

# An Evaluation of Wheel Chair Cum Bed Mechanism with Side Panel Movement for Bed

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## Abstract

Hospital beds are mainly designed to carry static load of patients and to provide more comfort to them by means of their ergonomic design. As a result, in the case of bed ridden patients bystanders will have to put in a lot of effort to move the patients to various positions, which are essential for their quick recovery. Patients will also have to be moved to various positions in order to prevent further complications in their existing medical conditions. Hence an affordable bed having various movements to bring the patients into suitable comfort positions becomes a necessity. The authors aim to solve these problems by the development of a conceptual bed here onwards known as care bed. Care bed is a novel concept which, by providing an additional side wise movement to the bed in addition to the bed to wheel chair transformation movements. As a surplus benefit of this added movement, easy transformation of patients from bed to stretcher became much simpler and easier to accomplish. The basic idea of care bed involves dividing the bed into three portions laterally as well as longitudinally, thus making a total of nine pieces. These pieces are joined by means of a hinge to allow relative movement between them. The hinges also restrict movements to that along only one axis at a time. So when bed to wheel chair transformation movement take place, the side wise panel movement does not cause any sort of hindrance and vice versa. The movements of the panel are accomplished by, means of single phase ac induction motor through the employment of power screw mechanism. This greatly helped to reduce the cost and complexity, that might have come into play when hydraulic or pneumatic systems may have been involved. By providing movement along the longitudinal and transverse axis, it became possible to rectify the conditions which might have culminated in the occurrence of hazardous pressure ulcer. In a nutshell it can be said that, care bed is a product that cater to the woes of bystanders as well as the patients and can be regarded as one among the rare attempts to do so. With the increasing number of bed ridden patients owing to various new ailments, increasing accidents and the rise in old age population, the product finds wide variety of application in the present and future times.

**Keywords: Power screw mechanism, Pressure ulcer, Wheel chairs, Single phase induction motor, Hospital Bed**

## I. INTRODUCTION

Wheel chair has become a boon for most of the movement impaired individuals right from its earlier introduction in 5th century BC in China. As time changed the requirement of the wheel chair also changed to cater to the needs of different classes of patients. Lots of research has been going on this field and which are aimed at fulfilling these requirements. The main problem faced by the bed ridden patients is the formation of pressure ulcer. They also, at times feel lonely and will be craving for a change in their ambience. In order to incorporate this desideratum, a wheel chair cum bed having adequate features to prevent the formation of pressure ulcer needs to be designed. Air beds and water beds are widely used as a remedy for pressure ulcers. But they have many disadvantages. They are inflatable air mattress, which means that it starts leaking air over time and even a small leak can tarnish the experience. Pump or controller problem is another disadvantage with air beds. When pump fails or malfunctions, it becomes difficult to maintain air pressure. This can make the bed unusable till the problem is resolved. Noise from the pump is another problem with airbeds. About 8% of people prefer these beds to traditional air mattresses. Waterbeds are exceptionally heavy and will put a strain on the flooring of buildings, especially on a wood floor. In order to move a waterbed, at first all of the water should be drained and also the frame must be disassembled. Hard sided water beds may necessitate special sized sheets. Making the bed

can be difficult. The heater in the waterbed can add up to energy consumption. Hence the developments of a system which could do away with the disadvantage of water bed and air bed needs to be developed.

## II. RELEVANCE

According to the census conducted by government of India 2001, 6,105,477 of the total population of 1,028,610,328 people are disabled with movement impairment which account for about 0.6% of the total. These people will need movement assisting devices for their locomotive purposes. According to the census conducted by government of India 2001, 6,105,477 of the total population of 1,028,610,328 people are disabled with movement impairment which account for about 0.6% of the total. These people will need movement assisting devices for their locomotive purposes. In addition to this the growing old age population coupled with various ailments, increases the requirement for these movement assisted devices. Besides these the problems faced by various bed ridden patients while resting on these devices may lead to various disease conditions such as pressure ulcer or otherwise known as decubitus ulcer in medical field.

According to another study, conducted by world health organization (WHO) in the year 2008 population ageing becomes a significant phenomenon in the coming years. Population ageing is a shift in the distribution of a country's population towards older ages. This is usually reflected in an increase in the population's mean and median ages, a decline in the proportion of the population comprising of children, and a rise in the percentage of the elderly population. Population ageing is a worldwide phenomenon and is highly prevalent in the most highly developed countries, even though less developed regions are not far behind. The Oxford Institute of Population Ageing, however, concluded that population ageing has slowed considerably in Europe and will have the greatest future impact in Asia. Population ageing arises from causes: increasing longevity and declining fertility. An increase in longevity rises the average age of the population by increasing the numbers of surviving older people. A decline in fertility reduces the number of babies, and as the effect continues, the numbers of younger people in general also reduce. Of these two forces, it is declining fertility that is the largest contributor to population ageing in the world today. More specifically, it is the large decline in the overall fertility rate over the last half century that is primarily responsible for the population ageing in the world's most developed countries. We soon will have older people than children and more people at extreme old age than ever before. This arouses various social issues such as required longer period of good health, a sustained sense of well-being, and extended periods of social engagement and productivity and dependency.

Lot of people are getting affected by diseases and the number of people paralyzed to bed is increasing. For those people skin disease called pressure ulcer will occur. Pressure ulcers occur due to pressure applied to soft tissue resulting in completely or partially obstructed blood flow to the soft tissue. Shear is also a cause, as it can pull on blood vessels that feed the skin. Pressure ulcers most commonly develop in individuals who are not moving about, such as being bedridden or are confined to a wheelchair. It is widely believed that other factors can influence the tolerance of skin for pressure and shear, thereby increasing the risk of pressure ulcer development. These may be protein-calorie malnutrition, microclimate (skin wetness caused by sweating or incontinence), diseases that reduce blood flow to the skin, such as arteriosclerosis, or diseases that reduce the sensation in the skin, such as paralysis or neuropathy. The healing of pressure ulcers may be slowed by the age of the person, medical conditions (such as arteriosclerosis, diabetes or infection), smoking or medications such as anti-inflammatory drugs.

Many patients are required to be moved frequently to various positions to avoid complications in their medical conditions. But moving a bed ridden person is very difficult even with the help of a bystander. Movement of the patient from the bed to the wheel chair is also very difficult. Studies have shown that prolonged sitting in a wheelchair can cause lower body swelling, venous pressure, abnormal spinal curvature as well as in vivo organ damage; while bedridden can also cause cardiac dysfunction, slow blood circulation, muscle relaxation and other organizations hazards. Therefore, timely bed chair posture adjustment helps the elderly ones and people with disabilities physical rehabilitation

## III. OBJECTIVES

The major problem associated with modern hospital beds for the bed ridden patients is that, it is very difficult to move the patient on the bed and in most of the cases; the patient has to be moved frequently to avoid complications in their medical conditions. In the present scenario it is very difficult even with the help of a bystander. So care bed is a solution for this problem. Care bed is a novel concept, which enables the movements of a bed to either side, to lift the head of the patient, to help movement of the leg side of the bed, assists in the transfer of the patient from the bed to the wheel chair and much more. The greatest advantage of care bed is that by the integration of electrical and mechanical system, all the operation can be made to run at a fingertip with the help of assisting keys or an actuating mechanism. In our concept a mechanism was employed so as to lift and lower the side panels to turn the patient to the side. A mechanism to lower the leg portion and to lift the head portion is also essential so as to bring the patient to a seating posture. A simple mechanism which enables the transfer of the bedridden patient in and out of the bed was also needed. In spite of all these equipment's and mechanism the cost of the product must be low and must be viable to a common man. The provision of control switches must be simple so that the device can be easily handled by a bed ridden patient. As a whole our care bed need to reduce the sufferings of a bed ridden patient to a great extend at a minimal cost and can be a helping hand to all the bed ridden sufferers in the world.

#### IV. LITERATURE REVIEW

In the journal “design and development of conceptual wheelchair cum stretcher” Sreerag C S, Gopinath C, ManasRanjan Mishra introducing a new design for a wheel chair which can be transformed into a bed. They also introduced new features like document holder, provision for oxygen cylinder, and rotatable handle into the new wheel chair cum stretcher. With the motivation of saving space and precluding exertion by the patient they adopted various research methods and it helped them to identify the various issues of the topic, the importance of safety and hygiene and significance of materials and manufacturing process involved in the whole product. Study shows that it is possible to save 50% space by the wheelchair- cum-stretcher design. The product will thus likely be an efficient mobility aid in hospitals.

Khalid Bin Hasnan describes a design of a novel concept wheelchair with the scaled prototype. A wheelchair-sized bed concept (patent pending) with 3 modes of ability (sitting-lying-standing) is proposed. The design and prototype stage has produced a new design of transformable wheelchair in dimension, detail profile, function and features. From scaled prototype, working space of the wheelchair at certain position could be obtained from model which would be useful in defining interaction between wheelchair and its real environment.

U.D Gulhane and R.J.Dahanke designed and fabricated a new modified wheel chair cum stretcher. A simple parallelogram mechanism has been synthesized for lifting. The mechanism is driven hydraulically. The hydraulic piston can be operated manually as well as automatically. The chair gets converted into stretcher while lifting automatically. Inverted slider crank mechanism are applied for the purpose. Five legged support provides required stability to the stretcher. The system can be made manual self-driven or motorized. The developed chair is economical as compared to the available modern automatic wheel chairs.

#### V. DESIGN

At first dimension of the bed frame was fixed with data available from a rigid bed wheel chair design with scaled prototype by Khalid Bin Hasnan, university of Tim Hassan On, Malaysia on international conference on industrial engineering and operations management. Dimensions of the bed frame was fixed as follows

$$\text{Length} = 205 \text{ cm} \quad \text{Width} = 79 \text{ cm}$$

The whole bed was divided into three portions along both longitudinal as well as transverse axes. A gap of 1.5 cm was left along the longitudinal section and a gap of 2.5cm among the transverse section, mainly for attaching hinges to the sectioned pieces of the load frames. Humans vary significantly in size and build. In some situations, it is sufficient to design for the smallest or largest likely dimension. In other situations, adjustable benches, chairs or devices are required for the full range of people. The science of anthropometrics uses data on human dimensions and ranges of motion that is how far various body parts can move. Researchers usually measure subjects from a particular group, then calculate the averages and study the differences. Anthropometric data are the bases for the human scale standards included in the building regulations and product design guidelines that designers must use. Another source comes from United Hospital Bed brochure, which has AN ISO 9001 standard. It stated that Standard hospital bed has range size 2030 – 2100 mm length, 900 – 1000 mm width and 600- 800 mm height. Anthropometric data and size of a hospital single bed are useful references to determine wheelchair parts dimension and separations.

From united hospital bed brochure which has an ISO 900 standard, weight of the body acting on each part of the bed frame was found out for a 120kg person. The percentage load distribution is as follows.

Table - 5.1  
Percentage load of the body acting on the bed.

<i>Segment</i>	<i>Percentage</i>
<i>whole body</i>	<i>100</i>
<i>Trunk</i>	<i>48.3</i>
<i>head and neck</i>	<i>7.1</i>
<i>Thigh</i>	<i>10.5</i>
<i>Shank</i>	<i>4.5</i>
<i>Foot</i>	<i>1.5</i>
<i>upper arm</i>	<i>3.3</i>
<i>Forearm</i>	<i>1.9</i>
<i>Hand</i>	<i>.6</i>

Force acting on the upper part of the bed frame (head portion)

$$\begin{aligned} &= \text{trunk} + \text{head and neck} \\ &= (0.403 + 0.71) \times 120 \times 9.8 \\ &= 648.7694 \text{ N} \end{aligned}$$

The height from the portion where the link joins the base is taken to be 35 cm. The link was assumed to join the base portion at a distance of 45cm away from it, in normal bed like portion. The length of the link was found as 55.509 cm.

In the next step the wheel base portion length of the system from the geometric centre toward the head portion is found out by consider the dynamics equilibrium of the forces acting on the link set up. Using the operation of dynamic equilibrium  $\Sigma M = 0$ , the length of the line is found out. the free body diagram of this portion is as follows.

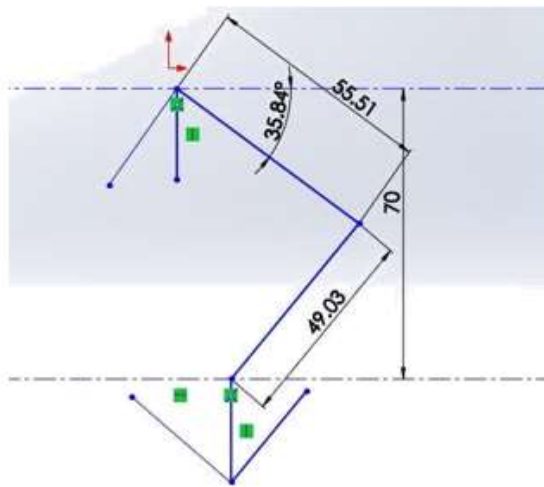


Fig. 3: Free body diagram of the link towards the head portion

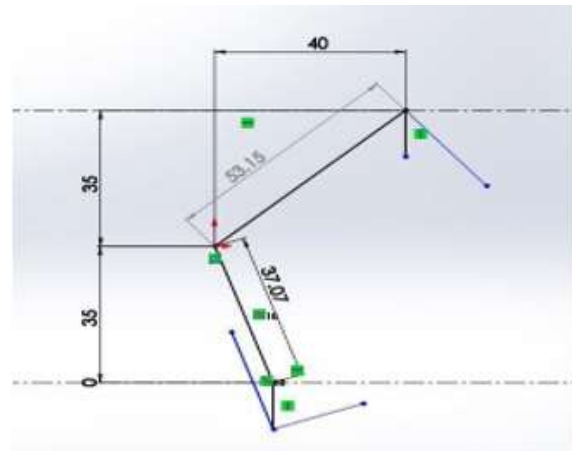


Fig. 4: Free body diagram for the leg portion.

The length of portion of the wheel base from the joining of links to the portion on the base is found to be 47.9382 cm

Similarly, for the leg portion free body diagram is drawn as shown in figure 4 and the length of the portion of the wheel base towards the leg side is found to be 11.98 cm.

Stress analysis of the main frame was performed using Dassault Solidworks2014. The stresses developed and the deformation produced during the application of the loads was analyzed. A factor of safety of 2.5 was adopted during the design analysis phase. The main frame was applied with 1500 N and 3000N, which will be applied as point loads on 4 points on the frame. The manual design phase was performed for a human of 120 Kg mass, which will be producing around 1500N with considerations of some dynamic forces which could be developed during the operation (Figure 5). The frame was found to withstand this load without any deformation. The analysis was continued until the load reaches 3000 N. At this load condition a deformation was observed on the frame.

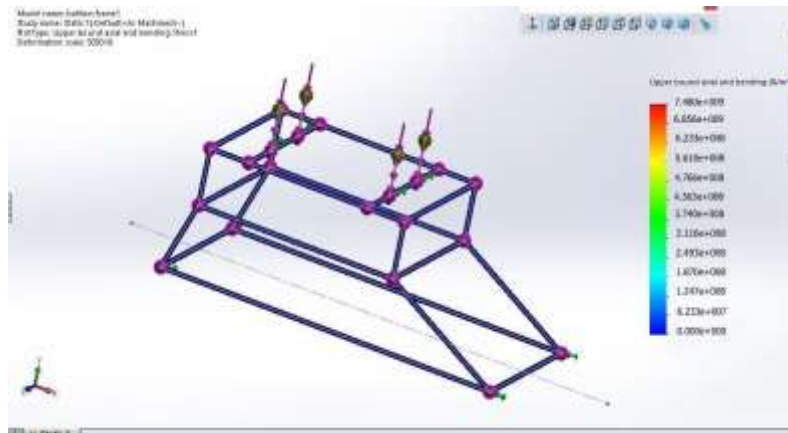


Fig. 5: Stress analysis for 1500N load.

## VI. FABRICATION PROCESS

### A. Material Selection

Cost, availability, weight and the strength of the material are the major factors which were considered during the selection of the material. Among the available materials different variance of steel (AISI 1018, 1020, 4130) and galvanized iron sections dominated the list. Among which AISI 1018 and AISI 1020 were eliminated due to increased weight. But if we use AISI 4130 the cost increases beyond nominal value which cannot be afforded by the buyers of the final product. A unique combination of all the factors is observed in GI sections.

Circular and square sections are the commonly available GI sections. But we preferred square sections for easy handling and welding purposes. Finally, square sections of GI are fixed for the frame work.

### B. Fabrication of bed frame

The total dimension of the bed is considered as about 213 cm. The whole of the bed is divided into 9 separate panels. Each panel are connected together using hinged joints. So the bed has 4 DOF. A total of 18 hinged joints are used for connecting the panels together. The size of the head portion is 88cm × 80cm. The size of the leg portion is 70 cm × 80cm.

### C. Fabrication of base

The base of care bed was designed by considering the dynamic equilibrium of the head and the tail portion of the bed frame. The wheel base of the proposed structure should be such that the moments acting on it due to swivelling of the frame part to either side, should not result in toppling of the entire structure. It means that the wheel base should be sufficiently long enough to withstand the swivelling tendency caused due to the net moment created. The forces acting on the link is mainly the weight of the patient. Since the weight of the patients much more than the weight of the frame structure which carries the patient, while making calculations the weight of the frame structure is not considered. Hence the moments which may act on the link and the supporting base can be confined entirely to the weight of the patient.

This force is resolved into two components – the one acting perpendicular and the one acting along the link. The moment is taken about the point where the link from the frame and the one from the base is assumed to meet. The force acting at the wheel portion is the reaction from the ground which can also be resolved into two forces as the one acting along as well as the one acting perpendicular to the link. The moment due to the forces acting along the link become zero when moments are taken about the point of intersection of the links. Thus the moments that may be acting on the frame can be considered to be caused due to the components of forces of the weight acting on the head portion and the reaction acting in a direction perpendicular to the link. The reaction from the ground is found out to be the reaction to the entire weight of the structure. This reaction is assumed to be equally distributed to all the four wheels and hence the reaction acting on each wheel is obtained by dividing the total weight by four.

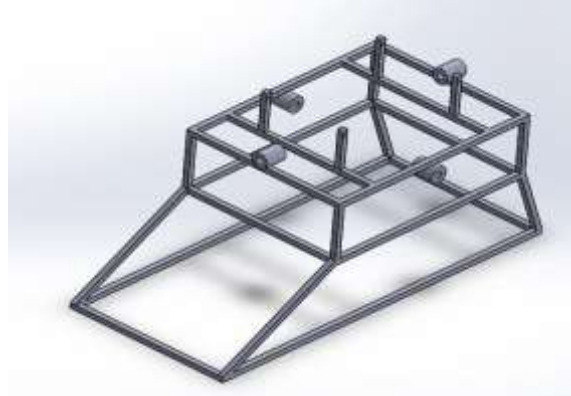


Fig. 7: CAD Model of base.

By considering the dynamic equilibrium, the length of the link to the supporting base and the angle  $t$  makes with the base is determined. In this way the wheelbase is determined for the head portion. The same approach is also adopted for designing the leg portion of bed fame wheel base with the net force acting found as 194.2776N.

### D. Fabrication of Mechanism and supports

In the current design two lead screws are used to convey the required motion to the links. Two motors supply power to the lead screw, via pulleys attached on the lead screw. For the side panel movement, a torque of 13.5KgCm is required. But for the bed to wheel chair conversion, higher torque is required which could not be provide directly by the available motor. To rectify the problem a worm gear box having 1:5 torque conversions is used along with the motor assembly. The gear box is attached to the base frame using a special mount. The motors are attached to the main frame in a similar manner. The ends of the two power screws are supported in special steel sections having 1-inch internal diameter and 1.5-inch outer diameter. The pulleys are directly mounted to the power screw and its transverse motion is arrested using nut and washer. To adjust tensions in the pulley a groove section is used to which the pulley can be bolted. The position of the pulley can also be adjusted using the nuts attached.



Fig. 8: power screw mechanism and its supports.

## VII. DRIVING MECHANISM

Here two single phase induction motors are used for driving the mechanism. For lightning and general purposes in homes, offices, shops, small factories single phase system is widely used as compared to three phase system as the single phase system is more economical and the power requirement in most of the houses, shops, offices are small, which can be easily met by single phase system. The single phase motors are simple in construction, cheap in cost, reliable and easy to repair and maintain. Due to all these advantages the single phase motor finds its application in vacuum cleaner, fans, washing machine, centrifugal pump, blowers, washing machine, small toys etc. When single phase ac supply is given to the stator winding of single phase induction motor, the alternating current starts flowing through the stator or main winding. This alternating current produces an alternating flux called main flux. This main flux also links with the rotor conductors and hence cut the rotor conductors. For self-starting a single phase induction motor of capacitor start is used here.



Fig. 9: The power screw is driven using a single phase induction motor.

## VIII. CONCLUSION

The problems faced by bed ridden patients are plenty. In many of the medical scenarios the movement of the patient within the bed and to secondary devices is essential to keep down their suffering. There are many conventional products available in the current scenario which incorporates a bed and wheel chair in the same design but they all lack many essential features that are required for a paralyzed patient. With a product as per the proposed design, the patient himself can perform all the necessary operations with a single push on his fingertip. Also the use of electrical system for the control rather than a hydraulic or pneumatic system will eliminate the chance of health effects from leakage or spillage etc. A stretcher cum wheel chair which is currently available in the market is having a price range of Rs 70,000 to Rs 1,50,000, in this scenario a better product having a lot of other operations possible, to be available at a nominal cost of 20,000, could be viable by a common man. Thus the product could a significant helping hand among the bedridden sufferers in the society.

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