

Case Study: Preliminary Design Standard for Bus Stop in Universiti Malaysia Sabah

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ABSTRACT The design of bus stops can cause various problems for passengers, bus drivers, and other vehicles on the road. Malaysia has not yet developed guidelines as a reference for bus stop design to meet consumer requirements, especially on Malaysia's university campuses. This study was conducted to propose a preliminary design for the bus stop in Universiti Malaysia Sabah (UMS). By referring to various design guidelines and the principles Universal Design, bus stop preliminary design recommendations for Universiti Malaysia Sabah (UMS) were developed. The proposed guideline provides a general overview of the 7 component physical criteria of the bus stop. This guideline may serve as a critical reference to designers, architects, or developers in building better, user-oriented bus stops in the future. This guideline can provide an important reference for designers, architects, or developers to build better, user-oriented bus stops in the future.

KEYWORDS: Bus stop; Preliminary design; Green Roof; Universiti Malaysia Sabah; Eco Campus

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Design Study

INTRODUCTION

Installation of green roofs in bus stops can minimize the negative impacts of urban development. Green roofs are normally used to manage stormwater runoff, reduce heat transfer, and enhance aesthetics. A green roof is a roof that contains plants or vegetation and it may be fully or partially covered on the roof. However, the standardized design guideline for green roofs installed on bus stops are currently not available in Malaysia. There is a total of 24 bus stops in UMS, 6 near the hostels, 15 near the faculty, and 3 near the intersections. Universiti Malaysia Sabah (UMS) was chosen for this study as the university that promotes a green environment as a part of its' Eco Campus initiative, therefore a green roof bus stop is aligned with the campus objectives. The purpose of this paper is to propose a preliminary design for the bus stop in UMS, which is easy to access, comfortable and safe for passengers to use based on a review of existing standards.

BUS STOP STANDARD

There are no published standards for designing bus stop in Malaysia. In this research, 12 existing bus stop design standards have been studied to identify the requirement of bus stop designs in several countries such as the USA, England, Australia, Singapore, Northern Ireland, and Canada. The guidelines of bus stops design for each country is to standardize bus stops across the region to provide a safe and comfortable bus stop. Besides that, the bus stop guidelines can provide a guide for the architecture and engineer or developer to the bus stop facilities. The standards for each region are shown in Table 1.

Table 1. Standards for bus stop

Bus Stop Design	Standard	Authors
Bus Stop Design Guidelines	<ul style="list-style-type: none"> Disability Standards for Accessible Public Transport 2002 (the Disability Standards) Australian Standards AS 1428.2 Australian Standards AS 1428.4 	Public Transport Authority, 2005
Bus Stop Design & Accessibility Guidelines	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) Public Rights-of-Way Accessibility Guidelines (PROWAG) 	Memphis Area Transit Authority, 2017
Accessing Transit: Design Handbook for Florida Bus Passenger Facilities	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) 	Higgins & Audirac, 2008
Bus Stop ADA Guidelines	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) 	UVLSRPC, 2020
Bus Stop Guidelines	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) 	Vicroads, 2006
Bus Stop Design Guide	<ul style="list-style-type: none"> Traffic Signs Regulations (Northern Ireland), 1997 	Roads Service, 2008
Bus Stop Design and Safety Guideline Handbook	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) California Building Code Senate Bill 375 	NV5 Engineering, 2014
Bus Stop Design Guidelines	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) Pedestrian Facilities in the Public Right-of-Way (PROWAG) 	PB, 2007.
Bus Stop Guidelines	<ul style="list-style-type: none"> The Land Transport (Road User) Rule 2004 	TriMet, 2010.
Bus Stop Specification Guidelines	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) 	InterCity Transit, 2010
Bus Stops Guidelines July 2010 Revision	<ul style="list-style-type: none"> Americans with Disabilities Act (ADA) 	TriMet, 2010
Section 4 Commuter Facilities Design Requirements	<ul style="list-style-type: none"> LTA Standard Details of Road Elements (SDRE) requirements. 	Land Transport Authority, 2013
Best Practises for Universal Design	<ul style="list-style-type: none"> Universal Design (UD) 	Sacramento Transportation & Air Quality, 2005

UNIVERSAL DESIGN

Universal Design as shown in Figure 1, refers to facility designs that accommodate the widest range of potential users, including people with mobility and visual disabilities and other special needs (Sacramento Transportation & Air Quality, 2005). There are seven principles to use the universal design which are:

- i. Equitable Use
- ii. Flexibility in Use
- iii. Simple and Intuitive Use
- iv. Perceptible Information
- v. Tolerance for Error
- vi. Low Physical Effort
- vii. Size and Space for Approach and Use

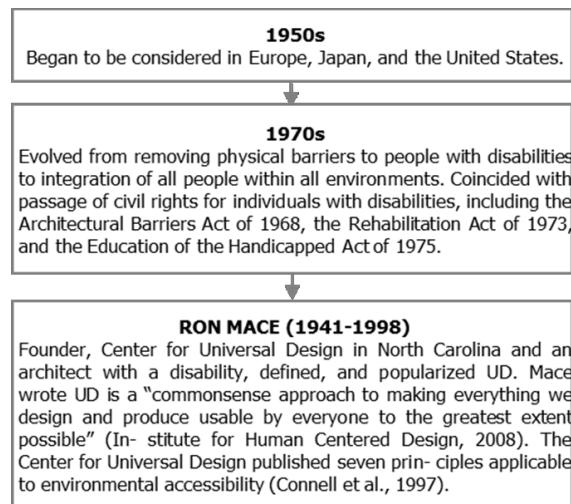


Figure 1. Background and history of Universal Design (UD) principles
Source: Roberts *et al.* (2011)

GREEN ROOF

A green roof as shown in Figure 2, is a roof that contains plants or vegetation, and it may be fully or partially covered on the roof (Ahmed & Alibaba, 2016). There are three types of green roofs, which are an intensive, semi-intensive and extensive green roof.

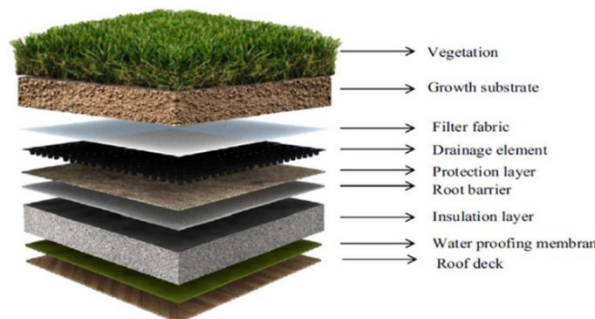


Figure 2. Green roof components
Source: le Trung et al., 2018

The green roof usually consists of the following layers: vegetation layer, substrate layer, filter layer, drainage layer and waterproof layer. The term and definition of vegetation layer, substrate layer, filter layer, drainage layer and waterproofing layer are summarized in Table 2.

Table 2. Definition of green roof layer

Green Roofs Layers	Definition	Authors
Vegetative Layer	The volume covered by the plants which extend life to the green roof system.	Magill et al., 2011 Mobasher, 2014
Substrate Layer	Providing nutrients and storing water can affect the growth of plants and the performance of green roofs.	Tolderlund, 2010
Filter Layer	Separate the substrate from the drainage layer to avoid silts and clays entering and clogging the drainage layer, thereby reducing its performance over time.	Cascone, 2019 Vijayaraghavan, 2016
Drainage Layer	Remove excess water from external or internal drains.	Cascone, 2019 Tolderlund, 2010 Vijayaraghavan, 2016
Waterproofing Layer	Prohibits water from penetrating the building and managing the run-off of the green roof.	Tolderlund, 2010

METHODOLOGY

The overview of the study methodology is presented in Table 3. A literature review was conducted to review 12 existing bus stop design guidelines is reviewed in USA, England, Australia, Singapore, Northern Ireland, and Canada. The bus stop design guidelines basically prepared by the authority of the corresponding countries. Existing bus stop design standards were studied to identify the dimension of the bus stop components designs in several countries.

Table 3. Sources of information and data gathered for each research phase

Phase	Data Collection Phase	Source	Data
1. Preliminary research	Literature review	Past research books, journal articles, documents	Terms, definitions, keywords
2. Project scope definition	Document Analysis	Design guideline for existing bus stops	Types, dimension, and components of bus stop design

PRELIMINARY DESIGN OF THE BUS STOP

The universal design applied in the preliminary design of green roof bus stop (UVLSRPC, 2020). The proposed criteria of each component in the green roof bus stop is shown below:

i. Bus stop sign (as shown in Figure 3)

The bottom of the sign should be no less than 2500 mm above the ground, the width of the sign should be no less than 450 mm, and the height should be no less than 620 mm (UpKeep, 2020).

- a. Bus stop signs were placed at the location where passengers board the front door of the bus. The bus stop sign marked the area where passengers should stand while waiting for the bus and serves as a guide for the bus operator in positioning the vehicle at the stop.
- b. The bottom of the sign should be at least 2100 millimeters above ground level and should not be located closer than 600 millimeters from the curb face.
- c. Locations for bus stops and signposts should be coordinated with local and/or state jurisdictions.
- d. Signs should not be obstructed by trees, buildings, or other signs and located away from visual distraction.

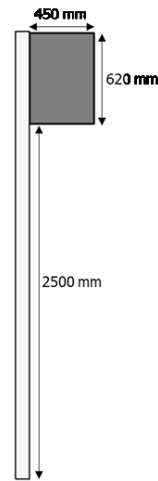


Figure 3. Proposed criteria for bus stop sign

ii. Lighting (as shown in Figure 4)

- a. Lighting that provides between two and five foot-candles should be installed.
- b. Fixtures should be vandal-proof but easily maintainable.
- c. Bus stops should be located near existing streetlights for indirect lighting.

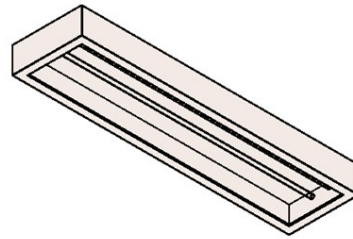


Figure 4. Proposed criteria for bus stop lighting

iii. Benches (as shown in Figure 5)

430 millimeter height benches were provided. A minimum separation of 610 millimeters (preferably 1219 millimeters) was maintained between the bench and the back-face of the curb.

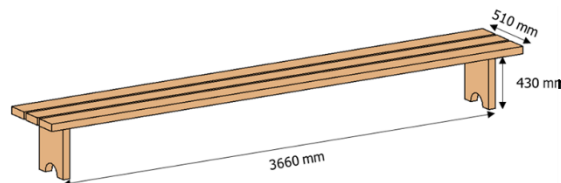


Figure 5. Proposed criteria for benches

- a. Bench was installed where there is shade and lighting or inside the shelter.
- b. Avoid locating benches on undeveloped rights-of-way and anchor to prevent unauthorized movement of the bench.
- c. Benches were placed to the back of a sidewalk to allow for pedestrian circulation.
- d. Constructed using materials that are resistant to weather; from which graffiti is easily removed.
- e. Benches were located away from driveways.

iv. Trash Receptacles (as shown in Figure 6)

One litter bin of capacity 150 liters was provided (UpKeep, 2020).

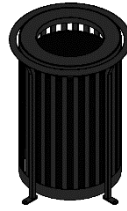


Figure 6. Proposed criteria for trash receptacle

- Constructed of materials that are resistant to weather; from which graffiti is easy removed.
- Anchor bin to prevent unauthorized movement.
- Minimum capacity of 30 gallons.
- Do not locate the bin in direct sunlight.

v. Shelter

The dimension of the bus stop was 4600mm (length) x 1515mm (width) x 2300mm (height) as shown in Figure 7.

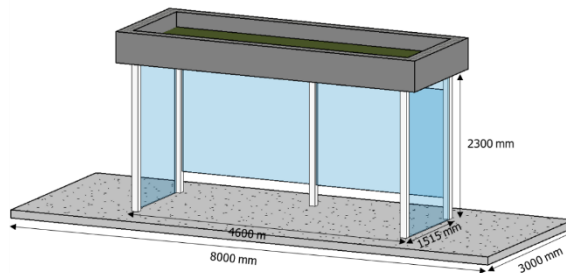


Figure 7. Proposed criteria for shelter

- Incorporate shelter dimensions that are 2700 millimeters by 1500 millimeters.
- Transparent sides for visibility and security.
- Constructed of materials that are resistant to weather; from which graffiti is easily removed.
- Waterproof with drainage away from the bus stop.

vi. Green Roof (as shown in Figure 8)

Proposed thickness of green roof layer is stated below:

- Substrate layer 50mm
- Filter layer 40mm
- Drainage layer 40mm
- Waterproofing layer

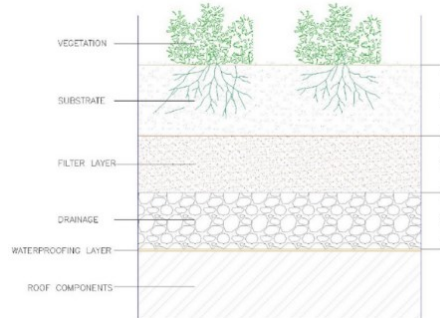


Figure 8. Detailed drawing of green roof

CONCLUSION

The preliminary design is based on the combination of various information from multiple countries. Universal design was utilized entirely in the development of this guideline in the fact that every criterion for each component mentioned are related to the principles of universal design. The

preliminary design proposed in this study included general standards, which involved technical elements in the design, such as the size of each important component of the bus stop. The green roof is recommended for the preliminary design for bus stops in Universiti Malaysia Sabah (UMS). The designer and campus development team should improve the bus stop according to the guideline.

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