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Design Of Public Facilities For Persons With Disabilities At Al-Azizi Mosque, Batam City Using The Axiomatic Design (AD) Method

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Abstract— Humans are special creatures both physically and intellectually. Humans have the ability to adapt, but not everyone will be able to make good adjustments, especially people with disabilities. It is known that out of a total of 7 billion world population in 2021, 15% of them are persons with disabilities. Based on data on persons with disabilities released by the Ministry of Social Affairs of the Republic of Indonesia, it is known that in the Riau Archipelago as many as 2733 residents are persons with disabilities. Physical illness or movement disorder is the most common disease among other diseases experienced by persons with disabilities in Indonesia. At present the accessibility needs of persons with disabilities in public buildings such as mosques should have met the needs of persons with disabilities but the reality on the ground shows that there are still minimal accessibility facilities in places of worship, especially mosques. Al-Azizi Mosque which is located in RT. 01 RW. 021 Tanjung Sengkuang Kec. Batu Ampar - Batam is currently still not paying attention to the accessibility of persons with disabilities. The purpose of this study is to design public facilities for Persons with Disabilities at the Al-Azizi Mosque in Batam City using the Axiomatic design (AD) method. The Axiomatic Design (AD) method is carried out by defining the basis for product development/design by providing a mapping technique between the function requirements and design parameters. This method can help so that the design and development of a product is more structured, logical, and focuses on a design that fits the function. It is hoped that with this research a public facility design can be formed that is able to accommodate the needs of disabled mosque users.

Keywords— Axiomatic Design, Design, Disability, Public facilities, Mosques

I. INTRODUCTION

Humans have the ability to adapt, however, not everyone will be able to make good adjustments, especially people with disabilities[1]. According toNoor (2017) the term disability is currently more often used to replace the term persons with disabilities. It is known that out of a total of 7 billion world population in 2021, 15% are persons with disabilities. Of that 15 percent, 80 percent live in developing countries[2]. The number of people with disabilities in Indonesia is estimated at 16.5 million, this data was conveyed by the Minister of Manpower Ida Fauziyah at the G20 Campaign[3]. A total of 2733 residents of the Riau Archipelago are persons with disabilities.[4]. According to Article 10 paragraph 4 of Law No.4 of 1997, persons with disabilities have equal opportunities in all aspects of life through the provision of accessibility[5].

Currently, the need for accessibility for persons with disabilities in public buildings such as mosques should have been met, but the reality on the ground shows that there is still a lack of accessibility facilities in places of worship, especially mosques.[6]. The number of physical ailments or movement disorders is the highest among other diseases experienced by persons with

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disabilities in Indonesia with a total of 65,586 residents.[4].

Al-Azizi Mosque which is located in RT. 01 RW. 021 Tanjung Sengkuang Kec. Batu Ampar - Batam is currently still not paying attention to the accessibility of persons with disabilities. On March 4, 2022 the Al-Azizi mosque received grant assistance from the Riau Islands provincial government. Currently the Al-Azizi mosque is undergoing repairs, for this reason now is the right time to design public facilities that will be developed at the Al-Azizi Mosque to accommodate the needs of persons with disabilities. This research is entitled Designing Public Facilities for Persons with Disabilities at the Al-Azizi Mosque in Batam City using the Axiomatic design (AD) method.

The Axiomatic Design (AD) method is a design tool or method for defining the basis for product/design development by providing a mapping technique between the requirements function and design parameters. This method can help to be more structured, logical, and focus on a design that fits the function[7]. So this research was conducted with the aim of designing/ designing a public facility for persons with disabilities at the Al-Azizi Mosque in Batam City using the Axiomatic Design Method.Based on the problems above, it is necessary to make improvements by designing toilets in the Al-azizi Mosque. The research method utilizes process mapping and the hierarchy of the Axiomatic Design method. Axiomatic Design is a method that has been widely used by researchers and is easy to use in describing designs (Suh, 2003). This method has also been proven to solve many problems both applied to finding a decision or designing a product (Herstein & Milnor, 1953; Luce & Weber, 1986; Liu et al, 2016). Axiomatic Design is a decision-making method which in its completion process is based on consumer needs (Suh, 1998; Lu et al, 2016).

This study aims to design comfortable toilets for users, both normal individuals and persons with disabilities, especially wheelchair users, so that these public facilities can be used comfortably, safely and more easily used independently.

II. RESEARCH METHOD

Data collection was carried out by interviewing members of the AL-Azizi mosque. Related data about the needs and complaints encountered in using mosque toilets. The data obtained is used as a reference in designing product proposals. collecting data by interviewing and distributing questionnaires to respondents. Interviews were conducted if there were several things not listed in the questionnaire to complete the data they had. The data collection process was carried out for one month. Before distributing the questionnaires, field surveys and empirical data were conducted. The customer attributes are also obtained from the design criteria for facilities for wheelchair users based on the Indonesian Minister of Public Works Regulation number 14/PRT/M/2017. The type of questionnaire used is an open questionnaire which gives freedom for respondents to fill in various wishes and expectations for the product to be designed. In addition to customer attributes, Indonesian anthropometric measurement data was also collected. This data was obtained from the Indonesian Ergonomic Association. Voice of Customers that have been collected are then categorized into customer attributes, carried out by elimination by removing/reducing words that have the same meaning or by combining the same categories. Axiomatic design makes consumers the basis for decision making or design (Lu et al, 2016).

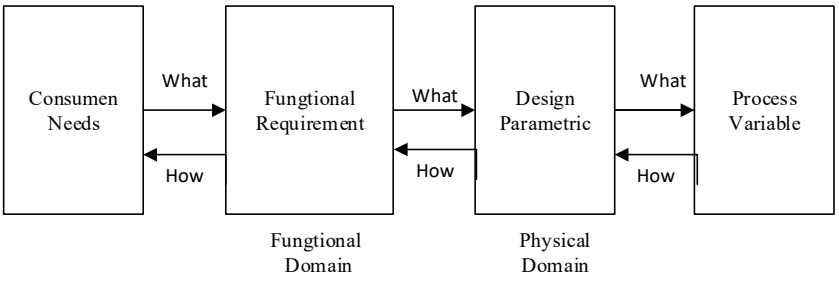

Fig 1. Domain Axiomatic Design

This study focuses on mapping the Axiomatic Design process from four domains, namely: the consumer domain contains a collection of criteria for consumer needs (CN) obtained from the results of data collection; the functional domain contains the abstraction of consumer needs formed into functional requirements (FR); the physical domain contains the design parameters (DP) of the functions (FR) that are formed and interconnected; and the process domain contains the processes that form the DP (PV) (Suh, 1998; Suh, 2003).

In this study, the concept of Axiomatic Design is used as an analytical method to obtain and explain the basic specifications for the design of public facilities for people with disabilities through a domain mapping process. These specifications can be obtained by analyzing the relationship between FR and DP (Suh, 2003).

III. RESULT AND DISCUSSION

Determination of Customer Attributes (CA)

Based on the Voice of customers that have been collected as many as 14 pieces are then categorized into customer attributes. D is done by elimination by removing/reducing words that have the same meaning/meaning and/or by combining them with the same category. Table 1. shows customer attributes

Table1.Customer Attributes

Voice of Customers		**Customer Attributes**
Complaint Category	**Complaint Category**	
Toilets Easily accessible by wheelchair users	Toilets Easily accessible by wheelchair users	Ease of access (Convenient) (CA1)
Easy to use wheelchair in toilet	Spacious room size / eight	
Has a handle facility	There is a handle on the toilet and ablution area	
Wide moving space	Convenient to move	
Safe	Avoid accidents	Safe and has markings/rmbu (CA2)
Signs and markings for persons with disabilities	Equipped with signs and markings	
Have priority access	Equipped with signs	
The distance between faucets in the ablution room is 80 cm – 100 cm with a faucet height of 80 cm – 100 cm (80 cm for wheelchair users)	The height of the faucet is according to anthropometry and standards	Size according to standard (Anthometry) (CA3)
The area of space in the toilet for persons with disabilities is at least 152.5 cm x 227.5 cm taking into account the space for wheelchair users	The size of the room area is according to anthropometry and standards	
Disabled toilet doors basically open to the outside of the toilet and have at least 152.5 cm of free space between the door and the outer surface of the toilet	The size of the door leaf is in accordance with the anthropometry and standards, and leads outwards	
The net width of the toilet door is at least 90 cm for persons with disabilities	Door size according to anthropometry and standards	
The size of the hand sink is at	The size of the sink	

least 45 cm x 60 cm b) The recommended height of the hand sink for wheelchair users is 75 cm	according to anthropometry and standards	
Dimensions of ablution places for persons with disabilities	The size of the ablution place is according to anthropometry and standards	
The water faucet for ablution is easy to reach	The height of the water faucet is according to anthropometry	

Concept Based Axiomatic Design

*Axiomatic designs*describes process design as a mapping of the what and how of the design domain itself (Thompson, 2014). The design concept of public facilities for persons with disabilities based on consumer needs, with the results of the design specifications can be seen in a hierarchical pattern as shown in Fig 1 below.

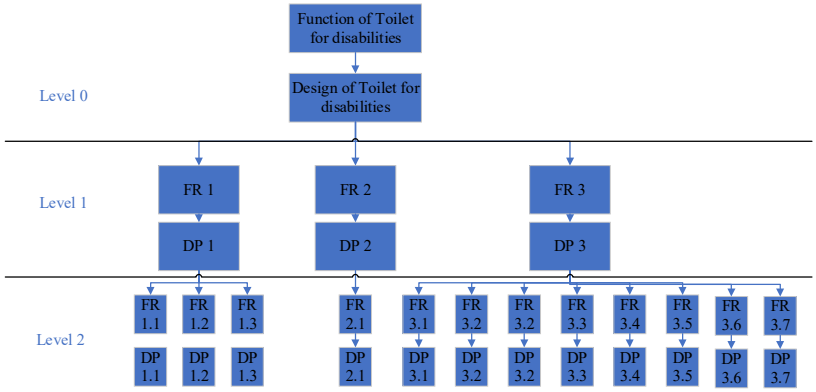

Fig 1.Design Hierarchy Pattern

a. Criteria for ease of access (convenient) to public facilities for disabilities.

Table 2 shows a comparison of FR and DP for the criteria of ease of access (Convenient)

Table2.Design Concept based on Ease of Access Criteria (Convenient)

ca	**CA Code**	***functional*Requirements**	**FR Code**	***Design*Parametric**	**DP Code**	***Process Variables***	**PVCode**
Ease of Access (Convenient)	CA1	Has a flat floor and Handrail	FR 1	Handle design	DP 1		PV 1
		Designing a flat toilet floor, ablution area and sink area without any variation in height	FR 1.1	Flat floor design without slope	DP 1.1	Flat floor	PV 1.1
		Designing handrails	FR 1.2	Hand grip diameter based on maximal grip diameter (5th	DP 1.2	Hand grip diameter = 3.09 cm	PV 1.2

				percentile)			
		Determine where to place the handrails	FR 1.3	Easy to reach, Forehand reach, height from sitting shoulder height + popliteal height (5th percentile)	DP 1.3	Handrail height = sitting shoulder height + popliteal height = 49.19 +36.41 = 85.6	PV 1.3

FR 1 and DP 1 dimensions related to ease of access (comfort) in product use are determined based on user needs and suitability for the required functions. Anthropometric measurements for FR 12 and FR 13 use the 5th percentile with the aim of meeting user needs in the smallest size. DP 12 size with a handle diameter of 3.09 cm. DP 13 with a height measurement for the handle in the toilet which is as much as 85.6 cm. with a length of 35.0 mm and for the DP 13 with a length of 472.7 mm.

b. Safe criteria and has markings/signs

Table 3 shows a comparison of FR and DP for safe criteria and has light markings.

Table 3.Design Concept based on Ease of Access Criteria (Convenient)

ca	**CA Code**	***functional*Requirements**	**FR Code**	***Design*Parametric**	**DP Code**	***Process Variables***	**PVCode**
Ease of Access (Convenient)	CA1	Has markings	FR 2	Signage/marking design	DP 2		PV 2
		Determine the position of the placement of the signs	FR 2.1	The height of the marker placement is eye height + popliteal height (5th percentile)	DP 2.1	Signpost height = sitting eye height + popliteal height = 51.11 + 36.41 = 87.52	PV 2.1

The dimensions of FR 1 and DP 1 are related to safe criteria and have markings/signs in the use of products determined based on user needs and suitability for the required functions. Anthropometric measurements for FR 21 use the 5th percentile with the aim of meeting user needs in the smallest size. The size of DP 21 is 87.52 with consideration of the placement of signs based on the height of the sitting eye + popliteal height, namely: 51.11 + 36.41 = 87.52 cm

c. Standard size criteria (Anthometry)

Table 4 shows a comparison of FR and DP for standard size criteria (anthropometry)

Table 4.Design Concept based on Ease of Access Criteria (Convenient)

ca	**CA Code**	***functional*Requirements**	**FR Code**	***Design*Parametric**	**DP Code**	***Process Variables***	**PV Code**
Standard size (Anthometry)	CA3	Designing the size of the facility room	FR 3	Facility room design	DP 3		PV 3
		Has a faucet height measurement according to	FR 3.1	Sitting shoulder height and popliteal height are used to determine the	DP 3.1	The recommended size according to the government is	PV 3.1

		anthropometry and standards		height of the faucet for ablution using the 5th percentile with the aim that the distance between the faucet and the feet is close to avoid splashing water on the body (Faucet height = Sitting shoulder height + Pop literal height)		between 80-100 cm, based on anthropometry, faucet height = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6	
		Has the size of the room according to anthropometry and standards	FR 3.2	The size of the room has taken into account the space for wheelchair users	DP 3.2	the area of the room based on government regulations is 152.5 x 227.5	PV 3.2
		The size of the door leaf is in accordance with the anthropometry and standards, and leads outwards	FR 3.3	Open the exit direction and have space for wheelchair users	DP 3.3	the distance between the outer surface of the toilet and the door leaf is 152.5 cm according to government regulations	PV 3.3
		Door size according to anthropometry and standards	FR 3.4	Door size for wheelchair entry (based on the width of the wheelchair)	DP 3.4	minimum door width of 90 cm	PV 3.4
		The size of the sink according to anthropometry and standards	FR 3.5	Sink height based on elbow height in sitting position + popliteal height + handwashing depth (5th percentile)	DP 3.5	The size of the sink is 45 x 60 height of the sink = elbow height in a sitting position + popliteal height + proper depth of hand washing = 36.41 + 30.19 + 9 = 75.6 cm	PV 3.5
		The size of the ablution place is according to anthropometry and standards	FR 3.6	Size according to standard	DP 3.6	The minimum width of the faucet drain is 30 cm, the height of the faucet = The size recommended by the government is between 80-100	PV 4.6

						cm, based on anthropometry, the height of the faucet = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6 , Handle height hands for ablution = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6	
		The height of handrails for toilets is in accordance with anthropometry	FR 3.7	Easily accessible, handrails on toilet = popliteal height + elbow height (5th percentile)	DP 3.7	Easy to reach, handrails on toilet = popliteal height + elbow height = 36.41+30.19 = 66.6 cm	PV 43.7

Proposal draft

From the results of the mapping and decomposition that have been determined then the attributes that are in the design are determined.

Table 5. Mapping results and decomposition

No	*Customer Attributes*	*Attribute*/Design criteria
1	Ease of Access (Convenient)	Flat floor
		Hand grip diameter = 3.09 cm
		Handrail height = sitting shoulder height + popliteal height = 49.19 +36.41 = 85.6
2	Has markings	Signpost height = sitting eye height + popliteal height = 51.11 + 36.41 = 87.52
3	Standard size (Anthometry)	The recommended size according to the government is between 80-100 cm, based on anthropometry, faucet height = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6
		the area of the room based on government regulations is 152.5 x 227.5
		the distance between the outer surface of the toilet and the door leaf is 152.5 cm based on government regulations
		minimum door width of 90 cm
		The size of the sink is 45 x 60 height of the sink = elbow height in a sitting position + popliteal height + proper depth of hand washing = 36.41 + 30.19 + 9 = 75.6 cm

		The minimum width of the faucet drain is 30 cm, the height of the faucet = The size recommended by the government is between 80-100 cm, based on anthropometry, the height of the faucet = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6 , Handle height hands for ablution = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6
		Easy to reach, handrails on toilet = popliteal height + elbow height = 36.41+30.19 = 66.6 cm

The design of public facilities for persons with disabilities is based on an analysis using the Axiomatic Design method, the following design results are obtained:

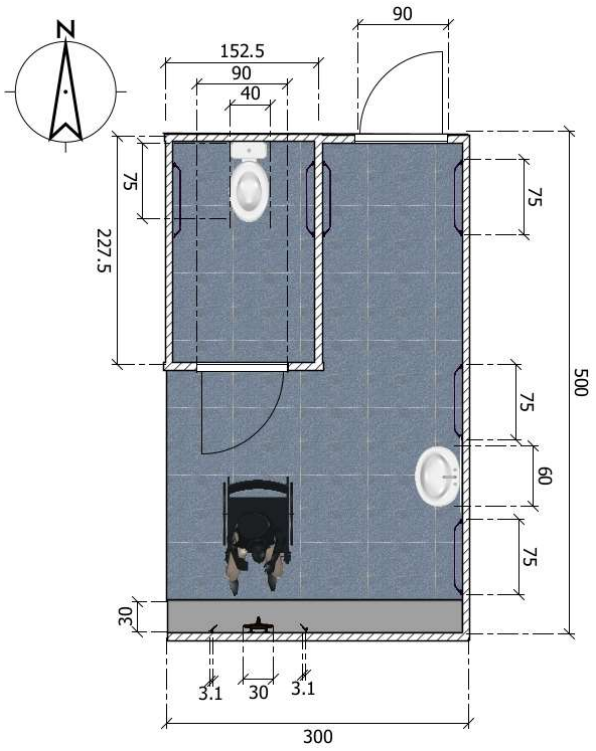

Figure 4.1 2D Public Facilities Design

Figure 4.23D Facility Design looks Isometric

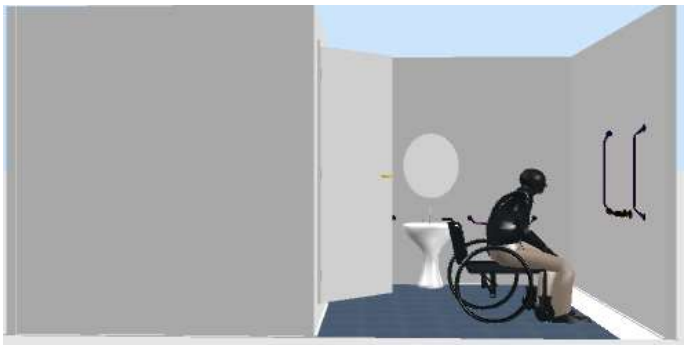

Figure 4.33D Facility Design side view near ablution area

Figure 4.4 3D Facility design side view near washing hands

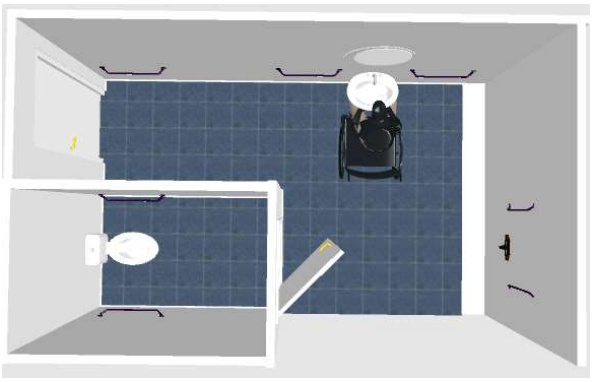

Figure 4.5 Facility Design top view

Design Evaluation

Evaluation is done by seeing whether the design that has been formed is in accordance with predetermined criteria or attributes.

Table 6 Design Evaluation Results

No	*Customer Attributes*	*Attribute*/Design criteria	Conclusi
1	Ease of Access (Convenient)	Flat floor	Fulfilled
		Hand grip diameter = 3.09 cm	Fulfilled
		Handrail height = sitting shoulder height + popliteal height = 49.19 +36.41 = 85.6	Fulfilled
2	Has markings	Signpost height = sitting eye height + popliteal height = 51.11 + 36.41 = 87.52	Fulfilled
3	Standard size (Anthometry)	The recommended size according to the government is between 80-100 cm, based on anthropometry, faucet height = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6	Fulfilled
		the area of the room based on government regulations is 152.5 x 227.5	Fulfilled
		the distance between the outer surface of the toilet and the door leaf is 152.5 cm according to government regulations	Fulfilled
		minimum door width of 90 cm	Fulfilled
		The size of the sink is 45 x 60 height of the sink = elbow height in a sitting position + popliteal height + proper depth of hand washing = 36.41 + 30.19 + 9 = 75.6 cm	Fulfilled
		The minimum width of the faucet drain is 30 cm, the height of the faucet = The size recommended by the government is between 80-100 cm, based on anthropometry, the height of the faucet = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6 , Handle height hands for ablution = sitting shoulder height + popliteal height = 49.19 + 36.41 = 85.6	Fulfilled
		Easy to reach, handrails on toilet = popliteal height + elbow height = 36.41+30.19 = 66.6 cm	Fulfilled

IV. CONCLUSIONS

Based on the results of the research, it can be found that based on the research, there are 3 customer attributes, namely: Ease of Access (Convenient), Has markings/signs, Size according to standards (Anthometry). From the decomposition results obtained 11 design attributes. It is advisable for future research to also consider the cost factor in the design of public facilities for persons with disabilities and not only use the axiometric design method

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