DESIGN AND FABRICATION OF STAIRCASE CLIMBING TROLLEY

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ABSTRACT:
Trolleys are one of the important and supporting machines in transportation of the material for one place to other within the organization. Almost all manufacturing industries and workshops are using the trolleys for moving the material. The main issues associated are the design for proper application with better capacity to handle the load. The trolleys are capable for moving the heavy material with least efforts. These are also useful in shifting of household material specially in shifting of the house. We have identified the need of special design which can be used for moving the material with staircase. The design of the trolley for staircase is discussed in this paper in detail. This design is suitable mainly for multistory buildings where we can move the material with ease. Tri-Star wheels are used to up and down lift the load with fewer efforts.

KEYWORDS: Trolley, Staircase Climbing Trolley, Tri-Star Wheels, etc.

INTRODUCTION:

Moving the heavy material from one place to other is always challenging. When it comes to movement of heavy material over staircase, it becomes more challenging in terms of the safety of people. The heavy material need to be handled with extra care and it needs more manpower to carry it over staircase. This situation is addressed by us with a design of trolley which is capable to move the material over stair case.

The space requirement has increased over the years with population and results in vertical expansion of the buildings in cities. Many industries also had expanded the infrastructure vertically to make it affordable. For the old building the capacities of lifts are small in terms of space and weight handling. There is no arrangement of new lift installation as changing the structure is impossible. Conventionally all the movement of the material in such building is happening with human. There is need for the system to reduce the efforts taken by human in this work with their lives in danger during handling of heavy material over the staircase. The trolleys are only capable for movement of material from one floor to other with ease. In case of Normal Trolley, we identify some of the problem which generally occurs in case of regular wheel arrangement. The usual wheel arrangement has various problems identified which are listed as follows: -

- Lifting weight on stairs.
- Low Stability on stairs.
- More efforts required to raise the load on stairs.

- For holding and breaking the trolley on stairs.
- Selection of better bearing on wheels.

OBJECTIVES OF WORK:

- The Project aims at making headway for developing a mechanism for transportation of considerable loads over stairs.
- Lifting material with heavy weight to upper level from the ground with painless work. Especially where there are no lifting facilities for (elevator) moving objects from lower to upper level or vice versa.
- To prove Tri-Star wheel arrangement is better than normal wheel structure at climbing the stairs.
- Weight reduction and minimum effort require carrying the load.
- Keep safety, weight, and size in perspective.

SYSTEM DESIGN:

Material Used:

C 45 (mild steel)

Take fos 2

$\sigma_t = \sigma_b = 540/\text{fos} = 270$ *N/mm²*

$\sigma_s = 0.5\ \sigma_t$

$= 0.5 \times 270$

$= 135$ N/mm²

Design of Motor:

Power of motor = 100 N- m /s

Rpm of motor = 30 rpm

Power of motor= P = 100 watt.

$P = \frac{2\pi N T}{60}$

Where,

N→ Rpm of motor = 30 rpm

T →Torque transmitted

$100 = \frac{2\pi \times 30 \times T}{60}$

T = 31.82 N-m

T = 31827 N-mm

Chain Sprocket:

Fig.1: Chain Sproket

Chain Sprocket of 44 and 18 teeth are taken

So, ratio: 2.44

T2 = 77799 N-mm

N2 = 12.27 rpm

Torque Transmitted:

Now, the load lifted by the trolley motor can be calculated by

Torque transmitted,

T = Force × radius

77799 = F × (115+75)

F = 77799/190 = 409.46 N

$F = \frac{409.46}{9.81}$

F = 41.71 Kg

Now, T3 is the maximum torque among all shafts, so we will check shaft for failure here.

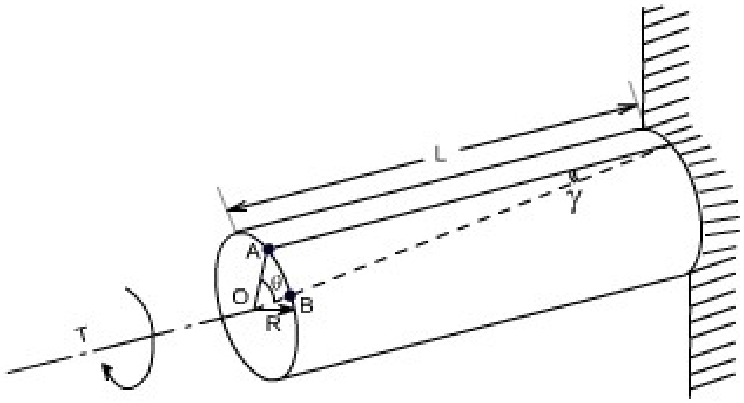

Fig.2: Shaft Failure Analysis

Maximum normal stress theory or Rankine's theory

The total weight on shaft coming is

W=41 kg= 410N

M= F x L

M= 410x60=24600 N-mm

$T_e = \sqrt{M^2+T^2} = \sqrt{24600^2+77799^2}$

T_e=81596 N-mm

$T_e = \pi/16 \times 135 \times d^3$

d^3=3078

d=$^3\sqrt{3078}$=14.54=15 mm

d= 15 mm

But we are using- 20 mm shaft so design is safe

For 20mm Shaft diameter we take standard breaking no. P204

Fig. 3 Standard Breaking P204

P=pedestal bearing

2=spherical ball or deep groove ball bearing

=04=5 * 4 = 20mm

Bore diameter of bearing.

Box Pipe Used as a Beam is Subjected to Fail under Bending:

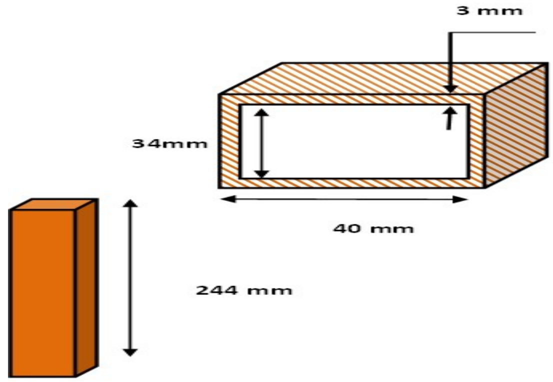

Fig. 4: Box Pipe Representation for Calculations

W = F = 500 N
M = W L / 4 = 500 X 450/ 4 =56250 N/mm
$Z = B^3 – b^3 / 6 = 40^3 - 34^3 / 6 = 4116\ mm^3$
$\sigma_b = M / Z$
$\sigma_b = 56250 / 4116 = 13.66\ N/mm^2$
$\sigma_{b\ INDUCED} < \sigma_{b\ ALLOWED}$
$13.66\ N/mm^2 < 270\ N/mm^2$
Hence our design is safe.

Design of bolt:

Material = C45 Steel
Diameter = 9.31 mm
Diameter of M10 bolt = 8 mm
Let us check the strength when initial tension in the bolt when belt is fully tightened
P = 981 N is the value of force
P = 981 N
Also, $P = \Pi /4\ dc^2 x\ ft$
981 x 4
ft = 3924/201 = 19.51 N / mm^2
3.14 x (8)^2

The calculated ft is less than the maximum ft hence our design is safe.$\sigma_t = \sigma_b = 135\ N/mm^2$ $\sigma_s = 67.5\ N/mm^2$

Design of transverse fillet welded joint:

Fig.5: Design of transverse fillet welded joint

Selecting weld size = 3.2mm

Area of Weld = 0.707 x Weld Size x R

= 0.707 x 3.2 x π x 20

= 142.150 mm2

Force Exerted = 30 x 9.81 = 300 N

Stress induced = Force Exerted / Area of Weld

= 300 / 142.15

= 2.11 N/mm^2

For filler weld:

Maximum Allowable Stress for Welded Joints = 210 Kgf/ cm^2

= 21 N/mm^2 Hence design is safe

The design and software analysis is presented in following section.

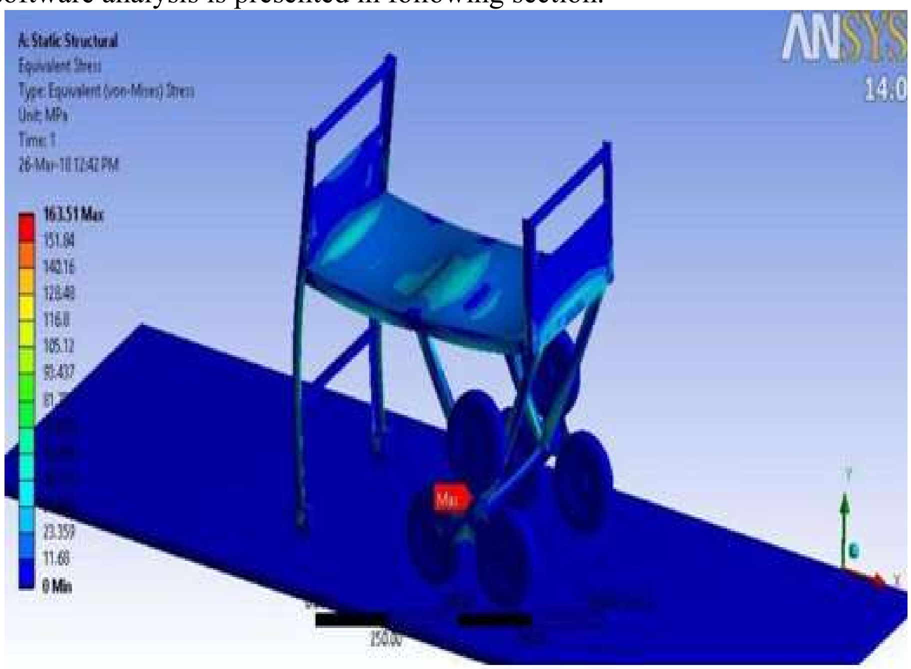

Fig.6: Stresses for Trolley under Load 9800 N

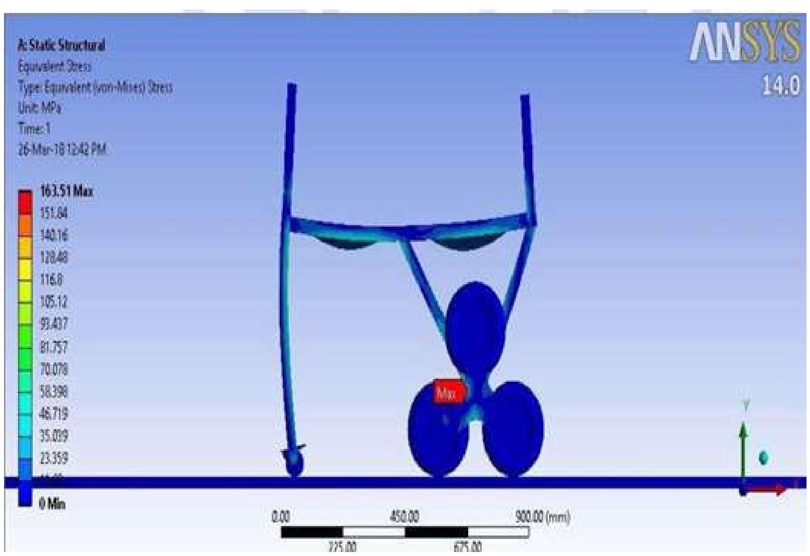

Fig.7: Side View of Von-mises Stresses for Trolley under Load 9800 N

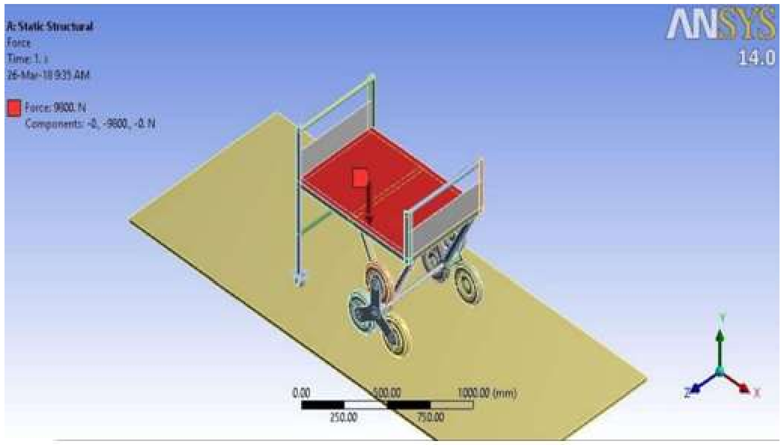

Fig.8: Application of 9800 N load at Platform for Trolley

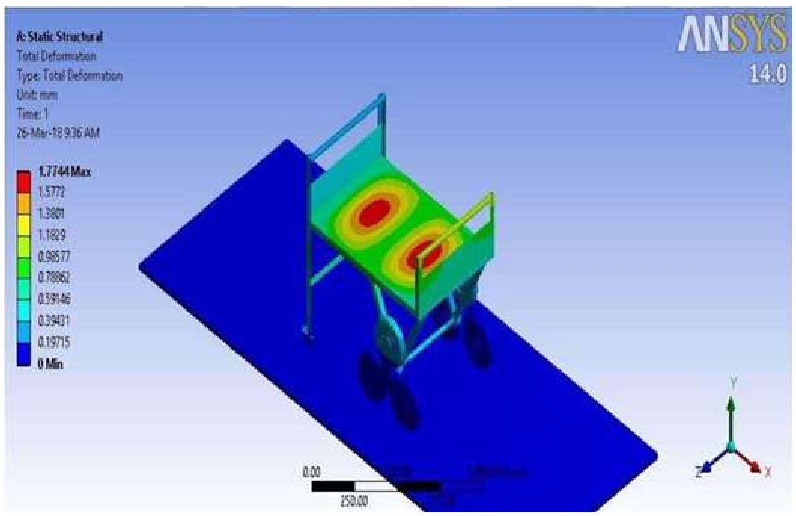

Fig.9 Total Deformation due to of 9800 N Load at platform

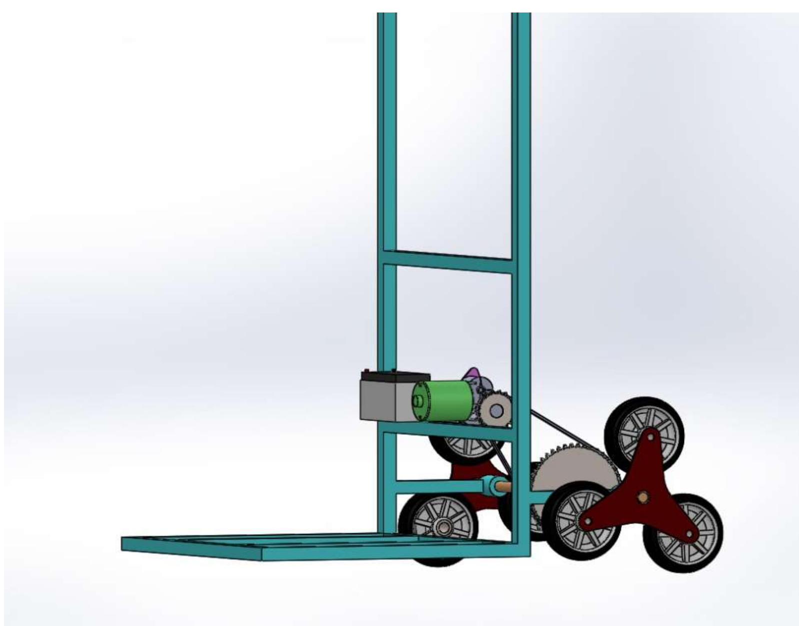

Fig.10: Side View of the Trolley Designed

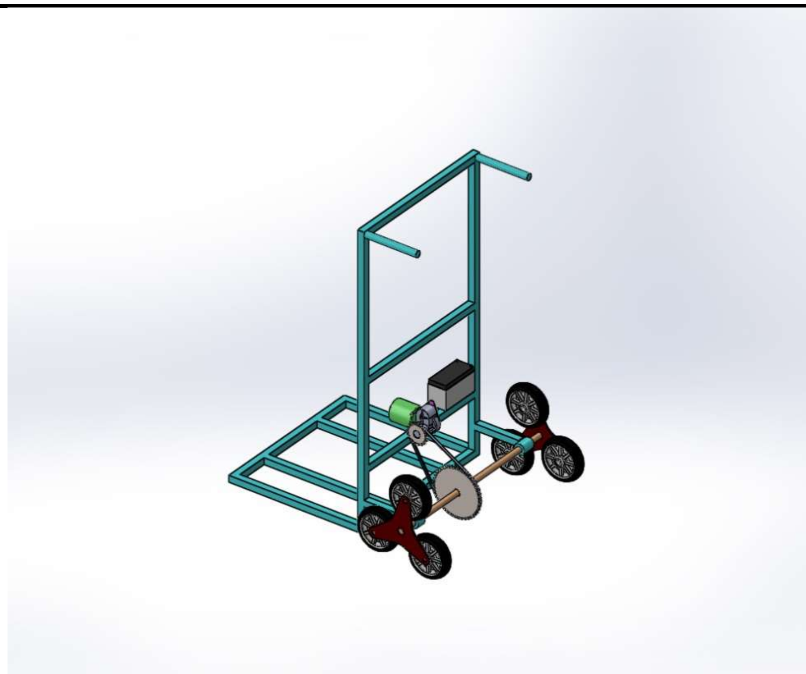

Fig.11: Complete View of Trolley Designed

CONCLUSION:

Trolleys for shifting of material are used since long time. The need of the time is to improve the design in order to make it suitable for new applications. Challenges of material shifting over different floors without lift are need of extra manpower, time and risk of loss of material and life which is not very sustainable. To overcome this situation we have designed a special trolley with capability to lift the material up and down stair. The design calculation and the CAD design of trolley for application of staircase presented in this paper in detail. The improvement in design is useful to manufacture this machine at low cost with good capacity to handle the load.

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