Elements identification for pedestrian comfort

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Abstract. This research paper aims to identify aspects that affect walking comfort. This research was triggered by the different conditions of pedestrian paths in Jakarta. Some areas in Jakarta lack the proper infrastructures that provide an optimal space for a human to walk comfortably. But how do we know that a pedestrian path is deemed comfortable by its users? Which aspects play a role to affect comfort? This research will try to look for these aspects so future urban designers will take them into consideration when designing a comfortable pedestrian path. There are a lot of theories about pedestrian and comfort, but we have selected 6 important aspects of pedestrian paths that provide comforting feeling to pedestrians. The more aspects the pedestrian has, the higher the sense of comforting feeling the users can feel.

1. Introduction
Pedestrian paths are one part of the city that can create enjoyable city life experiences. A city offers activities and community life that can give you a different perspective on how you see and enjoy it. However, to be able to enjoy the city from that kind of perspective, pedestrian paths must be able to accommodate the observer well. For example, in terms of facilities and comfort when walking through them.

According to Jacobs[1], pedestrian paths are not only limited to facilitate humans to walk. Pedestrian paths can be a trigger for a population and economy growth in an area. In addition, the pedestrian path must be enjoyed by all ages, from adults to children. Jacobs also stated that a good pedestrian path can protect pedestrians from various types of threats and vandalism. A path with a friendly environment will invite other people to walk there.

Why is the pedestrian path important to facilitate humans? Apart from using a vehicle, walking is an option to move between places. Walking is the most basic mode of transportation. Pedestrian paths are needed to ease humans who move between places by foot. Similarly, as the vehicle road which is built to facilitate vehicles, pedestrian paths need to be built to facilitate pedestrians in moving places by walking.

In addition of facilitating humans to walk, pedestrian paths can be developed into city attractions. This can occur because the pedestrian paths have a lot of potential usages besides facilitating people to walk. Pedestrian paths can become a space for people to enjoy their activities. For example, a large pedestrian path can be utilized by a certain group of street performers (Doubleday, 2018). Street performers can provide pedestrians with various attractions such as music performances, dances, and so on. These attractions can enhance the experiences of walking.
In this research, we will look at the elements that can also offer comfort to a pedestrian path so it does more than facilitating humans to walk. Theories about the design of a pedestrian path were studied to understand the needs of a pedestrian path. These theories were used to learn the needs of a pedestrian path. Moreover, pedestrian path requirements in each country, city, and region differ from one and another. Countries with a tropical climate may require different facilities or aspects from countries with a subtropical climate. However, there are some fundamental aspects that are needed to make a comfortable pedestrian path.

2. Literature Review
Before the advent of the invention of motorized vehicles, humans used to walk to reach their destination. But after vehicle technology emerged, walking activity began to decline. The environment, especially in urban areas, is often not pedestrian-friendly. Many urban environments are built with a focus on motorized vehicles despite the importance of a friendly environment for pedestrians. According to Leyden\(^2\), a friendly environment for walking will raise the potential for social interaction. This social interaction can develop into a community. Humans who live and interact in this community tend to live longer and become healthier physically and mentally.

Leyden also stated that social ties and society are the key components of a broader concept called social capital. Social capital is defined as social networks and interactions that raise the sense of trust and reciprocity among citizens. Humans who have a high level of social capital tend to be active and participate in communal activities run by their communities. They will also tend to be trusted more by the other residents. Pedestrian-oriented areas (e.g. mixed-use areas) are expected to improve this concept of social capital. The potential for human interaction will be higher. Interactions can occur anywhere such as at shops along the road, at street corner shops, local parks, and on the sidewalks. Many other benefits that can be obtained from a friendly environment for pedestrians. But how does an environment can become pedestrian-friendly? One of the ways is to create an environment that offers a comfortable walking experience.

Comforting feelings for pedestrians can be defined as a positive emotional reaction to the external environment (the walking environment) in different situations, including physiological, physical, social, and psychological reactions (Øvstedal, 2015). This comfort is influenced by various aspects that will be discussed below. The more positive aspects it has, the more comfortable a pedestrian path is. Meanwhile, comfortable pedestrian paths will provide a pleasant experience for pedestrians. In each section below, we discuss theories and research around aspects that affect pedestrian comfort.

2.1. Safety Aspect
To clarify the difference between the safety aspect and the security aspect, which will be discussed in the next section, the safety aspect is a physiological aspect. A safe pedestrian path encourages humans to use this path (Jacobs, 1961). On contrary, an unsafe pedestrian path (not maintained or without supervision) can cause vandalism and crimes to happen. This kind of problem can discourage people from using that path since it can threaten their own safety. Paths that are not passed by humans will eventually become a dead path and there will be no ‘community life’ in that area. Therefore, how can a pedestrian path become a safe and user-friendly path?

One way to produce safe pedestrian paths is the presence of a street watchers (Jacobs, 1961). The street watchers here referred to people who work as a shopkeeper or a person who sits near the pedestrian path. The role of the street watchers is to oversee the pedestrian path in front of their shop or their surroundings. The existence of this kind of overseer can prevent acts of vandalism or similar act to happen. Important to note that there should be a connection between the indoor (shops) and outdoor (path) so that this street surveillance system can work effectively. For example, a large window. A small window will limit the surveillance area. Barriers such as fences or walls on the left and right sides of the building will also reduce the system’s effectiveness, thus allowing vandalism to happen. This is caused by the presence of blind spots that are not under supervision where acts of vandalism can occur.
Variations of store types are also needed within one area (Jacobs, 1961). For example, there should be shops that open only in the morning, shops that are open all day, and shops that only open at night. This is intended so the surveillance system mentioned above can work all day long, which can guarantee the path safety all day long. If in one area, the entire shops only open in the morning, then the road becomes unsafe at night since there will be no surveillance by the street watchers. Vice versa, if all shops are only open at night, then the surveillance level becomes low in the morning.

One of the examples of the recommended shops is cafes. These cafes can be a hotspot for people so they can spend time in that area. They (staffs and customers) will function as the street watchers while they stay there. Figure 1 is an illustration of street watchers in an area. The area shaded with red is the area that is supervised by human visions while the black dot indicates human position. As we can see, the more people in the area, the higher level of supervision is. With this high level of supervision, the potential for vandalism or other crimes to occur is reduced. It is important to remember that changes in the density of street watchers can reduce the surveillance system at a certain time. The existence of retail such as cafe as a place for people to gather can resolve these potential problems since people tend to stay longer here.

2.2. Security Aspect
As the safety aspect above is felt physiologically, the security aspect here affects physically. A pedestrian path needs to ensure that users can walk safely (Øvstedal, 2015). Walking safely meant
walking without having an accident. This accident can occur because of a vehicle or the pedestrian path itself. Dangerous pedestrian paths will make its users uncomfortable. A simple example of a safe path is a flat, non-perforated path surface. Uneven surfaces can cause pedestrians to stumble or even fall while walking, which results in injuries. A similar case can happen with the hole, which raises the potential for pedestrians to fall or stumble.

Vehicles can also threaten pedestrians when they walk. In research by Appel, et al.\(^3\), the impact of a moving vehicle could be fatal for pedestrians. According to their research, the average speed of impact in both fatal and non-fatal pedestrian crashes is 34 km/hour. They also learned that pedestrians are usually hit from the side. It raises the need for a protection between the pedestrian paths and the vehicle paths to minimize the impact and potential accidents. Protection can be green lines (trees) or guardrails. The green line has additional positive value since it provides a shadow (canopy) that protects the path from sunlight. Details of this tree canopy will be discussed more in section 2.4.

Additionally, a busy environment with vehicles will be especially dangerous for children (Appleyard, 2005). Heavy traffic will reduce the mobility of children and adolescents. Areas and locations for them to play become limited due to the vehicles. The time for them to spend time outdoors is also reduced. Children who live in environments that are not dominated by vehicles can have a wider circle of friends because they have a higher potential to meet them. The same thing applies to adults. An environment that is not dominated by motorized vehicles will create the potential for greater social interaction. This social interaction can occur anywhere, one of the places is the pedestrian path.

2.3. Weather and Temperature
Of course, one of the biggest aspects that affect human comfort when walking is the weather and temperature (Øvstedal, 2015). In a survey conducted by Øvstedal\(^4\), sunny weather is the best weather for walking. Rain or snow weather reduce the walking comfort. Cloudy weather also provides comfort for walking as there will be less sunlight since some of it is blocked by the clouds. The sunlight here also affects walking comfort, which will be discussed below. The temperature can also be cooler than sunny weather.

In the survey, the range of air temperatures that are considered the most comfortable for humans is 16-22°C. The temperature range of 23-33°C is considered less comfortable. While the range of 0-15°C is considered the most uncomfortable. Keep in mind that this survey by Øvstedal was conducted in a European country that has 4 seasons. Then, what about the conditions of comfort temperatures range in Indonesia? Research conducted by Karyono\(^5\) learned that the temperature range considered comfortable in Indonesia ranged from 24-28°C. For comparison, the highest standard of comfort according to American standards (ANSI / ASHRAE, 1992) is 22-26°C. This difference in range is due to Indonesia's tropical climate.

As mentioned briefly above, sunlight is one of the factors that affect comfort when walking. According to research conducted by Bosselmann, et al.\(^6\), excessive sunlight will increase body temperature and will cause a sultry feeling, which will reduce the comfort level. Humans will tend to look for shade from the sun to get cooler air. Additionally, sunlight can also dazzle human views (Øvstedal, 2015). Shade from the sunlight will help to reduce the amount of sunlight that reaches the human body. Shade here can be created from the shadow of tall buildings or trees. Tree shade is more recommended since trees also function as air circulation and reduce the surrounding air temperatures. The discussion of the tree shading will be discussed more below.

2.4. Environment Conditions
Environmental conditions such as the cleanliness of the air from pollution, vehicle noises, and odors around the pedestrian path also have an effect (Øvstedal, 2015). Based on a survey by Øvstedal\(^8\), lanes that are too crowded with vehicles will make the pedestrians become uncomfortable because of the noises. Another variable such as odor pollution in an area also needs attention. The smell of garbage or other things will reduce the comfort level. The cleanliness variable is very related to this odor pollution. Similarly, air pollution also plays a role. If an area has a high level of air pollution, then humans will
not walk comfortably through there. Humans cannot breathe clean air. The main source of air pollut- 

Meanwhile, the presence of tree canopies along pedestrian paths can increase pedestrian comfort (Rosheidat & Bryan, 2010). Tree canopy provides cool air while walking under it. If a path does not have a tree canopy, the air temperature along the path tends to be high. The heat from the sunlight will be absorbed by the road surface and building walls. Trees can prevent it. As a result, the heat energy that is absorbed will be reduced and air temperature will be lower and becomes cooler.

Armson, et al.[7] also did a similar study. They studied the effects of tree canopies on decreasing air temperature. The results of their study stated that air temperatures can be reduced up to 12°C by using tree canopies. Planting trees can effectively reduce the surface temperature of roads and buildings. Tree shadow can become a canopy for pedestrians to walk comfortably. This shadow will prevent sunlight from reaching the human body. The sultry feeling won’t be felt because of the cool air produced by the tree.

2.5. Pedestrian Accessibility

Easy access between the public transport network and the pedestrian network also plays a role in affecting the walking comfort (Zakaria & Ujang, 2014). According to Zakaria and Ujang[8], a pedestrian-friendly city is a city which has an easy (convenience) access between the public transport network and the pedestrian path network. An example of the convenience here is several public transportation options that pass through a certain area. In addition to that, the walking distance from the station to the destination also needs to be considered. Research by Burke and Brown[9] shows that the walking distance from the bus stop to the destination point ranges from 400 meters to 1000 meters. Ranges from 0 to 400 meters is considered a comfortable walking distance. The range of 400 to 1000 meters is considered less comfortable. The distance of 1000 meters and above is considered even more uncomfortable.

The choice of several routes also provides comfort for pedestrians (Southworth, 2005). The variety of available routes can become a consideration for humans to choose their way of walking. Humans tend to choose the route that provides the shortest distance to reach their destination. Besides that, route variations also provide different scenery options. Research by Agrawal, et al.[10] showed the same results. In their survey, most respondents chose the routes with the shortest distance. Ambience such as views of the environment is also another reason for route selection. The presence of a tree canopy within the path is also taken for consideration. Another consideration is the condition of the pedestrian path. The path that is not maintained tends to be avoided as a travel route.

2.6. Pedestrian Facilities

The last aspect that affects pedestrian comfort is the facilities aspect (Øvstedal, 2015). The existence of facilities such as seats and public toilets can enhance pedestrian comfort. Based on a survey conducted by Øvstedal[11], facilities such as public seating are helpful for some of the pedestrians because they can rest for a while if they travel pretty far. Public toilets are also a good facility for pedestrians to have. It can help the pedestrian to do their needs.

Other facilities such as road sign (signage) also affect the comfort of one's walking (Øvstedal, 2015). Signages will make it easier for someone to find directions to reach their destination. A map that shows the surrounding area also helps humans better to find ways, especially for those first-timers who visit the area. Other kinds of road signs such as street names can also help to find the desired destination. Areas that don’t have street signs might make it harder for people to find their ways to their destination.

The size of the pedestrian path (width) also influences the attitude of a pedestrian (Lee, et al. 2009). The pedestrian path must have a width that suits the needs of the surrounding environment. For example, if the width is too narrow, then a pedestrian who’s passing the path will feel uncomfortable. Lee, at al.[11], found that humans tend to distance themselves from other people. The average distance between pedestrians is 1.72 meters. Giving this kind of distance is intended to provide a personal comfort zone for each human. Walking too close to other pedestrians will reduce the sense of comfort. The pedestrian path must be wide enough to prevent this to happen.
Other facilities such as crossings and lightings are also important (Zakaria & Ujang, 2014). The simplest type of crossing facility is the zebra crossing. Moreover, the more complex crossing facilities are crossing bridges and pelican crossing. Facilities such as pelican crossing are needed especially in areas with a lot of pedestrians. This facility helps to reduce the potential of accidents caused by motorized vehicles. The existence of these facilities will help to improve pedestrian comfort. Crossing the road that doesn’t have this facility will increase the potential for accidents to occur. On the other hand, lightings also are important, especially at night. Paths that lack lightings can increase the potential for crime to occur. A lot of lightings will reduce this threat. Lightings can be in a form of street lights that are specific for the pedestrian paths. Street lights that are combined its function to light the vehicle lanes can also function as lighting. Sometimes, lightings from the buildings around the path can also help to light up the path. It should be noted that to make it work, lightings from the surrounding buildings needs to be bright enough. The entire area of the pedestrian path needs adequate lighting.

![Literature synthesis diagram](Figure2.png)

Figure 2. Literature synthesis diagram, Source: Authors’ personal drawing

3. Conclusions

There are a lot of other theories that discussed the comfort of a pedestrian path. But as we studied these theories, we concluded that these 6 aspects are the fundamental aspects to create a comforting feeling while walking along the pedestrian path. Those 6 aspects are: (1) security aspects, (2) safety, (3) weather and temperature, (4) environmental conditions, (5) accessibility to public transport stops, and (6) facilities for creating comfortable pedestrian paths. In the future, pedestrian path design needs to pay attention to these aspects, so the design can produce a comfortable pedestrian path for its users. Future researchers are recommended to develop a more detailed list of these aspects as they can become a guideline in designing pedestrian paths.

4. References

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