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VOT : 71909

Mechanical Design and Fabrication of a Prototype Motorised Tricycle for the Disable

(Merekabentuk dan membina sebuah prototaip motosikal tiga roda untuk kegunaan orang kurang upaya OKU)

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ACKNOWLEDGEMENT

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PWTC, KUALA LUMPUR on 27th - 29th August 2004

under the title of

"**Tricycle for Wheelchair user**"

This report consists part of a paper presented at a
Proceedings of SEAMEC 2003, Kuching, Sarawak.

Full Design Detail can be found at PSZ at
the Undergraduate Final Design Project.

Mechanical Design and Fabrication of a Prototype Motorised Tricycle for the Disable

Abstract

This reports is on the research of a design of a motorised tricycle for disabled person. This tricycle is specifically designed to suit wheelchair occupants of healthy upper torso with pelvic to foot restraint. It is also designed to suit a commonly available wheelchair. Existing tricycle for disable requires a disabled person to dismount from the wheelchair onto the tricycle. The motorised tricycle in this project is designed to over-come this problem by allowing the disabled person to wheel up or down his wheelchair onto or down the tricycle. This is achieved using a specially designed platform that allows the wheelchair to be wheeled up or down. The prototype of this tricycle have been fabricated. The anthropometrics data that need to be considered in the design of the platform and frame of the tricycle have been taken into consideration at the design stage of the tricycle.

Keywords: Design for disabled, vehicle for disabled, anthropometrics

OBJECTIVE

To design and fabricate a prototype motorized tricycle to be used by the disable.

SCOPE

1. Literature review of available disable self assisted vehicle and related regulation and guideline.
2. Concept generation of possible solution based on available motorcycle engine (Modenas).
3. Selection of final concept based on generated concept.
4. Detail design of chosen concept.
5. Production of Engineering Drawing of the Tricycle.
5. Prototype fabrication of the tricycle.
7. Testing of the prototype

METHODOLOGY

1. A study of several regulation and guideline concerning the design of a vehicle for the disable in order to identify related design constraint.

2. Final design concept which comply with the regulation and guideline.

3. Production of final Engineering Drawing for fabrication purpose.

4. Fabrication of the design to based on produced engineering drawing

5. Design improvement. and modification.

6. Testing of final prototype.

1.0 INTRODUCTION

Mobility is an important requirement in providing motor-disabled adults opportunities for independent living and working. There have been many published examples of the disabled contributing to the workforce not just in service sector but also in industrial sector (Kochan, 1996, Burke 1999). Mobility may also contribute to self-employment of the motor-disabled.

A successful effort to include motor-disabled employees into the workforce not only involved adjustments to the workplace and work environment but also the issues of facilitating the transportation of these employees to and from work. Many specially designed vehicles have been built for this purpose.

This project that aims to design and fabricate a prototype tricycle to improve mobility of the motor-disabled with healthy upper torso but pelvic to foot restraint. In building this prototype the researcher discovered that relevant anthropometrics data on the disabled in Malaysia is virtually non-existence. Thus the researchers will use the American Disable Act (ADA) guidelines to build the tricycle.

This project is aimed to identify the guidelines that may be used for the design of the prototype for Malaysian motor-disabled population.

2.0 PROBLEM IDENTIFICATION

Various methods has been researched and used to increase mobility of the motor-disabled. Some focused on improving the mobility of the wheelchair [Krovt et.al, Sanders & Stott 1999]. These allow improvements in the use of the wheelchair but it is not a viable means for long-distance travel. Motorized vehicles such as buses, vans, cars and motorcycles are usually customized for this purpose.

Customised buses and vans are suitable for mass transportation but for individual transportation customized cars and motorcycles are more feasible. Customised motorcycles such as the tricycles has been used by the motor-disabled as a mean of transportation. These vehicles are cheaper and can be used on the road with approval from the appropriate authorities.

However existing tricycles are custom-made to suit individual requirements. These tricycles also require the disabled to get out of the wheelchair and onto the seat of the tricycle. These are some of the problems that the researchers in UTM tries to solve with the new tricycle design.

The new tricycle is a modification of a motorcycle that allows the disable to wheel-up the wheelchair onto the specially designed platform, secure the wheelchair for safety and drive. It is hoped that this new design will ease and improve mobility.

The basic task of anthropometry for the disabled is to shape the man's surrounding in accordance with his disabilities [Nowak, 1996]. Thus the use of anthropometrics data on the disabled is important in ensuring that the tricycle will fulfill the comfort and safety of the users. The prototype will be made based on the standard and guidelines provided by ADA due to the lack of data on Malaysian disabled population.

Once the prototype is built, fitting trials will be conducted to evaluate the tricycle. Fitting trials are an established technique in ergonomics where a product or

workplace is evaluated by trial using a mock-up or prototype on a selected user group that is representative of the total target population. [Case et.al. 2001]. This report discusses the anthropometrics data suggested by ADA in preparing for the prototype tricycle.

3.0 DESIGN CONSIDERATIONS

In building the prototype tricycle many design factors need to be considered. However this paper will only focus on the anthropometrics considerations in the design of the frame, handle, platform, ramp and footrest of the tricycle. Refer Figure 1.

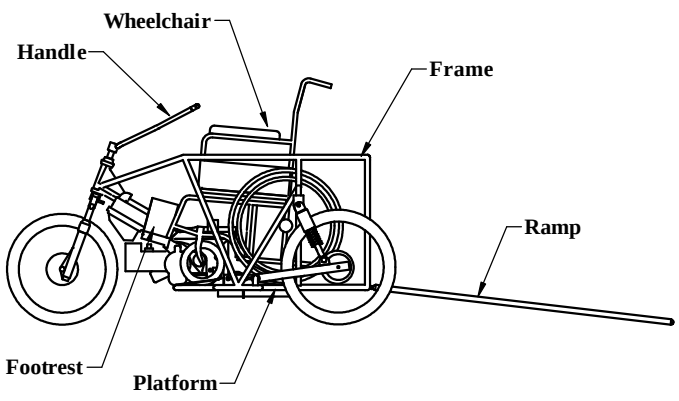


Figure 1 Schematic design of the tricycle

The design will focus on the anthropometrics data that will contribute to comfort of arm position, leg position and body posture. Refer Figure 2.

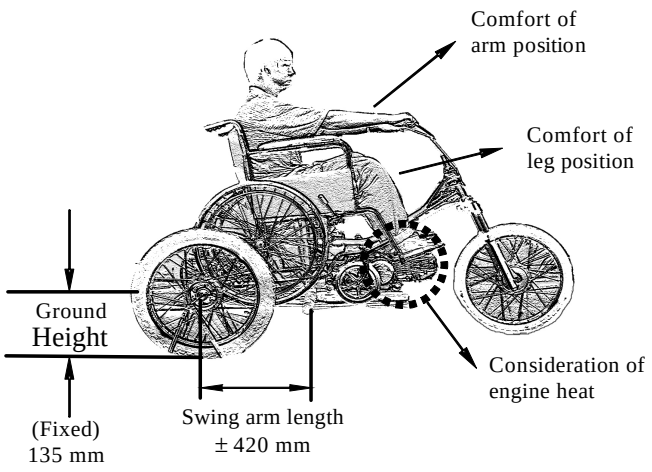


Figure 2 Consideration for design

3.1 Frame design

The frame basically consists of handrails on both sides of the platform. The function of the handrail is to assist the handicap in moving and adjusting wheelchair position on the tricycle. The handrail also acts as a safety fence. In designing the handrail ADA Standards For The Accessible Design Pt.36 is referred. The main factors that need to be considered are :

i) Width

The recommended minimum clear width for single wheelchair passage is 36 in (925mm).

ii) Height

The recommended height of the top of the handrail gripping surface is between 34 in and 38 in (865 mm and 965 mm) above floor surface.

iii) Diameter

The recommended diameter or width of the gripping surfaces of a handrail is 1.25 in to 1.5 in (32 mm to 38 mm)

iv) Other factors

Recommendations for structural strength is also provided in the standard.

3.2 Handle Design

No guideline is provided by ADA for the design of the handle of the tricycle. However section A4.2.5 and A4.2.6 recommended the reach range as between 17 in to 31 in (432 mm to 787 mm) radius. Section 4.2.5 suggests maximum forward reach of 48 in (1220 mm) to the minimum of 15 in (380 mm).

3.3 Platform design

Several issues are addressed in designing this platform. They are:

i) width

ADA Standards For The Accessible Design Pt. 36 section 4.2.1 recommended minimum clear width for single wheelchair passage shall be 32 in (815 mm) at a point.

ii) length

ADA Standards For The Accessible Design Pt. 36 section 4.2.4.1 recommended minimum clear floor space requirement to accommodate a single and stationary wheelchair and occupant is 30 in by 48 in (760 mm by 1220 mm).

iii) height

ADA Standards For The Accessible Design Pt. 36 does not provide this dimension.

3.4 Ramp design

In the case of ramps and landings with drop-offs, it is recommended that it should have projecting surfaces to prevent from slipping off. The minimum height of this edge is 2 in (50 mm). ADA Standards for the Accessible Design Pt. 36 section 4.8.2 recommended the maximum slope of a ramp shall be 1:12.

3.5 Footrest design

A special footrest has to be design apart from wheelchair footrest to facilitate the tricycle's user comfort. ADA Standards For The Accessible Design Pt. 36 does not provide dimension regarding designing the footrest.

4.0 ACCESSIBILITY AND MEASUREMENT

Several design factors have been considered in building the tricycle prototype. Each design factor will be elaborated in this section individually.

4.1 Frame design

The information on the design of the frame is adequate and will be applied in the prototype. However trials will be conducted to verify the suitability on the Malaysian disabled population. Refer Figure 3 and Figure 4. The proposed height is 26.4 in (671 mm).

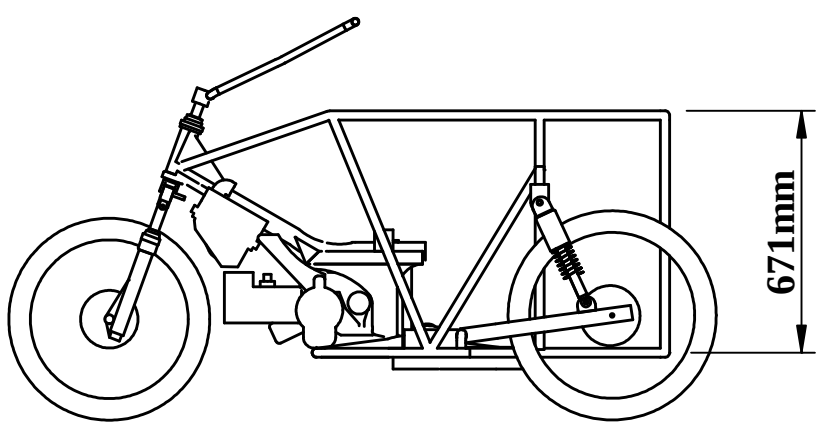


Figure 3 Side view of tricycle.

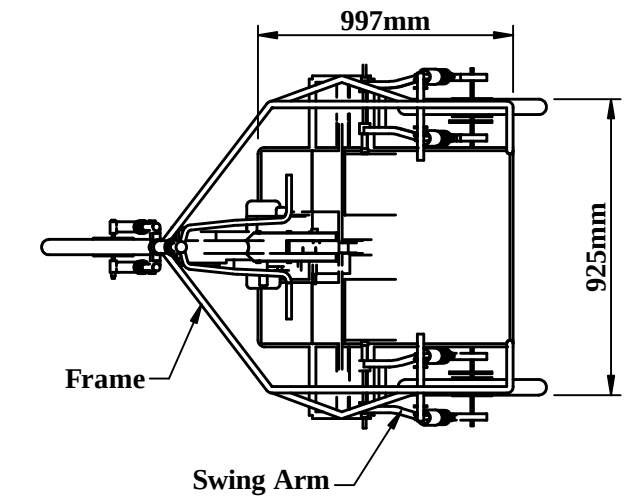


Figure 4 Tricycle plan view to show the width of frame and length of the platform

4.2 Handle design

Since no guideline is available on design of handle, the max-min reaches range will be used as a guideline. The minimum reach range of 22 in (560 mm) radius will be used for the prototype. The height of the handle will be set to 38.6 in (980 mm) well within the range suggested. In driving the tricycle, the user may be exposed to prolong position of extended arms. It would be desirable to allow the elbows to rest on the armrest of the wheelchair. Thus fitting trials is crucial here in determining the most comfortable posture and dimensions. Refer Figure 5.

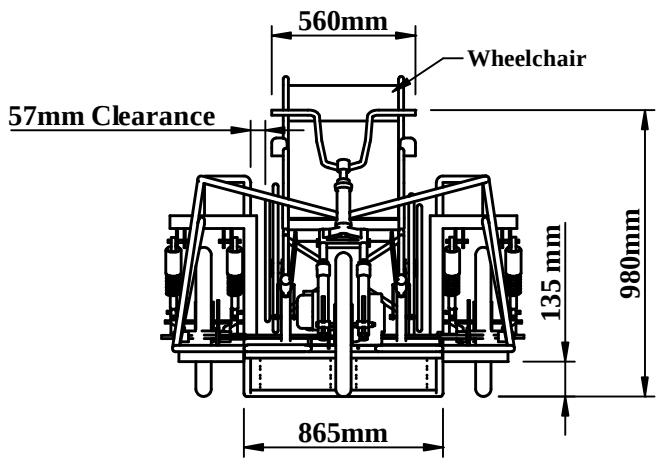


Figure 5 Front view of the proposed prototype tricycle

4.3 Platform design

Referring to Figure 4, the length of the platform chosen in this study is 39.25 in (997 mm). The dimension of the platform's length also took into consideration the front chassis length of the motor to drive the tricycle. The dimension of the platform's length is based on the swing arm length, comfort of arm position while driving, comfort of leg position while driving and consideration of engine heat emitted while driving. Please refer to Figure 2. The researchers has to conduct fitting trials on a selected group in order to obtain the best suited length dimension for the tricycle.

Figure 5 shows the platform's width to accommodate the wheelchair and its occupant. From Figure 5, the width dimension that had been chosen is 34 in (865 mm). The selected width dimension able to fit wheelchair size and its passage for the user to embark and disembark the tricycle. The clearance enable the wheelchair user to position him/herself ergonomically onto the tricycle. The clearance width is also important for the maneuvering of front wheel during disembarking the tricycle. The researchers has to conduct fitting trials on a selected group in order to obtain the best suited width dimension for the tricycle.

Figure 5 also shows the height of the platform from the ground. ADA Standards For The Accessible Design Pt. 36 does not provide this dimension. The height of the platform chosen for this prototype tricycle is 5.3 in (135 mm). The researchers will conduct fitting trials on a selected group in establishing the best-suited height of the platform. The platform height dimension will determine the slope and the length of the ramp.

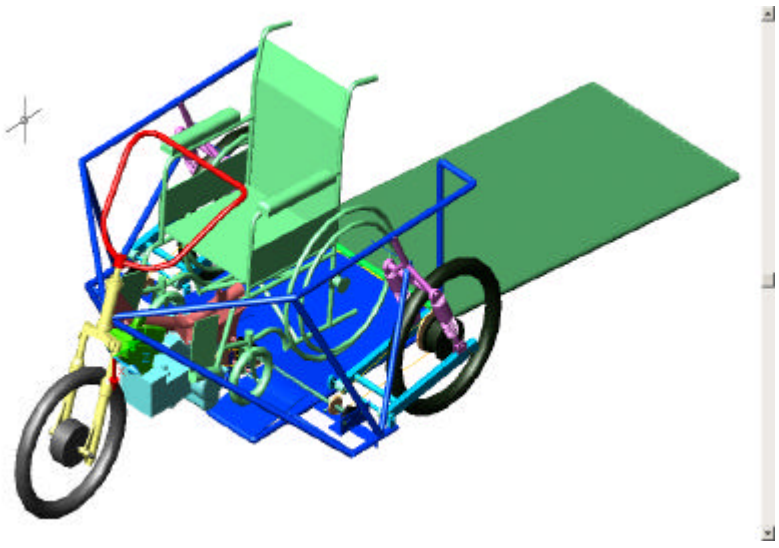
4.4 Ramp design

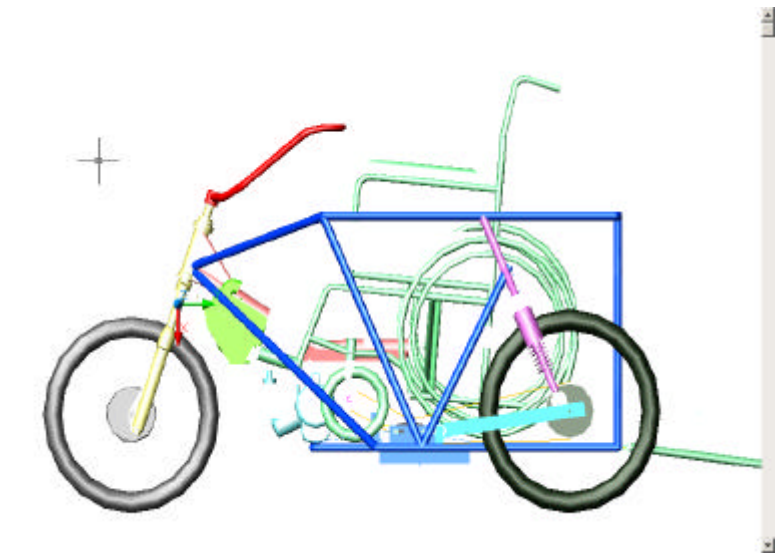
Figure 1 also shows the proposed length of the ramp. The proposed dimension in this study is 59.5 in (1511 mm). The length of the ramp and the height of the platform will determine its slope. For this proposed prototype tricycle the slope calculated is 1:11.

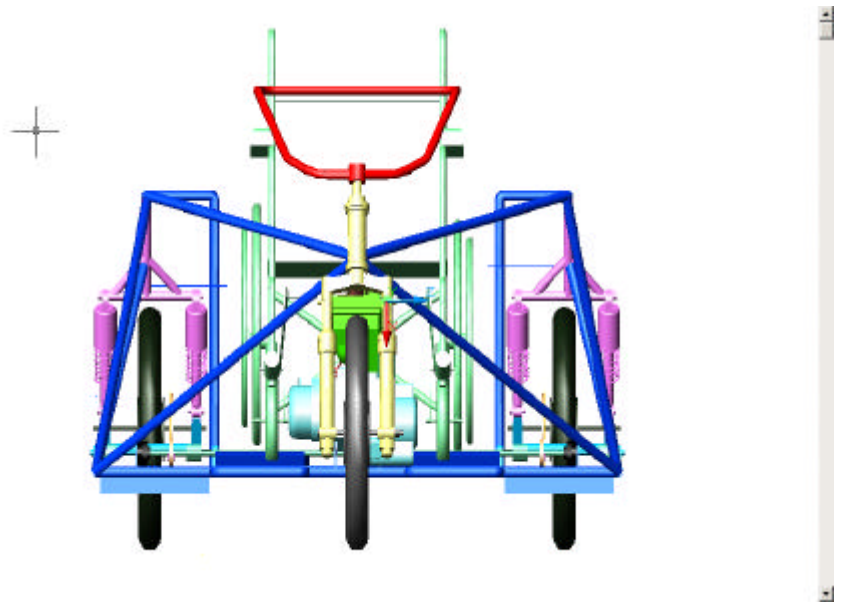
4.5 Footrest design

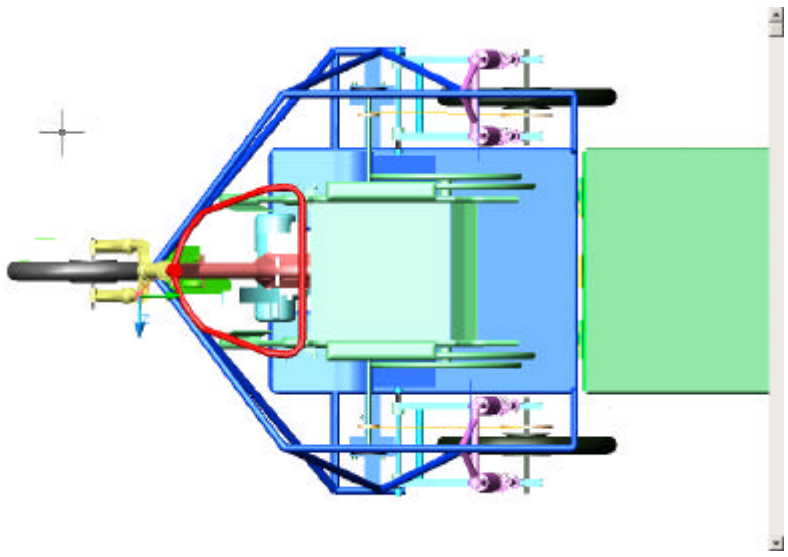
The footrest of the wheelchair cannot be used as it is hindered by the engine block that drives the tricycle. Thus an extra footrest needs to be incorporated into the tricycle. This special footrest is designed in such a way that it is part of the engine block cover design. It is foldable so that the tricycle user ca easily adjust his/her reach comfort while driving the tricycle.

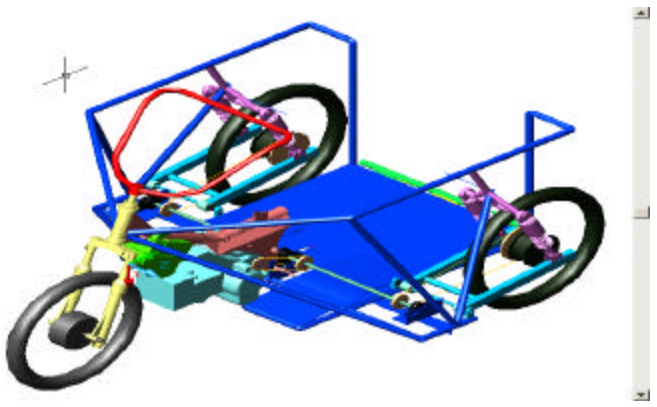
5.0 MODELLING USING COMPUTER AIDED DESIGN



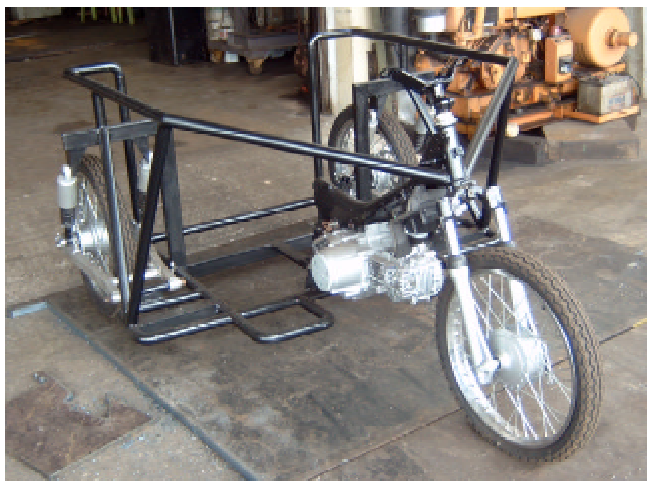








6.0 FABRICATION FOTO



7.0 FINAL PROTOTYPE FOTO

8.0 TESTING FOTO

9.0 CONCLUSION

We have reported five main design factors in building the prototype tricycle. Only ADA Standards For The Accessible Design Pt. 36 has been referred as dimension guideline in building the tricycle prototype. Albeit not all dimensions required are available. Other anthropometric data standard would be of helpful nevertheless is virtually non-existence.

The main parts of the prototype tricycle such as the frame, handle and platform have been fabrication. Fitting trials on a selected group of user should be conducted as field study to establish the suitable static and dynamic anthropometric data that will contribute to the comfort and safety for the users. Furthur inprovement on the tricycle should be carried out for furthur research project.

ACKNOWLEDGEMENT

The researchers would like to acknowledge MODENAS for contributing main motorcycle components and UTM research management center for their assistence in this project.

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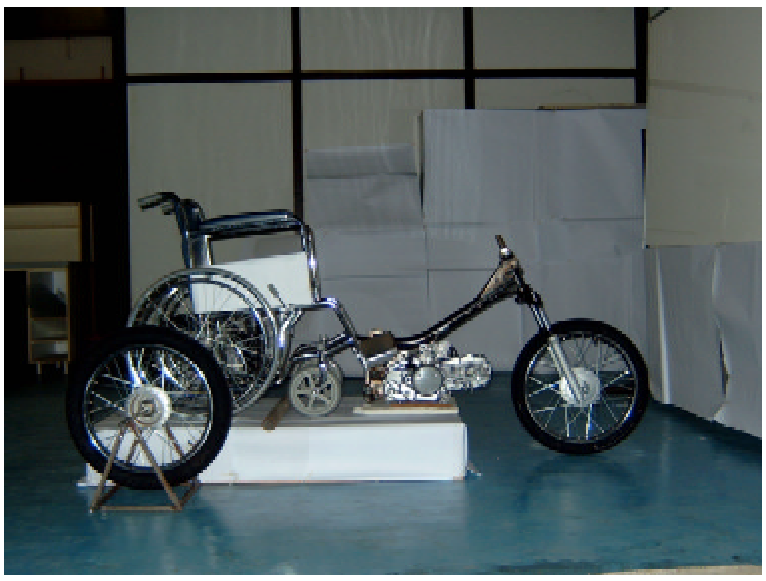
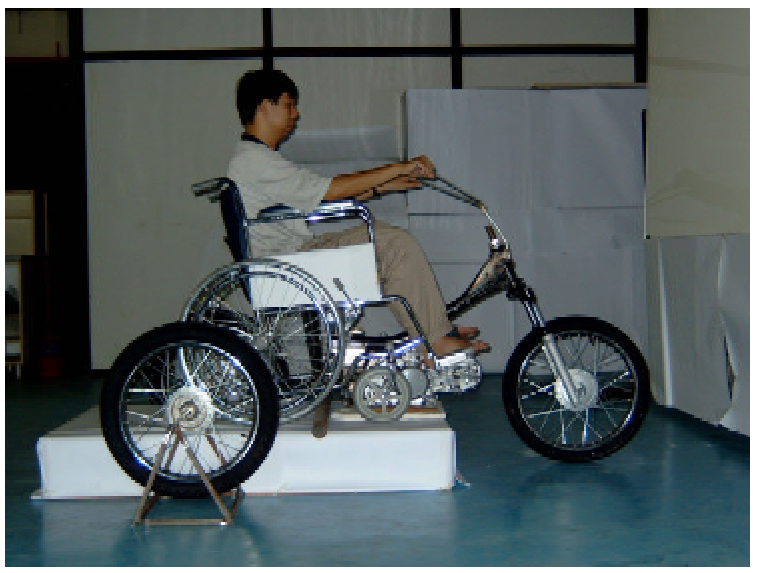
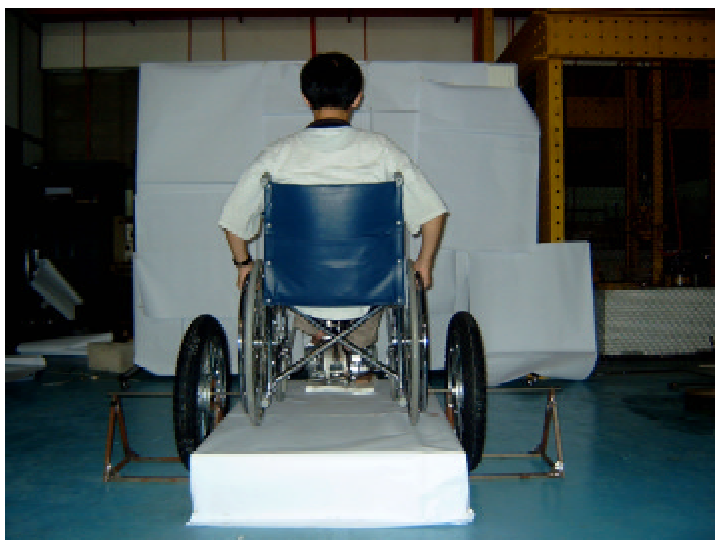
APPENDIX :
EXTRA FOTO








UTM


UTN

Khalid, H.M., Lim, T.Y., and Lee, N.K. (Editors), *Proceedings of SEAMEC 2003*, Kuching.

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Anthropometric factors in the design of a motorised tricycle for wheelchair users

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Abstract
This paper reports on an ongoing research on the motorised tricycle for disabled person. This tricycle is specifically designed to suit wheelchair occupants of healthy upper torso with pelvic to foot restraint. It is also designed to suit a commonly available wheelchair. Existing tricycle for disabled requires a disabled person to dismount from the wheelchair onto the tricycle. The motorised tricycle in this project is designed to overcome this problem by allowing the disabled person to wheel up or down his wheelchair onto or down the tricycle. This is achieved using a specially designed platform that allows the wheelchair to be wheeled up or down. The prototype of this tricycle is in fabrication. The anthropometrics data that need to be considered in the design of the platform and frame of the tricycle will be gathered from the fitting trial field study.

Keywords Anthropometrics, design, disabled users, motorised tricycle

1. Introduction

Mobility is an important requirement in providing motor-disabled adults opportunities for independent living and working. There have been many published examples of the disabled contributing to the workforce not just in service sector but also in industrial sector (Kochan, 1996, Burke 1999). Mobility may also contribute to self-employment of the motor-disabled.

A successful effort to include motor-disabled employees into the workforce not only involved adjustments to the workplace and work environment but also the issues of facilitating the transportation of these employees to and from work. Many specially designed vehicles have been built for this purpose.

Universiti Teknologi Malaysia is conducting a project that aims to design and fabricate a prototype tricycle to improve mobility of the motor-disabled with healthy upper torso but pelvic to foot restraint. In building this prototype the researcher discovered that relevant anthropometrics data on the disabled in Malaysia is virtually non-existence. Thus the researchers will use the ADA Standards For The Accessible Design Pt. 36 guidelines to build the tricycle and then conduct field study to gather information on the modifications required suiting the tricycle to the Malaysian motor-disabled population.

This project is aimed to identify the guidelines that may be used for the design of the prototype for Malaysian motor-disabled population.

2. Problem identification

Various methods has been researched and used to increase mobility of the motor-disabled. Some focused on improving the mobility of the wheelchair [Krovt et.al 1994, Sanders & Stott 1999]. These allow improvements in the use of the wheelchair but it is not a viable means for long-distance travel. Motorized vehicles such as buses, vans, cars and motorcycles are usually customized for this purpose.

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The new tricycle is a modification of a motorcycle that allows the disabled to wheel-up the wheelchair onto the specially designed platform, secure the wheelchair for safety and drive. It is hoped that this new design will ease and improve mobility.

The basic task of anthropometry for the disabled is to shape the man's surrounding in accordance with his disabilities [Nowak, 1996]. Thus the use of anthropometrics data on the disabled is important in ensuring that the tricycle will fulfill the comfort and safety of the users. The prototype will be made based on the standard and guidelines provided by ADA Standards For The Accessible Design Pt. 36 due to the lack of data on Malaysian disabled population.

Once the prototype is built, fitting trials will be conducted to evaluate the tricycle. Fitting trials are an established technique in ergonomics where a product or workplace is evaluated by trial using a mock-up or prototype on a selected user group that is representative of the total target population [Case et.al. 2001]. This paper discusses the anthropometrics data suggested by ADA Standards For The Accessible Design Pt. 36 in preparing for the prototype tricycle.

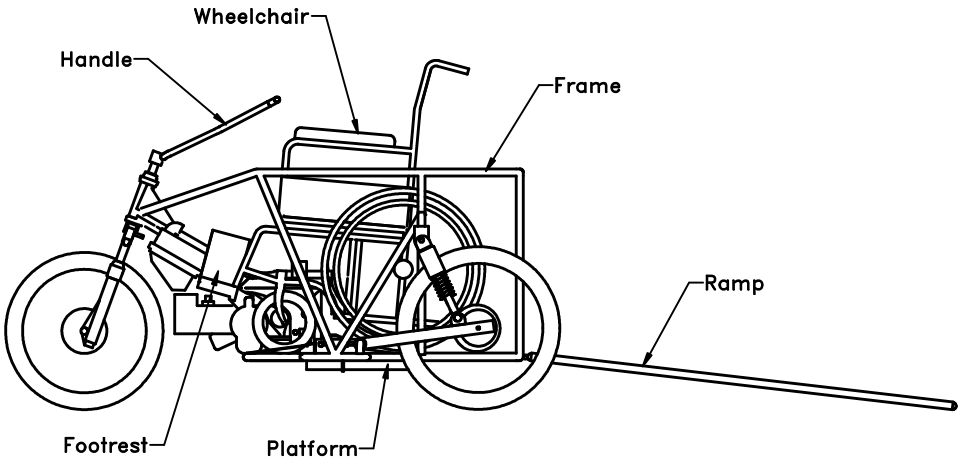

Figure 1: Schematic design of the tricycle

3. Design considerations

In building the prototype tricycle many design factors need to be considered. However this paper will only focus on the anthropometrics considerations in the design of the frame, handle, platform, ramp and footrest of the tricycle. Refer Figure 1.

The design will focus on the anthropometrics data that will contribute to comfort of arm position, leg position and body posture. Refer Figure 2.

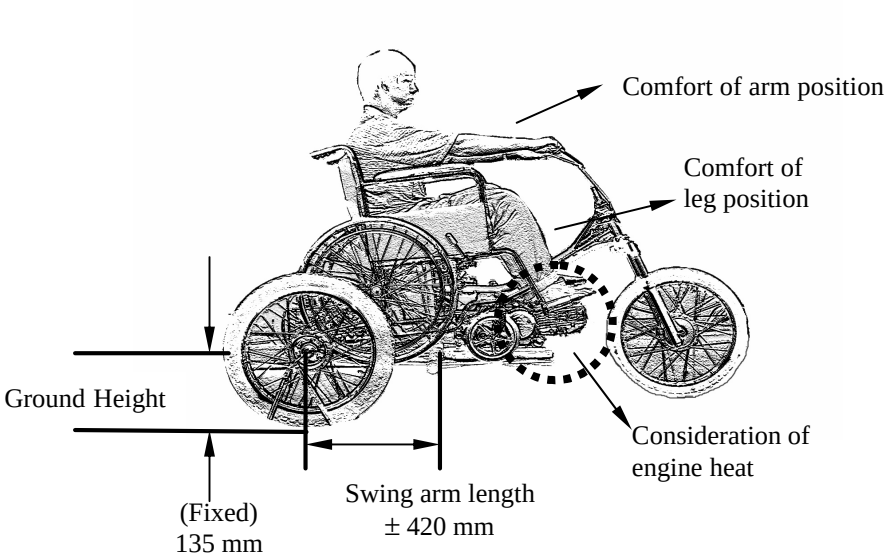

Figure 2: Consideration for design

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3.1 Frame design

The frame basically consists of handrails on both sides of the platform. The function of the handrail is to assist the handicap in moving and adjusting wheelchair position on the tricycle. The handrail also acts as a safety fence. In designing the handrail ADA Standards For The Accessible Design Pt.36 is referred. The main factors that need to be considered are :

i) Width
The recommended minimum clear width for single wheelchair passage is 36 in (915mm).

ii) Height
The recommended height of the top of the handrail gripping surface is between 34 in and 38 in (864 mm and 965 mm) above floor surface.

iii) Diameter
The recommended diameter or width of the gripping surfaces of a handrail is 1.25 in to 1.5 in (32 mm to 38 mm)

iv) Other factors
Recommendation for structural strength is also provided in the standard.

3.2 Handle design

No guideline is provided by ADA Standards For The Accessible Design Pt.36 for the design of the handle of the tricycle. However section A4.2.5 and A4.2.6 recommended the reach range as between 17 in to 31 in (432 mm to 787 mm) radius. Section 4.2.5 suggests maximum forward reach of 48 in (1220 mm) to the minimum of 15 in (381 mm).

3.3 Platform design

Several issues are addressed in designing this platform. They are:

i) Width
ADA Standards For The Accessible Design Pt. 36 section 4.2.1 recommended minimum clear width for single wheelchair passage shall be 32 in (815 mm) at a point.

ii) Length
ADA Standards For The Accessible Design Pt. 36 section 4.2.4.1 recommended minimum clear floor space requirement to accommodate a single and stationary wheelchair and occupant is 30 in by 48 in (760 mm by 1220 mm).

iii) Height
ADA Standards For The Accessible Design Pt. 36 does not provide this dimension.

3.4 Ramp design

In the case of ramps and landings with drop-offs, it is recommended that it should have projecting surfaces to prevent from slipping off. The minimum height of this edge is 2 in (50 mm). ADA Standards for the Accessible Design Pt. 36 section 4.8.2 recommended the maximum slope of a ramp shall be 1:12.

3.5 Footrest design

A special footrest has to be design apart from wheelchair footrest to facilitate the tricycle's user comfort. ADA Standards For The Accessible Design Pt. 36 does not provide dimension regarding designing the footrest.

4. Accessibility and measurement

Several design factors have been considered in building the tricycle prototype. Each design factor will be elaborated in this section individually.

4.1 Frame design

The information on the design of the frame is adequate and will be applied in the prototype. However fitting trials will be conducted to verify the suitability on the Malaysian disabled population. Refer Figure 3 and Figure 4. The proposed height is 26.4 in (671 mm).

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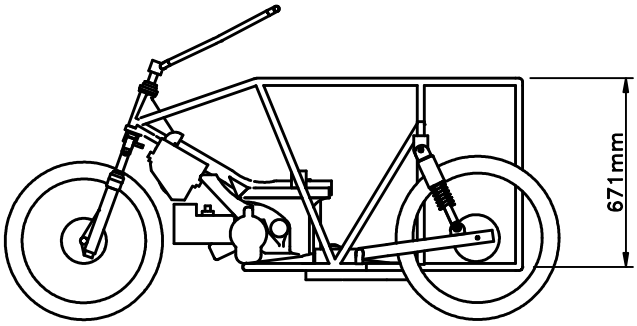

Figure 3: Side view of tricycle.

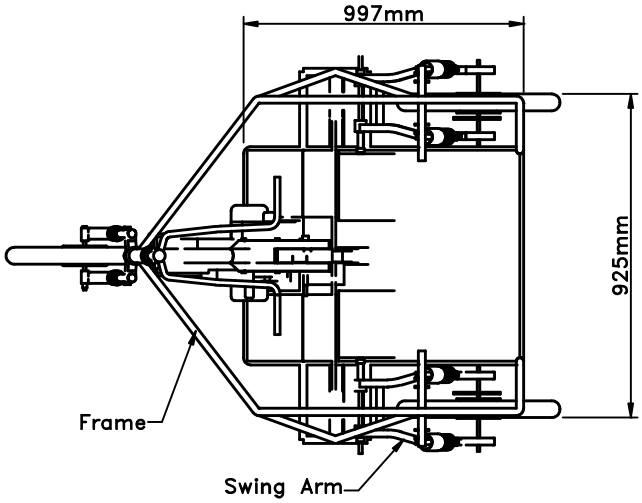

Figure 4 Tricycle plan view to show the width of frame and length of the platform

4.2 Handle design

Since no guideline is available on design of handle, the max-min reaches range will be used as a guideline. The reach range of 22 in (560 mm) radius will be used for the prototype. The height of the handle will be set to 38.6 in (980 mm) well within the range suggested. In driving the tricycle, the user may be exposed to prolong position of extended arms. It would be desirable to allow the elbows to rest on the armrest of the wheelchair. Thus fitting trials is crucial here in determining the most comfortable posture and dimensions. Refer Figure 5.

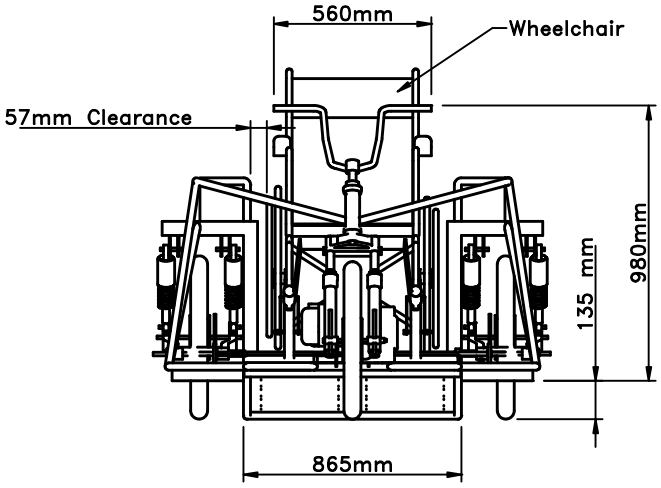

Figure 5 Front view of the proposed prototype tricycle

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4.3 Platform design

Referring to Figure 4, the length of the platform chosen in this study is 39.25 in (997 mm). The dimension of the platform's length also took into consideration the front chassis length of the motor to drive the tricycle. The dimension of the platform's length is based on the swing arm length, comfort of arm position while driving, comfort of leg position while driving and consideration of engine heat emitted while driving. Please refer to Figure 2. The researchers have to conduct fitting trials on a selected group in order to obtain the best suited length dimension for the tricycle.

Figure 5 shows the platform's width to accommodate the wheelchair and its occupant. From Figure 5, the width dimension that had been chosen is 34 in (865 mm). The selected width dimension would fit wheelchair size and its passage for the user to embark and disembark the tricycle. The clearance would enable the wheelchair user to position him/herself ergonomically onto the tricycle. The clearance width is also important for the maneuvering of front wheel during disembarking the tricycle. The researchers have to conduct fitting trials on a selected group in order to obtain the best suited width dimension for the tricycle.

Figure 5 also shows the height of the platform from the ground. ADA Standards For The Accessible Design Pt. 36 does not provide this dimension. The height of the platform chosen for this prototype tricycle is 5.3 in (135 mm). The researchers will conduct fitting trials on a selected group in establishing the best-suited height of the platform. The platform height dimension will determine the slope and the length of the ramp.

4.4 Ramp design

Figure 1 also shows the proposed length of the ramp. The proposed dimension in this study is 64 in (1626 mm). The length of the ramp and the height of the platform will determine its slope. For this proposed prototype tricycle the slope calculated is 1:12.

4.5 Footrest design

The footrest of the wheelchair cannot be used as it is hindered by the engine block that drives the tricycle. Thus an extra footrest needs to be incorporated into the tricycle. This special footrest is designed in such a way that it is part of the engine block cover design. It is foldable so that the tricycle user can easily adjust his/her reach comfort while driving the tricycle.

5. Conclusion

We have reported five main design factors in building the prototype tricycle. Only ADA Standards For The Accessible Design Pt. 36 has been referred as guidelines in building the tricycle prototype. Albeit not all dimensions required are available. Other anthropometric data standard would be of helpful nevertheless is virtually non-existence.

The main parts of the prototype tricycle such as the frame, handle and platform are under fabrication. Fitting trials on a selected group of user will be conducted as field study to establish the suitable static and dynamic anthropometric data that will contribute to the comfort and safety for the users.

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7. References

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