International Journal of Analytical, Experimental and Finite Element Analysis (IJAEFEA), Issue. 1, Vol. 4, March 2017.
e-ISSN: 2394-5141, p-ISSN: 2394-5133, pp 6-11
DOI:10.26706/IJAEFEA.2017.1.4.6-11

Design and Fabrication of Wheelchair cum Stretcher

Nitin G. Sushir[1]
nitingangadharsushir@gmail.com

Ravi B. Bopche[2]
ravibbopche@gmail.com

Prof. Hemant M. Bansod[3]
bansod.hemant@gmail.com

Mechanical Engineering Department
S. B. Jain Institute of Technology Management and Research, Nagpur

Abstract— *The number of disabled and physically weak, handicapped persons are increasing day by day. Therefore transportation medium is required for patients. Wheelchair and stretchers are commonly used in hospitals. And this medical equipment is used for transferring patients from one place to another. And during transferring patients creates problems to patients and also creates problems for attendant and nurse. Sometimes it creates problems to patient. And transferring patient from wheelchair to stretcher, stretcher to bed, and bed to wheelchair is always issue for both hospital staff and family members of patient. This system causes stress, body pain to patients and sometimes chances to sleep down the patient.*

Understanding the various issues regarding the mobility equipment a better design will be an asset for medical field and helpful for disabled person. This paper presents the design and fabrication of wheelchair cum stretcher. This project is specially design for patient to transfer patient from bed to wheelchair and wheelchair to stretcher. This innovation helps medical staff to transfer patient from chair to bed very easily because chair become a stretcher and it is adjustable to height of bed.

Conversion of wheelchair to stretcher and vice versa is achieved by simple linkage mechanism which is manually operated easy mechanism. Also the height of stretcher can be adjusted using hydraulic jack manually. It is placed in horizontal position. These jacks push against a lever, which lifts the main lift arm. This is a cost reducing Project which helps patients to do their daily things.

Index Terms—*stress, linkage mechanism, hydraulic jack*

I. Introduction

Wheelchair is one of the basic requirements in a hospital. It used for transporting a person/patient from one location to another. These patients generally have restricted movements due to their diseases or the weakness caused due to their diseases. Such patients have to make use of a wheelchair to move from one place to another. Patients may require moving due to reasons such as, need of fresh air, needing to visit bathrooms and/or to clean themselves. Wheelchair serves this purpose as it is cheap and most efficient device available.

A stretcher is a moving bed with wheels, designed to transfer patient who can’t walk or stand with the help of attendant or nurse. In accident cases and the people who are in critical stages are transfer in stretcher from one place to other place. It is mainly used for patients after operation and has design with metal body frame with bed at top for lay the patient, supported by metal frame with caster wheels.

Fig.1.Basic Stretcher

Fig.2.Basic Wheelchair

A. Statement of Problem

A problem remains problem until a solution is offered. With the limitations encountered in the use of wheelchair, stretcher should be overcome. There are various issue regarding transportation of patient like stress generation, body cramps, time consumption.And therefore the idea to design wheelchair cum stretcher which will overcome the above stated limitations and problems.

B. Scope And Importance of Study

The design and fabrication of wheelchair cum stretcher with the available engineering material has scope in present and future.Because this project will eliminate all the problems of present situation of hospital. This project has low cost, simple working, easy in maintenace and less time consuming and will be an important hospital tool for their work.

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C. Aim and Objective of Project

Wheelchair Cum Stretcher is capable to transfer patient easily from wheelchair to stretcher and vice versa by attendant or nurse. Mobility in both positions as on wheel chair as well as stretcher is possible very easily. Aim of this project is to donate this equipment to Govt. Daga Hospital, Nagpur. We want to contribute technically and socially through this project.

II. Construction of Wheelchair cum stretcher

- In Our project we have use Hydraulic bottle jack of capacity to lift weight of 3000 Kg with lifting height of stretcher base as per desire height, mechanism able to adjust height about 120 mm parallel to bed.
- Adjustment of height of hydraulic jack is done with the help of adjusting rod and less number of strokes are required to attained height.
- Back rest and Leg rest are designed such way that it can be turn from vertical position to horizontal position and vice versa very easily operate by attendant or nursing staff.
- Linkage mechanism is arranged to convert stretcher to wheel chair and vice versa very easily and also support the stretcher during the transfer patient from one place to another place.
- Linkage mechanism is easily leg and hand operated mechanism. And can be easily convert wheelchair to stretcher
- Wheels are attached at legs of stretcher to easily movement of stretcher.
- There are total six wheels are given for more stability but at a time only four wheels are in working and other two are non-working
- For the fabrication of chassis of wheelchair cum stretcher we have used MS square sectional pipe of 2.5cm x 2.5cm x 2 mm thickness dimensions.
- And MS sheet of 14 gauge is used for sheet metal work.
- Hinges are the most important part of wheelchair convertible stretcher. It is connected in between backrest and seat (base) and in between seat (base) and leg rest. It is connected in order to convert wheelchair into stretcher and vice versa.

III. Design And Calculations

Table 1
Weight Distribution

Human Weight Calculation (if we take Wt. is 100 kg)		
Different Parts Of Body	Weight in %	Wt. Of Human Body Parts
Trunk(Chest ,Back, Abdomen)	50.80%	50.8 kg
Thigh	9.88%	9.88 kg
Head	7.30%	7.30 kg
Lower Leg	4.65%	4.65 kg
Upper Arm	2.70%	2.70 kg
Fore Arm	1.60%	1.60 kg
Foot	1.45%	1.45 kg
Hand	0.66%	0.66 kg
Other	20.96%	20.96 kg

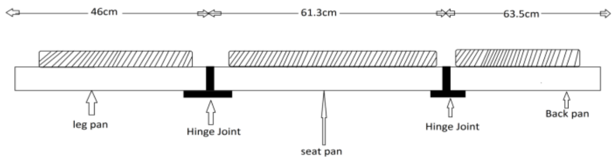
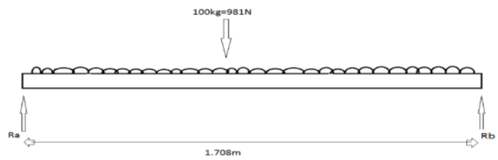


Fig: Length of all sections

Fig.3.Line Diagram of Model

A. SFD & BMD Calculation

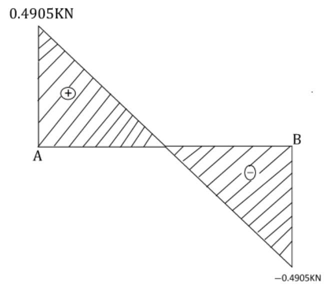
Case 1= For UDL



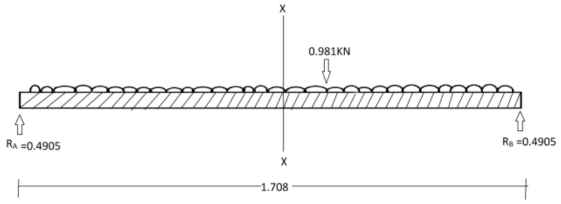
1) Weight acting= 100kg
=100×9.81
=981N
2) Length = 61.3+63.5+46cm
=1.708m

$\varepsilon F_y=0$ ↑+ ↓-
$R_A-(0.981)+R_B=0$
$R_A+R_B=0.981$
$\varepsilon M_A=0$ (↻ = +, ↺ = -)
$(0.981\times0.854)-(R_B\times1.708)=0$
$0.8378-1.708\,R_B=0$
$R_B=0.4905KN$
$R_A=0.4905KN$

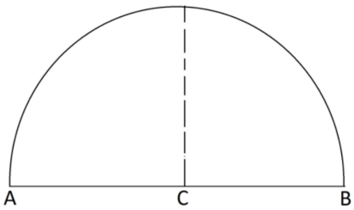
For SFD
1) $SF_{AL}=0KN$
2) $SF_{AR}=0.4905KN$
3) $SF_{BL}=0.4905-0.981=-0.4905KN$
4) $SF_{BR}=-0.4905+0.4905=0$



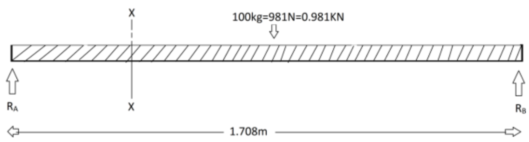
For BMD



$BM_A(x=0)= 0$ KN-m
$BM_{at}(x=l/2)= (0.981\times1.708)(1.708/2)=1.4308$KN-m
BMat(x-l)= 0KN-m

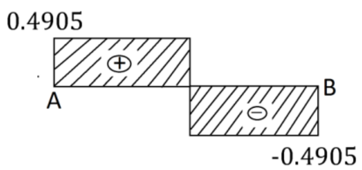


Case 2= For POINT LOAD

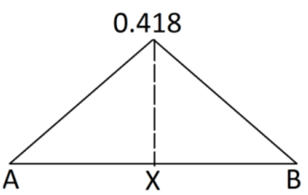


εFy=0 ↑+ ↓-
R_A-(0.981)+ R_B=0
R_A+R_B=0.981
$\varepsilon M_A=0$ (↻ = +, ↺ = -)
(0.981×0.854)-(R_B×1.708)=0
R_B=0.4905KN
R_A=0.4905KN

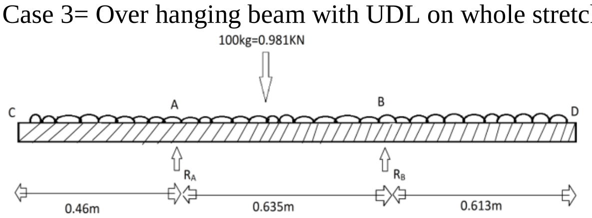
For SFD

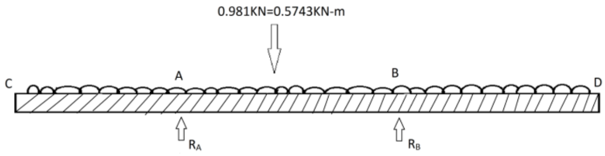


FOR BMD



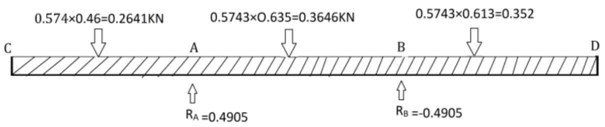
Case 3= Over hanging beam with UDL on whole stretcher





εFy=0 ↑+ ↓-
R_A-(0.981)+ R_B=0
R_A+R_B=0.981
$\varepsilon M_A=0$ (↻ = +, ↺ = -)
- (R_B×0.635)+(0.981×0.3175)=0
R_B=0.4905KN
R_A=0.4905KN

For SFD



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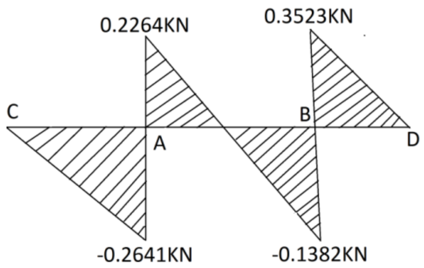
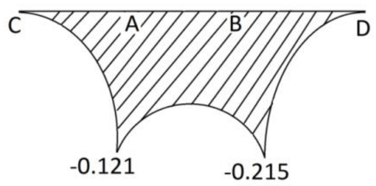
For SFD

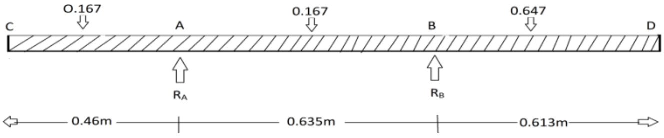


For BMD



Case 4: Overhanging beam with point load on whole stretcher
According to data sheet & Ref. Daga Hospital and from Research paper: "Design & Fabrication of stretcher cum wheelchair,

1) Wt. on back pan : 65.95kg = 647N = 0.647 KN
2) Wt. on seat pan : 17.02kg = 167N = 0.167 KN
3) Wt. on leg pan : 17.02kg = 167N = 0.167KN



1) εFy=0 ↑+ ↓-
   R_A+R_B=0.981
2) $\varepsilon M_A=0$ (↻ = +, ↺ = -)
   R_B=0.9821KN
   R_A=-0.0011KN

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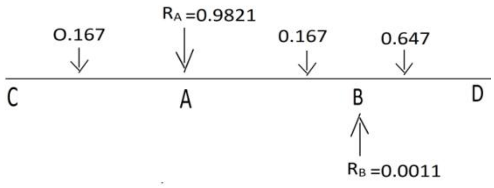
Therefore, changing sign convention.



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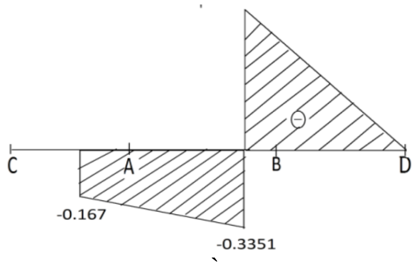
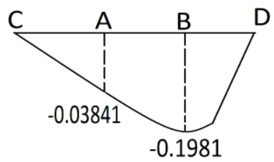
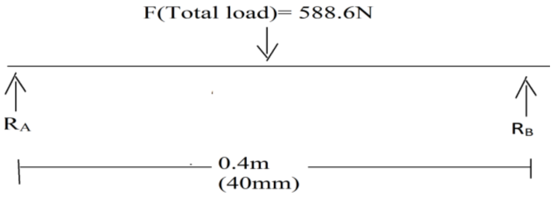


For BMD



B. Load Calculations
1) Load on wheels
Weight of model = 20kg =20×9.81=196.2N
Weight of human body = 100kg = 981N (Ref. Research paper)
Inclination angle ϴ=0°
Load acting on wheels = 196.2+981 = 1177.2N
Actual load acting on each wheels = 588.6N
2) Load on Back rest position
Weight of Frame (Back) = 6kg = 58.86N
Weight of human body = 65.95kg = 646.96N
Total load acting on back pan = 705.8295N
3) Load on leg rest position
Weight of Frame (Leg) = 6kg = 58.86N
Weight of human body = 17.02kg = 166.9662N
Total load acting on leg rest = 225.82N
4) Load on seat position
Weight of Frame = 8kg = 78.48N
Weight of human body = 17.02 = 166.9662N
Total load acting on seat = 245.45N

C. Stress Calculations
1) Stress on wheels
*Diameter of shaft (d) = 25mm
NOTE: Diameter of shaft is comes safe for design Fabrication purpose as calculation is done on shaft design by analytical method.
a) Bending stress
$\sigma_b = (^M/_Z) = (^M/_{I/Y}) = (^{MY}/_I)$
where M- moment
Y- dist from neutral axis to extreme fibre
And $y = d/_2$ (In case of circular cross section)
*Reference taken from text book of Machine Design By R.S.khurmi & J.K.Gupta.

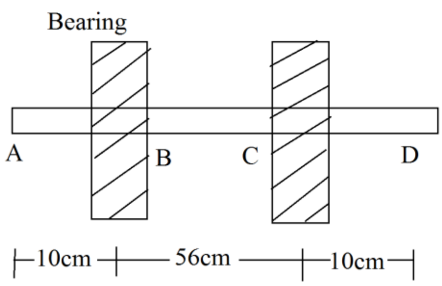


(M)taking moment of force = $F(l/_2)$ = 11772Nmm
(Y) = $d/_2$ = 12.5mm
(I) = $(\pi/_{64})(d^4)$ = 19174.75mm^4

σ_b= (11772×12.5)/(19174.75)
= 7.67N/mm^2

∴Design is safe.
b) Shear stress
Shear stress, $\tau = ^{TR}/_J$
Torque = $F \times ^l/_2$=11772Nmm
R= $^d/_2$ = 12.5mm
J = $\pi/_{32}(d^4)$ = 38349.51mm^4
τ = 3.837N/mm^2
1) Stress on back portion
a) Bending Stress
$\sigma_b = (^{MY}/_I)$
σ_b= 0.00275N/mm^2
∴Design is safe.
2) Stress on Seat portion
a) Bending stress $(\sigma_b) = (^{MY}/_I)$
1) Load on seat = 245.45N
2) $M=F(^l/_2) = 77.93\times10^3$Nmm
3) Y= 13.5mm
4) $I = (bh^3/12) = 1.19\times10^{10}$ mm^4
5) σ_b= 0.000654N/mm^2
$(\sigma_b)_{ind} < (\sigma_b)_{per}$
∴Design is safe.
3) Stress on leg portion
a) Bending stress $(\sigma_b) = (^{MY}/_I)$
1) σ_b= 0.000114 N/mm^2
∴Design is safe

D. Calculations for shaft



Step 1: Consider UDL
Assume load of human body = 100kg = 981N
Load of model = 20kg = 196.2N
Total load = 1177.2N

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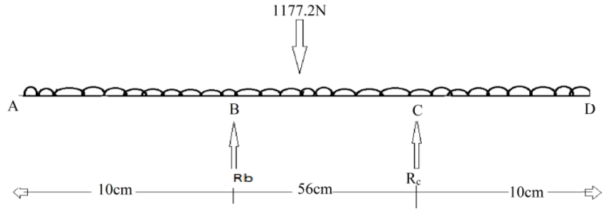
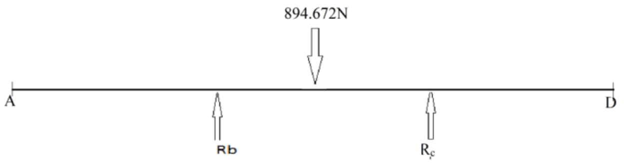




2) Taking moment about point (B) = (894.672×0.28)-(R_c× 0.56)

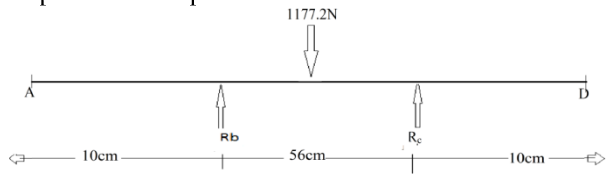
R_c = 447.336N

3)εFy=0 ↑+ ↓-

R_b+R_c-894.672=0

R_b=447.336N

Step 1: Consider point load



1) εFy=0

R_b+R_c = 1177.2

2) $\varepsilon M^f_B = 0$

(1177.2×0.28)-(R_c×0.56)=0

R_c= 588.6N

R_b=588.6N

Step 3: Bending Stress (σ_b) = ($^{MY}/_I$)

Where, M= $^{WL}/_4$ for point load

M =WL^2/8 FOR UDL

Ʈ = (I/Y)= ((π/64)D^4)/(D/2))

∴ Ʈ = (π/32)D^3

From Design Data book, pg no. 39, table no-∏-7

For SAE 1030 (Shaft material)

S_{eb}=225mpa

Fos= 2

∴σ_b = 112.5mpa

For point load :

M= $^{WL}/_4$ = $^{1177.2\times760}/_4$ = 223.668×10^3 – For point load

112.5 = (223.668×10^3) / (π/32)d^3

D(Dim. Of shaft) = 25.65mm

For UDL

M =WL^2/8 = (894.672$(760)^2$) / 8 = 53.83×10^6

112.5 = (53.82×10^6) / (π/32)d^3

D(Dim. Of Shaft) = 16.953mm

∴For actual fabrication we have taken d=25mm

IV. Working Of Wheelchair Cum Stretcher

- The working of wheelchair cum stretcher is very simple as it consist of linkage mechanism.
- This mechanism is manually operated and little force is required to push the Back pan in downward direction.
- As we pull the back pan in downward direction simultaneously leg pan moves in upward direction as these pans are connected with linkage mechanism so the motion is transmits through linkages.
- And in this way the wheelchair is converted into stretcher and then the main part of this project is height adjustment.
- Simple leg or hand operated lever is provided with hydraulic bottle jack, when we applied the force on lever, jack moves upward and it reaches maximum height in less time.
- And to decreases the height we have to reduce pressure of jack, stretcher comes in original height automatically.

V. Discussion & Conclusion

According to the various issues that have been discussed in paper we concluded that very costly and atomized equipment are used to transport the patient from one place to another. And due to high costing they are not affordable for every hospital. So our aim to design the simple model of combined wheelchair and stretcher which can reduce the cost of separate equipment and provide efficient model of wheelchair cum stretcher will provide ease to transfer the patient, model reduced the steps in transferring the patient from wheelchair to stretcher.

In most of the models that are in existence have some drawbacks such as scissor mechanism required uniform load to lift but in case of human being no uniform load is acting. The lead screw mechanism requires larger length of screw and number of rotation of screw required lifting the pan and also same number of rotation requires attaining original position. But this model overcomes the above problems as it consists of simple linkage mechanism to convert the position of wheelchair to stretcher and vice-versa. It requires minimum force for movements of pan. The hydraulic jack has simple mechanism of lifting, and it comes back to its original position without any external effort. The benefits of our project are ease to maintain, customized usability, easy adjustable, durable, cost beneficial.

Future scope of this project is to use for emergency cases in hospitals to transfer the patient from ambulance to stretcher and from stretcher to operation bed by using other mechanism to move the pans in horizontal direction.

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