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DESIGN OF MUNICIPAL TRANSPORT VEHICLES IN BALI PROVINCE

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ABSTRACT

Urban transport involves the movement of people and goods from one place to another using public vehicles, which can be either motorised or non-motorised. The presence of urban transport is crucial for supporting community mobility and can reduce the reliance on private vehicles. Ideally, urban transport should ensure both safety and comfort for drivers and passengers. However, in reality, safety and comfort are often inadequate. Issues such as overcrowded seating due to non-compliant designs, awkward entry and exit points that pose risks to passengers, lack of dedicated seating for disabled individuals, and absence of seat belts on all seats contribute to the problem. Moreover, many accidents involving urban transport are caused by the poor condition of the vehicles. Given these issues, this study is titled "Design of Urban Transport Vehicles in Bali Province." The research aims to analyse the current problems faced by urban transport systems. The goal is to develop a vehicle design that can restore the image of public transportation in Indonesia, particularly for urban transport or public minibus (angkot), and enhance safety, especially in Bali Province.

Keywords: car specification; design; public transport; public minibus safety

INTRODUCTION

Bali is one of Indonesia's tourist destinations renowned internationally. The use of public transportation in Bali has been steadily declining. A survey by the Public Transport Study (2005) indicated that only 5% of people used public transport, and this figure has continued to decrease. Currently, it is estimated that less than 1% of people use land-based public transport. Land transportation in Bali is significantly dominated by private vehicles, particularly motorcycles and cars. There is a notable imbalance between the growth rate of motor vehicles at 5.396% per year and road infrastructure at just 0.01% per year (BPS, 2019). This discrepancy leads to traffic congestion and air pollution, which in turn results in negative impacts on the community, such as deteriorating air quality, longer travel times, and increased vehicle operating costs. In this study, the author aims to improve the angkot (public minibus) system by developing alternative designs that align with the public transportation planning of the Bali provincial government. The angkot is planned to serve as a feeder service to larger public transportation systems such as Trans Metro Dewata and SARBAGITA.

The public minibuses are targeted to serve small areas close to residential neighbourhoods to meet local transportation needs. Therefore, to develop more comprehensive transportation policies in Bali, it is necessary to create long-term projections for the development of a connected and integrated transportation system. The redesign of angkots focuses on economic value, passenger comfort, and ergonomics, targeting users who are accustomed to private vehicles. The angkots are designed to be as comfortable as possible, maximising passenger capacity by providing both seated and standing areas. It is hoped that this design will offer recommendations to address current issues with public transport. By designing city transport vehicles in this way, it aims not only to improve the image of public transport in Indonesia—especially urban angkots that are safe—but also to provide alternative solutions for the development of an integrated public transportation infrastructure in Bali Province, particularly in Denpasar.

METHOD

In the research model, a city transport vehicle's safety was taken into consideration during design, using computer-based applications and analysed through calculations in accordance with existing regulations. The focus was on aerodynamic testing of the transport design, using SketchUp Pro 2023 software. Aerodynamics were incorporated to minimise air resistance for moving vehicles. This aerodynamic design was applied to the car body model to enhance vehicle stability and ensure passenger safety.

The analysis was carried out in multiple crucial phases, including:

a. Literature Review and Field Visits, as a stage for practical understanding and observing the production process directly, including the steps involved, the technology used, and risk management. This approach provided a better understanding of how the product is produced.
b. Data Processing and Calculation. This involved comparing chassis brands to determine the vehicle model for which the redesign or redesign of the city transport would be carried out.
c. Experiment and Design. This included analysing data related to dimensions, reliability, performance, fuel efficiency, and other characteristics.
d. Data Analysis Stage. This involved performing calculations using formulas to determine the vehicle’s carrying capacity, thereby establishing the maximum carrying capacity of the redesigned vehicle.
e. Conclusion. This stage involved summarising the results of the redesign, with conclusions drawn after the redesign analysis had been completed.

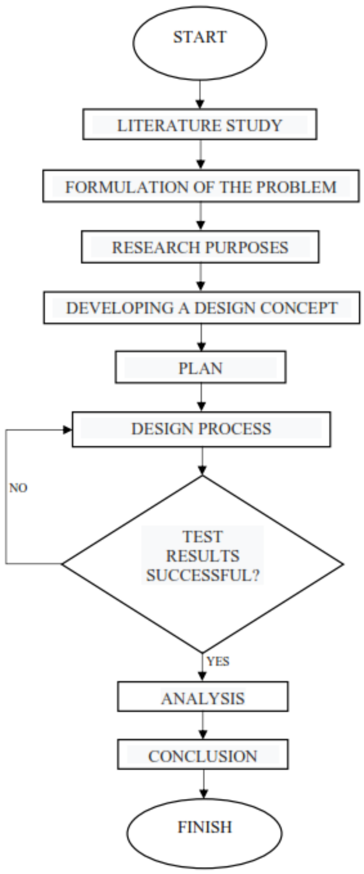

Figure 1. Research Scheme

RESULT AND DISCUSSION

Results of the Literature Review and Field Visits

The field visits, conducted as the initial stage of the design concept development, included market analysis, initial concept formulation, chassis comparison, and analysis. The visits aimed to review and apply industrial technology in management activities, production processes, and passenger car body manufacturing at PT. New Armada Magelang. In addition to gathering primary data, interviews were conducted with stakeholders including city transport users, government regulators, and body manufacturers. To further supplement the understanding of industrial technology application in management activities, production processes, and industry outcomes, additional visits were made to a bus body manufacturer at PT. Tentrem Sejahtera in Malang, East Java.

Results of the Data Processing and Sample Calculation Stage

This stage involved comparing chassis brands to determine the model of the vehicle for which the redesign or redesign of the city transport would be carried out. This step was crucial for obtaining data analysis related to dimensions, reliability, performance, fuel efficiency, and other characteristics.

Specification		Unit	Model				
			ELF NLR 55 Bx	Isuzu Traga	L300	FE 71L BC NC	GRANDMAX
Dimension	Length	mm	4,870	4,520	4,165	4,735	4,045
	Wide	mm	1,835	1,695	1,695	1,750	1,665
	Height	mm	2,170	1,955	1,915	2,055	1,900
	Axis Distance	mm	2,490	2,250	2,350	2,500	2,650
	Lowest Distance to Ground	mm	190	200	195	200	165
	Seat Capacity	person	16	3	3	16	9
Engine	Model	None	4JB1-TC	4JA1L	4N14	4V21-2AT4	3SZ-VE,DOHC VVTi
	Type	None	injection Diesel	Injection diesel	Diesel inter cooler, common rail	Common Rail	Bensin EFI (Electronic Fuel Injection)
	Cylinder Volume	cc	2.771	2,499	2,268	3907	1495
	Maximum Power	PS/rpm	100/3.400	80/3,500	99,25/3500	79/2500	97 / 6000
	Maximum Torque	Kgm/rpm	22,5/2000-3200	19,5/1,800	20,4 / 1000-3500	300/1000-2500	13,7 /4400
Wheel	Front Wheel	Pcs	225/75/R16	195R 14-8PR	185R 14	225/75-R16C	165R13C-8PR
	Rear Wheel	Pcs	225/75/R16	195R 14-8PR	185R 14	225/75-R16C	165R13C-8PR
Weight	Empty Weight	Kg	1590	1470	1165	1790	1270
	Gross Weight / GVW	Kg	5100	2950	2,540	5200	1840
Brake	Front	-	Hydraulic, dual line with vacuum booster	Control hydraulic dual circuit ventilated disc	Hydraulic system with vacuum servo assistance	Hydraulic System with Vacuum Servo Assistance, Dual Circuit	Ventilated discs with booster, drums,leading & trailing
	Rear	-	Expanding mechanism in rear transmission	Drum, Leading, Trailing	Internal expanding type behind the propeller shaft	Internal expanding type behind the propeller shaft	Mechanical on the rear wheel
Suspension	Front	-	Leaf spring	coil spring	Coil spring	Leaf spring	Coil spring

	Rear	-	Leaf spring	Leaf spring	Leaf spring	Leaf spring	Leaf spring
Others	Tank Capacity	ltr	75	50	100	70	43
	Turning Radius	m	5.7	4,5	4,7	5.2	4,7
	Climbing Power	%	29		27		
	Maximum Speed	km/h	108	113	105	120	96
	Accu	V-Ah	12-60	12-65	24 V	24 V	
	AC		available	unavailable	unavailable	available	available
	Fuel Consumption			1:12	1:8		

Based on the analysis of chassis selection and its economic aspects, The Isuzu Traga has been selected for the redesigned city transport vehicle based on a comprehensive analysis of chassis selection and economic factors. This choice is supported by its affordability compared to other models, a well-sized 50-litre fuel tank, and impressive fuel efficiency of 1 litre of diesel per 12 kilometres. The Isuzu Traga's gross vehicle weight of 2,950 kg, along with its dimensions of 4,520 mm in length, 1,695 mm in width, and 1,955 mm in height, make it suitable for Bali's urban roads. Additionally, its front coil springs and rear leaf springs provide effective handling of load, vibration, and shocks, making it ideal for passenger transport.The measurement of dimensions was carried out not only for aesthetic design purposes but also to achieve a balance between all these dimensions, ensuring the vehicle had optimal performance in terms of functionality, aesthetics, and safety. This was done to evaluate various design options before the actual construction of the vehicle.
Here are the results of the dimension measurements obtained:

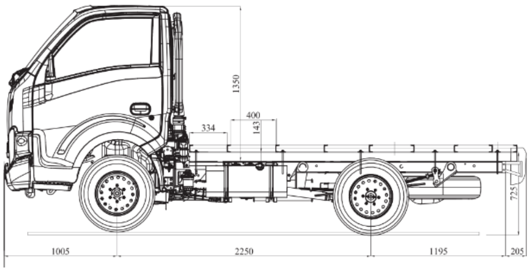

Figure 2. Results of the Chassis Dimension Measurements

Interior Dimensions. This includes passenger space and cabin capacity, covering the height, width, and length of the interior area.

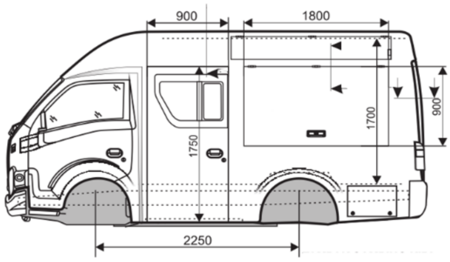

Figure 3. Body Dimensions from the Left Side View

Body measurements were taken to determine the proportions between the front overhang, front body length, rear overhang, and rear body length. This is important because, in some cases, it can affect manoeuvrability, the vehicle's ability to handle obstacles, and also impact the vehicle's balance and stability, especially in situations such as parking or navigating through tight spaces.

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Results of the Experimentation and Design Stage

The experimentation and design stage of the vehicle involved a series of steps to develop, measure, and test the redesign. This process included planning the redesign in accordance with existing regulations and considering the technical aspects of the vehicle.

Redesign of Public Minibus (Angkot)

1. Side view

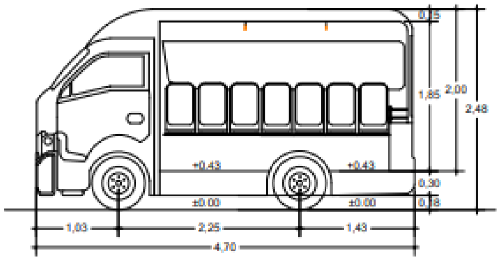

Figure 4. Right Side View

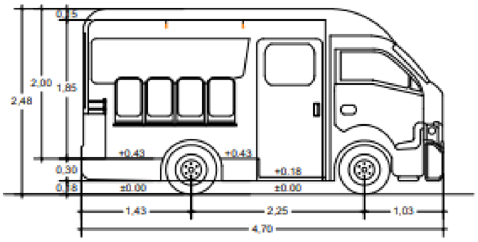

Figure 5. Left Side View

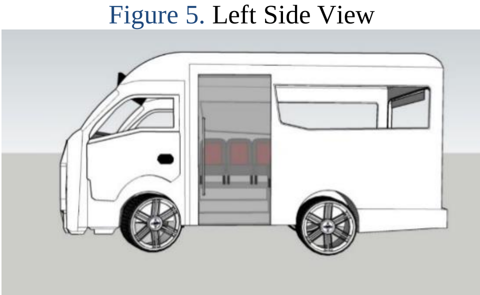

Figure 6. 2D Side View

2. Front View

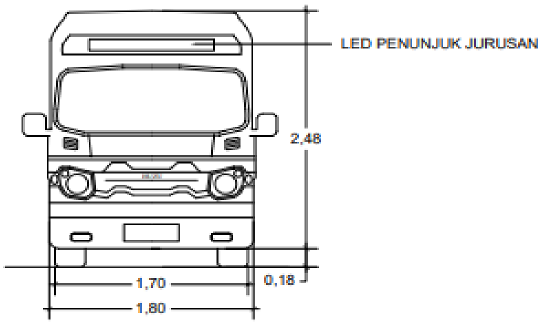

Figure 7. Front View

Figure 8. 2D Front View

3. Rear View

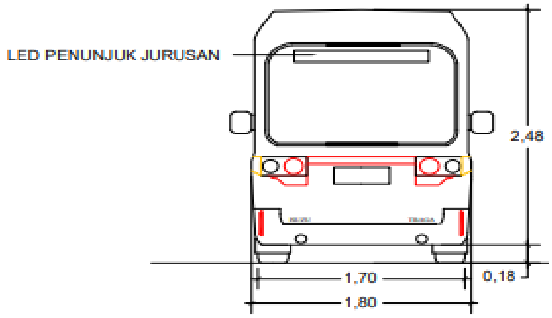

Figure 9. Rear View

Figure 10. 2D Rear View

4. Top View

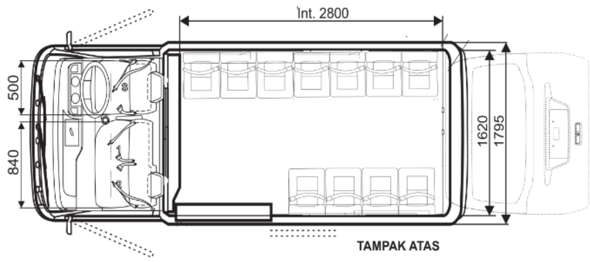

Figure 11. Top View

Data Analysis Results

The Isuzu Traga chassis that had been selected was then calculated using a formula to determine the vehicle's load capacity. To find the load capacity, the following calculation was performed:

the vehicle's weight (BK) was determined by summing the weight of Axle 1 (S_1) and Axle 2 (S_2).

The Traga chassis had the following specifications:

Maximum Permissible Weight (JBB) : 2.950 kg
S_1 : 1000
S_2 : 800

Finding BK

BK = S_1 + S_2
= 1000 + 800
= 1800 kg

Furthermore, to obtain the result for the cargo weight (L), the calculation involved summing the average weight of passengers and their baggage (70) multiplied by the number of seats (X), then subtracting the weight of the driver's baggage (10).

Finding L

L = 70 X - 10
= 70 (16) - 10
= 1.110 kg

Haulage

Passenger = 16 x 60 = 960
Goods = 15 x 10 = 150

From the results of the calculation above, by summing the vehicle's weight (BK) and the cargo weight (L), the following result was obtained:

Total weight = Vehicle's Weight (BK) + Cargo Weight (L)
= 1.800 + 1.110
= 2.910 kg

Hence, the total weight of the vehicle along with its cargo was found to be 2.910 kg. With this result, the Traga chassis to be manufactured and designed meets the safety requirements according to PP 55, as the total vehicle weight is still below the Maximum Permissible Weight (JBB).

Finding Maximum Axle Load (MST)

$R_1 = S_1 + L\frac{(a-q)}{a}$
$= 1000 + 1.110\ \frac{225-205}{225}$
= 1099 kg

$R_2 = S_2 + L.{}^{q}/_{a}$
$= 800 + 1.110.{}^{205}/_{225}$
= 1811 kg (MST)

Total load = 2910 kg

Thus, the calculation of the load capacity yielded the following result:

Maximum Permissible Weight (JBB) : 2950 kg
Actual Weight (JBI) : 2910 kg

From the calculations, a difference of 40 kg was found between the Maximum Permissible Weight (JBB) and the Actual Weight (JBI). The Maximum Axle Load (MST) of 1,811 kg is on Axle 2. The tire size for both Axle 1 and Axle 2 is 195 R14-8PR, with a maximum load capacity of 950 kg per tire. Therefore, the MST of 1,811 kg on Axle 2 can be supported by 2 tires, each with a maximum load capacity of 950 kg. Thus, the total maximum load capacity of the 2 tires is 1,900 kg. Since the MST of 1,811 kg is within the tire capacity of 1,900 kg, it does not exceed the limit and complies with the applicable regulations.

The seating design can be opened and closed when not in use to optimise cabin space for standing passengers. The design also allows passengers to perch on the seats, enabling those travelling short distances to stand comfortably. Considering that many users of this type of public transport are women and elderly individuals, the seats can be folded out as needed for sitting.

Standing room is prioritised for younger passengers, whether male or female, who use the transport for short distances. Seats must be designed to be as comfortable as possible, in accordance with regulations KEPUTUSAN DI REKTUR JENDERAL PERHUBUNGAN DARAT Number : SK.1131/AJ.003/DRJD/2003, here are the specifications for the seats used in the design of the safety-compliant public transport vehicle:

Seat Specifications

a. The seats are made from foam or similar fire-resistant materials;
b. The seat width is 440 millimetres;
c. The seat height is 1010 millimetres;
d. The seat length is 400 millimetres;
e. The effective aisle width is 800 millimetres, allowing for passenger traffic within the bus when it is occupied;
f. Each seat is equipped with a seat belt for safety;
g. The seats can be folded back by 32 degrees when not in use, widening the aisle.

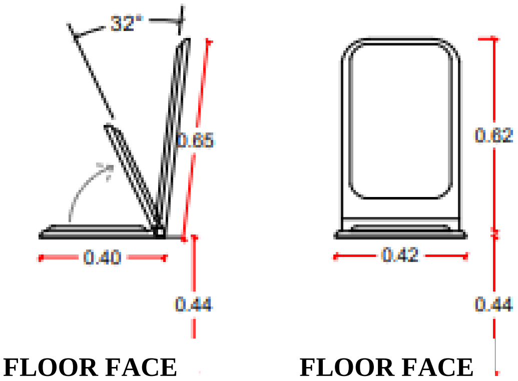

Figure 12. Detailed Seat Dimensions Design

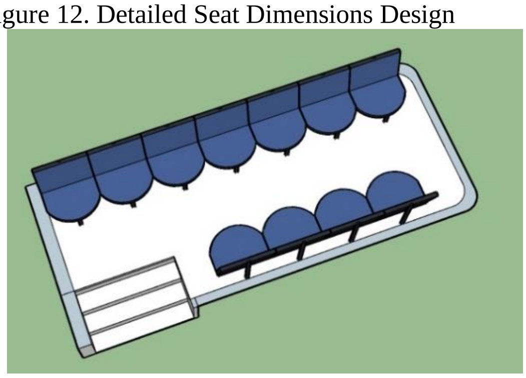

Figure 13. Top View Layout of the Passenger Cabin (2D Plan)

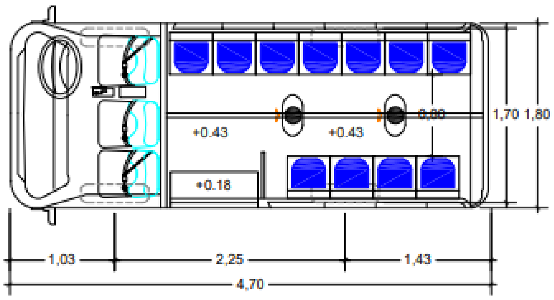

Figure 14. Passenger Seat Layout

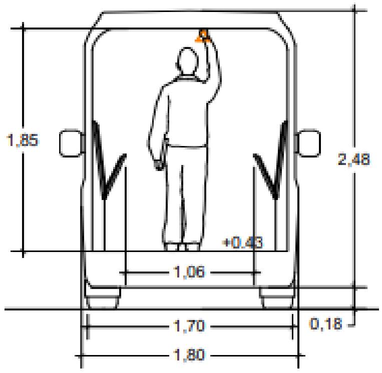

Figure 15. The Simulation of Standing Passenger

Figure 16. The Simulation of Standing Passengers in 2D Plan

This urban transport design accommodates both seated and standing passengers. According to the load capacity calculation, the Isuzu Traga chassis can carry up to 16 passengers, including the driver. As shown in Figure 5.26, the design includes 13 passenger seats, 1 seat for the driver, and space for 2 standing passengers with handgrips. The design is tailored to accommodate standing passengers up to a maximum height of 185 cm.

Figure 17. Simulation of Seating Passenger in 2D Plan

The selection of the Isuzu Traga chassis considers several factors such as price, required specifications, and suitability for urban transport. The Isuzu Traga chassis is priced at Rp. 211,000,000, while other options are priced as follows: Isuzu NLR 55 BX at Rp. 290,000,000, L300 at Rp. 213,000,000, FE 71L BC NC at Rp. 361,000,000, and Grandmax at Rp. 169,000,000. Although the Grandmax is cheaper, chassis selection is based not only on price but also on vehicle specifications such as dimensions, load capacity, suspension type, engine capacity, and fuel consumption.

The Isuzu Traga has the following specifications:

- Dimensions: Length 4,520 mm, Width 1,695 mm, Height 1,955 mm, Wheelbase 2,250 mm, Ground Clearance 200 mm
- Engine Capacity: 2,499 CC
- Maximum Power: 100 PS at 3,400 rpm
- Maximum Torque: 19.5 kgm at 1,800 rpm

- Fuel Tank Capacity: 50 liters, with a fuel consumption rate of 1 liter of diesel for 12 kilometers
- Gross Vehicle Weight (GVW): 2,950 kg
- Suspension: Front suspension with coil springs and rear suspension with leaf springs

These specifications make the Isuzu Traga a viable option for urban transport due to its balance of cost, performance, and suitability for city driving.
The technical aspects and design of the planned vehicle comply with Government Regulation No. 55 of 2012 on motor vehicles. The technical specifications of the vehicle are as follows:

- Vehicle Length: 4,700 millimetres
- Vehicle Width: 1,800 millimetres
- Vehicle Height: 2,480 millimetres
- Rear Overhang (ROH): 1,030 millimetres
- Front Overhang (FOH): 1,430 millimetres
- Wheelbase: 2,250 millimetres
- Ground Clearance: 180 millimetres

From the load capacity calculations for the planned vehicle:

- Passenger Capacity: 16 people (equivalent to 960 kg)
- Cargo Capacity: 150 kg
- Maximum Axle Load (MST): 1,811 kg on Axle 2, supported by tires with a maximum load of 950 kg per tire.

For Axle 2 (MST), it is supported by 2 tires with a maximum load of 2 x 950 kg = 1,900 kg. Thus, the MST of 1,811 kg on Axle 2 is well within the capacity of the tires with the specification 195 R14-8PR (max load 950 kg).

- Passenger Seat Specifications:
- Number of Seats: 13 passenger seats and 1 driver seat.
- Standing Space: Provision for 2 standing passengers, equipped with handgrips.
- Seat Material: Made from foam or similar fire-resistant material.
- Seat Width: 440 millimetres
- Seat Height: 1,010 millimetres
- Seat Depth: 400 millimetres
- Effective Aisle Width: 800 millimetres, to facilitate passenger movement within the bus.
- Seat Belts: Each seat is equipped with a seat belt.
- Foldable Seats: Seats can be folded back by 32 degrees to widen the gangway.
- Standing Passenger Accommodation: Designed to accommodate passengers up to a maximum height of 185 cm.

This design ensures that the vehicle meets safety regulations, provides adequate space for passengers and cargo, and accommodates standing passengers effectively. The proposed vehicle will include several key safety and comfort features. For safety, it will have seat belts installed on all seats, a light fire extinguisher (APAR) for emergencies, a glass breaker hammer for window emergencies, and a first aid kit stocked with essential medical supplies. To enhance passenger comfort, the vehicle will be equipped with air conditioning to maintain a pleasant temperature and an electronic route information board to keep passengers informed about routes and destinations. These features are intended to improve overall safety and comfort while adhering to safety regulations. Thus, the design of the urban transport vehicle was found to be highly suitable and feasible using the Isuzu Traga chassis, with its various advantages and a unit price, including the body and accessories, around Rp. 350 million. The use of this type of vehicle was based on field research; according to a study by Avianto & Dindayanti (2020) onducted in Denpasar, large buses were found to be unsuitable for urban public transport as they would exacerbate traffic congestion, given their dimensions of up to 12,000 millimetres in length and 2,500 millimetres in width. Meanwhile, research by Prasetyawan (2016) in Denpasar showed that the average load factor for public transport using medium-sized buses only filled 14 to 17 passengers. Therefore, this research indicates that the design of the safety-compliant urban transport vehicle using the Isuzu Traga chassis, capable of carrying 16 passengers, is well-suited to the needs.

CONCLUTION

The redesign of the safety-compliant urban transport vehicle adheres to Government Regulation No. 55 of 2012 on motor vehicles. The resulting design specifies a vehicle using the Isuzu Traga chassis, which accommodates 16 passengers and has a cargo capacity of 150 kg. The recommended design for the safety-compliant urban transport vehicle includes the following specifications: a length of 4,700 millimetres, a width of 1,800 millimetres, a height of 2,480 millimetres, a rear overhang (ROH) of 1,030 millimetres, a front overhang (FOH) of 1,430 millimetres, a wheelbase of 2,250 millimetres, and a ground clearance of 180 millimetres. The vehicle should be equipped with seat belts on every seat, a light fire extinguisher (APAR), a glass breaker hammer, and a first aid kit. For passenger comfort, the vehicle should include air conditioning (AC) and an electronic route information board. Further research is needed to determine the feasibility of manufacturing this urban transport vehicle. It is recommended for supporting urban transport in the region.

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