



Evaluation Characteristics of Pedestrian Pathway in Coastal Area

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Abstract. Research on pedestrian pathways in coastal areas is related to facilities provided and access in the area. The characteristic of coastal area is influenced by access to different types of surface material and seawater. Therefore, pedestrian pathway in this area has to focus on resistance design, safety, and environment-friendly facility available. This research aims to evaluate the characteristics of pedestrian pathways in coastal areas. The method used is a field study on coastal areas in the city of Manado, Indonesia. Data is gathered through photos and videos and compiled with computer program design AutoCAD. The result shows that the characteristics of coastal areas vary with different materials, pedestrian pathway availability, and the influence of seawater on the condition of the facility provided. Further research on coastal areas could be developed into a complex design for tourism areas supported by information technology and the influence of local culture.

Keywords. Pedestrian, coastal area, beach, seawater, pathway, Manado

1. Introduction

The pedestrian pathway is the infrastructure facility for users' safe and comfortable access. In coastal area pedestrian pathway is important to connect access to and from the beach area. Coastal area consists of different type of beach material and different level of land. The coastal area in the city of Manado as a study area is an area with high activity including business and tourism area. This research aims to evaluate coastal areas and their pedestrian facility based on characteristics of beach ground material. The method used is field study and computer laboratory study. Drawing programs such as AutoCAD are used to test design and construction alternatives for the coastal area. The study area includes Mega Mas Area, God Bless Park, and Malalayang Beachwalk Area as can be seen in Fig. 1.

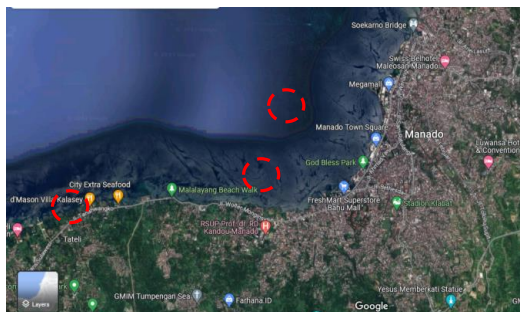


Fig. 1. Manado Coastal as Study area (Google Map, 2023)

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2. Literature Study

The pedestrian pathway needs to be safe and comfortable such as in housing area criteria including accessible distance [1]. Comfortable pedestrian areas should have easy communication and support activity, and the location can be accessed. In addition, principles such as connection and cleanliness should be available for pedestrian networks [1]. Pedestrian pathways should fulfill the needs of users including their activities and facilities [2, 3, 4, 5, 6, 7, 8, 9]

Development material seawater resistance for example is the test for its impact on concrete in which seawater has the most impact on carotin from the natural environment [10]. Carotin behavior in seawater includes variables of composition, pH, temperature, speed, microorganisms, and biofouling [10]. The use of 100% seawater and 20% tires on concrete as a replacement for aggregate results in the reduced strength of concrete up to 65% [11].

Local materials such as seawater and sand can be developed due to limited materials [12]. The impact on seawater for physic and mechanic properties where it can reduce the level of kinetic hydration and heat of macrostructure alchemy active slag powder [12].

The test of using paving blocks on pedestrian pathways has been conducted concerning colorful and recycled plastic on children's pedestrian pathways [7], [13].

The city of Manado coastal area exists along the city on the seaside from the north to the west south of the city. The type of coastal area is varied based on recent conditions.

3. Result and Discussion

The characteristics of coastal areas include pedestrian pathways from many sources including the type of beach material, impact of seawater, facility available, and material use. The characteristic can be seen in Table I.

TABLE I. CHARACTERISTICS OF THE COASTAL AREA

Characteristic	Source
White sand beach from marine animal	[14]
Sediment sources, color, size, and sorting on the beach	[15]
Beach sediments cliff erosion, rivers, glaciers, volcanoes, coral reefs, sea shells, the Holocene rise in sea level, and the cannibalization of ancient coastal deposits.	[15]







Heavy-mineral sands are deposits of heavy minerals hosted by sediments of sand, silt, and clay in coastal environments.	[16]
Beach material is mainly volcanic rocks, barite, and polymetallic deposits.	[16]
Beach sand, mud or pebbles	[17]
Seawater is a corrosive environment that affects infrastructure in polluted seawater.	[18]
Evacuation shelter for pedestrian	[19]
Walking and pedestrian spaces, the architectural side, and psychological aspects	[20]
Coastal zones increase climate change and sea-level rise, flooding and marine erosion	[21]
Corrosion of reinforcement due to seawater and avoid using corrosion inhibitor and/or corrosion-resistant reinforcement	[22]
The durability of seawater sea-sand concrete (SWSSC) and the corrosion resistance of embedded steel be improved with supplementary cementitious materials.	[23]
The reduction in strength increases with an increase in exposure time, caused by salt crystallization formation	[24]
Coral as an alternative to natural aggregates in marine structures	[25]

The type of coastal area includes sand beach, stones original and stone from other places, white sands and corals, revitalization with concrete on site, concrete block, and paving block. Types of facilities include bike station places, fences, plants, chairs, borders, lights, and information boards. Types of damage include corrosion on metal and steel, broken wood, broken stone, broken concrete, broken ceramics, broken paving stone, leak drainage

The types of beaches in the Manado coastal area are varied. The most common type is a black sand beach. The original type of beach ground material has been replaced due to the development of the area including reclamation of the beach. Material is replaced with black small stones, black large stones, and manmade material of bed concrete and a small block of concrete. White sands have also been filled in some parts of the area including the private beach and area to the southern part of the resort and can be found in the Meras and Bunaken area of Manado. This type of sand mostly exists in the northern part of Manado including the Likupang area.

The black sand beach area in many parts of Manado has been filled with garbage including rubber from car wheels and household rubbish. In the Mega Mas area, there are bins available to protect the area from unorganized rubbish. The type of beach can be seen in Table II.

TABLE II. TYPE OF BEACH

Type	Picture
Black sands Location Boulevard 2 Manado	
Black Rock Natural existing and from other coastal areas, Manmade rock Location Mega Mas Manado	
Black sand and rock Location Boulevard 2	
Concrete Location Manado Town Square	
Big black rock, Concrete, and reinforced Location Bahu Mall	
Type White sand and corals Location Meras	Picture 

Black rock and sand Location Malalayang Beach Walk	
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The type of beach in Manado and its surrounding area can be classified as the area of black sands with or without rocks and the area of white sands and corals. The area can be seen in Fig. 2.





Fig. 2. Type of beach in Manado and its surrounding area

Infrastructure available for access in the coastal area supports the access and facility for pedestrians and users. There are pedestrian pathways along the left and right sides of the road, access through the street available, bed planting, grass, wall border and bollard, and shelter for visitors. The type of infrastructure can be seen in Table III.




TABLE III. TYPE OF INFRASTRUCTURE

Infrastructure	Picture
Road, Pedestrian pathway, grass and trees (Mega Mas Area)	
Shelter, Grass, Pedestrian pathway, fence, road (Mega Mas Area)	
Pedestrian pathway, plant bed, bollard (Mega Mas Area)	

Infrastructure	Picture
Trees, wall as border, pedestrian pathway, street market, grass/plants, road edge line (Boulevard 2)	
Wall as border to the beach, pedestrian pathway, plants along the road, edge road line	

The type of pedestrian pathway is available in different materials such as concrete, stones, and paving blocks. Line as guidance for blind people available along the boulevard. The type of pathway be seen in Table IV.





TABLE IV. TYPE OF PATHWAY




Type	Picture
Soil and grass (Boulevard 2)	
Paving block (Boulevard 2)	
Pedestrian pathway as access to the facility, stone ball as street art (God Bless Park)	

Pedestrian pathway with Bollard, Wall disabled line, and, street light (Boulevard)	
Pedestrian pathway with color paving (God Bless Park)	

The type of damage in the coastal area is influenced by seawater with the impact of carotin on steel material and concrete with steel. The carotin can be seen on the floor, wall, and column of the facility. On the floor, the damage of seawater causes of broken floor and is unsafe for users. Another damage is the uneven paving block on the pathway. Sand-based paving block is moved to the side due to many causes such as uneven paving and joint area with different material of paving and concrete. With the result of the survey, the type of damage can be seen in Table V.


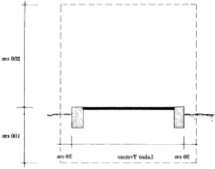
TABLE V. TYPE OF DAMAGE


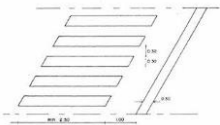





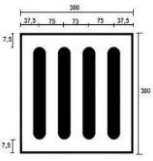
Type	Picture
Carotin on concrete Damage by seawater	
Join different types of paving blocks to create uneven surfaces and sand-based remove	
Carotin on a Building made of steel	
Broken floor surface with reinforced concrete.	

<p>Carotin and broken column</p>	
<p>Broken join wood stair handle and carotin on steel material</p>	
<p>Carotin on steel chain for boundary area.</p>	
<p>Broken join for utility facility</p>	

The condition of the pathway along Boulevard or Piere Tendeau Street from God Bless Park to Mega Mas area with 2,7 km has a variety of widths 2 to 8 meters wide and 30 to 40 cm high. Facilities available are a crossing area, traffic symbol, and lighting. Based on the standard available the existing condition can be seen in the table below.

TABLE VI. EVALUATION BASED ON STANDARD

Existing	Standard
<p>Pedestrian pathway</p>  <p>The size of the pedestrian has fulfilled standard yet poor maintenance of the area with rubbish along the area</p>	<p>Pedestrian standard [26]</p>  <p>The height space of a pedestrian minimum of 2.5 meters, a depth minimum of 1 meter, and a side space minimum of 0.3 meters.</p>
<p>Crossing facility</p>	<p>Standard [26], [27], zebra cross is a facility for pedestrians with clear signs. Guidance of pedestrian facilities in urban areas</p>




 <p>The Zebra cross paint has an unclear color.</p>	
 <p>Traffic symbol is available yet the rider uses the area to park their motorcycle.</p>	<p>Guidance [26]. The facility for pedestrian guidance includes available traffic symbols that can be seen clearly, and strongly during the day and at night.</p> 
<p>Street Lighting</p>  <p>Lighting is available with adequate distance and height.</p>	<p>Lighting should be available every 10 meters with a maximum height of 4 meters.[28]</p> 
<p>Disable line</p>  <p>Available disability line for blind people</p>	<p>Standard by Ministry of Public Works [28] Disability lines consist of block lines as guidance.</p> 

Based on the survey the number of visitors is 274 and 403 people on Monday, 227 and 254 people on Thursday, and 600 and 648 people on Saturday from 4 to 7 pm. In the area of business and pleasure, the number of pedestrians walking on Saturday is the highest compared to other days.

The characteristics of pedestrians can be divided into male, female, physical condition, and body shape. The number of pedestrians is 1276 and 1131 with male and female respectively. There are 10 disabled people 5 male and 5 female. The age of pedestrians is between 12 to 45 years old.

In comparison, surveys on other coastal areas with good design approaches particularly for business and tourism areas show the development of the area with users' consideration and environmentally friendly. Coastal areas such as Sanur, Bali, and Clarke Quay, Singapore based on surveys show various facilities for pedestrians and other users such as bikers to move more easily and safely. The evaluation of the design approach can be seen in Table VI.

TABLE VII. EXAMPLE OF PEDESTRIAN AREA FOR PROPOSE DESIGN

Picture	Evaluation
 <p data-bbox="268 728 577 751">Pedestrian area at Sanur Beach Bali</p>	<p data-bbox="618 469 946 583">Segregate pedestrians and bikers. Available sign and clear area with plants and ground material. It has direct access to be beach in the public area.</p>
 <p data-bbox="268 1001 498 1024">Merlion area in Singapore.</p>	<p data-bbox="618 772 946 839">Available access for pedestrians to the water and sightseeing, available sign for users</p>
 <p data-bbox="268 1213 533 1236">Area in Clark Quay, Singapore</p>	<p data-bbox="618 1030 946 1166">Segregate access for pedestrians to the bridge and to walk along the river with clear facilities for walking including ground material, plant bedding, and trees. Public facilities are available in this area.</p>

A section of the pedestrian pathway at Boulevard Manado can be seen in Fig 2.

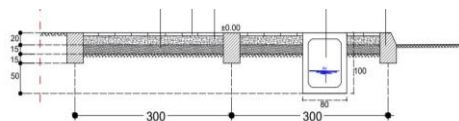


Fig. 3. Section of the pedestrian pathway

Based on the characteristics of pedestrian pathways in coastal areas, the design proposed for the area should consider the material used is protected from seawater, pedestrian access is easy and safe and facility is available. The design proposed can be seen in Fig 3.

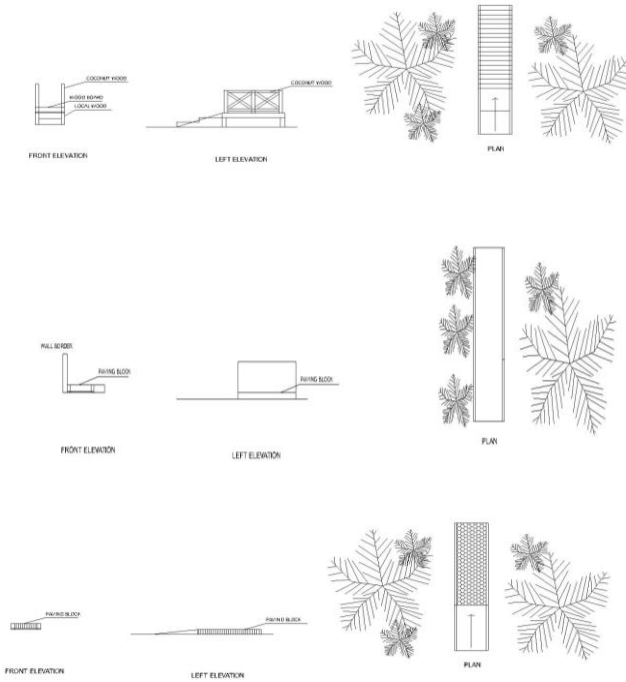


Fig. 4. The design proposed pedestrian pathway in the coastal area

4. CONCLUSION

Based on the evaluation of coastal areas, the characteristics of the pedestrian pathway include the type of beach ground material, the impact of seawater on the pedestrian facility, and the type of pedestrian facility for the area. The proposed planning approach is evaluated to improve the quality of access and facility for the pedestrian pathways in the coastal areas. Further research on pedestrian pathways needs to consider the complex area with the technology of information.

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References

- [1] Badan Standarisasi Nasional (BSN): SNI 03-1733-2004 *Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan*, (2004).
- [2] Makalew, F.P., Adisasmita S.A., Wunas S., Hamid S.: Influence of Children Pedestrian Behaviour on Pedestrian Space Usage, IOP Conf. Ser.: Mater. Sci. Eng. 2017, 271 012028, (2017).
- [3] Makalew, Febriane Paulina., Adisasmita, Sakti Adji., Wunas. Shirly and Aly, Sumarni Hamid.: Pedestrian Space Capacity and Movement Pattern for Elementary Students in Urban And Rural Area, International Journal of Geomate Vol.15 Issue 50, pp. 63 – 69, (2018).
- [4] Makalew, F.: Child Pedestrian Friendly Design Principle for the Settlement and Housing area, IOP Conference Series: Earth and Environmental Science 328 (1) (2019), 012018 Scopus, P (2019).
- [5] Makalew, F.P., Adisasmita, S.A., Wunas, Shirly dan Aly, S.H.: Influence of elementary students walking speed to children pedestrian pathway planning. IOP Conf. Series: Earth and Environmental Science IOP Publishing 419 (2020) 012096 Scopus doi:10.1088/1755-1315/419/1/012096 1, (2020).
- [6] Makalew, F. P., Supit S W M and Senduk, N.: Design Concept for Child Pedestrian-Friendly Prototype, 5th International Symposium on Infrastructure Development ISID, (2020).
- [7] Makalew, Febriane Paulina, Supit, Steve Wilben Macquarie dan Senduk, Novatus.: Construction System of Building Block for Child Pedestrian-Friendly Prototype, 3rd International Conference on Applied Science and Technology ICAST, (2020).
- [8] Makalew, Febriane Paulina., Wala, Mycle., Tombeg, Beldy., Mait, Rudolf.: Design and Construction of Pedestrian Pathway on Tourism Area Based on Local Wisdom Approach, 5th International Conference on Applied Science and Technology ICAST, (2022).
- [9] Makalew, Febriane Paulina., Runtunuwu, Sherley., Waney, Estrellita Varina Yanti and Supit, Steve Wilben Macquarie.: Characteristic of Shelter for Child Pedestrian, In Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021), pages 913-921 SCITEPRESS – Science and Technology, (2023).
- [10] Phull, B.: Shreir's Corrosion, <https://www.sciencedirect.com/science/article/pii/B9780444527875000469>, (2010).
- [11] Hamid, Salma., Naji, Khalid., Younis, Adel, dan Ebead, Usama.: Material performance and cost-effectiveness of seawater-mixed rubberized concrete, Case Studies in Construction Materials 15 (2021) e00735, (2023).
- [12] Zhao, Jihui., Long, Binqi, Yang, Gangqiang. Cheng, Zirui, Liu, Qiang.: Characteristics of alkali-activated slag powder mixing with seawater: Workability, hydration reaction kinetics, and mechanism, Case Studies in Construction Materials 17 (2022) e01381, (2022).
- [13] Supit, S.W. M. dan Makalew, F. (2019), Effects of Micro- and Ultrafine Metakaolin on Compressive Strength and Water Sorptivity of High Volume Fly Ash Concrete, AWAM International Conference on Civil Engineering AICCE 2019, Lecture Notes in Civil Engineering book series (LNCE, volume 53) Proceedings of AICCE'19 pp 415-427
- [14] Rampe, Meytij Jeanne., Lombok, Johny Zeth., Tiwow, Vistarani Arini., Tengker, Soenandar Milian Tompunu, and Bua, Jeniver, (2022). Characterization Of Silica (SiO₂) Based On Beach Sand From Sulawesi And Sumatra As Silicon Carbide (SiC) Base Material, Journal of Chemical Technology and Metallurgy, 58, 3, 2023, 467-476
- [15] Trenhaile, A.S. (2005). Beach Sediment Characteristics. In: Schwartz, M.L. (eds) *Encyclopedia of Coastal Science*. Encyclopedia of Earth Science Series. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3880-1_41
- [16] Anastasatou, Marianthi., Stamatakis, Michael, and Karageorgis, Aristomenis P. (2019). Mineralogy and geochemistry of beach black sands along the coastline of Milos and SW Kimolos Islands, Greece. Conference 15th Biennial Meeting of the Society for Geology Applied to Mineral Deposits Glasgow, UK

- [17] World Health Organization – WHO (2021), Guidelines on Recreational Water Quality: Volume 1 Coastal and Fresh Waters Geneva
- [18] Valdez, Benjamin., Ramirez, Jorge., Eliezer, Amir., Schoor, Michael., Ramos, Rogelio., and Salinas, Ricardo (2016), Corrosion Assessment of Infrastructure Assets in Coastal Seas, *Journal of Marine Engineering & Technology* Volume 15, 2016 - Issue 3
- [19] Kim, Jung Ok and Lee, Jae Kang (2018), A Study on Temporary Shelter Areas Using Pedestrian Networks in Coastal Cities, *Journal of Coastal Research*, Special Issue No. 91:Proceedings of The 3rd International Water Safety Symposium IWSS 2018 (SUMMER 2019), pp. 421-425, Coastal Education & Research Foundation, Inc
- [20] Burilo, N., Kruglikova, A., Tsyba, A., Makarikhina, I. & Volikova, A. (2023), Comprehensive Analysis of Pedestrian and Walking Spaces of Cities (Including Coastal Areas) ICCATS 2022: Proceedings of the 6th International Conference on Construction, Architecture and Technosphere Safety pp 406–414, Lecture Notes in Civil Engineering book series (LNCE, volume 308)
- [21] Rocle, Nicolas., Rey-Valette, Helena., Bertrand, François., Becu, Nicolas., Long, Natalie., Bazart, Cecile., Vye, Didier., Meur-Ferec, Chatherine., Beck, Elise., Amalric, Marion and Lautredou-Audouy, Nicole (2020), *Paving The Way To Coastal Adaptation Pathways: An Interdisciplinary Approach Based On Territorial Archetypes*, *Environmental Science & Policy Volume 110*, August 2020, Pages 34-45
- [22] Mangi, S.A., Makhija, A., Raza, M.S. *et al.* A Comprehensive Review on Effects of Seawater on Engineering Properties of Concrete. *Silicon* 13, 4519–4526 (2021). <https://doi.org/10.1007/s12633-020-00724-7>
- [23] Vafaei, D., X. Ma, R. Hassanli & Y. Zhuge (2020) Effects of Seawater and Sea-Sand on Concrete Properties: A Review Paper, Lecture Notes in Civil Engineering book series (LNCE, volume 101)
- [24] Wegian, Falah M. (2010) Effect of seawater for mixing and curing on structural concrete, *The IES Journal Part A: Civil & Structural Engineering*, 3:4, 235-243, DOI: [10.1080/19373260.2010.521048](https://doi.org/10.1080/19373260.2010.521048)
- [25] Jiang, J., Yang, H., Deng, Z. *et al.* Damage-constitutive model for seawater coral concrete using different stirrup confinements subjected to axial loading. *Front. Struct. Civ. Eng.* 17, 429–447 (2023). <https://doi.org/10.1007/s11709-022-0913-2>
- [26] Ditjen Bina Marga. (1999). Pedoman Teknik, Pedoman Perencanaan Jalur Pejalan Kaki Pada Jalan Umum, Departemen Pekerjaan Umum, Jakarta
- [27] Badan Standarisasi Nasional (BSN). 1991. SNI 03-2443-1991 Trotoar
- [28] Ministry of Public Works No. 30/PRT/M/2006 , Pedoman Teknis Fasilitas dan Aksesibilitas Pada Bangunan Gedung Dan Lingkungan, Technical Guidance Facility and Accessibility of Building and Environment

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