Planning of Pedestrian Facilities and Integrated Crossing Based on the Concept of Active Living on C UNTIRTA

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ABSTRACT

Campus C of Sultan Ageng Tirtayasa University does not yet have adequate pedestrian facilities and crossing facilities at the main gate are not yet available so that the analysis of pedestrian facilities and crossing facilities is carried out with the aim of knowing the types of pedestrian facilities and road crossing facilities needed and making pedestrian facility designs that use the concept of active living. Campus C of Sultan Ageng Tirtayasa University is located on Jalan Ciwaru Raya No. 25, Cipare, Serang City. Data collection was conducted using direct observation method. The data collected included pedestrian volume, traffic volume, crosswalk volume, and road geometric data. The results showed that the recommended crossing facility for segment 1 on Jalan Ki Ajurum No. 2 is a zebra crossing with waiting stalls with a maximum PV^2 result of 1748717534 (1×10^9). While for segment 2 on Jalan Ciwaru Raya No. 25 is a zebra crossing with a maximum PV^2 result of 1615465208 (1×10^9). The recommended effective width of sidewalks within Campus C of Sultan Ageng Tirtayasa University is divided into 2 sizes, namely 2 meters and 2.5 meters. Complementary facilities that support the concept of active living that can be recommended are by providing seating, lighting, shading in the form of trees, trash bins, drinking water taps at several points, and special paths for people with disabilities.

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1. INTRODUCTION

Pedestrian is a term used to refer to people who walk, especially along roads or areas designated for pedestrians [1]. One of the roles of pedestrian paths is to fulfill the social needs of its users, both in the form of interacting with others and as an open area that can be used for joint activities [2]. As one of the public places, the campus also requires an open area for its users. Circulation within the campus requires an area that can serve as a place for social interaction. This place also acts as a circulation path which is eventually known as a pedestrian path or an area that supports pedestrian mobility on campus [3]. While crossing facilities are the main means for pedestrians that function to connect two areas that are opposite each other [4]. Crossing facilities are divided into two types, namely level crossings and non-level crossings. Level crossings include zebra crossings and pelican crossings. Meanwhile, non-traditional crossings include pedestrian bridges (JPO) and tunnels [5]. Population growth in big cities has an impact

on the increasing number of vehicles and pedestrians on the road. This can lead to conflicts between the volume of vehicles passing by and pedestrians crossing [6].

The concept of Active Living is an approach to lifestyle that invites individuals to be more active on a daily basis [7]. This concept is not only limited to formal sports but also includes daily activities such as walking, cycling, and other physical activities that can be done in the neighborhood and workplace [8]. The aim of this concept is to encourage the public to be more active on foot so as to create healthy urban communities [9]. A person who is physically active will achieve a good level of health because the health of bones, muscles, and joints is maintained and the achievement of optimal heart and lung endurance capacity [10]. Complementary facilities found on pedestrian paths are by providing seating, lighting, shade, trash cans, drinking water taps, special paths for people with disabilities, and road crossings such as zebra crossings [11], [12].

Sultan Ageng Tirtayasa University (UNTIRTA) is one of the state universities located in Banten Province. UNTIRTA as an institution that continues to grow also needs to consider the application of this concept to create a good environment, not only improving accessibility and comfort but also can improve pedestrian safety and security and provide spaces that support learning and socializing activities [13]. Campus C or the UNTIRTA Faculty of Teacher Training and Education Campus is a campus that has a high density but has a large area [14]. On this campus, the division between pedestrian paths and motorized vehicle lanes does not yet exist, causing a lack of safety, smoothness, and comfort for pedestrians and motorists [15]. There are also no crosswalk facilities in front of the campus, which can reduce the interest of the campus community to walk [16]. This research aims to identify pedestrian needs and develop design recommendations that can support an active lifestyle in the campus environment. Thus, it is expected that the resulting design will not only improve the quality of life of the campus community but also support UNTIRTA's vision as a healthy, sustainable and innovative campus. The planning of pedestrian facilities and crossings was carried out by collecting primary data such as road width, traffic volume, pedestrians crossing and walking along the roads of the area [11].

2. RESEARCH METHODS

This research was conducted using direct observation method. The data collected were pedestrian volume, traffic volume, road crossing volume, and road geometric data [17]. Documentation of photographs of pedestrian paths and available pedestrian facilities is needed for visual evidence of the existing field [18]. In addition, a literature study was also conducted by collecting data from various sources such as scientific journals, books, technical reports, and technical guidelines. The sources reviewed included literature on active living concepts and technical planning standards including pedestrian facility planning guidelines [19].

The research location is Campus C of Sultan Ageng Tirtayasa University. Campus C or the Faculty of Education Campus of Sultan Ageng Tirtayasa University is located at Jalan Ciwaru Raya No. 25, Cipare, Serang District, Serang City, Banten. This research is divided into 2 segments, namely segment 1 which is located on Jalan Ki Ajurum No. 2, Serang District, Serang City, Banten. While segment 2 is located on Jalan Ciwaru Raya No. 25, Kec. Serang, Serang City. Segment 1, data collection was carried out on Monday and Wednesday while Segment 2 was carried out on Tuesday and Thursday [20], [21].

The following is a flow chart of this research.

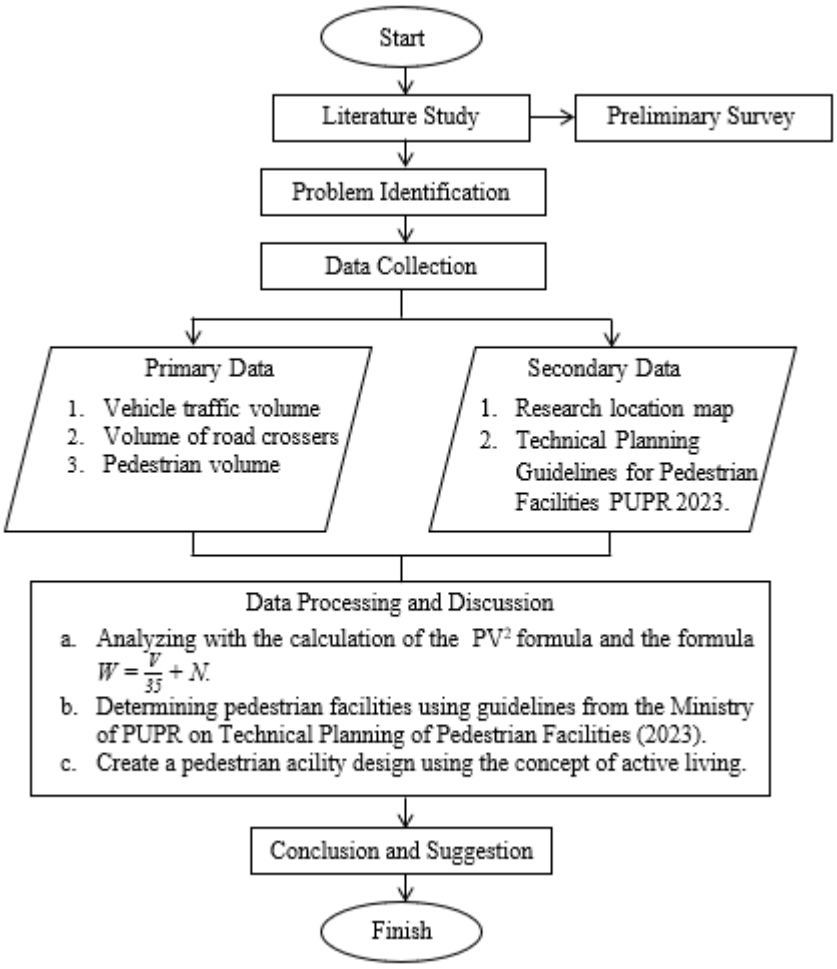

Figure 1. Research Flow Chart

In Figure 1, the stages of this research began with a literature study and preliminary survey, followed by problem identification and data collection. The data collected consisted of primary data (vehicle traffic volume, road crossings, and pedestrians) and secondary data (location map and PUPR 2023 technical guidelines).

There are 3 stages of data analysis carried out in this study, namely:

a. Pedestrian Facility Determination Analysis
   1) Conduct a pedestrian volume survey.
   2) Perform calculation and analysis with the formula $W = \frac{V}{35} + N$, where V is the volume of pedestrians and N is an additional width according to local conditions (m).

b. Analysis of Crossing Facility Determination
   1) Conduct a survey of pedestrians crossing the road and the volume of vehicles passing by.
   2) Analyze the calculation using the PV2 formula, where P is the volume of pedestrians crossing the road and V is the volume of vehicles passing by.
   3) After obtaining the results of the PV2 calculation, the next step is to determine the pedestrian crossing facilities by following the applicable procedures as recommendations for appropriate crossing facilities.

c. Design Recommendations for Pedestrian Facilities with the Active Living Concept.
   1) Conduct a survey of the existing conditions of pedestrian facilities at Campus C of Sultan Ageng Tirtayasa University.

The pedestrian paths at UNTIRTA Campus C have varying widths. In some areas, the path is wide enough for two people to walk hand in hand but there are also narrow areas that only allow one person to pass comfortably. There is vegetation such as trees along the pedestrian path, which provides shade and makes the environment more comfortable, especially during hot weathe.

2) Analyze the needs of pedestrian facilities using the Ministry of Public Works and Public Housing guidelines on Technical Planning of Pedestrian Facilities in 2023.
3) Provide design recommendations for pedestrian facilities that support the Active Living concept. 3D design recommendations are visualized using SketchUp software while 2D drawings use Autocad software.

3. RESULTS AND DISCUSSION

3.1 Pedestrian Facility Analysis

A sidewalk is part of a pedestrian path located in the area owned by the road [22]. Sidewalks usually have a coated surface, are positioned higher than the road surface, and are generally parallel to the vehicle traffic lane [23]. The effective width of the pedestrian lane based on the need for two pedestrians walking together or passing without colliding is at least 185 cm [17], [24].

The following the results of the calculation of the determination of pedestrian facilities in segment 1.

Table 1. Pedestrian Flow Calculation Analysis (per minute)

Segment 1			Segment 2		
Time	Average Pedestrian Time	Pedestrian (person/minute)	Time	Average Pedestrian Time	Pedestrian (person/minute)
07.00 – 08.00	22	1	07.00 – 08.00	23	1
08.00 – 09.00	108	2	08.00 – 09.00	118	2
09.00 – 10.00	84	1	09.00 – 10.00	180	3
10.00 – 11.00	104	2	10.00 – 11.00	183	3
11.00 – 12.00	83	1	11.00 – 12.00	299	5
12.00 – 13.00	187	3	12.00 – 13.00	103	2
13.00 – 14.00	95	2	13.00 – 14.00	118	2
14.00 – 15.00	76	1	14.00 – 15.00	267	4
15.00 – 16.00	100	2	15.00 – 16.00	129	2
16.00 – 17.00	106	2	16.00 – 17.00	207	3
Average		2	Average		3

From Table 1, for segment 1 the average pedestrian per minute is 2 people/minute/meter, the N value used is 1.5 because it is in an area with school service activities. After that, determine the minimum sidewalk width using the following equation [5].

$$W = \frac{V}{35} + N$$
$$= \frac{2}{35} + 1{,}5$$
$$= 1{,}5 \approx 2 \text{ m}$$

A minimum sidewalk width of 2 meters was obtained. These results are adjusted to the method from the Ministry of Public Works and Housing's 2023 Guidelines on Technical Planning of Pedestrian Facilities so that the effective width of the sidewalk used in segment 1 is 2.5 meters..

In segment 2, the average pedestrian per minute is 3 people/minute/meter, the N value used is 1.5 because it is in an area with school service activities. After that, determine the minimum sidewalk width using the following equation [5].

$$W = \frac{V}{35} + N$$
$$= \frac{3}{35} + 1{,}5$$
$$= 1{,}58 \approx 2 \text{ m}$$

A minimum sidewalk width of 2 meters was obtained. These results are adjusted to the method from the Ministry of Public Works and Public Housing's 2023 Guidelines on Technical Planning of Pedestrian Facilities, the effective width of the sidewalk used in segment 2 is 2.5 meters.

3.1.2 Analysis of the Determination of Crossing Facilities

The following are the criteria for determining level crossing facilities [5].

Table 2. Criteria for Determining Level Crossing Facilities

P (person/hour)	V (vehicle/hour)	PV^2	Recommendations
50-1100	300-500	$>10^8$	Zebra crossing or pedestrian platform*
50-1100	400-750	$>2 \times 10^8$	Zebra crossing with waiting stalss
50-1100	>500	$>10^8$	Pelican
>1100	>300		
50-1100	>750	$>2 \times 10^8$	Pelican with waiting stall
>1100	>400		

Description:
* = Pedestrian platform only on collector or local roads
P = 100 m pedestrian crossing traffic flow (person/hour)
V = Two-way vehicle traffic flow per hour (vehicle/hour)
PV^2 = Empirical formula for determining crossing facilities

The data required in this calculation is the average number of crossing flows and the average number of two-way vehicle flows that pass in 2 days. Segment 1 was conducted on Monday and Wednesday while segment 2 was conducted on Tuesday and Thursday.

Table 3. Calculation of Determination of Crossing Facilities

Segmen 1				Segmen 2			
Waktu	P	V	PV^2	Waktu	P	V	PV^2
07.00 – 08.00	55	5665	1748717534	07.00 – 08.00	14	3167	135403501,5
08.00 – 09.00	36	4731	805594689	08.00 – 09.00	100	3572	1269538808
09.00 – 10.00	42	3903	639639263	09.00 – 10.00	176	2975	1553284688
10.00 – 11.00	48	3890	718589987	10.00 – 11.00	174	2853	1412222162
11.00 – 12.00	31	3619	406011991	11.00 – 12.00	257	2497	1601755648
12.00 – 13.00	36	3197	367949124	12.00 – 13.00	103	2565	677660175
13.00 – 14.00	38	3163	375171338	13.00 – 14.00	90	2709	656811949,5
14.00 – 15.00	33	4437	649669977	14.00 – 15.00	224	2689	1615465208
15.00 – 16.00	25	4221	436512605	15.00 – 16.00	151	2719	1116337111
16.00 – 17.00	15	5981	536495704	16.00 – 17.00	195	2843	1576116555

From the table above, the maximum PV^2 result of segment 1 is 1748717534 (1×10^9) which occurs at 07.00 - 08.00 WIB. The P value of segment 1 at that time was 55 and V was 5665. These results are then adjusted to the method of determining crossing facilities from the Ministry of PUPR Regarding the Technical Planning of Pedestrian Facilities in 2023. The appropriate crossing facility is a pelican with waiting stalls. However, when compared to the existing conditions which show that the distance between the planned location of the crossing facility and the nearest intersection is less than 300 meters, the use of a pelican is expected to disrupt the smooth flow of traffic. Therefore, the recommended crossing facility for segment 1 is a zebra crossing with waiting stalls [25].

The maximum PV^2 of segment 2 is 1615465208 (1×10^9) which occurs at 2:00 pm - 3:00 pm. The P value of segment 2 at that time was 224 and V was 2689. These results were then adjusted to the guidelines used. In Table 2, the appropriate crossing facility is a pelican with waiting stalls. However, when compared to the existing conditions which show that the distance between the planned location of the crossing facility and the nearest intersection is less than 300 meters, the use of a pelican is expected to disrupt the smooth flow of traffic. Therefore, the recommended crossing facility for segment 2 is a zebra crossing [26].

3.1.3 Design Recommendations for Pedestrian Facilities Using the Active Living Concept

According to the guidelines, the effective width of the pedestrian path is at least 1.85 meters. Some areas in Campus C of Sultan Ageng Tirtayasa University have limited space due to narrow road conditions and physical elements such as parking or other facilities that limit sidewalk widening [27]. By considering the existing conditions in some narrow areas, the width of the pedestrian path is divided into 2 sizes, namely 2 meters for areas with limited space and 2.5 meters applied to areas that are more flexible [28]. Sidewalk paving uses andesite stone because it is more durable than paving blocks [13].

Figure 2 is the existing condition after the main gate of Campus C UNTIRTA. It can be seen that at that location there is no pedestrian path. There is empty land beside the road so that the recommended sidewalk width is 2.5 meters on the right and left without reducing the width of the road so as not to disturb motorists and pedestrians still feel comfortable.

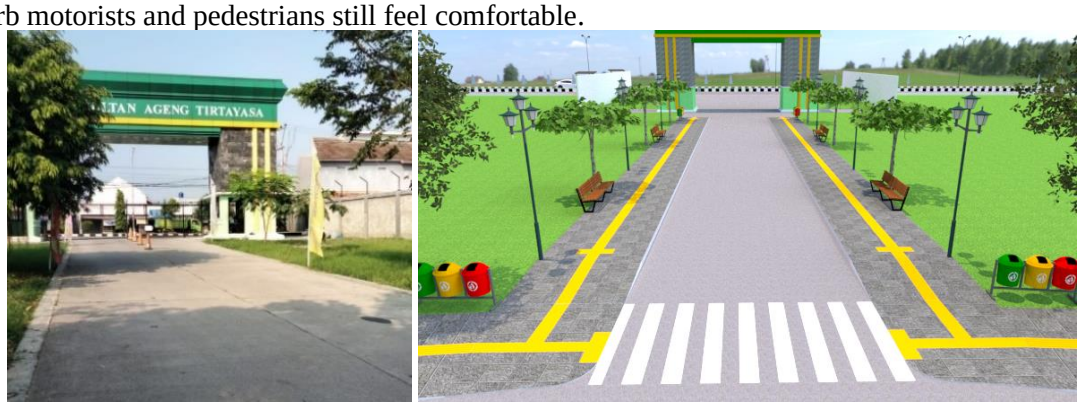

Figure 2. Existing Condition After Main Gate & 3D Sidewalk Design After Main Gate Campus C

Figure 3 is the existing condition of the road to Building C. The width of the road is 6 meters. At this location, the recommended sidewalk width is 2 meters because on the right side there is a mosque building. The left side utilizes the land beside the road while the right side reduces the width of the road. The kerb height in accordance with the guidelines used is 0.15 meters so that pedestrians do not feel difficult even though they climb the kerb.

Figure 3. Existing Condition & 3D Sidewalk Design Towards Building C

Complementary facilities recommended to support the concept of active living based on the Active Design Guidelines Promoting Physical Activity and Health in Design 2010 is to provide seating every 11 meters, lighting every 10 meters, shading in the form of trees, trash cans, drinking water taps, and special paths for people with disabilities [29].

Seating is provided so that pedestrians can sit down to enjoy the atmosphere, wait for someone, a place to rest when feeling tired after a long walk, or just reduce the boredom of walking on a long pedestrian path. In addition, students or staff can use this place to discuss, socialize, or work on group assignments. The concept of active living not only refers to physical activity, but also how the environment encourages active social engagement for mental and social well-being. At Campus C of Sultan Ageng Tirtayasa University, seating is provided on sidewalks with a width of 2.5 meters. While sidewalks with a width of 2 meters if provided with seating, the remaining area for pedestrians will be limited so that it can reduce the comfort and safety of sidewalk users. Seating is placed at every 11 meters by considering the characteristics of the location. The seats are 40-50 centimeters wide and 150 centimeters long. Seating is made of old teak wood because it is not susceptible to termites or mold and is resistant to exposure to sunlight and rain. The seats are permanently installed so they cannot be moved [13].

Lighting is not yet available in the sidewalk area of Campus C. It is not uncommon for students and staff to have activities until night so the presence of sidewalk lights is very important to ensure pedestrian safety, especially when walking at night. This is in line with the concept of active living which encourages physical activity to be carried out at any time without being hindered by time. The lighting uses galvanized iron poles. The lighting is symmetrically installed every 10 meters with a height of 3.5 meters [30].

Trees planted along the pedestrian path provide shade, especially during the day when the sun is hot. With natural shade, walking on campus will become more comfortable. In addition, trees can also improve air quality and the natural atmosphere around the pedestrian path [31]. This plays an important role in the active living concept because it invites students to do outdoor activities while enjoying a green and healthy environment. The shade tree is the Ketapang Laut Tree where the crown is shaped like a widening umbrella so that it can withstand direct sunlight.

With the presence of trash bins, pedestrians have easy access to dispose of garbage in its place so that garbage is not scattered on the pedestrian path. A clean and tidy environment provides comfort when walking or doing outdoor activities. This is an important part of the active living concept, which is to move in a healthy environment. Trash bins are placed every 20 meters and at meeting points such as intersections. On the sidewalks of Campus C of Sultan Ageng Tirtayasa University, there are no trash bins available. Waste bins consist of three types of barrels, namely for organic waste, inorganic waste,

and hazardous waste. The bins are permanently installed so that they cannot be moved and are equipped with a roof that still has a gap to allow waste to be disposed of easily [32].

Ready-to-drink water taps can increase the campus community's interest in walking, creating a more active, healthy, and pedestrian-friendly environment. Ready-to-drink water taps are placed on the pedestrian path near Buildings B and C, the Laboratory Building, and the Mosque. The sinks are made of natural stone which has high resistance to heat, rain and temperature changes.

Special pathways in the form of guideways and ramps are designed to improve accessibility and provide convenience for people with disabilities in activities in the public environment including campus. The guide path is in the form of tiles and has a line pattern placed in the middle of the pedestrian path [32]. While the ramp with a slope of 8% is designed to facilitate those who use wheelchairs.

Provide crossing facilities inside Campus C of Sultan Ageng Tirtayasa University in the form of a zebra crossing so that the pedestrian paths on both sides of the road remain connected so that pedestrians can move safely and comfortably without disturbing motorists.

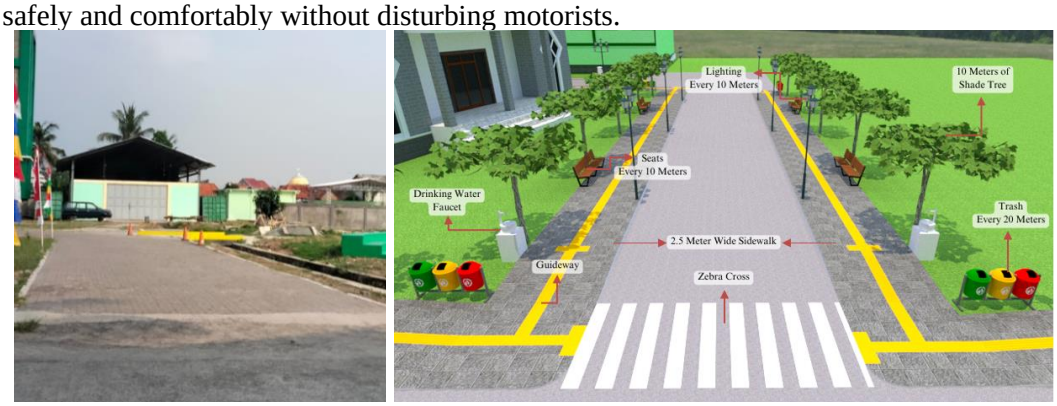

Figure 4. Existing Conditions that Do Not Have Pedestrian Facilities & Pedestrian Facilities that Can Be Provided at Campus C

3.1.4 Design Recommendations for Crossing Facilities Using the Active Living Concept

In segment 1, namely the Jalan Ki Ajurum No.2 section does not yet have a crosswalk facility. After analyzing to determine the need for crossing facilities, it is recommended to use a zebra crossing with waiting stalls. Waiting stalls are facilities provided for pedestrians to stop temporarily when crossing the road. Waiting stalls aim to improve pedestrian safety, especially on busy or wide roads [33]. The width of the waiting lap in Segment 1 is 1.7 meters following the width of the existing road median.

Zebra crossings equipped with waiting stalls provide a safe area for pedestrians to wait before crossing. Safety is a key factor that encourages more people to walk. This zebra crossing with waiting stalls is placed near the main gate of the campus so that visitors heading towards UNTIRTA Campus C can easily cross the road and immediately find the pedestrian pathways that connect to the campus buildings. The idea of shade at the end of the zebra crossing is provided to protect crossers from exposure to the sun or rain. The comfort enhanced by the shade can also motivate students to reduce the use of motorized vehicles and prefer walking.

Figure 5. Existing Conditions & 3D Design of Segment 1 Crossing Facilities

In segment 2, located at Jalan Ciwaru Raya No. 25, there is already a road crossing facility in the form of a zebra crossing. However, a re-analysis is needed to ensure that the existing infrastructure meets safety, comfort and accessibility standards for all road users, including pedestrians, children, the elderly and people with disabilities. By considering changes in traffic volumes, area development, and user needs, this evaluation can identify areas for improvement to make road crossings safer and more effective and support sustainable active mobility.

After an analysis to determine the need for crossing facilities, a zebra crossing is recommended. Judging from the peak hour in Segment 2, which occurs at 11:00 am - 12:00 pm, the idea of shade is given so that crossers are protected from the sun or rain and feel comfortable while waiting. Safety fences are also installed near the zebra crossing to direct pedestrians to cross in a safe place. The installation of bollards aims to prevent vehicles from parking in the area [34]. Good crossing infrastructure ensures that individuals, including students, can move safely, comfortably and efficiently around the campus while encouraging them to be more active in their daily lives.

Figure 6. Existing Condition & 3D Design of Segment 2 Crossing Facility

4. CONCLUCSIONS

From the results of the study, it can be concluded that based on the results of the analysis of crossing facilities, recommended crossing facilities in segment 1 are in the form of a zebra crossing with waiting stalls. The maximum PV^2 results occur at 07.00 - 08.00 WIB which is 1748717534 (1×10^9), the value of P (volume of crossers) is 55 and the value of V (volume of vehicles) is 5665. While in segment 2, the crossing facility is a zebra crossing. The maximum PV2 results occurred at 14:00 - 15:00 WIB which amounted to 1615465208 (1×10^9), the P value (volume of crossers) of 224 and the value of V (vehicle volume) of 2689.

Design recommendations for pedestrian facilities and crossing facilities using the concept of active living on Campus C of Sultan Ageng Tirtayasa University are crossing facilities that can be

recommended in segment 1, namely zebra crossing with waiting stalls and in segment 2 in the form of a zebra crossing. The idea of a shade at the end of the zebra crossing is given so that pedestrians are protected from heat or rain. These waiting stalls and shade can provide a comfortable resting area for those who need to pause in their journey. Good crossing infrastructure ensures that pedestrians can move safely, comfortably and efficiently around the campus while encouraging them to be more active in their daily lives.

The recommended effective sidewalk width for Campus C of Sultan Ageng Tirtayasa University is divided into 2 sizes, namely 2 meters for space-constrained areas and 2.5 meters applied to areas that are more flexible in terms of space. Recommended complementary facilities
to support the concept of active living based on the Active Design Guidelines Promoting Physical Activity and Health in Design 2010 is to provide a seat every 11 meters, lighting every 10 meters, shade in the form of trees, trash bins, drinking water taps, and special paths for people with disabilities.

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