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Ergonomic Analysis Based on Human-Centered Design for Batik Solo Trans Shelter

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ABSTRACT

Public transportation facilities need to accommodate diverse user characteristics to ensure safety, comfort, accessibility, and usability. Batik Solo Trans (BST) shelter in Surakarta still present several ergonomic issues related to seating comfort, wheelchair accessibility, information facilities, thermal conditions, boarding safety, and physical support for standing users. This study aims to conduct an ergonomic analysis based on Human-Centered Design (HCD) to identify user needs and ergonomic problems and translate them into design requirements for improving BST shelter facilities. The study integrates ergonomic evaluation and HCD through observation, anthropometric assessment, user needs identification, accessibility evaluation, and analysis of environmental and user–facility interactions. The results identified seven major design requirements: ergonomic seating dimensions, adequate wheelchair maneuvering space, an accessible wheelchair ramp with an appropriate slope, ergonomic information placement, improved shelter and ventilation, a safer boarding interface, and strategically positioned handrails. The findings demonstrate that accessibility should be considered as an integrated system, particularly regarding the relationship between ramp slope, circulation space, and wheelchair maneuverability. The integration of ergonomic evidence with user needs provides a structured basis for developing a more inclusive and user-oriented BST shelter design. The proposed approach can be applied as a design reference for improving public transportation facilities by considering anthropometric compatibility, accessibility, safety, comfort, and usability. Further research is required to validate the proposed design through prototype implementation and user-based usability testing under actual operating conditions.

INTRODUCTION

Public transportation plays an important role in supporting urban mobility by providing accessible and efficient transportation services for communities (Maria Margaretha & Aji Nugroho, 2023). In addition to the quality of transportation services, the physical infrastructure supporting public transportation, particularly shelters, influences the overall user experience (Goni et al., 2026). A shelter is not merely a place for passengers to wait for vehicles but also serves as an interaction space where users perform various activities, including walking, entering and leaving the facility, waiting, sitting, reading route information, and boarding or alighting from buses (Salsaqilah et al., 2023). Therefore, the design of shelters needs to consider the physical, cognitive, and environmental characteristics of users to ensure safety, comfort, accessibility, and usability (Syukrony & Suparman, 2024).

Batik Solo Trans (BST) is one of the public transportation services supporting mobility in Surakarta, Indonesia since 2009. The increasing utilization of public transportation requires supporting facilities that are capable of accommodating diverse user characteristics and activities (Zahra et al., 2026). However, shelter facilities may still present ergonomic problems, including inadequate dimensions of seating and circulation areas, limited accessibility for elderly and disabled users, insufficient protection from environmental conditions, and difficulties in accessing information. Such conditions may reduce user comfort and potentially create safety risks during activities at the shelter (shelter). Previous studies on public transportation facilities have emphasized the importance of accessibility, anthropometric compatibility, and user comfort in the design and evaluation of the BST shelter (Diansari et al., 2021).

Ergonomics provides an approach for evaluating the compatibility between humans and the physical environment by considering anthropometric characteristics, physical capabilities, posture, environmental conditions, and user activities (Putri & Setiawan, 2024). However, an ergonomic approach that focuses primarily on physical dimensions may not fully capture users' needs, preferences, perceptions, and experiences (Ferlania & Waskitho, 2026). Human-Centered Design (HCD) complements the ergonomic approach by placing users at the centered of the design process through the

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identification of user needs, analysis of user activities, development of design requirements, and evaluation of proposed solutions. The integration of ergonomics and HCD can therefore provide a more comprehensive basis for developing shelter designs that are not only physically appropriate but also accessible, safe, comfortable, and responsive to the actual needs of users.

Based on these considerations, an ergonomic evaluation of BST shelter facilities is needed to identify discrepancies between existing conditions and user requirements. The research focuses on identifying ergonomic problems associated with user activities, anthropometric suitability, accessibility, safety, comfort, and environmental conditions. The results are subsequently used to formulate user-centered design requirements for improving BST shelter facilities. Therefore, this study aims to conduct an ergonomic analysis based on Human-Centered Design for Batik Solo Trans shelter design by identifying user needs and ergonomic problems and translating the findings into design requirements for safer, more comfortable, accessible, and user-oriented shelter facilities.

LITERATURE REVIEW

Ergonomics is concerned with optimizing the interaction between humans and the systems, products, and environments in which they operate with human limitations (Destrien Salim & Eka Darmayanti, 2024). In the context of public transportation, ergonomic principles are important because users interact with transportation facilities through various physical and cognitive activities, such as walking, standing, sitting, accessing information, boarding, and alighting. Consequently, the design of transportation facilities needs to accommodate variations in users' anthropometric characteristics, physical capabilities, activity patterns, and environmental requirements include disabilities users. A shelter that is physically incompatible with its users may increase discomfort, restrict accessibility, and create potential safety risks.

Previous studies have demonstrated the importance of ergonomic considerations in public transportation facility design. Anthropometric analysis using Macroergonomic and Analysis Design (MEAD) can be used to determine appropriate dimensions for seats, handrails, ramps, and other facilities, while accessibility analysis ensures that facilities can be used by people with different physical capabilities (Diansari et al., 2021). The other research analysis the disabled-friendly for Batik Solo Trans shelter using SWOT analysis (Diansari et al., 2024). These approaches indicate that ergonomic design should not be limited to the dimensions of individual components but should also consider the interaction between users and the entire facility. However, anthropometric suitability alone does not necessarily guarantee a positive user experience because users may still encounter difficulties related to accessibility, information, environmental comfort, or the organization of activities within the public transport facility.

In public transportation facilities, Human-Centered Design is particularly relevant because users have diverse characteristics and expectations (Herliana et al., 2026). A single shelter may be used by young adults, elderly people, children, pregnant women, people with disabilities, and passengers carrying goods or luggage. These users may experience the same facility differently depending on their physical capabilities, familiarity with the transportation system, and travel purposes. Therefore, involving users in the design and evaluation process can reveal problems that may not be identified through technical measurements alone.

In these previous studies to shelter (shelter) and public transportation facility design using ergonomics, anthropometric suitability and user experience. The condition indicates the research gap in the integration of ergonomic analysis and Human-Centered Design for BST shelter development. The approach is expected to identify facilities comply with ergonomics requirements, key problem experience, and the design improvement are required based on the user needs.

METHOD

This research employs a Human-Centered Design (HCD) approach integrated with ergonomic analysis to evaluate and develop the design requirements of BST shelter. The research consists of four main stages: (1) identification of users and their activities, (2) identification of user needs and problems, (3) ergonomic evaluation of the existing shelter, (4) evaluation of the proposed recommendation facilities design. Human-Centered Design id used to understand the users and their interaction, while ergonomics analysis is used to evaluate the existing facilities with user anthropometric characteristics, physical activities, accessibility requirements and environmental conditions.

The research objects is the Batik Solo Trans shelter in Surakarta City. The analysis focuses on the physical components and supporting facilities that directly interact with users, including the waiting area, seating facilities, ramps or stairs, handrails, boarding area, and information facilities.

The participants consist of BST users with diverse characteristics and collected using interviews. User needs are categorized into safety, comfort, accessibility, usability, information and environmental protection. The research procedure can be represented in a flowchart as follows:

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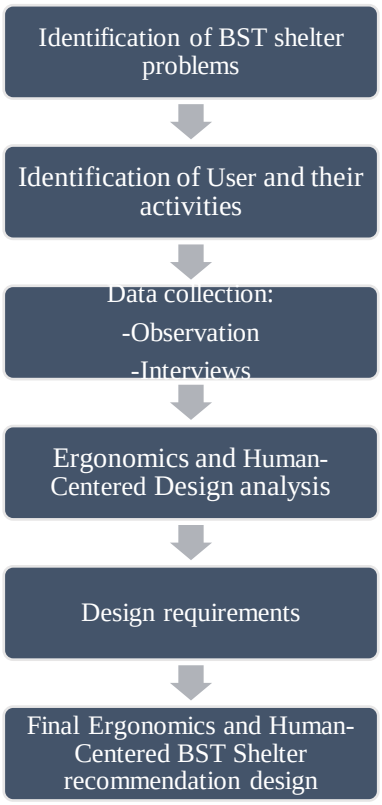

Fig. 1 Research Flowchart

RESULT

Based on the observation and interviews results with all respondents. The observation and ergonomic assessment of the Batik Solo Trans shelter identified seven major problems related to user interaction with the existing facilities. The identified problems were insufficient seating comfort, limited wheelchair movement, ramp is too steep for wheelchair users, difficulty accessing information, excessive heat during waiting, risk during boarding, and lack of support when standing. These problems were further analyzed by relating the observed conditions to user needs and ergonomic evidence.

Table 1 presents the mapping of the existing problems, user needs, ergonomic evidence, and corresponding design requirements.

Table 1. Integration of Existing Problems, User Needs, ergonomic Evidence and Design Requirements

Existing Problem	User Need	Ergonomic Evidence	Design Requirement
Insufficient seating comfort	Comfortable waiting	Anthropometric mismatch	Appropriate seat dimensions
Limited wheelchair	Easy accessibility	Insufficient circulation space	Adequate maneuvering area
Ramp is too steep for wheelchair users	Safe and independent access	Excessive ramp gradient and increased physical effort	Appropriate ramp slope and width
Difficulty accessing information	Easy-to-read information	Inappropriate position/height	Ergonomic information placement
Excessive heat during waiting	Thermal comfort	High environmental exposure	Improve shelter
Risk during boarding	Safe boarding	Unsafe boarding area	Improve boarding interface
Lack of support when standing	Safe standing	Limited hand support	Ergonomic handrail placement

Based on the identified requirements, the proposed BST shelter design incorporates seven major improvement components. The first component is an ergonomic seating system with dimensions determined based on anthropometric

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considerations. The second component is a wheelchair-accessible circulation area that provides adequate space for movement and maneuvering. The third component is an accessible wheelchair ramp with an appropriate slope, sufficient width, non-slip surface, and supporting handrails to facilitate safe and independent access for wheelchair users. The fourth component is an improved information system, in which information boards are positioned at an appropriate height and location for users. The fifth component is an improved shelter and ventilation system intended to reduce direct environmental exposure during waiting. The sixth component is an improved boarding interface that facilitates a safer and more organized transition between passengers and the bus. The seventh component is an ergonomic handrail system that provides physical support for users during standing and movement.

DISCUSSION

The results demonstrate that the existing Batik Solo Trans (BST) shelter has several ergonomic and user-centered issues related to seating, accessibility, information, environmental conditions, boarding, and physical support. These findings indicate that the performance of a shelter cannot be assessed solely from the availability of facilities. The compatibility between facility characteristics and users' physical capabilities, activities, and needs also needs to be considered. The integration of ergonomic analysis and Human-Centered Design (HCD) provides a broader perspective for identifying these interactions and translating them into specific design requirements.

Seating Comfort and Anthropometric Compatibility

The identified problem of insufficient seating comfort is associated with an anthropometric mismatch between users and the existing seating facilities. From an ergonomic perspective, seating dimensions should correspond to relevant anthropometric characteristics, particularly popliteal height, popliteal length, and hip breadth. Inappropriate seat dimensions may result in uncomfortable sitting postures and may increase physical discomfort during prolonged waiting.

This finding supports the principle that public transportation facilities should accommodate variations in user body dimensions rather than being designed around a single average user. Therefore, the proposed ergonomic seating system is based on anthropometric considerations to provide a more appropriate relationship between the user's body dimensions and the physical characteristics of the seat. The finding also demonstrates the importance of integrating quantitative anthropometric analysis into HCD because user perceptions of comfort need to be translated into measurable physical design requirements.

Wheelchair Accessibility and Ramp Design

Accessibility was identified as one of the important issues in the existing BST shelter. Two related problems were identified: limited wheelchair maneuvering space and a ramp that is too steep for wheelchair users. These findings indicate that the presence of an accessibility facility does not necessarily guarantee accessibility in practice.

A steep ramp can increase the physical effort required by wheelchair users when moving upward and may reduce the ability to access the shelter independently. The problem becomes more significant for users of manual wheelchairs because movement on an inclined surface requires greater propulsion effort. In addition, insufficient maneuvering space may make turning and positioning a wheelchair more difficult.

The proposed design therefore combines an adequate maneuvering area with an accessible ramp having an appropriate slope, sufficient width and a non-slip surface. This combination is important because ramp accessibility and circulation space are interdependent. A ramp with an appropriate slope may still be difficult to use if users do not have sufficient space to approach, turn, or position the wheelchair.

The finding emphasizes that accessibility should be treated as an integrated system rather than as an individual design component. This is consistent with the HCD principle of considering the complete user journey and interaction with the facility.

Information Accessibility

Difficulty in accessing information was identified as another user-related problem. Information facilities are important because passengers need to obtain route, destination, and operational information before and during their use of the transportation system. Information that is positioned too high, too low, visually obstructed, or otherwise difficult to access may increase users' cognitive and physical effort.

The proposed improvement focuses on ergonomic information placement, including appropriate height and location. This finding extends the ergonomic analysis beyond physical dimensions by considering the interaction between users and information systems. In an HCD context, information facilities should accommodate different users, including users with different heights, visual capabilities, and levels of familiarity with the transportation system.

Therefore, the effectiveness of an information system should be considered not only from whether information is provided but also from whether users can easily locate, reach, read, and understand it.

Thermal Comfort and Environmental Conditions

Excessive heat during waiting was identified as an environmental ergonomic problem. Unlike seating and accessibility issues, thermal discomfort is influenced by the interaction between the physical structure of the shelter and

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surrounding environmental conditions. Direct solar exposure and inadequate ventilation may increase discomfort during the waiting period.

The proposed improvement combines an extended shelter. This is important because increasing shelter coverage without considering air circulation may reduce solar exposure but may not adequately address thermal discomfort. This finding demonstrates that environmental ergonomics should be integrated into the design of transportation facilities. The shelter should provide protection against environmental exposure while maintaining adequate airflow and visibility. Thus, user comfort is influenced not only by individual facility components but also by their spatial and environmental configuration.

Boarding Safety and Physical Support

The results also identified risks associated with boarding and limited physical support for standing users. Boarding represents a critical interaction between the passenger and the transportation vehicle because users must move between the stationary facility and the moving transportation system. An inappropriate circulation or boarding configuration may increase the potential for conflicts between passengers and other users.

The proposed improved boarding interface is intended to create a more organized transition between the waiting area and the bus. Meanwhile, the ergonomic handrail system provides additional physical support for users while standing and moving. These features are particularly relevant for users who may have reduced balance or physical strength.

The findings indicate that safety should be considered throughout the entire user movement sequence, from entering the shelter to waiting and finally boarding the vehicle. This perspective is consistent with HCD because the facility is evaluated according to the user's complete activity rather than according to isolated physical components.

Implications for BST Shelter Design

The seven improvement components identified in this study are ergonomic seating, wheelchair-accessible circulation, accessible ramp design, ergonomic information placement, improved shelter and ventilation, improved boarding interface, and ergonomic handrails. Its represent interconnected design requirements rather than independent modifications.

The results suggest that improving one component may influence the performance of other components. For example, providing a wheelchair ramp requires sufficient circulation space at its entrance and exit. Similarly, the placement of seating and information facilities must not obstruct wheelchair movement or boarding circulation. Shelter dimensions should also accommodate seating, circulation and accessibility facilities.

Therefore, the proposed design should be considered as an integrated system. This perspective represents the main contribution of the study, as the ergonomic evaluation is translated into a comprehensive set of user-centered design requirements rather than limited to an assessment of individual facility dimensions.

Overall, the findings indicate that the application of Human-Centered Design combined with ergonomic analysis can provide a structured approach for identifying and addressing user–facility interaction problems in BST shelter design. The approach connects users' actual needs with measurable ergonomic requirements and subsequently translates them into physical design components. Further evaluation using a prototype or full-scale design is required to assess the effectiveness of the proposed improvements in terms of usability, comfort, accessibility, and user satisfaction.

CONCLUSION

This study identified several ergonomic and user-centered problems in the existing Batik Solo Trans (BST) shelter, including insufficient seating comfort, limited wheelchair maneuvering space, a steep ramp for wheelchair users, difficulty accessing information, excessive heat during waiting, boarding safety risks, and limited physical support for standing users. The integration of ergonomic analysis and Human-Centered Design (HCD) provided a systematic approach for relating these problems to user needs and translating them into specific design requirements.

The proposed human-centered BST shelter design consists of seven major improvement components: ergonomic seating, wheelchair-accessible circulation, an accessible wheelchair ramp, ergonomic information placement, improved shelter and ventilation, an improved boarding interface, and ergonomic handrails. These components are designed to address the interaction between users and the physical environment while considering anthropometric compatibility, accessibility, safety, comfort, and usability. The main contribution of this study is the integration of objective ergonomic considerations with user-centered requirements to develop a more comprehensive basis for shelter design.

The application of this approach can support the development of BST facilities that are more inclusive and responsive to the diverse characteristics of public transportation users, particularly wheelchair users and other users with specific accessibility needs. The findings can also be used as design input for improving the physical configuration and supporting facilities of BST shelters.

However, this study has several limitations. The evaluation was conducted within the context of selected BST shelter conditions and may not represent all shelters or all BST users. In addition, the proposed design has not yet been

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evaluated through a full-scale prototype or long-term field implementation. Further research should therefore include a larger and more diverse group of users, quantitative environmental measurements, detailed anthropometric validation, and prototype-based usability testing. Future studies may also evaluate the proposed design using objective indicators such as accessibility performance, physical workload, thermal comfort, boarding time, and user satisfaction to validate its effectiveness in real operating conditions.

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