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Fabrication and Analysis of Multi-Utility Stretch Chair
(MUSC)

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Abstract— **The main motive of developing Multi-Utility Stretch Chair (MUSC) is to fulfill the aim of becoming a social engineer by designing a multi-adapting product which can be used as a wheelchair and as a stretcher .The multi-functional MUSC can be used as a wheelchair with reclining back and front rests along with other supportive aids like the trays and bags. The trays will help the patient to read, write, and have food etc. being in the wheelchair itself. The bag provided can be used to keep the urine bag (i.e. in case of a paraplegic patient) and also as a pack to keep the amenities for regular purpose.**

The main advantage of this Multi-Utility Stretch Chair (MUSC) as a stretcher is that the wheelchair can be converted directly to the stretcher with variable height postures and there is a detachable tray to hold the oxygen cylinder. The reclining back and front rests works on the links connected using pin joints. The entire MUSC is foldable, so the space utilization by this product is minimized. There by reducing the extra space formed by an individual wheelchair and a stretcher by acting on a single unit. The MUSC can be collapsed and folded it can be made compact for the ease of carrying, transporting.

Most of the parts in the stretch chair are detachable as the demand varies with purpose of use. When MUSC is used as a wheelchair, depending on the need of the individual a detachable propelling mechanism to favor the ease of mobility can be provided. The materials used for fabricating the unit is Structural Steel which reduces the weight of the unit. The load analysis and real time load analysis was done on using ANSYS R15. The product and the results were found good.

I. INTRODUCTION

Space utilization is the main problem that everyone around the globe is facing right now. Every now and then each product is developed and brought into the market and the failure in replacing the outdated products by the new products is causing the major problem of ineffective utilization of space.

Due to the increasing population in India the city's, villages and streets are becoming more crowded the variation of such problem is reflected in different areas of the society. We are concentrating on one such problem where space consumption should be done in an efficient way.

In present scenario the situations at hospitals are chaotic at the time of an epidemic and this is the usual case at any time in a government hospital. So to overcome one such problem there are numerous design alternatives brought on the existing models of hospital equipment. The percentage of patients in India is increasing day by day. In hospitals patients need to be shifted from wheelchair to stretcher, stretcher to beds, bed to wheelchair, or vice versa; which creates unsafe conditions for patients. Restructuring the infrastructure is not an immediate remedy whereas by making changes to the existing design of the utensils in the hospital helps in the effective utilization of space. Transferring patients in hospitals is also a common problem for the caretakers. We are put forwarding such an idea to overcome these two crisis.

Fig. 1. Example of a Populated City and Crowded Hospital

As a solution to the problem faced, a new and improved unique product is being introduced which replaces the conventional two individual units of wheelchair and stretcher. The multi-utility stretch chair (MUSC) was improvised from the concept of "*developing of self-reclining wheelchair*" which was done as the initial phase of multi-utility stretch chair in the earlier semester. MUSC is capable of replacing the existing product and there by meeting the primary aim of achieving effective utilization of space.

II. OBJECTIVE

- A unique product as an alternative for individual wheelchairs and stretchers and thereby achieving the effective utilization of space.

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- A multifunctional chair for a paraplegic patient with certain supportive aids like propelling mechanism, reclining mechanism, supportive trays, holders etc.
- As a supporting product for the Doctors who conduct medical camps at remote areas. As the MUSC is compact it adheres to the ease of transporting.

III. MEDICAL TERMS USED

A. Paraplegia

Paraplegia is an impairment in motor or sensory function of the lower extremities. It is usually caused by spinal cord injury or a congenital condition such as spina bifida that affects the nueral elements of spinal canal. The area of spinal canal that is affected in paraplegia is either the thoracic, lumbar or sacral regions.

B. Quadriplegia or Tetraplegia

Tetraplegia is also called as quadriplegia, is paralysis caused by illness to a human that result in the partial or total loss of use of all their limbs and torso: paraplegia is similar but doesn't affect the arms. The loss is usually sensory and motor, which means that both sensation and control are lost. Tetraparesis or quadriparesis, on the other hand, means muscle weakness affecting all four limbs. It may be flaccid or spastic.

C. Disabilities

Disabilities is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Thus according to WHO "disability is a complex phenomenon, reflecting an interaction between features of a person's body and features of the society in which he or she lives"

IV. DESING AND ANALYSIS

Designing the components of Multi-Utility Stretch Chair (MUSC) plays an important role. Since all the components are detachable the design of the product should be precise. The material selection was the primary point in designing. The material selected for the fabrication of MUSC is Structural Steel. The properties of selected material structural steel is given below.

It is found that steel of these property is sufficient to take the load on the structure. The analysis of MUSC is done using ANSYS R15 and CATIA. The designed base structure of MUSC is shown in Fig. 2

TABLE I

Material	Structural Steel
Young's modulus	2 e+011N m^2
Poisson's ratio	0.266
Density	7860 kg m^3
Coefficient of thermal expansion	1.17e-005 K deg
Yield strength	2.5e+008 Nm^2

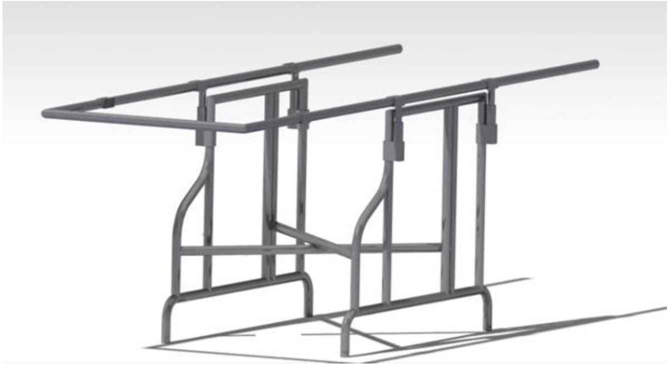

Fig. 2 Base Structure of MUSC

From this design we found that the load stress and deformation which will act on the structure will be distributed all over. The advantage of this design is that the provision for increasing height (gas lift) will not affect the sliding mechanism. By adopting this design we also found that the center of gravity will act at the middle portion, so the chance of back falling can be avoided. Moreover that the patient will not feel any sort of insecurity and will be more comfortable. By considering these much factors we selected our design as above shown.

Particulates	Value
Number of nodes	9139
Number of elements	27821
Number of D.O.F	27417
Number of Contact relations	0
Number of Kinematic relations	0

TABLE II

The next step after designing was to analyze whether the selected design is safe to take loads. By assuming a patient's weight will be in between 65 to 85, we have taken the test loads, 65kg, 70kg, and 80kg. Since the load acting on the unit is varying load, tetrahedral nodes are taken for the computation purpose. The table above shows the number of nodes, elements etc. taken during the load computation of the MUSC.

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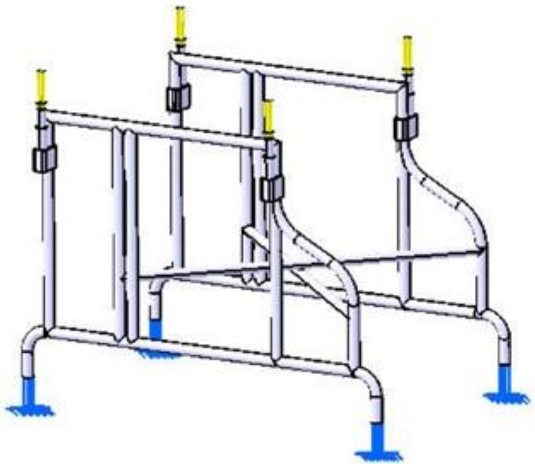

Fig. 3 Base part

As described early the analysis is done by taking three loads. The stress, strain and deformation for links and base structure are analyzed separately to ensure proper stability of MUSC. The base structure figure is shown in Fig. 3. In the figure above shows the load deposition on the structure of the MUSC. The weight from the links are given to the gas lift which are marked yellow in colour. The blue coloured part shows the position of caster wheels of MUSC, where the load is concentrated.

A. Test Load Analysis on 65 Kg

1) Stress Distribution on Structure and Links at 65 kg Test Load

The Fig. 4. below shows the stress distribution on the base of MUSC unit under the 65kg load. Maximum stress on the structure is marked in red colour. In the figure below the red portion area is small and negligible which means the design is safe under 65kg load.

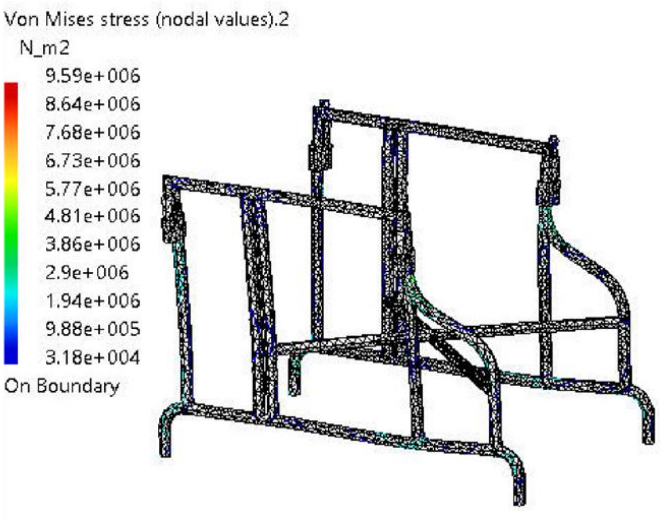

Fig. 4 Stress on Base Structure at 65 kg Test Load

The Fig. 5 shows the stress on links at 70 kg test load. Maximum stress is at area shown in red colour. Red coloured area is small and thus it is negligible. The maximum stress is 5.4462MPa which is in permissible limit and thus design of link is safe to take load.

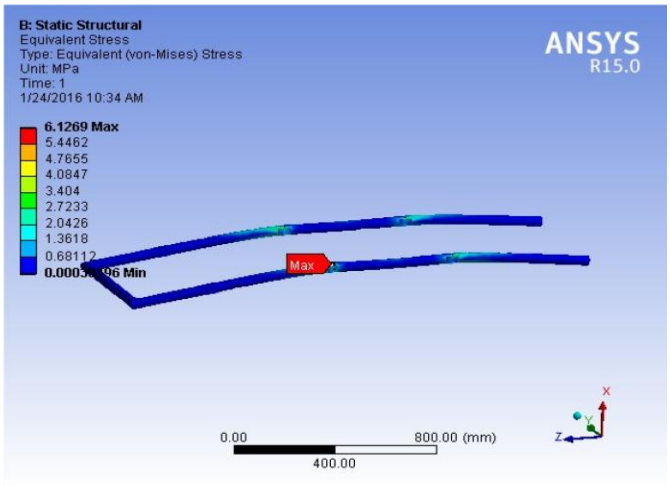

Fig. 5 Stress on Links at 65 kg Test Load

B. Test Load Analysis on 70 Kg

1) Stress Distribution on Structure and Links at 70 kg Test Load

The Fig. 6 shows the stress distribution on the base of MUSC unit under the 70kg load. Maximum stress that the structure can take is be marked in red colour. In the figure below the red portion area is small and negligible which means the design is safe under 70 kg load.

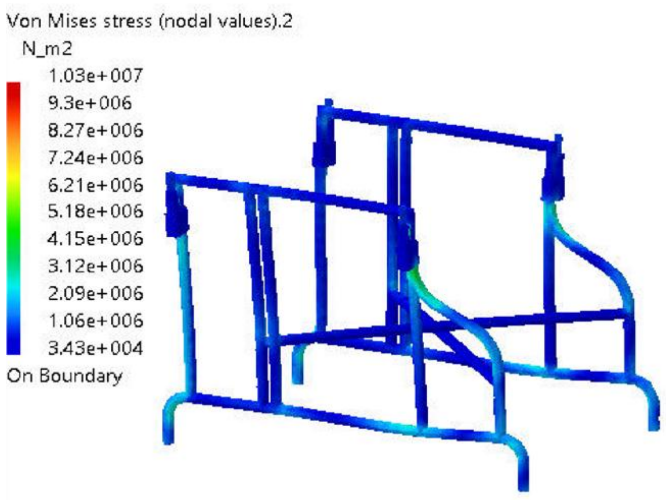

Fig. 6 Stress on Base Structure at 70 kg Test Load

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The Fig. 7 shows the stress on links at 70 kg test load. Maximum stress is at area shown in red colour. Red coloured area is small and thus it is negligible. The maximum stress is 5.535MPa which is in permissible limit and thus design of link is safe to take load.

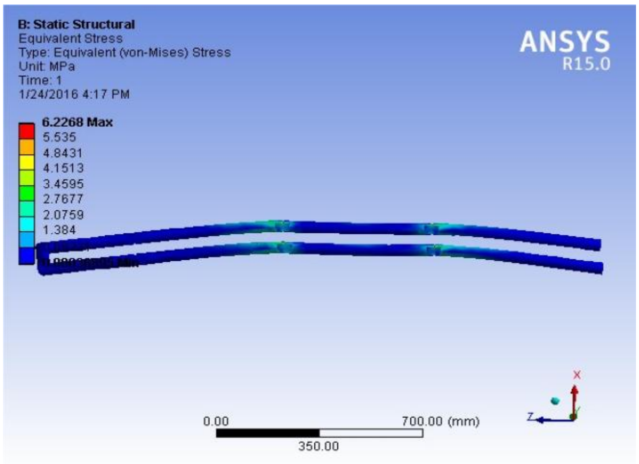

Fig. 7 Stress on Links at 70 kg Test Load

C. *Test Load Analysis on 80 Kg*

1) Stress Distribution on Structure and Links at 80 kg Test Load

The Fig. 8 below shows the stress distribution on the base of MUSC unit under the 80 kg load. Maximum stress that the structure can take is marked in red colour. In the figure below the red portion area is small and negligible which means the design is safe under 80 kg load.

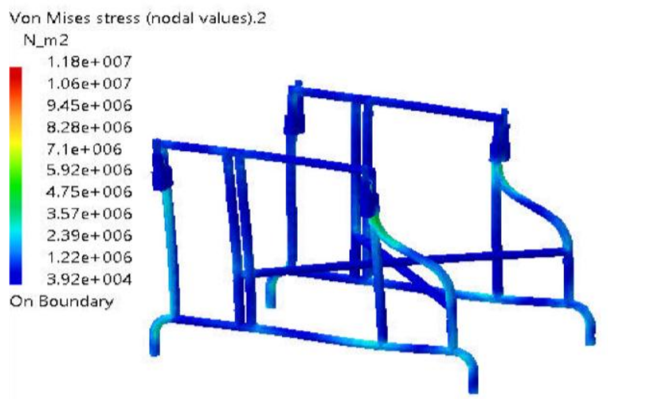

Fig. 8 Stress on Base Structure at 80 kg Test Load

The Fig. 9 shows the stress on links at 80 kg test load. Fig. 7

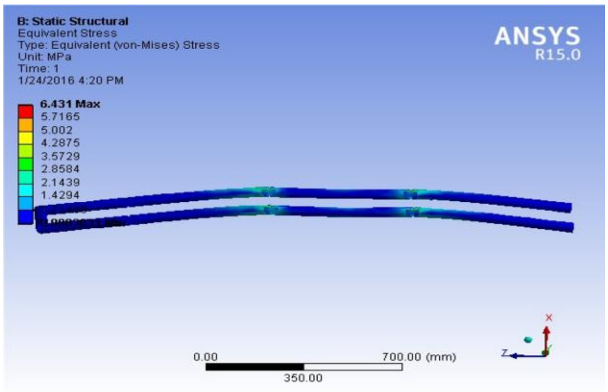

Fig. 9 Stress on Links at 80 kg Test Load

Maximum stress is at area shown in red colour. Red coloured area is small and thus it is negligible. The maximum stress is 5.7165MPa which is in permissible limit and thus design of link is safe to take load

V. PROJECT DESCRIPTION AND FABRICATION DETAILS

Analysis done on MUSC using ANSYS gives idea about weight bearing capacity of the entire structure. And the finalized design was found to be safe. And the proposed design of the product is shown in Fig. 10

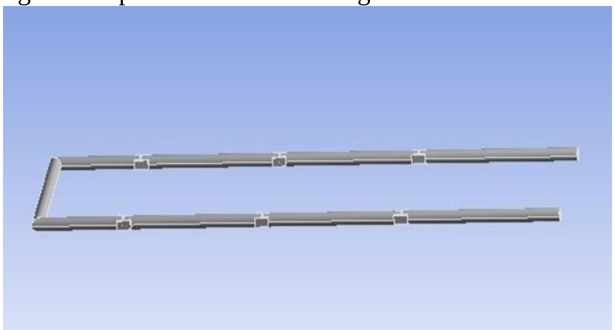

Fig. 10 Skeleton of Resting Link

Another important component provided in this is gas lift (4 in number) which is attached to the frame such that it connects the wheel stem to the seat. The gas lift is used to adjust the height of the entire unit during its conversion from wheelchair to stretcher and vice versa. The provisions for height adjustment is adopted to meet the specific requirement according to the need in situations. Further the rear wheel stem is furnished with multiple slots to support the arrangement of wheels having different dimensions i.e. caster wheel for stretcher and larger diameter wheels (say 24 inches) for wheelchair purpose.

The wheel span of MUSC is increased to about 5 inch compared to normal wheelchair to offer the proper balancing and to prevent the toppling. By increasing wheel span the center of gravity will shift towards the center of the unit thus reducing the chances of tumbling while converting it into a stretcher.

The core design of the frame is changed to a trapezium structure as shown in the drawing below. The 2D drawing gives the schematics of the components in the MUSC. The components in the product is discussed below.

A. *Schematic Drawing*

The first drawing represents the basic scheme of the MUSC and the gas lift attached to it will be in normal position. The seating post will be in unexpanded form and the gas lift will provide a cushion action. The pin joint will provide the smooth functioning of the links and there by reclining posture can be easily obtained.

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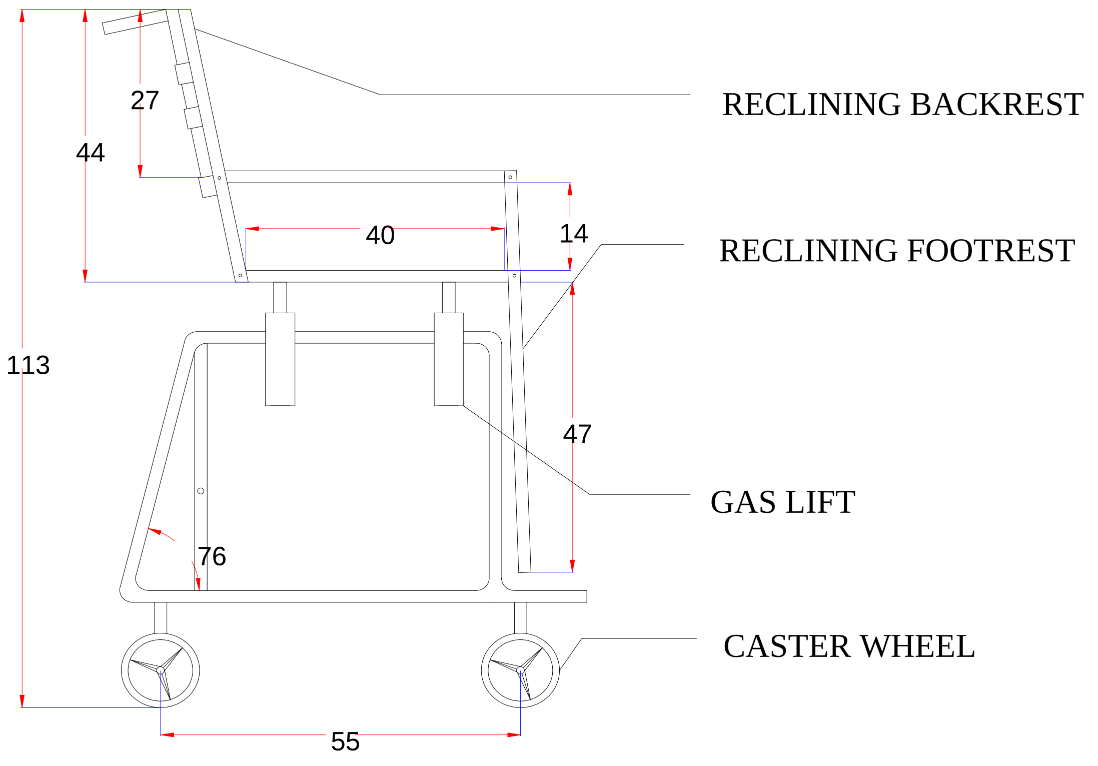

Fig. 11 Basic Structure of MUSC

This is the basic scheme from which it is converted to a wheelchair and stretcher. The figure shown above is provided with the reclining back and front rest which works on link mechanism. Each link is pin jointed to one another. The dimensions are as mentioned in the drawing.The maximum height is 113cm*, which varies as per the final design. There is a slotted pipe attached to the base frame, the slot which helps in attaching a bigger sized rear wheel. Various other detachable supporting aids are to be atteched to the basic design, and as there are limitations in the 2D sketch, we were unable to attach the detachable and oxygen tray.

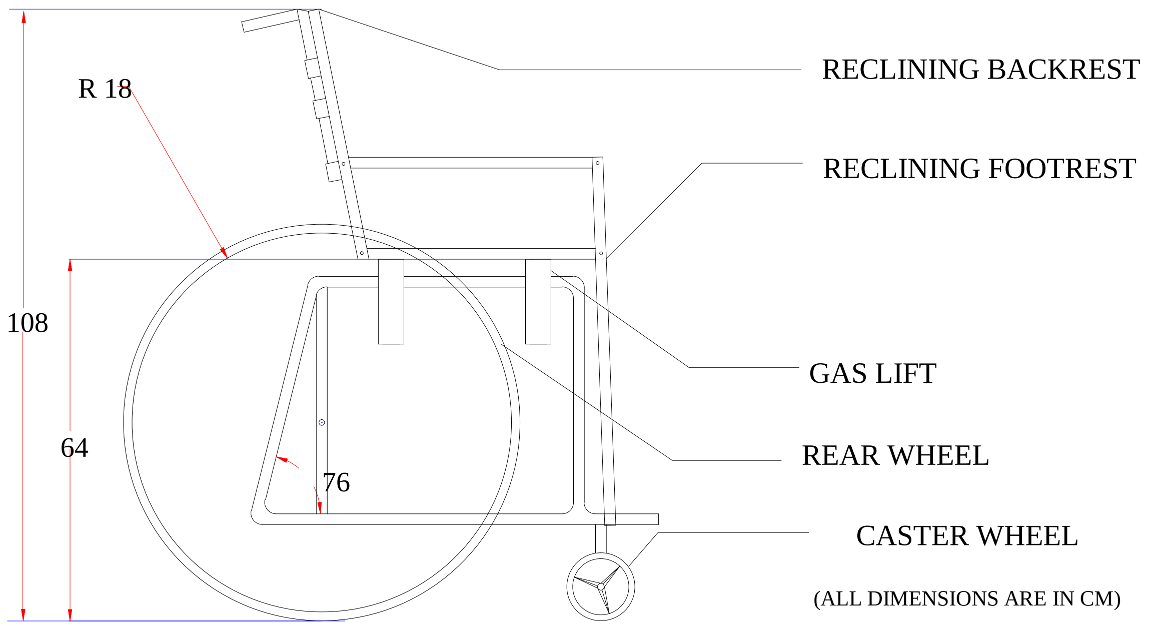

Fig. 12 MUSC as a Wheelchair

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The Fig. 12 is perticularly for the hospital purpose, and in a hospital there will always be an attender, who helps in the transportation of a patient from source to destination. So in this particular type bigger rear wheel is replaced by a caster wheel though bigger sized rear wheel with push rims makes one sitting on the chair self-reliable to attain propulsion. In a hospital, it is the least case where the patient himself propell using the push rims. In this, the gas lift will be in completely compressed form, and the height of the seat posture from the ground is almost similar to that of a normal wheelchair. The peculiar feature of this MUSC as wheelchair is that the caster wheels are replaced by bigger sized rear wheel.

For a paraplegic, providing bigger sized rear wheels with push rims makes the paraplegic independent. It is also provided with link mechanism to recline the back and front rest so that it supports the one sitting on the wheelchair with the comfort of being self sufficient. This avoids the help of a care taker. Thus the aim of making the paraplegic patient completely independent is achieved.

Fig. 13 shown below shows the completely stretched posture of the MUSC and in this design the musc is preferred to have the caster wheels instead of the bigger sized rear wheels to achieve the maximum degree of freedom. In a chaotic hospital the stretchers and wheelchairs have to be moved in a very limited space. So to utilise the limted space effectively, wheels with smaller dia having 360 degree rotation have to be installed.

In this design of MUSC, the gas lift is expanded upto the fullest. The height posture obtained meets the purpose of using MUSC as the stretcher and this peculiar characteristic of convertible nature of the MUSC helps in serving this product as a wheelchair and a stretcher.

The back rest is made into two separate pieces, where one slides through a mechanical bush when the overall length required needs to be varied, and as per the sketch, the overall stretched length can be obtained upto167 cm. In the actual design it varies and reaches upto 170-175 cms when MUSC is converted as a stretcher.

B. Components of Wheelchair

1) Links (using 19mm steel pipe)

Steel pipes of 19mm diameter (3/4 inch) are used to make the link mechanism in MUSC. There are 4 links pin jointed at the end. The basic 4 bar link mechanism is used in this type.Choosing steel as the primary material for making links helped in reducing the weight and smooth functioning of the joints. As the steel is light in weight and hard the load to be applied in the steel pipe links will be less compared to GI pipes.

2) Gas Lift

This is the most commonly seen component, which is attached to the easy chair, and the gas lift is supported by a tray which is placed beneath the seat. The tray carries a lever which actuates the working of the gas lift. A MUSC is provided with 4 gas lifts to hold the entire seating frame. The use of gas lift leads to an increase in comfort and ergonomic benefit. Proper ergonomic design prevents repetitive strain injuries and other musculoskeletal disorders. Nearly all gas cylinders are 28 mm in diameter, a worldwide standard.

3) Mechanical Bushes

A mechanical bush is a mechanical fixing between two possibly moving parts or a strengthened fixing point where the connected parts can take sliding motion and translational motion.
Caster Wheels

4) Caster Wheels

Caster wheels which provide the maximum degree of freedom as it turns whole of 360 degree, and when all the wheels are casters, it shall have multiple pivot point at which it can be turned and operated. Thus it gives better mobility when the larger rear wheels are replaced by small casters in MUSC.

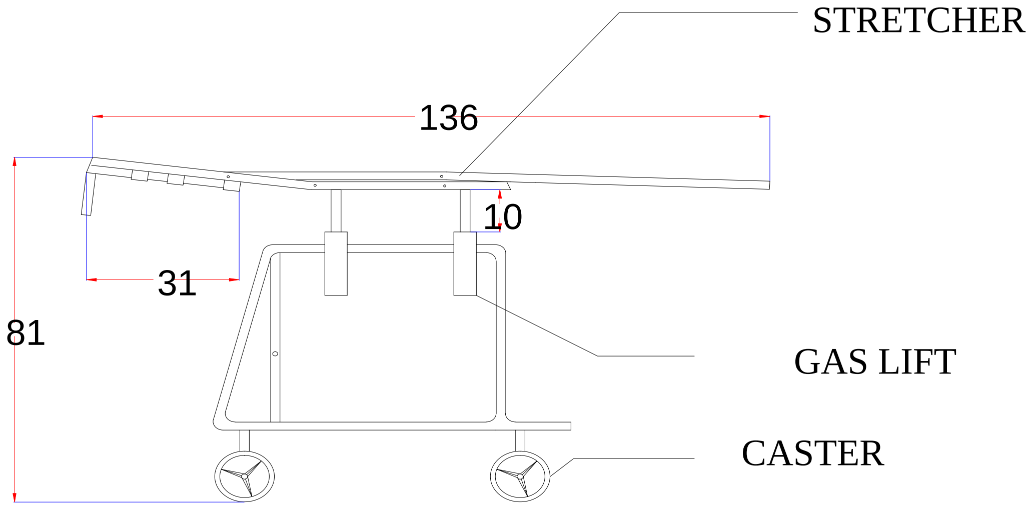

Fig. 13 MUSC as a Stretcher

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5) Rexine Cushion

This depends on the type of cushions installed on a chair. Rexine is a kind of artificial leather which has a cloth like texture, and is water resistant. Foam enabled rexine gives better shock absorbing capability. Foam size can be varied according to the cushioning effect required.is the most required part of a wheelchair. The stability and ability to absorb the shocks

6) Cotter Pin

To actuate the button of the gas lift, the mechanism introduced has a lever attached to the reducer. The lever and the reducer are attached to each other by a cotter pin. The size of the cotter pin used in MUSC is 5/16 inch

7) Flate Plates

Flat plates are mainly used to provide adequate strength for the structure by providing link mechanism. This type of attachments improves the load carrying capacity of the frame, and this helps in better load distribution

C. Specifications of Parts of MUSC

TABLE III

Part	Name of part	Material	Dimension	Specification
1	Link	Structural steel	19mm inner diameter, 22 mm outer diameter	Three number of links which are pin jointed.
2	Gas lift	Steel	6 cm diameter	Helps in height adjustment of link parts
3	Sliding rod	Structural steel	19mm inner diameter, 22 mm outer diameter	Slides and collapse the MUSC
4	Caster wheels	Cast iron	5 inch diameter	4 caster wheels at four ends for rolling MUSC
5	X Brace	Structural steel	19mm inner diameter, 22 mm outer diameter	Slides and collapse the MUSC

VI. RESULT AND DISCUSSION

The fabrication of MUSC is done successfully as per the design. The stability of the unit is checked and ensured at each stage of fabrication. The unit is found to be stable at each time during the development. Like the result shown in the simulation done by ANSYS R15 the deformation on the base structure and link is negligible.

The idea of motorizing the links to recline the front and back rests were eliminated. The primary reason was the inability of folding the system. By referring various journals we decided to equip the system with an electric motor or a compressor. Since the difficulty in folding was taken into consideration the idea of equipping the MUSC with a compressor also makes it heavier. The weight of the structure relied on the design. By taking into consideration the ease of folding and mobility the design was limited to manual mode of working without the aid of a motor or a compressor. This helped reduce size and weight. And the proposed design adhered to the standards of the requirements of the needy paraplegic patient.

The proposed design was tested okay using ANSYS R15. And the fabrication was completed as per the requirements. . The finished MUSC is decided to handover to a paraplegic to know well about the ease of handling the product.

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VII. CONCLUSION AND FUTURE SCOPE

The aim of designing a dual purpose stretcher cum wheelchair is to meet the space requirement in hospitals by achieving effective space utilization. We have referred various journals and articles related to our project and adopted various mechanisms which will be useful for the product. We finalized the design of the final product. And the 2D sketches were completed and as stated the next aid required in completing the finished product are the foldable cushions which helps in avoiding the butt sores.

We are planning to conduct a load test on the same and by using the simulation software. And we have decided to conduct a trial run of the product by asking a paraplegic to use it and to collect valuable feedback to improvise the various changes required.

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