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Development of Priority Scale Handling National Road Maintenance in Banten

Characteristics of Weekend Activities in Greater Jakarta

The Efficiency of a Bus Rapid Transit Utilizing a Passenger Information System

Analytic Hierarchy Process for Priority Policy on Road Access to Tourist Areas of Berau Regency East Kalimantan

Cycle Rickshaw: History and Problem

Urban Transportation: Performance and Problems (Case Study: Route ABG, CKL, and AT)

The Effect of Commercial Areas and Industrial Zone Improvement on Road Service Levels Between City Surabaya-Sidoarjo

Emission Reduction from Transportation Sector Using Carbon Footprint

The Influence of the Water Level in the Brake Fluid on the Rate of Increase in Temperature and Boiling Point of the Brake Fluid

Calibration and Validation of Walking Behavior Parameter (Case Study: Sky Bridge of Sultan Mahmud Badaruddin II Airport, Palembang)

The Relationship Between Trait Anger and Traffic Accident History in Denpasar, Manado, and Padang

Planning Reactivation Train for Kedungjati – Tuntang Using Google Earth, Global Mapper, and AutoCAD Civil 3D

Relationship of Emotional Maturity and Couples Adjustment on the Aircraft Crew

The Meaning of Membership in Motorcycle Community in the Campus

A Prototype of Track Gauge and Cant Measurement Device for Curved Railroad by Using Microcontroller

Design and Load Analysis Toward the Strength of Rim Modification Using SOLIDWORKS Software on Motorcycle as a City Transportation

Freeboard Monitoring System as An Early Warning System on Railroad Bridge With Solar Cell As Resource Energy

Analysis of Tariff Integration Between MRT and Transjakarta*

Investigating the Role of Activity-Travel Participation on Daily Travel Satisfaction in Bandung Metropolitan
| Author(s)                                                                 | Title                                                                 |
|--------------------------------------------------------------------------|----------------------------------------------------------------------|
| Tarita Apriliani Sitinjak, Ludfi Djakfar, Ahmad Wicaksono                | ONLINE TAXI CHOICE MODEL BASED ON PASSENGER PERCEPTION IN INDONESIA |
| Resdiansyah, Tri Nugraha Adikesuma, Fredy Jhon Philip.S, Nailah Nahdiyah | PERFORMANCE OF URBAN INFRASTRUCTURE ROAD USER SATISFACTION INDEX IN SATELLITE CITY |
| A R Indra Tjahjani, Nuryani Tinumbia, Wita Meutia                         | DYNAMIC SYSTEM MODELING IN THE SELECTION OF REGENCY ROAD PAVEMENT CONSTRUCTION TYPES |
| Najid                                                                    | EVALUATION OF SIDE FRICTION IN IHC FOR HIGHWAY TWO LAKES TWO WAYS    |
| Alfaizs Vi Afkara, Andyka Kusuma                                         | WALKING DISTANCE PERCEPTION IN JAKARTA MRT STATION AREA*               |
| Yosritzal, H Putra, B M Kemal, Erick Mas, Purnawan                       | IDENTIFICATION OF FACTORS INFLUENCING THE EVACUATION WALKING SPEED IN PADANG, INDONESIA |
| Aisyah Nur Jannah, Imam Muthohar, Danang Parikesit                       | EFFICIENCY ANALYSIS OF COMMUTER LINE STATIONS (CASE STUDY: TEBET STATION TO CELEBUT STATION, INDONESIA) |
| Muhammad Zainul Arifin, Achmad Wicaksono                                  | THE PROBABILITY PREDICTION MODEL OF MOTORCYCLIST ACCIDENT AGAINST IRMSMS AND AIS FROM THE POLICE DEPARTMENT, EAST JAVA (A CASE STUDY IN KEDIRI REGENCY AND SURABAYA CITY) |
| Febrina Rachmatika Andini, Naomi Sri Kusumastutie, Edi Purwanto, Pipit Rusmandani, Lovinia Arida Yusup | THE EFFECTIVENESS OF SPEED LIMIT SIGN AND MARKING AS THE SPEED MANAGEMENT DEVICES |
| Dwi Ratna Sulistyanyangrum, Daniel Oranova, Ravy Hayu Pramesyta, Imam Mukhla, Budi Setiyono, Ervina Ahyudanari | PAVEMENT DISTRESS CLASSIFICATION USING DEEP LEARNING METHOD BASED ON DIGITAL IMAGE |
| Iksirah El Husna, Anissofiah Azise, Sarifuddin                           | THE USE OF PERSONAL PROTECTIVE EQUIPMENT FOR REDUCING ACCIDENTAL RISK ON BOARD |
| Ferhat Januar Rediat Supriana, Martha Leni Siregar, Ellen Sophie Wulan Tangkudung, Andyka Kusuma | EVALUATION OF ODD-EVEN VEHICLE REGISTRATION NUMBER REGULATION BEFORE AND AFTER EXPANSION OF THE RULE IN JAKARTA |
| John Bosco Nyomukiza, Sri Prabandiyani Retno Wardani, Bagus Hario Setiadi | THE EFFECT OF CURING TIME ON THE ENGINEERING PROPERTIES OF SAWDUST AND LIME STABILIZED EXPANSIVE SOILS |
| Bagus Hario Setiadi, Djoko Purwanto, Y I Wicaksono                        | IMPROVEMENT OF POHOLES AND RUTTING ASSESSMENT IN SURFACE DISTRESS INDEX* |
| Hitapriva Suprayitno                                                     | INVESTIGATING THE UTILISATION OF DIFFERENT VARIABLES FOR DIRECT GRAVITY TRIP DISTRIBUTION MODEL FOR AIR PASSENGER DEMAND |
| Dian M. Setiawan, Noor Mahmudah, Rizqo Hainun Sully                      | PERFORMANCE ANALYSIS OF ROAD SEGMENT AND LEVEL CROSSING (JPL) 340 KM 155+795 AS ACCESS TO ADISUTJIPTO INTERNATIONAL AIRPORT OF YOGYAKARTA |
| Leksmono Suryo Putranto                                                  | TRAVEL BEHAVIOR RESEARCH IN INDONESIA: ITS ROLE TO IMPROVE NATIONAL WELFARE |
| Susanti Djalante, Hiroyuki Oneyama, La Ode Muhammad Nurrahmad Arsyad     | TOWARD SUSTAINABILITY: GREEN ROAD CONSTRUCTION IN INDONESIA |
|                                                                          | SEA TRANSPORTATION NETWORK DEVELOPMENT OF THE LIUKANG PORT |
|                                                                          | THE USE OF PERSONAL PROTECTIVE EQUIPMENT FOR REDUCING ACCIDENTAL RISK ON BOARD |
|                                                                          | EVALUATION OF ODD-EVEN VEHICLE REGISTRATION NUMBER REGULATION BEFORE AND AFTER EXPANSION OF THE RULE IN JAKARTA |
|                                                                          | THE EFFECT OF CURING TIME ON THE ENGINEERING PROPERTIES OF SAWDUST AND LIME STABILIZED EXPANSIVE SOILS |
|                                                                          | IMPROVEMENT OF POHOLES AND RUTTING ASSESSMENT IN SURFACE DISTRESS INDEX* |
|                                                                          | INVESTIGATING THE UTILISATION OF DIFFERENT VARIABLES FOR DIRECT GRAVITY TRIP DISTRIBUTION MODEL FOR AIR PASSENGER DEMAND |
|                                                                          | PERFORMANCE ANALYSIS OF ROAD SEGMENT AND LEVEL CROSSING (JPL) 340 KM 155+795 AS ACCESS TO ADISUTJIPTO INTERNATIONAL AIRPORT OF YOGYAKARTA |
|                                                                          | TRAVEL BEHAVIOR RESEARCH IN INDONESIA: ITS ROLE TO IMPROVE NATIONAL WELFARE |
|                                                                          | TOWARD SUSTAINABILITY: GREEN ROAD CONSTRUCTION IN INDONESIA |
|                                                                          | SEA TRANSPORTATION NETWORK DEVELOPMENT OF THE LIUKANG PORT |
|                                                                          | THE USE OF PERSONAL PROTECTIVE EQUIPMENT FOR REDUCING ACCIDENTAL RISK ON BOARD |
|                                                                          | EVALUATION OF ODD-EVEN VEHICLE REGISTRATION NUMBER REGULATION BEFORE AND AFTER EXPANSION OF THE RULE IN JAKARTA |
|                                                                          | THE EFFECT OF CURING TIME ON THE ENGINEERING PROPERTIES OF SAWDUST AND LIME STABILIZED EXPANSIVE SOILS |
|                                                                          | IMPROVEMENT OF POHOLES AND RUTTING ASSESSMENT IN SURFACE DISTRESS INDEX* |
|                                                                          | INVESTIGATING THE UTILISATION OF DIFFERENT VARIABLES FOR DIRECT GRAVITY TRIP DISTRIBUTION MODEL FOR AIR PASSENGER DEMAND |
|                                                                          | PERFORMANCE ANALYSIS OF ROAD SEGMENT AND LEVEL CROSSING (JPL) 340 KM 155+795 AS ACCESS TO ADISUTJIPTO INTERNATIONAL AIRPORT OF YOGYAKARTA |
|                                                                          | TRAVEL BEHAVIOR RESEARCH IN INDONESIA: ITS ROLE TO IMPROVE NATIONAL WELFARE |
|                                                                          | TOWARD SUSTAINABILITY: GREEN ROAD CONSTRUCTION IN INDONESIA |
|                                                                          | SEA TRANSPORTATION NETWORK DEVELOPMENT OF THE LIUKANG PORT |
The Effect of Commercial Areas and Industrial Zone Improvement on Road Service Levels Between City Surabaya-Sidoarjo

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Abstract—The Regional Government Policy of Surabaya City which prohibits industrial zones outside industrial estates in Surabaya urban areas encourages the growth of new industrial zones in the hinterland area of Surabaya city or Gerbangkertosusilo region, including Gresik Regency, Sidoarjo Regency and Mojokerto Regency. The problem occurs because the development of industrial estates and reserves and services relies on primary arterial roads, so that there is a build up of continuous traffic flow and movement flows from generation / attraction from land use so that the road becomes congested. The purpose of this study is to find out land use interaction model, knowing network performance and knowing the travel time that must be passed. And analyze what components influence calculation of travel time. We descriptively described the road characteristics and analyzed quantitatively, correlation analysis and multiple linear regression analysis and other quantitative analyzes used to evaluate and formulate the model and its impact on the level of service of the road and travel time calculation. The research showed that along the Surabaya-Sidoarjo road segment, there are currently industrial dominated land use activities with a percentage of 66.2% and 14.8% of commercials, Vc = 69,029 pcu/day (internal) + 57,326 pcu/day (external) = 126,354 pcu/day. The trip higher than the road’s capacity which 6,820 pcu/hour. The level of road service is bad at certain hours; noon (8:00 to 19:00) with F value. The influence of the pulling volume of movement from zona industry outside the Industrial Estate is 9,452 pcu/day or 13.69% of the total Land Use and the Commercials is 48,388 pcu/day or 53.42% of the total Lands Use.

Keywords: land use, commercials area, industrial area, level of service

I. INTRODUCTION

The Surabaya City Government policy in the era of the 1990s encouraged the development of industrial area to get out of the urban areas of Surabaya because the density was already very high in urban areas. This policy has an impact on the emergence of Industrial Area outside of Industrial Estates which are scattered in the Gerbangkertosusila area [1]. Jalan Waru Surabaya-Sidoarjo is one of the primary artery roads which is an area of industrial zone shifting from the city of Surabaya, which in turn causes an increase in movement on the road. The growth of Industrial Zones on the road triggers the development of other land uses such as residential areas, trade areas and services, offices and others.

There are 22 industrial zones and 122 trade and service areas recorded. Along the road from Surabaya to Sidoarjo, it is now filled with land use activities dominated by industry with percentage reaching 66.2 per cent, trade and service 14.8 per cent and the rest consists of housing, terminals, offices and other facilities. Of course, this road segment is a solid road segment with the use of land that can become a center of activity that is quite solid as well. Activities on the Surabaya-Sidoarjo road can be regarded as a road with a high level of activity. The rapid growth of land use along the road from Surabaya to Sidoarjo resulted in the emergence of a center of activities that occurred from morning to evening. The dominance of industrial land use has increased the potential for large or heavy vehicle movement to become more, besides it has not been added to the trade and service activities in the segment.

The existence of industry is inseparable from the existence of transportation in the flow of distribution of raw materials and finished goods requiring transportation equipment to be taken to the destination. Shipping activities by four-wheeled vehicles reach 15 to 25 percent of the volume of vehicles weighing on the road [2]. Industrial estates have caused several impacts related to transportation. One of the impacts is the loading and unloading of goods or raw materials that occur can cause congestion delays [3].

This is one of the reasons for the selection of central location of industrial, service, trade and other activities related to the level of accessibility. The road’s level of service has a significant effect on the development of land use change or land use growth in certain roads [4]. The rapid development of land use on the primary arterial road corridor has an impact on increasing traffic movements both continuous flows and local movement flows from land use growth on frontage roads [5]. The concept of Mix Uses which was initially proposed to reduce the movement of traffic flow between land uses actually adds to the attraction and generation of traffic movements from the development of land use that occurs in the primary arterial road segment [6,7].

The accumulated flow of continuous traffic between the cities of Surabaya-Sidoarjo and the increase in the flow of movement from the attraction and generation of land use on the corridors of the primary arterial road causes the total flow of traffic movements beyond the capacity of the road [8].
In accordance with its function, the primary arterial road is a liaison between orde-1 traffic flow between cities to orde-1 or orde-2 city, between Surabaya City and Sidoarjo city, but coupled with the presence of traction movements and seizures of traffic flow movements from land use that is along the road corridor [8]. They combine land use models with transportation models to display the interaction of land use systems and urban road network systems over time in a combination of combined interaction models. The advantage of this approach is that exogenous data input is needed eg the land use model can be calculated directly on the local land use (internal volume) added by continuous current flow (external volume) and vice versa [9].

Transportation problems have begun since the 1960s and 1970s, some of the problems associated with transportation are congestion, air and sound pollution, accidents and also delays [10]. Therefore, if the land-use interaction with the existing transportation on the road from Surabaya to Sidoarjo is not controlled then it will cause many problems. So it is necessary to do the control related to the potential existence of Core Urbanism phenomenon in these road.

This study aims to determine the characteristics of the development of land use along the Waru Surabaya-Sidoarjo road segment, obtain a land use interaction model-road network system and measure the service level of the corridor and find out the effect of the contribution of the current flow of industrial zones to the level road services in the corridor.

Integration of land use planning and transport planning is increasingly being acknowledged as an important component of creating sustainable cities [11]. Land use development planning, infrastructure investment, and regulation in transportation planning need to accommodate about changes in land use behavior, in the future, and traveling behavior from land use activities [12]. The linkage between land use and transportation is in the trip generation and attraction factor. Increasing the trip generation and attraction is proportional to the increasing load of the existing road around the land [1]. Increasing the flow of traffic movement on the road has the potential to increase congestion, a condition where the traffic flow that passes through the road exceeds the planned road capacity resulting in free road segments approaching below 30 km/hour or even to 0 km/hour resulting in queue vehicles [13]. Congestion is a big problem in big cities in Indonesia. One of the causes of congestion is because the large number of traffic movements has exceeded road capacity. Reduced effective road space can also be a cause of reduced road capacity. Reduced effective road space can be caused by vehicles parked on the road or other activities such as street vendors, etc [14]. Congestion is also influenced by urban land use, that the land use function can form a resurrection zone pattern, a zone of pull movement or the volume of internal movement flows on the road segment [8].

II. METHOD

The research location is located in the corridor of Surabaya-Sidoarjo through several main roads along with the characteristics of land use. This research type is descriptive research by trying to explain how existing condition at research location relation with Core Urbanism. The descriptive approach taken to produce output is related to the general description of traffic conditions, land use, characteristics of road network, and land use growth in the corridor of Waru Surabaya-Sidoarjo (Fig. 1). The steps of research conducted in a systematic, factual and accurate based on existing conditions and phenomena that occur at the sites. The research step begins with literature study, preliminary study, data retrieval, data processing, data analysis, and conclusion (Fig. 2).

Some quantitative methods used include analysis of road loading characteristics (analysis of degree of saturation), analysis of generation and trip pull (multiple linear regression analysis), and modeling of land use interactions. From the interaction of the model it can be seen the level of road service that occurs [2].

Data collection methods used: Primary survey consists of; field observations, interviews/ questionnaires, traffic counting, recording vehicle license platesand and cross-
sectional measurements of the road. Secondary surveys consist of; literature surveys, agency surveys and similar research studies.

A. Capacity on Road:

\[
C = C_0 \times FCW \times FCSP \times FC_{SF} \times FC_{CS}
\]  

(1)

Notes:

\(C\) = Capacity (pcu/hour)  
\(C_0\) = Basic Capacity (pcu/hour)  
\(FCW\) = Traffic Length adjustment factor  
\(FCSP\) = Median Adjustment Factor or Direction Separator  
\(FC_{SF}\) = Side Constraint Adjustment Factor  
\(FC_{CS}\) = City Size Adjustment Factor

B. Road network performance or service level using the following calculation:

\[
VCR = \frac{V}{C}
\]  

(2)

C. Road Network – Land Use Interaction Model [14]

\[
VCR = \left(\sum V_{\text{internal}} + \sum V_{\text{external}}\right) / C
\]  

(3)

Notes:

\(VCR\) = Ratio Volume Capacity (level of service)  
\(V\) = Traffic Volume (pcu/hour)  
\(V_{\text{internal}}\) = Amount of Vehicle Volume from Generation/Attraction of Land Use  
\(V_{\text{external}}\) = Amount of on-going Vehicle Volume on the Main Street  
\(C\) = Road Capacity (pcu/hour)

D. The analysis used to find out how the relationship between land use and road network using the following equation:

\[
V_{\text{total}} = V_{\text{internal}} + V_{\text{external}}
\]  

(4)

Notes:

\(V_{\text{total}}\) = Total volume of vehicle movement per hour in the corridor on the main road.  
\(V_{\text{internal}}\) = Total volume of vehicle movement/hour from generation or attraction of land use.  
\(V_{\text{external}}\) = Total volume of external vehicle movement per hour in the main road corridor of vehicle movement per hour from neighborhood roads or alleys plus continuous volume of vehicle movement per hour on the main road.

\[
V_i = e_1 Y_1 + e_2 Y_2 + e_3 Y_3 + \ldots + e_n Y_n
\]  

(5)

Total volume of movement of vehicle / hour from land use in the corridor of the main road.

Notes:

\(e_1 = V_1 / Y_1\) = Volume ratio of vehicle movement out or incoming from the land use at certain hours compared to the total volume of vehicle movement/day.

Y1 = Volume of vehicle movement/day of influence of the trip generation/attraction of land use for housing  
Y2 = Volume of vehicle movement/day of influence of the trip generation or attraction for education  
Y3 = Volume of vehicle movement/day of influence of the trip generation or attraction for healthy  
Y4 = Volume of vehicle movement/day of influence of the trip generation or attraction for office  
Yn = Volume of vehicle movement/day of influence of the trip generation or attraction for Land use

while:

\(V_{\text{external}}\) = Total volume of vehicle movement external per hour present in the corridor of the main road

\[
V_e = V_{\text{Ex-1}} + V_{\text{Ex-2}} + \ldots + V_n + V_{\text{Ex-5}} + V_{\text{Ex-6}}
\]  

(6)

\(V_{\text{Ex-1}}\) = Volume of vehicle movement per hour from neighborhood streets / alleys - 1  
\(V_{\text{Ex-2}}\) = Volume of vehicle movement per hour from neighborhood streets / alleys – 1  
\(V_{\text{Ex-5}}\) = The continuous volume of vehicle movement per hour on the main road  
\(V_{\text{Ex-6}}\) = The continuous volume of vehicle movement per hour on the main road

### TABLE I. DEPENDENT VARIABLE AND INDEPENDENT VARIABLE FOR LAND USE

| No. | Land Use         | Dependent Variable             | Independent Variable                              |
|-----|------------------|--------------------------------|---------------------------------------------------|
| 1   | Settlement/Housing | YHousing : X1 (Number of Family Members) | X2 (Number of Motor Vehicles) X3 (Income)          |
| 2   | Elementary School, Y Junior High School, Senior High School | Y Education : X4 (Number of Students) | X5 (Number of Teachers) X6 (Number of Classes) |
| 3   | University       | Y University : X7 (Building Area) | X8 (Number of Student)                            |
| 4   | Office           | Y Office : X9 (Number of Employees) | X10 (Number of Visitors) X11 (Building Area)      |
| 5   | Hospital         | Y Hospital : X12 (Daily Patient Amount) | X13 (Number of In-Room Places)                    |
| 6   | Commercials      | Y Commercials : X14 (Building Area) | X15 (Number of Visitors) X16 (Number of Employees) |
| 7   | Industry         | Y Industry : X17 (Number of Employees) | X18 (Parking Area) X19 (Land Area)               |
| 8   | Terminal         | Y Terminal : X20 (Number of Vehicle) | X21 (Agent/Visitor manager)                      |
The population in the core urbanism control study is the path with arterial hierarchy in East Java (Surabaya-Sidoarjo). Arterial road connects the city level to one, with the city level unity, or connect the city level with the second level, or connect the city level with the third city level. The sampling technique used in this study is simple random sampling technique (simple random sample). The sample determination is assumed that all members of the population have equal opportunity to choose. The variable approach used in this research is conducted by using land based modeling approach and road network is shown in TABLE I.

III. RESULTS AND DISCUSSION

A. Corridor Characteristic of Surabaya-Sidoarjo

Characteristics of Surabaya-Sidoarjo Corridor road is a 4/2 D, with hotmix asphalt pavement. The Surabaya-Sidoarjo road corridor has a road median with a width of 1.5 meters along the road. Related to the width of road (Space Benefit Road) which is equal to 8 meters with the division of each lane is 4 meters. Effective road shoulder width for Surabaya-Sidoarjo road segment is < 0.5 meter. There are some side activities of the road (side barriers) such as on street parking activities ranging from two-wheeled vehicles, four wheels to heavy vehicles. Besides other side barriers that is the activity of the entry of the vehicle from the surrounding land. Associated with the calculation approach of road capacity coefficient has value \(C_0=6.600\), \(FC_{SW}=1.08\), \(FC_{SP}=1\), \(FCSF=0.92\), \(FC_{SF}=1.03\), and has a capacity value of roads of number 8.000-12.000 pcu/hour. Obviously if it is not controlled both in terms of transportation and land use will affect to the road’s level of service along the corridor. Analysis conducted within the period of 08:00 to 19:00 obtained the results of the road’s level of service that is in class F. If it is seen from the movement of vehicles that occur on average every hour has a volume of vehicles reaching the number 8.000-12.000 pcu/hour. Obviously if it is not controlled both in terms of transportation and land use will further exacerbate the road’s level of service on the potential congestion that occurred.

C. Land Use Model

The results of modeling land use independent and dependent variables in land use modeling using multiple linear regression analysis along the corridor Surabaya-Sidoarjo generate the following data shown in TABLE III.

| Land Use      | Trip Generation Model | Coefficient of Determination |
|---------------|------------------------|------------------------------|
| Settlement/   | Housing                | YHousing = -0.389 + 0.232   |
| Settlement/   | Housing                | (X1) + 0.027 (X2) + 0.034   |
| Elementary    | Education              | YEducation = -0.254 + 0.141 |
| School,       |                        | (X4) + 0.112 (X5) + 0.024   |
| Senior High   | School                 |                             |
| University/   | College                | YUniversity = -0.355 + 0.008 |
| College       |                        | (X7) + 0.149 (X8)           |
| Office        |                        | YOffice = 0.108 + 0.662     |
| Office        |                        | (X9) + 0.659 (X10) + 0.00007194 (X11) |
| Hospital      |                        | YHospital = 13.715 + 0.291  |
|               |                        | (X12) + 0.055 (X13)         |
| Commercial    |                        | YTrade and Services = -0.431 |
|               |                        | + 0.18 (X14) + 0.075 (X15) |
| Terminal      |                        | YTerminal = 206.338 + 0.004982 (X20) + 0.000115 (X21) |
| Industry      |                        | YIndustry = -0.497 + 0.363 (X17) + 1.184 (X18) |
| Terminal      |                        | YTerminal = 206.338 + 0.004982 (X20) + 0.000115 (X21) |

D. The Road’s Level of Services

The total volume of vehicles passing through the Surabaya-Sidoarjo corridor is divided into local and continuous flows. The local flow is the flow leading to and out of the land along the corridor, while for the continuous flow is the current that passes only through the corridor (Fig. 3).

It was found that the increasing total vehicle volume will affect to the road’s level of service along the corridor. Analysis conducted within the period of 08:00 to 19:00 obtained the results of the road’s level of service that is in class F. If it is seen from the movement of vehicles that occur on average every hour has a volume of vehicles reaching the number 8.000-12.000 pcu/hour. Obviously if it is not controlled both in terms of transportation and land use will further exacerbate the road’s level of service on the potential congestion that occurred.

B. Land Use Characteristic

Land use in the road corridor from Surabaya-Sidoarjo with total land use area of 5,967,019 m² dominated by Industrial land use with an area of 3,952,112 m² or 66.2 per cent of the total area while the smallest land use area is a terminal with an area of 12,000 m². The dominant land use is the type of industry as much as 66.2 per cent and commercials as much as 14.8 percent. It may invite employees working in the industrial sector as well as in the trade and services sectors, which will impact the volume of traffic vehicles passing along the Surabaya-Sidoarjo road.
IV. CONCLUSIONS

From the result of the comparison of the volume of movement of vehicles from the trip generation/trip attraction of land use in the Surabaya - Sidoarjo (69.047 pcu/day) road segment, the volume of continuous vehicle movement on the main road (57.326 pcu/day), indicates that; most of which dominate the movement of vehicles is the movement of generation/attraction of land for 69.047 pcu/day. So the more land build in the main road will increase the level of congestion on the main road. In the Surabaya-Sidoarjo Road segment, the volume of vehicle movement from the trip generation/attraction generated land (pcu per day) is greater than the volume of continuous movement on the main road (pcu per day). For land that contributes the largest volume of movement is the use of industrial and commercials land use.

The result of calculation of service level of corridor in the road section from Sidoarjo to Surabaya; Interaction Model of Land Use-Road Network, shows that; from 06.00am to 20.00pm the road’s level of service is F. The current condition of the boundary between Surabaya and Sidoarjo is almost biased or connected to each other due to the rapid growth of land use. some solutions that can be given are as follows:

1. It is time for the Sidoarjo regency governement to limit the growth of land use functions along the Coridor Surabaya-Sidoarjo in particular the use of industrial land and trade & services and encourage the development of industrial zones outside the main road corridors of Surabaya-Sidoarjo.

2. The separation of the flow of traffic must be carried out continuously with the flow of local movements due to generation and the pull of movement from land use by building the frogate road as has been done by the Surabaya City governement on A. Yani Street.

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