Traffic Impact Analysis Of The Surabaya Waterfront Land Development On Dr. Ir. H. Soekarno Road Intersection

Muhammad Robin Al Maheri[1a], Kurnia Hadi Putra[2a], Theresia Maria Chandra Agusdini[3a], Ratih Sekartadji [4a]

Department Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Indonesia
muhammadrobinalmaheri@gmail.com

Abstract. *The Surabaya City Government is currently planning a reclamation project in the coastal area of East Surabaya, specifically through the development of the Surabaya Waterfront Land area. This plan has received considerable public attention due to its potential to cause significant impacts on traffic conditions, particularly on Dr. Ir. H. Soekarno Road. The area serves as an economic growth center with dense tourism, office, and educational activities, thus causing traffic congestion that negatively impacts the economic sector. This research aims to analyze and compare the performance of four main intersections, namely Kertajaya Intersection, Dharmahusada Indah Intersection, Mulyorejo Intersection, and Kenjeran Intersection, under existing conditions and post-traffic generation due to the reclamation project. The analysis is conducted based on PKJI 2023 guidelines, which represents the latest national standard for intersection capacity analysis in Indonesia, providing more accurate and updated methodologies compared to previous standards such as MKJI 1997. The analysis results show that under existing conditions, several intersections have experienced congestion. Under post-traffic generation conditions, all intersections experience significant increases in saturation levels, even exceeding ideal capacity. Based on the traffic flow distribution results due to this generation, the construction of a 6/2 D road type (six lanes, two directions) on the Outer East Ring Road (OERR) is recommended as an alternative to reduce high vehicle volume.*

Keywords: Dr. Ir. H. Soekarno Road Intersection, Signalized Intersection, Outer East Ring Road (OERR), Surabaya Waterfront Land, PKJI 2023

1. Introduction

The coastal reclamation plan in East Surabaya by the Surabaya City Government has attracted significant public concern due to its potential impact on traffic, particularly on Dr. Ir. H. Soekarno Road. This area serves as an economic growth center with dense tourism, office, and educational activities. The reclamation project involves the construction of four islands covering 1,085 hectares to be implemented in phases over 20 years and is expected to generate significant traffic volume in the surrounding areas. Previous research (Luqman & Wibisono 2024) using MKJI 1997 provisions showed that saturation levels at major intersections are already in critical condition: Kertajaya Indah (1.05-1.54), Dharmahusada Permai (1.25-1.5), and Mulyorejo (1.43-1.69), indicating the occurrence of congestion. Four signalized intersections along Dr. Ir. H. Soekarno Road, Raya Kertajaya Indah, Dharmahusada Indah, Mulyorejo, and Kenjeran frequently experience congestion during peak hours due to high traffic volume. Coastal area development is expected to worsen these conditions and decrease intersection performance. This research analyzes traffic impacts at these four intersections by comparing current performance with post-development scenarios using PKJI 2023 provisions (Direktorat Jenderal Bina Marga 2023). The objective of this research is to provide critical considerations for the large-scale reclamation project in East Surabaya and identify potential benefits and solutions to implementation challenges.

2. Method

This research uses a capacity and degree of saturation calculation approach based on PKJI 2023 guidelines, which is the national standard for traffic analysis in Indonesia.

2.1 Data Collection

Traffic count surveys were conducted for one week from 06:00 to 19:00 at all four intersections. The survey employed manual counting methods with trained surveyors positioned at each approach. Each surveyor team consisted of three personnel: one for vehicle counting, one for data recording, and one for quality control. Vehicle classifications were recorded according to PKJI 2023 standards, distinguishing between light vehicles (LV), heavy vehicles (HV), and motorcycles (MC). Data validation was performed through cross-checking between surveyors at 30-minute intervals, video recording during peak hours for verification, weather condition monitoring to ensure data validity, and hourly data compilation and consistency checks. Peak hour identification was conducted by analyzing hourly traffic volumes across all survey days, with Tuesday evening (16:30-17:30) identified as the critical peak hour across all intersections based on the highest total vehicle volume.

JCEPD-ISSN: 2830-3628

2.2 Trip Generation Analysis

Traffic generation estimates for the Surabaya Waterfront Land project were derived through comparative analysis with Pantai Indah Kapuk (PIK) Jakarta, which serves as a comparable waterfront development. The PIK data was obtained through field surveys and secondary data from PT Granting Jaya (2025). Trip generation rates were calculated per hectare of developed land and adjusted for the Surabaya context considering local economic conditions and transportation patterns. The proportional method was applied based on the land area ratio between PIK (1,160 Ha) and each development block in Surabaya Waterfront Land.

2.3 Future Traffic Prediction

Twenty-year traffic growth projections were calculated using the compound growth rate method based on Surabaya's historical vehicle registration data from the Department of Transportation. The annual growth rate was determined at 3.2% for light vehicles and 2.8% for motorcycles, consistent with regional urbanization trends.

2.4 Determination of Saturation Flow

$$S = S_0 \times F_{SF} \times F_{CS} \times F_G \times F_P \times F_{LT} \times F_{RT}$$

Description:
S_0 = Base saturation flow (pcu/hour)
F_{SF} = A correction factor for S_0 due to side friction around the road
F_{CS} = An adjustment factor for S_0 related to city size
F_G = An adjustment factor for S_0 due to the longitudinal gradient of the approach
F_P = An adjustment factor for S_0 due to parking activities near the intersection arm
F_{LT} = An adjustment factor for S_0 due to left-turn movement
F_{RT} = A correction factor for S_0 due to right-turn movement

2.5 Determination of Cycle Time and Green Time

$$S = \frac{(1{,}5 \times W_{HH} + 5)}{1 - \sum R\frac{q}{j}critical}$$

Description:
S = Cycle time (Seconds)
W_{HH} = Minimum green time in each cycle (Seconds)
R_{qj} = Ratio for saturation flow when divided by $^{q}/_{S}$
$Rq_{/_j}$ critical = Maximum $^{q}/_{S}$ value when equivalent phase begins

$$W_{Hi} = (S - W_{HH}) \times \left(1 - \sum R\frac{R\frac{q}{j}critical}{\sum\left(R\frac{q}{j}critical\right)i}\right)$$

Description:
W_{Hi} = Green time duration (Seconds)
i = Phase i indicator

2.6 Determination of Capacity

$$C = S\frac{G}{c}$$

Description:
C = APILL Intersection Capacity (pcu/hour)
S = Saturation flow (pcu/hour)
G = Total green cycle time in one rotation (seconds)
c = Cycle time (seconds)

2.7 Degree of Saturation Analysis

$$D_S = \frac{q}{C}$$

Description:
D_S = Degree of Saturation
q = Traffic flow on that approach (pcu/hour)
C = Capacity (pcu/hour)
Performance criteria based on PKJI 2023: DS ≤ 0.75: Good performance; 0.75 < DS ≤ 0.85: Acceptable performance; DS > 0.85: Poor performance (congested).

2.8 Queue Analysis

$$N_q = N_{q^1} + N_{q^2}$$

If $D_S \leq 0{,}5$, then $N_{q^1} = 0$ and if $D_S \geq 0{,}5$, then

$$N_{q^1} = 0{,}25 \times C \times (D_S - 1) + \sqrt{\frac{((D_S - 1) \times 2) + (8 \times (D_S - 0{,}5))}{C}}$$

$$N_{q^2} = S \times \frac{(1 - R_H)^2}{(1 - R_H \times D_S)} + {}^{q}/_{3600}$$

Description:
N_{q^1} = Number of vehicles stopped before green time
Queue length is calculated using the equation:

$$P_A = N_{q_{max}} + \frac{20}{LM}$$

2.9 Delay Analysis

Average delay is calculated using the equation:

$$T_i = T_{LLi} + T_{Gi}$$

Description:
T_i = Average stopping delay for approach I (sec/pcu)
T_{LL} = Traffic transition delay (sec/pcu)
T_G = Geometric delay (sec/pcu)
Average traffic delay is calculated using the equation:

$$T_L = s \times \frac{0{,}5 \times (1 - R_H)^2}{(1 - R_H \times D_S)} + \frac{N_{q^1} \times 3600}{c}$$

Description:
s = Cycle time (seconds)
R_H = Green time ratio
C = Vehicle volume (pcu/hour)

Average geometric delay is calculated using the equation:

$$T_G = (1 - R_{KH}) \times P_B \times 6 + (R_{KH} \times 4)$$

$$R_{KH} = 0{,}9 \times \left(\frac{N_q}{q \times s}\right) \times 3600$$

Description:
P_B = Vehicle value at an approach
R_{KH} = Proportion of vehicles that must stop at the intersection before the green light turns on

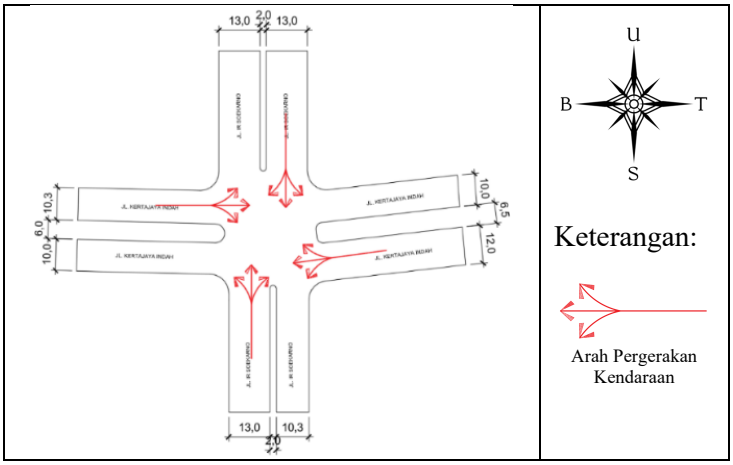
3. Results and Analysis

3.1 Intersection Capacity Under Existing Conditions

Peak hour traffic surveys conducted during Tuesday evening (16:30-17:30) revealed critical traffic conditions across all studied intersections. The following sections present detailed analysis for each intersection.

3.1.1 Kertajaya Indah Intersection Performance Analysis Under Existing Conditions

The analysis results show whether the degree of saturation has exceeded the established limit of 0.85.

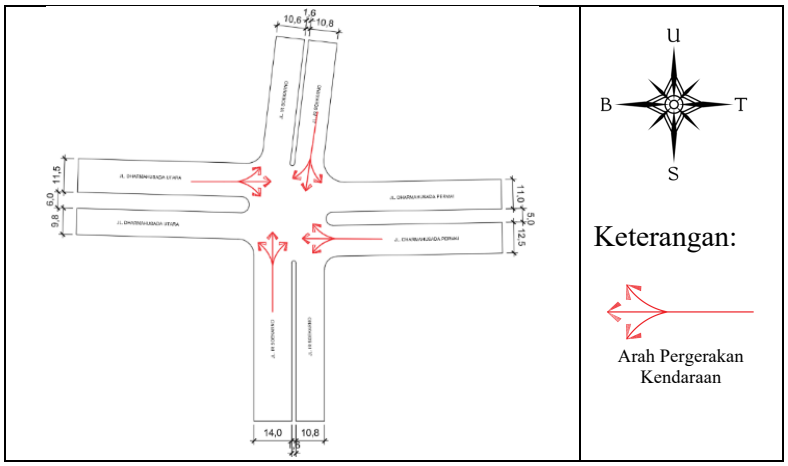


Source: Personal Documentation, 2025

Table 1. Total Motor Vehicle Volume Kertajaya Indah Intersection

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Capacity (C)	Degree of Saturation (D_S)
N	Straight	1859	895,9	798,94	1304,26	1,48
	Turn Right	821	451,85	413,48		
	Turn Left	1078	580,6	530,8		
	Total	**3758**	**1928**	**1743**		
E	Straight	1715	756,5	655,37	1139,00	1,14
	Turn Right	700	330,05	292,67		
	Turn Left	435	210,55	191,8		
	Total	**2850**	**1297**	**1140**		
S	Straight	3539	1178,45	938,54	1574,08	1,42
	Turn Right	776	375	336,84		
	Turn Left	1828	680,05	567,1		
	Total	**6143**	**2234**	**1842**		
W	Straight	2187	1023,3	905,10	1334,42	1,79
	Turn Right	1410	774,6	709,83		
	Turn Left	1105	595,15	544,39		
	Total	**4702**	**2393**	**2159**		

3.1.2 Dharmahusada Indah Intersection Performance Analysis Under Existing Conditions

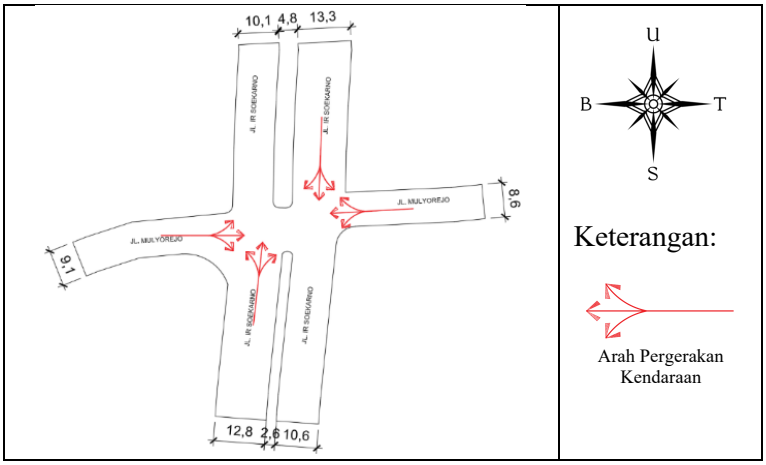


Source: Personal Documentation, 2025

Table 2. Total Motor Vehicle Volume Dharmahusada Indah Intersection

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Capacity (C)	Degree of Saturation (D_S)
N	Straight	3413	1134,25	901,21	1536,92	2,03
	Turn Right	2409	1198,6	1070,44		
	Turn Left	1647	790,05	702,18		
	Total	**7469**	**3123**	**2674**		
E	Straight	493	213,7	185,56	891,28	0,82
	Turn Right	449	143,6	111,98		
	Turn Left	784	371,75	328,1		
	Total	**1726**	**729**	**626**		
S	Straight	4885	1297,6	933,52	2087,53	0,75
	Turn Right	473	170,4	138,36		
	Turn Left	290	104,7	85,08		
	Total	**5648**	**1573**	**1157**		
W	Straight	221	152,2	145,99	1047,55	0,48
	Turn Right	326	229,1	218,84		
	Turn Left	201	120,55	112,39		
	Total	**748**	**502**	**477**		

3.1.3 Mulyorejo Intersection Performance Analysis Under Existing Conditions



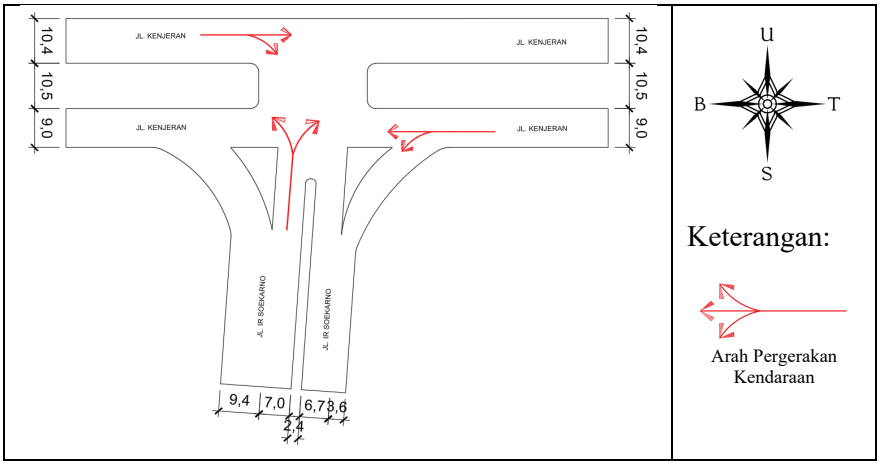
Source: Personal Documentation, 2025

Table 3. Total Motor Vehicle Volume Mulyorejo Intersection

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Capacity (C)	Degree of Saturation (D_S)
N	Straight	2166	1018,3	935,11	1892,01	0,18
	Turn Right	653	367,85	353,42		
	Turn Left	384	143,8	138,07		
	Total	**3203**	**1530**	**1427**		
E	Straight	375	200,25	183,18	628,73	0,98
	Turn Right	366	197,45	180,32		
	Turn Left	408	216,3	198,51		
	Total	**1149**	**614**	**562**		
S	Straight	1539	719,4	640,5	1792,83	0,68
	Turn Right	847	301,9	244,9		
	Turn Left	681	191,15	140		

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Capacity (C)	Degree of Saturation (D_S)
	Total	**3067**	**1212**	**1025**		
W	Straight	498	109,6	69,55	348,86	0,96
	Turn Right	577	111,2	61,88		
	Turn Left	512	113,7	72,96		
	Total	**1587**	**335**	**204**		

3.1.4 Kenjeran Intersection Performance Analysis Under Existing Conditions



Source: Personal Documentation, 2025

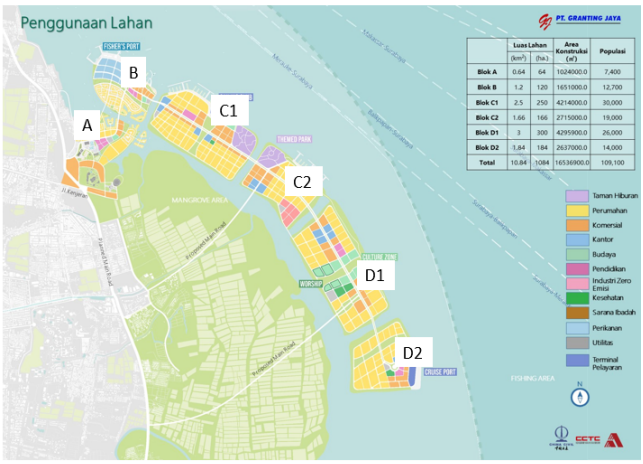
Table 4. Total Motor Vehicle Volume

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Capacity (C)	Degree of Saturation (D_S)
E	Straight	1890	988,9	897,43	1838,35	0,89
	Turn Right	0	0	0		
	Turn Left	1405	653,35	580,57		
	Total	**3295**	**1642**	**1478**		
S	Straight	0	0	0	983,39	1,22
	Turn Right	1118	571,05	516,72		
	Turn Left	1696	631,75	524,08		
	Total	**2814**	**1203**	**1041**		
W	Straight	3250	976,2	740,46	1930,47	0,94
	Turn Right	3048	846,35	622,19		
	Turn Left	0	0	0		
	Total	**6298**	**1823**	**1363**		

Under existing conditions, the average of the four intersections shows a high degree of saturation, indicating that road capacity has approached or even exceeded optimal limits. This condition can cause increased traffic delays, vehicle queue lengths, and decreased movement efficiency at each intersection.

3.2 Intersection Capacity in 20-Year Future Prediction and Vehicle Generation Impact Due to Surabaya Water Front Land Project

Based on vehicle growth data in Surabaya City which increases significantly every year, and considering the impact of the Surabaya Waterfront Land project, it is estimated that the number of vehicles will experience a greater surge in the next 20 years. This estimation is also based on vehicle generation data at Pantai Indah Kapuk (PIK) Jakarta which is compared to the planned land area.



Source: PT Granting Jaya, 2025

Table 6. Percentage of Vehicle Count Against Land Area

Region	Area	Unit	Total Vehicles	Protected	Opposing	Percentage of PIK Land Area
PIK Land Area	1160	Ha	10925,0	8743,5	8631,8	
Block D1 D2 (Kertajaya)	484	Ha	4558,4	3648,2	3601,5	41,7%
Block C2 (Dharma Husada Indah)	166	Ha	1563,4	1251,2	1235,2	14,3%
Block C1 (Mulyorejo)	250	Ha	2354,5	1884,4	1860,3	21,6%
Block A & B (Mulyorejo)	184	Ha	1732,9	1386,9	1369,2	15,9%

Intersection capacity and traffic flow distribution generated by the Surabaya Water Front Land development are analyzed based on existing conditions for each approach. This evaluation is intended to assess the impact of traffic volume increases on intersection performance and to identify traffic engineering measures needed to optimize mobility within the area.

3.2.1 Performance Evaluation of Kertajaya Intersection Under Generated Traffic Conditions

20-Year Vehicle Volume Forecast + Trip Generation Volume

Table 7. Total Motor Vehicle Volume and Degree of Saturation

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Degree of Saturation (D_S)
N	Straight	3446	1843	1692	3,05
	Turn Right	1750	936	859	
	Turn Left	2248	1202	1104	
	Total	**7444**	**3980**	**3655**	**3,05**
E	Straight	3319	1568	1394	2,37
	Turn Right	1457	688	612	
	Turn Left	935	442	393	
	Total	**5711**	**2698**	**2398**	**2,27**
S	Straight	6556	2471	2045	3,00
	Turn Right	2149	810	670	
	Turn Left	3825	1442	1193	
	Total	**12531**	**4723**	**3908**	**3,00**
W	Straight	3966	2102	1926	3,70
	Turn Right	3030	1606	1472	
	Turn Left	2327	1233	1130	
	Total	**9322**	**4942**	**4528**	**3,70**
Existing + Generated		**35008**	**16343,61**	**14488,74**	

3.2.2 Performance Evaluation of Dharmahusada Intersection Under Generated Traffic Conditions

20-Year Vehicle Volume Forecast + Trip Generation Volume

Table 8. Total Motor Vehicle Volume and Degree of Saturation

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Degree of Saturation (D_S)
N	Straight	4941	2045	1751,4	3,73
	Turn Right	5377	2224,95	1905,9	
	Turn Left	3539	1464,46	1254,5	
	Total	**13856**	**5734**	**4912**	**3,73**
E	Straight	940	393	338	1,50
	Turn Right	616	257,41	221,11	
	Turn Left	1643	687,12	590,21	
	Total	**3199**	**1338**	**1149**	**1,50**
S	Straight	8705	2380	1716	1,43
	Turn Right	1176	321,59	231,86	
	Turn Left	723	197,63	142,49	
	Total	**10764**	**2993**	**2171**	**1,43**
W	Straight	401	272	263	0,85
	Turn Right	603	409,28	395,13	
	Turn Left	315	213,92	206,52	
	Total	**1319**	**895**	**864**	**0,85**
Existing + Generated		**29138**	**10960,16**	**9096,64**	

3.2.3 Performance Evaluation of Mulyorejo Intersection Under Generated Traffic Conditions

20-Year Vehicle Volume Forecast + Trip Generation Volume

Table 9. Total Motor Vehicle Volume and Degree of Saturation

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Degree of Saturation (D_S)
N	Straight	3284	2122,3	2003,4	1,69
	Turn Right	1546	775,9	732,4	
	Turn Left	1546	301,8	284,9	
	Total	**6376**	**3200**	**3021**	**1,69**
E	Straight	808	419,5	392,2	2,05
	Turn Right	727	413,5	386,6	
	Turn Left	727	453,4	423,9	
	Total	**2262**	**1286**	**1203**	**2,05**
S	Straight	3146	1559,0	1333,4	1,45
	Turn Right	1530	639,5	546,9	
	Turn Left	1530	395,4	338,2	
	Total	**6205**	**2594**	**2219**	**1,45**
W	Straight	1244	250,6	156,1	2,26
	Turn Right	1052	248,2	154,6	
	Turn Left	1052	291,2	181,3	
	Total	**3347**	**790**	**492**	**2,26**
Existing + Generated		**18190**	**7870,08**	**6933,88**	

3.2.4 Performance Evaluation of Kenjeran Intersection Under Generated Traffic Conditions

20-Year Vehicle Volume Forecast + Trip Generation Volume

Table 10. Total Motor Vehicle Volume and Degree of Saturation

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Degree of Saturation (D_S)
E	Straight	3708	1880	1717	1,69
	Turn Right	0	0	0	
	Turn Left	2435	1235	1128	

Approach Code	Direction	Ver/hour	Protected (pcu/hour)	Opposing (pcu/hour)	Degree of Saturation (D_S)
	Total	**6143**	**3115**	**2844**	**1,69**
S	Straight	0	0	0	2,34
	Turn Right	2555	1107	967	
	Turn Left	2765	1198	1047	
	Total	**5320**	**2305**	**2014**	**2,34**
W	Straight	6573	1944	1448	1,87
	Turn Right	5656	1673	1246	
	Turn Left	0	0	0	
	Total	**12229**	**3616**	**2694**	**1,87**
Existing + Generated		**23692**	**9036,82**	**7552,21**	

3.3 Summary of Degree of Saturation for Existing Conditions and Due to Trip Generation

The following table shows the degree of saturation at several intersections in Surabaya based on current conditions and predictions due to traffic generation.

Table 11. Table of Degree of Saturation (Existing & Prediction)

Intersection	Approach	Existing Traffic Conditions	Predicted Impact from Trip Generation
Kertajaya	North	1,48	3,05
	East	1,14	2,73
	South	1,42	3,00
	West	1,79	3,70
Dharmahusada Indah	North	2,03	3,73
	East	0,82	1,50
	South	0,75	1,43
	West	0,48	0,85
Mulyorejo	North	0,81	1,96
	East	0,98	1,91
	South	0,68	1,45
	West	0,96	2,26
Kenjeran	North	0,89	1,69
	East	1,22	2,34
	South	0,94	1,87

The above data indicates that at several intersections, the degree of saturation has exceeded the threshold limits. Road segments are beginning to experience saturated conditions and even congestion, particularly with future traffic generation.

3.4 Traffic Congestion Mitigation Alternatives

An alternative for alleviating traffic congestion is to distribute a portion of the traffic flow to the planned OERR Road that will be constructed. This measure aims to reduce the burden on existing approaches, thereby optimizing intersection performance and minimizing potential congestion. The largest traffic distribution is planned through Kertajaya Intersection.

Table 12. Traffic Flow Distribution Alternatives

Traffic Flow		Degree of Saturation After Adjustment	Distributed Flow
29%	1098	0,8500	2882
29%	744	0,8500	1954
29%	1303	0,8500	3420
29%	1363	0,8500	3579

JCEPD-ISSN: 2830-3628

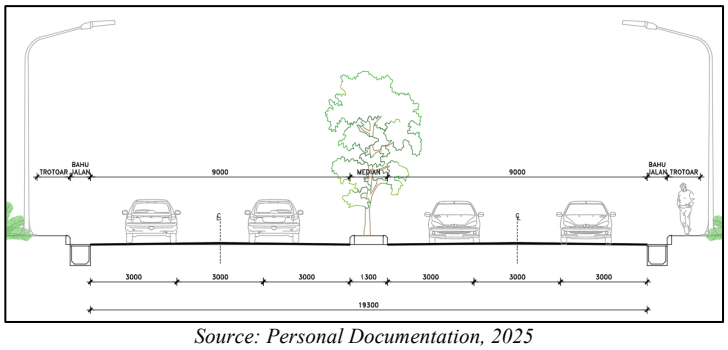
3.5 OERR Road Capacity

To address the projected traffic surge, a comprehensive traffic redistribution strategy through the construction of the Outer East Ring Road (OERR) is proposed.

Table 13. OERR Road Capacity

Direction	Basic Capacity C0 (pcu/hour)	Adjustment Factor				Capacity C	Traffic Flow q (pcu/hour)	Degree of Saturation DS
		Lane Width FC LW	Direction Separation FC DS	Side Frictio FC SF	City Size FC CS			
North	5100	0,92	1	1	1,04	4880	2,882	0,59
South	5100	0,92	1	1	1,04	4880	3,579	0,73

The recommended 6/2-D (six lanes, two directions with median divider) configuration provides adequate capacity with DS values well within acceptable limits (DS < 0.75). This configuration is considered capable of optimally accommodating traffic flow, reducing the burden on existing road networks, and supporting smooth vehicle movement in the Surabaya Waterfront Land development area.



Source: Personal Documentation, 2025

4. Conclusion

This comprehensive analysis of the traffic impacts from the Surabaya Waterfront Land development reveals that all four studied intersections currently operate under stressed conditions with degree of saturation values ranging from 0.48 to 2.03, and the proposed development will exacerbate these conditions with projected DS values reaching 3.73, representing traffic demand that exceeds design capacity by nearly four times. The study demonstrates that without immediate intervention through the construction of a 6/2-D type Outer East Ring Road (OERR) with a design capacity of 4,880 pcu/hour per direction, the development will create gridlock conditions that could paralyze traffic movement in East Surabaya. The analysis using PKJI 2023 guidelines indicates that the OERR can effectively redistribute 29% of critical traffic flows, reducing intersection DS values to acceptable levels below 0.85, making it an essential prerequisite rather than an optional enhancement for the waterfront development. The magnitude of predicted traffic impacts suggests that while the Surabaya Waterfront Land project offers potential economic benefits, it poses significant risks to urban mobility that require mandatory infrastructure investments, synchronized phased development approaches, and comprehensive traffic management strategies including signal optimization, public transportation enhancement, and travel demand management to prevent systematic traffic failure and ensure sustainable regional mobility.

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