Jurnal Teknologi

Full paper

A New Design of Multi-Functional Portable Patient Bed

M. N. Mohammed[a*], N. G. Khrit[a], M. A. Abdelgnei[a], Es. Abubaker[a], A.F. Muftah[a], M. Z. Omar[a], M. S. Salleh[a]

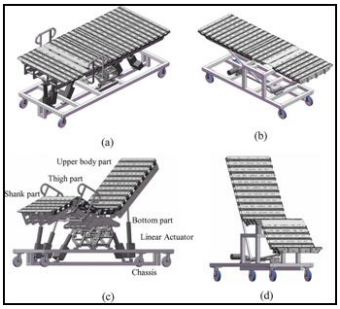
[a]*Department of Mechanical and Materials Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor Darul Ehsan, Malaysia*

*Corresponding author: mohammed.ukm@gmail.com

Article history

Received : 29 March 2012
Received in revised form : 20 June 2012
Accepted : 30 October 2012

Graphical abstract



Abstract

A patient's portable bed defined as a very special designed bed used for patients denotes the "special design" of such a device which has typical features meeting the needs of a bedridden patient. It is also defined as an advanced device or mechanism used to carry and transfer a patient's body which is typically developed to meet the patient's physical demands such as mobility or movement. A new method in a rehabilitation bed for transporting a bedridden patient is developed and applied to avoid staying at hospital with costly medical treatment and such obstacles, therefore to conquer these problems, the proposed design of the bed is formulated based on literature survey as well as consult the medical staff. This paper discusses the specification ,mechanism design and evaluating healthcare activities for development of a new style of active bed that provides high mobility with comfortable sleeping for bedridden persons and it also can meet the demands of those who may be required to take hospital beds to use at home particularly in a case of nursing disabled persons..

*Keywords:*Patient's bed; home care; chronic illnesses, mechanism design, rehabilitation bed

1.0 INTRODUCTION

Due to the advances of modern technologies, a wide variety of means equipped with more modern designed materials have been developed for patients. Such means have been developed in a way that they suit the patient's injury and the affected area. The major motivation of carrying out the present research was a number of the troubles encountered by bedridden patients and caregivers in the healthcare scale. Many patients spend a long time at hospital under unneeded special and costly medical treatment, thus, being far from their families, feeling alone and bored. What worse is that they are encountered by two major problems related to posture changing and moving problems when he/ she is required to stay on the bed for a long time. Another motivation for conducting the present study was that sometimes, such a hospital bed is needed by some people to be used at home and particularly, for nursing disabled persons. To overcome such burdens and obstacles, Shih-Wei *et al.* [1] developed and applied a new bed design concept for the bedridden patients which can perform various functions since it consists of twelve pieces including the upper part, the bottom part, the thigh part, and the shank part as displayed in Figure 1. Such features make the bed very flexible for patients to be able to overcome such problems concerning their physical demands as it becomes possible for him/ her to rise up from a lying to sitting position, rise the legs up, and turn the body right or left. Since it is combined with the transferring function, the patient can be transferred more comfortably and more safely via using the belt transfer system [1-2]. However, this cannot be done with the regular bed as it lacks the necessary elements which support the patient with the possibility to move or have a typical position depending on his/ her case and cannot offer support to the back, thigh or shank [4]. Thus, such problems and obstacles were the reasons motivating those specialists to develop a new type of bed which can meet all patients' need [5-8]. Therefore, the major aim of the present study was to develop a prototype of hospital bed along by using basic technological devices with a new mechanism for laying and transporting a bedridden patient and enabling the patient to have more mobility and a more comfortable position at home.

2.0 DESIGN CONCEPT

In attempting to meet the patients' needs, a survey was conducted for many cases (patients and caregivers) which aimed at proposing a new prototype to provide their needs. The survey form was divided into 3 parts. First part gathers basic information on the background of the respondents such as gender, weight and height; whilst the second part gathers information on their experience and expectation for using the patient's bed while the

last part shows rating the performance of the product from the viewpoint of hospital's maintenance workers and nurses, as well as opinions and suggestions to improve the current design. About 30 respondents have answered the questionnaire. Fig.1 represents features that interested by respondents, 69% of the respondents hope to use the bed with backrest and thigh rest features. According to the statistical analysis that indicated show large number of pains is related to postural stability. Feeling pain corresponds to lower back area is 56% while upper back area is 35%. The rest of the problems are not very significant despite feeling boredom (23%) as shown in the chart.

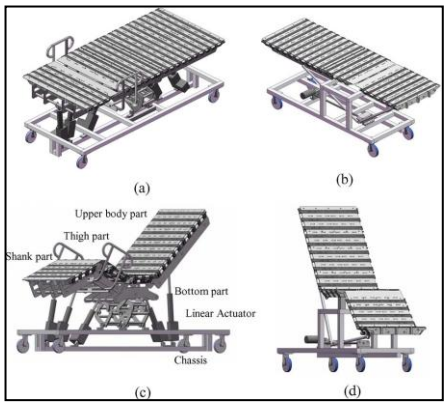


Figure 1 The simple mechanism of the multi-function main bed and nursing bed (a) main bed before transformation. (b) Nursing bed before transformation. (c) Main bed after transformation. (d) Nursing bed after transformation.[3]

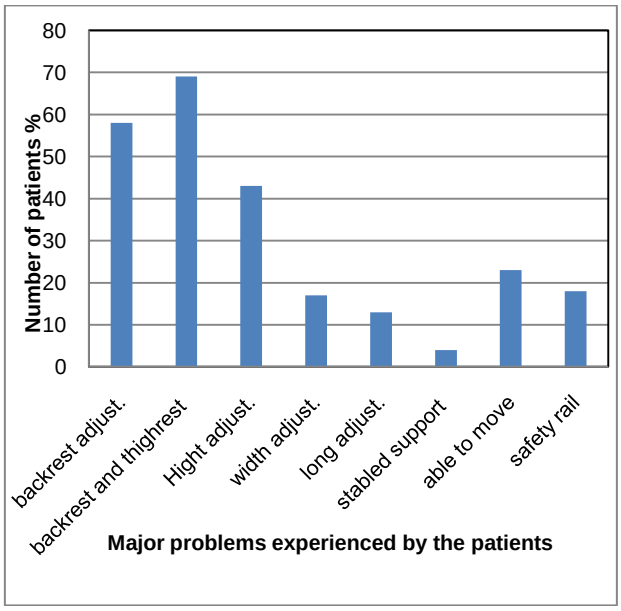


Figure 2 The importance of major needs from viewpoint of respondents

It was found that although many beds were used in hospitals, this typical design of such a bed having main parts similar to the standard Gatch type in the market [12] was suitable to solve the main problems related to ergonomic issues, easiness to separate and transfer. Moreover, the design was found to be more convenient to fulfill the necessary safety requirements as well as performance and improved durability. It was stated that the anthropometric data of adult bodily proportions in East Asia countries were the basics for designing these features and the dimensions used in this bed development [8-9]. Therefore, this extensive use of the data made the bed suitable and relevant to the target market in Malaysia. Figure 3 and 4 display the structure and assembling scheme of the portable patient's bed as a whole.

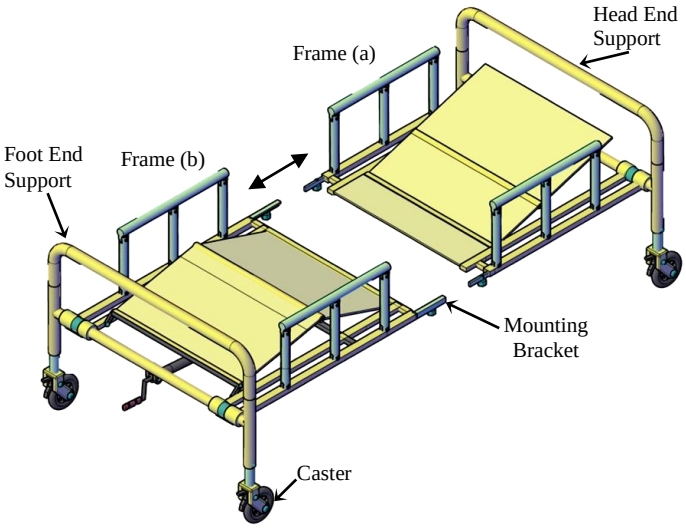


Figure 3 Overall design and assembly mechanism of the bed

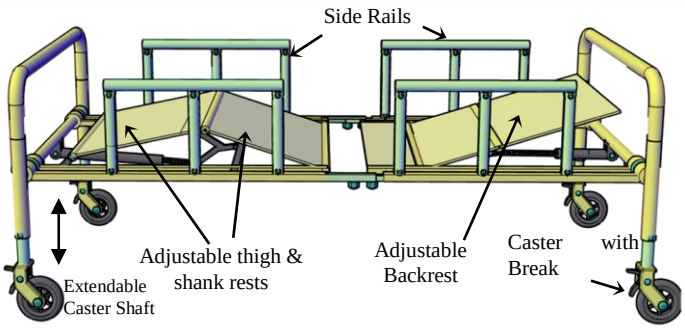


Figure 4 Ergonomic and safety enhancement of the bed

As displayed in the figures, the parts of the bed represented by the side shape of the laying seat are the backrest, thigh rest and shank rest seats which have separate designs so that the ergonomic effects can be more enhanced. As estimated, the overall dimension of the laying seat is about 1900mm length 910 mm width. It is also possible to expand the length until 100 mm by making adjustment to the connection bar between frames. The material which suits the laying seat is the polyvinyl chloride (PVC) due to its light weight and strength.

■3.0 MECHANISM DESIGN

The current study was prepared and proposed based on the various ways and instructions on how to design and develop patient's bed. The design of new concept of the new prototype was conducted through using computer-aided design (CAD) software's: AutoCAD and CATIA to design the main mechanism of the bed. The major design specifications of the bed are listed as follows:

- Length: 190 cm and can be adjusted at the connecting bar to 200 cm
- Width: 950 cm (laying seat).
- Height: 550 cm
- Backrest angle arise from 0 – 75^o
- Thigh and Shank rest angle arise from 0 - 45^o
- Weight 65 kg
- Able to support over 250 kg.
- Ability to fold side rails.
- Ability to separate the bed to two main parts
- Ability to fold side stands when the bed transported.
- Wheel with four brake with diameter 150 mm

The all parts of the patient bed illustration can be seen in Figure 5

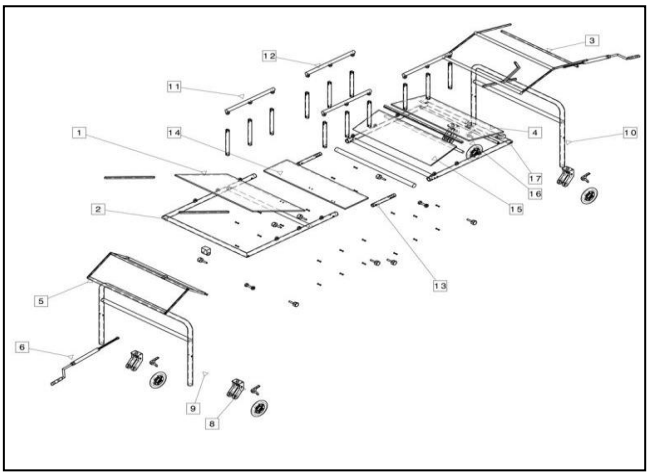


Figure 5 The dissociation of main parts of the bed

■4.0 MECHANISM FOR CONNECT TO SUPPORT FUNCTION

The ability to be separated from the middle of the main frame and turning the side supports at the same level of the frame are the major characteristics in this design mechanism. Such a structure makes it possible for the user to make bed as long as he/she needs in approximate length of 100 mm [8-9]. By implementing such a new mechanism, it is becoming easier to get the parts of the bed separated and transported. The two side stands are articulated, removable and built with aluminum alloy [10]. The design of the articulation systems permits the side stands to fold positions by turning them toward the main frames. Figure 6 & Figure 7 display the structure and assemblage of the prototype proposed which show evidently the points that can be folded and adjusted.

■5.0 MECHANISM FOR POSTURE CHANGING FUNCTION

Another characteristic of this new bed design is that such a design provides users with sufficient degrees of freedom to as to be able to alternate or change the bed posture. Moreover, the backrest is designed in a way that it is combined with a suitable mechanism to serve the patient's preferences [11-14]. The user can adjust it to a maximum of 75^o upward to the initial position. This is because it is provided with a handle crane mechanism which can be used for satisfactory and optimum adjustment. Adjustment is also provided through the designed thigh and shank rest, and the mechanism of this part quite resembles the backrest. Both of the thigh rest and the shank rest can be raised simultaneously in positions just opposite to each other. The importance of such a mechanism is represented by its function to serve the ergonomic requirements which indicate forming the thigh support to simulate the human knee set when it is turned as seen in Figures 8, 9 and 10.

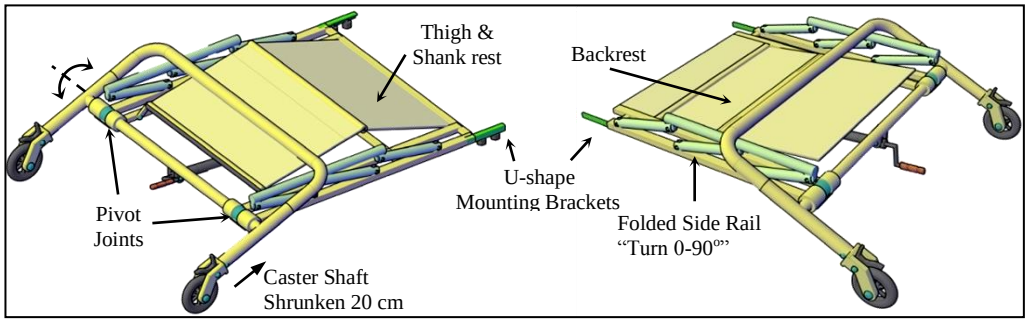


Figure 6 Connect main frame to support

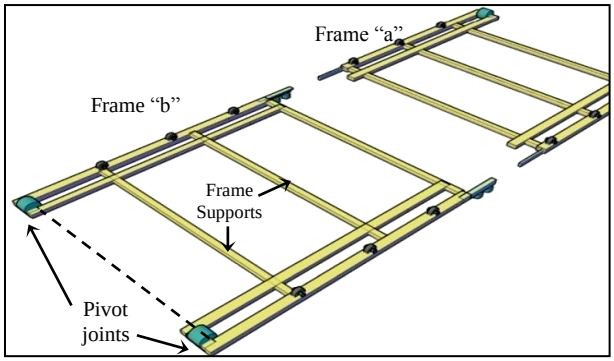


Figure 7 Structure and link the main frame

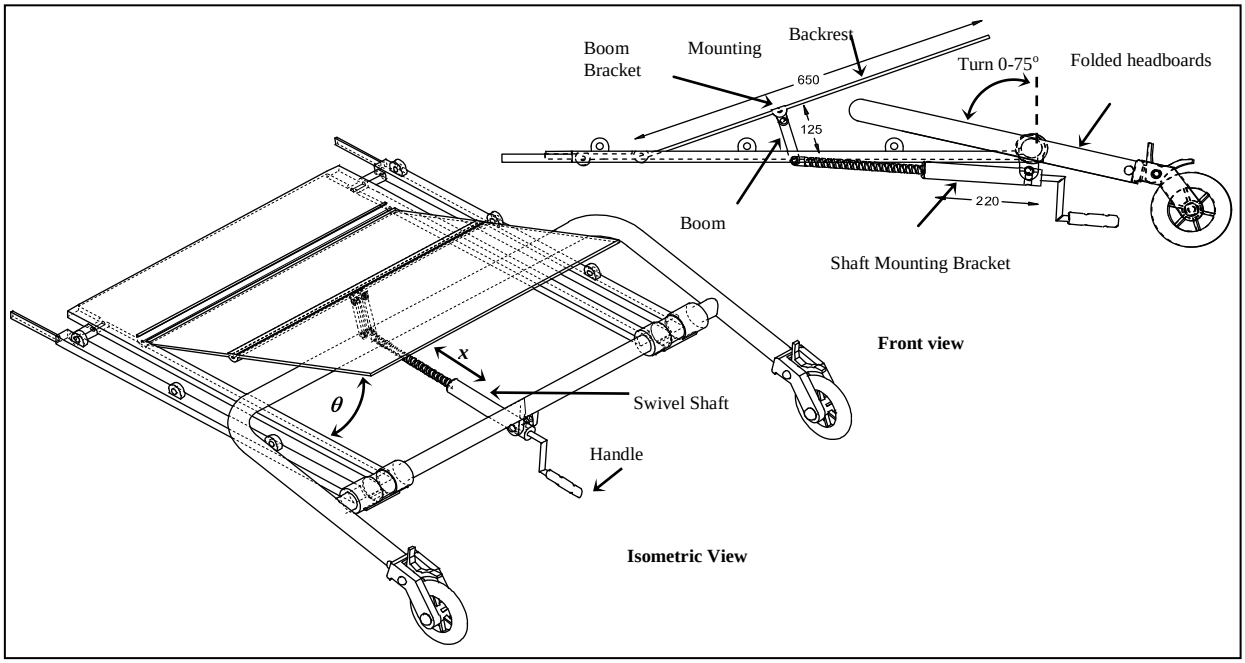


Figure 8 Assembly mechanism of the backrest

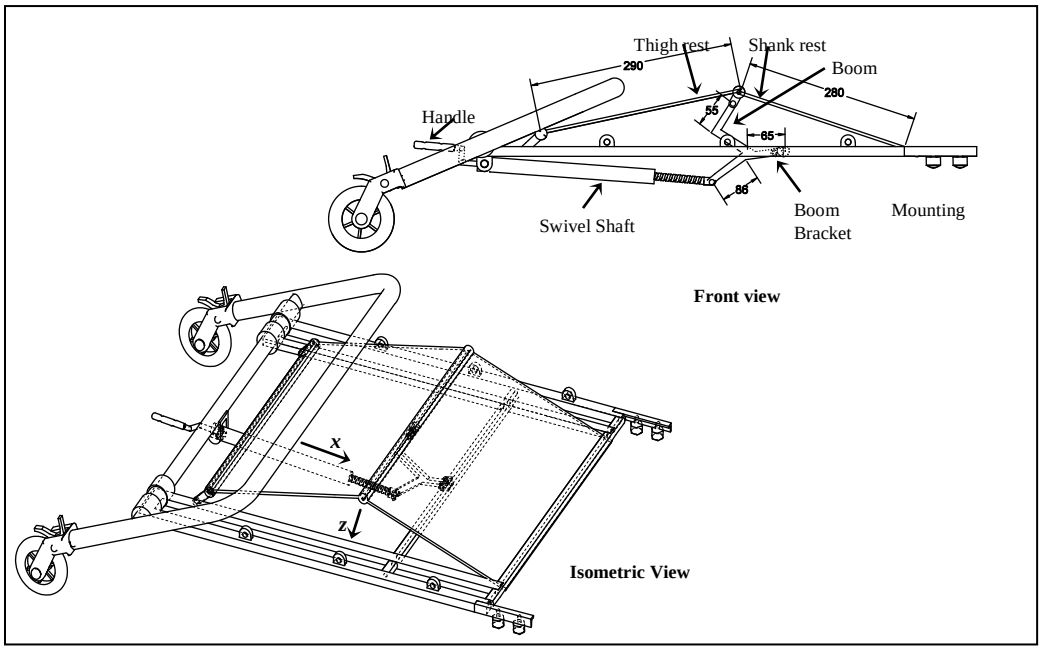


Figure 9 Assembly mechanism of the thigh and shank rest

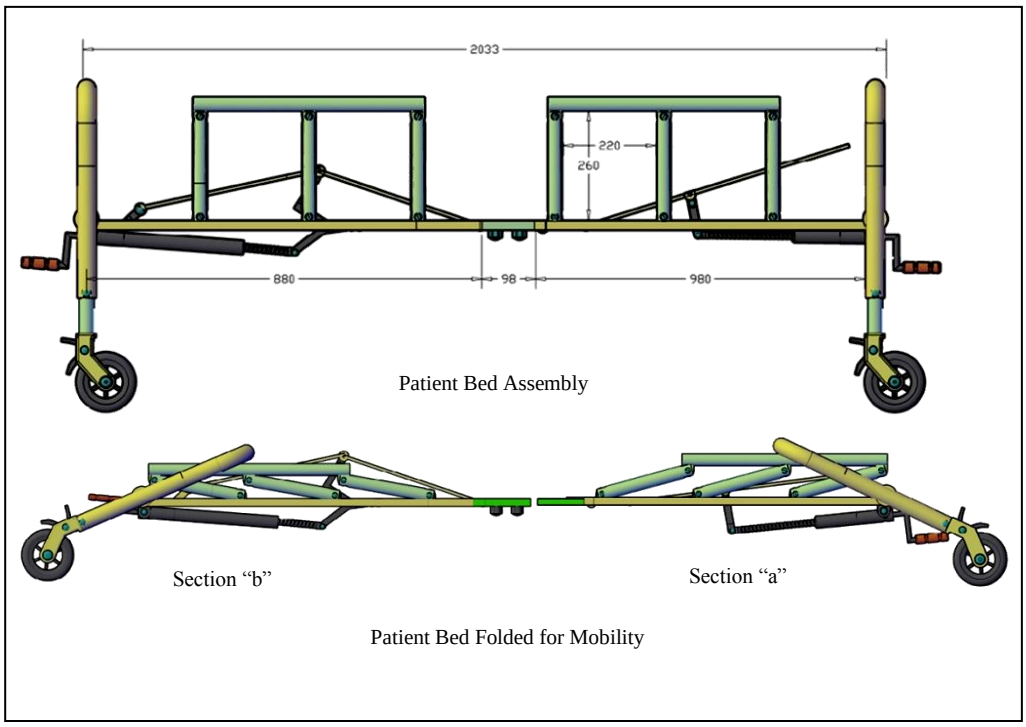


Figure 10 Front view with dimensions for the structure and assembling scheme design

■6.0 MECHANISM OF GUARD RAILS

In designing the guard rails, the non-existence of any space left within since the safety of the patient is one of main importance, the rail that has a distance greater than 220 mm was taken into consideration [15-16]. They were designed and developed in a way that only minimal gaps and no slots were left so that the patient would not be easily entrapped. Moreover, attaching the rails to the bed frame was done in a way that no gap was larger than 120 mm between the mattress and the rail as illustration in Figure 11. The main specification of multifunctional bed design with weight and material parts can be seen in table 1.

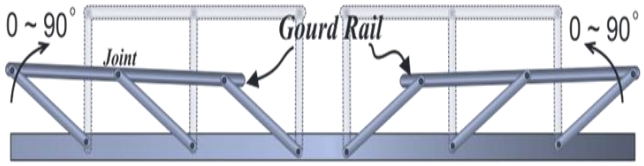


Figure 11 Assembly mechanism of the guard rails

Table 1 The specification of multifunctional bed design

No.	Quantity	Part	Material	Weight (Kg)
1	1	Back rest assembly		21.7
1.a	1	Backrest support	Age-hardening wrought Al-alloys	2.326
1.b	1	Backrest frame	Age-hardening wrought Al-alloys	18.352
1.c	1	Backrest crane	Steel	1.022
2	1	Leg rest assembly		20.18
2.a	1	Leg rest mechanism parts	Age-hardening wrought Al-alloys	4.51
2.b	1	Leg rest frame	Age-hardening wrought Al-alloys	14.45
2.c	1	Leg rest crane	Steel	1.22
3	4	Side Rails bars	PVC	1.02
4	12	Side Rails details	PVC	0.125
5	2	Connecting bar	Steel	0.26
6	2	Side Stands	Age-hardening wrought Al-alloys	5.5
Total				65

■7.0 CONCLUSION

To conclude, the paper provided a detailed discussion of the mechanism design concept of the multifunctional bed. The application of this methodology has been related to a re-developing a hospital bed for laying and transporting a bedridden patient to improve the life quality for these patients. This proposed portable patient's bed was designed similarly to the standard Gatch type found in the market with additional and more specifications than other types. Using flexible mechanism of the backrest, thigh and shank rest through two manual cranes one at head board and another one at foot board, the design enhancement was successfully achieved as an acceptable ergonomic function with folded side rails and no sharp edges on the bed. The bed has specific features such as the ability to separate into two main parts and carry it easily with flexible and rotating wheels. Furthermore, aluminum alloy was added to the specifications previously requested for lightweight and resistance to corrosion. All the features and the dimensions employed in this design were based on anthropometric data of adult bodily proportions in East Asia countries. We have a full description of the final designs and we believe that the aim of this research will help patients and meet their need of more quality care.

References

[1] Shih-Wei Peng and Feng-Li Lian. 2007. Design of Multi-functional Bed for Bedridden Patient.
[2] Spano and Asada. 1998. An Active Surface Wave Bed for Transporting Humans and Elastic Bodies, ASME IMECHE, Anaheim, CA November 15–21.
[3] Shih-Wei Peng, Feng-Li Lian. 2010. Mechanism Design and Mechatronic Control of a Multifunctional Test Bed for Bedridden Healthcare, IEEE/ASME Transactions on Mechatronics. 15: 2. April 2010.
[4] M. N. Mohammed, M. A. Abdelgnei, N. G.Khrit, Es. Abubaker, A. F. Muftah, D. A. Wahab, S. Abdullah and M. Z. Omar. 2011. Portable Patient's Bed, Advanced Processes & Systems in Manufacturing .
[5] David Ulman. 2003. *The Mechanical Design Process*. Third ed. McGraw Hill.
[6] Dieter. 2009. *Engineering Design*. Fourth ed. McGraw Hill.
[7] Robert Bridger. 2003. *Introduction to Ergonomic.* Taylor & Francis Group.
[8] Yu-Cheng Lin. 2004. The comparisons of Anthropometric Characteristics among Four Peoples in East Asia, http://www.sciencedirect.com.
[9] Darliana Mohamad, Baba Md Deros, Ahmad Rasdan Ismail and Dian Darina Indah Daruis. 2010. Development of A Malaysian Anthropometric Database, Conference on Manufacturing Technology and Management.
[10] Ashby.1999. *Materials selection in Material Design.* Butterworth-Heinemann.
[11] Raymond A. Failor, Eugene Hayton, Mark Reuter. 1989. Patient Transport Apparatus Including Trendelenburg Mechanism and Guard Rail, US Patent, No. 4858260, Aug 22.
[12] José da Silva Junior. 2010. Maria Belén Salazar Posso, Laurentino Corrêa de Vasconcellos Neto, Hospital Bed Project for Home Care, Rev Esc Enferm USP 2010. 44(2):301–6.
[13] K. Ohashi, N. Suzuki, K. Miyauchi, T. Dohi, T. Tsuji, I. Sakuma. 2000. Development of Equipment for Transfer to Save Manpower for Nursing, in Proc. ICMA, Osaka, Japan. 621–626.
[14] Robert A. Solomon, Stanley J. Axe, Sr. 1991. Bed Rail Mechanism. US Patent, No. 4993089 , 19 Feb 1991.
[15] Kap-Ho Seo , Tae-Yong Choi and Changmok Oh. 2011. Development of a Robotic System for the Bed-Ridden, Mechatronics 21. 227–238.
[16] Adjustable Hospital Bed from China, http://www.chinasuppliers.globalsources.com/china suppliers/ Adjustable-Hospital-Bed.htm.