalently, Ethiopia is one of the countries that are in rapid economic development. This influences the travel pattern of the community from their origin to any destination. Road traffic congestion and excessive delay during peak hours in the morning and afternoon at junction in Addis Ababa have increased over the year. This traffic congestion, long queues and excessive delay during peak hours in the morning and afternoon at junction have major problems in the city. However; little research was available to compare the study of operational performance between roundabout and with overpass intersection. And compare study of operational performance between before constructing flyover bridge roundabout and after overpass intersection. This problem will continue and it may more difficult in the future due to the rapid growth of population and vehicle numbers in Addis Ababa. Therefore, it is essential to evaluate

This study carried a detailed examination of the level of services and the impact of the new overpass bridge and used this knowledge to develop various management approaches to improve the situation. This thesis is primarily concerned with determining the causes for rising saturation levels, as well as analyzing delays at selected intersections using SIDRA software.

1.3. Objectives of research

1.3.1. General Objective of the research

The general objective of this study is to evaluate the impact of the new constructed overpass bridge compared to the previous roundabout at imperial gerji road.

1.3.2. Specific Objective of the research

The following listed specific objectives were achieved by this assessment:

1. To analyze traffic congestion at the selected roundabout.
2. To identify the main causes of traffic congestion at roundabout.
3. To assess the current and prior situation of level of service at the roundabout before and after constructing overpass bridge.

1.4. Research questions

To be able to find a solution to the problems, the following research questions are given forth:

1. What is the degree of traffic congestion at the specified roundabout?
2. What are the main causes of traffic congestion and Make suggestions about ways to reduce traffic congestion?
3. What is the roundabout current and prior degree of performance(LOS) before and after constructing Overpass Bridge?

1.5. Significance of study

The significance of roundabouts must be addressed when junction case studies are evaluated. Roundabouts are workable solutions for many traffic problems at different kinds of intersections. Roundabouts frequently improve connectivity, safety, and accessibility. Roundabouts slow down traffic and make drivers more alert. The junction's capacity and traffic flow are enhanced by the roundabout. They are typically less expensive and require less space, and they have less problem areas, especially for right-turning vehicles. However, the roundabouts were primarily created to accommodate moderate traffic levels. The study were evaluated the function of junction while redevelopment of the road that influences by the project. In addition, the study analyses problems and the study advances academic understanding of roundabout improves road capacity and promotes additional study of the issue.

1.6. Scope and limitation of study

The goal of the assessment is to assess the roundabout when developing the road to increase the volume of capacity and provide corrective measures. It is crucial to evaluate the junction's level of service by field observations with the purpose of assessing the functional features of the chosen intersection. Data on traffic volume, layout, as well as additional appropriate information was obtained. The data are then condensed and examined using the chosen analytical techniques. Addressing the relevant elements that have an effect on the roundabout's operational characteristics based on the research results, and then discussing appropriate corrective measures. Despite the fact that Addis Ababa has a number of roundabouts that are very significant, the research was primarily focused on the road due to time and financial restrictions. The study's emphasis is limited to specific areas; it is expected to provide a broad review of a practical traffic control system for city arterial roads. Budget and timing also limited.

1.7. Organization of the Paper

The paper is structured into five chapters: an introduction in chapter one, a review of related literature in the second chapter, the research design and methodology in the third chapter, findings and results in the fourth chapter, and chapter five deals with conclusions and recommendations in its last section.

1.8 Description of the research area

Addis Ababa is in the horn of Africa, with the coordinates 9°01'48" North, 38°44'24" East, with an elevation of 2355 m above sea level. The city has a total size of 527 km², and it is divided into 116 wereda and 11 administrative sub-cities. The city's expanding need for mobility and transport is a primary driver of Addis Ababa's population growth. This could pose significant operational issues, particularly at peak times. (Google E. , 2017)

The study was selected from the main road corridors that represent significant traffic activities in Addis Ababa in order to assess the functional features of intersections in imperial Gergii.



Figure:1-1 Location of the study area (Source: (Google E. , 2017))

CHAPTER TWO: LITERATURES REVIEW

2.1 Introduction

The study was assisted by reviewing and organizing the literature in accordance with the problem description and research objectives. Before investigating roundabout case studies, the relevance of roundabouts must be addressed. The study used several theoretical, empirical, and methodological literatures review to understand the topic area from various viewpoints, which was presented. Roundabouts are effective tools for handling a wide range of traffic issues at various sorts of crossings. Intersections typically promote transportation, accessibility, and security. Roundabout also slow traffic and make drivers more careful. Roundabouts are more than just a means of traffic control. Roundabouts have the ability to transform an area. A roundabout not only improves a route, but it may also be used as a gateway to improve the aesthetics of the area. An intersection is a device that enhances road safety, increases driver concentration, reduces idle time, and efficiently flows traffic through a place. Roundabouts are both cost-effective and safe. (Carmel, 2008)

2.2 Theoretical Literature Review

2.2.1 Level of service roundabout (LOS)

In urban planning, the word and concept of service level is one that is widely used to describe transportation planning. For many surveys, a travel planner finds it helpful. It aids in project planning, both current and future. The length of your trip is significantly influenced by the standard of the transportation provider. LOS is a crucial component in transportation planning. To ensure that all travelers may arrive at their destinations on time and with the least amount of stress and difficulty, LOS was created. A level of service is an instrument that measuring the effectiveness of transportation networks in an unbiased manner. It typically assesses how well a system provides a particular level of service. Such conditions are usually described by LOS in terms of things like autonomy, velocity and transit period of movement, traffic jams, comfort, convenience, and safety. Level of Service is a term and idea that is extensively used in town planning. There are six levels of service that are generally acknowledged, ranging from A to F. For many surveys, a travel planner finds it helpful. A word and idea widely used in urban planning is "a representing the ideal operational state," which is defined as "free flow" and "Level of Service." For many surveys, a travel planner finds it helpful. F the worst, also known as forced or broken flow. Urban road variables include traffic density, speed limits, and intersection frequency all having a substantial influence for the LOS. (Planningtank, 2013)

LOS	Signalized intersection	Un Signalized intersection
A	≤ 10 Sec	≤ 10 sec
B	10-20 Sec	10-25 Sec
C	20-35 Sec	15-25 Sec
D	35-55 Sec	25-35 Sec
E	55-80 Sec	35-50 Sec
F	>80Sec	>50 Sec

Table 2.1: Level of Service Criteria. Source: (Planningtank, 2013)

2.2.2 Types of service roundabout

Level of Service A: Free-flowing traffic with almost no effect on individual users from the activity of other users. Level of Service B: Continuous traffic flow with substantial control over operational conditions, including speed, but with significant input from other users. Level of Service C: Limited flow that is constant but has a lot of interactions with other traffic. The total amount of convenience and comfort significantly decreases with this grade. Level of Service D: Greater flow in which flow is constant but speed and freedom of mobility are severely limited, as well as safe and reliability have reduced. Level of Service E: Inadequate standards for relief and simplicity, as well as an unsteady stream at or around capability. And; Level of Service F: Accelerated network traffic in which more traffic is coming toward a place than can be managed. Stop-and-go waves define LOS Insufficient trip times, inadequate comfort, and greater accident exposure. (Novikov, The Analysis of Traffic Flow Forced traffic flow., 2017)

A roundabout degree of performance is evaluated by estimating or measuring the control delay of each movement on a side road. The degree of service at signalized and un signalized roundabouts changes because of different conditions and driver perception. Depending on the control delay, the Degree of performance Roundabouts are more commonly employed in metropolitan settings, usually where two roads of different ranges intersect and the volume is insufficient for a signalized intersection. Pedestrians and bikes, in addition cars from public city transportation, must be considered. The intersection's pedestrian and cycling issues must be addressed (Ivana Nedevska a, Methodology for Analysing Capacity and Level of Service for Roundabouts with one Lane, 2017).

The maximum hourly rate at which persons or vehicles can fairly be expected to travel a point or uniform segment of a lane or roadway during a certain time period under current road, traffic, and

control conditions. While capacity is a quantitative, quantifiable indicator, level of service (LOS) is a qualitative term that characterizes operating circumstances in a vehicle flow and their perception by motorists and passengers. The HCM (Highway Capacity Manual) sets particular metrics of effectiveness for each highway facility type to assess level of service. Control delay is a measure of efficacy used to define the level of service perceived by consumers at intersections. All crossroads cause some delay in addition to control delay. To estimate the efficiency for a given roundabout design, three performance indicators are commonly used: saturation level, waiting, and vehicle volume. Each statistic provides a distinct viewpoint on the level of service that a roundabout were delivering under a specific combination of traffic and geometry conditions. The analyst should estimate as many of these parameters as practicable whenever possible. Acquire the most comprehensive evaluation of the efficiency of a specific roundabout design before calculating a specific performance metric for a roundabout entry, a capacity estimate must be obtained in all circumstances (Kimber R. , 2002)

2.2.3 Classifications of Roundabout

Modern intersections are at-grade near-circular intersections. They are an effective intersection type because they have fewer conflict locations and lower speeds, and they make decision making easier than other intersection kinds. They also require less upkeep than traffic lights. Roundabouts that are well-designed have been shown to minimize crashes (particularly fatal and serious injury incidents), traffic delays, fuel consumption, and air pollution. They also help to reduce traffic congestion by reducing vehicle speeds through geometric design rather than relying exclusively on traffic control systems. The creation of intersections is an iterative process. A junction with good design strikes a balance between efficiency and safety a smooth curve, channelization, and deflection are produced by good design in order to provide constant speeds, clearly indicated lane lines, and enough sight distances. (WSDOT, 2019)



Figure 2.1 multi-lane roundabouts. Source: (FHWA, 2010)



Figure 2.2 a single-lane roundabout. Source: (FHWA, 2010)

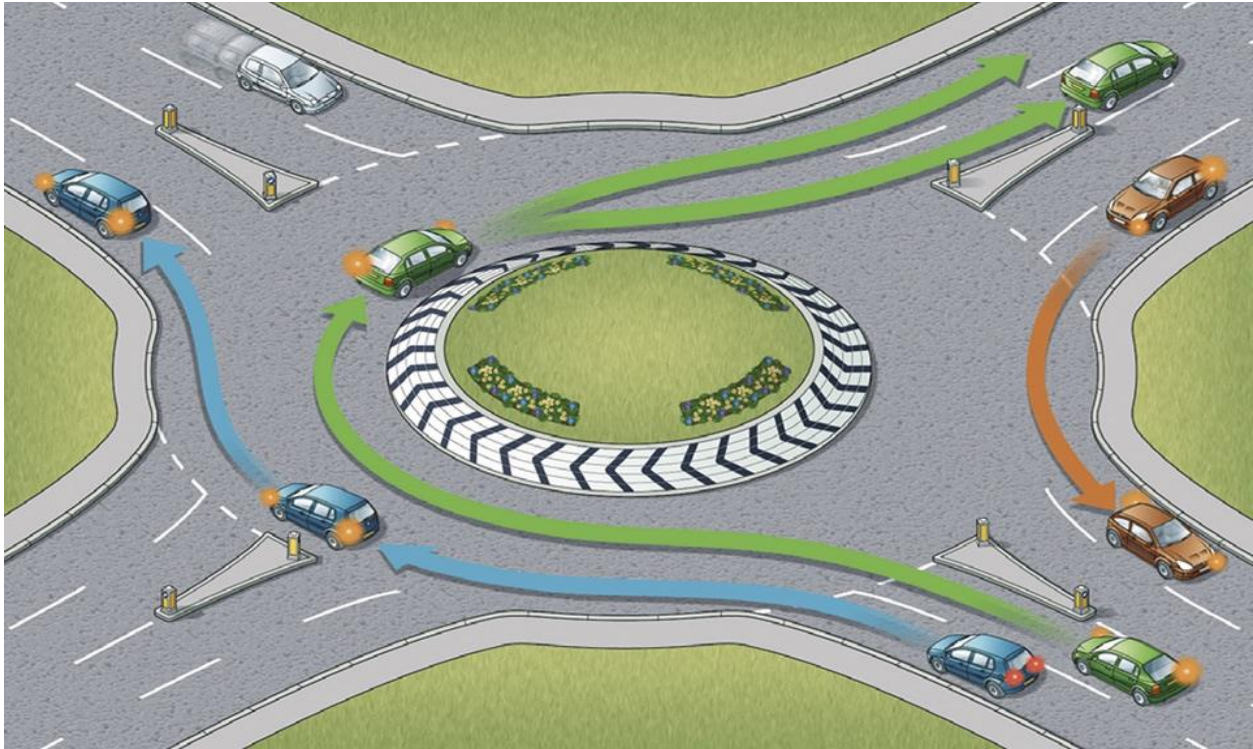
There are five common types of roundabouts: small, narrow, single-lane, multilane, and funnel. Mini-roundabouts are tiny, one-lane roundabouts that are typically utilized in urban and suburban areas when the speed limit is 40 km/h or less. Mini-roundabouts are therefore often not appropriate for usage on higher-volume roads. Compact roundabouts combine features of both single-lane and mini-roundabouts. A compact roundabout is similar to a mini-roundabout in that it may only need a small

amount of additional pavement, have a totally mountable center island, and frequently be built on top of an existing curb or sidewalk. Single-lane roundabouts have one circulating lane and single-lane entry at each leg. They often have a landscaped central island, mountable raised splitter islands, and a mountable truck apron. Multilane roundabouts have several revolving lanes and a minimum of one access or departure with two or more lanes. It is standard procedure for vehicles to straddle adjacent lanes when navigating roundabouts. Teardrops are commonly associated with interchange ramp terminals, most notably during ring connections. Intersections that curve. support the design principle. Teardrop intersections, unlike circular roundabouts, do not permit uninterrupted 360° movement, leading to fewer vehicle conflicts since traffic travelling on the crossroad across the intersections of slope terminals does not meet a yield when it reaches the teardrop intersections (WSDOT, 2019)

Road traffic travels around a center roundabout in a clockwise direction at roundabouts in the UK, with those who are already on the roundabout and those who are approaching it on the right often receiving priority. They are made to maintain safe traffic flow without the use of traffic lights. We break out every type of roundabout you may see in this post, along with tips on how to navigate them safely (Google, 2022).

Intersections are junctions that are round in shape. Intended to keep traffic going, if possible, without necessarily requiring any stops, with all vehicles moving clockwise from right to left. No matter the size, managing Using intersections while learning to drive very simple. They come in a variety of sizes, and some even feature traffic lights. In essence, you must keep in mind that you must yield to all vehicles entering the roundabout from your immediate right (Success, 2022).

Try to be aware of and follow all available information when you get close to an intersection, including lane markings, traffic lights, and signs directing you to the proper lane. You ought to using mirrors, signals, and Move about at all times Decide which exit you need to take as soon as possible. Send the proper signal. Get into the proper lane, synchronize your signals to avoid confusing other drivers, and modify your speed and position to meet the flow of traffic. Observe the speed and positioning of all the other drivers on the road. When you arrive at the roundabout, you should unless otherwise indicated by signs, road markings, or traffic lights, give way to traffic coming in from the right. Verify that you can enter the roundabout without giving way by looking at the road markers. If so, go ahead, but check to your right before you join. Be mindful of all other drivers who are currently in intersection; they might not be signaling properly or at all. Before you move off, be sure the vehicle ahead of you has departed (HighwayCode, 2022).



2.3 Figure geometric elements of roundabout (HighwayCode, 2022)

Depending on the size and number of lanes used, roundabouts are classified into three fundamental categories. Mini-roundabouts, single-lane roundabouts, and multilane roundabouts are the three types of roundabouts. Mini-roundabouts are only one-lane roundabouts with a central island that is fully accessible. They are most frequently employed in low-speed urban settings with typical operating speeds of no more than 30 mph. demonstrates a typical mini-roundabout with its key features. Mini-roundabouts may be helpful in certain situations where right-of-way restrictions prevent the design of a traditional roundabout. Mini-roundabouts are extremely affordable for retrofit applications since they normally ask for just slight enlargement slopes at angles and minimal additional paving at the crossing roads. They are typically advised when there is not enough right-of-way for a conventional single-lane roundabout to fit the design vehicle. Mini-roundabouts are thought of as pedestrian-friendly because of their diminutive size, short crossing distances, and extremely minimal auto velocity when entering and leaving (NCHRP, 2010).

One circulation channel and a single-lane entry for each leg. Roundabout with only one lane. Their wider inscribed circle diameters and non-traversable center set them apart from mini-roundabouts. Islands. The entrance, the circulation lane, and the exit all permit significantly faster speeds because to their design. The geometric layout often features high splitter islands, a truck apron, crosswalks, and a central island that cannot be traversed. The right-of-way that is available and the design vehicle selected both have a significant impact on the roundabout's size. Roundabouts with multiple

lanes feature at least one entry with multiple lanes. On one or more approaches, the roundabout may occasionally have a varied number of lanes. Roundabouts with entry on one or more approaches that flare from one to two or more lanes are also included in this category. In order to handle more than one vehicle going side by side, these call for bigger circulatory highways. Several-lane roundabout when compared to single-lane roundabouts, the speeds at the approach, on the circulation roadway, and at the exit are comparable or possibly a little faster. Raised splitter islands, a truck apron, a non-traversable middle island, and the proper entry path deflection are all part of the geometric design (FHWA, 2010).

2.2.4 Performances of Roundabout for users

Reliable roundabouts must be simple to locate in the traffic system, have a layout that is clear to approaching cars, and promote slow traffic entering the intersection. To enable drivers to see clearly, there should be enough space between them. Pay attention to how other vehicles, bikes, and pedestrians are moving (AACRA, 2016).

Intersection Roundabout usage has been demonstrated increase safety. a method for enhancing intersection safety by reducing conflict types, reducing the severity of crashes, and encouraging cars to slow down as they approach and pass through intersections. This is valid when twoway stop and signal systems are replaced in countryside, suburban, and city settings. Although collision frequencies have decreased generally, there has been a notable difference between pedestrians and motorcyclists and between bicyclists and motorcyclists based on the study and bicycle treatments. Roundabouts are a good choice for traffic calming since they reduce conflict sites, slow down traffic, and make decisionmaking simpler. Consequently, the effect of reducing vehicle (Collins, 2008)

Lack of concentration, poor awareness, and possibly even dozing off while driving. An appropriate behavioral state is defined as follows to prevent any misunderstanding or ambiguity: A condition is a state of being (such as an emotional state, mood, or the motorist is in) that has a strong influence on how they drive, such as a state of weariness or intoxication. In this situation, a driver displays behaviors that are consistent with being overworked. Drivers see the world through a variety of sensory organs, which being considered as channels for information. The process of perception involves the extraction and analysis of unprocessed sensory data in order to produce meaningful information It can be put to use additional mental processing (Absil, 2008).

Driving efficiency is evaluated in connection to how drivers behave in response to various road events, such as varied curve radii, roundabouts, or variations in the altitude of the road. Finally, utilizing a grading system based on pertinent driving metrics, drivers are graded with regard to

driving-efficiency. As might be predicted, the capacity to control speed variations was crucial for driving effectiveness, but differences in the angle of the brake and throttle pedals were also found to be significant. This work can be used as a foundation for the purpose of comparable techniques to bigger data sets, ideally employing driving data that was obtained naturally. As a consequence of this, crucial to determine a driver's preferred speed in various road and traffic conditions in order to better understand their behavior (C. Friis, 2013).

To complement the better design of crossing treatments for contemporary roundabouts, pedestrian education is necessary. The capacity of road authorities to apply more advanced engineering requirements for pedestrian crossing treatments has been demonstrated, although improving the impact of pedestrian assertiveness in improving pedestrian accessibility to roundabout crossroads should also be assessed. Due to the defined curved vehicle trajectories and the lack of a pedestrian signal at the majority of crossings, crossing at current roundabouts is difficult. Being able to react dedicated to passenger assurance therefore a crucial part of efforts to reduce road traffic casualties. The majority of pedestrians do not consider avoiding accidents when crossing roundabouts because they think drivers are aware (Mark Lenters, 2010).

2.3 Delays at roundabouts

Each entry approach's intersection lag is specified individually. Congestion and geometric delay make up the two distinct parts of the lag time for an entrance strategy. When drivers wait for an appropriate space in the moving traffic, idling delays happen. Vehicles slowing down when entering the roundabout cause a geometric delay. The highway capacity manual (HCM2000) defines control delay as the quantity of time a driver spends accelerating into a line, decelerating to the front of the line, waiting for a suitable void in the rotating stream, and then accelerating out of the line. Theoretical, empirical, or computer simulation methods were used by researchers to create delay models with different forms for at-grade junctions. Theoretical methods rely on academic concepts of driver and vehicle behavior. Performance at the junction. Even though this method may allow the researcher to extend findings to a number of situations, its theoretical presumptions restrict its applicability to depict actual traffic conditions. The simulation approach is comparable to the theoretical approach in that it relies on some theoretical presumptions on how drivers interact with other road users. The simulation approach, however, gives more freedom to integrate specific driver-traffic behavior and enhance the realism of the models (Engineering, 2012).

According to the HCM model for delay at an signalized intersection, the analytical model of average control delay for a specific lane depends on the lane's capacity and degree of saturation. The total amount of time delayed when driving past a crosswalk with respect to approach and departure cruise speeds including all acceleration and deceleration delays, delay due to cruise at a lower speed) is known as control delay. Speed and delayed stopping. When none exists other cars, a vehicle navigating an intersection was facing a geometric delay. Little law for queue length was used to construct an analytical model for halted time delay estimation at single lane roundabouts. Their model needs a value for the headway distribution of the rushing flow, the arrival rate at the roundabout approach, and the average accepted gap for individuals. Using information obtained from video films and the 0.01 second accurate Incident the average delay time was modified to assess the overall approach travel time. A known location upstream of any waiting to the yield served as the explanation for a travel zone. Bar. Each vehicle that completed the travel zone trip had its approach travel time measured. By definition, the roundabout's geometric delay increased the approach delay. Vehicles are measured for the geometric delay during off-peak hours. When a car crosses an intersection unaffected by other vehicles. After that, the average delay was estimated by deducting the free flow time from the recorded journey time (Engineering, 2012).

2.3.1 Delay measures

Any kind of delay elongates travel times and slows down mobility. As a result, time-related measures and measures of delay are closely related. Specific problem areas or locations, whether they are recurring or not, can be identified by using Lag as an efficiency indicator. Nonrecurring. Recent research on nonrecurring congestion has shown the significance of incident-related delays and the advantages that can result from their decline. Lag time is regarded as a good indicator of congestion intensity on a roadway link or in the system as a whole. Delay is the difference between desired or free flow and actual travel time. Even so, this measure does not provide a lot of information regarding the accurate factors that main reason overcrowding. A small mile of lag corresponds to the product of the duration of a highway section and the distinction among the actual travel ratio, which is equal to 60 minutes split by the section's speed, and the adequate travel rate (Schrank.F, 2014).

2.4 Evaluation tools for roundabout analysis

The evaluation of the tools took place on different levels. First, the tools were evaluated qualitatively in terms of their application, incorporation of roundabout geometrics and driving behavior, ease of use and input requirements, outputs, and capabilities. Other difficulties. The second stage involves actually applying the technologies using case studies intersections quantify

how well they could reproduce real-life settings. Based on these assessments, several tools were tentatively chosen for usage in Ontario and were further reviewed for compatibility and capacity to be merged into an evaluation strategy (Gagnon, 2008)

The applicability of various roundabout operational analysis techniques has been considered ongoing discussion; nonetheless, only a few researches exist. That compare the tools in depth, and even fewer that compare forecasts to observed North American data. of the research majority have concentrated on the macro-analytical models, particularly RODEL (from the United Kingdom) and SIDRA, that have included comparisons to field data. (From Australia). Examples include Akçelik et al. who use a single case study roundabout to compare the Australian gap-acceptance model to the RODEL/ARCADY linear regression models (Akçelik, 1997).

Gagon et al, (2008) just completed a study that compared aaSIDRA, RODEL, PARAMICS, SYNCHRO/SimTraffic, and VISSIM It was applied to two investigation intersections in New Hampshire, and the writers of this work having an identical concern in mind. The two places were newly renovated. renovated constructed, single-lane roundabouts with standard geometry. Field delays were compared to the estimations utilizing basic characteristics of the five designs calibrated parameter values in the study. When measurement, aaSIDRA and VISSIM were shown to be the best at replicating the observed delays, while un calibrated results varied significantly. The authors also noted that calibration could be particular to the location and lacking universal set of values accessible (Akçelik, 1997)

The three discussed micro-simulation techniques are all separate tests that process each automobile over a network of roads utilizing different separate models such as car-following and gap-acceptance. The intricacies of their sub-models vary between the tools. How they are used, as well as how the user communicates with the program. The user can configure the specific geometry of the roundabout as well as a variety of hometown and international automobile and rider behavior factors with each of the three instruments. AIMSUN and PARAMICS both compute significant gaps using input geometry and driver behavior, with some behavioral factors defined as a distribution that matches the real-world allocation of gaps that were allowed or rejected. The gap size in VISSIM properly into the design, necessitating being able to (Akçelik, 1997)

2.5 Road Traffic

Road traffic refers to the movement of vehicles and pedestrians through, on, and along any stretch of a network of roads that have been designated as public. The circulation of cars or pedestrians through a place or along a road. The flow of vehicles, pedestrians, ships, or planes along a path. The

information or signals transmitted across a communications system the people or goods transported by a transportation system

2.5.1 Evaluation of congestion in roundabout

Congestion is a transportation condition characterized by slower velocity, longer travels times, and increased vehicular queuing. When traffic demand is high enough that an intersection between vehicles slows the flow of traffic, this causes some overcrowding. A traffic jam occurs when all vehicles are completely stopped for extended periods of time. In other words, traffic congestion occurs when a greater number of vehicles attempt to utilize more than a particular road infrastructure can manage without surpassing permissible limits of wait time or difficulties.

The sequence in which techniques based on geometry and regression to evaluate capacity/delay equations are utilized in roundabout operation. The performance of inflowing and circulating cars within the roundabout is evaluated using the Tanner model using the critical headway (gap-acceptance theory). Finding headway (a safe gap) requires crossing the roundabout's threshold, which prevents oncoming traffic from driving the intersection. The critical and follow-up headway, a crucial measure for assessing the performance of junctions operations, is used to determine approach capacity. This approach is sensitive to the roundabout's spatial characteristics which include the inscribed circle's diameter and entry angle. Driver performance can be influenced by traffic flow, which is a crucial roundabout parameter (GmbH, 2008).

The causes of traffic congestion differ depending the degree of the problem, traffic, and driving behaviors, which vary from country to country. The primary factors include population, population density in metropolitan areas, and diversity in motorized vehicles, a weak public transportation system, and private/government owned vehicles, road intersections, and passenger attitudes that raise demand for roadways. The amount of slum dwellers, job opportunities in the region, few parking places, poor urban planning, people's economic status, signal failure, and other factors all contribute to increased traffic congestion. Vehicle accidents, breakdowns, work zones, poor climatic circumstances, and a faulty traffic signal system all contribute to traffic congestion while negotiating a roundabout. Heavy cars Moreover, its amount of stops required by buses are daily routine actions that produce traffic congestion. Low travel speeds (20 to 30kmph) to traffic before approaching a roundabout are the causes of roundabout congestion. Roundabouts encourage continuous traffic flow in a circle. Drivers do not slow down in the roundabout if presently is not traffic, but they do not speed up when there is traffic. The routes utilized in one-way driving and intersection gates are slightly bent to allow nonstop drivers to enter a crossroads and assist individuals proceed counterclockwise in the circle, resulting in head-on collisions (GmbH, 2008).

2.5.2 Types of Traffic Congestion

Traffic jams is probably going to vary. Due to the inherent scarcity of the necessary adequate amounts of data, non-recurring congestion costs may be more challenging to measure. It could be argued that the costs are higher because drivers were unable to plan their routes in order to give credit for possibility of overcrowding, or that the costs did not apply. Some routes are becoming more and more prone to irregular congestion, such as accident black spots. In such circumstances, drivers may gain knowledge (Mussone, 2015)

Recurrent congestion is primarily caused by an excessive the amount of cars attempting to utilize the route at once. During the morning and afternoon rush hours on weekdays, when most people leave for work and return home around the same time, there is frequently congestion.

The other primary cause of traffic congestion is non-recurrent congestion. Non-recurring congestion is linked to sporadic circumstances or particular, one-time occurrences like traffic incidents, truck spills, accidents, work zones, or unusual or disruptive individual maneuvers. Drivers, erratic facility maintenance procedures, bad weather, and special occasions. Nonrecurring congestion is more challenging to predict and manage due to its sporadic nature (Mussone, 2015).

2.5.3 Traffic Congestion Factors

Different factors contribute to traffic congestion. The following factors contribute to traffic congestion: the movement of people and a large amount of freight at the identical period, slow growth in infrastructure supply, and trips that are delayed due to unforeseen events. However, frequent collisions, vehicle breakdowns, improperly timed traffic signals, special events, and weather are all factors that contribute to traffic congestion (Schrank.F, 2014)

Furthermore, a study conducted by (Abdel-Aal, 2012) summarizes the main causes of traffic jams as shown below Roads are not very wide, but because of illegal dumping, they are becoming narrower and contributing to traffic congestion. Therefore, there is always a chance to enlarge the route in accordance with their right-of-way to ease traffic congestion. Additionally, this process won't involve the need for land acquisition; it was less expensive and takes less time.

Illegal Parking: - Each day, unauthorized car park on the road causes congestion. Some of the major causes of severe traffic congestion on various parts of the routes is vehicle on-road parking.

Population growth:- Every one of the places that are part of towns are facing population increase, which is negative for traffic management and may be a major factor in traffic (Abdel-Aal, 2012).

Larger community buying power: - Due to this the greater purchasing power of city dwellers, private transportation is becoming more and more common, but the established roads and highways

are not accepting or shifting to accommodate the growing number of vehicles. As a result, there is alarmingly increased traffic (Abdel-Aal, 2012).

Poor urban planning: - the growth plan includes long-term planning for town planning. That strategic plan, however, is inappropriate. Most of the time, it is seen that few roadside land has been forgotten illegally; however, due to the hazy development plan, these kinds of movements are wasting time (Abdel-Aal, 2012).

Ineffective lane management is a critical factor in traffic control. Even in a single, undivided road, a variety of vehicles attempt to pass other vehicles. This is the main reason why city roads lack lane dividers that separate lanes. The passageway into the opposing lanes of traffic (Abdel-Aal, 2012).

2.5.4 Traffic congestion's effects

Congestion causes waiting, slower speeds, and longer travel times, all of which cost the economy and have a variety of effects on urban areas and their dwellers. Overcrowding has a variety of indirect effects; including marginal environmental Congestion influences resources, quality of life, stress, and safety, as well as non-vehicular road space users such as sidewalk users and road frontage properties. The effects of traffic congestion can be categorized into three categories: impact on the economy, health, and the environment Traffic jams has a significant economic impact because society loses money in four main ways, as illustrated below (Abdel-Aal, 2012).

Losing labor hours;

Cost of additional transportation;

Additional fuel consumption;

Transportation operating expenses; and

Various charges

The impact of traffic congestion on the environment It's obvious in two ways: sound pollution and air pollution cause environmental pollution in two ways. The following are the consequences of sound emissions: students in the nearby school have their studies disrupted by noise, and the nearby society causes headaches, difficulties concentrating and sleeping, bad tempers, and hearing problems. As a result, as traffic becomes more congested and vehicles stop for longer periods of time with their engines running, they emit a large amount of greenhouse gases, which are lighter than air but extremely dangerous to our health and can even cause death (Abdel-Aal, 2012).

Congestion has various societal consequences. Congestion causes queuing, slower speeds, and longer travels times, all of which cost the economy and have a variety of effects on urban areas and their inhabitants. Congestion also has a number of unintended consequences. Such as the minimal

resources and environmental impacts of congestion, the effects on quality of life, stress, and safety, and moreover the effects on non-vehicular road space users such as sidewalk users and road frontage properties. Overcrowding prevents us from moving freely, disrupts business activities in cities, and lowers productivity. It has an impact on a wide range of activities, services, goods, and market opportunities in cities that are best served by transportation mobility. The document Traffic jams, as an outcome of problematic city trips circumstances, reduces productivity by increasing Producers and merchants keep warehouses. The timely delivery of logistics is critical to business operations. However, traffic congestion impedes freight movement in cities, reducing productivity (Lomax, 1997)

Road congestion is affected by the views of the road users and gives two definitions for "Congestion" and "Unacceptable Congestion. "As a result, "congestion" was defined as a travel time or delay that exceeds what is reasonable usually accumulated under light or free-flow travel conditions and "unacceptable congestion" as driving time or lag more than an agreed-upon standard. In transportation planning, flow serves as a significant variable that indicates the situation of the traffics movement. In terms of vehicular stream, overcrowding is typically regarded as the state where the speed-flow graph is reverted or sloped positively. Like a result, congestion may be defined as a stage in the existing traffic pattern that represents a condition in which demand exceeds capacity or speed falls below acceptable levels (Lomax, 1997).

Different factors contribute to traffic congestion. The following are the principal reasons of urban gridlock:-Only 70% of people are aware of the serious violations of traffic laws. Because of this lack of knowledge and people's unwilling to follow the rules, there is traffic congestion the lack of city street planning; Dhaka City's roads are not pre-planned. The government continues to build roads because the city needs them. That is why there is no pre-planned strategy. In addition, we are experiencing traffic congestion as a consequence of an unplanned event (Kefyalew, 2017).

Lack of a Mass Transport Network: For a developing country like ours, we require a large scale transport network to spread traffic equitably. The traffic stream were under a lot of pressure in the event that of a mass traffic system, and engender a traffic jam (Traffic jams is a local issue, not a generic one; the reasons vary from case to case, and they are directly related to the road under consideration. Because the causes differ from place to place, even within the same city or country, not all of the Reasons and solutions are generic (Kefyalew, 2017)

2.5.5 Alleviation of traffic congestion

Major traffic congestion mitigation strategies are expanding roadway capacity, expanding transit services, increasing residential densities, use of toll ways and use on ramp metering, provision of adequate facilities for pedestrians and cycles, Prohibiting on-street parking of vehicles, and simultaneously developing off-street parking facilities Effectiveness and advancements have been a concern when it comes to urban traffic congestion. The proposed solution focused on ways to increase the effectiveness of the city's traffic system. One remedy, for instance, is to increase the number of urban roads networks, enhanced traffic control, and improved public mass transit (Abdel-Aal, 2012)

Among the primary concerns of urban decision-makers is congestion. A brief survey of policy declarations from major cities demonstrates the significance of traffic congestion to the general public, elected leaders, and road and transportation agencies. different cities. But there isn't much. There is agreement among the member nations on the kinds of policies that are most effective at reducing urban congestion. There is possibly even less agreement on what congestion exactly is, whether it is a "solvable" issue, and, in some places and situations, whether it even is an issue at all. What guidance can be given to policy-makers looking to ensure the best outcomes for transportation policies as a result of such a wide gap in opinions regarding approaches and policies for dealing with congestion (Kosolapov, 2007)

The following are major contributors to traffic congestion:

Lane-blocking traffic incidents

Challenging weather conditions

Sudden increases in traffic demand

Slowdowns in traffic

Faulty traffic control devices

Various factors can occur simultaneously in many instances. One cause of traffic congestion can lead to another, such as when inclement weather causes an increase in traffic as drivers rush home. Traffic causes more than just commuting delays. Congestion can exacerbate problems for delivery drivers and the supply chain, slowing the replenishment of food and other necessities in communities with few local sources. Congestion can also have an impact on the public's perception of a community. Intolerance to frequent driving may deter new companies and prospective households relocating to the area. One of the simplest ways to reduce travel jam is to eliminate the problem caused by overly numerous individuals attempting to go rapidly the same time any

particular route. When a civil engineer's design provides alternate roads to the similar location, the amount of cars in congested regions can be reduced. This decreases the frequency of automobiles merging into traffic and enables all roadways to share it. must wait in it. Another option is to minimize the amount of passenger automobile lanes accessible. and increase the amount of accessible lanes public transportation. A civil engineer's by trading some free highway lanes for vehicle lanes, shared lanes as well as walkways, planners can minimize the total amount of cars on the path. Designers of cities and construction realized the value of putting in place the facilities required to guarantee the safety and effectiveness other means of transit so as enhance the utilization for these methods. Increasingly, cities are spending money on amenities like Bicycle lanes, driving lanes, transit-only lanes; transport tunnels, rail or trolley lines, and other facilities are available. The complete typical car lanes are being eliminated increases the level of effectiveness anticipated via authorized other means of transit facility, according to a Streets blog article. It is more effective to create completely separate streets or exclusive areas to reduce traffic than to simply paint paths or notifications stated of the pavement (Kosolapov, 2007).

2.5.6 Premature congestion

The initial event is the beginning of traffic congestion at significantly lower rates of owning a car since could be expected. Metropolises in emerging economies are legendary for their congestion. In Bangkok's downtown, non - peak traffic is said to move at a speed of no more than 10 km/h.15 km/h or less is the speed limit in Kuala Lumpur and Sao Paulo, Manila, Mexico, and Shanghai. Unusually, though, this doesn't happen because, compared to industrialized nations, developing nations have comparatively high rates of mobility. In fact, fewer than 100 cars are owned by every 1000 people in the majority of developing countries, compared to 400 or more in the wealthier industrialized nations, and the developing world is actually following a pattern very similar to that in terms of the Earnings and automobile owning are related. Here are a few instances. for this occurrence. Multiple towns have experienced rapid population growth, regularly as a consequence of unchecked immigration, that also causes cities to expand faster than infrastructure can keep up. Vehicle usage and ownership are also in developing nations, ownership growth rates of 15-20% annually are not unusual, outpacing population growth (Gwilliam, 2003)

2.6 Over pass Bridge

An overpass (also known as an over bridge) is a bridge, road, railway or other similar construction that spans another A route or railroad. The grade separation is formed by a flyover and an underpass working together. Stack interchanges are composed of multiple overpasses. An intersection between two roadways, or between a highway and a pedestrian route or railway at

different levels, when clearance for vehicles at the ground step is gained by elevating the higher level. In addition, the upper level of such a crossing. As a result, a bridge can be as simple as a plank used to cross a stream or as complex as a vast structural span built to carry traffic across a wide river. The foundation, substructure, and superstructure are the three primary components of a bridge. Each of these fundamental sections contains additional components.

The plan design is made at the onset to its formation about an urban overpass; its significance is clear to all. It can fulfill the goal of achieving traffic smoothness, clearly identify the position and direction of flyover construction, and assurance of safety, preservation of urban land, reduction of building and operation costs, improved integration of the urban environment, convenience in urban planning, and enhancement of the urban aesthetic. Urban flyover plans are designed using traffic engineering the basic theory is science; study is conducted based on macro traffic planning, road property and position, surrounding environment, and traffic network. The attributes of the flyover node are confirmed; following that, mainstream traffic tunnels are collocated according to the flow of surrounding traffic to ensure the plan's specified purpose (Zhou, 2012).

2.6.1 The Function of an Overpass

An overpass plays a clear role in the traffic on the roads. An overpass is a visible characteristic of road traffic. An overpass performs a number of functions (Wang, 2011)

It takes over signal control at level junctions.

It essentially avoids flat junction problem points.

It can ensure constant traffic movement.

It improves the ability for city roads to operate.

It saves time, gasoline, and has some financial advantages.

2.6.2 Form of urban overpass

The city overpass can take the following shapes, depending on the number of urban crossings: three-way intersections and four-way intersections. (1) There are four different types of three-way intersections: horn, half cloverleaf, T, and double Y. (2) There are other types of four-way intersections, including full and partial cloverleaves, row types, semi-directional types, and directional types. Furthermore, there are crossings that have more than four complicated intersections. They speak of the aggregate of the previously mentioned situations (Wang, 2011)



Figure 2.4 Over pass bridge. Source: Google



Figure 2.5 over Pass Bridge. Source: Google

2.6.3 Design difficulties and analysis

The selection of an overpass type is problematic due to the tiny land size and constrained utilization space. For the flyover, there are three different types of collocation Approaches which may be employed ring type, directional type, and composite type. These are the featured ones (Wang, 2011)

Ring overpass

A top means of dealing with the interconnection of several roadways is a ring overpass. In some historical road networks, the horizontal ring overpass is upgraded to a flyover. It is widely observed in several Chinese cities. However, as a road with a limited radius cannot guarantee traffic volume, force is used to increase the radius. The rapid road or main road is positioned alongside the connecting road of a large-scale flyover. Consequently, it is inappropriate for the massive flyover (Wang, 2011)

Total directional overpass

The overpass benefits from features including a short route, rapidity, smooth traffic, and a compact land area. Complex structural layers, various bridge span structures, and high cost are among the flaws. In general, it is appropriate for overpasses linking to rapid main roads with five lanes or fewer.

Composite overpass

Three-way and four-way overpasses are created using standard type selection; a composite overpass consists of a number of overpasses. They are often appropriate for six-way and higher six-way overpasses. The ramp with distinct stratification and high traffic volume makes use of directional or semi-directional type; otherwise, non-directional type is collocated. Flexible structure, concentrated and spread collocation are among its strong points. Distributed collocation, a big land area, and a lengthy diversion are among the flaws (Wang, 2011).

2.7 Intersection geometry and design

An intersection has two traffic flow directions: clockwise for left-side driving and anticlockwise for right-side driving. As a result, cars are required to drive along the identical way, reducing the number of conflict locations. The geometric elements of a roundabout, such as the number of lanes circulating lanes, the lanes width, horizontal and vertical alignments, design speed, and availability of queue space at the approaches, all have a clear effect on a roundabout's capacity. An intersection capability of affected by the number of conflict points (Wong, 2012). The route ability to carry is also impacted by base factors like the weather and pavement quality. Another aspect is traffic conditions, which includes the various vehicle types in the traffic stream, such as cars, micro and mini buses, trucks, etc., in addition to that distribution of traffic on the highway by lanes and directions. A Junction volume measures influenced by control parameters such as signal phasing, traffic lights, the duration of cycle times (Mounir, 2018)

Finding the ideal balance between a number of parameters, operational effectiveness, and safety provisions is the process of designing a roundabout. There are various geometric patterns for roundabouts; they can have one or more circulating lanes. The operating performance as far as the of only one lane junction capability and lag and a double lane roundabout are theoretically similar. There are clear rules for driving around roundabouts; yet, failing to adhere to them might compromise safety due to lane changes made by drivers, their behavior in multilane roundabouts, or their failure to observe the give way rule when approaching the A rectangular intersection crossroads that is intended to improve efficient and safe traffic flow and to lessen delays and crossing conflicts. Crossing conflicts, such as right-angle and head-on, occur in signalized or give

way road intersections. is one of the primary causes of deadly road collisions. People have more freedom to operate vehicles as they wish and according to their own rules when conflict points rapidly increase. This disease makes drivers more aggressive, which causes collisions (NCHRP, 2010).

2.8 Major Geometric Elements of a Modern Roundabout

The parameters and principles for the design of each geometric component of an intersection are presented in this section. However, the designer needs to keep in mind that these parts are interdependent. The geometry's interaction between its parts is significantly more significant than its constituent parts alone. To be able to accomplish all overall safety and capacity goals, care must be given to ensure certain of the geometric components are compatible with one another (Kingdom, 2007)

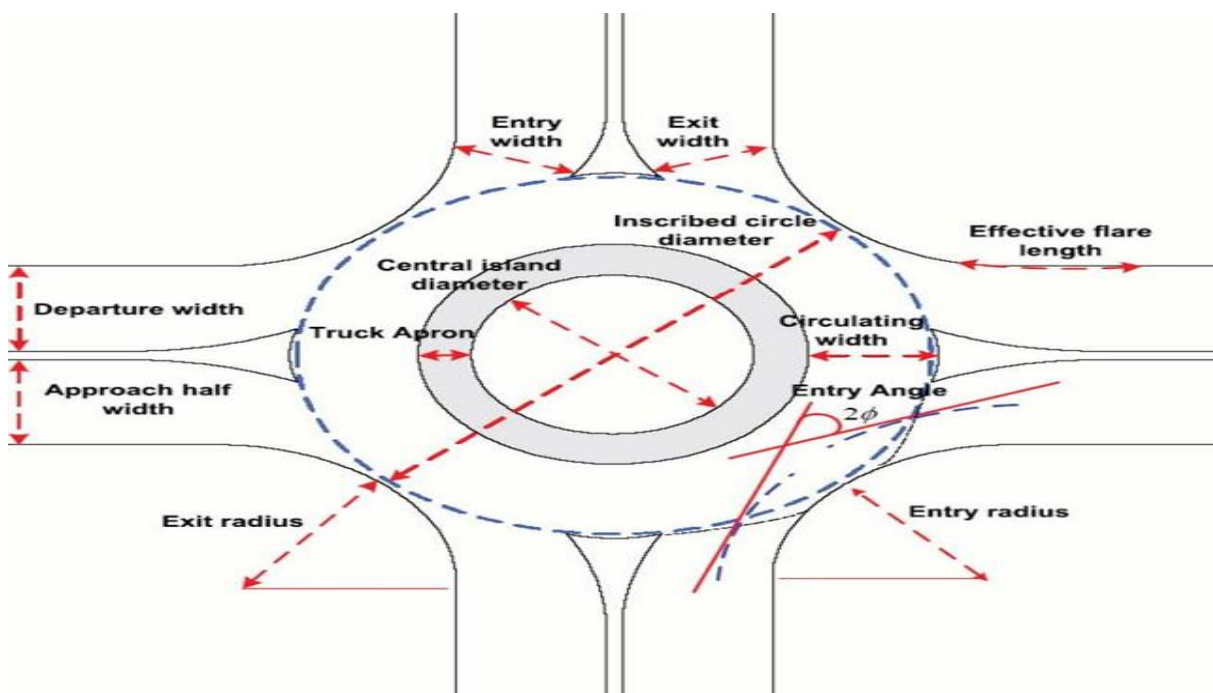


Figure 2-6 Major Geometric Features of Modern Roundabout. Source: Department of Transport UK

Inscribed circle diameter

The central island diameter (which includes the apron, if present) and twice the circulatory highway are added to determine the inscribed circle diameter, which is the distance across the circle that the outer curb (or edge) of the circulatory roadway inscribes. The diameter of the inscribed circle is influenced by many design goals. Before deciding on the best size for a particular site, the designer frequently has to experiment with several diameters. The extent to the inscribed circle at single-lane roundabouts is mostly influenced by how the design vehicle must turn. The diameter needs to be

large enough to fit the intended vehicle while still keeping a sufficient deflection. To fit a design vehicle, the inscribed circle's diameter needs typically be at least 30 meters (100 feet). The design vehicle can typically be accommodated at double-lane roundabouts without any problems. The necessity to achieve deflection or the need to accommodate the entries and exits around the perimeter with suitable entry and exit radii between them typically determines The dimensions of the junction. Typically, the inscription a double-lane roundabout's circumference must be at least 45 meters (Krammes, 1995).

Entry width

The main factor affecting a roundabout's capacity is entry width. The length of the entrance as a whole, rather than just The amount of access lanes, determines an approach's capacity. To put it another way, the entrance capacity progressively rises with improvements in entry width that are gradual. Due to, the width rather than the amount of access is typically used to characterize the basic widths of entry and circulating highways. Entrance with a minimum width of 6.0 meters (20 feet) that may allow multiple traffic streams are striped to indicate different lanes. Whenever it has greater one roadway of travel anticipated to circulate, the circulatory route is typically not striped (Krammes, 1995)

Circulatory roadway width

The width of the entry and the turning needs of the design vehicle are used to calculate the necessary width of the circulatory route. In overall, it must consistently have at least 120 percentage of the optimum entry length. Allowable length of entryway angle need to stay the same the whole roundabout. The circulation route at single-lane roundabouts should only be big enough for the design vehicle. The sweeping route of the car is designed using proper car-turning patterns or a CAD-based software application should be determined. Each rotational revolution. The important path for calculating length of the movement highway spans typically the left-turn maneuver. According to AASHTO guidelines, there should be a minimum of 0.7 m (2.1 ft) between the outside border of the tier road as well as the corner line (Krammes, 1995)

Central Island

The raised, impassible section that the circulation lane envelops in a roundabout is known as the center island; this region may also include a traversable apron. Usually, the island is manicured for cosmetic purposes and to make it easier for approaching drivers to see the circle. Always increase the central islands, not depressed, therefore it is difficult for approaching drivers to recognize depressed islands typically, the shape of the middle island should be circular. Constant speeds are encouraged nearly the middle region by having a circular roadway Using a curvy uniform

dimension island. Instead of that, irregular or oblong shapes are more driving challenges that can encourage faster speeds on the straightaways and slower speeds around the oval's curves. The entering cars' ability to assess the speed and appropriateness of voids in the curve travel may be hampered by this speed discrepancy. Moreover, it may mislead passing motorists, increasing the likelihood of loss-of-control collisions. As noncircular core islands get larger, the aforementioned drawbacks become more severe due to faster circulating speeds (Krammes, 1995)

Entry curves

The set of one or more curves along the right curb (or edge of the pavement) of the entry highway that lead into the circulation roadway is known as the entry curves. Contrast it with the entry path curve, which is determined by the radius of the vehicle's quickest route through the entry geometry. With its major effects the entrance diameter is an important factor in terms of volume and protection. in determining how well a roundabout function. The entry radius regulates the degree of deflection imposed on a vehicle's entry path along with the entry width, circulatory roadway width, and central island shape. In general, higher accident speeds among arriving and moving cars are caused by larger entry radii, which result in quicker entry speeds. The entering curve is shaped curvilinear tangential to the circulatory roadway's outer edge. The approach roadway's inner (left) edge must be the project curvilinear in a tangential direction to The principal area. a common entrance geometry for a roundabout. To meet the speed goals is the main goal when choosing the incoming curve's length. the shortest route for vehicles should be used to determine an optimum design speed before adjusting the entry radius. The entry path radius (R_1) should ideally be equal to or smaller than the circulating path radius (Brilon, 1999).

Exit curves

In order to reduce the possibility of traffic jams at the exits, exit curves typically have bigger radii than entry curves. The necessity to maintain moderate speeds at the pedestrian crossing on exit, however, balances this. The length of the exit path should not be less than the length of the circulating path. Vehicles were moving too quickly to navigate the exit geometry and risk colliding with the Splitter Island or oncoming traffic in the adjacent approach lane if the exit path radius is less than the circulating path radius. In order to maintain moderate speeds at the downstream pedestrian crossing, the exit path radius shouldn't be noticeably bigger than the general route length. The departure arc of a double-lane junction is harder than that of a single-lane junction. Similar to the entry. There are methods and recommendations for preventing conflicts between departure lanes at double-lane roundabouts (Brilon, 1999)

Splitter islands

All intersections should have splitter islands (also known as separator islands or median islands), with the exception of those with very tiny diameters, where the splitter island would obscure the visibility of the central island. Their goal is to offer Assist in speed control, direct traffic into the roundabout, physically separate incoming and exiting traffic streams, provide shelter for pedestrians (including those with wheelchairs, bicycles, and baby carriages), and discourage wrong-way movements. Furthermore, splitter islands can be used as a location to hang signs. The Arrival and departure curves on a leg constitute the splitter island enclosure. In order to offer enough protection for pedestrians and other road users, the island's entire length should typically be at least 15 meters (50 feet).to make nearby cars aware of the roundabout's geometry. Divider Cay ought to also continue past the departure curve's endpoint stop traffic from unintentionally entering the route of oncoming travel (Brilon, 1999)

Stopping sight distance

The stopping sight distance is the length of the road that must pass before a driver can see and respond to an obstacle in the road and arrive at a full halt. Each corner of a junction, as well as every approach while entering and leaving, should have a stopping sight distance. Equation for measuring stopping sight distance (expressed in metric units) is suggested by National Cooperative Highway Research Program (NCHRP) Report 400, Determination of Stopping Sight Distances

$$d = (0.278) (t) (v) + 0.039 \frac{v^2}{a}$$

Where: d = stopping sight distance, m;

t = perception-brake reaction time, assumed to be 2.5 s;

V = initial speed, km/h; and

a = driver deceleration, assumed to be 3.4 m/s².

Super elevation

The circulation path should generally feature a 2 % transverse slant towards the facility landmass. Four key factors make this method of tilting outward recommended.

It improves safety by elevating the primary area and increasing visibility.

It allows slower circulation speeds.

It decreases the amount of breaks in the cross slopes of the entrance and departure lanes; and

It assists in the drainage of surface water to the intersection perimeter.

Street urban issues in Addis Ababa

Look at Addis Ababa's street map gives the impression that there is no one pattern. Gridiron? Not at all! A gridiron pattern can be seen in a few neighborhoods, particularly newer ones in outlying locations. Is the network radial? Yes, perhaps. Major roadways emanate from major roundabouts in certain city centers. Consider Arat Kilo, where important streets radiate from the large circle that hugs the Victory Statue. One major route leads to Kotebe, another to Sidist Kilo, another to Piassa, and yet another to Meskel Square. Similar patterns can be found in Mexico's roundabouts, Churchill Square, the Giorgis roundabout, the Sidist Kilo roundabout, and many others. The old roundabouts are frequently centred on historical landmarks, whereas the new ones lack in landscape design inventiveness. These roundabouts serve an important function in improving the flow of traffic in a city with a restricted number of traffic signals at intersections. In addition, the Europeans may have impacted the design of roundabouts and radial patterns in the larger scheme of urban transportation planning. Although Ethiopia is the only country that has never been colonized by European powers, the country's urban planners were influenced by European planning ideas, which helped shape the city into what it is today. (library, 2014)



Roundabouts are common in Addis Ababa. The picture shows Victory Square in Aral Kilo
Source: academic library, 2014



Neighborhood streets are full of potholes. Source: academic library, 2014

2.9 Empirical Literature Review

2.9.1 Causes of Traffic Congestion at roundabout in Addis Ababa

Different factors contribute to traffic congestion. According to Getu (2017), the causes of traffic congestion are as follows: first, many people and a large amount of freight moving at the same time; second, slow supply growth; and third, many trips being delayed due to irregular events. However, frequent collisions, vehicle breakdowns, incorrectly timed traffic signals, special events, and weather are all factors that contribute to traffic congestion. The following is a summary of another study by Tewodrose (2007) that identifies the main reasons of traffic congestion: on-street parking, vehicle damage, deterioration of current traffic signals, work zone environment, traffic accidents, and reduction of road capacity. In addition to the aforementioned, a study conducted in 2017 by Kefaylew summarizes the main reasons behind traffic congestion as follows: Highways are not very wide, and as a result of unlawful possession on the road, they are becoming narrower and becoming a source of traffic congestion. As a result, every opportunity exists to enlarge the road in accordance with their right-of-way in order to relieve traffic congestion. Furthermore, because land acquisition would not be required in this procedure, it will be less expensive and less time consuming. Every day, illegal parking on the road causes traffic congestion. On-road parking of automobiles is one of the primary causes of severe traffic congestion on various routes. (Tadele,2014)

Therefore, Addis Ababa's traffic congestion results in issues like longer wait times for taxis and buses, delays to workplaces and educational institutions, longer transit times, increased energy consumption, air and noise pollution, delays in the delivery of commodities, and environmental expenses. Increasing development, along with insufficient public transportation services and infrastructure suitable to non-motorized means of transportation, contributes to traffic congestion and road safety issues in the city. Several factors have been identified as major contributors to the issue, including a poor road system, a lack of understanding of road traffic safety, a mixed traffic flow system, inadequate legislation and enforcement, poorly maintained vehicles, inadequate emergency medical services, and the absence of a law requiring traffic accident insurance. With growing automobile density, air quality has suffered, posing health issues for city people. Not only has that, but the risk of an accident increased. Consuming dirty air can cause a number of health concerns, including respiratory problems and cardiac problems. (Mokonen, 2012)

As summarized by Kefeyalew, Although the selected road corridor serves as a vital link between Addis Ababa and trade centers in the eastern and southern regions of the country, as well as between Addis Ababa's trade centers and southern residential areas, traffic flow on it is extremely congested. Due to people commuting to the city center for daily work and business activities, traffic volume is highest in the morning from Kality to Meskel Square. However, traffic volume from the Bihere Tsige and Addis Sefer approaches at Adey Abeba is nearly constant throughout the day, with the highest traffic during the evening peak period. Sometimes, even in the middle of the day, there is traffic congestion at the Meskel Flower intersection because LRT piers impede the smooth flow of traffic. When this happens, there are no traffic cops there. Out of the four road segments that were examined for travel time, Riche-Meshualekiya and Nifas Silk-Adey Abeba and Akaki-Kality Masetegna had the longest travel times in the morning, whereas Riche-Meshualekiya has the longest travel times during the morning peak. However, compared to other road segments, the Global-Meskele Flower road stretch has less significance highway sections.(Kefyalew,2017)

2.9.2 Traffic Congestion Control Measures

Effective traffic management tactics that minimize traffic congestion. If traffic management systems are implemented appropriately, they may be able to mitigate the aforementioned effects. According to kefeyalew(2017), traffic management serves three main purposes:

- Increasing truck carrying capacity;
- maximizing the capacity to convey people; and
- The improvement of safety and aesthetics by designating a portion of a roadway for use by pedestrians only.

Additionally, as the Federal Highway Administration of the United States Department of Transportation noted in 2005, the following are the main tactics to alleviate congestion:

- ✓ Increasing roadway, transportation, and railway capacity;
- ✓ Increasing the efficiency of current infrastructure; and
- ✓ Allow passengers to use the system in less congested ways.

However, because grade-separated intersections generate more traffic, increasing the capacity of the road by adding lanes may not be able to reduce traffic congestion. When roadways are not congested, traffic increases; nevertheless, as congestion increases, traffic decreases until it reaches a self-limiting equilibrium. Should as capacity grows, traffic volumes raise once again until they attain a new balance (Grant-Muller). & Laird (2007)). The link between road capacity and traffic volume

Traffic jams can be measured in a variety of ways, resulting in varying cost estimates and the benefits of various congestion mitigation tactics. As a result, the trip time technique is used in this study. Used to analyzed congestion and its economic effects. The parameters listed below were utilized to compute the following congestion performance metrics for each urban highway section: trip time, Data on traffic volume, average travel speed, threshold travel speed, travel rate, trip duration, and journey distance delay, delay rate, delay ratio, total segment delay, vehicle volume, and vehicle weight occupancy Travel time is the amount of time it takes to travel between two sites. To analyzed congestion levels, the travel time for the specified road segments is determined. The largest travel time for this road segment happened during morning peak periods, while the smallest travel time occurred during midday since most people came to core business centres such Merkato, México, Piazza, Arat kilo, Amist kilo, and Sidist kilo during the day. early dawn hours (Kefyalew,2017)

2.9.3 Gerji-imperial round about congestion and level of service

The Gerji-Imperial roundabout has a volume to capacity ratio of 1.749. In other words, the roundabout was very crowded. In order to function satisfactorily, the level of saturation ought to be lower than 0.85. That being said, the operational Unsatisfactory is a feature of the roundabout. Similarly, the typical wait that cars experienced at the roundabout takes roughly 508.4 seconds, which is more than the permissible value range. Thus, it might be said that the roundabout is doing more than it can. Furthermore, the imbalance between the number of approach lanes and circulating lanes, along with the large volume of traffic and pedestrians, the insufficiency of the inscribed circle diameter, and the roundabout connection with various road types, were contributing reasons to the vehicle delays. Additionally, the researcher came to the conclusion that the roundabout's total level of service, as determined by the data, was scored F, indicating that it provided subpar service. (Bewket, 2017)

2.9.3 General Geometric Configuration of karl roundabout Addis Ababa

Roundabouts come in three or six-legged varieties. Additionally, adding a leg to the roundabout is usually preferable to maintaining or building a nearby secondary intersection. AACRA manual limit for multi-lane lanes to a maximum of four legs, each leg at roughly a 90° angle. Go-arounds. A karl roundabout is an intersection with four legs. This is inside the typical bound. When all of the axes of the legs pass through the center of the roundabout, the central island is optimally situated. Because this configuration is not always achievable, the island should be centered on the main axis

first. All approach legs on the Karl roundabout are symmetrically arranged. The main geometric aspects of this roundabout, based on general assessments, are the Center Island, circulation roadway, Splitter Island, truck apron, crosswalk marker (zebra crossing), and sidewalks. It was then linked by dual carriageways in both directions. geometric elements, as recommended by AACRA for safe and efficient operation (Emebet, 2015)

An analysis of the typical roundabout in Addis Ababa

The subsequent section compares each roundabout to an effective roundabout in terms of the degree of speed calming and pedestrian safety, based on a field survey and spot speed analysis. The pedestrian facilities offered by Karl, German, City Tip, and Kore are comparable as well. Offered at every approach leg, however zebra crossing and crosswalk markers need to be improved.

Name	Truck apron(m)	85th speed(km/h)	Central island diameter (m)
Karl roundabout	2.19	45.80	26.00
German roundabout	2.07	53.58	51.00
City Tip roundabout	1.04	65.19	19.00
Kore roundabout	1.22	54.79	38.0

Table: Every roundabout's comparison.

Although truck aprons often offer a reduced level of operation, it is preferable to offer sufficient deflection while still allowing for the design vehicle. The AACRA standard is then installed on Karl and German roundabouts, and a sufficient truck apron will enable safe roundabout operation. Function. Additionally, the deflection of the Karl roundabout is larger than that of the German roundabout. There is sufficient truck apron at the roundabout to guarantee the required slowdown in speed. Roundabouts should provide a turning path for the largest vehicles that are likely to use the facility often. Automobiles, minibuses, medium buses, and large buses are constantly going through the Karl and Kore roundabouts. Trucks and truck trailers, on the other hand, are occasionally passing through as well. However, the German and City Tip roundabouts are industrial zones. Vehicles such as automobiles, minibuses, medium buses, large buses, trucks, and truck trailers are always available. As a result, the City Tip roundabout is beneficial in terms of speed 65km/h. Overall, there is sufficient evidence to conclude that 85% of the observed vehicles enter

roundabouts like Karl, German, City Tip, and Kore at speeds of 46, 54, 65, and 55 km/h, respectively, below the 60 km/h AACRA speed limit, with the exception of City A roundabout tip. Consequently, driver's exhibit improved driving habits as a result of generally slowing down and maintaining open lines of communication about speed with other drivers. (Emebet, 2015)

2.9.4 Congestion in Addis Ababa roundabout

The majority of the Addis Ababa roundabouts are either severely overloaded or experiencing major issues, according to samples of the capacity analysis data. It is typical to observe that at peak hours, the real field conditions that have been observed At these roundabouts, traffic cops must control the flow of traffic because traffic control Devices are unable to control traffic flow or function. According to the report, the primary Issues include the inadequate quantity of entry lanes, the amount of circulation lanes, heavy pedestrian activity, high traffic volume, and uneven traffic on the approaches, which are not advised for roundabouts in actuality. Additionally, the majority of roundabouts were constructed more than 40 years ago using unclear service restrictions. Even although recent roundabout driving (traffic) standards are enforced to Addis Ababa roundabouts, some crucial Geometric elements, such as deflection and island splitters, do not exist at some roundabouts. The most essential geometric characteristic that causes drivers to slow down and avoid collisions with neighboring leg incoming cars is deflection. The center island aprons are also not properly mounted to serve big vehicles. (Tewodros, 2007)

2.9.5 Methodological Literature Review

Research methodology is made up of three primary components. The first component of the field survey is to analyze the general geometric condition in relation to AACRA requirements. The evaluation includes general geometric configuration, geometry of roundabout elements, and road user facilities. Second, a questionnaire covers questions about experience and safety perception from both walkers and drivers. Finally, utilizing laser technology, conduct a spot speed study to acquire speed data (Gebremedhin, 2015)

The use of right methodology and materials is critical for achieving the full and proper results of any type of research. However, due to financing and time limitations, it is impossible to consider all of the essential data when conducting any research. As a result, collecting the relevant data is critical. It represents the entire data population. Primary and secondary data were used in this study. Both qualitative and quantitative data were collected using different techniques. To gather both qualitative and quantitative data for the study corridor, both primary and secondary data were collected. The level of service and the degree of traffic congestion were determined using

quantitative statistics, while qualitative data were used to gain information regarding the public's view of traffic congestion. So, in order to analyze both primary and secondary traffic data was processed (Kefyalew, 2017)

The research began with a reconnaissance tour of the areas in order to pick and view the geometry of the road segments, as well as to identify locations for camera recording sites to record vehicle traffic and pedestrian movements. The performance of the road facility at peak hours, LOS increase through reversible lane extension, congestion trend analysis, and impact video recording of pedestrian intervention and directional distribution discrepancy Manual traffic counts were also performed at the Gurd shola intersection while the film was being recorded on that main highway. After assessing the impact of the reversible lane on existing traffic congestion, the problems and drawbacks are discussed. the investigation. The analysis of congestion trend change decides whether or not it is necessary to extend the period for corrective action (TENAW, 2021)

The sidra intersection software version 5.1 models were used in the study to answer the specific purpose of investigation quantitative data and analysis. There are two sorts of models in the software: macroscopic and microscopic. The Macroscopic Models model crossings as isolated places using traffic volume flows. Microscopic Models, on the other hand, imitate the movement of individual vehicles. As a result, network-wide analyses are possible. One of the macroscopic models was used in this investigation. To analyze traffic operations at roundabouts and signalized intersections, the SIDRA software programed was used. Using Sidra intersection software, the level of service (LOS) and performance of a roundabout and a signalized intersection were examined. To compare the operational performance of the Ayer-Tena intersection following the implementation of Showing a possible new signalized intersection with the current Roundabout (Mebratu, 2017)

2.10 Analytical Method

SIDRA software

SIDRA traffic analysis is used to model specific intersections but is insufficient for all analytical tasks that call for computer-based traffic operations modeling. SIDRA is a micro-analytical tool for the assessment of intersectional effectiveness. Powerful software called Sidra Intersection is used to design and assess individual intersections and networks of intersections for various vehicle types. An investigation of indicated crossings, signalized and un signalized pedestrian crossings, un signalized roundabouts, give way/yield sign control, all-way stop sign control, and signalized single point interchanges are all possible using this tool. It can display The accepted norm of the service, delays, fuel usage, gas emissions, cost of vehicle operation, and time cost. Professionals in traffic design, operations, and planning use the software package Sidra Intersection to determine the ability to handle of intersections and networks, their level of service and efficiency, and the timing of signalized intersections and networks. The SIDRA package was used to evaluate the effectiveness of intersections with four-legged crossings when indicate supervision, yield control, and two- and four-way stop control are used under various traffic conditions. Fluctuations in terms of the amount of entrance paths, lane lengths, turning volume splits, and volume levels are examples of such conditions. The analyses results show believe intersections are a good option design two-lane pathways to junctions and high the amount of left or through traffic crossing. Roundabouts perform well when compared to junctions with lighted one-lane entrance and high traffic volumes. Junction efficiency can be estimated for any fraction of the total amount of left-turning flow. To be greater than those of signal-controlled junctions with entrances using two and three path. This study makes options for roadway engineers on the circumstances that should be met (Jurnal, 2018)

The Australian Road Research Board (ARRB), Transport Research Ltd., developed the SIDRA software to design and evaluate the performance of intersections such as signalized intersections, roundabouts, two-way stop control, and yield-sign regulate junctions. In determining and contrasting the marked junction's performance, the SIDRA has some advantages ahead of any other type of program. According to the SIDRA method emphasizes consistency of Evaluation of efficiency and operation methods for roundabouts, sign-controlled, and signalized intersections by utilizing an integrated modeling framework. As shown below, the SIDRA program requires input data to analyze traffic in the intersection (Akçelik, 1997)

Percentage of heavy vehicles for each direction and movement.

Peak hour factor (PHF).

The number of lanes.

The radius of Island.

The width of Lane.

Lane path

Empirical approach with various restrictions, like the requirement that data be gathered at capacity (or oversaturated flow) levels. To ensure the accuracy of the results, sufficient data must be gathered. However, this method can be rigid at certain cases, like that when the value is much beyond the range of the regressed data. As a result, scientists searched for additional trustworthy techniques to estimate roundabout capacity. A gap acceptance theory (Analytical Method) is generally seen as being a more suitable instrument. The gap acceptance technique provides a logical foundation in order to evaluate capacity, which is a benefit of this approach. Secondly, it is simple to understand the meaning of the parameters utilized and to make adjustments for unexpected circumstances. Furthermore, gap acceptance theoretically connects traffic interactions at roundabouts with the availability of gaps in traffic flows (Taekratok, 1998).

Tanner's capacity equation (2.8.1) for priority intersection served as the foundation for with growing that the gap acceptance capacity formula. The equation has been modified to correspond with data collected in the field. Tanner's equation has been adapted for usage in Australia with adjustments. All model input parameters relating to intersection design and driver behavior are critical for calibrating the traffic model to represent specific intersection conditions. Gap-acceptance parameters (particularly follow-up headway and critical gap) are important

Parameters that reflect driver behavior at roundabouts. The total roundabout design (configuration of approach roads, number of approach and circulation road lanes, and lane allocation to movement) has an instant effect on capacity and performance. The shape of intersections, in addition to total traffic stream rates and patterns, influence gap-acceptance factors, in addition to overall approach and circulation road lane use, which has a substantial impact on capacity and performance (Akçelik, 1997).

Identifying the main and subdominant entry slots according to flow is another crucial component of Akcelik's concept. The dominant lane has the maximum flow rate, while the remaining lanes are subdominant. This component's purpose is to allow dominant and subdominant entrance lanes to have varying critical gap and follow up timings. The differential between dominant and subdominant lanes appears to be fairly essential because vehicles utilizing the left most entry lane must find a space in both circulating lanes, whereas vehicles using the right most entry lane must only cope with traffic in the outermost circulating lane.

An empirical gap-acceptance approach has been utilized to model roundabout capacity and performance in the aaSIDRA equation (2.8.2). The aaSIDRA model contains impacts first turnaround (lower crucial gaps at higher circulate flows), and foremost focus (unbalanced O-D patterns), and unequal lane utilization (both approach and circulating lanes), as well as the effects of roundabout layout and driver behavior. According to the Highway Capacity Manual's (HCM) definition of capacity under actual conditions, capacity can be calculated as the service rate for each traffic lane in under saturated conditions (v/c ratio less than 1). Under contrast, approach capacity is measured under oversaturated conditions (Akçelik, 1997).

2.11 Research Gap

According to the studied literature, many countries have their own ways of Capacity Analysis, which are given by different scholars, but we may categorize them as completely Roundabout Geometry dependent approach that is known as the Empirical Method. Analytical Method includes a gap acceptance technique that incorporates driver behavior and familiarity, vehicle type, circulating and entering splits, and conflicting circulating flow. aaSIDRA does not use a solely analytical method to calculate roundabout capacity. It is a semi-empirical-analytical approach because it employs some geometric techniques elements for the analyses. It can be feasible distinguish rotary and traffic circles from current roundabouts using driving (Traffic) laws and geometric elements. Modern roundabout driving or traffic rules priorities circulation. Vehicles, no pedestrian access, no parking, and one-way circulation. Yield line, approach flare, deflection, and Splitter Island (not for small roundabouts) are the geometric features.

Which methods or formulas proposed by other researchers or countries are appropriate for Addis Ababa?

As the regression or empirical method is entirely dependent on the geometry parts of the intersection, it can be difficult to locate the required architectural characteristics (components) of Addis roundabouts, which can be a problem. During the evaluation, there was a problem. Furthermore, the quantitative technique is more likely than the empirical method because it takes into account the traffic situation. As a result, the Analytic technique with SIDRA software and some geometric aspects is recommended for this thesis. With reality, AACRA also suggests SIDRA software. For capacity analysis, this is created by combining the Analytic technique with some geometric aspects.

Nonetheless, several studies on intersection evaluation have been conducted. Their findings were ascribed to roundabout vehicle delays, poor service quality, and fuel costs. According to the many studies that have been undertaken and analyzed with the aim of this research, the majority of them focus on one aspect of the intersection problem. Previous studies has also left it unclear how far the execution has progressed of software. As a result, this study is different from the others that were previously described in that its main focal areas are examining current and prior interaction. Accordingly, the research questions for this study were designed in light of this gap

CHAPTER THREE: RESEARCH METHDODOLOGY

3.1 Study Area

Addis Ababa, located in the horn of Africa and has the coordinates 901'48" North, 38o44'24" East, and having a 2355 m above sea level average elevation. The City covers over 527 km² in total area. The City, which is the most important commercial and industrial center in the city, is divided into 116 wereda and 11 administrative sub-cities. The key challenge Addis Ababa is the city's expanding need for mobility and transportation. This could lead to serious operational issues, such as congestion and least level of service especially during peak times. The study selected is an example of main road corridors that represent significant traffic activities (Google E. , 2017)

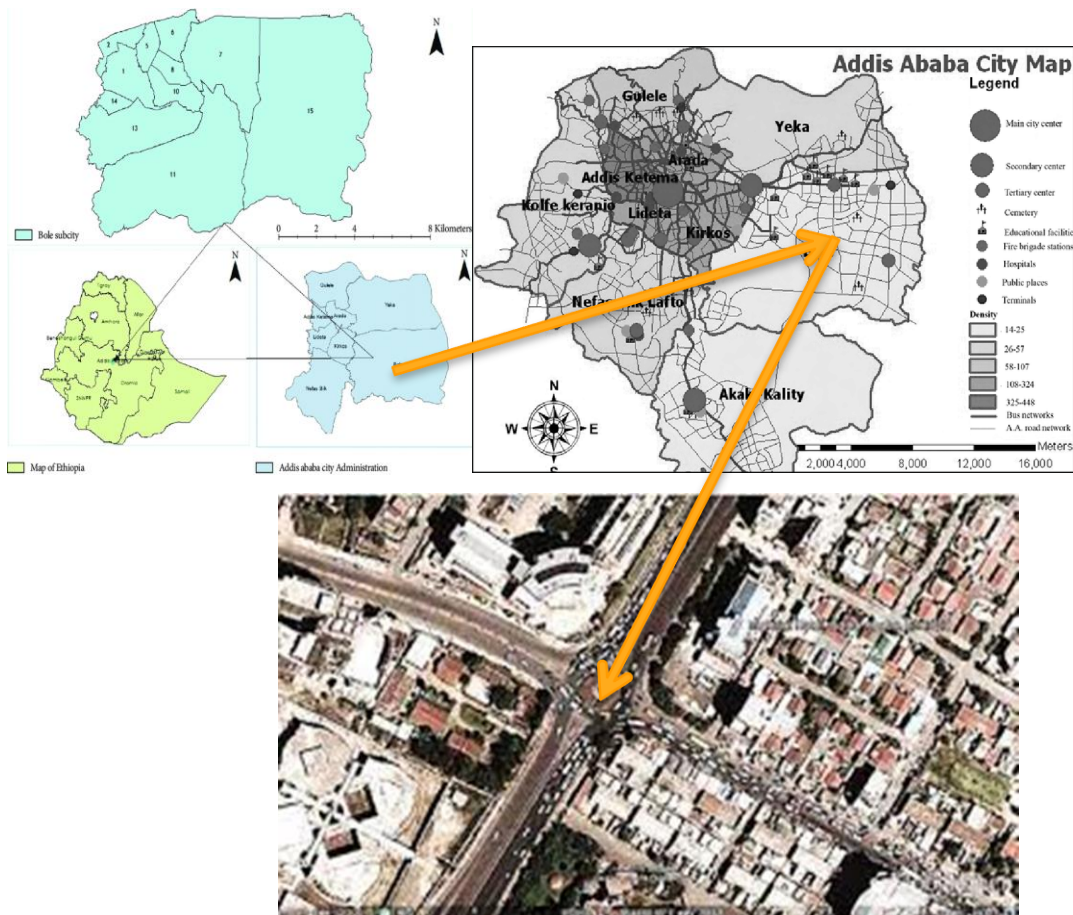


Figure 3-1: Selected Research area Source: (Google, 2022)

3.2 Study Variables

The study variables are classified into two categories. Both of these are independent and dependent variables.

Independent variables

Delay	Vehicle type and volume
Capacity	Lane number
Lane width	Road condition
Saturation flow rate	Traffic flow conflict

Dependent variables.

Degree of performance (LOS)

3.3 Study Design

The investigation began with a reconnaissance survey of the locations to choose and examine the geometry of the road segments. Performance of the road infrastructure at peak hours, the investigation of congestion trends, the effects of pedestrian intervention, the directional distribution difference, and LOS improvement by the inclusion of reversible lanes were all done using Manual traffic counts also included to perform the count at Gerji-Imperial junction. After evaluating the impact of the reversible lane on existing traffic congestion, challenges and drawbacks are also addressed by the study. The congestion trend change analysis is leads to whether it is necessary for extension of time on the remedial measure or not. The result and discussion leads to a certain conclusion and the study proposed recommendation based on the stated findings.

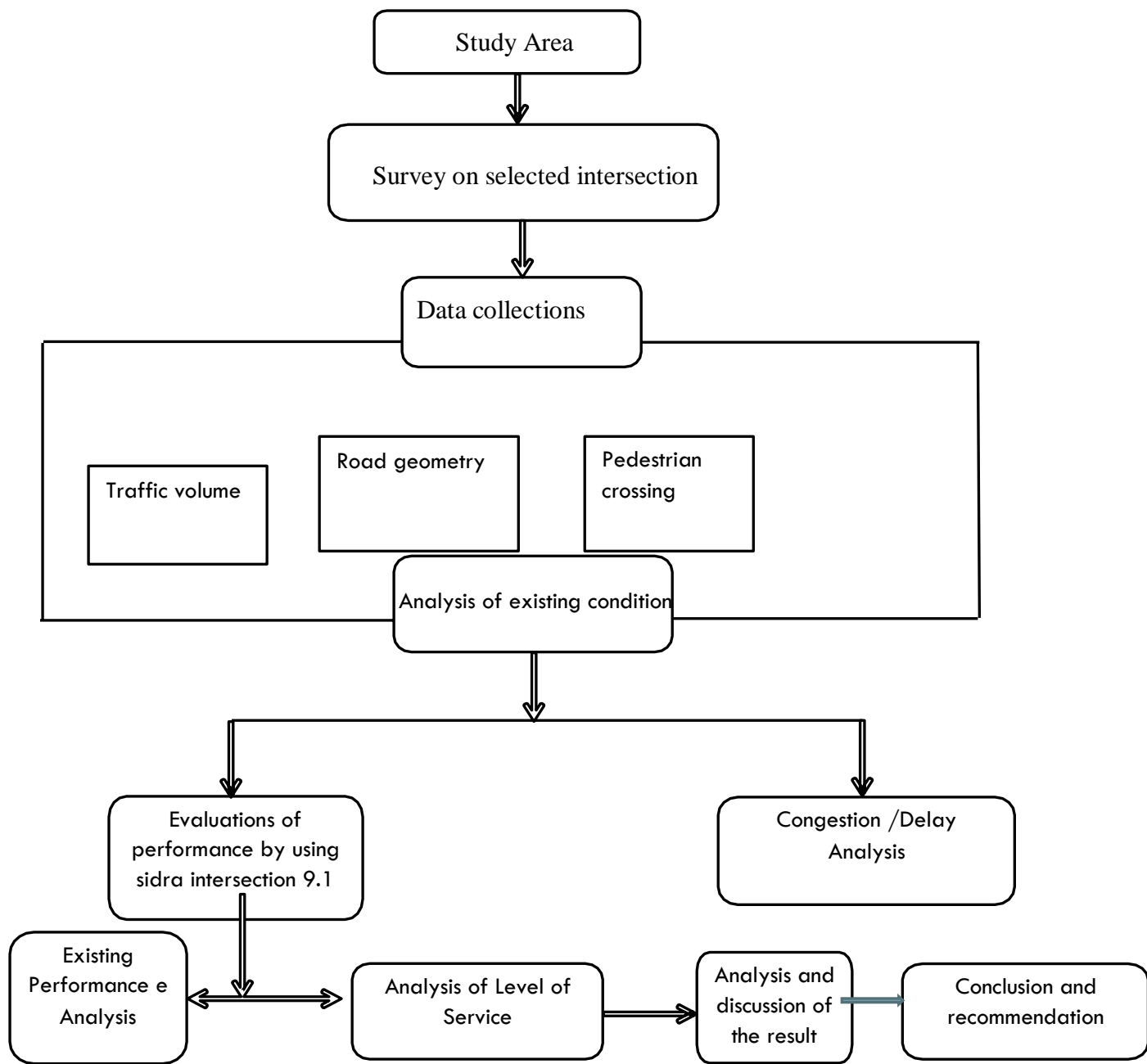


Figure 3.2 shown a graphical clarification of the study design.

3.4 Data type and source

Different data were needed to accomplish the study's goal and respond to the posed research questions. These data can be divided into two categories :(1) Primary data, and (2) Secondary data.

Primary data

Primary data which was directly gathered through site observation and field measurement. Consequently, it was challenging to collect primary data for every aspect of the research region. Instead, potential sample crossings and road segments were thought of along the study area. Data gathered from a primary source are as follows:

Site investigation about traffic jams condition; Traffic count survey; Lane width; and Median width; Number of lane.

Secondary Data

Secondary data were gathered from journals, research papers, both published and unpublished, and manuals. The following information was obtained from a secondary source.

Vehicle classification from ERA Manual; Intersection layout from Google Earth; Approach Dimensions from Google Earth; Images from Google Earth; and PCU from ERA Manual.

3.5 Sample Size

The sample size was determined by a field survey, and all relevant inputs were collected directly at the research location and supplemented by interviews from local people, traffic officers and engineers.

3.6 Method of data collection

The term "data collection methods" refers to the equipment used to extract specific data from the units of investigation. To accomplish the research's goals, data were gathered using a combination of primary and secondary sources. There was an attempt to utilize the strategies outlined in the sections that follow to gather data.

Field observations and visits the use of field visits and observations had been among the crucial methods for gathering first-hand information. The information gathered during a field visit and observation helps pinpoint a bus station's location and a taxi loading area loading and unloading, intersection kinds, movement types, speed limits, grades, and the occurrence of traffic jams in the research region.

Field measurement the geometrical characteristics with selected study road crossings were used to collect field measurements. These include the width of traffic lanes, the volume of lanes, and the median width in meters.

3.6.1 Traffic Volumes Survey

Traffic volume studies are carried out to identify the quantity, movement, and categories of cars at the chosen roundabout approaches. For this study, Traffic data was collected manually by competent individuals using a vehicle statistic. A knowledgeable individual was assigned to cars and people in each in a manual mobility count, the entrance point to the Gerji Imperial crossroads was counted. Information on flow quantity was collected by taking into account various sorts of vehicles. (Light vehicle, buses, trash vehicles, and tankers) as well as moving methods (through turn, left turn, and right turn). The following factors were considered in order to properly analyze the necessary data: Tuesday, Wednesday, and Thursday represent the average value of weekday traffic, while Monday and Friday exhibit substantial traffic variations. Low traffic volume occurs on weekends (Saturday and Sunday).by utilizing The typical report sheet for a physical traffic flow survey.

3.6.1.1 Days and period to record traffic Data

In this study, traffic volume measurements were taken for each intersection every 15 minutes for seven days (one week) in order to fully analyze the data. The following factors were taken into account based on traffic volume

Monday has a large traffic Movements compared to other usual weekdays Tuesday Wednesday, and Thursday have equivalent traffic patterns. Saturday and Saturday (weekends) observed less traffic. This research period of data recording Traffic volume Analysis was done for twelve hours per day 6:00-11:59AM Morning and to afternoon 12:00-6:00 PM for seven days in each intersection

3.6.2 Passenger Car Unit (PCU)

Because various types of cars in a transportation flow share varied effects, it is necessary to have a single unit to count the number of cars in order to conduct traffic volume. As a result, all vehicles that use the condor must be changed to a common unit known as a passenger car unit. Table 3-6

below shows the PCU used in this research, which were taken from the Manual of Highway Capacity 2000.

	Passenger Car Vehicle					Goods Vehicles		
	Car and Tax	4WD	Mini bus taxi	midi bus	Standard Bus	small	Medium	Large
PCU	1	1	1.5	1.5	1	1.5	3	3

Table 3-3: Passenger car units for vehicles

3.6.3 Geometric Data

Different geometric data, such as island diameter, circulation breadth, and number of islands, were required by the Intersection. Circulatory lanes, entry lanes, entry lane number, and average lane width at the roundabout junction's entrance. These measurements were made with a tape meter as well as by studying the present roundabout configuration.

3.7 Method of data analysis

There are multiple computer programmers available to analyses intersections and signalized junctions have vehicular functions. The application is divided into two categories. There are Models at the macro and micro levels. The macroscopic models crossings as independent places using The amount of traffic flows. One of the macroscopic models (SIDRA) software programs is used to analyze traffic operations at intersections. used. AACRA in fact also recommends the capacity analysis software SIDRA Intersection, which was created by combining analytical techniques containing certain design components. The Signalized & Un-signalized Intersection Design and Research Aid SIDRA intersection version 9.1 software preferred for this research for capacity evaluation of roundabout. SIDRA is Professionals in traffic design, operations, and planning use the software package Sidra Intersection to calculate signalized junction and network capability, level of service and efficiency, and junction and network capacity timing.

3.8 Method of data presentation

Data presentation involves using visual tools, like graphs tables and chart to compare two or more data sets. You can depict how the information relates to other data using a graph. Following data analysis, this procedure aids in information organization by visualizing and presenting the information in a more readable format. This method is beneficial in almost every industry because it enables experts to communicate their findings after conducting data analysis.

Research objective	Research question	Type of Data	Methodology Quantitative research (numerical data)	Method of data Analyze
1. To analyze traffic congestion at the selected roundabout	1. What is the degree of traffic congestion at the specified roundabout?	Primary data Traffic count survey; Lane width; Median width; Number of lane	Traffic Volume Count Survey and Geometric Data	Sidra Intersection 9.1
2. To identify the Traffic Congestion Mitigation Measures	2. What are Traffic Congestion Mitigation Measures?			
3. To assess the current and prior situation of level of service at the roundabout before and after constructing overpass bridge.	3 What is the roundabout's current and prior level of service (LOS) before and after constructing Overpass Bridge??			
4. To assess the capacity of roundabout junctions	4. What is the current capacity of gerji-imperial roundabout?	Secondary data		
5. To identify the main causes of vehicle delays and fuel energy consumption in roundabout.	5 What measure to mitigation vehicle delay and consumption of fuel energy at roundabout?	Vehicle classification from ERA Manual; Intersection layout from Google Earth; Approach Dimensions from Google Earth; Images from Google Earth; PCU from ERA Manual;		

Table 3.4 Summary of a data type, methodology, and analyze with research objective and question

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The key results from the data collected are presented and described in this section, and various aspects of the finding discussed. Field study results and Sidra software analysis are all included in analysis and results. Initially, the findings of the field study to describe the chosen intersections. Results of the sidra analysis. After utilizing the gathered data and adhering to the procedures outlined in the research, the research assessment was carried out on the chosen roundabout. Using SIDRA Road segment Version 9.1 Software, the findings are displayed in the parts that follow along with brief justifications.

4.2 Traffic Congestion Analysis

Congestion can be measured in a variety of ways. As a result, in this study, the saturation level was used to analyze congestion. For each roundabout leg portion, the following factors were utilized to generate the congestion performance measures traffic volume data, average travel speed, delay, vehicle volume, and vehicle occupancy.

4.2.1 Analysis of Traffic volume at the selected intersections

Traffic volume Analysis was done for twelve hours per day 6:00-11:59AM Morning and to afternoon 12:00-6:00 PM for seven days in each intersection. The directional traffic volume was analyzed Gerji-imperial four legs non signalized intersection.u0

4.2.2 Traffic Volume Analysis for Imperial-Gerji Intersection

This intersection is located between bole and ambessa garage intersection approach and it has four entry lanes and has top bridge. It has the highest traffic volume towards the gerji and bole approach in the morning, midday and afternoon peak period. Those two approaches have high traffic during peak hours, and there is a major road at this intersection Figures 4-1 and 4.2 show the amount of traffic at the Imperial-Gerji non Signalized Intersection bole and gerji approach.

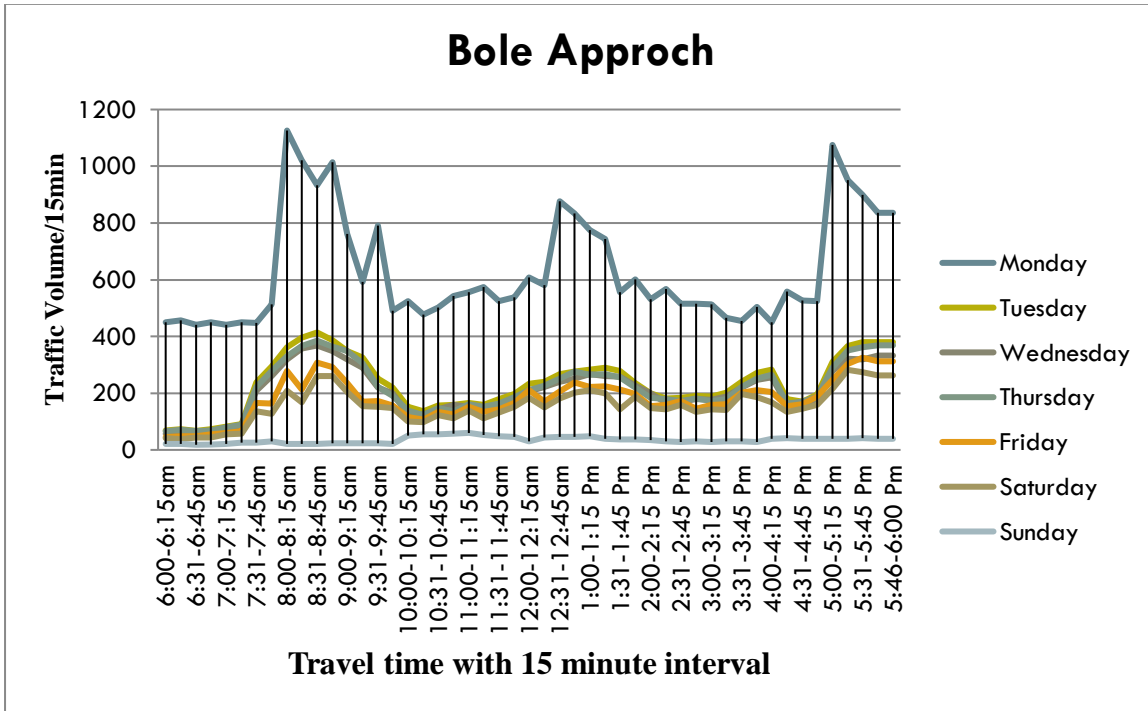


Figure 4. 1 Traffic flow Pattern per 15 min interval for Bole Approach Source: own data

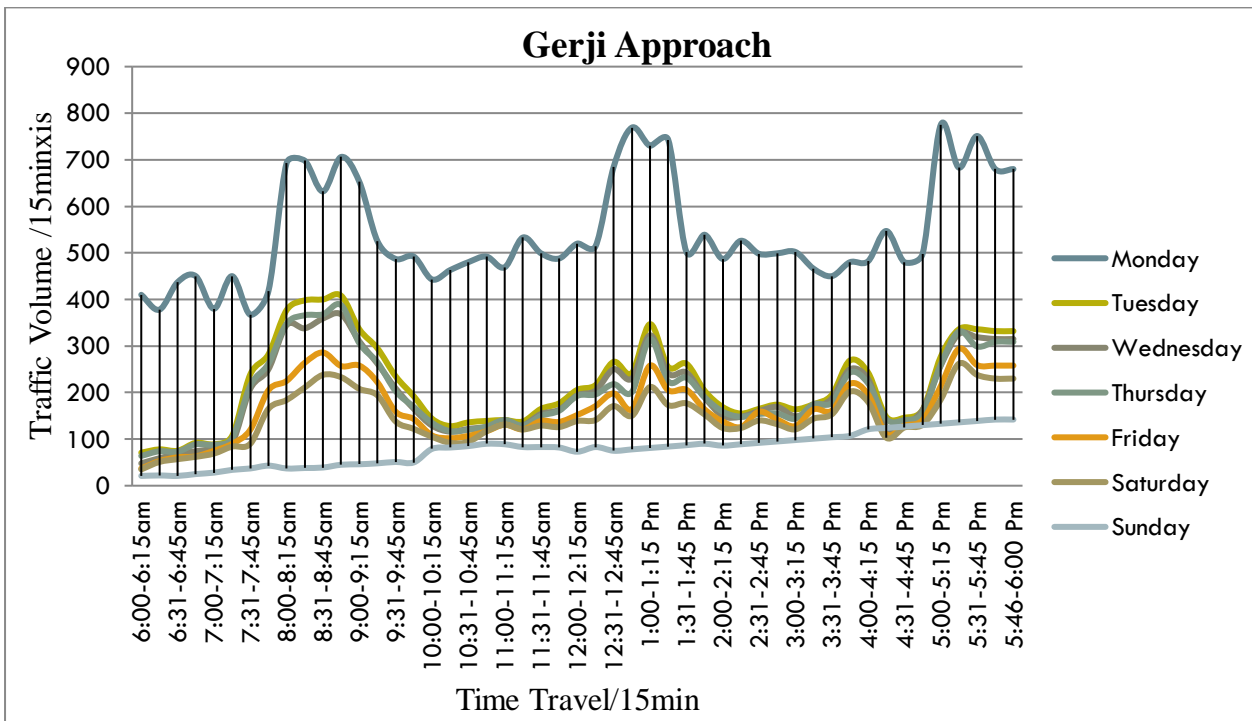


Figure 4. 2 Traffic Flow Pattern per 15 min interval towards Gerji Approach Source: own data

As shown in Figures 4.1 and 4.2 above, analysis of Traffic volume (vehicle/15 minutes) in one week, Monday and Thursday show high traffic variation from other weekdays due to the fact that Monday is the first working day and all government and non-government institutions are open.

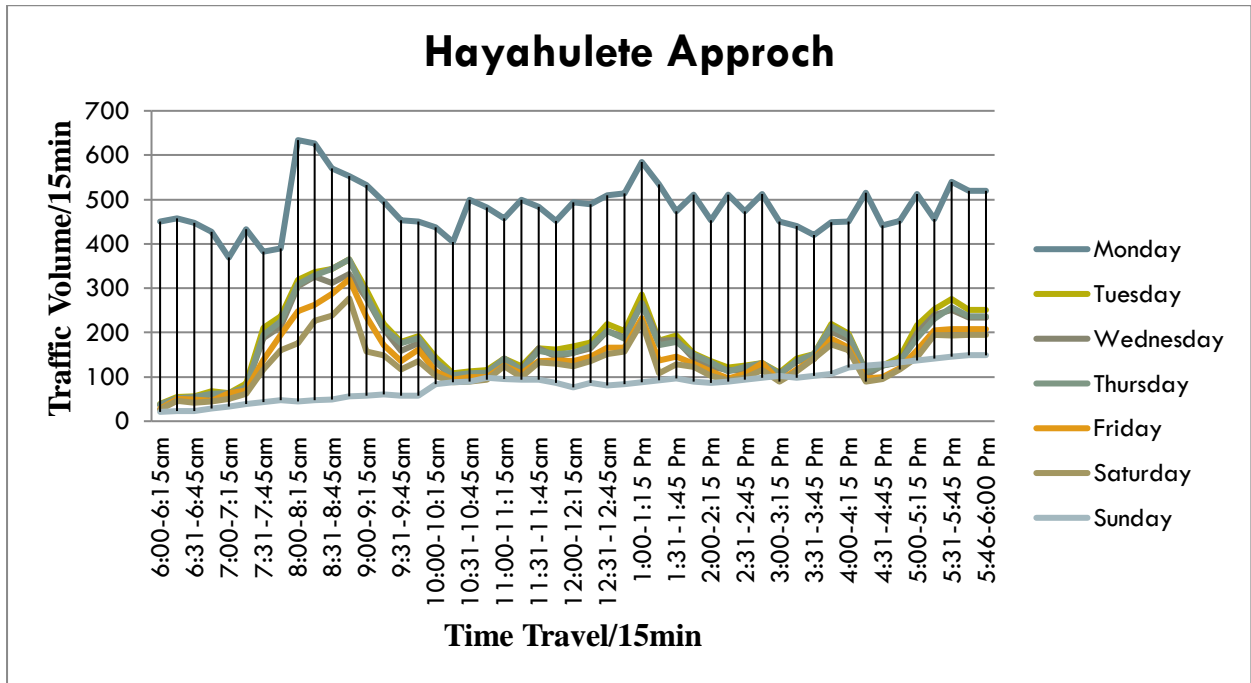


Figure 4. 3 Traffic flow Pattern per 15 min interval for Hayahulete Approach Source: own data

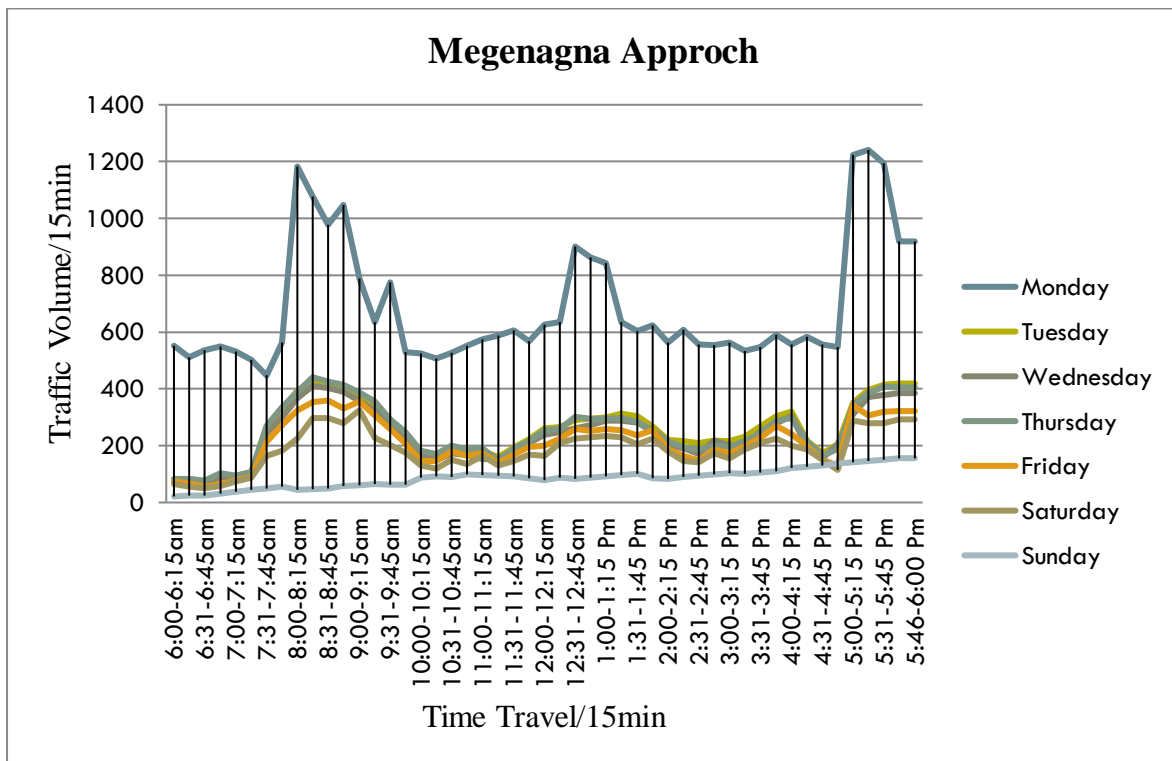


Figure 4. 4 Traffic flow Pattern per 15 min interval for Megenagna Approach Source: own data

Figures 4.3 and 4.4 indicate that traffic volume towards Hayahulet and megenagna Approaches also high vehicle flow at rush hour in morning, midday, and afternoon. It is the main road at the non-signalized Imperial-Gerji intersection. In general, the Imperial-Gerji non-signalized intersection is more congested towards all Approaches during the evening and morning peak periods.

4.2.3 Degree of saturation

Is the key metric for estimating transport efficiency the efficiency of the service decreases as the saturation value rises because the flow is so great, there is more congestion, which causes the vehicles to be quite close to one another direct evaluation of a given roundabout's sufficiency is provided by overload level or amount to capability ratio. The Australian design approach advises that a suitable level of saturation for an entrance route is less than 0.85 functioning, despite the fact that there are no absolute criteria for the degree of saturation. Once saturation levels exceed this range, the roundabout performance is expected to decline quickly. As the outcomes of the investigation if it exists a continuous green light and a continuous line of vehicles on the approach, the maximum flow that can be discharged from a traffic lane is referred to as saturation flow. It is a measure of a lane's maximum capacity and is determined by a number of elements, such as the topography of the road, visibility conditions, and the categorization of the vehicles, such as heavy vehicles. Peak Hour Factor (PHF) is a calculation that converts hourly volume into the volume rate that represents the busiest 15 minutes of the hour.

$$\text{Peak factor} = \frac{\text{Volume PCU during peak hour}}{4 \times \text{Highest volume in PCU during 15 min interval of peak hour}}$$

	Bole Approach						Gerji Approach					
	Tuesday		Wednesday		Thursday		Tuesday		Wednesday		Thursday	
	8:00am-9:00am		12:45pm-1:45pm		5:00pm-6:00pm		8:00am-9:00am		12:45pm-1:45pm		5:00pm-6:00pm	
	Volume			Volume			Volume			Volume		
Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	
Peak 15 min	414	424.9	266	285.1	369	395	408	420	323	340.1	331	360
Peak 1 hour	1557	1599.6	1035	1111.6	1370	1471.4	1583	1630	1044	1102	1199	1290
Peak hour factor	0.94		0.97		0.93		0.97		0.81		0.9	
Volume	1599.6		1111.6		1471.4		1630		1102		1290	
Capacity	900		900		900		900		900		900	
V/C	1.78		1.24		1.63		1.81		1.22		1.43	

	Hayahulete Approach						Megenagna Approach					
	Tuesday		Wednesday		Thursday		Tuesday		Wednesday		Thursday	
	8:00am-9:00am		12:45pm-1:45pm		5:00pm-6:00pm		8:00am-9:00am		12:45pm-1:45pm		5:00pm-6:00pm	
	Volume			Volume			Volume			Volume		
Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	Vehicle	PCU	
Peak 15 min	365	377	334	345.6	362	380	428	440	410	428.8	441	460.8
Peak 1 hour	1363	1403.7	1266	1322.6	1377	1437.2	1668	1711	1568	1636	1671	1739.6
Peak hour factor	0.93											
Volume	1403.7		1322.6		1437.2		1711		1636		1739.6	
Capacity	900		900		900		1200		1200		1200	
V/C	1.56		1.47		1.60		1.43		1.36		1.45	

Table 4. 2 Manual calculation Volume Capacity Ratio for Each Approach Source: own data

According to the analysis data volume capacity ratio in peak hour as illustrated in table 4.5, the Gerji-Imperial roundabout degree of saturation is greater than 0.85, which is more than allowed number and indicates that there is congestion, and it is surveying more than it is capable of.

4.2.5 Speed Control

Roundabout geometry and the operating speeds of the approaching highways are just two of the many variables that affect the speeds at roundabouts. As a result, controlling speed often involves controlling both the speed at intersection, as well as velocity of the incoming roads. Design speed is the maximum speed that a driver could theoretically travel through a roundabout if they took the quickest route, regardless of lane line markings. The 85th percentile approach speed should not exceed the entrance curve radius's selection a top speed of 60 km/h (AACRA, 2003) Since collision severity is more closely related to speed than volume, intersection layout velocity is the most crucial factor in terms of safety performance. Although crash frequency is more closely related to volume, speed is also a key factor in collision severity. Hence, the to ensure optimal safety performance, roundabout design speed needs must be taken into account.

4.2.6 Vehicle Composition

Table 4.6 shows the share composition value based on the analyzed data on Tuesday peak hour traffic flow and the share of traffic % on each approach at entry legged.

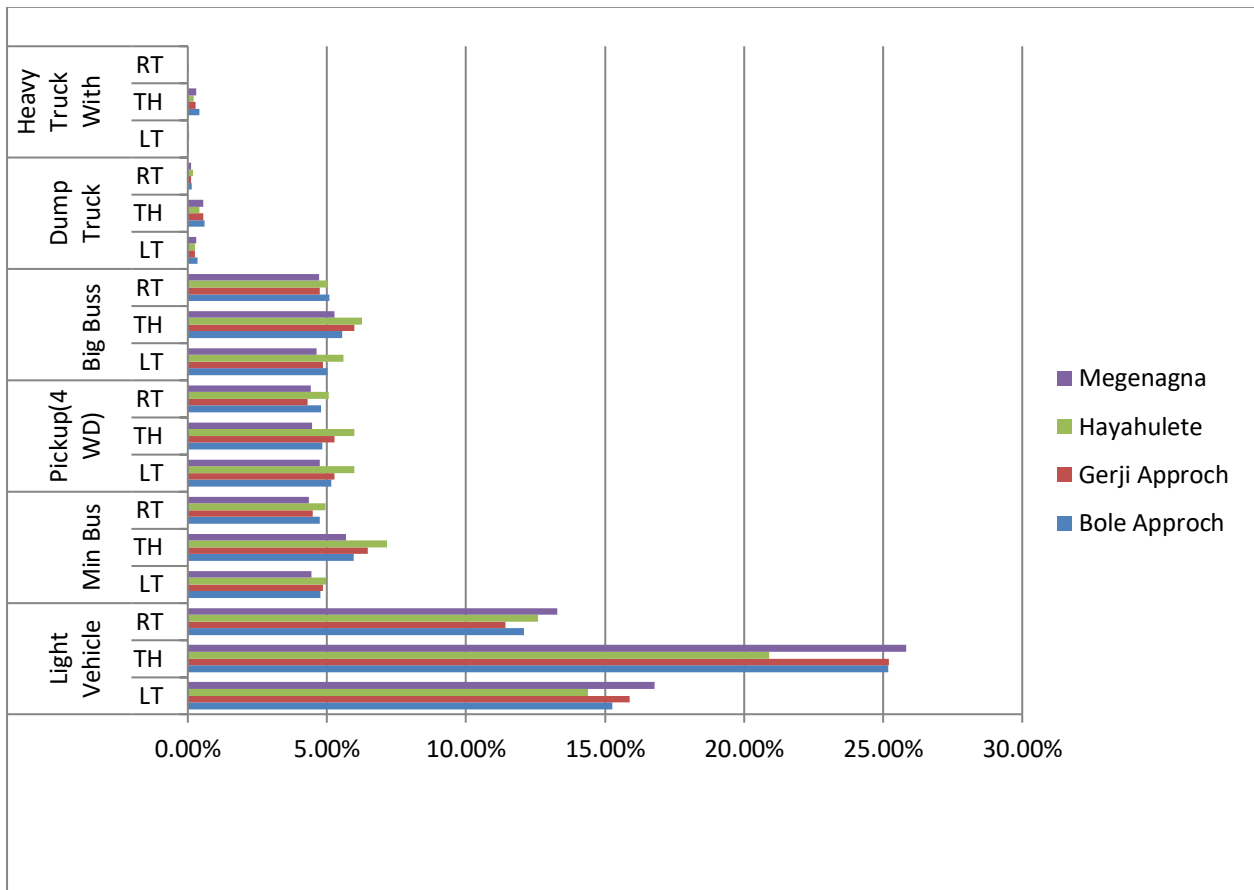


Figure 4.5 Tuesday's percentage share of each entry leg Source: own data

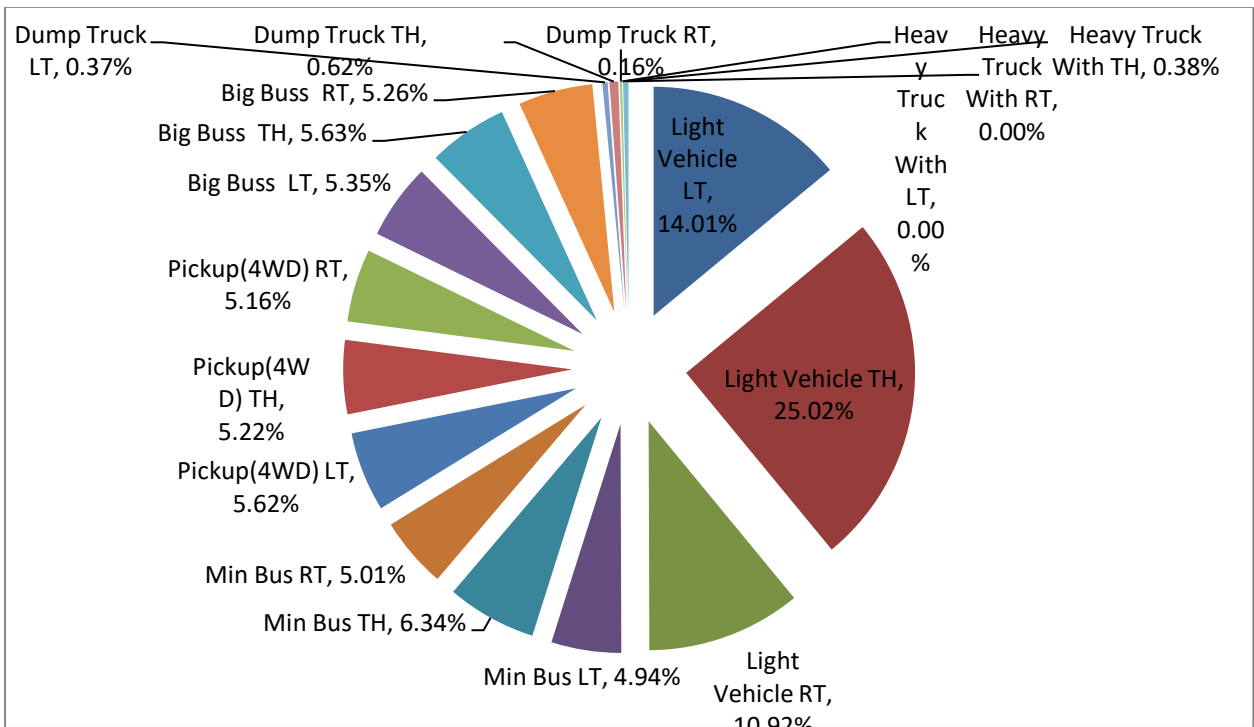


Figure 4.6 Wednesday's percentage share of each entry leg Source: own data

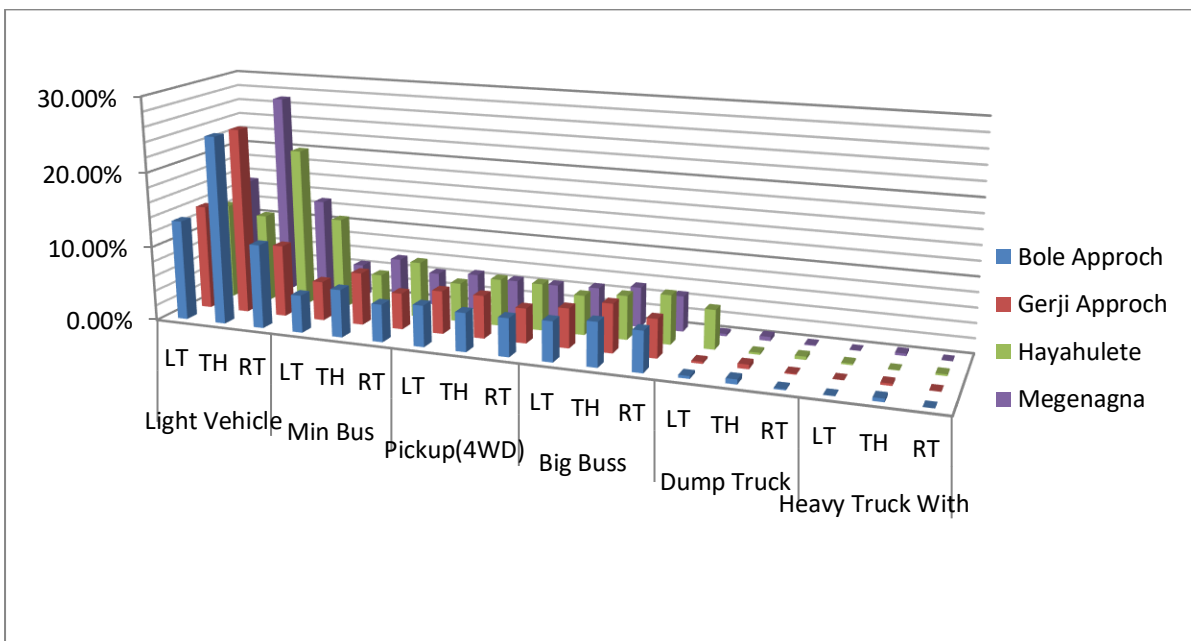


Figure 4.7 Thursday's percentage share of each entry leg Source: own data

4.3 Main Cause Traffic Congestion and Mitigation Measures

Congestion on road networks is a phenomenon that happens as demand increases and is typified by slower speeds, longer travel durations, and increased vehicular waiting. Congestion occurs when transportation demand is high enough that interactions between vehicles hinder the flow of traffic. There are five typical causes of congestion, such as saturation or just having too many cars. Construction and maintenance, insufficient public transportation, weather and accidents, and bad driving habits. Since traffic jams is variable in structure, different places and times may require different mitigation strategies. The following basic congestion measures are listed in decreasing order.

- Enhance the public transportation system
- Maximize geometric design, especially in relation to creating grade separated intersections at grade intersections.
- Improve road capacity.
- Enhancing traffic control strategy.
- Optimizing parking operations.
- Reduce improper street trading; and.
- Work hour's flexibility.

4.4 Level of service analysis at selected roundabout before and after Constructing Over Pass Bridge

Analysis of the level of service at each intersection was undertaken using SIDRA Intersection 9.1 version software to determine congestion at intersections. Data such as traffic volume, geometric data, cycle length, and pedestrian volume are necessary to assess the level of service at each intersection. Geometric data for the road were gathered by field measurement and Google Earth; traffic volume and cycle length were calculated manually.

4.4.1 Passenger car equivalents (pcu)

The number of passenger cars that were produce the same operational conditions as a single heavy vehicle of a specific kind under equal road, traffic, and control conditions is known as the passenger car equivalent (PCE) or passenger car unit (PCU).Is a statistic used in transportation engineering to evaluate a highway's traffic flow The effect a form of transportation has on traffic characteristics (such headway, speed, and density) in comparison to a single car is also known as a passenger car equivalent. For instance, typical PCE (or PCU) values a measurement unit that involves converting various vehicle kinds into the equivalent passenger cars in terms of function.

vehicle Type	Equivalent PCU	
	% Composition of vehicle	
	5%	10% above
Motor cycle	0.5	0.5
Light Vehicle	1	1
Min Bus	1.4	2
Pickup(4WD)	1	1
Big Buss	1.5	2
Dump Truck	1.5	2
Heavy Truck With Trailer	2	2.2

Table 4.2 IRC Recommended PCU Factor for various vehicle on urban road

The recommended pcu factor should be multiplied by the volume of various vehicle types, according to the table below, in order to transform a heterogeneous vehicle into a homogeneous vehicle, in keeping with the analysis's conclusions.

No	Intersection	Approach Leg	Vehicle Type		Total Traffic Volume	PCU Conversion Factor	PCU	Pedestrian volume
1	Imperial-Gerji	Bole	Light Vehicle	LT	814	1	814	4236
				TH	2025	1	2025	
				RT	642	1	642	
			Min Bus	LT	470	1.4	658	
				TH	635	1.4	889	
				RT	472	1.4	660.8	
			Pickup(4WD)	LT	539	1	539	
				TH	513	1	513	
				RT	515	1	515	
			Big-Bus	LT	538	1.5	807	
				TH	595	1.5	892.5	
				RT	556	1.5	834	
			Dump Truck	LT	38	1.5	57	
				TH	66	1.5	99	
				RT	18	1.5	27	
			Heavy Truck With Trailer	LT	2	2	4	
				TH	51	2	102	
				RT	0	2	0	

Table 4.3 Bole approach legged passenger car unit value. Source: own data

No	Intersection	Approach Leg	Vehicle Type	Total Traffic Volume	PCU Conversion Factor	PCU	Pedestrian volume	
1	Imperial-Gerji	Gerji	Light Vehicle	LT	732	1	732	5231
				TH	1862	1	1862	
				RT	491	1	491	
			Min Bus	LT	472	1.4	660.8	
				TH	646	1.4	904.4	
				RT	438	1.4	613.2	
			Pickup(4WD)	LT	531	1	531	
				TH	530	1	530	
				RT	433	1	433	
			Big-Bus	LT	481	1.5	721.5	
				TH	607	1.5	910.5	
				RT	486	1.5	729	
			Dump Truck	LT	26	1.5	39	
				TH	56	1.5	84	
				RT	13	1.5	19.5	
			Heavy Truck With Trailer	LT	2	2	4	
				TH	28	2	56	
				RT	3	2	6	

Table 4.4 Gerji approach legged passenger car unit value. Source: own data

No	Intersection	Approach Leg	Vehicle Type		Total Traffic Volume	PCU Conversion Factor	PCU	Pedestrian volume
1	Imperial-Gerji	Hayahulet	Light Vehicle	LT	596	1	596	3654
				TH	1374	1	1374	
				RT	563	1	563	
			Min Bus	LT	401	1.4	561.4	
				TH	590	1.4	826	
				RT	398	1.4	557.2	
			Pickup(4WD)	LT	503	1	503	
				TH	503	1	503	
				RT	425	1	425	
			Big-Bus	LT	473	1.5	709.5	
				TH	529	1.5	793.5	
				RT	423	1.5	634.5	
			Dump Truck	LT	21	1.5	31.5	
				TH	35	1.5	52.5	
				RT	16	1.5	24	
			Heavy Truck With Trailer	LT	4	2	8	
				TH	18	2	36	
				RT	0	2	0	

Table 4.5 Hayahulete approach legged passenger car unit value. Source: own data

No	Intersection	Approach Leg	Vehicle Type		Total Traffic Volume	PCU Conversion Factor	PCU	Pedestrian volume
1	Imperial-Gerji	Megenagna	Light Vehicle	LT	1187	1	1187	3987
				TH	2719	1	2719	
				RT	1007	1	1007	
			Min Bus	LT	532	1.4	744.8	
				TH	696	1.4	974.4	
				RT	523	1.4	732.2	
			Pickup(4WD)	LT	566	1	566	
				TH	540	1	540	
				RT	529	1	529	
			Big-Bus	LT	556	1.5	834	
				TH	637	1.5	955.5	
				RT	568	1.5	852	
			Dump Truck	LT	38	1.5	57	
				TH	66	1.5	99	
				RT	15	1.5	22.5	
			Heavy Truck With Trailer	LT	3	2	6	
				TH	38	2	76	
				RT	0	2	0	

Table: 4.6 Megenagna approach legged passenger car unit value Source: own data

4.4.2 The configuration of the elements of the Imperial Gerji Roundabout

The main geometric elements of this roundabout, according to general observations, are the central island, circulatory roadway, splitter island, truck apron, crosswalk marking (zebra crossing), and sidewalks (see figure 4.7.1). Relating to how it is connected by dual roadways in both directions, Table 4.7.1 including the elements as advised by AACRA to accomplish safe and effective operation.

No.	Geometric Elements	Current Condition	AACRA standard
1	Central Island Diameter	21m	See table 4.8
2	Approach leg		Entry lane
	Hayahulet		2
	Bole		3
	Megenagna		3
	Gerji		2
No.	Geometric Elements	Current Condition	AACRA standard
3	Number of circulatory lane	10	See table 4.8
4	Average lane width	3.6	
5	Circulatory road width	11	
6	Number of exit lanes	4	
7	Roundabout lanes	2	

Table 4.7 Overview of Current Intersection Configuration

Different geometric data, such as island diameter, circulation width, and number of intersections, are required in accordance with the SIDRA Intersection Version 9.1 specification. At the roundabout junction's entrance, there are circulation lanes, entry lanes, an average lane width, and an entry lane count. Both a tape meter and observation of the roundabout's current configuration are used to measure these statistics. Table 4.7.2 provides an overview of the gathered geometric data.

Speed environment (km/h)	Central island diameter (m)	Circulating width (m)
40	15	11.10
50	15	11.10
60	25	11.30
70	30	10.00
80	40	9.60
90	40	9.60
100	40	9.60

Table 4.8 initial selection of two lane roundabouts' minimal central island diameters (AACRA, 2003)

4.4.3 Inscribed circle diameter

The approved inscribed ring a range of diameters for city dual lanes intersections, as per FHWA, is 45 m to 55 m, and the present inscribed circle diameter as well as the Gerji-Imperial roundabout's present inscribed circle diameter is 38m, it is lower than the lowest suggested significance It was among the contributing variables that greatly affected the roundabout's capacity. A small enough length of an inscribed circle cannot fit enough automobiles in the circulation lane.

4.5 Case One Gerji-Imperial Level of Service before Constructing Over Pass Bridge

The level of service Using SIDRA version 9.1 software, analyses at crossings were carried out. The following information is required in order to figure out the degree of service: Traffic volume, the geometry of the route, and the amount of pedestrians. The Addis Ababa City Roads Authority provides the road's geometric information; video cameras and a by hand travel density analysis method are used to measure traffic volume. The necessary information includes the following: the dimension of the island, the circulatory length, the amount of circulatory lanes, the number of entrance lanes, and the average lane length at the roundabout junction; the number of lanes, their widths and configurations, the grade, the width of the median, the moments of left and right turns, the moments of through turns, the moments of right turns, the peak hour factor, and the heavy vehicle factor.

Intersection	Geometric Data							Volume Data					
	Gerji- Imprial	Approach Leg	Number of Entry lane	No of Exit lane	Lane Width(m)	Grade direction of flow	Median Width(m)	Total Traffic Volume			Peak Hour Factor	Heavy Vehicle F	
LT								TH	RT	LT		TH	RT
	Bole	3	3	3.5	2.14	0	513	604	440	97	3.5	1.4	1.3
	Hayahulet	3	3	3.3	2.5	1	507	646	430	97	2.4	0.8	1.5
	Megenagna	3	3	3.5	0.95	0	468	528	381	93	2.1	1.2	2.3
	Gerji	3	3	3.3	0.68	0.95	551	639	481	94	3.4	2.6	2.6

Note: LT: left turn, TH: Through, and RT: Right turn

Table 4.9 SIDRA intersection analysis program input parameters

4.6 Output results from SIDRA intersection 9.1 analysis software before Constructing Over Pass Bridge

SIDRA Intersection version 9.1 software is used in together with the HCM 2000 right hand rule to analyze level of service. The level of analysis for the intersections suggests that the intersection are performing above capacity and have virtually LOS F, indicating that vehicles is traveling at extremely low speeds, with substantial delays and volumes. The degree of performance results derived by SIDRA software is presented in Table and figure below (Appendex1, 2023).

Lane Level of Service

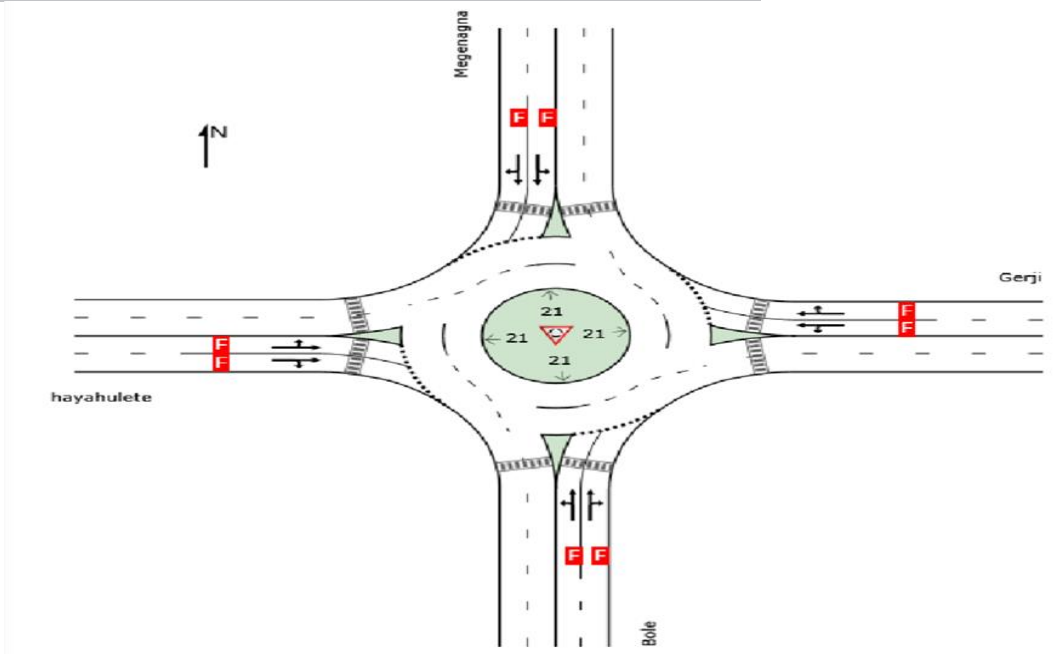
Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road MUTCD (FHWA 2009) example number: 3C-6 Roundabout Guide (TRB 2010) example number: A-7 Site Category: Existing Design

Roundabout

	Approaches				Intersection
	South	East	North	West	
LOS	F	F	F	F	F



DEGREE OF SATURATION

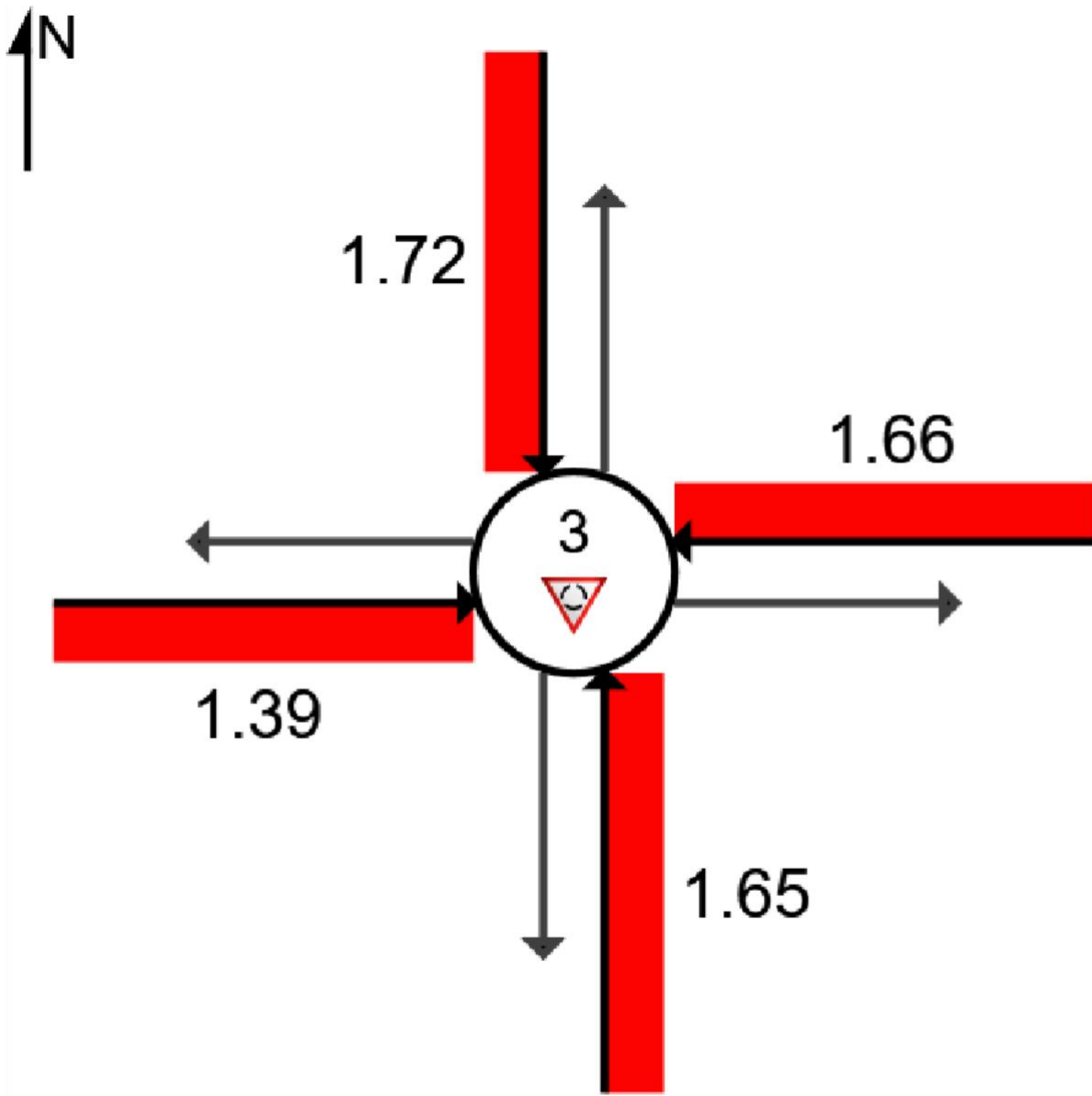
Ratio of Arrival Flow to Capacity, v/c ratio (worst lane for the approach)

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category:
 Existing Design

Roundabout



Colour code based on Degree of Saturation



[< 0.6] [0.6 - 0.7] [0.7 - 0.8] [0.8 - 0.9] [0.9 - 1.0] [> 1.0]

DEGREE OF SATURATION

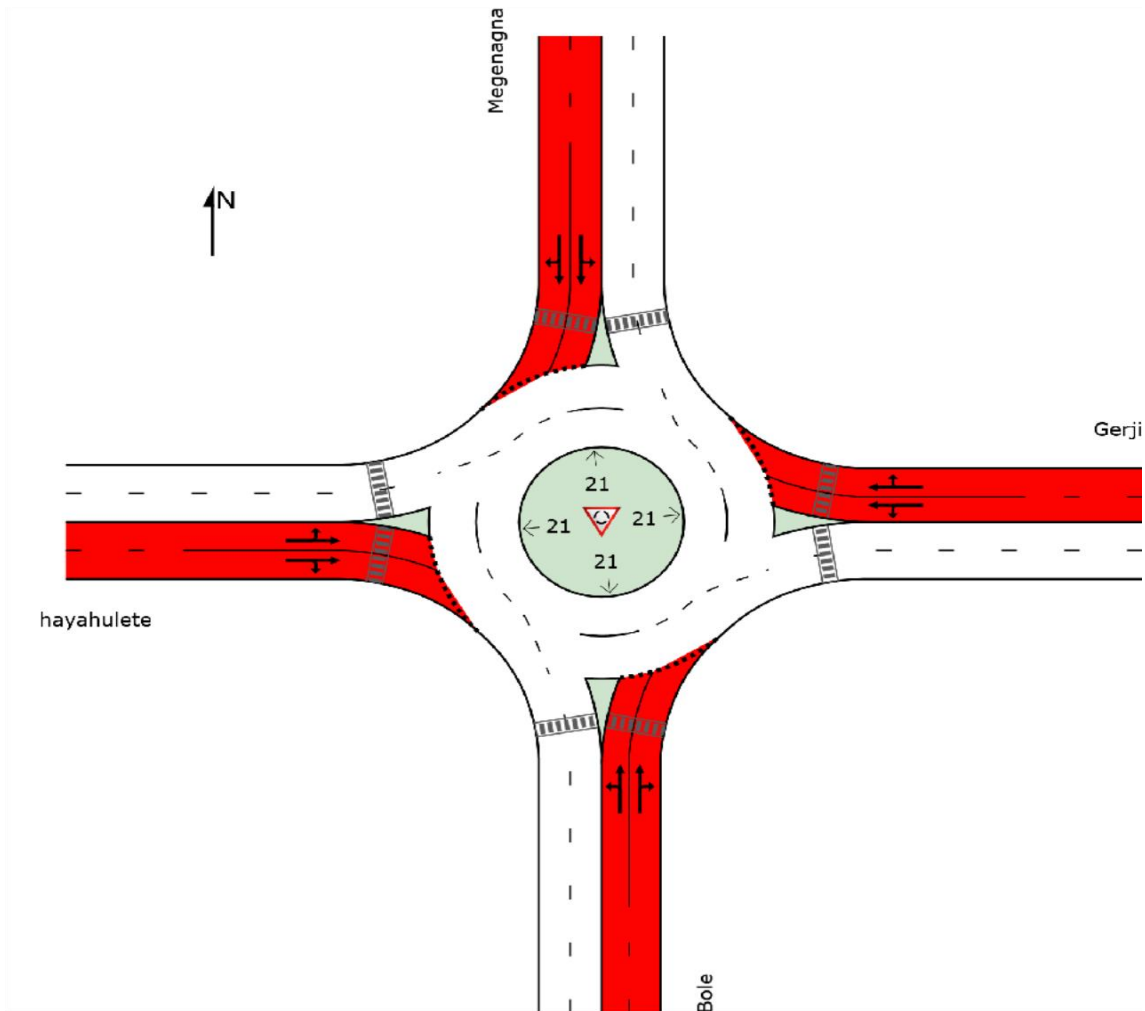
Ratio of Arrival Flow to Capacity, v/c ratio per lane

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

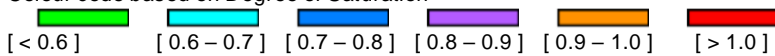
Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category: Existing
 Design

	Approaches				Intersection
	South	East	North	West	
Degree of Saturation	1.65	1.66	1.72	1.39	1.72



Colour code based on Degree of Saturation



DEGREE OF SATURATION

Ratio of Arrival Flow to Capacity, v/c ratio per movement

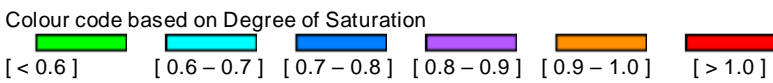
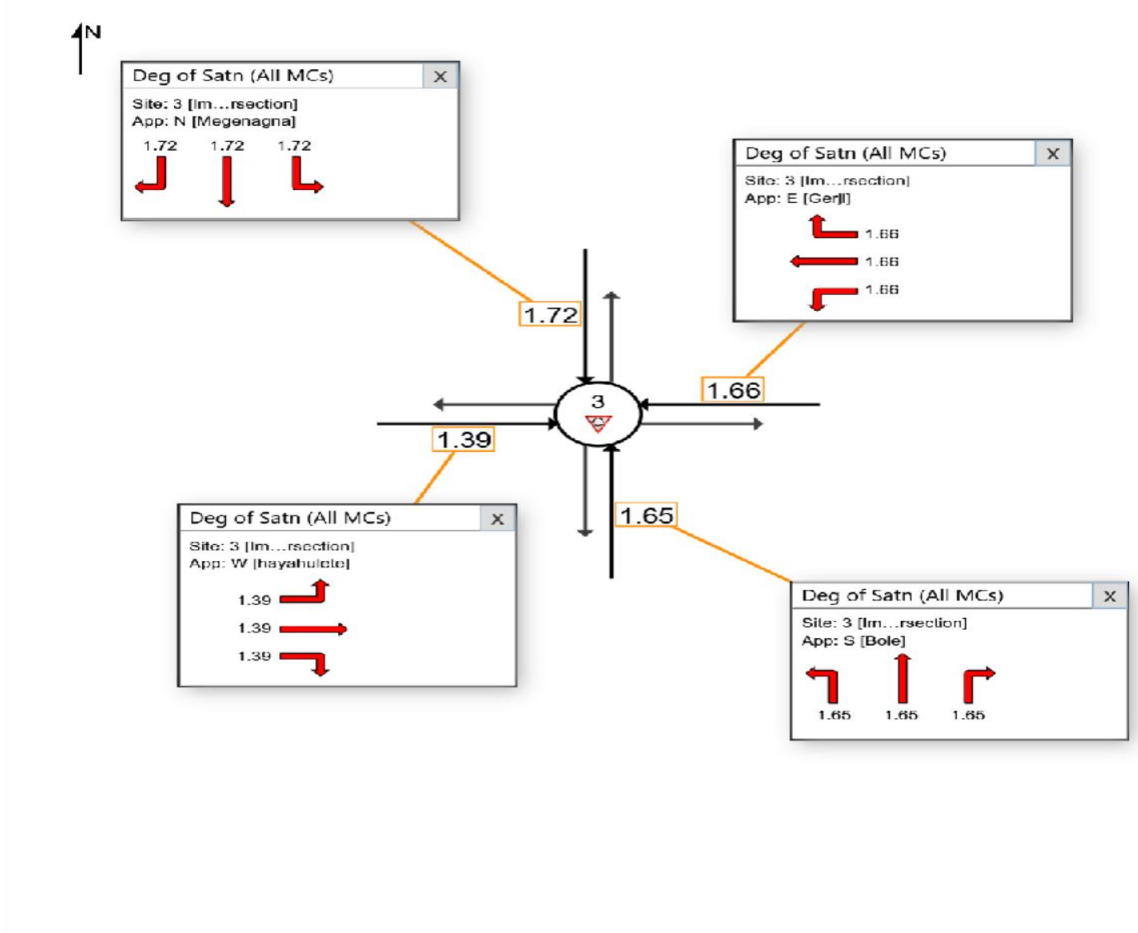
Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating Site
 Category: Existing Design

Roundabout

All Movement Classes



MOVEMENT SUMMARY

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout

Roundabout

Vehicle Movement Performance															
Mov ID	Turn	Mov Class	Demand Flows [Total HV] veh/h %		Arrival Flows [Total HV] veh/h %		Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h	
South: Bole															
513	L2	All MCs	558	0.0	558	0.0	1.647	319.0	LOS F	103.2	784.4	1.00	8.33	15.07	3.9
604	T1	All MCs	657	0.0	657	0.0	1.647	317.2	LOS F	116.8	887.3	1.00	8.87	15.94	3.9
440	R2	All MCs	478	0.0	478	0.0	1.647	316.3	LOS F	116.8	887.3	1.00	9.16	16.43	3.8
Approach			1692	0.0	1692	0.0	1.647	317.5	LOS F	116.8	887.3	1.00	8.77	15.79	3.9
East: Gerji															
507	L2	All MCs	551	0.0	551	0.0	1.665	326.4	LOS F	106.4	808.8	1.00	8.53	15.37	3.9
646	T1	All MCs	702	0.0	702	0.0	1.665	324.8	LOS F	120.4	914.8	1.00	9.07	16.24	3.8
430	R2	All MCs	467	0.0	467	0.0	1.665	323.8	LOS F	120.4	914.8	1.00	9.37	16.73	3.7
Approach			1721	0.0	1721	0.0	1.665	325.0	LOS F	120.4	914.8	1.00	8.98	16.09	3.8
North: Megenagna															
481	L2	All MCs	599	0.0	599	0.0	1.720	350.0	LOS F	117.2	890.7	1.00	8.96	16.11	3.6
639	T1	All MCs	695	0.0	695	0.0	1.720	348.4	LOS F	132.4	1006.3	1.00	9.52	17.01	3.6
551	R2	All MCs	523	0.0	523	0.0	1.720	347.5	LOS F	132.4	1006.3	1.00	9.84	17.52	3.5
Approach			1816	0.0	1816	0.0	1.720	348.7	LOS F	132.4	1006.3	1.00	9.43	16.86	3.5
West: hayahulete															
468	L2	All MCs	509	0.0	509	0.0	1.394	209.0	LOS F	69.2	525.7	1.00	6.56	11.52	5.5
528	T1	All MCs	574	0.0	574	0.0	1.394	207.0	LOS F	77.7	590.8	1.00	6.95	12.15	5.5
381	R2	All MCs	414	0.0	414	0.0	1.394	206.0	LOS F	77.7	590.8	1.00	7.15	12.47	5.5
Approach			1497	0.0	1497	0.0	1.394	207.4	LOS F	77.7	590.8	1.00	6.87	12.02	5.5
All Vehicles			6726	0.0	6726	0.0	1.720	303.4	LOS F	132.4	1006.3	1.00	8.58	15.32	4.0

4.7 Case Two Gerji-Imperial Level of Service after Constructing Over Pass Bridge

LANE LEVEL OF SERVICE

Lane Level of Service

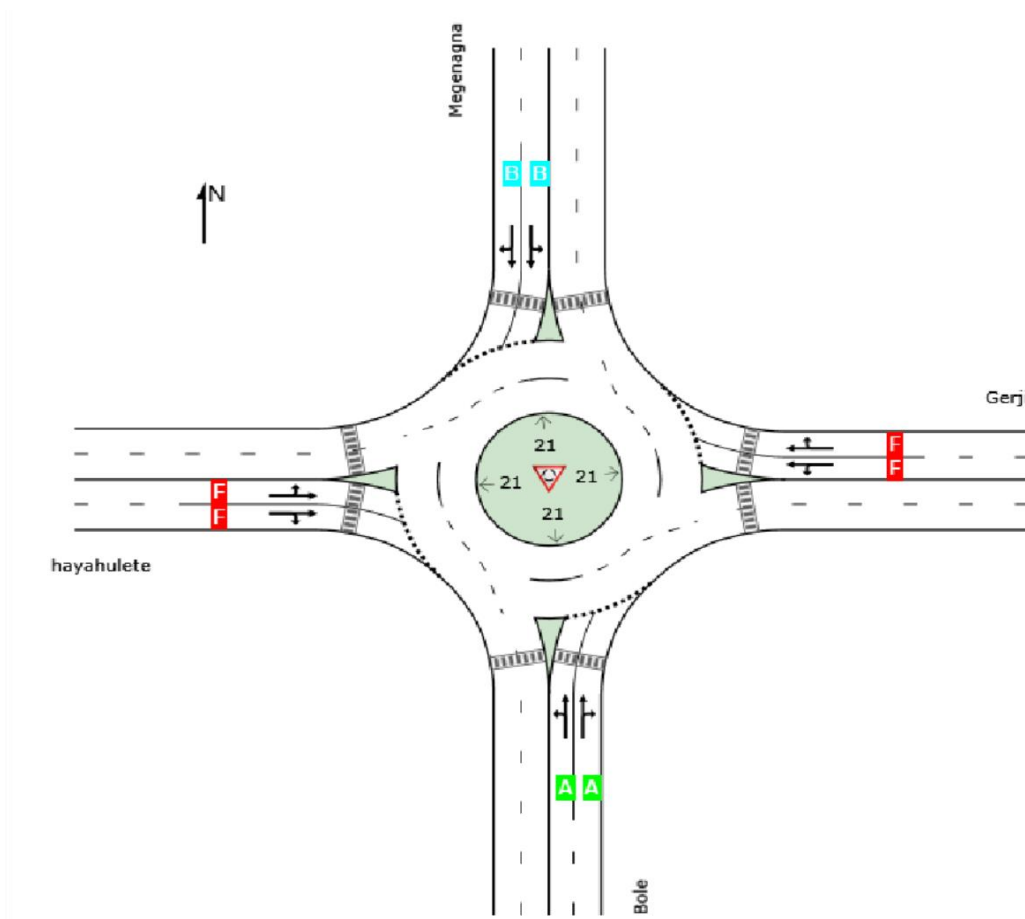
 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category: Existing
 Design

Roundabout

	Approaches				Intersection
	South	East	North	West	
LOS	A	F	B	F	F



MOVEMENT SUMMARY

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category: Existing
 Design

Roundabout

Vehicle Movement Performance															
Mov ID	Turn	Mov Class	Demand Flows		Arrival Flows		Deg. Satn	Aver. Delay	Level of Service	95% Back Of Queue		Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed
			[Total HV] veh/h	%	[Total HV] veh/h	%				[Veh.] veh	[Dist] m				
South: Bole															
51	L2	All MCs	55	0.0	55	0.0	0.163	10.0	LOS A	0.6	4.3	0.69	0.69	0.69	21.8
66	T1	All MCs	72	0.0	72	0.0	0.163	9.2	LOS A	0.6	4.3	0.67	0.67	0.67	24.7
35	R2	All MCs	38	0.0	38	0.0	0.163	8.9	LOS A	0.6	4.3	0.66	0.66	0.66	25.0
Approach			165	0.0	165	0.0	0.163	9.4	LOS A	0.6	4.3	0.68	0.68	0.68	23.7
East: Gerji															
507	L2	All MCs	551	0.0	551	0.0	1.104	85.0	LOS F	42.9	325.9	1.00	4.08	5.87	10.8
646	T1	All MCs	702	0.0	702	0.0	1.104	83.6	LOS F	46.4	352.5	1.00	4.19	5.99	10.7
430	R2	All MCs	467	0.0	467	0.0	1.104	82.7	LOS F	46.4	352.5	1.00	4.26	6.06	10.7
Approach			1721	0.0	1721	0.0	1.104	83.8	LOS F	46.4	352.5	1.00	4.17	5.97	10.7
North: Megenagna															
60	L2	All MCs	91	0.0	91	0.0	0.274	12.4	LOS B	1.0	7.6	0.73	0.76	0.78	21.0
99	T1	All MCs	108	0.0	108	0.0	0.274	11.4	LOS B	1.0	7.6	0.72	0.74	0.76	23.8
84	R2	All MCs	65	0.0	65	0.0	0.274	11.0	LOS B	1.0	7.6	0.71	0.73	0.75	24.1
Approach			264	0.0	264	0.0	0.274	11.6	LOS B	1.0	7.6	0.72	0.74	0.76	22.8
West: hayahulete															
468	L2	All MCs	509	0.0	509	0.0	1.023	62.5	LOS F	27.1	206.0	1.00	3.04	4.35	12.2
528	T1	All MCs	574	0.0	574	0.0	1.023	60.7	LOS F	29.2	221.8	1.00	3.10	4.42	13.0
381	R2	All MCs	414	0.0	414	0.0	1.023	59.8	LOS F	29.2	221.8	1.00	3.14	4.46	13.0
Approach			1497	0.0	1497	0.0	1.023	61.1	LOS F	29.2	221.8	1.00	3.09	4.41	12.7
All Vehicles			3647	0.0	3647	0.0	1.104	65.9	LOS F	46.4	352.5	0.97	3.32	4.71	12.3

4.8 Current capacity of gerji-imperial roundabout

4.8.1 Analysis of Volume to capacity

The research begins by attempting to answer the question of whether the existing facility is capable of serving the maximum predicted traffic on the roundabout. As indicated in the prior literature, the volume to capacity ratio assists in testing the road's adequacy for maximum estimated traffic during peak periods. Maximum passenger vehicle volumes are observed in the last hour of the morning peak periods (i.e. 8:00-9:00 a.m.) according to the observed flow pattern in the directional distribution study above. During reversible lane operation during the first hour of evening peak periods (i.e. 4:00-5:00 p.m.) on the Megenagna-Bole road and hayahulete –gerji. When doing the volume to capacity ratio, testing the roadway capacity for the route's highest predicted traffic can provide a representative number. Table 4.10 and 4.11 shown their figurative interpretations.

Volume/Capacity Ratio during lane operation (8:00-9:00 a.m.)

Road Segments	Peak Volume (PCU)	Bus & Truck (PCU)	Bus & Truck Proportion on Rate	Base Capacity (Pc/hr/lane)	Capacity (Pc/hr/lane)	Volume to Capacity
Megenagna to bole	243	910	0.5	900	1080	0.22
Hayahulet to Gerji	1862	985	0.5	900	1080	1.7

Table 4.10: Volume/Capacity Ratio during lane operation (8:00-9:00 a.m.& 4:00-5:00 p.m)

The volume to capacity ratios observed are 22% and 170% of the route capacity at Megenagna to Bole, respectively, indicating that Megenagna to Bole is under capacity due to the construction of a new overpass bridge, but Hayahulet to Gerji leg worked beyond capacity.

4.9 Vehicle delay and fuel consumption at a roundabout and Mitigation Measures

4.9.1 Estimated delay and fuel, and mitigation for vehicle

One parameter used to analyze congestion is delay. The gap among the permitted travel time and the actual journey time is used to compute it. When compared to the amount of time when there is free flow, wasted time is the additional time spent in congestion. A common metric used to assess an intersection's effectiveness is delay. At both signalized and un-signalized intersections, the Guidelines of Road Efficiency cites delay as the key measure of efficacy, the quality of the service being derived from the estimate of delay. Total section delay is a useful metric to calculate the whole length of a road sector's congestion in metropolitan settings, to conduct economic analysis, and to make

judgments that are simple for the public in general and policymakers to understand and put into practice. Figure output from the analysis reveals that the average vehicle delay is 303.4 seconds, which is much longer than what is advised for each service level. Hence, this demonstrated that the Gerji-Imperial roundabout provides poor service. To implement mitigation measures that reduce the time required to build a new overpass bridge from hayahulete and gerji segment, as well as to increase the roundabout diameter and width of the route

4.9.1 Fuel consumption for each vehicle at selected roundabout

Fuel Consumption, Emissions & Cost (Total)							
Mov ID	Turn	FuelTotal L/h	CO2 Totalkg/h	CO Total kg/h	HC Totalkg/h	NOX Totalkg/h	CostTotal \$/h
South: Bole							
513	L2	100.3	235.7	0.16	0.026	0.058	1094.25
604	T1	108.5	254.9	0.16	0.029	0.056	1239.41
440	R2	75.1	176.5	0.11	0.020	0.036	890.25
Approach		283.9	667.1	0.43	0.075	0.151	3223.90
East: Gerji							
507	L2	100.5	236.3	0.16	0.026	0.058	1084.70
646	T1	118.1	277.6	0.18	0.031	0.061	1352.39
430	R2	74.9	176.0	0.11	0.020	0.036	887.98
Approach		293.5	689.8	0.44	0.078	0.156	3325.08
North: Megenagna							
481	L2	114.5	269.0	0.18	0.030	0.065	1268.12
639	T1	123.0	289.1	0.18	0.033	0.063	1420.29
551	R2	88.4	207.8	0.13	0.024	0.042	1055.57
Approach		325.9	766.0	0.49	0.086	0.171	3743.98
West: hayahulete							
468	L2	71.9	169.1	0.11	0.018	0.047	720.80
528	T1	71.7	168.5	0.11	0.018	0.040	767.40
381	R2	48.3	113.4	0.07	0.012	0.025	542.69
Approach		191.9	451.0	0.29	0.049	0.112	2030.88
All Vehicles		1095.3	2573.9	1.65	0.288	0.589	12323.85

At peak hour, fuel consumption in each leg bole approached 284 L/h, megenagna leg 326 L/h, hayahulete approached 192L/h, and gerji approach utilised 294L/h, indicating a significant amount of fuel loss at the roundabout. (Appendex1, 2023)

4.10 Interviews were conducted to assess the effects before and after the construction of the overpass bridge.

Demographic	Response					
	Pedestrians		Traffic Officer		Derivers	
	No	%	No	%	No	%
Gender						
Male	20	60.6	10	71.42	22	68.75
Female	13	39.4	4	28.58	10	31.25
Age						
18-24	5	15.15				
25-34	8	25	12	85.71	26	81.25
35-44	10	31.25	2	14.29	6	18.75
45-54	4	12.5				
55+above	6	18.75				
Level of Education						
Complete high school	17	51.51	11	78.57	19	59.37
Diploma	4	12.12	3	21.43	5	15.62
Bachelor degree	10	30.3			7	21.87
Master's degree	2	6.1			1	3.14
PHD						

Table 4.10 Demographic data of pedestrians, traffic officers, and drivers

4.10.1 Interview Response for pedestrians, police officers, and drivers before and after constructing Overpass Bridge.

1. Is there vehicle congestion along round before constructing Overpass Bridge?
2. How do you see the current vehicle traffic flow along the street after constructing Overpass Bridge?
 - A) Very high congested B) Low congestion C) No congestion
3. Rank the major causes of congestion
 - A) Imbalance of vehicle volume and road capacity Inflexible work schedule
 - B) Illegal in street vehicle parking Un- availability of mass transport
 - C) Un- integrated land use In-formal on street trading
 - D) Poor vehicle condition Poor traffic management E) Bottlenecks Bad weather condition
 - F) Traffic accidents Special events Lack of good mass transport

4. What do you suggest to minimize congestion along the street after constructing Overpass Bridge?

A)Improve the road capacity B)Improve parking management C)Use mass transport D)Flexible work schedule F)Mitigate street on street trade G)Introduce HOV lane H)Improve traffic management strategy I)Improve light rail way transportation

According to the interviewer respondent, before the construction of the overpass bridge, there was congestion, a long queue, and it was difficult to manage a high volume of different vehicles, but after the construction of the overpass bridge, we saw an improvement, but still high congestion in two approaches and no traffic jams in others.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter includes the conclusion remarks for the primary findings in chapter four, as well as important recommendations based on the main concerns investigated in this research study. The key objective of this chapter is to convey comprehensive overviews of the research by summarizing the main findings of the analytical section and providing additional study options. As a result, the first section of the chapter begins by summarizing and concluding the study reviews and key results.

5.2 Summary

Based on the analysis, the following findings were identified; analysis of the impact and performance of overpass bridges provides significant understanding and useful indications about the performance of the city road network system. Roundabouts with Flyover Bridge need to be built to run more than 85% of their maximum capacity of junction. This study emphasized on the capability of roundabout and evaluation of the level of service at Gerji Imperial Roundabout, as well as its most significant functional component. The degree of congestion at the roundabout is 1.721, based on the findings of SIDRA junction 9.1 software, which is much higher than the recommended limit for delivering a sufficient level of service. As a result of the delay, fuel consumption was 1095.3L/H, CO₂ emissions were 2573.9Kg/h, hydro carbonate emissions were 0.288Kg/h, and nitrogen oxides (NO_x) emissions were 0.589, suggesting that the congestion had an impact on the surroundings. (Appendex1, 2023)

5.3 Conclusions

The following conclusions are reached based on the findings of this study's analysis.

Case One: Before constructing overpass Bridge

- ✚ The congestion ratio for the Imperial- Gerji roundabout is 1.72. This indicates that the intersection was over-congested for proper operation, the saturation level should be less than 0.85. As a result, and the roundabout operational function is inadequate.
- ✚ Main causes of congestion, such as saturation or just having too many cars. Construction and maintenance, insufficient public transportation, weather and accidents, and bad driving habits
- ✚ According to the study findings the level of service of imperial-Gerji intersection before constructing overpass bridge were **F** It indicates that the intersection was providing inadequate service. The volume of traffic is increasing. a site beyond the amount that can be served, resulting in forced traffic flow. **LOS F** is distinguished by stop-and-go traffic, long travel durations, a lack of comfort and convenience, and an increased risk of an accident.

- ✚ The current capacity of volume to capacity ratios observed are 22% and 170% of the route capacity at Megenagna to Bole, respectively, indicating that Megenagna to Bole is under capacity due to the construction of a new overpass bridge, but Hayahulet to Gerji leg worked beyond capacity. The intersection capacity has been overrun. Also, one of the reasons contributing to vehicle delays was an imbalanced large number of lanes and circular lanes, as well as high vehicle flow and populations, insufficient diameter of inscribed circle, and roundabout interaction with various road types
- ✚ According to the analysis, the overall fuel consumption due to the delay was 1095.3L/H, the carbon dioxide(CO₂) emission was 2573.9Kg/h, the hydro carbonate(HC) was 0.288Kg/h, and the nitrogen oxides (NOX)were 0.589, indicating that the congestion had an impact on the environment. Similarly, the average delay of automobiles at the intersection is around 303.4 seconds, which is above the acceptable range. As a result, it has been determined that the intersection is being used in more than of its capacity.

Case Two: After constructing overpass Bridge

- ✚ The volume capacity ratio of the Imperial-Gerji intersection Hayahulete and Gerji approach is 1.104. The megenagna approach was 0.274, and the bole approach was 0.163, indicating that the saturation level was less than 0.85, indicating that the operation was acceptable.
- ✚ According to the findings of the study, the Hayahulete and Gerji approaches remained LOS F after the building of the overpass bridge, it shows that the intersection provided insufficient service.
- ✚ the level of service of the Megenagna approach as a result of the overpass bridge construction was LOS B, It indicates that the intersection was acceptable in terms of flow, but that traffic conditions began to limit speeds with the installation of the overpass bridge, and
- ✚ The level of service of the Bole approach was LOS A, and It meant that the intersection was free-flowing, with few vehicles at rapid speeds. In addition.

5.4 Recommendations

The following recommendation has been forwarded to key policymakers for consideration.

- ❖ Geometric components of Imperial-gerji roundabouts should be modified and built appropriately in accordance with modern roundabout design guidelines since they are highly useful in terms of capability and traffic safety.
- ❖ To enhance the capability of an intersection during peak hours, I suggested constructing an additional flyover bridge from Hayahulete to Gerji, similar to the one built from Megenagna to Bole.
- ❖ I recommend constructing an additional channel in the four-way intersection approach to increase the intersection's capacity during peak hours and to enhance the level of service to LOS B.
- ❖ I suggest reducing traffic jams, expanding the route systems, and developing a public transportation system.
- ❖ It can be preferable to separate pedestrians from vehicular traffic at intersections where too much walker flows have been detected since the impact of regular traffic flows and junction capacities. In addition, this activity is required for the Pedestrian safety becomes critical.

5.5 Recommendations of future research

Considering the data acquired for analysis had been limited, especially at rush times, the diagram created by this research provides the only insight into the issue of my research. Further investigation with more data collecting is recommended in this regard in order to refine the chart and apply it in the improvement of intersection traffic level of services. The improved graphic may help the Addis Ababa City Road Authority in improving roundabout intersections. They can also use it to forecast traffic capacity in terms of land use. As a result, if because increased land use generates more traffic, the charts can be utilized to easily forecast traffic in relation to each intersection.

References

- AACRA. (2016). Addis Ababa City Roads and Transport Bureau. World Bank.
- Abdel-Aal, M. M. (2012). Factors Affecting Road Capacity Under non-Ideal Conditions . Nova Journal of Engineering and Applied Sciences , 1-6.
- Absil, N. E. (2008). Driver Behaviour Model For the Multi-Agent Real-time Simulation. Neil E. Absil.
- Akçelik, R. (1997). Lane-by-lane modelling of unequal lane use and flares at roundabouts and signalised intersections: the SIDRA solution. Vermont South VIC 3133, Australia.
- Appendix 1. (2023). Sidra intersection 9.1 output result. Software.
- Brilon, W. (1999). Investigation of Mini-Roundabouts. sage, 1-15.
- C. Friis, L. S. (2013). Pedestrian Microsimulation. A comparative study between the software programs Vissim and Viswalk. Semantic Scholar.
- Carmel. (2008). Roundabouts to Increase Community Resilience. sage.
- Collins, R. R. (2008). Evaluation of a Roundabout at a Five-Way Intersection: An Alternative Analysis Using Microsimulation. USA: UNIVERSITY OF MINNESOTA.
- EBN. (2021). Ethiopian Business Review .
- Engineering, J. o. (2012). Journal of Engineering and Sustainable Development . Academic Scientific Journals.
- Fambro, D. (1997). Determination of Stopping Sight Distances National Cooperative Highway Research Program, Transportation Research Board. National Academy Press, 4-9.
- FHWA. (2010). U.S. Department of Transportation. Retrieved from https://highways.dot.gov/sites/fhwa.dot.gov/files/Roundabouts_508.pdf
- Gagnon, C. (2008). Calibration Potential of Common Analytical and Micro-simulation Roundabout Models. England: University of Vermont, Burlington.
- Gebremedhin, E. T. (2015). EVALUATION OF EFFECTIVENESS OF TRAFFIC CALMING AT ROUNDABOUTS WITHIN NIFAS SILK LAFTO SUB CITY. Addis Ababa: ADDIS ABABA UNIVERSITY.
- Getu. (2015). Investigating Pedestrian Injury Crashes on Modern Roundabouts in Addis Ababa, Ethiopia. sage.
- Gilbert Gedeon, P. (2015). Roundabout Planning, Design, and. sayntific journal.
- GmbH. (2008). Research Gate. Retrieved from https://www.researchgate.net/figure/Cause-of-Traffic-Congestion-_tbl1_347174044
- Google. (2017).

- Google. (2022). Retrieved from
TheoryTest.org.uk,+2022Road+traffic&nfpr=1&sa=X&ved=2ahUKEwjMxfqBpLuBAxWIVv
EDHW4vA3oQvgUoAXoECACQAg&biw=1366&bih=657&dpr=1&bsh=1#ip=1
- Google, E. (2017).
- Gwilliam, K. (2003). Taylor & Francis. Retrieved from <https://www.tandfonline.com/>
- Harwood, D. (1996). Intersection Sight Distances. National Cooperative Highway Research Program, Transportation Research Board. National Academy Press, 5-13.
- HighwayCode. (2022). The Highway Code. UK: high way code UK.
- Hundi, D. J. (2008). Highway capacity manual. USA: the Transportation Research Board TRB.
- Ivana Nedevska a, S. O. (2017). Methodology for Analysing Capacity and Level of Service for Roundabouts with one Lane. Elsevier.
- Ivana Nedevska a, S. O. (2017). Methodology for Analysing Capacity and Level of Service for Roundabouts with one Lane. Elsevier.
- Jon, K. (2018). Adevanced community. elsevier.
- Jurnal, K. (2018). Evaluating Operational Performance of Intersections Using SIDRA. Resarch gate, 3-12.
- Kefyalew, T. A. (2017). Analysis of Traffic Congestion and its Economic Cost in Addis Ababa A Case Study of Meskel Square to Kality Interchange. Addis Ababa: Addis Ababa university.
- Kimber. (2002). Time-dependent queueing at road junctions: Observation and prediction. Elsevier.
- Kimber, R. (2002). Time-dependent queueing at road junctions: Observation and prediction. Elsevier.
- Kingdom, D. (. (2007). Geometric Design of Roundabouts (Vols. Volume 6, Section 2,). IRELAND: THE HIGHWAYS AGENCY, TRANSPORT SCOTLAND.
- Kosolapov. (2007). Managing urban traffic congestion. Athens: EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT.
- Krammes, R. e. (1995). Horizontal Alignment Design Consistency. washington DC: u.s. Department of Transportation.
- library, A. (2014). Academic library. 2014.
- Lomax, T. T. (1997). Quantifying Congestion. Washington D.C: National Academy Press.
- Mark Lenters, P. E. (2010). Improving Pedestrian Performance and Driver Response at Unsignalized Roundabout Crosswalks. Transportation Association of canada, 1-15.

- Mebratu, H. (2017). COMPARATIVE STUDY OF OPERATIONAL PERFORMANCE BETWEEN ROUNDABOUT AND SIGNALIZED INTERSECTION ADDIS ABABA CITY. Addis Ababa: Jimma University.
- Mounir, M. (2018). Factors Affecting Road Capacity Under non-Ideal Conditions in Egypt. Nova, 3-7.
- Mussone, L. (2015). Sensitivity analysis of traffic congestion costs in a network under a charging policy. Elsevier, 44-54.
- NCHRP. (2010). NCHRP REPORT 672 Roundabouts:An Informational Guide. USA: TRANSPORTATION RESEARCH BOARD .
- Novikov. (2017). The Analysis of Traffic Flow Forced traffic flow. Elsevier.
- Novikov. (2017). The Analysis of Traffic Flow Forced traffic flow. Elsevier.
- Planningtank. (2013). Level of service on roundabout. Retrieved from <https://www.google.com/search?q=Planning+Tank+2013,+Level+of+service+on+roundabout.&source=lmns&bih=657&biw=1366&cs=0&hl=en&sa=X&ved=2ahUKEwidjLWzyraBAxXB7LsIHbnPAfQQ0pQJKAB6BAgBEAI&bsh=m=rime/1#ip=1>
- Pratelli, A. (2006). Design of modern roundabouts in urban traffic systems. WIT Transactions on The Built Environment,.
- Quezon, P. T. (2006). Causes of Delays During Construction. International Journal of Scientific & Engineering Research, Volume 8.
- Schrank.F. (2014). Traffic congestion relief associated with public transport. Springer Link.
- Success, D. T. (2022). Complete learner driver guide to roundabouts. Retrieved from <https://www.drivingtestsuccess.com/blog/dayinsures-currrys-giveaway>
- Taekratok, T. (1998). Modern Roundabouts for Oregon. Oregon: Oregon Department of Transportation.
- Tank, P. (2013). Level of service on roundabout.
- TENAW, A. M. (2021). ASSESSEMENT ON THE CHALLENGES AND EFFECTIVENESS OF PEAK HOUR TRAFFIC MANAGEMENT IN ADDIS ABABA. Hawassa: Hawassa University.
- UK. (1993). Geometric Design of Roundabouts.
- UN-Habitat. (2017). Honiara Urban Resilience and Climate Action Plan.
- Wang, C. (2011). Design of Urban Road Overpass Plan. Highway Project. Universal Scientific, 83-86.
- Wong, S. C. (2012). Performance evaluations of the spiral-marking roundabouts in Hong Kong. Universal Sanitific, 3-12.

WSDOT. (2019). WSDOT Development Division, Design Office – Design Policy, Standards, and Safety Research. Washington: WSDOT publications:.

Zhou, T. C. (2012). Analysis of Urban Overpass Plan Cases. Urban Road, Bridge and Flood Prevention. Universe Scientific, 24-26.

ANNEXES

ANNEX: I PUBLISHABLE ARTICLE

Analysis of Traffic Congestion and its Economic Cost of Gerji-Imperial Roundabout: A Case Study in Addis Ababa

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Abstract: *Cities worldwide have experienced numerous issues, including traffic congestion, air pollution, noise pollution, and accidents. These issues, particularly transportation congestion, are projected to worsen in the near future. Due to traffic congestion, commuters' travel time and vehicle operating costs increase as fuel consumption and pollution rates rise. Following its economic growth, Addis Ababa has experienced traffic congestion, causing continuous problems for both road users and non-users. This article focuses on traffic congestion analysis and its economic cost by examining traffic congestion causes, consequences, patterns, and particularly its economic cost on roundabout. The trip time approach was utilized to analyze traffic congestion, whilst the level of service study was performed utilizing SIDRA intersections based on delay. Following that, the traffic cost is calculated by taking into account the delay to passenger vehicles, which includes operating costs, extra fuel wasted due to congestion, delay to truck vehicles, which includes operating costs, extra fuel wasted due to truck congestion, business cost, and finally the environmental cost of traffic congestion. Finally, based on the field visit study, solutions to reduce traffic congestion are recommended. Based on the investigation, it was discovered that the average annual cost of congestion, including delays, wasted fuel, and operational costs for trucks and passenger cars at each road segment, is roughly Birr 95.92 million. Furthermore, studies indicate that traffic congestion has an adverse effect on the environment, since it leads to higher fuel use and pollution emissions that was 2,818,420.5kg of CO₂ in environment.*

Keywords: *Congestion, Sidra, delay*

1. Introduction

Traffic congestion at Addis Ababa crossroads is now common during the morning and afternoon. As a result, traffic officers must intervene to control traffic flow by bypassing traffic control systems. Cities around the world are currently dealing with traffic congestion, air and noise pollution, and accidents. These urban difficulties, particularly transportation congestion, are anticipated to worsen in the near future. As a result, Addis Ababa is currently experiencing traffic congestion. Individuals are experiencing a variety of side effects, such as temporal delays during the day. Activities, air pollution, noise pollution, excessive vehicle fuel use, excessive vehicle for those businessmen, it creates operating costs such as higher costs for spare parts and unnecessary fuel. Higher expenses because supply may not be available at the time, extra inventory costs to be avoided. Congestion has an impact on their business, causing them to lose time and their employees to perform poorly. their abilities day-to-day activities of the population of Addis Ababa.

2. Literature Review

2.1 Definition of Traffic Congestion

There is no universally agreed-upon definition of traffic congestion. One of the primary reasons for this lack of agreement is that congestion is both a physical phenomenon relating to how vehicles impede each other's progress as demand for limited road space approaches full capacity and a relative phenomenon relating to user expectations with regard to road system performance. Congestion is described as a condition of traffic delay (when the flow of traffic is delayed below normal speeds) caused by the number of vehicles attempting to use the route exceeding the capacity of the traffic network to accommodate them. Traffic delays can have a wide range of negative consequences for people and the corporate economy. (Brilon, 1999)

2.2 Causes of Traffic Congestion

Different factors contribute to traffic congestion. According to Schrank et al (2013), the causes of traffic congestion are as follows: first, many people and a large amount of goods moving at the same time; second, slow development in supply; and third, numerous journeys being delayed due to unforeseen circumstances. The Economic Cost of Traffic Congestion in Addis Ababa (Case of Imperial Gerji). However, frequent collisions, vehicle breakdowns, incorrectly timed traffic signals, special events, and weather are all factors that contribute to traffic congestion. Habtamu (2017) summarized the key causes of traffic congestion in another study as follows: traffic accident, construction zone, damage to existing traffic signals. In addition to the preceding, Mahmud1 et al, (2012) research summarizes the key reasons of traffic congestion as follows:

1) Narrow roads

Streets are not very wide, and as a result of unlawful possession on the road, they are becoming narrower and becoming a source of traffic congestion. As a result, every opportunity exists to enlarge the road in accordance with their right-of-way in order to relieve traffic congestion. Furthermore, because land acquisition would not be required in this procedure, it will be less expensive and less time consuming.

2) Illegal Parking

Illegal parking on the road has been creating congestion every day. On-road parking of vehicles is one of the main reasons behind serious traffic congestion on different parts of the routes.

3) Increasing number of population

All the areas under cities are facing an increasing number of populations which is a bad indicator for the traffic management and this could be a vital reason behind traffic.

4) Higher purchasing power of the public

Due to the higher purchasing power of the citizen of cities, the popularity of private transportation is increasing and but existing roads and highways are not supportive or changing according to the increasing number of vehicle. As a result vehicle congestion is increasing at an alarming rate

5) Improper planning of city development

Development Plan has its long term city development planning. However, that planning is not proper. Most of the time it is seen that some illegally ceased roadside land, but due to the vague development plan these kinds of movements are going in vain.

6) Improper lane management

Lane management is an important fact in managing the traffic. Many types of the vehicles try to overtake other vehicles even in the single undivided road. This is the main reason that the city roads are unequipped with the lane dividers which divide the lane into incoming and outgoing traffic.

2.3 Traffic Congestion's Effects

Congestion causes queues, slower speeds, and longer travel times, all of which cost the economy and have a variety of effects on metropolitan areas and their residents. Congestion also has a number of indirect effects, such as the marginal environmental and resource implications of congestion, effects on quality of life, stress, and safety, and effects on non-vehicular road space users such as pavement users and road frontage properties. The effects of traffic congestion can be classified into three categories: economic, health, and environmental. Traffic congestion has a significant economic impact since society loses money in four ways, as illustrated below. (Mounir, 2018)

- Loosing man-hours; Extra transportation cost; Extra fuel consumptions; Vehicle operating cost; and Miscellaneous cost.

Due to traffic congestion, the main sufferers are classified as follows:

(i). General peoples

Most People are suffering some kind of physical or mental discomfort due to traffic congestion

And some ways of suffering are listed as follows: Breathing problem, headache, mental stress,

Hearing problem, unexpected sweating, tiredness, and eye problem. (Fambro, 1997)

(ii). Vehicle operators

The ways of sufferings for the vehicle operators are almost similar to other people. The main sufferings due to traffic congestion are: headache, pain in the body, and excessive sweating. Analysis of Traffic Congestion and its Economic Cost in Addis Ababa Traffic congestion impacts on the environment can be viewed it two ways as sound pollution and air pollution causes environmental pollution in two main ways. The effects of sound pollution are: students in the nearby school are disrupted their study by noise and to the nearby society causes headache difficulty in concentration and sleeping, bad tempers, and experiences hearing problems. So, air pollution as traffic becomes congested it introduces air pollution through periods of time and their engine is on, they emit SO_x, NO_x much which are lighter than air but very dangerous for our health and they even can cause death (Mussone, 2015)

2.4 Traffic Congestion Factors

Different factors contribute to traffic congestion. The following factors contribute to traffic congestion: the movement of people and a large amount of freight at the identical period, slow growth in infrastructure supply, and trips that are delayed due to unforeseen events. However, frequent collisions, vehicle breakdowns, improperly timed traffic signals, special events, and weather are all factors that contribute to traffic congestion (Schrank.F, 2014)

Furthermore, a study summarizes the main causes of traffic jams as shown below Roads are not very wide, but because of illegal dumping, they are becoming narrower and contributing to traffic congestion. Therefore, there is always a chance to enlarge the route in accordance with their right-of-way to ease traffic congestion. Additionally, this process won't involve the need for land acquisition; it was less expensive and takes less time. Illegal Parking: - Each day, unauthorized car park on the road causes congestion. Some of the major causes of severe traffic congestion on various parts of the routes is vehicle on-road parking. Population growth:- Every one of the places that are part of towns are facing population increase, which is negative for traffic management and may be a major factor in traffic (Abdel-Aal, 2012)

3. RESEARCH METHODOLOGY

3.1 Study Area

Addis Ababa, located in the horn of Africa and has the coordinates 9°01'48" North, 38°44'24" East, and having a 2355 m above sea level average elevation. The City covers over 527 km² in total area. The City, which is the most important commercial and industrial center in the city, is divided into 116 wereda and 11 administrative sub-cities. The key challenge Addis Ababa is the city's expanding need for mobility and transportation. This could lead to serious operational issues, such as congestion and least level of service especially during peak times. The study selected is an example of main road corridors that represent significant traffic activities (Google, 2017)

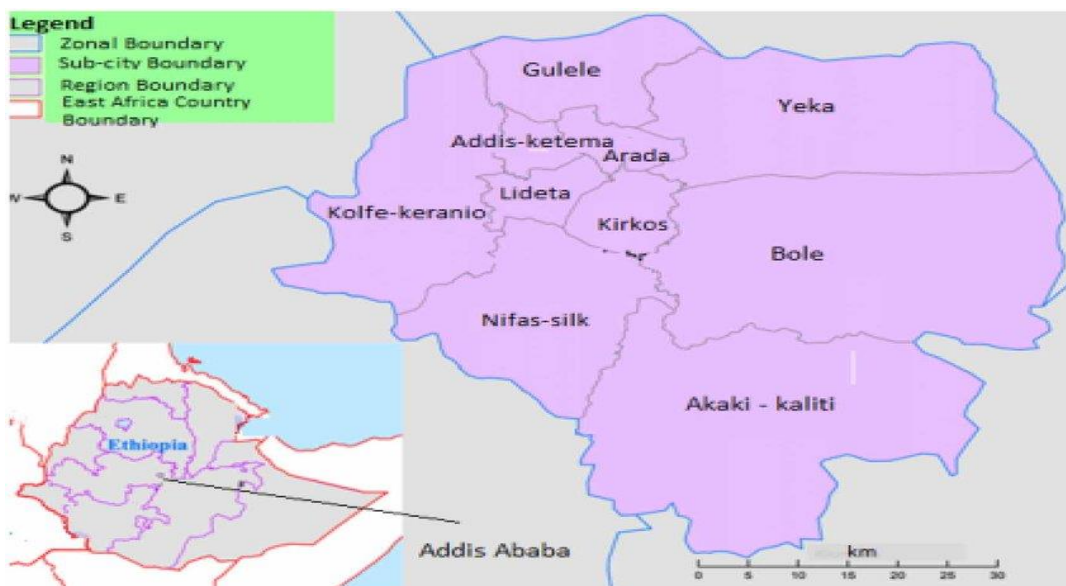


Figure 3-1: Selected Research area Source: (Google, 2022)

3.2 Research Design

To analyze the operational characteristics of congestion and economics, the level of service of the junction must be determined through field observations, which include traffic volume data, geometry data, and other relevant data. The data is then reduced and analyzed using the chosen methods of analysis. Based on the results of the investigation, analyses the contributing variables that affect the operational features of the congestion and, consequently, address the corrective solutions. The study has used quantitative data and analysis with the SIDRA INTERSECTION software version 9.1 models to address the specific research objective. Relevant data. The data is then filtered and analyzed using the methods of analysis that have been chosen. Analyses the factors that affect the roundabout's operating capabilities, as well as the preventative procedures, based on the analysis results.

3.3 Sample Size

The sample size was determined by a field survey, and all relevant inputs are collected directly at the research location.

3.4 Study Variables

The study variables are categorized into two. These are dependent variable and independent variables.

Dependent variable

- Delay

Independent Variables

- Volume of Vehicle, Lane width, Lane number, Road conditions, and Saturation flow rate

3.5 Process of Data Collection

Different data are needed in order to accomplish the objective of the study and provide answers to the research questions that have been created. These data can be divided into two categories: (1) Primary data, and (2) Secondary data.

3.6 Analysis Software

There were various computer programmers available to analyze traffic operations at roundabouts and signalized intersections. The software classified into two types: There are macroscopic and microscopic models. The macrocosm Intersections are modeled using traffic volume flows in models.as isolated locations. The, on the other hand, tiny models are used to imitate the movement of separate cars, enabling for a network-wide analysis. One of the macroscopic models was used for research. The software program (SIDRA) is used to analyze traffic. At the roundabout, operations are taking place. In reality, AACRA is likewise a SIDRA Intersection software is recommended for capacity. Analysis created via the use of analytic techniques with some geometric features. Because of this the Signalized and Un-signalized Intersection It was preferable to use Design and Research Aid (SIDRA) software. For capacity analysis due to the following factors:

4. RESULTS AND DISCUSSION

4.1 Analysis of Traffic volume at imperial gerji roundabout

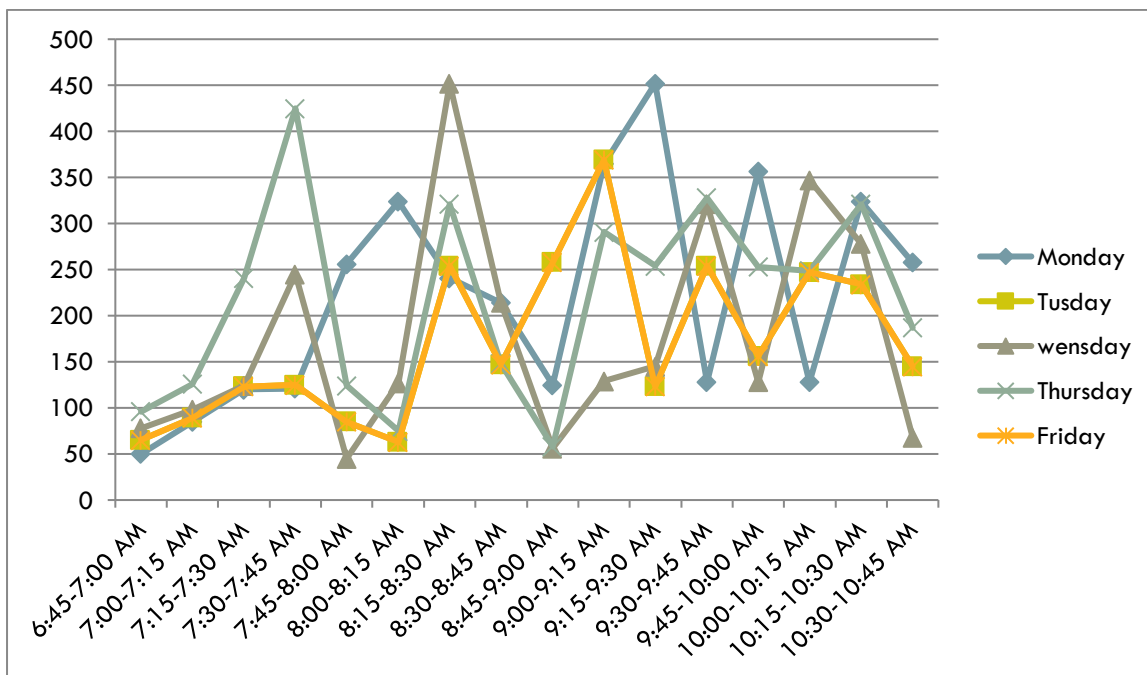
Traffic volume Analysis was done for twelve hours per day 6:00-11:59AM Morning and to afternoon 12:00-6:00 PM for seven days in each intersection. The directional traffic volume was analyzed Gerji-imperial four legs non signalized intersection.

4.2 Analysis of Traffic Congestion

Congestion can be assessed in a variety of ways, yielding varying estimates of the costs and benefits of various congestion-reduction techniques. As a result, the trip time technique is employed in this study to analyze congestion and its economic effects. For each urban roadway stretch, the following parameters were utilized to generate the congestion performance measures: journey time, traffic volume statistics, average travel speed, threshold travel speed, travel rate, travel time, travel time index, delay, delay rate, delay ratio, total segment delay, vehicle volume, and vehicle speed are all examples of travel time.

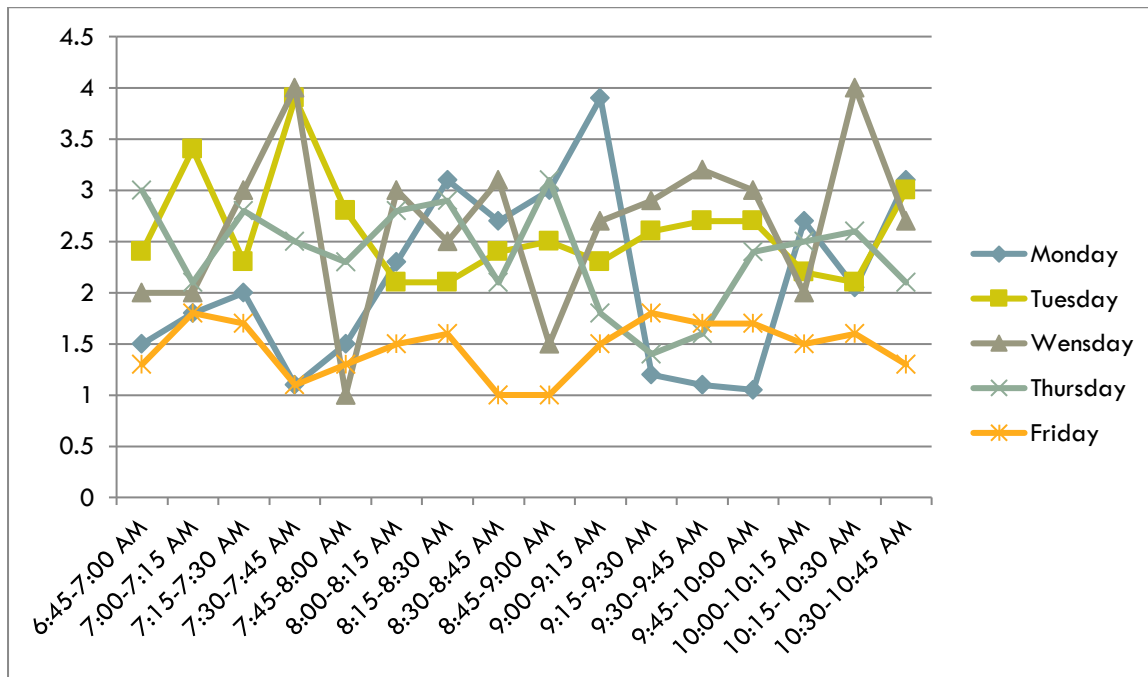
4.3 Travel Time

The selected approaches' average travel time was determined at 15-minute intervals. According to the results presented in Figure 4.4.3 below, the morning and evening peak periods had the lowest travel time because most people travel in the city center. During the morning peak period, the Gerji-Imperial approach is extremely congested.



4.4 Travel Speed

Figure 4.4 below shows the average travel speeds for the selected Approach at each intersection. The findings demonstrate that during the morning peak hours at the intersection of Gerji-imperial the intersection was most congested when the approach speed was less than 4 kilometers per hour.



4.5 Delay, Delay Rate, Delay Ratio and Percent of Daily Delay

Delay is the amount of extra time spent travelling due to road congestion, and it is calculated using the baseline speed measured on the lowest travel time throughout the day. The delay occurred during the morning and evening peak hours, although the length of each section differed. As a result, interpreting delay straight from the number before converting to the same unit length is challenging. Even though the imperial gerji road segment is the lowest, the delay on this segment is the most due to the huge number of people and interference movements on the road segment.

4.6 Passenger car equivalents (pcu)

The number of passenger cars that were produce the same operational conditions as a single heavy vehicle of a specific kind under equal road, traffic, and control conditions is known as the passenger car equivalent (PCE) or passenger car unit (PCU).Is a statistic used in transportation engineering to evaluate a highway's traffic flow The effect a form of transportation has on traffic characteristics (such headway, speed, and density) in comparison to a single car is also known as a passenger car

equivalent. For instance, typical PCE (or PCU) values a measurement unit that involves converting various vehicle kinds into the equivalent passenger cars in terms of function.

4.7 Output results from SIDRA intersection 9.1 analysis software

MOVEMENT SUMMARY

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category:
 Existing Design

Roundabout

Vehicle Movement Performance													
Mov ID	Turn	Mov Class	Demand Flows [Total HV]	Arrival Flows [Total HV]	Deg. Satn	Aver. Delay	Level of Service	95% Back Of Queue [Veh.]	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed	
			veh/h %	veh/h %	v/c	sec		Dist] m				km/h	
South: Bole													
51	L2	All MCs	55 0.0	55 0.0	0.163	10.0	LOS A	0.6	4.3	0.69	0.69	0.69	21.8
66	T1	All MCs	72 0.0	72 0.0	0.163	9.2	LOS A	0.6	4.3	0.67	0.67	0.67	24.7
35	R2	All MCs	38 0.0	38 0.0	0.163	8.9	LOS A	0.6	4.3	0.66	0.66	0.66	25.0
Approach			165 0.0	165 0.0	0.163	9.4	LOS A	0.6	4.3	0.68	0.68	0.68	23.7
East: Gerji													
507	L2	All MCs	551 0.0	551 0.0	1.104	85.0	LOS F	42.9	325.9	1.00	4.08	5.87	10.8
646	T1	All MCs	702 0.0	702 0.0	1.104	83.6	LOS F	46.4	352.5	1.00	4.19	5.99	10.7
430	R2	All MCs	467 0.0	467 0.0	1.104	82.7	LOS F	46.4	352.5	1.00	4.26	6.06	10.7
Approach			1721 0.0	1721 0.0	1.104	83.8	LOS F	46.4	352.5	1.00	4.17	5.97	10.7
North: Megenagna													
60	L2	All MCs	91 0.0	91 0.0	0.274	12.4	LOS B	1.0	7.6	0.73	0.76	0.78	21.0
99	T1	All MCs	108 0.0	108 0.0	0.274	11.4	LOS B	1.0	7.6	0.72	0.74	0.76	23.8
84	R2	All MCs	65 0.0	65 0.0	0.274	11.0	LOS B	1.0	7.6	0.71	0.73	0.75	24.1
Approach			264 0.0	264 0.0	0.274	11.6	LOS B	1.0	7.6	0.72	0.74	0.76	22.8
West: hayahulete													
468	L2	All MCs	509 0.0	509 0.0	1.023	62.5	LOS F	27.1	206.0	1.00	3.04	4.35	12.2
528	T1	All MCs	574 0.0	574 0.0	1.023	60.7	LOS F	29.2	221.8	1.00	3.10	4.42	13.0
381	R2	All MCs	414 0.0	414 0.0	1.023	59.8	LOS F	29.2	221.8	1.00	3.14	4.46	13.0
Approach			1497 0.0	1497 0.0	1.023	61.1	LOS F	29.2	221.8	1.00	3.09	4.41	12.7
All Vehicles			3647 0.0	3647 0.0	1.104	65.9	LOS F	46.4	352.5	0.97	3.32	4.71	12.3

LANE SUMMARY

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6 Roundabout
 Guide (TRB 2010) example number: A-7 Site Category:
 Existing Design

Roundabout

Lane Use and Performance															
	Demand Flows		Arrival Flows		Cap.	Deg. Satn	Lane Util.	Aver. Delay	Level of Service	95% Back Of Queue		Lane Config	Lane Length	Cap. Prob. Adj. Block.	
	[Total veh/h]	[HV %]	[Total veh/h]	[HV %]						[Veh]	[Dist]			Adj. Block.	Adj. Block.
South: Bole															
Lane 1	77	0.0	77	0.0	473	0.163	100	10.0	LOS A	0.6	4.3	Full	300	0.0	0.0
Lane 2 ^d	88	0.0	88	0.0	538	0.163	100	8.9	LOS A	0.6	4.3	Full	300	0.0	0.0
Approach	165	0.0	165	0.0		0.163		9.4	LOS A	0.6	4.3				
East: Gerji															
Lane 1	820	0.0	820	0.0	743	1.104	100	85.0	LOS F	42.9	325.9	Full	300	0.0	7.5
Lane 2 ^d	901	0.0	901	0.0	816	1.104	100	82.7	LOS F	46.4	352.5	Full	300	0.0	10.0
Approach	1721	0.0	1721	0.0		1.104		83.8	LOS F	46.4	352.5				
North: Megenagna															
Lane 1	123	0.0	123	0.0	450	0.274	100	12.4	LOS B	1.0	7.6	Full	300	0.0	0.0
Lane 2 ^d	141	0.0	141	0.0	515	0.274	100	11.0	LOS B	1.0	7.6	Full	300	0.0	0.0
Approach	264	0.0	264	0.0		0.274		11.6	LOS B	1.0	7.6				
West: hayahulete															
Lane 1	711	0.0	711	0.0	695	1.023	100	62.5	LOS F	27.1	206.0	Full	300	0.0	0.0
Lane 2 ^d	786	0.0	786	0.0	768	1.023	100	59.8	LOS F	29.2	221.8	Full	300	0.0	0.0
Approach	1497	0.0	1497	0.0		1.023		61.1	LOS F	29.2	221.8				
All Vehicles	3647	0.0	3647	0.0		1.104		65.9	LOS F	46.4	352.5				

DEGREE OF SATURATION

Ratio of Arrival Flow to Capacity, v/c ratio per lane

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Roundabout

	Approaches				Intersection
	South	East	North	West	
Degree of Saturation	1.65	1.66	1.72	1.39	1.72

4.8 Congestion Economic Cost Analysis

The economic cost of traffic congestion is a major concern around the world. There is no single method for calculating the economic cost of traffic congestion, and it varies based on the economic profile of the area and the specific pattern of congestion. This article describes processes for calculating the economic cost of traffic congestion using the trip time methodology. It provides an overview of the economic cost of congestion in Addis Ababa, particularly at the Imperial Gerji roundabout, which includes passenger car delay costs, passenger car excess fuel consumption due to congestion, truck vehicle delay costs and excess fuel consumption due to congestion, cargo delays, vehicle delay costs that include operators' costs and vehicle operating costs excluding fuel cost. The following parameters must be known in order to determine overall congestion costs: Total segment delay (Vehicle min), vehicle occupancy, total segment delay (person min), total segment delay (person min), delay per Total Segment Delay (person min) Analysis of Traffic Congestion and its Economic Cost in Addis Ababa (Case of Imperial Gerji Intersection traveler (annual hrs.), passenger car fuel economy (liter/km), passenger car fuel economy (liter/km), truck fuel economy (liter/km) fuel wasted by passenger cars, annual fuel wasted by trucks, annual fuel consumed of trucks, annual passenger vehicle delay cost, annual passenger fuel cost, annual truck delay cost, annual truck fuel cost, annual commodity congestion sensitivity, CO2 emissions

4.9 Passenger Delay Cost

Passenger delay cost is the expense experienced by passengers as a result of traffic congestion. Vehicle occupancy data is calculated by multiplying the capacity of each vehicle by the number of vehicles on the road segment and dividing by the total number of vehicles on the road segment. The annual conversation factor is calculated by multiplying the daily passenger vehicle count by a factor of ten. Annual passenger cars are delayed by hours. There is no service on Sundays and holidays. Congestion. Ethiopia has 52 Sundays and 11 holidays each year. So, annual discussion the factor is 365 minus 63, which is 302.

5. Conclusion

Based on the results of the study the following major conclusions are formulated:

- ❖ Total congestion costs, including delay costs and wasted fuel costs of passenger and truck vehicles at the road segments, were calculated at ETB 64,940,309.52, 32,265,882.55, 65,517,437.03 and 109,244,561.02 in the four approached directions.
- ❖ Congestion has also had an environmental impact due to the release of various pollutants. CO₂ is the most significant of the several pollutants.
- ❖ The total environmental cost of CO₂ generated by imperial gerji road segments was ETB 904,263.07 due to congestion.
- ❖ The costs of atmospheric damage were estimated to be between \$10 and \$50 per ton of carbon dioxide; however some estimates are as high as \$300 or more per ton. So, in this article, a \$50 cost for atmospheric damage was accounted for, which is equivalent to Birr2120/1000kg or Birr1.8/kg of CO₂.

References

- AAbdel-Aal, M. M. (2012). Factors Affecting Road Capacity Under non-Ideal Conditions . *Nova Journal of Engineering and Applied Sciences* , 1-6.
- Absil, N. E. (2008). *Driver Behaviour Model For the Multi-Agent Real-time Simulation*. Neil E. Absil.
- Akçelik, R. (1997). *Lane-by-lane modelling of unequal lane use and flares at roundabouts and signalised intersections: the SIDRA solution*. Vermont South VIC 3133, Australia.
- C. Friis, L. S. (2013). Pedestrian Microsimulation. A comparative study between the software programs Vissim and Viswalk. *Semantic Scholar*.
- Collins, R. R. (2008). *Evaluation of a Roundabout at a Five-Way Intersection: An Alternatives Analysis Using Microsimulation*. USA: UNIVERSITY OF MINNESOTA.
- EBN. (2021). Ethiopian Business Review .
- Engineering, J. o. (2012). Journal of Engineering and Sustainable Development . *Academic Scientific Journals*.
- Fambro, D. (1997). Determination of Stopping Sight Distances National Cooperative Highway Research Program, Transportation Research Board. *National Academy Press*, 4-9.
- Gagnon, C. (2008). *Calibration Potential of Common Analytical and Micro-simulation Roundabout Models*. England: University of Vermont, Burlington.
- GGwilliam, K. (2003). *Taylor & Francis*. Retrieved from <https://www.tandfonline.com/>
- Harwood, D. (1996). Intersection Sight Distances. National Cooperative Highway Research Program, Transportation Research Board. *National Academy Press*, 5-13.
- HighwayCode. (2022). *The Highway Code*. UK: high way code UK.
- Hundi, D. J. (2008). *Highway capacity manual*. USA: the Transportation Research Board TRB.
- Ivana Nedevska a, S. O. (2017). Methodology for Analysing Capacity and Level of Service for Roundabouts with one Lane. *Elsevier*.
- ISuccess, D. T. (2022). *Complete learner driver guide to roundabouts*. Retrieved from <https://www.drivingtestsuccess.com/blog/dayinsures-currys-giveaway>
- Taekratok, T. (1998). *Modern Roundabouts for Oregon*. Oregon: Oregon Department of Transportation.
- Tank, P. (2013). Level of service on roundabout.
- Wang, C. (2011). Design of Urban Road Overpass Plan. Highway Project. *Universal Scientific*, 83-86.

ANNEX II: Sidra Intersection 9.1 Analysis out put before constructing Overpass Bridge

LANE LEVEL OF SERVICE

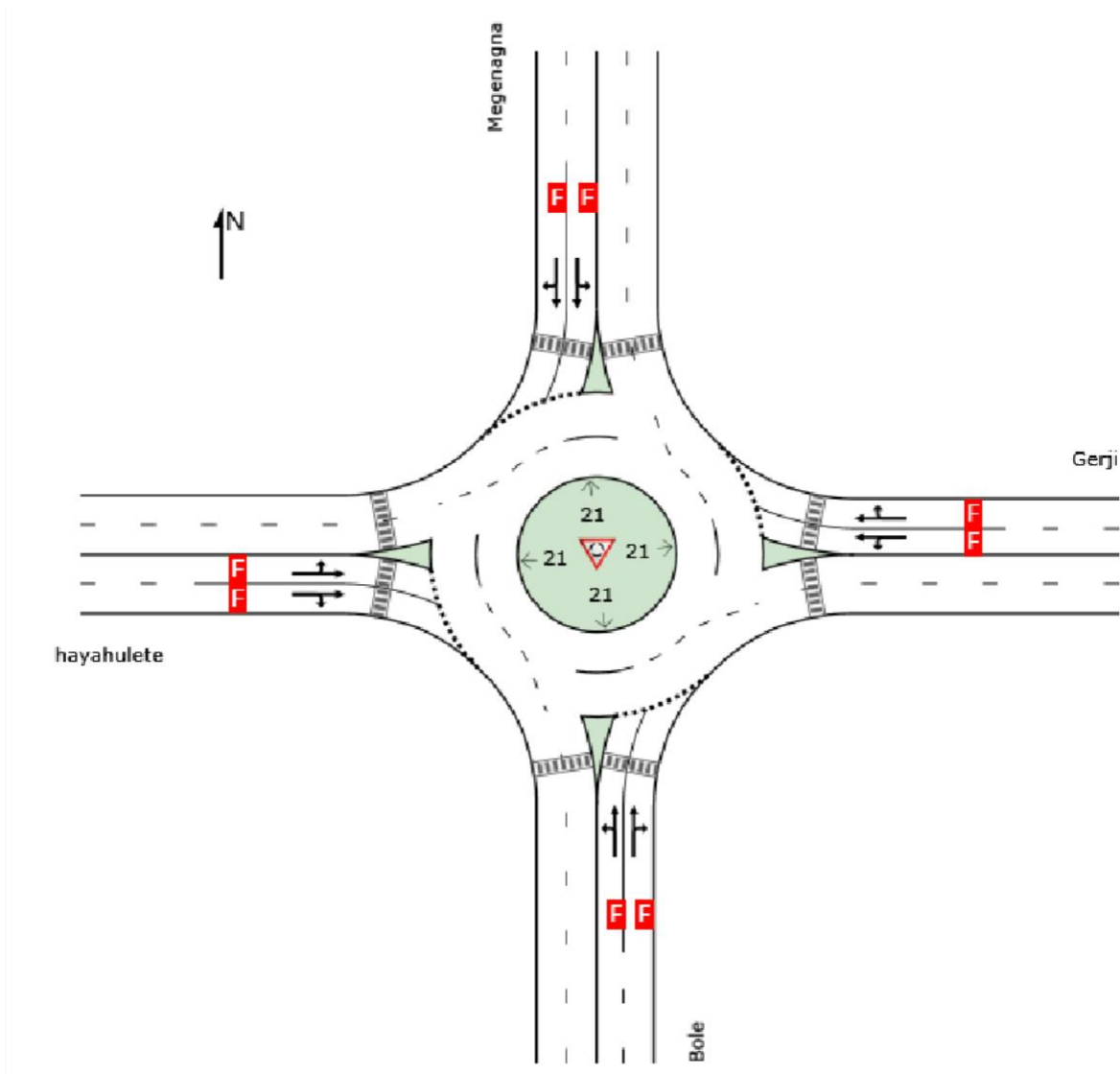
Lane Level of Service

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

	Approaches				Intersection
	South	East	North	West	
LOS	F	F	F	F	F



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Options

tab).

DEGREE OF SATURATION

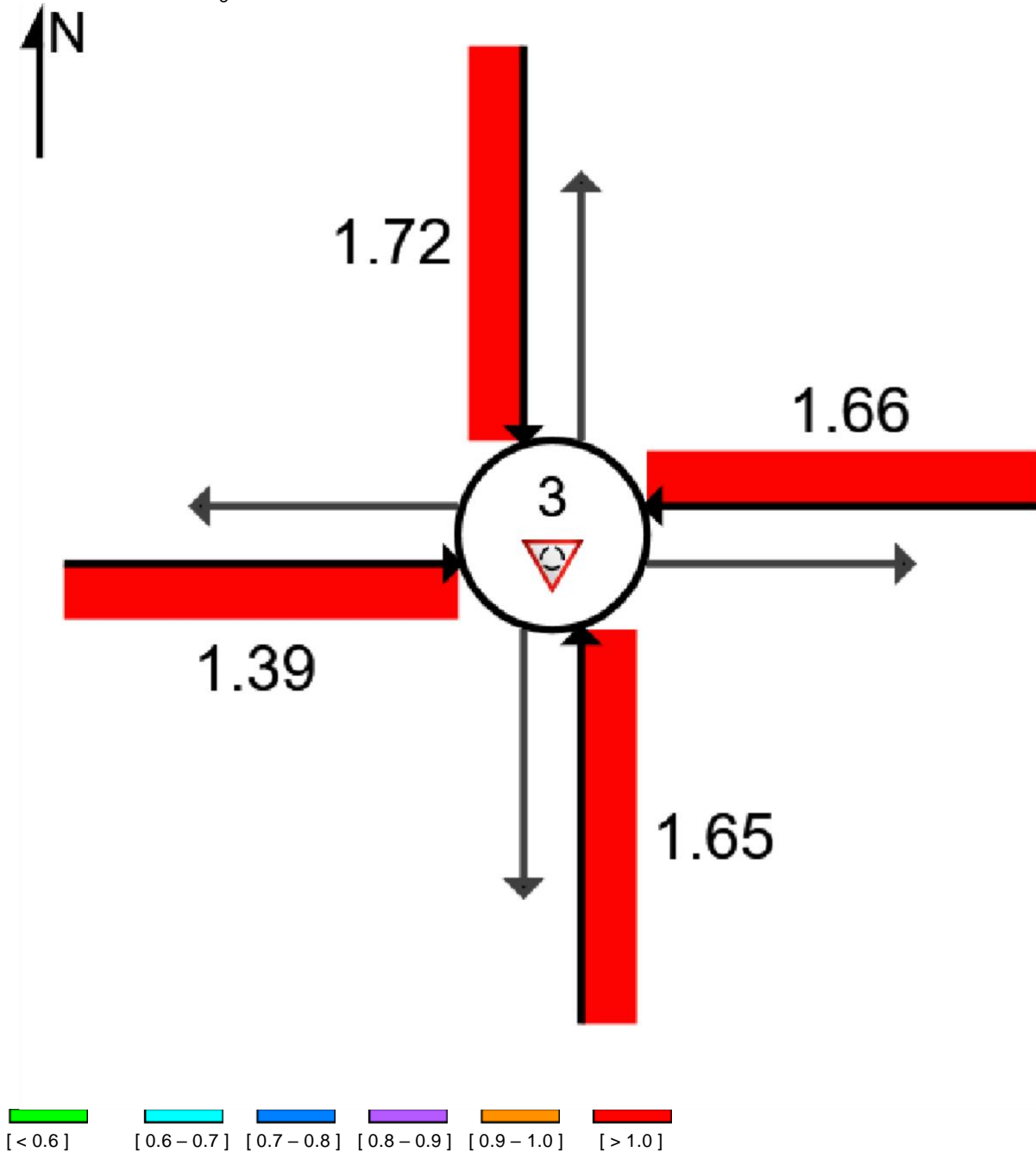
Ratio of Arrival Flow to Capacity, v/c ratio (worst lane for the approach) 

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)] Output

produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
MUTCD (FHWA 2009) example number: 3C-6
Roundabout Guide (TRB 2010) example number: A-7 Site
Category: Existing Design
Roundabout

Colour code based on Degree of Saturation



DEGREE OF SATURATION

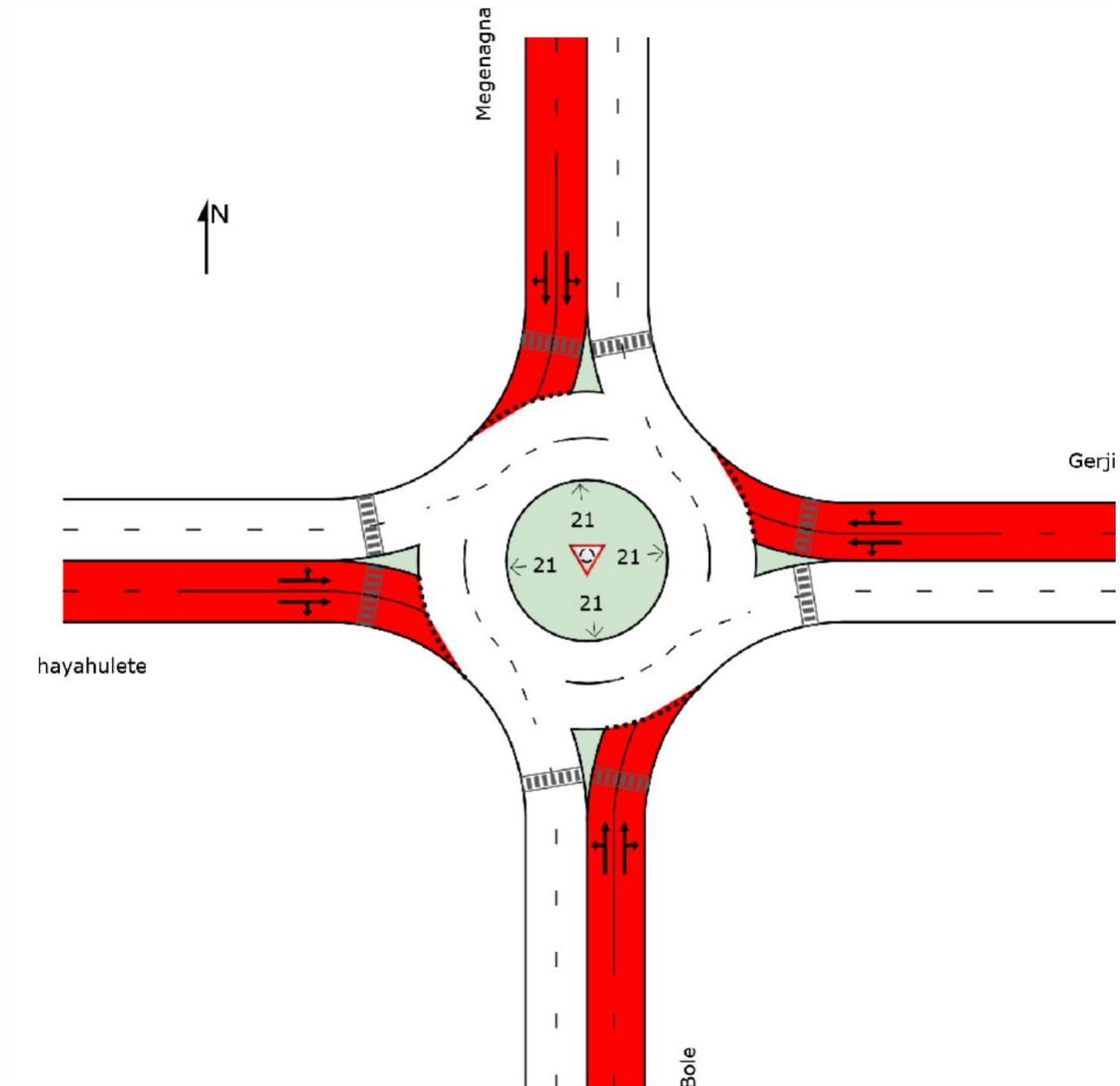
Ratio of Arrival Flow to Capacity, v/c ratio per lane

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

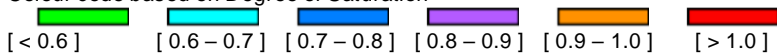
Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

	Approaches				Intersection
	South	East	North	West	
Degree of Saturation	1.65	1.66	1.72	1.39	1.72



Colour code based on Degree of Saturation



DEGREE OF SATURATION

Ratio of Arrival Flow to Capacity, v/c ratio per movement

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

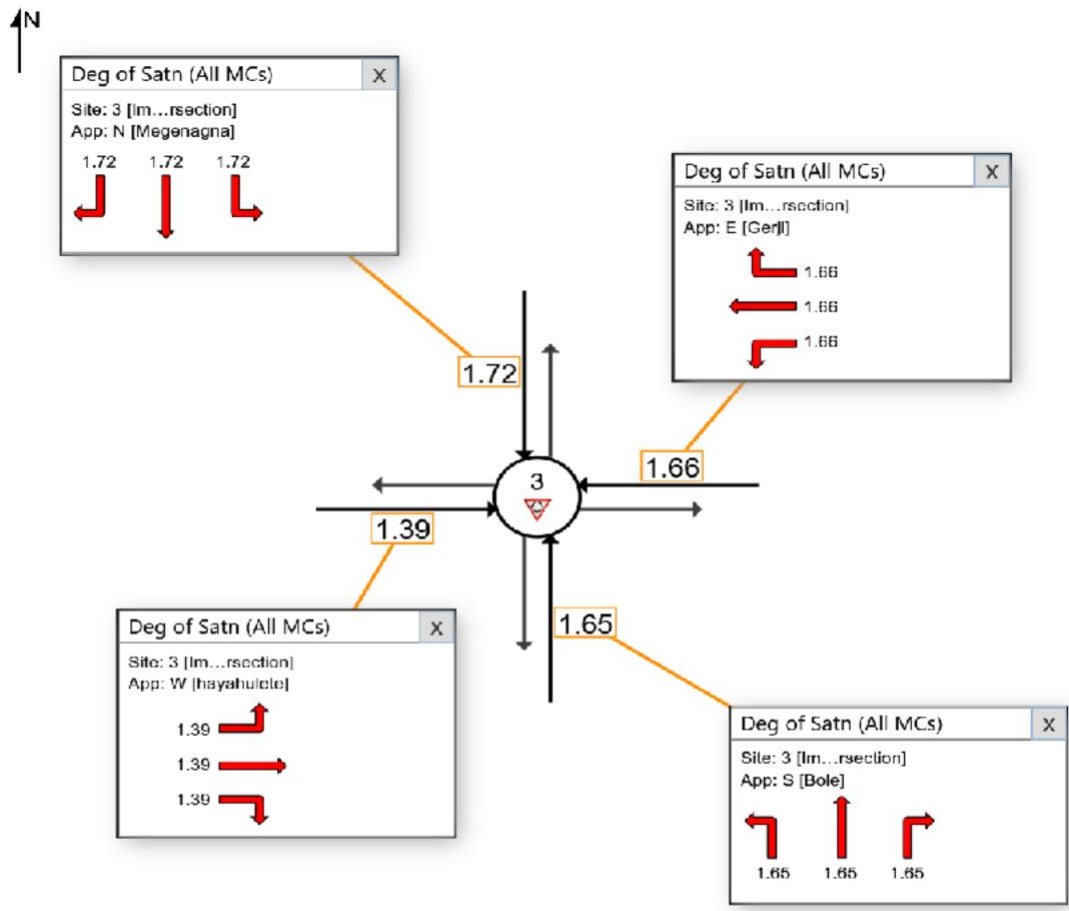
Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

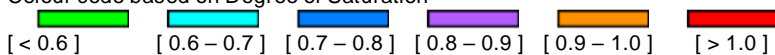
Use the button below to open or close all popup boxes. Click value labels to open selected ones. Click and drag popup boxes to move to preferred positions.

Close All Popups

All Movement Classes



Colour code based on Degree of Saturation



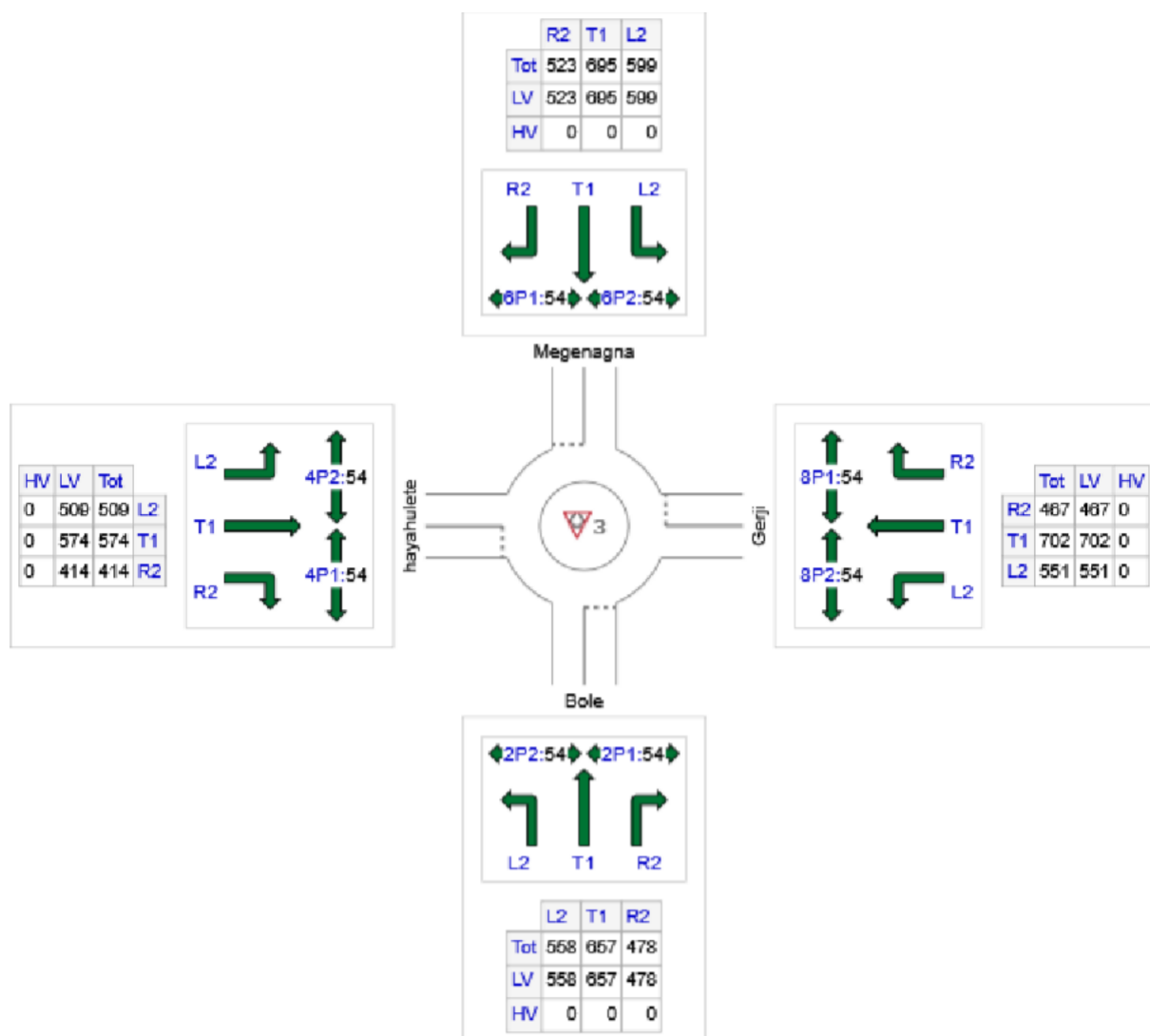
APPROACH MOVEMENT ARRIVAL FLOWS

Site Approach Movement Arrival Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Bole	1692	1692	0
E: Gerji	1721	1721	0
N: Megenagna	1816	1816	0
W: hayahulete	1497	1497	0
Total	6726	6726	0

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand effects. In Network analysis, Arrival Flows will be reduced if Upstream Capacity Constraint exists.

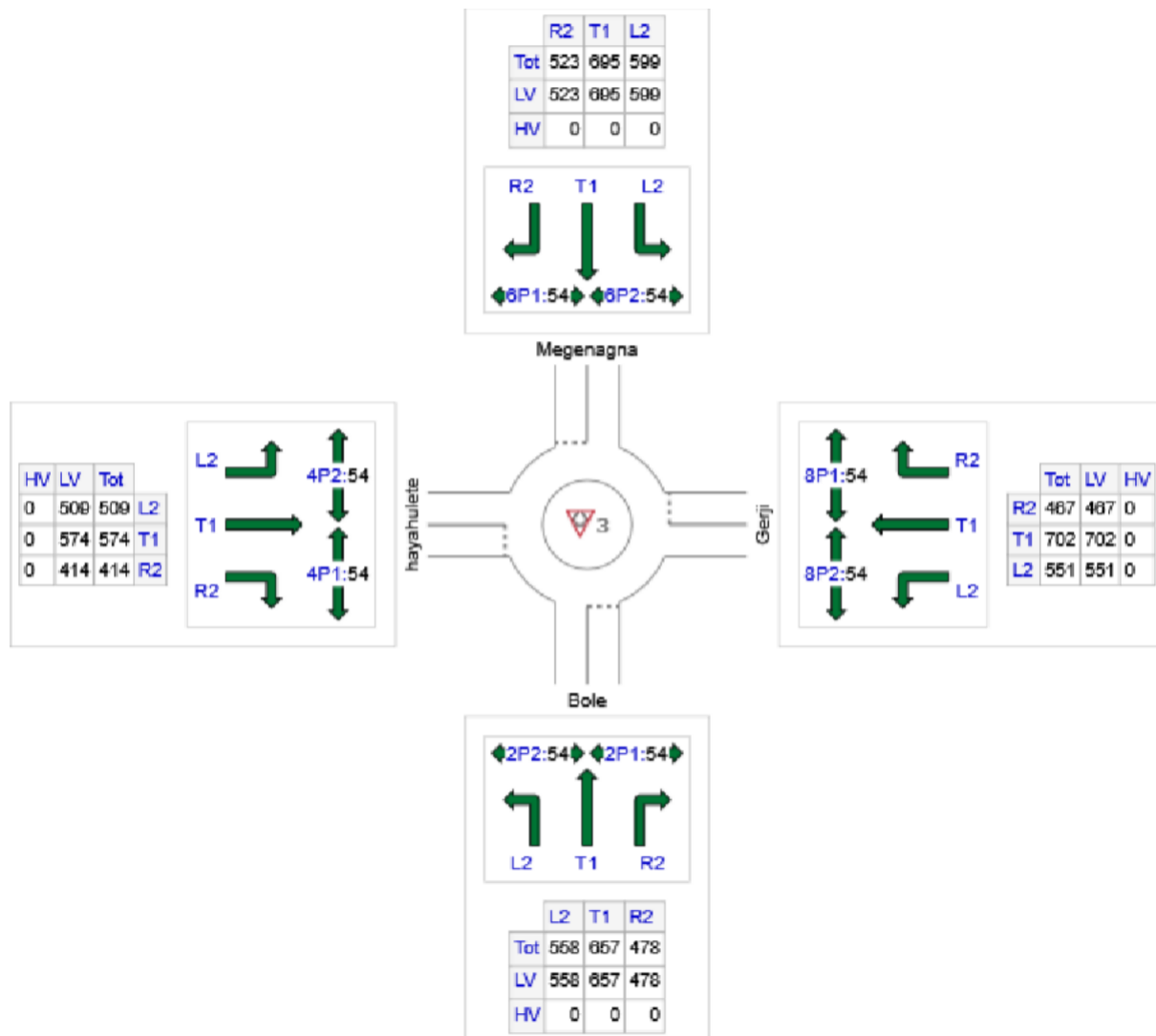
APPROACH MOVEMENT DEMAND FLOWS

Site Approach Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Bole	1692	1692	0
E: Gerji	1721	1721	0
N: Megenagna	1816	1816	0
W: hayahulete	1497	1497	0
Total	6726	6726	0

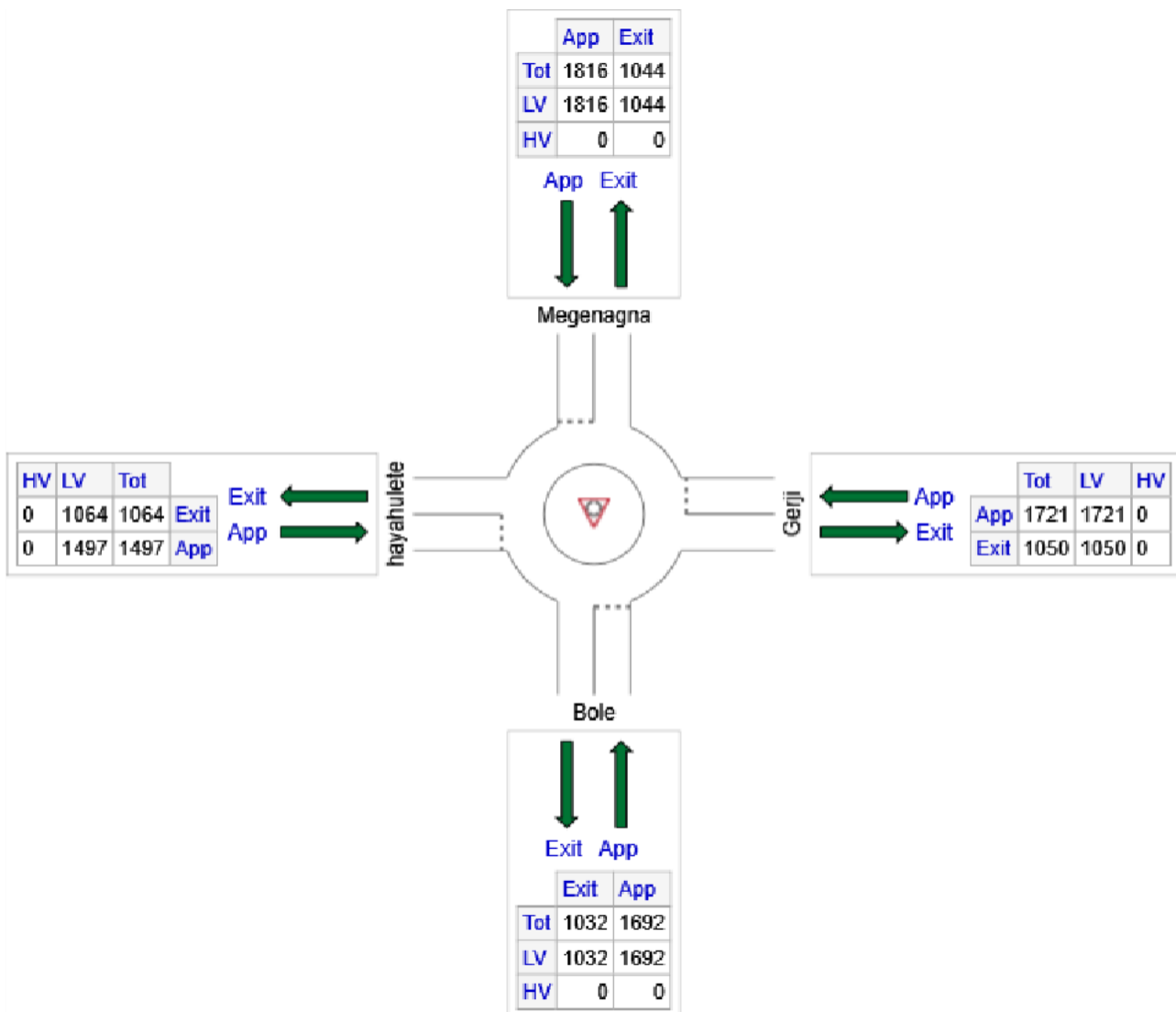
APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Arrival Flow Rates (veh/h)

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout



Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand effects. In Network analysis, Arrival Flows will be reduced if Upstream Capacity Constraint exists.

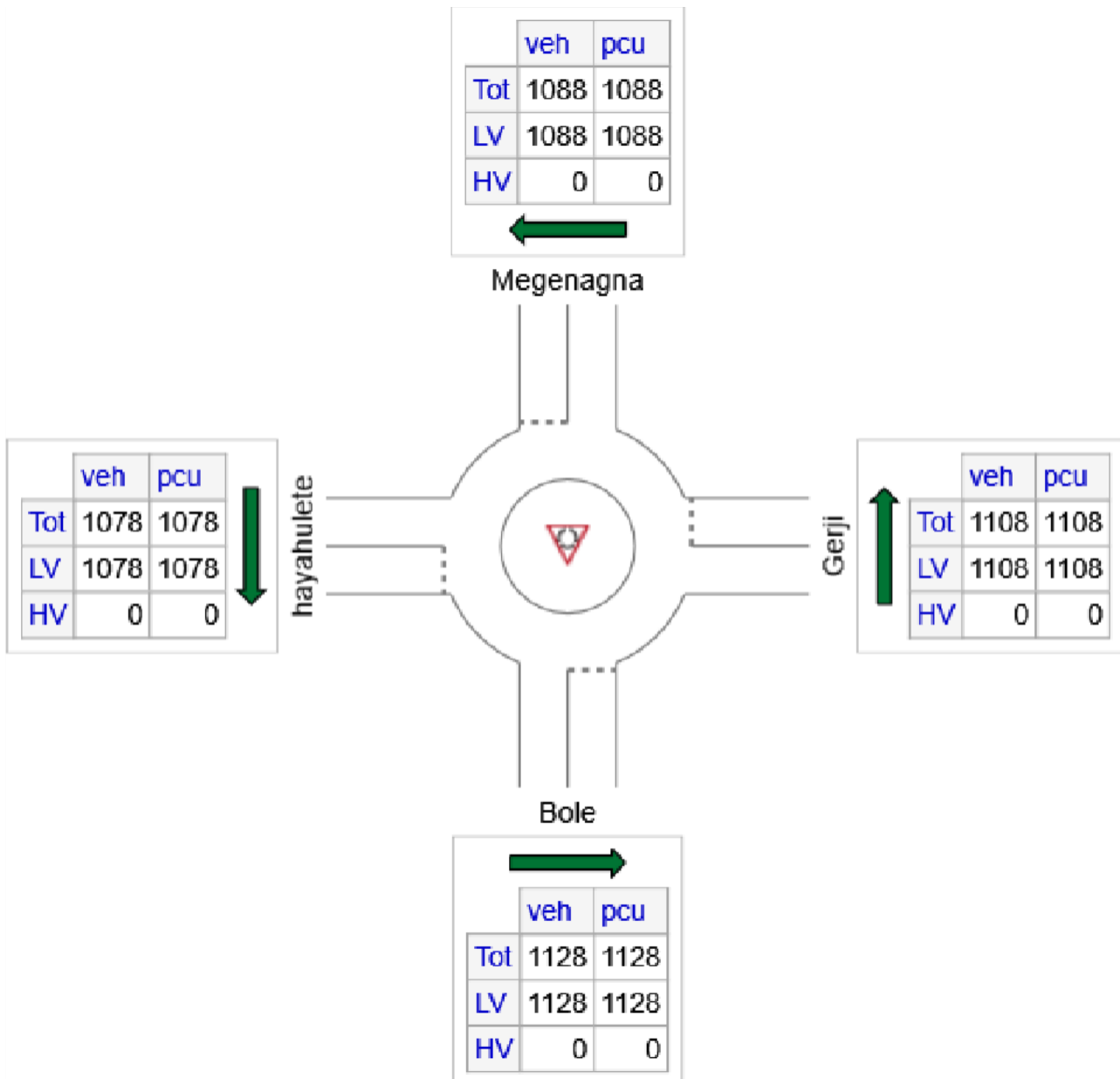
ROUNABOUT CIRCULATING FLOWS

Total Values for All Movement Classes Based on Site Arrival Flow Rates
 (veh/h and pcu/h)

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout



Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand effects. In Network analysis, Arrival Flows will be reduced if Upstream Capacity Constraint exists.

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 Organisation: Fenerbahce | Licence: PLUS / Enterprise | Processed: Thursday, May 25, 2023 12:01:34 PM Project:
 C:\Users\hpl\Desktop\Urban planning\For this\Desu\sidra\Case One.sip9

APPROACH LANE FLOWS

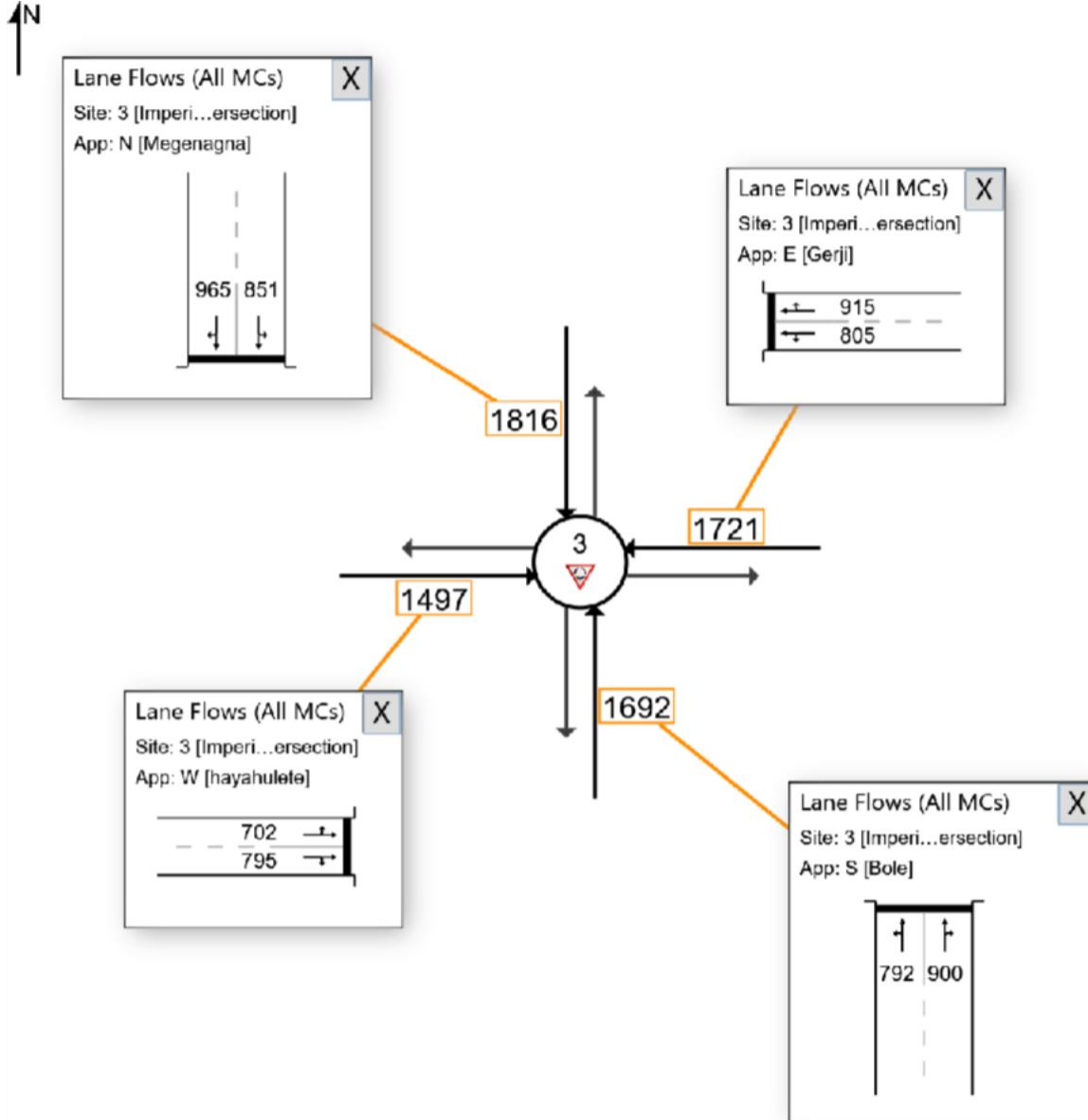
Lane flow rates based on arrival flows (veh/h)

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

All Movement Classes



Lane Flows are based on Arrival Flows adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

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Organisation: Fenerbahce | Licence: PLUS / Enterprise | Processed: Thursday, May 25, 2023 12:01:34 PM Project:
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MOVEMENT FLOWS FOR SITE (DEMAND)

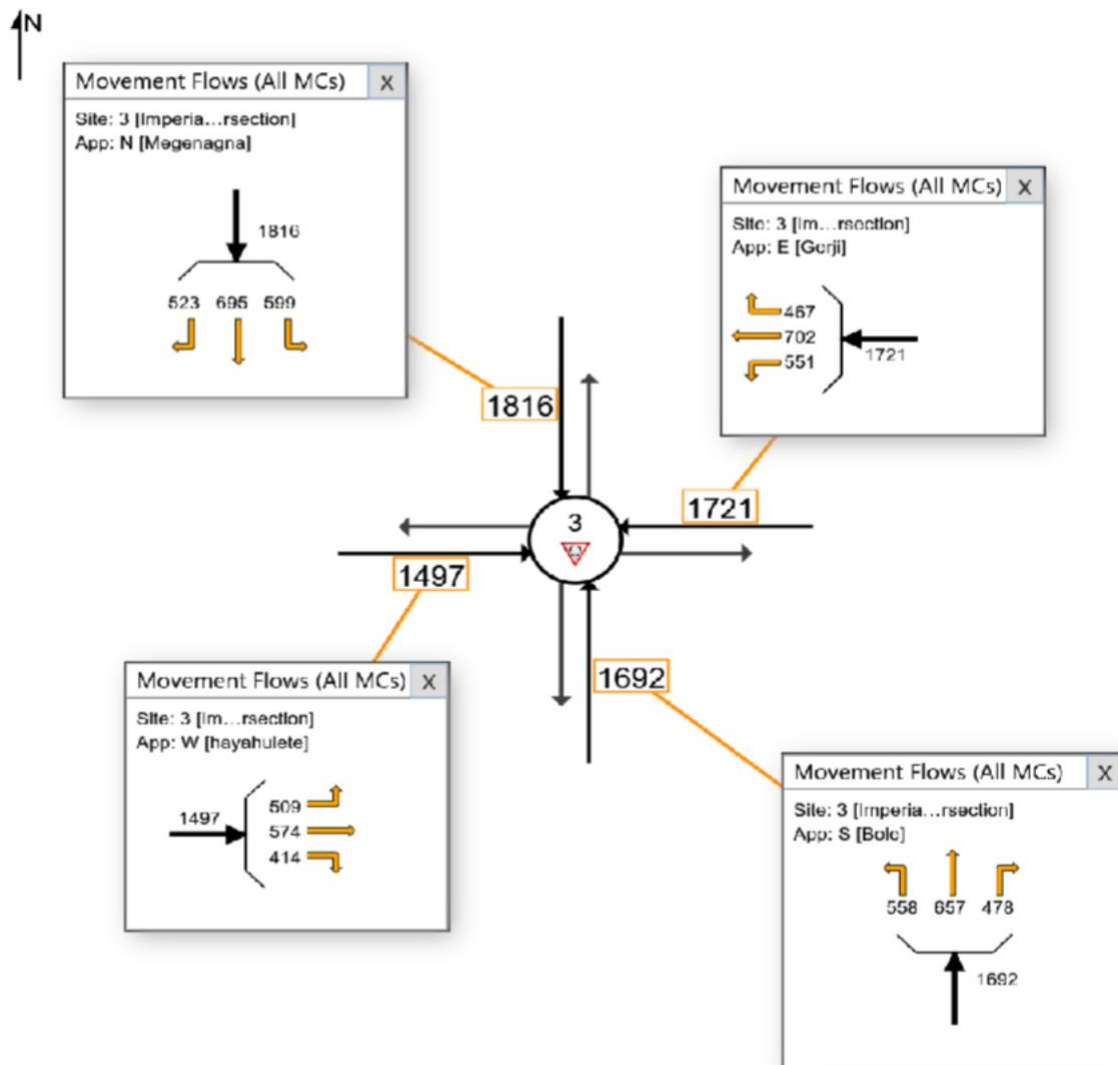
Approach movement demand flow rates by movement class (veh/h) ▼

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
MUTCD (FHWA 2009) example number: 3C-6
Roundabout Guide (TRB 2010) example number: A-7 Site
Category: Existing Design
Roundabout

All Movement Classes



INTERSECTION SUMMARY

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Intersection Performance - Hourly Values			
Performance Measure	Vehicles:	All MCs	Persons
Travel Speed (Average)	km/h	4.0	4.0 km/h
Travel Distance (Total)	veh-km/h	2648.7	3178.4 pers-km/h
Travel Time (Total)	veh-h/h	660.1	792.1 pers-h/h
Desired Speed	km/h	30.0	
Speed Efficiency		0.13	
Travel Time Index		0.38	
Congestion Coefficient		7.48	
Demand Flows (Total)	veh/h	6726	8071 pers/h
Arrival Flows (Total)	veh/h	6726	
Percent Heavy Vehicles (Demand)	%	0.0	
Percent Heavy Vehicles (Arrivals)	%	0.0	
Degree of Saturation		1.720	
Practical Spare Capacity	%	-50.6	
Effective Intersection Capacity	veh/h	3911	
Control Delay (Total)	veh-h/h	566.80	680.16 pers-h/h
Control Delay (Average)	sec	303.4	303.4 sec
Control Delay (Worst Lane by MC)	sec	350.0	
Control Delay (Worst Movement by MC)	sec	350.0	350.0 sec
Geometric Delay (Average)	sec	0.0	
Stop-Line Delay (Average)	sec	303.4	
Idling Time (Average)	sec	234.3	
Intersection Level of Service (LOS)		LOS F	
95% Back of Queue - Veh (Worst Lane)	veh	132.4	
95% Back of Queue - Dist (Worst Lane)	m	1006.3	
Ave. Que Storage Ratio (Worst Lane)		1.35	
Effective Stops (Total)	veh/h	57705	69246 pers/h
Effective Stop Rate		8.58	8.58
Proportion Queued		1.00	1.00
Performance Index		1487.6	1487.6
Cost (Total)	\$/h	12323.85	12323.85 \$/h
Fuel Consumption (Total)	L/h	1095.3	
Carbon Dioxide (Total)	kg/h	2573.9	
Hydrocarbons (Total)	kg/h	0.288	
Carbon Monoxide (Total)	kg/h	1.65	
NOx (Total)	kg/h	0.589	

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Options tab).

Roundabout LOS Method: Same as Sign Control.

Intersection LOS value for Vehicles is based on average delay for all vehicle movements. Roundabout

Capacity Model: US HCM 6.

Delay Model: HCM Delay Formula (Stopline Delay: Geometric Delay is not included).

Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand effects. In

Network analysis, Arrival Flows will be reduced if Upstream Capacity Constraint exists.

Gap-Acceptance Capacity Formula: Sieglach M1 implied by US HCM 6 Roundabout Capacity Model.

Site Model Variability Index (Average value of largest changes in Lane Degrees of Saturation from the third to the last Main (Timing-

Capacity) Iterations): 8.1 %

Number of Iterations: 7 (Maximum: 10)

Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 1.7% 1.0% 0.7%

Intersection Performance - Annual Values

Performance Measure	Vehicles:	All MCs	Persons
Demand Flows (Total)	veh/y	3,228,522	3,874,226 pers/y
Delay (Total)	veh-h/y	272,064	326,476 pers-h/y
Effective Stops (Total)	veh/y	27,698,440	33,238,130 pers/y
Travel Distance (Total)	veh-km/y	1,271,377	1,525,652 pers-km/y
Travel Time (Total)	veh-h/y	316,836	380,204 pers-h/y
Cost (Total)	\$/y	5,915,446	5,915,446 \$/y
Fuel Consumption (Total)	L/y	525,734	
Carbon Dioxide (Total)	kg/y	1,235,474	
Hydrocarbons (Total)	kg/y	138	
Carbon Monoxide (Total)	kg/y	790	
NOx (Total)	kg/y	283	

1 Hours per Year: 480 (Site)

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MOVEMENT SUMMARY

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Vehicle Movement Performance															
Mov ID	Turn	Mov Class	Demand Flows		Arrival Flows		Deg. Satn	Aver. Delay	Level of Service	95% Back Of Queue		Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed
			[Total HV]	%	[Total HV]	%	v/c	sec		[Veh. veh	Dist]				km/h
			veh/h		veh/h					veh	m				
South: Bole															
513	L2	All MCs	558	0.0	558	0.0	1.647	319.0	LOS F	103.2	784.4	1.00	8.33	15.07	3.9
604	T1	All MCs	657	0.0	657	0.0	1.647	317.2	LOS F	116.8	887.3	1.00	8.87	15.94	3.9
440	R2	All MCs	478	0.0	478	0.0	1.647	316.3	LOS F	116.8	887.3	1.00	9.16	16.43	3.8
Approach			1692	0.0	1692	0.0	1.647	317.5	LOS F	116.8	887.3	1.00	8.77	15.79	3.9
East: Gerji															
507	L2	All MCs	551	0.0	551	0.0	1.665	326.4	LOS F	106.4	808.8	1.00	8.53	15.37	3.9
646	T1	All MCs	702	0.0	702	0.0	1.665	324.8	LOS F	120.4	914.8	1.00	9.07	16.24	3.8
430	R2	All MCs	467	0.0	467	0.0	1.665	323.8	LOS F	120.4	914.8	1.00	9.37	16.73	3.7
Approach			1721	0.0	1721	0.0	1.665	325.0	LOS F	120.4	914.8	1.00	8.98	16.09	3.8
North: Megenagna															
481	L2	All MCs	599	0.0	599	0.0	1.720	350.0	LOS F	117.2	890.7	1.00	8.96	16.11	3.6
639	T1	All MCs	695	0.0	695	0.0	1.720	348.4	LOS F	132.4	1006.3	1.00	9.52	17.01	3.6
551	R2	All MCs	523	0.0	523	0.0	1.720	347.5	LOS F	132.4	1006.3	1.00	9.84	17.52	3.5
Approach			1816	0.0	1816	0.0	1.720	348.7	LOS F	132.4	1006.3	1.00	9.43	16.86	3.5
West: hayahulete															
468	L2	All MCs	509	0.0	509	0.0	1.394	209.0	LOS F	69.2	525.7	1.00	6.56	11.52	5.5
528	T1	All MCs	574	0.0	574	0.0	1.394	207.0	LOS F	77.7	590.8	1.00	6.95	12.15	5.5
381	R2	All MCs	414	0.0	414	0.0	1.394	206.0	LOS F	77.7	590.8	1.00	7.15	12.47	5.5
Approach			1497	0.0	1497	0.0	1.394	207.4	LOS F	77.7	590.8	1.00	6.87	12.02	5.5
All Vehicles			6726	0.0	6726	0.0	1.720	303.4	LOS F	132.4	1006.3	1.00	8.58	15.32	4.0

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Options tab).

Roundabout LOS Method: Same as Sign Control.

Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement. LOS

F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 6).

Roundabout Capacity Model: US HCM 6.

Delay Model: HCM Delay Formula (Stopline Delay: Geometric Delay is not included).

Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.

Gap-Acceptance Capacity Formula: Sieglach M1 implied by US HCM 6 Roundabout Capacity Model.

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

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LANE SUMMARY

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Lane Use and Performance															
	Demand Flows		Arrival Flows		Flows Cap.	Deg. Satn	Lane Util.	Aver. Delay	Level of Service	95% Back Of Queue		Lane Config	Lane Length	Cap. Adj.	Prob. Block.
	[Total veh/h]	[HV %]	[Total veh/h]	[HV %]						[Veh m]	[Dist]				
South: Bole															
Lane 1	792	0.0	792	0.0	481	1.647	100	319.0	LOS F	103.2	784.4	Full	300	0.0	56.8
Lane 2 ^d	900	0.0	900	0.0	547	1.647	100	316.3	LOS F	116.8	887.3	Full	300	0.0	100.0
Approach	1692	0.0	1692	0.0		1.647		317.5	LOS F	116.8	887.3				
East: Gerji															
Lane 1	805	0.0	805	0.0	484	1.665	100	326.4	LOS F	106.4	808.8	Full	300	0.0	62.3
Lane 2 ^d	915	0.0	915	0.0	550	1.665	100	323.8	LOS F	120.4	914.8	Full	300	0.0	100.0
Approach	1721	0.0	1721	0.0		1.665		325.0	LOS F	120.4	914.8				
North: Megenagna															
Lane 1	851	0.0	851	0.0	495	1.720	100	350.0	LOS F	117.2	890.7	Full	300	0.0	100.0
Lane 2 ^d	965	0.0	965	0.0	561	1.720	100	347.5	LOS F	132.4	1006.3	Full	300	0.0	100.0
Approach	1816	0.0	1816	0.0		1.720		348.7	LOS F	132.4	1006.3				
West: hayahulete															
Lane 1	702	0.0	702	0.0	503	1.394	100	209.0	LOS F	69.2	525.7	Full	300	0.0	25.3
Lane 2 ^d	795	0.0	795	0.0	571	1.394	100	206.0	LOS F	77.7	590.8	Full	300	0.0	31.4
Approach	1497	0.0	1497	0.0		1.394		207.4	LOS F	77.7	590.8				
All Vehicles	6726	0.0	6726	0.0		1.720		303.4	LOS F	132.4	1006.3				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Options tab).

Roundabout LOS Method: Same as Sign Control.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.

LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).

Roundabout Capacity Model: US HCM 6.

Delay Model: HCM Delay Formula (Stopleveline Delay: Geometric Delay is not included).

Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.

Gap-Acceptance Capacity Formula: Siegloch M1 implied by US HCM 6 Roundabout Capacity Model.

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

^d Dominant lane on roundabout approach

Approach Lane Flows (veh/h)										
South: Bole										
Mov.	L2	T1	R2	Total	%HV	Cap.veh/h	Deg. Satn	Lane Util.	Prob. SL	Ov. Lane No.
From S To Exit:	W	N	E		v/c					
Lane 1	558	234	-	792	0.0	481	1.647	100	NA	NA
Lane 2	-	422	478	900	0.0	547	1.647	100	NA	NA

Approach	558	657	478	1692	0.0		1.647				
East: Gerji											
Mov.	L2	T1	R2	Total	%HV		Deg.	Lane	Prob.	Ov.	
From E						Cap.veh/h	Satn	Util.	SL	Ov.	Lane
To Exit:	S	W	N			v/c	v/c	%	%	%	No.
Lane 1	551	254	-	805	0.0	484	1.665	100	NA	NA	
Lane 2	-	448	467	915	0.0	550	1.665	100	NA	NA	
Approach	551	702	467	1721	0.0		1.665				
North: Megenagna											
Mov.	L2	T1	R2	Total	%HV		Deg.	Lane	Prob.	Ov.	
From N						Cap.veh/h	Satn	Util.	SL	Ov.	Lane
To Exit:	E	S	W			v/c	v/c	%	%	%	No.
Lane 1	599	252	-	851	0.0	495	1.720	100	NA	NA	
Lane 2	-	443	523	965	0.0	561	1.720	100	NA	NA	
Approach	599	695	523	1816	0.0		1.720				
West: hayahulete											
Mov.	L2	T1	R2	Total	%HV		Deg.	Lane	Prob.	Ov.	
From W						Cap.veh/h	Satn	Util.	SL	Ov.	Lane
To Exit:	N	E	S			v/c	v/c	%	%	%	No.
Lane 1	509	193	-	702	0.0	503	1.394	100	NA	NA	
Lane 2	-	381	414	795	0.0	571	1.394	100	NA	NA	
Approach	509	574	414	1497	0.0		1.394				
Total %HV Deg.Satn (v/c)											
All Vehicles	6726	0.0		1.720							

Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

Merge Analysis

Exit Lane Number	Short Lane Opng Length	Percent in Lane	Opposing Flow Rate	Critical Gap	Follow-up Headway	Lane Capacity Flow	Deg. Satn	Min. Delay	Merge Delay
	m	%	veh/h	sec	sec	veh/h	veh/h	v/c	sec
There are no Exit Short Lanes for Merge Analysis at this Site.									

Variable Demand Analysis

	Initial Demand	Queued Demand	Residual Queued Demand	Time for Residual Demand to Clear	for to	Duration of Oversatn
	veh	veh	veh	sec	sec	sec
South: Bole						
Lane 1		0.0	77.8	582.4		NA
Lane 2		0.0	88.4	582.4		NA
East: Gerji						
Lane 1		0.0	80.4	598.1		NA
Lane 2		0.0	91.4	598.1		NA
North: Megenagna						
Lane 1		0.0	89.0	647.7		NA
Lane 2		0.0	101.0	647.7		NA
West: hayahulete						
Lane 1		0.0	49.5	354.2		NA
Lane 2		0.0	56.1	354.2		NA

FUEL CONSUMPTION, EMISSIONS & COST

 Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Fuel Consumption, Emissions & Cost (Total)							
Mov ID	Turn	FuelTotal L/h	CO2 Totalkg/h	CO Total kg/h	HC Totalkg/h	NOX Totalkg/h	CostTotal \$/h
South: Bole							
513	L2	100.3	235.7	0.16	0.026	0.058	1094.25
604	T1	108.5	254.9	0.16	0.029	0.056	1239.41
440	R2	75.1	176.5	0.11	0.020	0.036	890.25
Approach		283.9	667.1	0.43	0.075	0.151	3223.90
East: Gerji							
507	L2	100.5	236.3	0.16	0.026	0.058	1084.70
646	T1	118.1	277.6	0.18	0.031	0.061	1352.39
430	R2	74.9	176.0	0.11	0.020	0.036	887.98
Approach		293.5	689.8	0.44	0.078	0.156	3325.08
North: Megenagna							
481	L2	114.5	269.0	0.18	0.030	0.065	1268.12
639	T1	123.0	289.1	0.18	0.033	0.063	1420.29
551	R2	88.4	207.8	0.13	0.024	0.042	1055.57
Approach		325.9	766.0	0.49	0.086	0.171	3743.98
West: hayahulete							
468	L2	71.9	169.1	0.11	0.018	0.047	720.80
528	T1	71.7	168.5	0.11	0.018	0.040	767.40
381	R2	48.3	113.4	0.07	0.012	0.025	542.69
Approach		191.9	451.0	0.29	0.049	0.112	2030.88
All Vehicles		1095.3	2573.9	1.65	0.288	0.589	12323.85
Intersection		1095.3	2573.9	1.65	0.288	0.589	12323.85

Fuel Consumption, Emissions & Cost (Annual Values)							
	Fuel Total L/y	CO2 Total kg/y	CO Total kg/y	HC Total kg/y	NOX Total kg/y	CostTotal \$/y	
Vehicles	525,734	1,235,474	790	138	283	5,915,44	6
Persons						5,915,44	6

Fuel Consumption, Emissions & Cost (Rate)							
Mov ID	Turn	Fuel Efficiency L/100km	CO2 Rateg/km	CO Rate g/km	HC Rate g/km	NOX Rate g/km	Cost Rate \$/km
South: Bole							
513	L2	44.5	1044.7	0.69	0.117	0.259	4.85
604	T1	42.2	991.7	0.63	0.111	0.219	4.82
440	R2	40.9	960.7	0.59	0.108	0.196	4.84
Approach		42.6	1001.1	0.64	0.112	0.226	4.84
East: Gerji							
507	L2	45.1	1060.4	0.70	0.119	0.262	4.87
646	T1	42.9	1009.3	0.64	0.113	0.223	4.92
430	R2	41.6	978.8	0.61	0.110	0.200	4.94
Approach		43.3	1018.0	0.65	0.114	0.230	4.91
North: Megenagna							
481	L2	47.2	1110.3	0.73	0.125	0.270	5.23
639	T1	45.2	1063.3	0.68	0.120	0.232	5.22
551	R2	44.0	1035.2	0.64	0.117	0.210	5.26
Approach		45.6	1071.3	0.68	0.121	0.239	5.24
West: hayahulete							
468	L2	34.9	820.9	0.55	0.089	0.228	3.50
528	T1	31.9	750.2	0.48	0.082	0.180	3.42
381	R2	30.3	712.5	0.44	0.078	0.155	3.41
Approach		32.5	764.7	0.49	0.083	0.190	3.44
All Vehicles		41.4	971.8	0.62	0.109	0.222	4.65
Intersection		41.4	971.8	0.62	0.109	0.222	4.65

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QUEUE ANALYSIS

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Lane Queues (Distance)															
Lane Number	Contn. Lane	Deg. Satn	Prog. Factor (Queue)	Overflow Queue (m)	Back of Queue (m)		Queue at Start of Gap (m)		Cycle-Average Queue (m)		Queue Storage Ratio		Prob. Block. %	Prob. SL Ov. %	Ov. Lane No.
					Av.	95%	Av.	95%	Av.	95%	Av.	95%			
South: Bole															
Lane 1		1.647	1.000	299.1	315.6	784.4	315.7	784.6	- ¹	- ¹	1.05	2.61	56.8	NANA	NA
Lane 2		1.647	1.000	339.8	357.0	887.3	356.1	885.1	- ¹	- ¹	1.19	2.96	100.0		NA
Approach		1.647			357.0	887.3	356.1	885.1	- ¹	- ¹	1.19	2.96			
East: Gerji															
Lane 1		1.665	1.000	308.9	325.4	808.8	325.5	808.9	- ¹	- ¹	1.08	2.70	62.3	NANA	NA
Lane 2		1.665	1.000	350.8	368.1	914.8	367.2	912.5	- ¹	- ¹	1.23	3.05	100.0		NA
Approach		1.665			368.1	914.8	367.2	912.5	- ¹	- ¹	1.23	3.05			
North: Megenagna															
Lane 1		1.720	1.000	341.6	358.4	890.7	358.8	891.7	- ¹	- ¹	1.19	2.97	100.0	NANA	NA
Lane 2		1.720	1.000	387.3	404.9	1006.3	404.3	1004.8	- ¹	- ¹	1.35	3.35	100.0		NA
Approach		1.720			404.9	1006.3	404.3	1004.8	- ¹	- ¹	1.35	3.35			
West: hayahulete															
Lane 1		1.394	1.000	194.2	211.5	525.7	208.3	517.8	- ¹	- ¹	0.71	1.75	25.3	NANA	NA
Lane 2		1.394	1.000	219.5	237.7	590.8	233.4	580.2	- ¹	- ¹	0.79	1.97	31.4		NA
Approach		1.394			237.7	590.8	233.4	580.2	- ¹	- ¹	0.79	1.97			
Intersection		1.720			404.9	1006.3	404.3	1004.8	- ¹	- ¹	1.35	3.35			

Roundabout Capacity Model: US HCM 6.

Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.

Gap-Acceptance Capacity Formula: Sieglösch M1 implied by US HCM 6 Roundabout Capacity Model.

Short Lanes are not included in determining Queue Storage Ratios.

¹ Cycle-Average Queue is not given as it is larger than the Back of Queue because the delay estimate includes a large delay experienced after the analysis period in oversaturated conditions.

Lane Queues (Vehicles)															
Lane Number	Contn. Lane	Deg. Satn	Prog. Factor (Queue)	Overflow Queue (veh)	Back of Queue (veh)		Queue at Start of Gap (veh)		Cycle-Average Queue (veh)		Queue Storage Ratio		Prob. Block. %	Prob. SL Ov. %	Ov. Lane No.
					Av.	95%	Av.	95%	Av.	95%	Av.	95%			
South: Bole															
Lane 1		1.647	1.000	39.4	41.5	103.2	41.5	103.2	- ¹	- ¹	1.05	2.61	56.8	NA	NA
Lane 2		1.647	1.000	44.7	47.0	116.8	46.9	116.5	- ¹	- ¹	1.19	2.96	100.0	NA	NA
Approach		1.647			47.0	116.8	46.9	116.5	- ¹	- ¹	1.19	2.96			
East: Gerji															
Lane 1		1.665	1.000	40.6	42.8	106.4	42.8	106.4	- ¹	- ¹	1.08	2.70	62.3	NA	NA
Lane 2		1.665	1.000	46.2	48.4	120.4	48.3	120.1	- ¹	- ¹	1.23	3.05	100.0	NA	NA

Approach	1.665		48.4	120.4	48.3	120.1	- ¹	- ¹	1.23	3.05				
North: Megenagna														
Lane 1	1.720	1.000	44.9	47.2	117.2	47.2	117.3	- ¹	- ¹	1.19	2.97	100.0	NA	NA
Lane 2	1.720	1.000	51.0	53.3	132.4	53.2	132.2	- ¹	- ¹	1.35	3.35	100.0	NA	NA
Approach	1.720		53.3	132.4	53.2	132.2	- ¹	- ¹	1.35	3.35				
West: hayahulete														
Lane 1	1.394	1.000	25.6	27.8	69.2	27.4	68.1	- ¹	- ¹	0.71	1.75	25.3	NA	NA
Lane 2	1.394	1.000	28.9	31.3	77.7	30.7	76.3	- ¹	- ¹	0.79	1.97	31.4	NA	NA
Approach	1.394		31.3	77.7	30.7	76.3	- ¹	- ¹	0.79	1.97				
Intersection	1.720		53.3	132.4	53.2	132.2	- ¹	- ¹	1.35	3.35				

Roundabout Capacity Model: US HCM 6.

Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.

Gap-Acceptance Capacity Formula: Siegloch M1 implied by US HCM 6 Roundabout Capacity Model.

Short Lanes are not included in determining Queue Storage Ratios.

¹ Cycle-Average Queue is not given as it is larger than the Back of Queue because the delay estimate includes a large delay experienced after the analysis period in oversaturated conditions.

Continuous Lane Performance

Lane Number	Deg. Satn	Unint. Speed	Unint. Travel Delay	Hdwy Spacing	Aver. Vehicle Length	Occup. Time	Space Time	Space Occup. Ratio	Time Occup. Ratio	Density	LOS (Density Method)
	v/c	km/h	sec	sec	m	m sec	sec	%	%	veh/km	pc/km

There are no Continuous Lanes at this Site.

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ROUNDBOUT ANALYSIS

Site: 3 [Imperial-Gerji Intersection (Site Folder: General)]

Output produced by SIDRA INTERSECTION Version: 9.1.1.200

Roundabout with 2-lane approaches and circulating road
 MUTCD (FHWA 2009) example number: 3C-6
 Roundabout Guide (TRB 2010) example number: A-7 Site
 Category: Existing Design
 Roundabout

Roundabout Basic Parameters

Location	Name	Central Island Diam	Circ Width	Insc Diam	Entry Radius	Entry Angle	Circ Lanes	Entry Lanes	Av.Entry Lane Width	App. Dist UpstrSignal	PropExtra Queued	Bunching
		m	m	m	m	°			m	m		%
South	Bole	21.00*	11.00*	38.0 ⁷	30.0*	30.0*	2	2	3.75*	300.0	NA ⁵	0.0
East	Gerji	21.00*	11.00*	38.0 ⁷	30.0*	30.0*	2	2	3.75*	300.0	NA ⁵	0.0
North	Megegnagna	21.00*	11.00*	38.0 ⁷	30.0*	30.0*	2	2	4.00*	300.0	NA ⁵	0.0
West	hayahulete	21.00*	11.00*	38.0 ⁷	30.0*	30.0*	2	2	4.00*	300.0	NA ⁵	0.0

Roundabout Capacity Model: US HCM 6

- 5 Not Applicable (single Site analysis or unconnected Site in Network analysis).
- 7 Inscribed diameter value was specified by the user.
- * These parameters do not affect estimated capacity values in the HCM 6 Roundabout Capacity Model.

Roundabout Entry and Circulating / Exiting Stream Parameters

To Approach	Turn	Lane No	Lane Type	Opng Flow	Opng Flow	In-Bunch Hdwy	Prop. Bunched	Cap Const	Priority Sharing	OD Gap Factor	Acc Factor	Follow-up Hdwy (tf) [sec]	Critical Hdwy [sec]	Gap (tc) Dist] tf / tc	Ratio
				veh/h	pcu/h	sec						sec	sec	m	
South: Bole															
Model Calibration Factor (HCM 6): 1.00															
Entry/Circ Flow Adj (HCM 6): None															
West	L2	1	Subdom.	1128	1128	0.00	0.000	No	No	-	1.00	2.67	4.65	32.9	0.57
North	T1	1	Subdom.	1128	1128	0.00	0.000	No	No	-	1.00	2.67	4.65	32.9	0.57
North	T1	2	Dominant	1128	1128	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.7	0.59
East	R2	2	Dominant	1128	1128	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.7	0.59
East: Gerji															
Model Calibration Factor (HCM 6): 1.00															
Entry/Circ Flow Adj (HCM 6): None															
South	L2	1	Subdom.	1108	1108	0.00	0.000	No	No	-	1.00	2.67	4.65	32.6	0.57
West	T1	1	Subdom.	1108	1108	0.00	0.000	No	No	-	1.00	2.67	4.65	32.6	0.57
West	T1	2	Dominant	1108	1108	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.4	0.59
North	R2	2	Dominant	1108	1108	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.4	0.59
North: Megegnagna															
Model Calibration Factor (HCM 6): 1.00															
Entry/Circ Flow Adj (HCM 6): None															
East	L2	1	Subdom.	1088	1088	0.00	0.000	No	No	-	1.00	2.67	4.65	32.9	0.57
South	T1	1	Subdom.	1088	1088	0.00	0.000	No	No	-	1.00	2.67	4.65	32.9	0.57
South	T1	2	Dominant	1088	1088	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.6	0.59
West	R2	2	Dominant	1088	1088	0.00	0.000	Yes	No	-	1.00	2.54	4.33	30.6	0.59
West: hayahulete															
Model Calibration Factor (HCM 6): 1.00															
Entry/Circ Flow Adj (HCM 6): None															
North	L2	1	Subdom.	1078	1078	0.00	0.000	No	No	-	1.00	2.67	4.65	33.5	0.57
East	T1	1	Subdom.	1078	1078	0.00	0.000	No	No	-	1.00	2.67	4.65	33.5	0.57
East	T1	2	Dominant	1078	1078	0.00	0.000	Yes	No	-	1.00	2.54	4.33	31.3	0.59
South	R2	2	Dominant	1078	1078	0.00	0.000	Yes	No	-	1.00	2.54	4.33	31.3	0.59

Roundabout Capacity Model: US HCM 6

Circulating Lane Flow Rates

Circ. Lane No	Circulating Flow Rate		Percent
	veh/h	pcu/h	
South: Bole			
Lane 1	854	854	75.7
Lane 2	275	275	24.3
Approach	1128	1128	
East: Gerji			
Lane 1	850	850	76.8
Lane 2	257	257	23.2
Approach	1108	1108	
North: Megenagna			
Lane 1	821	821	75.4
Lane 2	267	267	24.6
Approach	1088	1088	
West: hayahulete			
Lane 1	822	822	76.2
Lane 2	257	257	23.8
Approach	1078	1078	

Roundabout Capacity Model: The US HCM 6 Roundabout Capacity Model option is in use. This model considers only the total circulating flow and not the flow rates in individual circulating lanes. To model the effects of flow distribution in circulating lanes on the entry capacity results, you should use the SIDRA HCM roundabout capacity model.

Gap Acceptance Cycle Parameters (Lanes)

OpposedLane	CycleTime sec	Blocked Timesec	Unblocked Timesec	Unblocked Time Ratio	Minimum Delaysec
South: Bole					
1	12.77	8.25	4.52	0.354	5.7
2	11.63	7.17	4.46	0.383	5.0
East: Gerji					
1	12.70	8.12	4.58	0.361	5.7
2	11.58	7.07	4.52	0.390	5.0
North: Megenagna					
1	12.63	7.99	4.64	0.368	5.6
2	11.54	6.96	4.58	0.397	4.9
West: hayahulete					
1	12.60	7.93	4.67	0.371	5.6
2	11.52	6.91	4.61	0.400	4.9

Roundabout Capacity Model: US HCM 6