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# Design and Fabrication of Folding Bed with Defecation System

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**ABSTRACT:**The project aimed to create an innovative and practical solution for patient care in healthcare settings. The project involved designing and developing a folding bed with a built-in defecation system that included electric actuators, portable toilet, poo powder, servo motors, Arduino, water pump, water spray, and dryer. The prototype folding bed with defecation system was designed to be comfortable and supportive for patients while providing a hygienic and practical solution for healthcare professionals. The electric actuators allowed for easy and efficient operation of the bed, while the portable toilet and poo powder provided a hygienic and environmentally friendly solution for waste management. The servo motors were used to open the bed piece, allowing for easy cleaning and maintenance of the portable toilet. The Arduino microcontroller provided a reliable and efficient way to control the operation of the bed and the defecation system, ensuring consistent performance and reducing the risk of human error. The project was successful in designing and developing a prototype folding bed with a built-in defecation system that showed significant potential for use in hospitals, nursing homes, and other healthcare facilities. The system provided an innovative and effective solution for patient care, making it easier and more hygienic for patients and healthcare professionals to manage waste and providing a comfortable and supportive bed for patients.

**KEYWORDS:**Folding bed, Defecation system, portable toilet, Bed with faeces system, medical bed.

## I. INTRODUCTION

India is currently one of the most populous nations in the world with a total population of 1.4 billion. The Senior in India 2021 report by the National Statistical Office (NSO) projects that India's elderly population (those 60 and older) would reach 194 million in 2031, up from 138 million in 2021, a 41% rise over a ten-year period. Anybody can become bedridden owing to a variety of medical conditions. However, since individuals develop various health problems as they age, the senior population is more susceptible to becoming bedridden. To prevent people from becoming bedridden, the main course of action is to locate a way out. By caring for both their physical and emotional health, this can be accomplished. The prevention of a patient becoming bedridden involves the patient's family, friends, and medical experts, including geriatric physicians, geriatric physiotherapists, psychologists, counsellors, etc.

A state of immobility known as bed rest might manifest as the inability to move or even sit up straight. It's distinct from bed rest, a non-invasive method of care that's typically associated with rehabilitation or activity restrictions. The significant risk of thrombosis and muscle atrophy are some of the more severe effects of being bedridden. To help treat disease, this is a voluntary medical procedure that is still done today. According to current thinking, this treatment has no advantages for the majority of the illnesses examined. Bedrest due to accidents or other illness is still sometimes recommended, but it is now viewed as risky. Bedridden patients may experience difficulties to defecate. The many consequences of bed rest include a loss of endurance and physical strength. It is possible to develop contractures, osteoporosis from inactivity, and joint degeneration. Being bedridden increases the risk of experiencing an elevated heart rate, reduced cardiac output, hypotension, and thromboembolism. Pressure sores can occur in bedridden individuals with disability. Continued confinement to bed and a decrease in such demands are correlated with the capacity to transition to a chair and the unfavourable attitudes of carers

It is frequently impossible for persons who are bedridden to use ordinary toilets. The patient's physical and psychological health may suffer if they are unable to use the restroom on their own. Patients who are bedridden can use the restroom securely and respectably with the aid of special medical equipment. For both carers and patients who are immobile, toilet care can be incredibly stressful. An innovative technical answer to the problems of toilet care is provided by bedridden toilet systems. A case study showing the advantages of using a bedridden toilet system was



published in the journal of Health and Technology. The results of the study showed that using a bedridden toilet system had a beneficial effect on a patient's psychological health.

## **II. LITERATURE REVIEW**

Youn-Sik Hong proposed “Smart Care Beds for Elderly Patients with Impaired Mobility”[1]. A number of pressure sensors are placed beneath the mattress cover in this bed to take into account both a person's normal physical attributes and the specific body regions where bedsores are most likely to develop. The body region is divided into three vertical and three horizontal areas in order to regulate the pressure ulcer area and prevent falls. A Study on Examining User Comfort in Hospital Beds proposed by Güzide Güzelbey Esengünet.al [2] shows the comfort of the hospital beds has a significant impact on how well interactions between the beds and their users work. The two main objectives of this study are to identify the comfort standards for hospital beds and to suggest a checklist for assessing the comfort of hospital beds based on those standards. R de J Portillo-Velez et.al [3] proposed a paper where the affordable assistive robotic bed's mechatronic design process is shown in this work, from the initial requirements through the mechanical design and integration of the electronics and embedded control, while industrial design is appropriately merged with all of the robotic bed's modules. S Premkumar et.al [4] developed a 5-position 4-actuator automated bed to prevent bed sores. Bedsores are a condition that is typically either disregarded or not properly addressed for people who are continuously bedridden, especially those who are paralysed or in a coma. When bedsores progress to more advanced stages (stage 3, stage 4) beneath the skin's surface, they can potentially expose the bones. Atul B. Andhare and Anil M. Onkar presented paper on “Design and development of multifunctional patient bed with integrated toilet”. In their paper, a new bed for people who are bedridden is shown. It features a feature that allows you to use a toilet by raising it to bed height using a specially made mechanism. It has an aperture in the bed for commode usage. The platform's mattress hides the commode opening. The commode is returned to its original location beneath the bed after usage. The toilet entrance is then covered. The patient can also turn to the side in this bed. The backrest and side turning can both be used at the same time.

## **III. PROBLEM STATEMENT**

From the existing research papers and information about the bed with defecation system, we identified certain challenges such as, the ability of the patient to cope and adjust is negatively impacted by hospitalization. The use of crank mechanism causes hand pain and fatigue in caregivers and waste had to be cleaned up every day. Since they are unable to move owing to illness, the patients find it difficult to use the restroom.

## **IV. OBJECTIVES**

The objectives are made from the literature surveys to provide a bed for use in both hospitals and private residences. To fabricate foldable bed using actuators. Creating a faeces system in the middle of the bed using an open-close bed piece mechanism.

## **V. METHODOLOGY**

Conduct a literature review to understand the existing designs and technologies for foldable beds with defecation systems. Identify the needs and preferences of the users and stakeholders, such as healthcare professionals and patients. Define the functional and technical requirements for the bed, including its size, weight, folding mechanism, defecation system, and materials. Based on the design requirements and specifications, create a conceptual design for the bed that meets the identified needs and preferences. Create detailed engineering drawings and specifications for the bed and defecation system using computer-aided design (CAD) software. Select and source the materials and components needed for the bed, including the electric actuators, portable toilet, water pump, and poo powder. Conduct simulations and tests to validate the design and ensure that it meets the functional and technical requirements. Based on the engineering design, fabricate a prototype of the bed and defecation system. Install the electric actuators to enable the bed to fold into the sitting position and return to the lying position. Install the portable toilet under the hole in the middle of the bed and connect it to the water pump and flush system. Test the functionality of the bed and defecation system and make any necessary adjustments or modifications. Evaluate the performance of the bed and defecation system based on relevant parameters such as ease of use, safety, hygiene, durability, and cost-effectiveness. Conduct usability testing with volunteers to gather feedback and identify areas for improvement. Use the feedback to make any necessary changes to the design and functionality of the bed and defecation system. Prepare a report documenting the design, fabrication, and evaluation of the folding bed with defecation system, including the results of usability testing and any modifications made to the design.



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## VI. DESIGN AND CAD MODELLING OF THE BED

**1.Design calculation****1.1Design of head part**

The sheet metal is considered as made of mild steel. The sheet metal is used for the head part or the backrest and free to move up position with flat hinge connected at one end. The backrest is moved up with the help of flat links and a circular shaft which is connected to electric actuator.

Length of the head part sheet,  $l_1 = 0.7874$  m

Width of the head part sheet,  $b_1 = 0.8128$  m

Thickness of the head part sheet,  $t_1 = 0.0508$  m

Density of mild steel  $\rho = 7860$  kg/m<sup>3</sup>

Area of the head part sheet,  $A_1 = l_1 \times b_1 = 0.7874 \times 0.8128 = 0.6399$  m<sup>2</sup>

Mass of the head part sheet,  $m_1 = l_1 \times b_1 \times t_1 \times \rho$

$= 0.7874 \times 0.8128 \times 0.0508 \times 7860 = 255.54$  kg

Assumed weight of the person,  $w_1 = 100$ kg

Acceleration due to gravity  $g = 9.81$  m/sec<sup>2</sup>

Effective weight on the head part is considered as  $2/3 W$ ,

as part of the body is supported by backrest,  $M_1 = 67$ kg

Weight of head part sheet and person considered as  $2/3W = m_1 + M_1$

$= 255.54 + 67$

$= 322.54$  kg

Force acting on head part  $F_1 = M_1 \times g = 67 \times 9.81 = 657.27$  N

Stress acting on head part sheet,  $s_1 = F_1/A_1 = 657.27/0.6399$

$= 1.02 \times 10^3$  N/m<sup>2</sup>

Tensile strength of mild steel sheet metal = 400 MPa

Yield strength of mild steel sheet metal = 250 MPa

**1.2 Design of mid part**

The sheet metal used in mid part is considered as made of mild steel. The mid part is stationary and connected to the support. The mid part has a hole at the centre for the defecation system.

Length of the mid part sheet,  $l_2 = 0.4318$  m

The width and thickness of the sheet metal is same, hence

Width of the mid part sheet,  $b_1 = 0.8128$  m

Thickness of the mid part sheet,  $t_1 = 0.0508$  m

Density of mild steel  $\rho = 7860$  kg/m<sup>3</sup>

Area of the mid part sheet,  $A_2 = l_2 \times b_1 = 0.4318 \times 0.8128 = 0.3509$  m<sup>2</sup>

Mass of the mid part sheet,  $m_2 = l_2 \times b_1 \times t_1 \times \rho$

$= 0.4318 \times 0.8128 \times 0.0508 \times 7860$

$= 140.13$  kg

Assumed weight of the person,  $w_1 = 100$ kg

Acceleration due to gravity  $g = 9.81$  m/sec<sup>2</sup>

Effective weight on the mid part is considered as  $1/3 W$ ,

as part of the body is supported by backrest,  $M_2 = 34$ kg

Weight of mid part sheet and person considered as  $1/3W = m_2 + M_2$

$= 140.13 + 34 = 174.13$ kg

Force acting on mid part  $F_2 = M_2 \times g = 34 \times 9.81 = 333.54$  N

Stress acting on mid part sheet,  $s_2 = F_2/A_2 = 333.54/0.3509 = 950.52$  N/m<sup>2</sup>

Tensile strength of mild steel sheet metal = 400 MPa

Yield strength of mild steel sheet metal = 250 MPa

**1.3 Design of leg part**

The sheet metal used in leg part is considered as made of mild steel. One end of the sheet is connected to the mid part sheet with flat hinges. The leg part moves in vertical axis i.e it moves downward with help of flat links and steel rod which is connected to the electric actuator.

Length of the leg part sheet,  $l_3 = 0.6604$  m

The width and thickness of the sheet metal is same, hence

Width of the leg part sheet,  $b_1 = 0.8128$  m

Thickness of the leg part sheet,  $t_1 = 0.0508$  m  
 Density of mild steel  $\rho = 7860$  kg/m<sup>3</sup>  
 Area of the leg part sheet,  $A_3 = l_3 \times b_1 = 0.6604 \times 0.8128 = 0.5367$  m<sup>2</sup>  
 Mass of the leg part sheet,  $m_3 = l_3 \times b_1 \times t_1 \times \rho$   
 $= 0.6604 \times 0.8128 \times 0.0508 \times 7860$   
 $= 214.32$  kg  
 Assumed weight of the person,  $w_1 = 100$ kg  
 Acceleration due to gravity  $g = 9.81$  m/sec<sup>2</sup>  
 Effective weight on the leg part is considered as  $1/3 W$ ,  
 as part of the body is supported by leg part,  $M_3 = 34$ kg  
 Weight of leg part sheet and person considered as  $1/3 W = m_3 + M_3$   
 $= 214.32 + 34 = 248.32$ kg  
 Force acting on leg part  $F_3 = M_3 \times g = 34 \times 9.81 = 333.54$  N  
 Stress acting on leg part sheet,  $s_3 = F_3/A_3 = 333.54/0.5367 = 621.46$  N/m<sup>2</sup>  
 Tensile strength of mild steel sheet metal = 400 MPa  
 Yield strength of mild steel sheet metal = 250 MPa

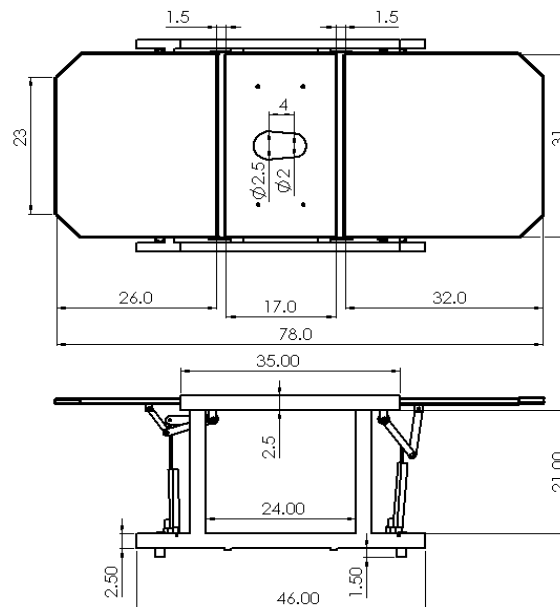


Fig.1 2D drawing of bed in inches

## 2. CAD modelling

The model represents a bed made of mild steel and sheet metal which can be folded into a sitting position. The head-side of bed is lifted up using electric actuator and foot-side of bed is lowered down using the actuator. Both the actuators are connected to bed by a shaft along with flat links. The electric actuators are powered by a DC power supply. The middle part of the bed is stationary and has a hole in centre for defecation system. A portable toilet is kept right under hole made at the centre of the bed. CAD (Computer-Aided Design) modelling of a smart foldable medical bed involves using specialized software to create a digital 3D model of the bed design. The model can include details such as dimensions, materials, mechanisms, and features of the bed, such as sensors, motors, and controls. The CAD software allows designers to manipulate the model to test different configurations and make changes before moving to physical prototyping. They can simulate how the bed will function, fold, and unfold, and ensure that all components fit together correctly. CAD modelling also enables designers to create accurate technical drawings and specifications, which can be used for manufacturing and assembly instructions. Overall, CAD modelling is an important tool in the design process for creating a smart foldable medical bed that meets the necessary functional, safety, and aesthetic requirements. CAD modelling is a digital design process that allows designers to create 3D models of products using specialized software.

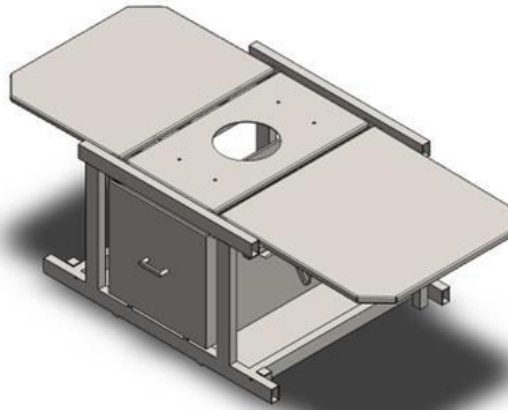


Fig.2 Isometric view of folding bed

### VII. WORKING PRINCIPLE

A folding bed's operation requires the use of mechanics that allow the bed to be effortlessly folded and unfolded. A folding bed typically comprises of a frame composed of sturdy materials such as mild steel. The frame is designed to be sturdy enough to support the patient's weight while remaining lightweight enough for easy handling and transit. Electric actuators are utilised to fold and unfold the bed at both the head and leg ends, making it simple to switch between sitting and sleeping positions. The actuators are powered by a direct current (DC) supply. The wheels allow the bed to be moved anywhere. When the patient needs to relieve himself, a button is pressed, causing the bed to fold into a sitting posture. A bed component in the centre of the bed opens and rotates to one side. When the bed is not in use, the servo motors open and close the bed component that covers the hole. The motors are controlled by an Arduino, which receives signals from the bed's switches. Under the bed, there is a drawer with a portable toilet kept on the edge of the drawer atop a metal frame. An electric actuator is attached to the frame so that when the hole in the middle of the bed is opened, the actuator pulls the metal frame towards the centre of the bed by using the power supply. The water pump pumps water to the portable toilet's basin during the patient's excretion process so that the waste can be flushed. When engaged, the pump connects to the bed's water supply system and pumps water into the toilet at a high pressure of 140 PSI, which is enough to flush the waste. A little pump and nozzle are used simultaneously to spray water onto the patient's behind. The moist section is dried with a dryer. The dryer is used to dry the toilet bowl before the bed piece is closed after the waste has been flushed and the toilet bowl has been washed with water. The drier sends hot air into the toilet bowl, which dries the surface and removes any remaining moisture. In order to keep the system clean and hygienic, a drier must be used. The toilet bowl would remain moist without the drier, which may promote the growth of bacteria and create unpleasant odours. Poo powder is spilled during waste flushing, which helps with moisture absorption and prevents the growth of germs and other bacteria that might cause diseases. The trash can be disposed of once a week because of the poo powder. Once the excretion process is complete, a button is pressed, causing the portable toilet to travel to the drawer's edge. To close the opening in the middle of the bed, the bed component rotates and is raised. Using electronic actuators, the bed finally transitions from its sitting posture to its resting position.

### VIII. RESULTS AND DISCUSSIONS

The foldable bed with faeces system was successfully designed and created, fulfilling all project requirements and objectives. The bed was composed of strong and light materials, making it simple to move and manage. It was simple for patients to get in and out of bed because the bed could be folded into a sitting posture thanks to the electric actuators. The portable toilet that was positioned beneath the bed's centre hole was part of the defecation system. The liquid excrement that had accumulated in the portable toilet was degraded and neutralised using the poo powder. The bed piece was opened by the servo motors so that the portable toilet could slide out for cleaning. The electric actuators and servo motors on the bed were all controlled by a power source. The water spray and dryer were used to clean and dry the toilet after use, while the water pump supplied water to the toilet for flushing.

The folding bed with faeces system has tremendous promise for application in healthcare settings by offering a creative and useful patient care solution. The bed was made with the patient's comfort and support in mind, as well as the ease of use and practicality for medical professionals. The natural and organic poo powder was used in the defecation system to breakdown and neutralise the liquid waste, offering a hygienic and environmentally beneficial waste management solution. This aided in the reduction of germs and other microbes that might cause diseases, resulting in a cleaner

environment for patients and healthcare staff. The system has tremendous promise for application in hospitals, nursing homes, and other healthcare facilities, offering a sanitary, ecologically friendly, and practical patient care option.



Fig 3 Folded view of bed

#### IX. CONCLUSION

In conclusion, the foldable bed with defecation system design and manufacturing was effective in meeting its goals of creating and developing an original and useful solution for patient care in healthcare settings. The foldable bed with defecation system was created to be useful for healthcare providers as well as comfortable, supportive, and simple to use for patients. The bed and defecation system were able to operate smoothly and efficiently thanks to the use of electric actuators, portable toilets, poo powder, servo motors, water pumps, water sprays, and dryers, ensuring a hygienic and environmentally responsible solution for waste management.

The faeces system for the folding bed demonstrated considerable promise for application in healthcare settings, offering an original and useful solution for patient care. The method was created to make things easier for medical staff while also giving patients a relaxing and encouraging environment.

The project's provision of an effective and practical answer for patient care served to highlight the significance of innovation and technology in healthcare. The creation of the foldable bed with defecation system has the ability to better patient outcomes and the standard of care provided in medical facilities. It is possible to modify and extend the system further, making it even more useful and practical for both healthcare professionals and patients. Instead of using the bed piece mechanism, new mechanisms can be used to open and close the opening in the centre of the bed. It is also possible to use other cutting-edge technology, such as AI and machine learning.

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