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The Impact of Traffic Congestion on Roads: A Highway Case Study Ligung-Majalengka

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ABSTRACT

Traffic congestion has become an increasingly complex and pressing global problem. Rapid population growth, rapid urbanization, and increasing private vehicle ownership have greatly increased traffic volumes in a number of cities in various parts of the world. This study aims to determine problems related to road density and congestion in the context of infrastructure development and urbanization. This paper discusses the problem of road density. The Ligung highway is usually busy during rush hours, which often occurs in the morning and also in the afternoon. This situation is caused by the working hours of factory employees and children going to school in the morning and returning home at the same time in the afternoon. The location of this research is in Ligung, which is on Jalan Raya Ligung which will lead to the Jatiwangi-Kadipaten road ± 1000 meters. This writing focuses on speed and density analysis to help determine the average vehicle speed and average vehicle density. Apart from using qualitative methods, field observations were also carried out to determine and detect the volume of highways, vehicles passing, and the speed of vehicles passing, how congested the highway was. Ligung. Primary data consists of the number of vehicles passing, Microsoft Excel 2021 and Traffic Counter software. Secondary data is MKJI 1997. For data, the highway section consists of a road through two opposing traffic lanes (2/2 UD). The level of congestion and density of traffic conditions on the surveyed roads are also displayed using speed and density data. To obtain information on traffic density and road performance in the area, these parameters must be observed and analyzed further.

1. Introduction

Traffic congestion has become an increasingly complex and pressing global problem. Rapid population growth, rapid urbanization, and increasing private vehicle ownership are increasing traffic volumes in many cities around the world. As a result, traffic jams have become a daily problem, not only impacting community activities but also having a negative impact on the economy, environment and public health. Recent research shows that traffic congestion not only causes significant economic losses, but also plays a role in increasing greenhouse gas emissions and air pollution. The human eye's sensitivity to weather, road conditions, and to weather, other external elements are now being used to detect traffic jams in India (Manchanda, Rathi, & Sharma, 2019).

CWZ is one of the main factors causing traffic congestion and congestion for road users (Vyas & Varia, 2023). Traffic congestion has become a complex and multidimensional national issue. This condition not only has an impact on the economy through increasing operational costs and decreasing productivity, but also causes various social problems, such as stress and health problems. To improve road safety, Shanghai city government began drafting a transportation white journal in 2012, it declared safety to be its top priority and set a goal of reducing road fatalities by 25 percent within the next decade (Wang, et al., 2019). Apart from that, congestion also contributes to environmental degradation due to increased air and noise pollution.

Traffic congestion is a major problem in metropolitan cities, especially in Majalengka city which has a large population and rapid vehicle growth. Traffic congestion that often occurs in Majalengka (Akbar & Saputra, 2024). One of them is that the rush hour entry and exit of factory employees and school children has become the main focus due to the rapid increase in the number of private vehicles.

The population is increasing rapidly, both natives and migrants, will have an impact on increasing transportation needs, either public or private transport, however roads and volumes do not increase (Wartono, Sidabutar, Indrawan, & Panusunan, 2023). To address this issue, the Indonesian government has improved road infrastructure and public transportation systems. However, Majalengka city really needs a more efficient solution to thoroughly investigate the traffic congestion problem.

The Ligung highway is generally busy during rush hours which occur in the morning and evening. This situation is caused by the working hours of factory workers and children who go to school in the morning and return home at the same time in the afternoon. It is evident that traffic congestion is a serious problem in industry and education. The analysis shows that the traffic density relationship on the highway follows a linear and logarithmic pattern (Haryati & Najid, 2021). Based on this relationship, the value of the capacity and traffic performance of the road section is also calculated.

The purpose of this paper is to investigate issues related to road traffic congestion in the context of infrastructure development and urbanization, the problem of road congestion will be discussed in this paper. By analyzing these issues, it is expected to understand urban mobility and its impact on the environment. This research is also to help the government find solutions and suggestions that can be implemented. Therefore, it is expected to be useful in understanding issues related to urban mobility and development. Thus, the title of this journal is the impact of traffic congestion on highways: a case study of the Ligung-Majalengka highway.

2. Literature Review

2.1 Transportation

As in everything else in life, transportation has its own history Therefore, in this journal I want to discuss about history of transport and transport (Maslich & Voronova, 2024). Transportation began around 3500 BC with the advent of the wheel. It was discovered in the 1st century BC, but some say it was discovered 300 years before Mesopotamia. In the 1800s to 1860s, mechanical transportation such as steamboats and trains began to develop. Then, between 1860 and 1920, the first automobile and airplane were invented. During the 20th and 21st centuries, transportation systems evolved rapidly as technology advanced.

The transportation industry has contributed significantly on the mobility of people and goods across it various geographical areas (Iyer, 2021). The transportation sector is consideredan important part of the country`s economy (Verma & Subramanian, 2021). Thisdevelopment is considered beneficial for public transit services and positively correlates with preservation of open space and ecosystems, improved accessibility, reduced private car use and traffic volume, thereby reducing existing pollution (Karjalainen & Juhola, 2019). Currently, the development of public transportation is very rapid, there are various types of public transportation that now exist, starting from sea transportation, road transportation, river transportation, air transportation, and rail transportation. Thus, transportation is very influential for humans to move from starting point to destination point in a very short time. Driving globalization and uniting the world at an unprecedented level (Anugraha, Rifai, Taufik, & Isradi, 2024). Transformation has transformed urban mobility to be less predictable and follow more ambiguous patterns, with urban mobility acting as an “active organism” that changes and adapts to new situations and patterns (Bharadiya, 2023). Even though there is a variety of transportation, Indonesia's transportation system still faces many challenges. Congestion in big cities, uneven infrastructure, and the high number of accidents are problems that need immediate attention. Apart from that, integration between modes of transportation is still a big challenge for the government and related stakeholders. Therefore, the government can improve the mobility of a city by providing a fairly well-organized transportation system (Saif, Zefreh, & Torok, 2019).

2.1 Traffic

Today's traffic is increasingly complicated because of the many sophisticated technologies. Smart transportation systems, autonomous cars, and location-based applications are changing our travel experience. Today's transportation systems include cars, train services, and several types of shared mobility that have developed recently, including digital app platforms, bicycle rentals, and electric scooter rentals (Jiang & Luo, 2022). What is worrying is that this manifestation of modern traffic continues to grow with no signs of abating, creating a nightmare that is destroying the quality of urban

life (Benmessaoud, Cherrat, & Ezziyyani, 2023). Therefore, to develop cities and urban areas, it is important to understand regulations, modern traffic dynamics, and creative solutions to better manage them. Such as the implementation of smart transportation technology and advanced traffic management systems (Fatimah & Rifa'i, 2024).

The traffic function involves organizing and controlling vehicular and pedestrian traffic to create an effective and safe mobility system. Road safety refers to the quality of roads as determined by the accident rate, which reflects the level of safety of road users against road accidents and their consequences (Batrakova & Gredasova, 2019). First, transportation facilitates the movement of individuals and products, encourages regional connections, and supports economic activity. Second, traffic conditions contribute to urban expansion and improvement of transport infrastructure, which is an important element of urban planning. Establish a virtuous cycle between economic expansion, infrastructure improvements, and individual well-being (Firmansyah, Rifai, & Taufik, 2022). To maintain order and avoid chaos, traffic flow needs to be regulated by traffic signs, markings and navigation systems. In addition, regulations, standards and enforcement by traffic authorities can also improve road safety. Finally, traffic indicates the mobility and progress of a region, and reflects the social, economic and infrastructural progress of a society. Road safety refers to the quality of roads as determined by the crash rate, which reflects the level of safety of road users against crashes and their consequences (Golob, Recker, & Alvarez, 2020).

Several parts make up the transportation system, each of which is responsible for coordinating the flow of vehicles and pedestrians on roadways. Roadways serve as the main routes for vehicular traffic, while traffic lights coordinate the movement of vehicles and pedestrians at intersections (Natalia & Rifa'i, 2023). One of the functions of traffic signs is to visually and explicitly convey important rules and information to road users. Different lane segments are designated for different vehicle types and speeds: aiding more effective traffic management. Finally, sidewalks and pedestrian facilities support the smooth coexistence of vehicles and pedestrians, creating a safe space for pedestrians. An effectively operating transportation system consists of a mix of the following elements: collaborate efficiently. Since the spatial and temporal correlation between road sections is complex, the focus of experts' research is to consider the spatial relationship between road sections in traffic estimation models (Rachman, 2024).

2.2 Road Section

A road segment is a specific area on a highway that runs between two specific points. The term denotes a stretch of road that contains one or more lanes, which has elements such as intersections and additional supporting infrastructure (Rahayu, Rifai, & Akhir, 2022). There are different categories of roads, such as freeways, arterial roads, and public roads, depending on their function and environmental characteristics. Roads play an important role in the transportation system that connects places. Designing and supervising roadways requires a thorough understanding of the layout, capacity, and characteristics that affect vehicle and pedestrian movement (Yoon, Noble, & Liu, 2019). So that a road network can be designed that is efficient and supports community mobility, by utilizing information and communication technology (Agustian & Pamadi, 2024).

The road network has different routes designed for specific destinations and journeys. Road transportation problems will likely continue to increase iin the future along with increasing mobility needs in the United States of Amerika around the world (Bartle & Devan, 2020). Originally, toll roads were roads intended to serve as routes that reduced travel time and increased efficiency. A paid service that facilitates long-distance travel, allowing activities to be carried out quickly and effectively. Second, arterial roads serve as major routes that connect centers of economic and social activity within regional cities. Third, local roads are roads that meet the transportation needs of local communities or neighborhoods. Finally, designated lanes including bus lanes, bicycle routes, and pedestrian paths are designed for specific purposes, with a focus on improving public transit or promoting sustainable transportation. Understanding these road segments is critical to developing better urban design and effective transportation systems. It can help develop a more accommodating urban environment for pedestrians and transit users (Muizz, Rifa'i, & Fajarika, 2024).

The road network is considered one of the important elements in the structure of the city and has many roles in urban life (Hu, et al., 2020). Easy access with very well developed road and

transportation infrastructure aims to become a tourist destination and revitalize local businesses providing positive impact on the lives on local communities (Kanwal, Rasheed, Pitafi, Pitafi, & Ren, 2020). Smooth and well-maintained roads make it easy for tourists to access tourist destinations. This ease of access will attract more tourists and have a positive impact on the economy of the surrounding area. In this way, local tourism can develop faster and be more diverse. Encouraging regional economic growth and creating new jobs (Herdiana, Rifai, Taufik, & Prasetijo, 2024).

3. Method

The type of research that will be applied in this research is by utilizing qualitative research methods. Qualitative methods usually use analysis and are descriptive in nature. Qualitativeresearch uses data to guide interpretation and uses data to generate new hypotheses and research questions (L. Haven & Van Grootel, 2019). First, transportation facilitates the movement of individuals and products, encourages regional connections, and supports economic activity. Second, traffic conditions contribute to urban expansion and improvement of transport infrastructure, which is an important element of urban planning. Establish a virtuous cycle between economic expansion, infrastructure improvements, and individual well-being. This research was conducted on Monday, January 06, 2025 at 06.00 - 07.00 when people do activities such as going to work and school, at 12.00 - 13.00 during break time, and at 16.00 - 17.00 when people have finished doing activities.

The location of this research is in Ligung, namely on Jalan Raya Ligung which will lead to the Jatiwangi-Kadipaten road ± 1000 meters. For more details, it can be seen in Figure 1.

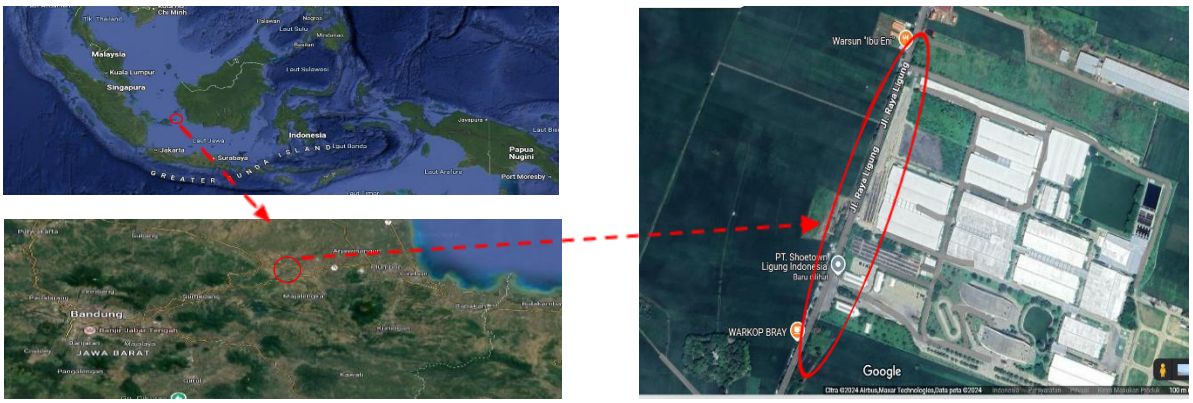

Figure. 1 Testing data

4. Results and Discussion

4.1 Road Segment Data

The Ligung highway is anindustrial area, this road is often crossed by pedestrians, motorbikes, private cars or heavy goods transport. Transport vehicles are permitted to use this road. Data and existing conditions of the road:

1. Two-lane road with two-way traffic.
2. Lane Dimensional breadth of each road section ±3,5 meters.
3. Road markings, either in the form of white or yellow lines, serve as a physical barrier between one lane and another.

Figure. 2 Condition of the Ligung highway which coincides in front of Soeton Ligung Indonesia.

4.2 Road Volume Analysis Results

Road The quantity of the road section that is being used with the capacity of vehicles passing in a certain time. Expressed in vehicles per hour (smp/h). The calculation of road volume is very important to determine the flow of traffic flow in a particular place. Data - data on Traffic volume on the road is very important for planning and managing transportation flows. Road Volume contributes to Ascertain the smoothness Of occurring traffic at that location. The capacity of a road can be analyzed With knowledge of the number of Transportation units passing By means of road.

Table. 1 Road Density Volume Test Results

No	Senin	Jumlah Kendaraan (ken/jam)					Jumat Kendaraan (Smp/jam)				
	Waktu	LV	HV	MC	UM	Total	LV	HV	MC	UM	Total
1	06.00-07.00	72	28	3209	148	3457	72	36,4	1604,5	148	1860,4
2	11.00-12.00	25	12	1012	69	1118	25	15,6	506	69	615,6
3	16.00-17.00	82	25	3182	128	3417	82	32,5	1591	128	1833,5
No	Selasa	Jumlah Kendaraan (ken/jam)					Jumlah kendaraan (Smp/jam)				
	Waktu	LV	HV	MC	UM	Total	LV	HV	MC	UM	Total
1	06.00-07.00	75	26	3145	136	3406	75	33,8	1572,5	136	1820,3
2	11.00-12.00	23	10	1035	52	1120	23	13	517,5	52	671,5
3	16.00-17.00	85	23	3113	118	3339	85	29,9	1556,5	118	1762,4
No	Rabu	Jumlah Kendaraan (ken/jam)					Jumlah kendaraan (Smp/jam)				
	Waktu	LV	HV	MC	UM	Total	LV	HV	MC	UM	Total
1	06.00-07.00	73	29	3223	145	3470	73	37,7	1611,5	145	1867,2
2	11.00-12.00	27	11	1063	59	1170	27	14,3	531,5	59	631,8
3	16.00-17.00	89	30	3198	129	3446	89	39	1599	129	1856

The data shows that the peak vehicle volume is 1867.2 vehicle units per hour (PCU/H) between 06:00 and 07:00, when many vehicles cross the studied road section. The largest traffic flows during these times can lead to peak hour traffic conditions, as many cars of returning factory workers use this section of road during these hours.

4.3 Vehicle Speed Analysis Results

The speed of vehicle use is very important to determine the speed pattern in traffic flow during different times Analyzing the flow characteristics along the road section of the Kasokandel highway. Patterns The level of speed as information to determine the speed of vehicles during peak hours there is a more efficient buildup of traffic flow vehicles. Vehicle speed can be analyzed by knowing what is used.

Table. 2 Vehicle Results

No	Senin	Jarak Tempuh	Jumlah Data	Waktu Tempuh	Space Mean Spade	
	Waktu	(m)	Pengamatan	(Detik)	(m/jam)	(km/jam)
1	06.00-07.00	110	12	20,12	5,47	19,69
2	11.00-12.00	110	12	11,26	9,77	35,18
3	16.00-17.00	110	12	19,25	5,71	20,55
No	Selasa	Jarak Tempuh	Jumlah Data	Waktu Tempuh	Space Mean Spade	
	Waktu	(m)	Pengamatan	(Detik)	(m/jam)	(km/jam)
1	06.00-07.00	110	12	20,06	5,48	19,72
2	11.00-12.00	110	12	11,19	9,83	35,38
3	16.00-17.00	110	12	19,18	5,73	20,62
No	Rabu	Jarak Tempuh	Jumlah Data	Waktu Tempuh	Space Mean Spade	
	Waktu	(m)	Pengamatan	(Detik)	(m/jam)	(km/jam)
1	06.00-07.00	110	12	22,54	4,88	17,57
2	11.00-12.00	110	12	11,22	9,80	35,28
3	16.00-17.00	110	12	21,49	5,12	18,43

Observations showed that vehicles reached their peak average speed of 35.38 Km/h on Tuesday between 12:00 and 13:00, when traffic is usually smoother and vehicles can travel at relatively high speeds. Meanwhile, the lowest average vehicle speed was recorded on Wednesday between 6am and 7am, at 17.57 Km/h. During this time period, there was a decrease in vehicle speed, which is likely due to the reduced volume of vehicles.

4.4 Vehicle Density Analysis Results

Measures the density of significant vehicular traffic Within the road section over Duration of time. Mean speed (Us) Speed is measured in kilometers per hour, while traffic volume (Q) is quantified in vehicles per hour (Smp/hr), flow speed is similarly quantified in vehicles per hour (smp/hr), Traffic density also needs to be measured using vehicles All data is presented on an hourly basis these measurements are used to conduct traffic density testing. Based on the intensity of traffic flow tested along the lane. This volume data is very important with vehicle counts Along the road, the rate of flow represents the number of vehicles passing a given point within a specific time period that pass through a lane during an hour. To analyze the traffic density on the analyzed road segment, this parameter is also helpful. The results of traffic density testing are in tabel 3.

Tabel. 3 Traffic density test results

No	Senin	Space Mean Speed	Volume (Q)	Rate Of Flow	Kepadatan (D)
	Waktu	(Us) (Km/Jam)	(Smp/Jam)	(Smp/Jam)	(Smp/Jam)
1	06.00-07.00	19,69	1860,4	7441,6	377,9
2	11.00-12.00	35,18	615,6	2462,4	69,9
3	16.00-17.00	20,55	1833,5	7334	356,8
No	Selasa	Space Mean Speed	Volume (Q)	Rate Of Flow	Kepadatan (D)
	Waktu	(Us) (Km/Jam)	(Smp/Jam)	(Smp/Jam)	(Smp/Jam)
1	06.00-07.00	19,72	1820,3	7281,2	369,2
2	11.00-12.00	35,38	671,5	2686	75,91
3	16.00-17.00	20,62	1762,4	7007,61	339,8
No	Rabu	Space Mean Speed	Volume (Q)	Rate Of Flow	Kepadatan (D)
	Waktu	(Us) (Km/Jam)	(Smp/Jam)	(Smp/Jam)	(Smp/Jam)
1	06.00-07.00	17,57	1867,2	7468,8	425,8
2	11.00-12.00	35,28	631,8	2527,2	71,63
3	16.00-17.00	18,43	1856	7424	402,8

Test results show that vehicles reached a peak density of 425.8 PCU/h on Wednesday, from 06:00 to 07:00, during heavy traffic when vehicles were moving slowly at relatively low speeds. At the same time, the minimum vehicle density was recorded on Wednesday from 12:00 to 13:00, at 75.91 PCU/hr. During this time, the vehicle density seems to be decreasing.

5. Conclusion

Based on the analysis and discussion, the volume of vehicles at 06:00-07:00 reached its highest point at 1867.2 vehicles per hour, indicating that the traffic was heavy. The vehicle speed analysis shows that on Tuesday, the average speed peaked between 12:00-13:00, at 35.38 km/h, indicating that the traffic was relatively smooth. Meanwhile, the lowest average speed was recorded between 06:00-07:00 at 17.57 km/h, indicating a decrease in vehicle movements during this period, which is likely due to a decrease in the number of vehicles. Vehicle density on Jalan Raya Ligung peaked at 06.00-07.00 at 425.8 PCU/h, while the lowest density was recorded at 75.91 PCU/h on Thursday between 12.00-13.00.

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