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Accessibility and Permeability in Transit Area. Case Studies in Jakarta-Depok Train Stations

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Abstract: Public transportation, especial trains, is widely used by the community as a means of transportation and, generally, people walk as a part of using public transportation modes. The existence of pedestrian space is important as a connector between modes of transportation or destinations. This writing discusses the effect of space accessibility and permeability in the mobility of train stations. Space accessibility and permeability are the convenience and continuity of space equipped with its facilities. This is related to the ability of the environment to present a pedestrian-friendly environment known as walkability. Walkability accommodates its environment with several aspects considered in environmental factors.

Keywords: Pedestrian, Space, Station, Walkability

1. Introduction

According to Burgees, R., and Jenks, M., the dense population of cities can be handled by readjusting the spatial structure of urban spatial development, by making cities compact, and applying the concept of accessibility, so that city dwellers have easy access¹). Accessibility is formed from the shape of the city, the city already exists, it was not built from scratch, so it needs adjustment²). Land ownership regulations, transportation and communication methods largely influence the shape and density of the environment³). This is implemented in pedestrian movement and public transportation to various facilities or places. The space can be a public space, an office, or a house, the hustle and bustle of using public spaces can be supported by urban furniture in the space. They tend to be open, without boundaries to form a common public space⁴). Residual space in public spaces with high density allows the formation of new public spaces⁵). Stations become public spaces with needs supported by facilities and one of the transit points because of the use of the train as one of the transportation that is widely used by the city community. Transport enables urban shaping by spatial development and at the same time, land use planning processes can have an impact on individual mobility⁶). Its presence close to government buildings, social facilities, settlements, and commercial areas makes the station area strategic in providing space for movement with easy access. Continuity between users and public transportation is reached by walking, so it is necessary to pay attention to the existence of pedestrian space.

The existence of roads and spaces is a factor that affects the mobility of its users. In its application, a concept that adapts to its environment is needed, access is one of the important roles of permeability, that access is limited by the existence of a public-private role, both physically and visually⁷). The purpose of this paper is to understand the effect of accessibility and permeability in the station area related to the presence of pedestrian space and facilities in the area on pedestrian mobility. The scope of the discussion starts from pedestrians as one of the pedestrian spaces, then looks at the relationship with the environment to find out the application of pedestrian movement space design by providing accessibility and permeability which is formed from the walkability of the area, to know the effect on pedestrian mobility. They need to have sidewalks to provide a sense of safety and comfort for pedestrians⁸), who have easy access on through roads for road users such as commuters who rely on moving by foot.

2. Pedestrian and Facilities in The Transit Area

To make it easier for urban communities to reach their destinations and have access to public transportation, a transit area has been developed which can be a meeting point between these modes of transportation. Pedestrian, cyclist-friendly movement and networks connecting local lines to various destinations⁸) and transit stations are referred to as transit development⁹). The development of the transit-oriented area is known as Transit-Oriented Development (TOD). TOD has a variety of land functions such as residential, trade, services, offices, open spaces,

and public spaces in the environment, as well as making the environment pedestrian-friendly (walkable) making it easier for users to travel by foot, bicycle, or public transportation modes¹⁰.

A friendly public transportation-based movement system is a system where people can quickly and easily switch between modes of movement. Where possible, the system provides 'access to access'. The central points of these higher access zones serve as transportation exchange points. This place is a place where transportation modes are integrated with the use of various combinations of transportation modes¹¹. Regarding environmental infrastructure, pedestrian facilities are a supporting factor, with the presence of opportunities provided by the environment, pedestrians can walk on the sidewalk and cross at the crossing that has been provided¹¹, to protect it in traffic and provide direct access to the destination¹². There are pedestrian facilities that support walking activities¹³, these facilities are (I) pedestrian paths, such as (1) sidewalks; (2) crossings, which include pedestrian bridges, zebra crossings, pelican crossings, and tunnels; (3) non-sidewalks and (II) complementary pedestrian paths, such as: (1) waiting stalls; (2) signs; (3) markers; (4) traffic lights; (5) complementary buildings, as well as other complements, including green lines, lighting, seats, and safety fences¹⁴. Pedestrian bridge as pedestrian circulation which gives accessibility of their path¹⁵. Pedestrians will use pedestrian bridges to get a sense of security, provided that the distance traveled has a significant distance¹⁶. The sense of safety that pedestrians get is not only through the existing facilities on the pedestrian but the presence of other road users can provide a sense of safety for pedestrians¹⁷. Walking is one of the transportation that does not cost money and is environmentally friendly¹⁸. Some Indonesians choose to walk instead of using bicycles or traditional transportation such as tricycles and wagons as their non-motorized transportation¹¹. City dwellers love high accessibility in the center of public facilities¹⁹. In this regard, walkability aspects are introduced as one of the indicators for the development of pedestrian paths in the city. Aspects of walkability make an area a pedestrian-friendly environment. Walkability can also be used as a measure of the quality and connectivity of pedestrian paths in urban areas¹¹.

Table 1. Aspect to evaluate the condition of walkability

Attributes / Facilities	Aspect
<ul style="list-style-type: none"> • Sidewalk • Crosswalk • Barrier 	Elevation
<ul style="list-style-type: none"> • Crosswalk • Sidewalk 	Dimension
<ul style="list-style-type: none"> • Signage / Mark • Street tree & Shade roof • Street Furniture (trash cans, chairs, public telephones) • Street Lighting 	Obstacle
<ul style="list-style-type: none"> • Street tree & Shade roof 	Thermal Comfort
<ul style="list-style-type: none"> • Street Furniture (trash cans, chairs, public telephones) • Barrier • Street Lighting 	Safety & Convenience
<ul style="list-style-type: none"> • Signage / Mark 	Equipment

Source : Reprocessed from Caetano, F. et al. 2021²⁰.

The pedestrian facilities/attributes that exist in the walkability aspects make the environment walkable²¹. Walkable pedestrians are not only from pedestrian support facilities that make the environment walkable, but an environment that can provide a sense of security for road users. This security can be accepted with active road conditions, in addition to increasing activity on the road, it also provides natural surveillance for road users¹⁷. Distance can affect the risk experienced both age and gender²². The atmosphere of the room can be changed by adding or changing the visuals of the user's vision²³. A pedestrian-friendly environment comes with environmental accessibility and permeability. The concepts of accessibility and permeability are not easily defined, accessibility reflects an easily accessible range using a mode of transport or a combination of transport²⁴, while permeability means the ability to pass particles by penetrating them both physically and visual⁷. Pedestrian satisfaction from various built environmental factors around the station that will facilitate their access to public transport is defined as walking accessibility and permeability, the choice of continuous access, and the extent to which an urban area allows the movement of people by foot or bicycle²⁵. High pedestrian movement should be balanced with the availability of adequate facilities and infrastructure, this was created to create a walkable pedestrian path by providing environmental factors such as; comfort, safety, and friendliness for pedestrians¹².

3. Pedestrian and Facilities of The Study Area

This writing method is a study of literary studies with the theory used sourced from books and journals as well as conducting field surveys (case studies), with a discussion of the accessibility and permeability of space and pedestrian facilities to their mobility with walkability aspects. Space and its facilities are evaluated by fulfilling the walkability aspects to see the categories of accessibility and permeability, these categories affect pedestrian mobility. The discussion is processed and presented in the form of diagrams, tables, and narratives.

The case studies were carried out in Depok Baru Station, Pondok Cina Station, and Lenteng Agung Station, these three areas as a comparison between stations. The selection of the area is based on the suitability of the characteristics and differences in the function of the area at the three stations. Data were collected through observation and documentation in the form of photos, maps, and writings. The data collection time period is divided into 2 different periods, namely on weekdays and weekends. The first period is at 05.00 – 09.00 (Indonesia local time) and the second period is at 16.00 – 19.00 (Indonesia local time). The selection of time periods is based on activities that are classified as busy by adjusting the high-density currents that occur at stations and the difference in the majority of destinations on weekends. From the analysis of the observations made, it can be used to determine the effect of accessibility and permeability on pedestrian mobility in the station area.

The first observation location is the Depok Baru Station area, this location is in Pancoran Mas District, Depok City. In this case study, the areas to be observed are the two station gates up to the point of road-based public transportation. The station's west exit has a reach to a road-based transport point of less than 100m. To get to that point there is space for movement in the form of a sidewalk that can be used by pedestrians. There are other road-based transportation points on either side of the station.

3.1 Depok Baru Station



Fig. 1: First location of the case studies (Source : Self-created)

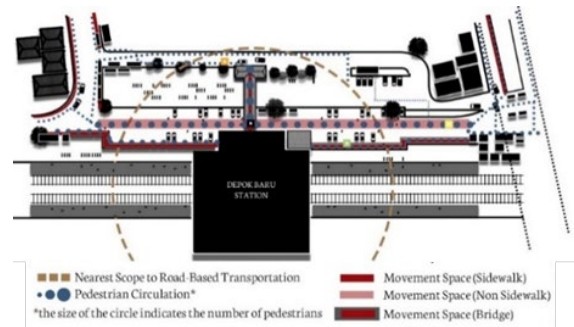


Fig. 2: The block plan of the west exit of Depok Baru Station (Source : Self-created)

Each lane has space for movement in the form of sidewalks and non-pavements with a different number of pedestrians. To see a comparison of the accessibility and permeability of space/path, it is seen from the perspective of 4 different spaces. These spaces/paths are evaluated by looking at the presence of attributes/facilities, then seeing how many aspects of walkability can be met (Table 1 & Table 2).

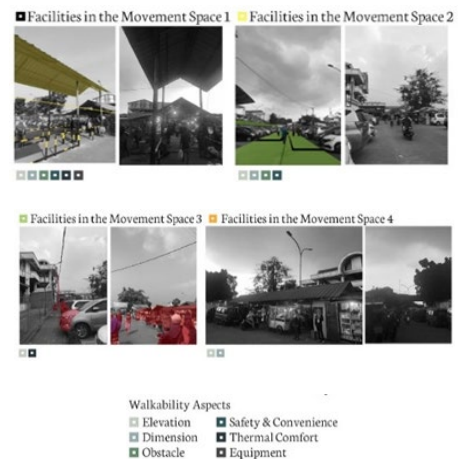


Fig. 3: Analysis of the West Exit of Depok Baru Station (Source : Self-created)

The spaces are divided into 4 as in the picture above. Spaces 1 and 2 are spaces for movement with many users, apart from being accessible to and from the station, these spaces have pretty good accessibility and permeability so that they support the use of space. This support can be seen from the availability of facilities available in these spaces. Available facilities such as a shaded roof in space 1 help facilitate pedestrian passage by protecting it from direct sunlight or rain. Facilities in space 2 such as pedestrian paths which have dimensions that are wide enough so that they can meet the walkability aspect (dimension). Pedestrian facilities as an attribute of the walkability aspect (Table 1), help provide accessibility and permeability of pedestrian space. Meanwhile, spaces 3 and 4 are not widely used by the pedestrian, even though these spaces have facilities for movement such as sidewalks and shaded roofs. This is due to the lack of accessibility and permeability of the 3rd and 4th movement space (only fulfills 2 aspects of walkability).

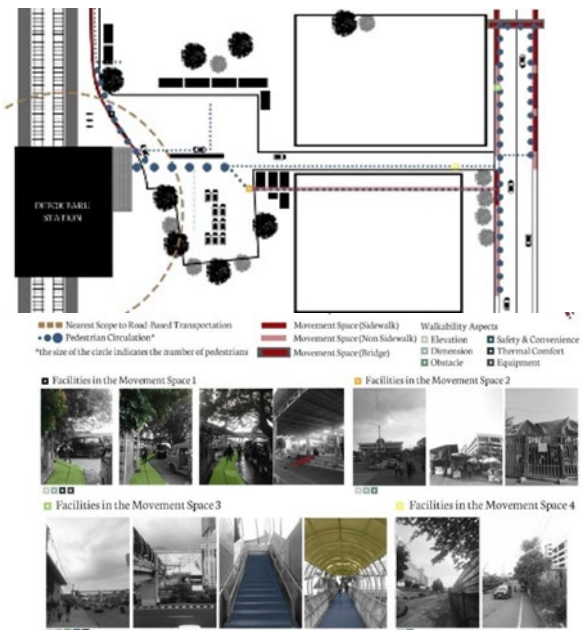


Fig. 4: Analysis of the east door of Depok Baru Station (Source : Self-created)

The same thing was also done at the east exit of Depok Baru Station. This door is directly connected to Depok Terminal, small and large scale transportation is at the terminal and is a road-based transportation option to continue the travel. Many pedestrians use spaces 1 and 3 as their space to move, the presence of sidewalks helps the movement of pedestrians, although some aspects of walkability such as dimensions, safety, and comfort are not met, accessibility and permeability are still quite good (meets more than 4 aspects). Non-walking space is a circulation of choice for pedestrians to move from Depok Baru Station to Jalan Margonda or cross the road using a pedestrian bridge. Space 2 tends to be used by pedestrians because it has a separator between pedestrian paths and vehicle lanes, while space 4 does not fulfill many aspects, so that accessibility and permeability are lacking, and make the lane not widely used.

3.2 Pondok Cina Station



Fig. 5: Second Location of the case studies (Source : Self-created)

The next observation location is the Pondok Cina Station area, this location is in Pondok Cina, Beji, Depok City. The observed area is the station gate to the points of road-based public transportation located on Jalan Margonda.

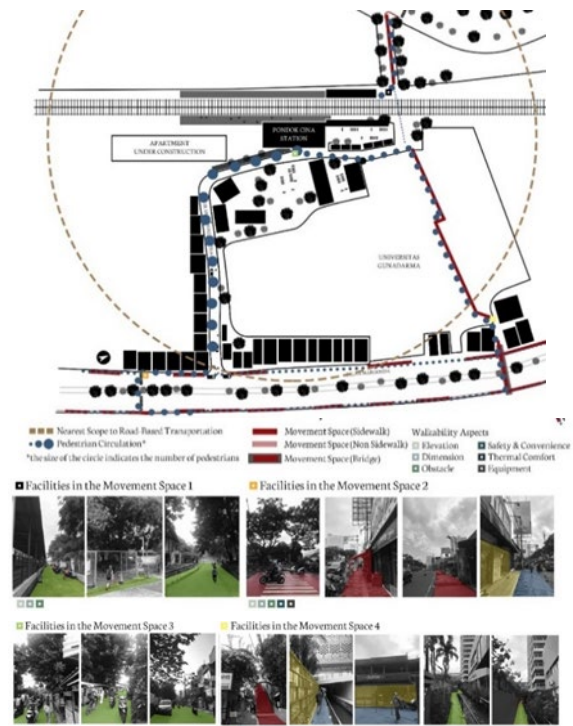


Fig. 6: Analysis of Pondok Cina Station (Source : Self-created)

A similar process of analysis was carried out in this area, to see a comparison of the accessibility and permeability of space/path through the perspective of 4 different spaces. These spaces/paths are evaluated by looking at the presence of attributes/facilities, then seeing how many aspects of walkability can be met. The spaces are divided into 4 as shown above (Figure 6). An area that is full of commercial functions and campuses and near the city's main road, Pondok Cina Station has space facilities that can make it easier for pedestrians to get to these areas. However, the existence of a separate space for movement from the vehicle path is only found in circulation through Universitas Gunadarma (space 4). Even so, the use of space in space 3 (Jalan St. Pondok Cina) tends to be chosen by pedestrians compared to space 4. This is related to space 3 fulfills more walkability aspects, such as (1) flat tread elevation; (2) space dimensions ($\pm 3m$); (3) safety with street lighting and visual access to the road from buildings along the street; (4) supporting facilities in the form of direction markers. Space 1 is the closest option to get to the Universitas Indonesia and space 2 is the crossing route to Jalan Margonda with crossing facilities in the form of a zebra cross. This crossing is more widely used than the crossing in the form of a bridge in space 4.

3.3 Lenteng Agung Station



Fig. 7: Third location of case studies
(Source : Self-created)

The last observation location is the Lenteng Agung Station area, this location is in Jagakarsa District, South Jakarta City. The area to be analyzed is the two station doors up to the point of road-based public transportation

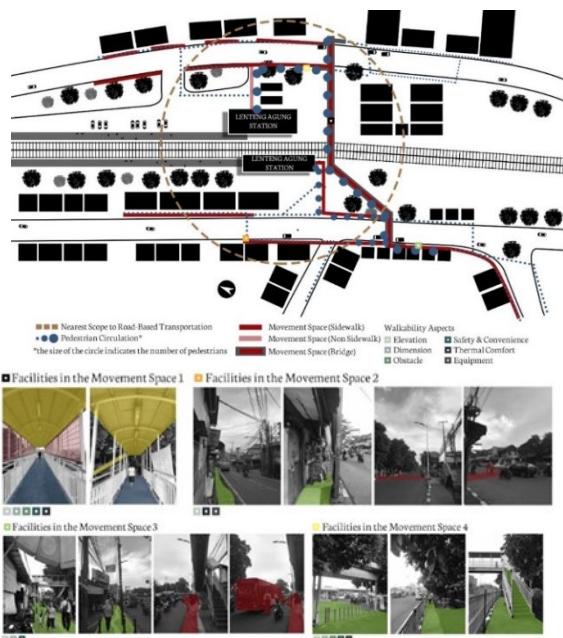


Fig. 8: Analysis of Lenteng Agung Station
(Source : Self-created)

The analysis process in the previous areas was also carried out in this area, to see a comparison of the accessibility and permeability of the movement space/path through 4 different spaces. These spaces/paths are evaluated by looking at the presence of attributes/facilities, then seeing how many aspects of walkability can be met. The four spaces are divided as shown above (Figure 8). Pedestrians who want to cross the railroad crossing can use the pedestrian bridge or enter the station. Use of bridges is also used as a space to cross vehicle lanes although the use of bridges with longer distances (across train crossings) is more widely used than those used to cross vehicle lanes. The movement space facility (sidewalk) which is forwarded to the pedestrian

crossing facility (People's Crossing Bridge) with walkability aspect, makes space 1 (People's Crossing Bridge) and space 3 (Depok-Jakarta sidewalk) used by pedestrians as space facilities. Likewise, with space 2 (towards the east gate) and space 3 (towards the west gate), the availability of sidewalks with walkability aspects makes this path used as a space for movement, but there are some accesses that remain pedestrian circulation even though space does not have facility for movement.

4. Discussion


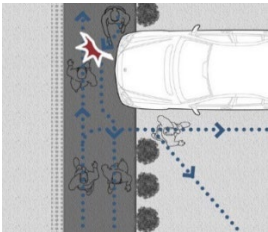

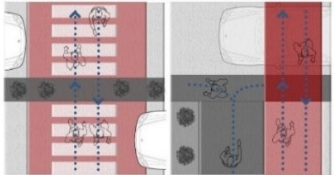
Spaces and facilities are evaluated with the fulfillment of walkability aspects, aiming to see their accessibility and permeability. Pedestrian facilities as an attribute of the walkability aspect (Table 1), help provide accessibility and permeability of pedestrian space. The following table is an evaluation indicator of the fulfillment of walkability aspects. The descriptor formed is an indication of the formation of accessibility and permeability of how many aspects of walkability are met.


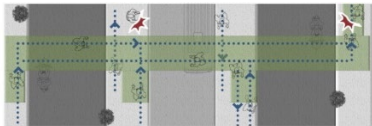

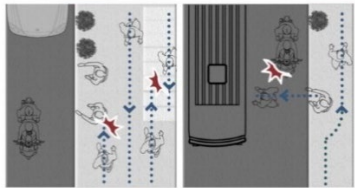
Pedestrians in the areas of Depok Baru Station, Pondok Cina, and Lenteng Agung have different characteristics but the mobility is similar. Pedestrian movement in the space is supported by facilities, both in the form of lanes and complementary paths. The fulfillment of the walkability aspect indicates the ease and continuity of access. Accessibility comes through the facilities available in the space and permeability provides access options through continuous spaces and facilities. With different accessibility and permeability, the mobility of pedestrians in the space can be seen as follows (Table 3).

Table 2. Accessibility and permeability indicators

Fulfillment of the Walkability Aspect	Formed Accessibility and Permeability Descriptors
<3	Not Good
3-4	Good
>4	Pretty Good

Table 3. Pedestrian movement and mobility

Movement Space – Fulfillment of the Walkability Aspect	Pedestrian Mobility	Movement Space – Fulfillment of the Walkability Aspect	Pedestrian Mobility
<p>Depok Baru Station Space 3 (pedestrian space)</p>  <p>(Figure 3)</p> <p>(Accessibility and Permeability formed Not Good) (Table 2)</p>	<p>Accessibility: slightly disturbed due to narrowing of space due to not continuous barrier</p> <p>Permeability: continuity of movement space comes with the presence of a sidewalk, which can continue the movement of pedestrians from the station, another choice of space in the form of a non-pavement on the other side</p>  <p>Mobility: the movement of pedestrians will avoid obstacles so that it becomes disorganized and accumulation occurs when there are people passing by because the width of the remaining space is <2 meters</p>	<p>Pondok Cina Station Space 1 (pedestrian space)</p>  <p>(Figure 6)</p> <p>(Accessibility and Permeability formed Pretty Good) (Table 2)</p>	<p>Accessibility: Crossing the pedestrian street is facilitated by the presence of a crossing path</p> <p>Permeability : Choice of lanes available in the form of a continuous zebra crossing and pedestrian bridge with space for movement in the form of a sidewalk</p>  <p>Mobility: the choice of use between the zebra cross and the pedestrian bridge based on the crossing point. Both have sufficient width of space and are continued with sidewalks, so that pedestrian movement is not hampered</p>

Movement Space – Fulfillment of the Walkability Aspect	Pedestrian Mobility	Movement Space – Fulfillment of the Walkability Aspect	Pedestrian Mobility
<p>Lenteng Agung Station Space 1 (pedestrian space)</p>  <p>(Figure 8)</p> <p>(Accessibility and Permeability formed Pretty Good) (Table 2)</p>	<p>Accessibility: Pedestrians are facilitated by sidewalks that are on each side of the road. To cross the vehicle lane there is a path in the form of a pedestrian bridge</p> <p>Permeability: The space for movement in the form of a sidewalk on each lane is continued with a pedestrian bridge to cross the road, the choice of crossing path is only a pedestrian bridge</p>  <p>Mobility: the movement of pedestrians across the train line can only be through the pedestrian bridge, because there are barriers given on each side of the road, so that movement is safer and more organized. As the only crossing facility, this pedestrian bridge is widely used by pedestrians.</p>	<p>Lenteng Agung Station Space 3 (pedestrian space)</p>  <p>(Figure 8)</p> <p>(Accessibility and Permeability formed Good) (Table 2)</p>	<p>Accessibility: the easy access route is not equipped with complementary facilities such as bus stops, so that when the point is used as a transportation waiting area and there is a pedestrian bridge, pedestrian access is hampered.</p> <p>Permeability: The crossing path that is continued with the sidewalk makes it easy for pedestrians to move, but the sidewalk stops at a certain point which makes pedestrians have no choice of space</p>  <p>Mobility: movement is hampered and disorganized due to not continuing the sidewalk and there is a buildup of road users who do not have complementary lane facilities, such as waiting areas. However, the existence of sidewalks leads pedestrians to bridges as crossing facilities.</p>

5. Summary and Conclusion

Pedestrians are part of forming the city, the activities carried out daily in moving from their place of origin to their destination become the role of structuring the transit area. The station area as a transit area is a place for many people to move, the use of public transportation is one of the options for advanced vehicles to their destination. With the nearby stations of several city functions such as, commercial, public services, education, and settlements, the movement of this transit space is active. In moving, space is needed to walk, because in general users of public transportation are pedestrians. The space for movement is in the form of pathways (sidewalks, non-walkways, and crossings) and complimentary lanes (waiting stalls and markers). The selection of space and facilities refers to the accessibility and permeability of the path by considering the aspects of walkability (elevation, dimensions, barriers, comfort, complimentary facilities, and security) that can provide a walkable environment. From the three station areas, the results of observations and analysis show that pedestrians tend to choose a space that meets walkability aspects. However, some pedestrians still choose to move space without facilities to move places. From this writing, it can be concluded as follows:

1. In identifying the accessibility and permeability of the movement space, it can be seen through space and facilities available on the pathway. These facilities are described through walkability aspects. Walkability is the ability of the environment to be traversed/used by pedestrians, by providing comfort, safety, and ease of walking through the space and its facilities. With these spaces and facilities, the environment can provide accessibility and permeability of space for movement. The walkability aspects are combined with the crowds of the lanes and the movement of pedestrians in the station area. From this, it is obtained: (a) the path that meets more than 4 aspects of walkability will provide good accessibility and permeability of the space so that the path tends to be widely used and more organized; (b) pathways that meet 3 to 4 aspects of walkability provide sufficient accessibility and permeability so that the path tends to be used even if it is blocked; (c) paths that meet less than 3 walkability aspects provide less accessibility and permeability so that the path tends to be unorganized and obstructed and can make pedestrians use spaces outside the design, such as; breaking fences, demolishing walls, and using vehicle lanes for circulation and pedestrian crossings.
2. Accessibility and permeability of the space required for pedestrians to use the path. Accessibility is the ease of accessing space and facilities available in an environment, while permeability is the choice and continuity of access to space and facilities provided by the environment, both in terms of view and space. Both of them provide convenience in using pedestrian

space, but accessibility is more likely in the use of space while permeability is in the use of space and visuals (direction of view). In terms of space, a path that has accessibility (easy access) does not necessarily have permeability (choice and continuity of access), because it could be that the environment does not have other path choices, while a path that has permeability will provide easy walking, but when the environment has access options, not necessarily the choice of path has easy access / accessibility. Thus the two complement each other and enhance the pedestrian space.

Pedestrian movement in an environment that has good accessibility and permeability will tend to be more user-friendly, barrier-free, organized, and pedestrian-friendly. In this case the mobility of pedestrians is influenced by the accessibility and permeability of the space. Environmental factors such as convenience, comfort, and security as well as environmental aspects such as high density, diversity of building functions, and the availability of space and facilities in the station area support the environment to become a walkable environment. However, the main factor of the friendliness of pedestrian space that is interrelated, namely, accessibility and permeability of the movement space, which is present through pedestrian facilities with walkability aspects.

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