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Enhancing Inclusivity: Designing Disability Friendly Pedestrian Pathways

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ABSTRACT

Pedestrian pathways should be designed to meet the needs of regular pedestrians and accommodate individuals with disabilities. Presently, a substantial number of pedestrian routes across Indonesia remain inaccessible to those reliant on wheelchairs and people with disabilities. This study aimed to evaluate and design disability-friendly pedestrian pathways for optimal accessibility and safety in Indonesia. A pedestrian pathways model was derived using a triangulation of data methodology (a review of literature, observation and simulation, and a focus group discussion convening stakeholders). Based on research results, none of the pedestrian pathways meet the criteria for individuals with disabilities. The Customer Satisfaction Index (CSI) score on pedestrian pathways indicates the unsatisfied category. Pedestrians with physical limitations argue that pedestrian pathways cannot provide comfort to support their movement. The evaluation results show that people with disabilities face difficulty accessing pedestrian pathways. This research produces pedestrian pathway designs based on three universal principles: adequate maneuvering space, clear signage and information, and appropriate surface materials. These universal design principles refer to efforts to create accessible, safe, and comfortable environments for everyone, regardless of age and physical ability.

1. INTRODUCTION

Individuals with disabilities are citizens entitled to equal access to and fair provision of transportation services [1, 2]. The UN Convention on the Rights of Persons with Disabilities by Strauss et al. [3] and Indonesian Law No. 8 of 2016 by Mahmudah et al. [4], individuals with disabilities possess the same rights as those without disabilities, including the rights to life, social welfare, accessibility, and independent living.

Public spaces are conceived as open or closed spaces that are constructed for the usage of every individual without any discrimination in society (park, garden, stop, etc.). Everybody has the responsibility to create solutions for the public [5]. The American Disabilities Act (ADA) is federal legislation passed in 1990 that prohibits discrimination against people with disabilities, defines accessibility as the road that, from a node in the interior of a building to the public space, does not include any obstacles and provides continuity [6].

The UN Standard Rules on Accessibility make the following recommendations regarding access to the physical environment [7]:

(a) States should initiate measures to remove the obstacles to participation in the physical environment. Such measures should develop standards and guidelines and consider enacting legislation to ensure accessibility to various areas of society, including housing, buildings, public transport services, transportation, and other means of street environments, and other outdoor.

(b) States should ensure that architects, construction engineers, and others who are professionally involved in the design and construction of the physical environment have access to adequate information on disability policy and measures to achieve accessibility.

(c) Accessibility requirements should be included in the design and construction of the physical environment from the beginning of the design process.

(d) Organizations of persons with disabilities should be consulted when standards and norms for accessibility are being developed. They should also be involved locally from the initial planning stage when public construction projects are being designed, thus ensuring maximum accessibility.

Pedestrian pathways constitute a crucial component of transportation needs and the lives of individuals with disabilities [8]. Indonesian government regulations stipulate that the planning and execution of public infrastructure and its surroundings must incorporate accessibility provisions for all individuals, including those with disabilities [9, 10]. Schwartz [11] stated that each pedestrian pathway should adhere to the following criteria, e.i.: (a) accessibility for all pedestrians, including those with physical limitations; (b) the selection of plant species that provide coverage and directional cues; (c) appropriate and easily reachable furnishings; (d) visible information boards and signs; and (e) the presence of ramps and markers for individuals with disabilities, which should be functional as intended [12]. The essential components of a pedestrian pathway encompass drainage systems, ramps, guiding blocks, illumination fixtures, waste disposal facilities, seating arrangements, and bollards [13].

In Indonesia, a significant number of pedestrian pathways remain inaccessible to wheelchair users with disabilities [14]. Uneven surfaces (undulating or pockmarked) are commonly observed on pedestrian pathways [15]. Moreover, the principal accessibility feature, ramps, do not conform to prevailing technical standards, including spatial dimensions (length, width, and height) and incline parameters [16]. Additionally, the improper positioning pedestrian pathway amenities such as bollards further impedes access for individuals with disabilities.

This study aimed to evaluate and design disability-friendly pedestrian pathways for optimal accessibility. The stages carried out in this research include: evaluating the existing conditions of pedestrian pathways, undertaking rigorous simulations of pedestrian accessibility, and providing targeted recommendations to establish pathways universally accessible, particularly for individuals with disabilities.

2. OBJECT AND METHODS OF RESEARCH

The object study for this research is in Kendari City, Indonesia. As one of the major cities in eastern Indonesia, the availability of public open spaces equipped with pedestrian pathways is crucial for the community, including individuals with disabilities. Three important street in Kendari City are objects for observing the condition of pedestrian pathways, namely Abunawas Street, Abdul Silondae Street, and Tebaunungggu Street (Figure 1). This location exhibits characteristics of residential areas, office districts, educational zones, and cultural heritage areas.

Figure 1. The layout of the study site

The stages carried out in this research include:

(a) Evaluate the condition of existing pedestrian paths.

This study evaluated three distinct entrance streets along the pedestrian pathway. Each locations exhibited unique characteristics in terms of the pedestrian pathway layout. A comprehensive assessment was conducted for each location's accessibility and comprehensiveness, considering essential features such as guiding blocks, bollards, curbs, and ramps designed specifically for wheelchair users with disabilities.

(b) Conducting a satisfaction survey of pedestrian path users

The survey was conducted on 131 pedestrian pathways users who have physical limitations, namely the elderly, pregnant women, visually impaired, and physically disabled. The Customer Satisfaction Index (CSI) method measures pedestrian path user satisfaction. The satisfaction parameters include accessibility, connectivity, circulation, security, and safety. There are five categories of Customer Satisfaction Index (CSI) assessment, which can be seen in Table 1.

(c) Carry out simulations of pedestrian entry access.

The access points to the three pedestrian pathways were facilitated by ramps that differed in shape and size. Variations in incline, elevation, length of the ramp surface, and width uniquely characterized each ramp. A simulation was executed to assess the usability of these three entry ramps for wheelchair users. This simulation involved the active participation of 35 individuals who used manual wheelchairs to evaluate the practicality and effectiveness of wheelchair accessibility.

(d) Designing disability-friendly pedestrian pathways.

In order to establish an ideal pedestrian pathway model accessible to individuals with disabilities, data collection was conducted based on triangulation methodology. Data triangulation involves a data collection technique that amalgamates various existing data and sources [17].

The data triangulation approach employed in this study encompasses three integral components: (1) a literature review of universal design principles, (2) observation and simulation exercises involving wheelchair users on pedestrian pathways, and (3) a focus group discussion (FGD) convening stakeholders such as pedestrian pathway providers and domain experts. The FGD sessions involved the participation of a diverse cohort of 30 individuals, representing disabled individuals, urban planning specialists, landscape design authorities, architecture experts, transportation planning professionals, public health scholars, and practitioners from the Department of Public Works. The primary objective of these FGD sessions was to collaboratively formulate a pedestrian pathway model, fostering both safety and comfort, particularly for individuals with disabilities.

Table 1. Interpretation of customer satisfaction index

CSI Score	Category
0 < CSI ≤ 20%	very unsatisfied
20% < CSI ≤ 40%	unsatisfied
40% < CSI ≤ 60%	quite satisfied
60% < CSI ≤ 80%	satisfied
80% < CSI ≤ 100%	very satisfied

3. RESULTS AND DISCUSSION

3.1 Evaluation of current pedestrian pathway conditions

In general, pedestrian pathways are conventionally designed to cater to the needs of pedestrians under normal conditions, while also addressing the requirements of those with limitations [18]. Thus, the provision of specialized designs and amenities becomes imperative to facilitate individuals with disabilities, ensuring their ability to engage in pedestrian activities akin to those without disabilities [19, 20].

The provision of disability access pathways in public roads is a critical aspect of efforts to foster an inclusive and accommodating society for all individuals, including persons with disabilities. Despite efforts to enhance pedestrian infrastructure, significant issues persist [21]. Sidewalks often prove inadequate for individuals using wheelchairs or other mobility aids. Uneven surfaces, obstructions such as rocks, and sidewalks blocked by parked vehicles or other physical barriers constitute tangible mobility obstacles for persons with disabilities. Insufficient tactile or visual cues also contribute to navigational difficulties, potentially leading to hazardous situations. Moreover, the lack of societal awareness regarding the importance of maintaining accessibility for persons with disabilities exacerbates the issue. Occasionally, sidewalks are utilized for parking or commercial purposes (Figure 2, further encroaching upon space for pedestrians, including those with disabilities. This creates an environment not only hazardous but also inhospitable to individuals with limited physical or sensory abilities. The ramifications of this situation not only curtail the freedom of movement for persons with disabilities but also engender feelings of isolation and restrict their participation in economic and social life [22].

(a) (b)

Figure 2. Misuse of pedestrian access for illegal parking (a) and informal vending (b)

Pedestrian pathways need evaluation to ensure the comfort of both pedestrians and individuals with disabilities. The following are the outcomes of the assessment of the existing pedestrian pathway conditions taken by sampling on Abunawas Street, Abdul Silondae Street, and Tebaununggu Street (Figure 3).

(a) (b) (c)

Figure 3 Pedestrian pathway access in Abunawas Street (a), Abdul Silondae Street (b) and Tebaununggu Street (c)

3.1.1 Pedestrian pathways access on Abunawas Street

There are two entrances and exits along Abunawas Street of the pedestrian pathway, with a total pathway length of 180 meters. Within Abunawas Street, there is a 16 centimeters-wide curbing delineating the pedestrian pathways, which itself spans a width of 3.3 meters. The pathways surface was constructed using paving blocks. Notably, this street lacks handrails and guidelines. Within this street, there is a drainage system intersecting the pedestrian pathway, connecting the road surface to the city's drainage channel, spanning 30 centimeters in width. Furthermore, a buffer zone measuring 2.7 meters is present in this street. Notably, there exists an elevation difference of 35 centimeters between the road surface and the pedestrian pathway, alongside a drainage channel measuring 1.2 meters in width.

3.1.2 Pedestrian pathways access on Abdul Silondae Street

Pedestrian pathways on Abdul Silondae Street has a path length of 330 centimeters and are equipped with facilities adapted to individuals with disabilities, including *ramps*, *bollards,* and guidelines. Within the pedestrian pathway, there are two entrance and exit points, spanning a pathway length of 330 meters. The completeness of this street entails a 20 centimeters-wide curbing, a pedestrian pathway width of 4.4 meters surfaced with paving blocks, guidelines, and ramps tailored for wheelchair users with disabilities. Additionally, bollards, guidelines, and streetlights are present to illuminate the pathway during nighttime hours. However, the spacing of the bollards, set at 80 centimeters intervals, presents a challenge for wheelchair users to access the pedestrian pathways, despite their function in preventing motor vehicles from entering.

3.1.3 Pedestrian pathways access on Tebaununggu Street

The pedestrian pathways on this street run parallel to Abdul Silondae Street; this layout greatly facilitates pedestrian users in accessing the right side of the public open space area, which is a heavily frequented area by visitors. The pedestrian pathways boasts a width of 4.4 meters and stands 30 centimeters above the road surface. The length of this pathway spans 443 meters, bordered by curbing measuring 20 centimeters. The pedestrian pathways is equipped with ramps, bollards, and guidelines. Bollards are present at intervals of 90 centimeters, featuring a bend at their upper part. However, their presence within this street results in wheelchair users facing difficulties while attempting to access the pedestrian pathway due to the significantly narrow entrance.

Table 2. Evaluation of pedestrian pathway amenities

Completeness	**Abunawas Street**	**Abdul Silondae Street**	**Tebaununggu Street**
Pedestrian pathway:			
Pathway width	3.3 m	4.4 m	4.4 m
Pathway height	35 cm	25 cm	30 cm
Pathway length	180 m	330 m	443 m
Surface material	Paving Block	Paving Block	Paving Block
Ramp:			
Incline	14º	8º	10º
Surface material	Textured cement	Textured cement	Textured cement
Width	75 cm	150 cm	160 cm
Height	35 cm	25 cm	30 cm
Bollard	No	Yes	Yes
Guide lines	No	Yes	Yes
Curb Ram	No	No	No
Handrailing	No	No	No
Curb:	Yes	Yes	Yes
Width	15-35 cm	15-25 cm	15-30 cm
Height	15-35 cm	15-25 cm	15-30 cm

Based on the observation outcomes of the pedestrian pathways in Abunawas Street, Abdul Silondae Street, and Tebaununggu Street, the compilation of pedestrian amenities (ramps, guidelines, curbing, and handrails) can be summarized as depicted in Table 2.

The observations conducted on the pedestrian pathways in all three locations reveal that none of the streets currently possess complete pedestrian amenities, particularly in terms of ramp facilities. The dimensions of width, height, incline, and slope of ramps in Abunawas Street, Abdul Silondae Street, and Tebaununggu Street varied. Consequently, none of the pedestrian pathways meet the criteria for accessibility by individuals with disabilities.

3.2 User satisfaction assessment of pedestrian pathways

A pedestrian-friendly pathway for persons with disabilities is essential to supporting the smooth accessibility of its users. Assessment of user satisfaction with pedestrian pathways on Abunawas Street, Abdul Silondae Street, and Tebaununggu Street, was carried out through surveys of pedestrian pathways with physical constraints such as the elderly, pregnant women, the visually impaired, and the physically disabled. Respondent characteristics are shown in Table 3 below.

Table 3. Characteristics of respondents based on disability

No.	Criteria	Number of Respondent	Percentage %
1.	Elderly	56	13.9
2.	Pregnant women	28	7.1
3.	Visually impaired	12	3.0
4.	Physically disabled	35	8.7
	Total	**131**	**100**

Table 2 showed that there were respondents with disabilities who carry out activities in the pedestrian pathways area and answered questions, consisting of the elderly (13.9%), pregnant women (7.1%), visually impaired (3.0%), and physically disabled (8.7%). There for, it can be concluded that there are 131 users with disabilities who carry out their activities.

To assess user satisfaction with pedestrian pathways, five variables are used: Accessibility, connectivity, circulation, security, and safety. Table 4 shows the results of respondents' satisfaction assessments.

The assessment of five variables of pedestrian pathway user satisfaction was analyzed using the Customer Satisfaction Index (CSI). The CSI value is obtained through several stages, namely the mean importance score (MIS) to calculate the average level of importance, the weight factors (WF) to assess the percentage of each attribute, the mean satisfaction score (MSS) to get the average value of each performance, and the weight score (WS), which is the product of the weight factors (WF) and the mean satisfaction score (MSS).

Based on Table 4, it can be seen that the Customer Satisfaction Index for all parameters shows the unsatisfied category (20% < CSI ≤ 40%), meaning that pedestrian pathways users who have physical limitations believe that the pedestrian pathways are not able to provide comfort in supporting their movements.

3.3 Accessibility simulation on pedestrian pathway

Pedestrian pathway amenities catering to individuals with visual impairments and wheelchair users include key elements such as the base space dimensions, guidelines, and ramps [18, 19]. Ramps serve as aids to facilitate movement along pedestrian pathways [23, 24]. The design of ramps aims to ensure a surface that is both non-slip and free from grooves [13, 25]. The objective of the simulations was to assess the comfort of ramps across all three pedestrian pathway segments when accessed by wheelchair users. The simulations aimed to ascertain the ideal dimensions and incline for ramps. A group of 35 individuals with disabilities who used wheelchairs participated in these simulations (Figure 4).

(a) (b) (c)

Figure 4. Simulation on the pedestrian pathway accessibility in Abunawas Street (a), Abdul Silondae Street (b) and Tebaununggu Street (c)

Table 4. The result of the user satisfaction assessment of pedestrian pathways

No.	Criteria		Question	MIS	MSS	WF	WS	CSI	Category
1.	Accessibility	A1	Pedestrian path (size, material and slope of pedestrian path)	1.51	1.20	32.88	39.39	24.22	unsatisfied
		A2	Ramp availability (size, material and handrail, completeness and slope)	1.27	1.14	27.71	31.67		
		A3	Availability of road signs and markings (size, space, type, location and completeness)	1.81	1.27	39.40	50.07		
2.	Connectivity	B1	Pedestrian paths connect with transport elements	1.78	1.53	24.60	37.65	28.08	unsatisfied
		B2	Crossing lanes available	1.77	1.46	24.57	35.88		
		B3	Pedestrian path continuity	1.87	1.16	25.95	30.12		
		B4	Intermodal switching facilities transport	1.80	1.48	24.88	36.78		
3.	Circulation	C1	Dimension of pedestrian path	1.71	1.31	50.52	65.97	27.11	unsatisfied
		C2	Presence of obstructing objects on the pedestrian pathway	1.67	1.41	49.48	69.60		
4.	Security	D1	Security system	1.72	1.14	24.70	28.11	32.75	unsatisfied
		D2	Pedestrian path lighting	1.70	1.28	24.31	31.19		
		D3	Speed control facility	1.73	1.97	24.74	48.74		
		D4	Buffer zone between road and pedestrian	1.83	1.12	26.25	55.72		
5.	Safety	E1	The difference in height level of the pedestrian path with the road body	1.70	1.08	19.23	20.82	24.46	unsatisfied
		E2	Availability of pedestrian path markings and signs/signals	1.74	1.19	19.65	23.35		
		E3	Pedestrian path condition	1.91	1.16	21.58	25.04		
		E4	Material surface texture	1.78	1.34	20.14	26.95		
		E5	Crossing lanes	1.71	1.35	19.40	26.14		

3.3.1 Accessibility simulation of pedestrian pathway on Abunawas Street

Accessibility on the pedestrian pathway in Abunawas Street involves a ramp with dimensions of 136 centimeters in length, 75 centimeters in width, an elevation of 35 centimeters from the asphalt surface to the pedestrian pathway, and an incline of 14°. Based on the simulations conducted on the ramp in Segment 1 (Figure 4), individuals with disabilities encountered difficulties when accessing the pedestrian pathway. The ramp width measures 75 centimeters, while the average width of a wheelchair is around 80 centimeters. The narrow width and inadequate incline make wheelchair users need help from others to push their wheelchairs. Furthermore, the simulated incline of 14° poses a potential danger to individuals with disabilities.

3.3.2 Accessibility simulation of pedestrian pathway on Abdul Silondae Street

Abdul Silondae Street constitutes a pedestrian pathway with a remarkably high density of users. The ramp within this street has dimensions of 175 centimeters in length, 150 centimeters in width, an incline of 8°, and an elevation of 25 centimeters from the road surface to the pedestrian pathway. Based on the simulations conducted on the pedestrian pathway in this street, individuals with disabilities could access the ramp. The ramp's width, length, and incline facilitated independent access for individuals with disabilities to the pedestrian pathway. However, there are three bollards within this street, spaced at intervals of 80 centimeters. Given the average width of a wheelchair being 80 centimeters, the passage was extremely narrow, posing challenges for individuals with disabilities.

3.3.3 Accessibility simulation of pedestrian pathway on Tebaununggu Street

Tebaununggu Street represents a pedestrian pathway with an exceedingly high user density. The ramp within this street has dimensions of 175 centimeters in length, and 160 centimeters in width, an elevation of 30 centimeters from the road surface to the pedestrian pathway, and an incline of 10. The simulation on the pedestrian pathway, indicates that individuals with disabilities face challenges when accessing the ramp. Wheelchair users require more effort to maneuver their chairs uphill. While the ramp is still accessible, it is not an easy task due to the steep incline. In this segment, there are 3 bollards spaced at intervals of 90 centimeters, but these bollards have a bend at the top, causing the gap between them to narrow. This setup makes it difficult for wheelchair users to access the pedestrian pathway.

3.4 Pedestrian pathways accessibility based on universal design principles

According to Republic of Indonesia Law No. 19 of 2011 regarding the Convention on the Rights of Persons with Disabilities, universal design refers to the concept of creating products, environments, programs, and services that can be accessed and utilized by all individuals without the need for specific adaptations for particular groups [26]. Universal design should not exclude or discriminate against aids for specific groups or communities with special needs, instead, the design should be usable by the general population [27]. In essence, the design of facilities within pedestrian areas should accommodate individuals with diverse abilities. Both the form and usage of such facilities should be straightforward to ensure ease of use and minimize burden for users [28].

In order to achieve universal accessibility, assessing pedestrian pathways at the study location using the principles of universal design is a crucial step towards identifying areas in need of improvement (see Table 5). Several metrics employed, such as adequate width and maneuvering space, clear signage and information, appropriate surface materials, reveal significant disparities between existing conditions and expected accessibility standards [29].

Criteria for accessibility based on the principles of universal design at the study site refer to efforts aimed at creating environments that are easily accessible, safe, and comfortable for everyone, regardless of age, physical ability, or background [30]. These criteria involve several key aspects, such as:

a) Physical Accessibility: Roads should be designed without significant physical barriers, such as flat sidewalks free from obstructions like stairs or damaged ramps. Signs and directions should be easily visible and accessible to everyone.
b) Sensory Accessibility: Design should consider various senses, such as vision, hearing, and touch. Traffic lights with auditory signals and safe pedestrian crossings for the visually impaired are examples of sensory accessibility implementation.

Table 5. Analysis of pedestrian pathway accessibility depend on universal design

No.	Parameter	Existing Conditions	Design Needs	Concepts
1	Adequate Maneuvering Space	The presence of physical barriers such as utility poles, trees, or other public facilities located in the middle of the sidewalk can restrict maneuvering space and impede movement.	Roads should be designed considering sufficient maneuvering space for wheelchairs, mobility aids, and individuals.	Moving or reducing physical barriers on sidewalks, such as utility poles or obstructing trees, to ensure smooth flow and easy access.
2	Clear Signage and Information	Inconsistency in signage usage, difficult-to-read text sizes, or signage not meeting the needs of users with visual or hearing impairments.	Road signs, markings, and surrounding information should be designed clearly and legibly.	Signage should be positioned in easily visible and accessible locations for all road users. Signs need to be placed at appropriate heights to ensure easy readability by pedestrians, including those using wheelchairs.
3	Appropriate Surface Materials	The road surface typically consists of asphalt or concrete. Meanwhile, pedestrian pathways or sidewalks may vary in materials, including concrete, paving blocks, or other substances.	The design of road surfaces and sidewalks should prioritize safety and comfort for road users.	Surface materials should be durable and stable, particularly in areas subjected to heavy loads from vehicular traffic or mobility aids. This will ensure that the surface remains safe and accessible over the long term.

c) Cognitive Accessibility: Signs and instructions should be designed clearly and easily understandable. This helps individuals with cognitive challenges navigate and move around the environment more easily.

Uneven sidewalks, a lack of clear signage, insufficient safe pedestrian crossings, or mismatches with the needs of individuals with various physical and sensory challenges can pose problems that need to be addressed.

3.5 Recommendation for disability-friendly pedestrian pathways

Based on the evaluation and simulations, the pedestrian pathways at the study site do not currently meet all the specific requirements for accessibility by individuals with disabilities and have not yet been established to meet universal design accessibility criteria. Uneven sidewalks, the unavailability of clear signs, a lack of safe pedestrian crossings, or mismatches to the needs of people with various physical and sensory challenges are problems that need to be fixed. Therefore, it was redesigned to be more inclusive, and paying attention to universal design is a necessity [31]. This could include:

(a) Adequate maneuvering space

Ensuring that sidewalks are designed with a flat surface, free from obstacles, and wide enough to allow wheelchair users or people with disabilities. Assistive devices can move comfortably. In accordance with existing guidelines, the width of movement space regulated for crutch users is a minimum of 95 centimeters from right to left and a minimum of 120 centimeters from front to back. Meanwhile, for the blind, the minimum width of movement from right to left is a minimum of 90 centimeters, from front to back, a minimum of 95 centimeters, and the minimum building height is 210 centimeters. Meanwhile, for wheelchair users, the minimum width of movement from right to left is 160 centimeters, with a minimum building height of 130 centimeters.

Figure 5. Design of pathways with guiding paths

Pedestrians must be equipped with guiding blocks or guide lanes. These guiding blocks are placed on the sidewalk and are yellow in color, with signs appearing in the form of tubes or circles (Figure 5). The tubular embossed sign is a block that is used as a guide. The guide block must have 600 millimeters of free space on the left and right of the block [32]. Meanwhile, circular embossed signs are warning blocks that are usually placed at sidewalk stops, up or down ramps, entering crossing areas, or bus stops [33]. The placement of this warning block must have a minimum strip width of 600 millimeters to clarify the movement between the pedestrian path and the sidewalk. Pedestrian pathways can also be equipped with passing places. A passing place is an area used to overtake other pedestrian path users. These facilities are usually used on sidewalks that are less than 1.5 meters wide [34]. Therefore, to increase pedestrian comfort, especially for people with disabilities, it is recommended that this passing area be at least every 50 meters.

(b) Clear signage and information

Pedestrian pathways must be equipped with important signs and information boards, with appropriate placement, and consider various forms of communication to ensure everyone can understand them (Figure 6). For the blind or those with low vision, they will rely on providing information by sound or feeling it while walking [35]. One of the markers is the sound of traffic or sloping road supports, so they can be signs and warning sources that can be detected. Therefore, it is necessary to provide information, including verbal messages, audible sound signals, and raised signs, at each facility to provide understanding for people who are blind or have low vision.

Figure 6. Design of information and signage on pedestrian pathways

(c) Appropriate surface materials

The sidewalk surface as a pedestrian pathway can be made using block paving material. Paving material is quite resistance to weather. Apart from that, if damage occurs to the paving, it can be repaired quickly because there is no need to replace the entire sidewalk with only the damaged part. If it rains, water will easily absorb into the ground because of the presence of air voids in paving. Paving has a texture that is not slippery when exposed to water [36].

Ramps are part of the facilities on pedestrian pathways that function to make it easier for pedestrian users to move to higher or lower areas [37]. This facility is very helpful for wheelchair users for mobilization. In Indonesia, a significant portion of individuals with disabilities rely on manual wheelchairs, demanding substantial effort to maneuver the wheels and adequate space for maneuvers [2, 16]. To ensure access to pedestrian pathways, ramps with sufficient width, incline, and ramp length are essential [11, 25]. The ramp design is made parallel to the existing sidewalk line so as not to interfere with street activities. Apart from that, having the ramp parallel to the sidewalk does not cause the ramp to quickly become damaged or degrade due to heavy traffic (Figure 7).

According to Ayodeji and Adejuyigbe [38] and Nitzan et al. [39], the average wheelchair size is approximately 110-140 centimeters in length and 80 centimeters in width. The average lateral reach limit for wheelchair users is about 180 centimeters, and the forward reach limit is about 130 centimeters. The pathway should include a ramp with a maximum height of 25 centimeters, a width of 150 centimeters, an incline of 7°, and a ramp length of 204 centimeters (Figure 8). The presence of bollards at the end of ramps is not recommended. However, if bollards are installed on the pedestrian pathway, a minimum distance of 100 centimeters between bollards is advised to provide space for individuals with disabilities to pass through [40].

Figure 7. Design of ramp on pedestrian pathways

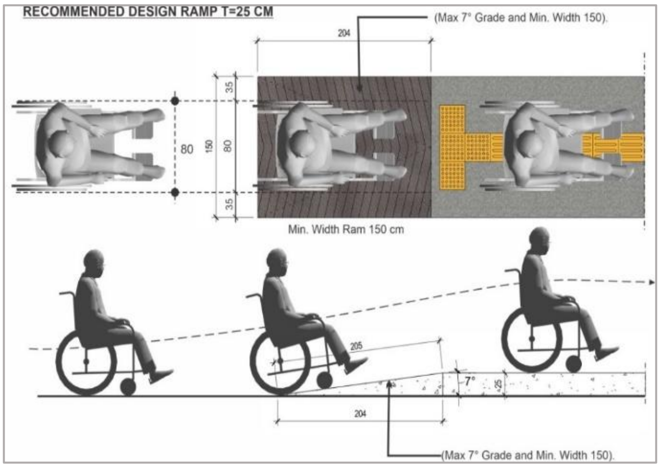

Figure 8. Recommendation for entry access of pedestrian pathways

4. CONCLUSIONS

Based on observations, simulations, and analyses, it can be concluded that the use of pedestrian facilities, especially by individuals with disabilities, in Kendari City, Indonesia, is not effectively supporting community mobility and activities. Pedestrians, particularly those with disabilities, continue to face various obstacles, potential conflicts, and limitations in pedestrian pathways. The built environment, circulation patterns, and physical conditions of pedestrian pathways significantly impact pedestrian mobility. Improvements are particularly needed in the built environment aspect of pedestrian pathways, although further analysis reveals shortcomings in this area. Strategies for design optimization of pedestrian pathways should involve addressing specific issues to improve their effectiveness. Designs should be versatile and accommodating to disabilities, tailored to the potential of the pathways and pedestrian behaviors, facilitating easy and optimal implementation.

According to the research results, the pedestrian pathways in all three locations reveal that none of the streets currently possess complete pedestrian amenities. The Customer Satisfaction Index in the parameters of accessibility, connectivity, circulation, security, and safety, shows the unsatisfactory category (20% < CSI ≤ 40%), meaning that pedestrian pathways users who have physical limitations believe that the pedestrian pathways are not able to provide comfort in supporting their movements.

According to Republic of Indonesia Law and the Convention on the Rights of Persons with Disabilities, universal design refers to the concept of creating products, environments, programs, and services that can be accessed and utilized by all individuals without the need for specific adaptations for particular groups. Universal design, sometimes also called inclusive design or barrier-free design, is the design and structure of an environment so that it can be understood, accessed, and used to the maximum extent possible by all people, regardless of their age or abilities. Based on the universal design concept, a pedestrian pathway must pay attention to three aspects: adequate width and maneuvering space, clear signs and information, and appropriate surface materials. Research findings show that, based on the data triangulation, the recommended pedestrian pathways must be designed with a flat surface, free of obstacles, and wide enough for wheelchair users or people with disabilities to pass through. Pedestrian pathways must be equipped with important signs and information boards, with appropriate placement, and consider various forms of communication. Paving can be used as a surface material for pedestrian pathways. Additionally, entry access for the pedestrian pathway to ensure safety and comfort for individuals with disabilities must have a ramp with a maximum height of 25 centimeters, an incline of 7°, a ramp length of 204 centimeters, and a minimum ramp width of 150 centimeters.

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