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Construction of a Road Network in Central Surabaya and Traffic Conditions in The Girilaya Road Surabaya City Based on Geographic Information Systems

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Abstract

The purpose of this study was to create a road network in the form of a geographic information system and to find out the traffic conditions that occurred on the Girilaya road, Surabaya City in 2021. This traffic condition research used a method that refers to the calculation of congestion figures. In accordance with field observations, the road with the type of road 2/2 UD is two lanes – two-way undivided, with a road width of 6 meters for a total of 2 directions with a shoulder of 1 meter each on the right and left sections.

The facilities on these roads are not equipped with traffic signs such as (no stopping, no parking, speed limit). The highest average daily traffic volume on this road segment is from 07.00 – 18.00 as many as 1725.8 vehicles/hour. Motorcycles are the most dominant type of vehicles passing through these roads. From the analysis of the level of congestion carried out, the results showed that the side barriers on the road segment were categorized as moderate (M) at 378.6 events/hour.

Congestion occurs because of the density of activities and vehicles reduce speed and stop on the side of the road. This results in the value of service on the road section being D indicating that the flow of vehicles is obstructed, the speed is low and the volume of vehicles is above capacity. Therefore, the role of the government is very important to reduce the level of congestion that occurs and drivers are more orderly in carrying out activities on these roads.

Keywords
Geographic Information Systems, Traffic Congestion, Volume.

1. Introduction

Today's information technology can be applied to all fields of work. Information technology can be used as a means of information to create a road network in the form of a geographic information system. Making it easier for users of the system to find information from the road network.

The advantage of Web GIS is that it can be used by anyone with access to the internet. So it is very good if the use of Web GIS as a medium to present something. Actually there is already information about the road network made by the relevant agencies in the form of manual maps and digital maps. how to get it is also still limited and difficult. For this reason, this research must display or provide a web-based Geographic Information System (GIS) that can be useful and can be accessed by everyone without being limited by time and place, namely via the internet. Based on the above background, this research as a final project intends to take the title "Making a Road Network in Central Surabaya and Traffic Conditions in the Girilaya Road, Surabaya City Based on Geographic Information Systems.

1.1 Map

A map is a picture of the earth's surface drawn on a flat plane with a certain scale. Describe several functions and types of maps, namely as follows:

The main function of the map is perhaps for orientation or navigation. In each case, most maps available to the general public, with the exception of weather charts, are produced to assist with orientation and navigation. People use orientation maps to be able to get from one place to another on a pre-selected/determined route, and want to be able to check the map/chart whether they are still on the right path during their journey.

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1.2 Geographic Information System (GIS)

Geographic Information System (GIS) is a computer system used to manipulate geographic data. This system is implemented with computer hardware and software that functions for data acquisition and verification, data compilation, data storage, data change and updating, data management and exchange, manipulation, retrieval, presentation and data analysis. In general, there are two types of data that can be used to present or model the phenomena that occur in the actual field. This type of data such as position data, coordinates, space, and spatial. While the second is the type of data that represents the descriptive aspects of the modeling of the phenomenon which includes the items or properties concerned to the time dimension. This data is usually referred to as attribute data or non-spatial data. Attribute or non-spatial data types are used by database management systems (DBMS). This system can be used in the scope of business, education, engineering, management, academia, trade, offices, and matters related to the description of spatial data attributes. The limitation in DBMS is that it can only answer non-spatial questions (Prahasta, 2009).

Information systems can be broken down into several subsystems which are illustrated in the diagram below.

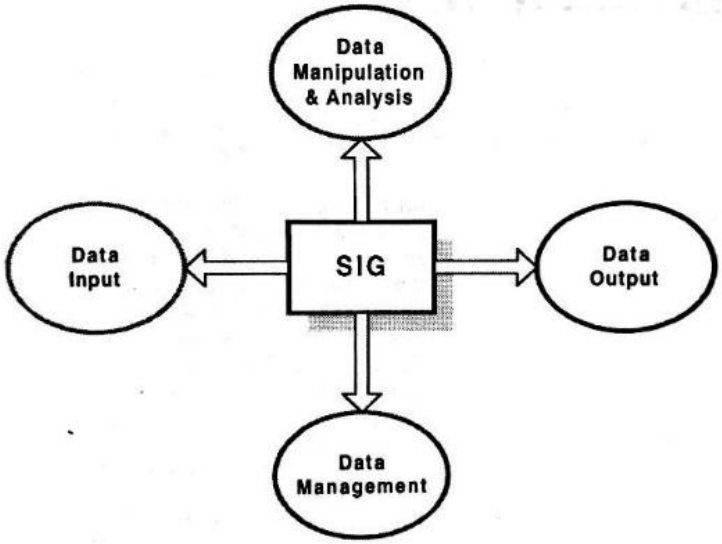

Figure 1. Geographic Information System Subsystem (Source: (Prahasta, 2009)

1.3 Web-based Geographic Information System (Web-GIS)

Web-GIS is basically a development of a GIS application based on the internet. This is because the development of applications in the network environment has shown great potential in relation to geo-information. Web-GIS is a web-based geographic information system consisting of several interrelated components. Web-GIS is a combination of graphic mapping design, digital maps with geographic analysis, computer programming, and a database that is interconnected into one web design and web mapping. For example, there is an online map for a city where users can easily access and use it to search for a location to be searched. (Esri, 1990)

1.4 Portal for ArcGIS

Some content obtained from various sources, both desktop-based, browser-based, and applications from the device in question needs to be stored on an internal computer. Internal start use and processing to be carried out. Restricted by a computer network security system which is no other use to protect data within its access rights. As the reason for using an internal database system, only internal users are allowed to access the content. Portal for ArcGIS is used to publish maps or content related to spatial analysis to ArcGIS Server (Esri, 1990).

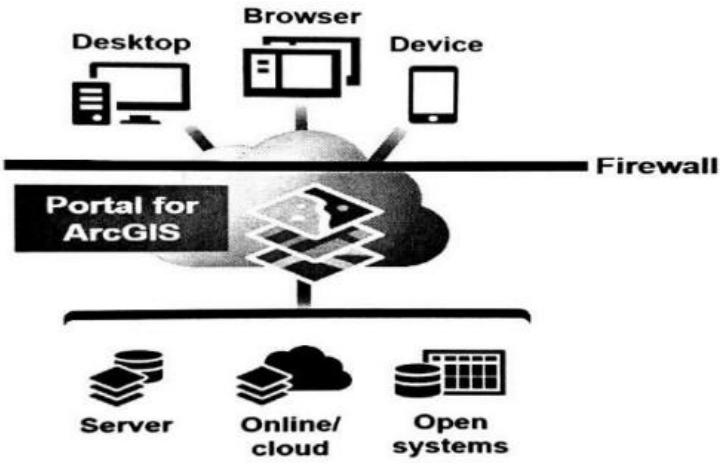

Figure 2. Portal Schematic for ArcGIS (Source: (Prahasta, 2009)

1.5 ArcGIS Server

ArcGIS for web-based server has functions as geocoding, geographic analysis, conversion, network analysis, and geo-geodatabase management. ArcGIS Server is used for geographic analysis because Portal for ArcGIS cannot use this feature. Thus, they both become a single entity where the output is web-based content that can be used within a single scope of user needs. ArcGIS server also has a function for users who are connected to the internet to publish server-based maps (Esri, 1990).

1.6 Database System Components

As a system, the database system has many integrated components including hardware, users, operating systems, database management systems (DBMS), other application programs, and databases (Prahasta, 2009). Hardware components include CPU (processor), memory (RAM), storage (hard disk, CD, etc.), keyboard, monitor, mouse, network (cable and internet network).

1.7 Geodatabase

An ArcGIS geo-database is a collection of geographic datasets of various types retrieved in a file folder system, Microsoft Access database, or multiuser DBMS (such as Oracle, Microsoft SQL Server, Postgre SQL, Informix, or IBM DB2). Geo-databases come in many forms, have a variety of users and can range from small, single-user databases building files to larger workgroups, departments, and enterprises. Geo-databases can be accessed by many users (Esri, 1990). However, a geo-database is more than just a collection of datasets. In ArcGIS Geo-database can mean many things, among others (Esri, 1990)

1.8 Road

The classification of road functions according to the Surabaya City Regional Regulation Number 12 of 2014 concerning the Surabaya City Regional Spatial Plan 2014-2034 is:

5. Freeway is a public road for continuous traffic with full control of the entrance and without any level crossing and is equipped with a road-owned fence.
6. Toll road is a public road which is part of the road network system and as a national road whose users are required to pay tolls.

1.9 Web

WWW, better known as the web, was originally a service for presenting information on the internet using HTML. Web is synonymous with the internet, because of its current popularity, the web has become an application interface for conducting transactions and presenting complete information from all over the world

1.10 HTML

HTML stands for Hyper Text Markup Language. HTML documents are pure text files that can be created with any text editor. This document is known as a web page. An HTML document is a document that is presented in the surfer's web browser. This document generally contains information or application interfaces on the internet.

There are two ways to create a web page: with an HTML editor or with a plain text editor (eg notepad). For practice or trying out the material in this paper, you should use notepad, after that near the end you can use

an HTML editor, this is intended so that you understand and get used to primitively creating web documents. Choose a name, any name, then add an extension of ".htm" or ".html" (double quotes do not need to be written as they are used for description only).

1.11 Transportation

Transportation explains that a system consisting of certain facilities along with a flow and control system that allows people or goods to move from one place to another efficiently at any time to support human activities. In this case, transportation has three elements, namely: there is a load that can be transported, there is a vehicle used as a means of transportation and there is a road that can be accessed. There are several types of land transportation, ranging from non-motorized such as bicycles, wagons, horse carts, tricycles, and so on, as well as motorized vehicles such as motorcycles and cars. People usually use private transportation such as private cars, rentals, or motorbikes to meet their transportation needs. Road users who do not use private vehicles can use mass transportation such as buses, public transportation, base or online motorcycle taxis and so on

1.12 Definition of Traffic Congestion

Congestion is an indication where the demand and use of the road crossing approaches or exceeds the design capacity of the transport infrastructure. The number of vehicles crossing a road approaches the physical capacity of existing road facilities and makes traffic speed slower so that the overall ability of traffic crossings decreases, where traffic is hampered but is still running.

Traffic jams often occur in areas that have a very high intensity of activity, land use and population. Traffic jams often occur due to high traffic volume, which is caused by a continuous mix of traffic (through traffic). The nature of traffic jams is a routine occurrence, which usually affects the use of resources, besides that traffic jams can also disrupt activities in the surrounding environment. The broad impact is that it affects the smooth running of socio-economic and cultural activities in an area .

2. Methodology

Against this background, roads in Surabaya function as a medium of socialization and accessibility for the community, so it is necessary to monitor and manage these roads in an integrated manner, and be able to provid the desired information in a short time. The results of this study are expected to be able to find out several things as follows:

1. Creating road network information in Simokerto District, Genteng District, Tegalsari District, Sawahan District and Gubeng District, Surabaya City interactively using a web-based Geographic Information System (GIS).
2. Provide information and make it easier to process road network data in the Surabaya City area online.
3. Knowing the traffic conditions of the Girilaya road in Surabaya

2.1 Research Sites

Research locations in this study are all arterial, collector and local road networks located in Simokerto District, Genteng District, Tegalsari District, Sawahan District and Gubeng District, Surabaya City.

Primary Data Collection. Primary data was obtained from the results of a direct survey at the research site, by measuring the dimensions of the channel directly and taking documentation at the research location. Data

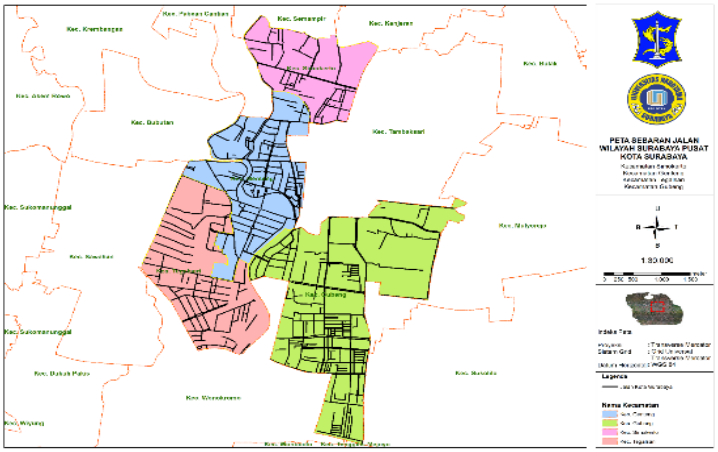

Figure 3. Research Locations

2.2 Data Used

The data used in this study are:

2) Traffic Volume Data

The method used to collect traffic volume data is done manually. To obtain this data, 2 observation posts were placed which were occupied by 2 officers for the recording section accompanied by the type of form for the number and type of vehicle. The postal point was chosen to make it easy to count the passing vehicles. Classification of types of vehicles that pass on the road:

f. Light Vehicles (LV): Passenger cars and small trucks (pick ups)
g. Heavy Vehicle (HV): Big truck
h. Motorcycles (MC): Motorcycles and three-wheeled vehicles
i. Non-motorized vehicles: bicycles and trishaws

3) Road Geometry Data

The method of collecting road geometry data is carried out by direct measurements in the field. The purpose of the measurement process is to determine the type of location, number of lanes, lane width, and parking conditions. Measurements with a roll meter and measurement times were carried out at night due to sloping traffic so that the measurement process ran smoothly and precisely.

Table 1.

Street Name	Number Of Lanes	Lane Width (M)
Girilaya Street (South Direction)	1	3
Girilaya Street (North Direction)	1	3

2.3 Data Collection Method

In this study the data collection methods used are:

1. Field Survey

The field survey conducted in this study aims to determine the condition and position of the research object, namely the road network in the city of Surabaya correctly and accurately.

2. Documentation Study

The documentation method is a method of collecting data by looking at written records and can be accounted for as well as being strong and official evidence. The documentation method used in this research is to collect spatial data and attribute data from relevant agencies to obtain relevant and accurate data. The agency is the Public Works Department of Highways and the City of Surabaya.

2.4 Data Processing Stage

Data processing using a computer (PC) / Laptop with ArcGIS 10.4 application. After all the data needed in this research is collected, then data processing is carried out to obtain information related to the road network in the city of Surabaya. The steps taken are:

1. Entering and processing data sources
2. Doing digitization
3. Adding spatial data information attributes
4. Display road information
5. Create a digitized Geodatabase
6. Export data using ArcGIS Online
7. Testing online

2.5 Digitizing Maps

Data analysis was carried out after the research data processing was completed. The research results were processed using ArcGIS 10.4 software. The data processing is done by digitizing several themes, including: village boundaries, sub-district boundaries, and roads (based on their classification). So that the final result of the digitization is a web-based geographic information system for the road network in the city of Surabaya.

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2.6 Map Layout

A map to be printed must first be arranged in the layout of its supporting properties. This is necessary to clarify the information contained on the map. The layout of the map properties will have an effect on the map information. Therefore, before printing, a map must be designed as well as possible. Some that must be considered or important to include in the layout are:

1. Insert map
2. Map grid
3. Map scale
4. Map legend
5. Map maker label
6. Designing map orientation
7. Map frames

Figure 4. Example of a road network map layout

3. Result and Discussion

3.1 Research Results

Jalan Girilaya is the name of a street in the city of Surabaya. Jalan Girilaya is a central area because from the north it is Jalan Banyu Urip, from the south it is Jalan Kupang Gunung. On the road is the point where there are shops, restaurants, traffic flows that are active in daily activities.

The width of the Girilaya road section is actually 5 meters with the width of each right and left shoulder of 1 meter. In a very densely populated residential area on the side of the road with insufficient parking provided so that many consumers or buyers put motorbikes to cars on the side of the road which results in overcrowding on these roads.

In addition, the increasing number of pedestrians crossing along the road segment, from the flow of slowly moving vehicles such as bicycles and motorcycle tricycles in and out of the roadside. This causes congestion so that congestion often occurs on the Girilaya road. The following is the Geometric data of the 100-meter-long Girilaya road segment.

j. Road Type: 2/2 UD (2 lanes – 2 undivided directions)
k. Road : 1 meter on the right side and 1 meter on the left side
l. Road Width: 5 meters for a total of 2 directions
m. Population : 201,766 inhabitants (2020)

The research to determine the condition of the Girilaya road, a survey was carried out on Wednesday 2 June 2021 to Tuesday 8 June 2021. The survey was carried out for 3 hours. In the morning at 07.00 – 08.00, in the afternoon at 12.00 – 13.00, and in the afternoon at 17.00 – 18.00. The research was carried out by 5 people, 2 surveyors to observe the movement of daily traffic vehicles and 3 people in charge of observing side obstacles that occur on the road segment. Based on data obtained from survey observations, it is continued with the

calculation of traffic volume, road capacity, side obstacle class, degree of saturation, speed and level of service based on the Indonesian Road Capacity Manual (MKJI, 1997).

3.2 Traffic Volume

Traffic volume is the total number of vehicles passing a certain point on a certain road segment at a certain time. Expressed in units of passenger car vehicles (SMP). For the planned traffic volume (VLHR) is the estimated traffic volume at the end of the planned traffic year expressed in pcu/hour. The traffic volume survey is carried out by directly counting the number of vehicles passing the observation point using a counter. The survey was conducted by 3 surveyors at the observation point for each direction of traffic, where the surveyor will calculate the types of vehicles that pass on the road segment by classifying the vehicle classification. The types of vehicles observed are:

n. Light Vehicles (LV): Passenger cars and small trucks (pick ups)
o. Heavy Vehicles (HV): Big trucks
p. Motorcycles (MC): Motorcycles and three-wheeled vehicles
q. Non-motorized vehicles: bicycles and rickshaws

Calculations On Monday in the direction of Kupang Gunung smp/hour (17:00-18:00).

Table 2.

LV x EMP LV	= 540 x 1.0	=	540 smp/jam
HV x EMP HV	= 10 x 1.2	=	12 smp/jam
MC x EMP MC	= 1143 x 0.25	=	285,75 smp/jam

So the total in junior high school / hour is obtained: 540 + 12 + 285.75 = 837.75 junior high school / hour Calculations On Monday in the direction of Banyu Urip smp/hour (17:00-18:00).

Table 3.

LV x EMP LV	= 599 x 1.0	=	599 smp/jam
HV x EMP HV	= 9 x 1.2	=	10.8 smp/jam
MC x EMP MC	= 1113 x 0.25	=	278.25 smp/jam

it can be seen that the maximum volume on Monday afternoon at 17.00 – 18.00 WIB is 1725.8 smp/hour, this is due to the density of trading activities, namely the number of restaurants, shops, and very high hours of returning from work. While the sloping traffic volume occurred on Saturday afternoon at 12.00-13.00 WIB of 989.4 smp/hour due to the quiet activity at that hour.

The data taken in this survey are vehicles that stop and park on the shoulder of the road, pedestrians who are parallel and also crossing the road, vehicles entering and leaving the road and slow vehicles. From this research, it is multiplied by the side resistance weight factor. In this survey, it is conducted with a distance of 100 meters and selects the most segment data. The table of side resistance survey results can be seen in the appendix and the following table of total side resistance is shown in table 1.

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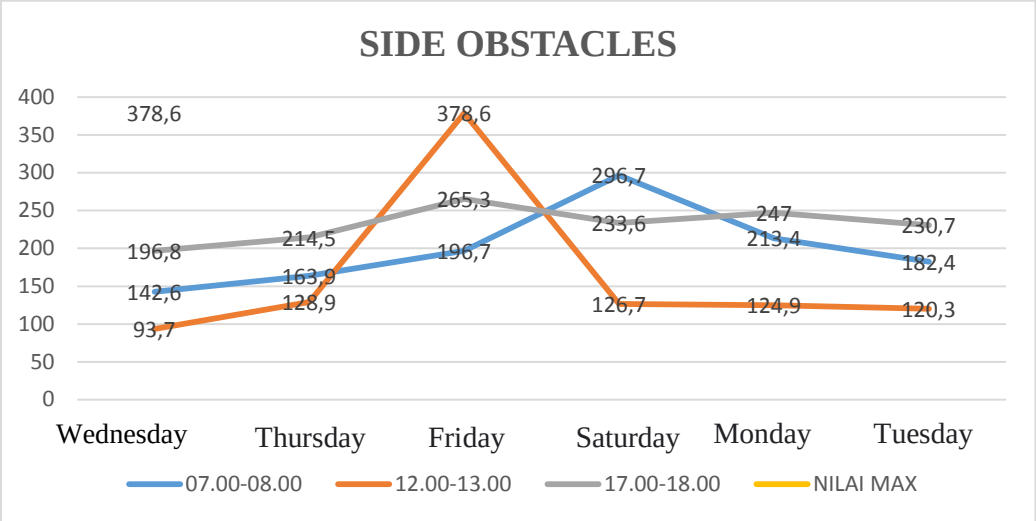

Figure 5. Total side drag results for events per 100 meters per hour (Two-sided)

The Girilaya road section is a type 2 lane 2 undivided direction (2/2 UD), with a width of 3 meters per lane for each lane. The calculation of the speed of free traffic flow is calculated based on the Indonesian Road

Capacity Manual (MKJI, 1997) for urban roads. For the basic free flow speed and adjustment factor taken from the 1997 MKJI, the following is the calculation of the vehicle traffic flow speed based on the (MKJI, 1997).

r. Basic Free Flow Speed of Light Vehicles (km/h) Fvo = 42 km/h
s. Effective Traffic Lane Width Speed (km/h) FVw = -3
t. Adjustment Factor for Side Barrier Conditions FFVsf = 0.93
u. City Size Adjustment Factor FFVcs = 0.90
v. FV = (Fvo + FVw) x FVw x FFVsf x FFVcs FV = 32.6 Km/Hour. Based on the calculation results above, it is found that the speed of free traffic flow on the Girilaya road due to side barriers in the area that has been reviewed is 32.6 Km/Hour. .

3.3. Road Capacity

The capacity of the Girilaya road section uses the (MKJI, 1997) regulation procedure for urban road conditions. The following is the calculation of the capacity with the occurrence of side barriers on the road.

w. Co Basic Capacity = 2900 Km/Hour
x. Road Width Adjustment Factor FCw = 0.87
y. FCsp Directional Separator Adjustment Factor = 0.94
z. FCsf Side Resistance Adjustment Factor = 0.93
aa. City size adjustment factor FCcs = 0.90
bb. Capacity C = Co x FCw x FCsp x FCsf x FCcs C = 1985 smp/hour Based on the above calculation, it can be seen that from the calculation results according to the (MKJI, 1997) procedure, the capacity value of the Girilaya road segment for a total of 2 directions is 1985 smp/hour.

3.4 Degrees of Saturation

The degree of saturation is the ratio between traffic volume and road capacity. The calculation of the degree of saturation in the presence of side resistance can be seen as follows:

DS = Q/C

Information:

Q = Vehicle Volume

C = Capacity

Vehicle volume from the results of the daily traffic survey is on average on Mondays at 17.00 – 18.00 with a total of 1346 pcu/hour.

Capacity (C) = 1985 pcu/hour

Then = 1725.8/1985 =0.869

From the results of the calculation of the degree of saturation, we can see that the recapitulation of the degree of saturation is in table 2.

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Table 4. The results of the calculation of the degree of saturation per hour in the presence of side resistance

Time	Wednesday	Thursday	Friday	Saturday	Monday	Tuesday
07.00-08.00	0,7116	0,685	0,746	0,669	0,812	0,752
12.00-13.00	0,5890	0,512	0,541	0,498	0,621	0,663
17.00-18.00	0,7729	0,764	0,669	0,594	0,861	0,810

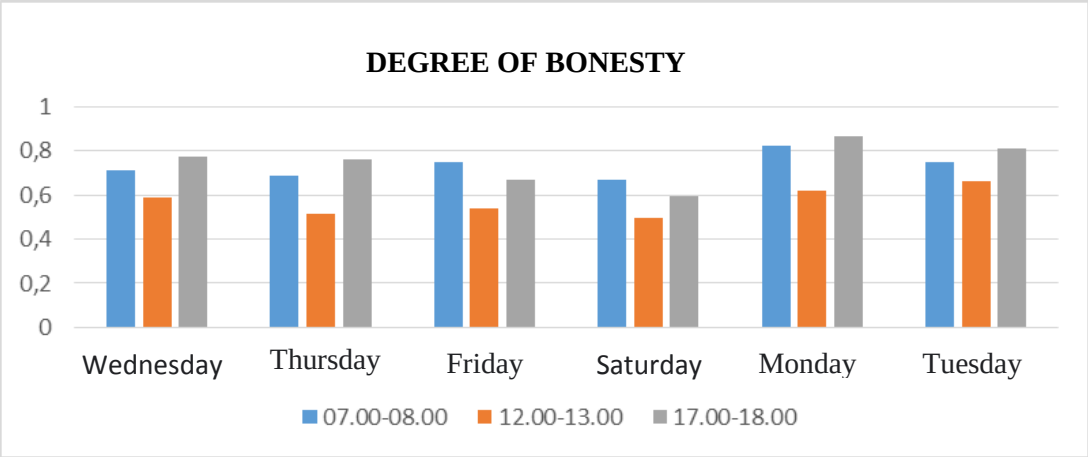

Figure 6. Graph of the Degree of Saturation on the Girilaya Street

Based on the analysis, it can be seen that the value of the degree of saturation that exceeds the maximum limit of the degree of saturation in a few hours of observation time is past the DS limit > 0.75 – 0.80 based on MKJI 1997 even the road capacity up to DS is 0.869, then the results result in the level of service being D, namely: the current is close to no stable and low speed. This makes road performance not optimal and an action needs to be taken to improve traffic management on these roads such as road markings, parking system settings, providing traffic signs on the side of the road.

From the results of the analysis of congestion analysis on the Girilaya road, data analysis was carried out based on procedures using guidelines (MKJI, 1997) so the results of the research can be described as follows:

1. The highest vehicle volume on Monday in the afternoon on Jalan Girilaya at 17.00 – 18.00 WIB is 1606 km/hour. This is due to the high volume of vehicles due to the dense activity of returning home from work and accompanied by high activity around shops, kiosks and restaurants.
2. Side obstacles obtained on Friday at 12.00 - 13.00 WIB are included in the medium side obstacle class (M) which is 396 events / hour due to the road shoulder or the edge of the segment being used as a parking lot and vehicles stopping on the road resulting in disruption of traffic flow on the road Girilaya.
3. The results of the analysis showed that the value of the degree of saturation on Monday in the afternoon at 17.00 – 18.00 WIB was 0.809, so it was produced according to the (MKJI, 1997)guidelines, the level of service for the road section was D, which explained that the flow was approaching unstable and the speed was low.

3.5 Development of a Web-Based Road Network Geographic Information System

The creation of a Web-based road network Geographic Information System is carried out after the research data processing is complete. The research results were processed using ArcGIS 10.4 software. So that the final result of the manufacture is a web-based geographic information system for the road network in the city of Surabaya. The road network to be processed according to road function in the form of arterial, collector and local roads is in the Simokerto District, Genteng District, Tegalsari District, Sawahan District and Gubeng District, Surabaya City. The data processing is done by digitizing several attributes, including:

1. Street Name
2. District Boundaries
3. Village boundaries
4. Road Length
5. Road Width
6. Type of Road Function
7. Type of Pavement
8. Identification of the Base of the Road
9. Identification of the End of the Road.

The road network that will be inventoried is 347 road sections with details:

1. Bubutan sub-district totaling 101 roads
2. Genteng sub-district totaling 83 roads
3. Simokerto Subdistrict with 24 Roads
4. Tegalsari sub-district totaling 72 roads
5. Sawahan sub-district totaling 67 roads

4. Conclussion

Based on the results of road network data management based on Geographic Information Systems and analysis of the Girilaya road segment due to side obstacles that occur, the following conclusions can be drawn:

1. The highest volume of vehicles on the Girilaya road is 1725.8 pcu/hour. This is due to the high volume of vehicles due to the dense activity of returning home from work and accompanied by high activity around shops, kiosks and restaurants.
2. The highest side obstacle is on Friday with the category of moderate side obstacle class (M) 378.6 events/hour, due to the fact that there are many rows of shops, kiosks, restaurants and places of worship for Muslims for Friday prayers, there is no parking space. which is provided properly so that it is very disturbing the traffic flow activity of the Girilaya road.
3. Based on observations that have been made the value of the worst service level is D. This shows that the flow of vehicles is hampered, the speed is low, the volume of vehicles is above capacity.
4. With GIS software, a web-based road network can be created with a web page link https://arcg.is/1bL0CX0 which can find out the classification of the road network in Central Surabaya City according to road function, government administration and axis load, as well as other information such as name the road, the length of the road and the LHR of the road being researched

With GIS software, an interactive web-based geographic information system for the road network in Surabaya can be made that can be accessed by everyone without being limited by time and place, namely via the internet.

From the results of the analysis that has been done, suggestions that can be given by the author are:

1. To reduce the level of side barriers, namely for the surrounding community to be more obedient when driving, not to drag each other, not to put parking on the shoulder of the road during purchase transactions, place the vehicle on land that is thought to be empty, awareness for kiosk owners, shops and restaurants to provide parking space appropriate so as not to disrupt the flow of traffic on the road. And for truck drivers who ignore the time limit for entering the Girilaya road, it causes delays in morning and evening activities.
2. In particular, for the government to complete traffic signs for maximum speed, parking is prohibited, stopping is prohibited and so on and it is hoped that it will not interfere with traffic flow on Girilaya road.
3. The government is expected to expand the road due to the very high volume of traffic on the road and improve the function of the shoulder of the road as a pedestrian area so that it functions properly.
4. Based on the conclusions above, it is recommended that digital data processing should be carried out regularly by the relevant agencies on the road network.

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