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Pedestrian Characteristics on Interurban Residential Area

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Abstract: *The purpose of this study was to determine the characteristics of pedestrian and pedestrian traffic modeling on the interurban residential area, Makassar, Indonesia. Male pedestrians who walk without carrying goods, under 15 years of age, walk with the greatest speed, which is an average of 0.82 m/s and 0.4 m/s for the category of male pedestrians aged over 60 years. The average walking speed for women without carrying things with age less than 15 years, 15-30 years, 30-45 years, 45-60 years, and over 60 years, respectively, is 0.63 m/s , 0.55 m/sec, 0.5 m/sec, 0.47 m/sec, and 0.45 m/sec. Meanwhile, male and female pedestrians who walk with goods for each age category have an average speed of 0.8 m/s, 0.5 m/s, 0.48 m/s, 0, respectively. 44 m/sec, 0.47 m/sec, 0.42 m/sec, 0.47 m/sec, 0.38 m/sec, 0.35 m/sec, and 0.37 m/sec.*

Keywords: *pedestrian, age, residential area, interurban, characteristics*

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I. INTRODUCTION

Increasing the economy of a region will affect the mobility of the community. Walking can connect between trade areas, cultures, and settlements for close distance. Several factors that influence a person's ability to walk include economy, distance, travel time, security, the comfort of pedestrian facilities, climate, age, and the number of items carried. In South Sulawesi Province, Sungguminasa City functions as a satellite city in supporting the economy of Makassar City. The two cities are connected by one of the roads, namely the Daeng Tata Lama road section on the border of Makassar City and Sungguminasa City as a densely populated residential area. The purpose of this study was to determine the characteristics of pedestrian and pedestrian traffic modeling in the interurban residential area.

Pedestrian rights and obligation are (Indonesia Law No.22, 2009): pedestrians are entitled to the availability of supporting facilities, in the form of sidewalks, crossings, and other facilities, pedestrians have the right to get priority when crossing the road at the crossing, If available as referred to above, pedestrians have the right to cross in the place chosen by paying attention to themselves, require pedestrians to use parts of the road that are intended for pedestrians or the edge of the road to cross the road in a designated place, and pedestrians must pay attention to the safety and smoothness of traffic.

Some previous researches are modeling Pedestrian Facilities (Sidewalks) provides the results of the analysis using the Greenshield model linear regression analysis in obtaining the relationship between volume, speed, and density as follows, the relationship of speed and density S = 63.28344 - 40.9198 .D, the relationship of volume and density V = 63.28344 - 40.9198.D^2 and the relationship of volume and velocity V = 1.5465 S - 0.024438. S^2 (Limpong, et al, 2015), Characterization and Modeling of Pedestrian Flow in Hospital and Academic Environments, the results of research that for educational locations, men's walking speed is greater than women's walking speed, this is inversely proportional to the hospital environment. The modeling results show that the free flow speed in the campus environment is 68,052 m/min with a density of 3.15 ped/m^2. While in the hospital environment is 75,099 m/min and the density are 4.36 ped/m^2 (Alhassan and Mahros, 2016). Effect of Pedestrian Characteristics at Signalized Intersection, with the results of research on the average running speed of male pedestrian are 1.5 m/ sec and women are 1.4 m/s. The average running speed for the 21 - 60 years age group is 1.5 m/sec (Varsha and Bindhu, 2016). Evaluation of Pedestrian Flow Characteris9tics of Different Inside a Railway Station, pedestrian speeds on the stairs larger than the corridor. The speed of walking based on age, the more age increases the less the speed of walking. Pedestrians with carrying goods have lower speeds than pedestrians without carrying goods (Patra,et.al 2017). Pedestrian Flow Characteristics Under Heterogeneous Traffic Condition, examine the characteristics of pedestrians on heterogeneous traffic in three different locations, obtained Farmgate location has a level of service C, Shukrabad and Shahbag with a level of service B. Average speed when free flow for all three locations is 1.18 m/s (Emtenan and Shahid, 2017). A Review of Pedestrian Flow Characteristics and Level of Service Over Different Pedestrian Facilities, the focus of research is based on height, culture, location with many traders, friction/parking of vehicles, travel destinations, and environmental conditions, with pedestrian results in the countries of Saudi Arabia, Iraq,

Bangladesh, Indonesia, and Sri-Lanka have lower walking speeds than pedestrians in the USA, UK, and Canada. In developed countries, the pedestrian speed at the 15th percentile intersection (1.11-1.31 m/s) exceeds the design junction speed of 0.95 m / s. and is higher than the crossing speed of 1.2 m/s (Banerjee, et. al 2018). Pedestrian speed is determined by the width of the crossing, the width of the pedestrian island and the average delay (Ankit, et.al, 2019). Changes in vehicle lanes and traffic flow accompanied by signal control and crossing gaps are strongly influenced by pedestrians (Ruijin, 2018). Pedestrian level of service is strongly influenced by police patrols, street lighting, sidewalk cleaners, sidewalk barriers, curb surfaces, traffic speed, and traffic volume (Greetha and Manoranjan, 2019). Competition and coordination of road space between pedestrians and other modes of transportation is an important issue that appears in urban areas (Obi and Ed, 2020). Increasing the number of pedestrians will reduce the distance between pedestrians, resulting in turbulence in the crossing (Arash and Amir, 2018). Reducing the benefits of illegal behavior and increasing the punishment externally can reduce the behavior of crossing illegally based on a herd mentality (Cao, et.al, 2017). Pedestrian travel in urban areas is affected by speed restrictions in the new traffic-free environment (Jorg, et al, 2012). Decisions of crossing youth pedestrians on unmarked roads are influenced by vehicle speed and distance between pedestrians as well as to vehicles (Peng, et.al, 2019).

II. EXPERIMENTAL PROCEDURE

1.1 Study Location

The location of the study was conducted at Daeng Tata Lama street section, Makassar, Indonesia, with observations for 6 hours, each in the morning peak hour at 07.00 - 09.00 a.m., afternoon peak hours at 12.00 - 02.00 p.m., and afternoon peak hours at 4.00 - 6.00. p.m.5 minutes interval and 50 m segment length.

1.2 Free-Flow Speed Model

Mathematical equations for the relationship between flow, speed, and density can be written

$$Q = k.V$$

Where:
Q: flow (ped/second)
K: density (ped/second/m^2)
V: speed (m/second)

Free-flow speed occurs when pedestrians can freely determine speed without experiencing obstacles. Speed has a relationship that is inversely proportional to density. The greater the density value, the lower the speed. Maximum density or jam occurs when the flow is equal to the capacity and speed reaches zero. When the flow becomes maximum, the density will increase, but the speed will decrease, this condition will continue to deteriorate until pedestrians cannot determine the speed or move lanes and become unstable, where this condition causes maximum density or congestion.

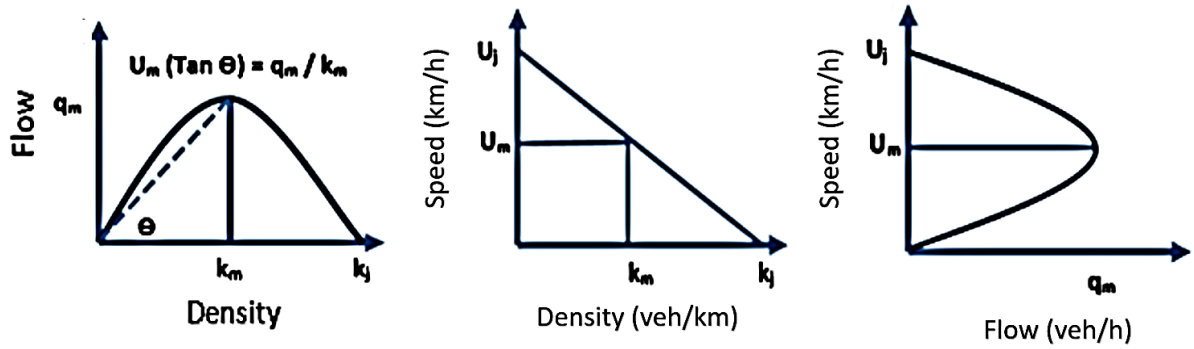
Mathematically, the relationship between flow, speed, and density is expressed by the modeling equation as follows [16]:

Density – flow	$Q = Vf.D - (\frac{Vf}{Kj}) K^2$
Speed – density	$V = Vf - (\frac{Vf}{K})K$
Speed – flow	$Q = V.Kj - \left(\frac{Kj}{Vf}\right) V^2$

Where:
Q: Flow
Vf: free flow speed
K: density
Kj: density maximum
V: speed

The graph of the relationship between flow, speed, and density linearly/Greenshields (Highway Capacity Manual, 2010) can be seen in Figure 1.

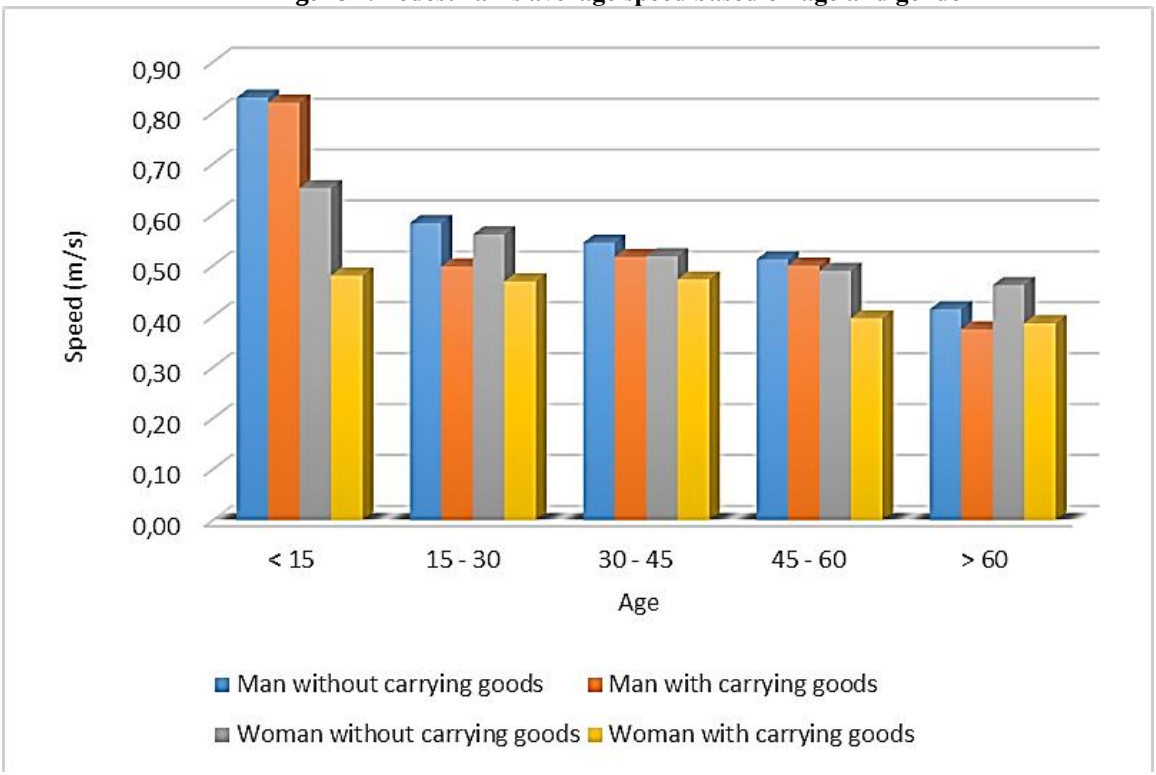
Fig 1. The relationship between flow, speed, and density Greenshields Model



III. RESULTS AND DISCUSSIONS

Characteristics of pedestrian is separated by sex, age, and carrying goods. It is assumed that gender, age, and belongings affect one's speed in walking. The higher the age of a person the less speed in walking, the same thing can also be seen from belonging, the load that is brought causes the speed to be limited, where someone carrying goods while walking, the speed is lower than that which does not carry goods, especially if the heavy goods.

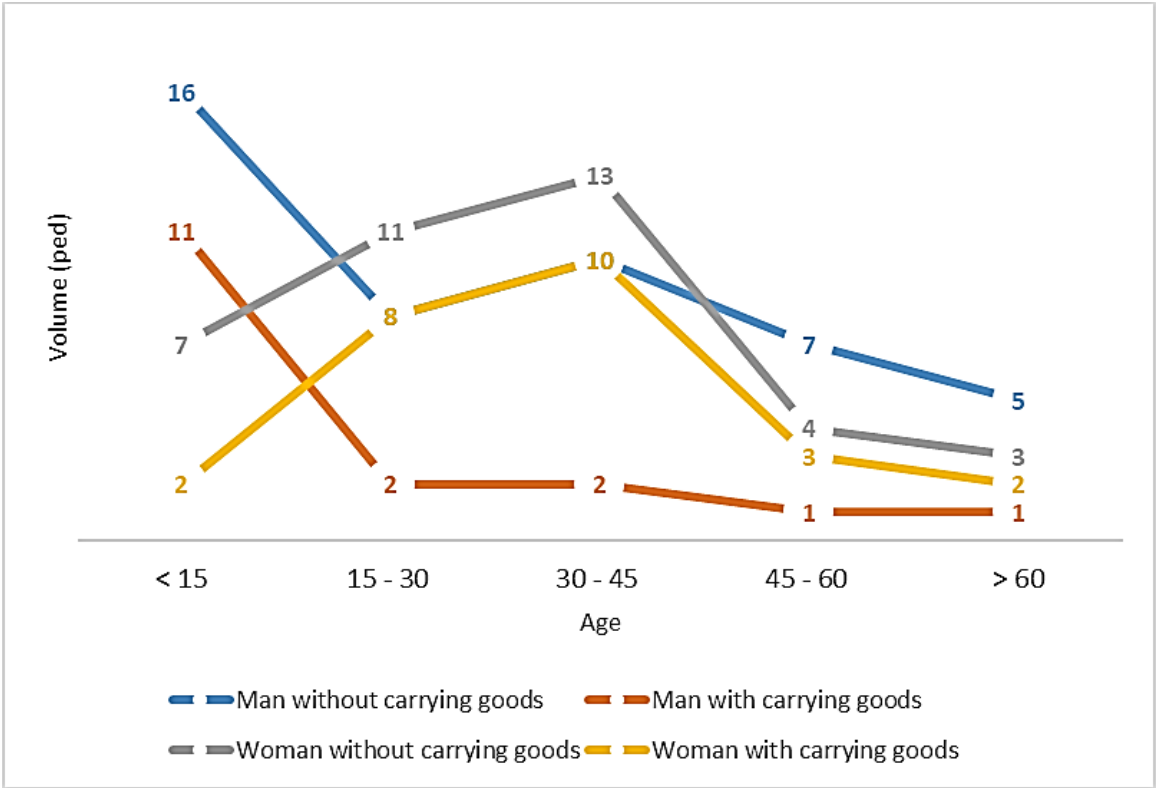
Figure 2. Pedestrian's average speed based on age and gender



In Figure 2, men and women of all ages have greater walking speeds than those who walk with carrying goods. For the category of men who walked without carrying goods with under 15 years of age running at the greatest speed, which averaged 0.82 m/sec, followed by men aged 15-30 years at 0, walking speed 57 m/sec, 30 - 45 years with a walking speed of 0.53 m/sec, 45 - 60 years with a walking speed of 0.5 m/sec, and 0.4 m/sec for the category of men aged more than 60 years. Average walking speed for women without carrying goods with age less than 15 years, 15-30 years, 30-45 years, 45 - 60 years, and more than 60 years, respectively 0.63 m/seconds, 0.55 m/sec, 0.5 m/sec, 0.47 m/sec, and 0.45 m/sec. Whereas for men and women who walk with belongings for each age category have an average speed of 0.8 m/sec, 0.5 m/sec, 0.48 m/sec, 0.44 m/sec, 0.47 m/sec, 0.42 m/ sec, 0.47 m/sec, 0.38 m/sec, 0.35 m/sec, and 0.37 m/sec. The graph of pedestrian average speed based on age, gender, and with or without carrying goods can be seen in Figure 2.

The highest number of pedestrians was a group of men who walked without carrying goods with the age of less than 15 years, which is equal to 16 pedestrians. Whereas for the group of men who walked by carrying goods with the age of less than 15 years who were school children amounting to 11 pedestrians. For groups of women aged 30 - 45 years who walk without carrying goods as big as 13 pedestrians and who carry belongings as big as 10 pedestrians. Pedestrians aged 45 to over 60 are only 11 pedestrians. More specifically, the graph of the number of pedestrian volumes based on age, sex, and with or without carrying goods is presented in Figure 3.

Figure 3. Pedestrian's volume based on age, gender, and with or without carrying goods



3.1. Flow and Speed of Pedestrian

The number of pedestrians in residential areas on the city border is not much. Because almost households have their own vehicles. From the observations during the morning to evening peak hour, it was seen at rush hour at 7:15 a.m. to 7:20 a.m. and 08:30 - 08:35 a.m the number of pedestrians was 4. For daytime peak hour at 12:45 - 12.50 pm, the number of pedestrians was 6, then decreases gradually at 1:05 p.m. - 1.25 p.m., but a drastic decline occurs at 13.35 - 13.40 where no pedestrian is crossing the area. At afternoon peak hour the number of pedestrians is 11 seen from 5:05 a.m. to 5:10 p.m., where at this hour is the end of the office and school work activities. In the next hour, the flow of pedestrians in general decreased gradually, although some time experienced an increase but not significantly. Pedestrian flow fluctuations can be seen in Figure 4.

Figure 4. Pedestrian flow fluctuations on interurban residential area

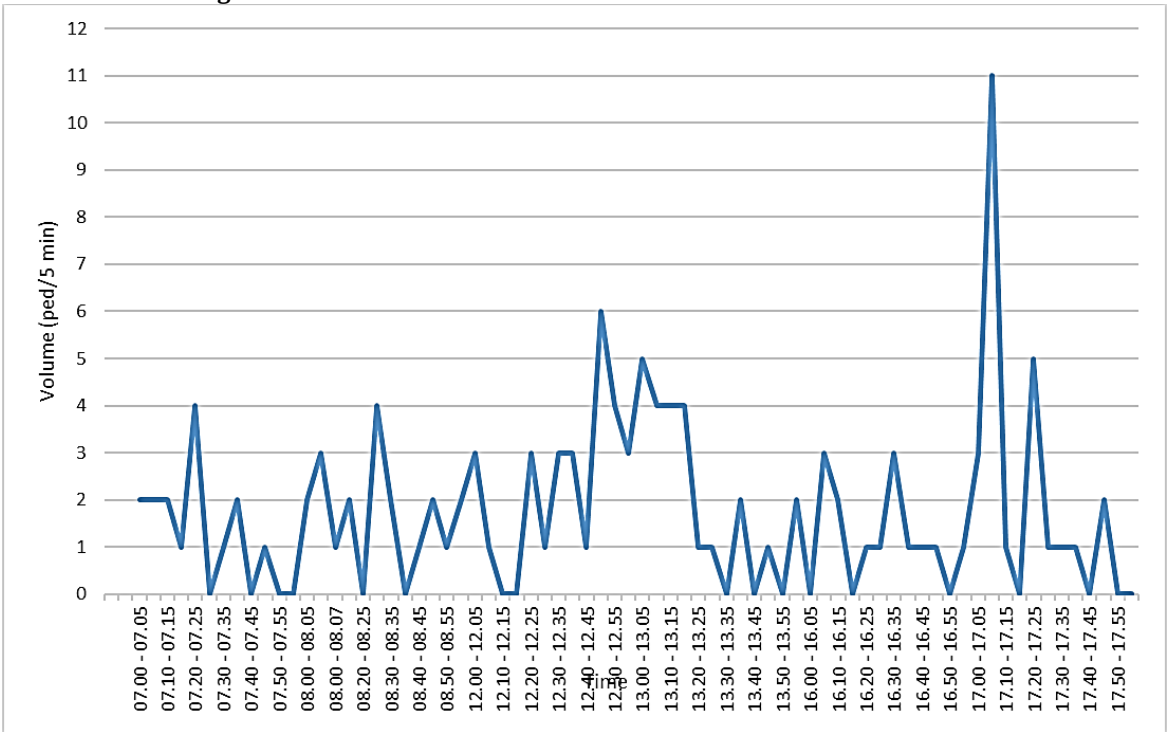


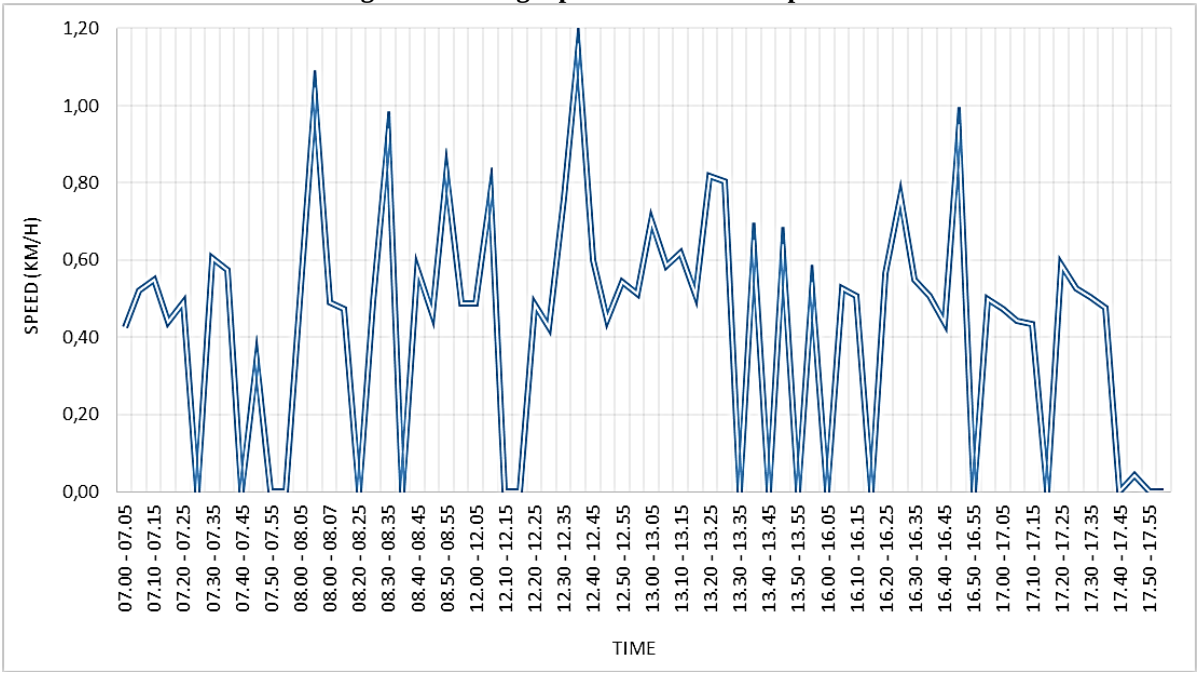
Figure 5. Pedestrian hourly fluctuations on interurban residential area

If calculated hourly, the pedestrian traffic volume ranges from 12 to 41 pedestrians. The number of pedestrians in the morning has no significant increase or decrease, namely the lowest of 12 and the highest as many as 18 pedestrians. Unlike the case with afternoon peak hours, the number of pedestrians experienced a greater increase than the morning peak hour. At 12.00 - 01.20 p.m., there was a gradual increase from 28 to 41 pedestrians. Because at this time it was the end of school activities. For the afternoon rush hour occurs at 4.30 - 5.35 p.m. with the highest number of pedestrians at 28 pedestrians, then until 6.00 p.m. the number of pedestrians decreases. More specifically, the fluctuations per pedestrian hour are shown in Figure 5.

The average speed of pedestrians is 0.04 m / sec to 1.20 m / sec. The lowest speed comes from pedestrians over 60 years old and carrying goods. Pedestrians with less than 15 years old. The speed of walking is influenced by several factors, namely: weather, a load of belongings carried, desire to quickly go to a

destination, age, and gender. Fluctuations in the average speed of pedestrians on interurban residential areas of the city border can be seen in Figure 6.

Figure 6. Average speed fluctuations of pedestrian



3.2. Flow-speed-density Relationship

The Greenshields model is used to find out the mathematical equations of the relationship between flow, speed, and density of pedestrians. Modeling is divided into three categories, namely the relationship of flow, speed, and density of pedestrians without carrying goods, carrying goods, and combinations of the two previous categories, as shown in Table 1.

Table 1. Traffic modelling for pedestrian on interurban area

Parameters	V-K	Q-K	Q-V
Without carrying goods	80-(80/0,1)k	80-(80/0,1)k^2	0,1V-(0,1/80)V^2
With carrying goods	34-(34/0,65)k	34-(34/0,65)k^2	0,65V-(0,65/34)V^2
With and without carrying goods	37-(37/0,48)k	37-(37/0,48)k^2	0,48V-(0,48V/37)V^2

The pedestrian traffic modeling results from the relationship of speed and density of categories without carrying good, carrying goods, and a combination of both, respectively 80 - (80/0,1) k; 34 - (34/0.65) k; and 37 - (37/0.48) k. The mathematical equation of the relationship of flow and density for each category is 80 k - (80/0,1) k^2; 34 k - (34/0.65) k^2; and 37 k (37/0.48) k^2. Relationship between flow and speed for pedestrian categories without carrying goods, carrying goods, and a combination of both, 0.1 V - (0.1/80) V^2, respectively; 0.65V-(0.65/34) V^2; and 0.48 V - (0.48/37) V^2.

From the graph of the relationship between speed and density, the free flow speed is seen for the category belongings which is equal to 80 m/5 minutes, with carrying goods that are equal to 34 m/5 minutes, and a combination of both categories which is 37 m/5 minutes. Increasing density deccreases the average speed. The value of R^2 for all three categories is 1.

Figure 7. Relationship between Speed and Density of Pedestrian

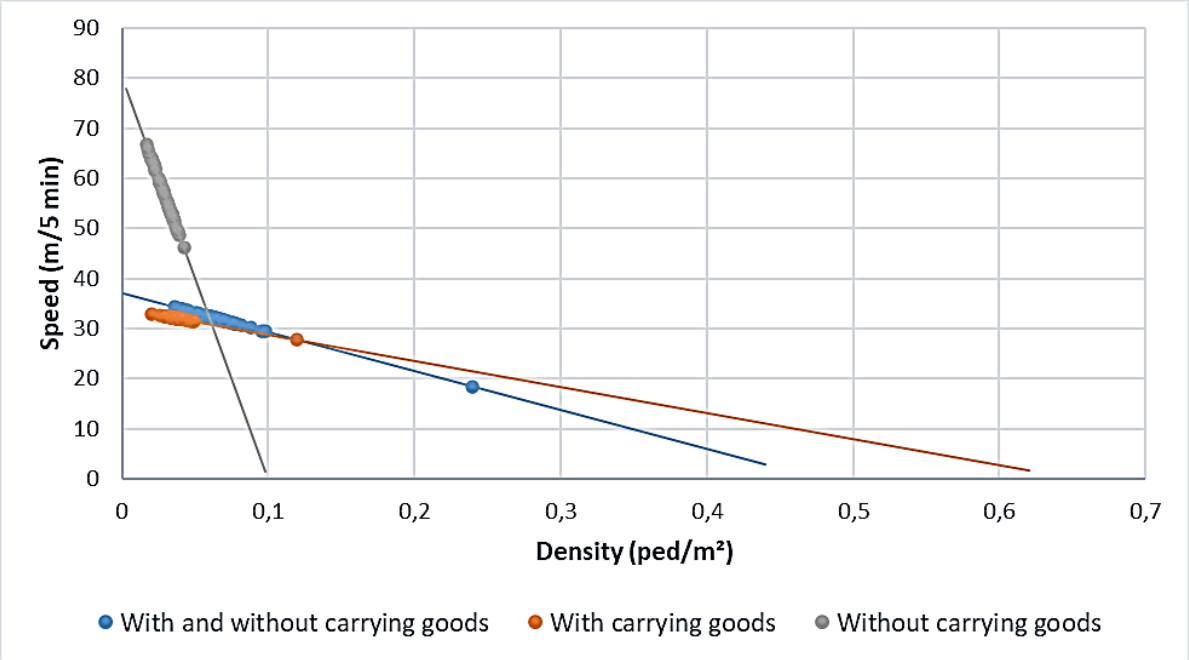


Figure 8. Relationship between flow and density of pedestrian

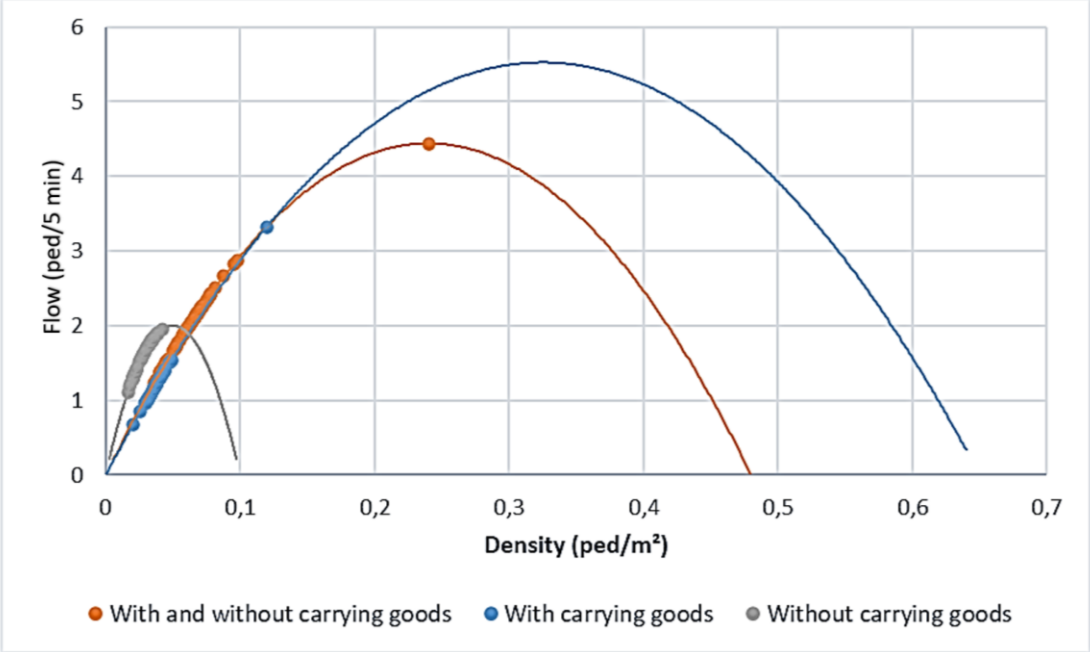
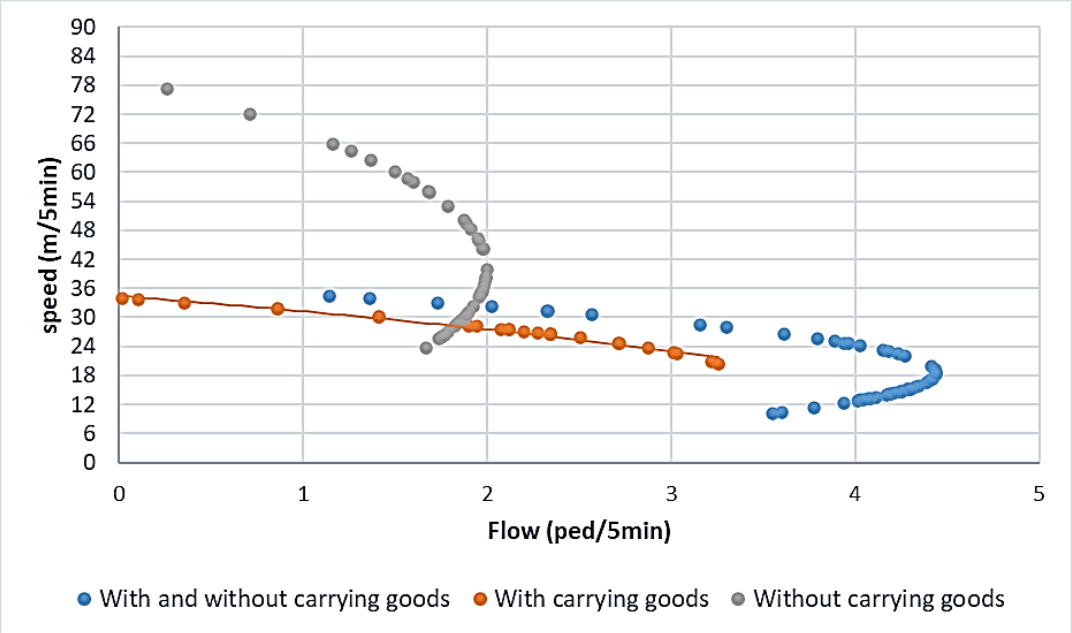


Figure 9. Pedestrian flow and speed relationship



IV. CONCLUSION

Male pedestrians who walk without carrying goods, under 15 years of age, walk with the greatest speed, which is an average of 0.82 m/s and 0.4 m/s for the category of male pedestrians aged over 60 years. The average walking speed for women without carrying things with age under 15 years, 15-30 years, 30-45 years, 45-60 years, and over 60 years, respectively, is 0.63 m/s , 0.55 m/sec, 0.5 m/sec, 0.47 m/sec, and 0.45 m/sec. Meanwhile, male and female pedestrians who walk with goods for each age category have an average speed of 0.8 m/s, 0.5 m/s, 0.48 m/s, 0, respectively. 44 m/sec, 0.47 m/sec, 0.42 m/sec, 0.47 m/sec, 0.38 m/sec, 0.35 m/sec, and 0.37 m/sec.

REFERENCES

[1]. Alhassan.H., M. , dan Mashros.N., 2016. Characterization and Modeling of Pedestrian Flow in Hospital and Academic Environments, Universiti Teknologi Malaysia, Jurnal Teknologi, Volume 78, Nomor 4, 49-57.

[2]. Ankit. B., Tripta. G., and Umesh. S., 2019, Modelling The Pedestrian Speed at Signalized Intersection Crosswalk for Heterogeneous Traffic Conditions, Scientific Journal on Traffic and Transportation Research, Volume 31, 416-434.

[3]. Arash, S., and Amir, A.R., 2018, A Study of Pedestrian Movement on Crosswalks Based on Chaos Theory, International Journal of Transportation Engineering, Volume 6, Seri.4, 317-329

[4]. Banerjee.A., Maurya.A.K., dan Lämmel.G., 2018, A Review of Pedestrian Flow Characteristics and Level of Service Over Different Pedestrian Facilities, Collective Dynamics 3, A17:1–52

[5]. Cao. Y., Chen, S., and Xiao, Z., 2017, Analysis of Pedestrian Violation Behavior Based on Herd Mentality, Advances in Social Science, Education, and Humanites Research, Volume 130, 605-610.

[6]. Emtenan.A.M.T., dan Shahid.S.I., 2017. Pedestrian Flow Characteristics Under Heterogeneous Traffic Conditions, American Journal of Civil Engineering 5(5): 282-292

[7]. Greetha. R. B., and Manoranjan, P., 2019, Modelling Perceived Pedestrian Level of Service of Sidewalks: A Structural Equation Approach, TRANSPORT, Volume 34, Issue 3, 339-350

[8]. Jorg, D., Ingo, J.M., and Andreas, D.L., 2012, Pedestrian Simulation for Urban Traffic Scenarios, Conference:Proceedings of The Summer Computer Simulation Conference 2012.44th Summer Simulation Multi Conference,

[9]. Law Number 22 of 2009 about Traffic and Roads.

[10]. Limpong.R., Sendow.T., Jansen.F.,2015. Modeling of Pedestrian Flow Facilities (sidewalk), Sam Ratulangi University, Jurnal Sipil Statistik Volume 3 No.3, 212-220

[11]. Obi, T., S., and Ed, M., 2020, A Sequential Sampling Model of Pedestrian Road Crossing Choice, GeoSim 20: Proceeding of the 3rd ACM SIGPATIAL

[12]. Patra.M., Sala.E., dan Ravinshankar.K.V.R., 2017. Evaluation of Pedestrian Flow Characteristics Across Different Facilities Inside a Railway Station. Science Direct. Transportation Research Procedia, Volume 25, 4763-4770

[13]. Peng. C., Jingmin. X., and Jingliu. Y., 2019, Modelling Adolescent Pedestrian Crossing Decision at Unmarked Roadway, International Journal of Safety and Security Engineering, Volume 9, Issue 4, 305-315.

[14]. Ruijin, H., 2018, Research for Urban Traffic Simulation Model of Cross-Street Pedestrian Influence, IOP Conference Series: Earth and Environmental Science, Volume 189, Traffic Engineering and Transportation System.International Workshop on Geospatial Simulation, 10-19

[15]. Transportation Research Board, 2010, Highway Capacity Manual.

[16]. Varsha.V., and Bindhu.B.K., 2016. Effect of Pedestrian Characteristics at Signalized Intersection, International Journal of Engineering Research and Technology, Volume 5, Issue 08, 29-33