



## DESIGN AND ANALYSIS OF STAIR CLIMBING TROLLEY WITH ANTI SLIPPAGE MECHANISM

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**ABSTRACT-** A common challenge in the rise of staircase trolley. To raise the trend of this sector, there is a requirement to improve the existing design of the tri-wheel setup. The changes in the design may lead to beginning of a new era in this field with the availability of economical and efficient designs. The objective of this paper is to study and design the improvisation of existing staircase trolley. Here, the design for the tri-wheel setup of staircase trolley so that it can be effectively climb the staircase with minimal efforts and without slippage on the staircase. Moreover, it will climb more steps with less manpower during the uplift of the trolley on steps. Trolley is generally use for the carrying heavy weights with the help of less human effort. The manufacturing of the trolley deals with proper design, accurate fabrication and prescribed analysis using finite element software gives better motion which resist to high load by applying less effort this paper deals with manufacturing of such stair climbing trolley with simple mechanism(i.e. ratchet mechanism) with anti-slippage mechanism. initially the model is sketched using solid works and imported into ANSYS software for structural analysis used to find von-mises stresses under load which deals to fabricate trolley with better performance under heavy duty with less effort.

**Index Term-** Staircase Climbing Trolley, anti-slippage mechanism, less man power, efficient use.

**Introduction-** Staircase trolley is a crucial element in climbing the steps which helps to get maximum results with less effort between surface and wheels. Due to application of load in the downward direction, this need to apply more force for a regular trolley to climb the staircase. While designing, the two most important parameters to be considered are firstly, the shaft must rotate in one direction(with anti-slippage mechanism) and secondly the tri-wheel motion should be rotated restricting the motion of individual wheels. The different conditions like flat and staircase are the two different surface where the trolley can move without any difficulties.

Firstly, let's consider the trolley moving on flat surface, which is having set of three wheels on both sides connected with shaft. While moving on the flat surface the trolley will move on the two wheels on the both sides(total four wheels on the surface). On the other hand, the motion of the third wheel is restricted on the both the sides for a smooth motion of the trolley. So, in this interval the need is to achieve the motion by constricting the motion of third wheel which will be done naturally when load applied, the wheels automatically stop rotating on its axis.

Secondly, while climbing on staircase the motion of the individual wheel restricted by applying break. Moreover the wheels must rotate on the central axis, which is on the shaft. So that when the two wheels on the flat surface will stay constant and the third wheel will give the support to climb for the first wheel in the same manner moving to the second step the wheel in the air will incline to the stair and give support to the rest two wheels, in the mean while the central shaft will rotate so that the wheels will climb the stairs. This helps the user to climb stair with luggage makes easier.

Here, by restricting the motion of two things which are central shaft moving in backward direction by using bearing in the shaft so there will be no gravitational force acting on the trolley while moving on the staircase. Second is the motion of individual wheels

over its own axis, this will help in gripping of motion of the trolley. The whole process of the synthesis is categorized into two parts. In the first phase, motion on the flat surface is carried out. In the second phase, motion on the staircase can be achieved by followed modification in design. Even though main researchers investigated on fabrication and design of stair climbing trolley less effort where implemented to perform analysis on cabin structure and wheel alignment. In this paper the efforts are insisted to carry analysis on entire trolley structure is including wheels and fabricated with optimal measurements with suitable materials. It requires much effort, time to lift a heavy weight component and to transport them to different locations. This type of problems raises in industrial sector, factory, manufacturing units and production sector where heavy mechanical components are to be transported from one place to another place and also from one floor to another floor using simple mechanism in involved in such operation it becomes very much difficult to move heavy components to different locations.

**Literature Review-** Many researchers performed various experimental investigations on stair climbing vehicles such as trolley, trucks, chair for handicapped person, forks etc. it requires an in depth study of maximum load acceptable for a cabin and how stress transferred to wheels alignment.

Pratik H. Rathod designed and fabricated a hand truck which climb stair with less effort which is useful for library, hospital, regular goods carrier etc. the main modification in this truck where made at wheels using plat surface roller plat attached instead of traditional wheel frame. The mechanism based on retched arrangement mechanism. The maximum bending moment was calculated. The inclination of 44 degrees plays a major role which covers more than 90% of all stairways within this limit. There is an optional maximum inclination warning alarm that alerts the operator of an inclination of more than 44 degrees. When truck operated with exceeding the limit there should be taken the necessary safety precautions.

Md. A. Hussain designed and manufactured a stair climbing vehicle using modified form of frame arrangement i.e. a curved wheel frame which move on rough surface. To address several technical issues in designing this vehicle is stability and maintain high speed at vehicle wheel arrangement while climbing stairs. The frame arrangement consists of sun, planetary, idler wheel which are assembled to the shaft which reduces application of load. However, the steepness of the stairs is also the important concern of this study. The vehicle has four set of wheels arrangement to support its weight when it moves over the flat terrain. Each wheel frame consists of three sub-wheels attached with the sun wheel through three idler gears.

Ashish Singh worked on four-wheeled robot will have the capability of climbing the stairs of height equal to its diameter. It will possess maximum gripping capacity and stability during motion in rough terrain owing to the 4 differential driven wheel configurations. The main goal of this investigation involved within this project such as the robot should be upgradeable with a variety of application sensors, e.g. cameras, thermal vision, or chemical sensors. To be usable in any search and rescue or security application, the robot has to be operational without changing batteries for at least two hours.

Raj Kishor Kumar investigated on stair climbing functionality is embedded in the design through its structure and mechanism. The product mainly consists of modules viz. seat, links and frame. Anthropometric measures are considered in the dimensioning of seat. Focus is laid on different parameters such as form, functionality, technology and architecture of the product. The design is validated by developing Digital Mock-ups of individual parts are generated in PRO-E Creo software and are assembled to form the final product. Necessary simulations of the product are generated in virtual environment of PRO-E Creo software. The physical and focused prototype indicating the structure and functionality is developed using thermocol material. Here wheel carriers are made in RP (Fused Deposition Modelling) using ABS (Acrylo Butadiene Styrene) material. Wheelchair is embedded with some additional features like integrated commode facility, after gathering costumer requirements from different subjects.

P. Jey Praveen Raj designed device such as hand trolley used to relieve the stresses of lifting while on flat ground. However these devices usually fail when it comes to carrying the load over short fleet to carry heavy objects up the stairs with less effort compared to carrying them manually .The main objective of the project is to find an efficient and user friendly method of carrying various objects through stairs using minimum effort from the user and to also provide a smooth movement while climbing the stair. Under this project we have manufactured a stair climber with tri lobed wheel frames at both sides of the climber and three wheels on each sides are used in the tri lobed frame. The wheel assembly is rotated by a gear- motor mechanism where a DC gear motor is used to provide the necessary power for rotation and a pinion-gear mesh is used for reducing the rotating speed of the wheel. The motor is connected to a lead acid battery of similar ratings and they are in turn connected to DPDT switch.

Roshan Alaspure designed AND fabricated a Stair Climbing Wheel Mechanism which can be considered as Alternate for lifting goods in such a way that it can be climb a stepped path with its modified wheel structure using manual metal arc welding (MMAW) or stick Welding. An electric current is used to strike an arc between the base material and consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapours that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination.

P. P. Gondole fabricated a stair climbing hand trolley with proper dimensions of Height 4 feet, Lower frame 38 X 38 cm, Length of each arm of trigonal wheel axial geometry 15 cm, Diameter of shaft 15 mm. The major components used to fabrication process are square bar cast iron pipe, Round bar shaft of SAE 1030, rubber rest, caster wheels (industrial rubber), iron plate, long guzzon pin. Mathematical calculations are made to this work to exhibits expected results and carried load across the stair very easily thus climbing across stairs transportation of goods very easily.

**Summary of Literature-** Pratik H. Rathod started the way of stairclimbing trolley with his new design and later on many researchers did the improvements in the design. designed and fabricated a hand truck which climb stair with less effort which is useful for library, hospital, regular goods carrier etc. the main modification in this truck where made at wheels using plat surface roller plat attached instead of traditional wheel frame. The mechanism based on retched arrangement mechanism. The maximum bending moment was calculated. The inclination of 44 degrees plays a major role which covers more than 90% of all stairways within this limit. There is an optional maximum inclination warning alarm that alerts the operator of an inclination of more than 44 degrees. When truck operated with exceeding the limit there should be taken the necessary safety precautions.

**Traditional method for taking up heavy loads on the first floor-** Traditionally, the collie carry heavy loads on their head and sometimes this much load may cause injury to them.

**Calculations-** As designing the staircase trolley, the designing as a prototype and took the dimensions smaller.

Various parts in this trolley-

The cart- The length of the cart is 40 inch along with and the width of the kart is 20 inch. As there are various mountings they are made according to the requirements.

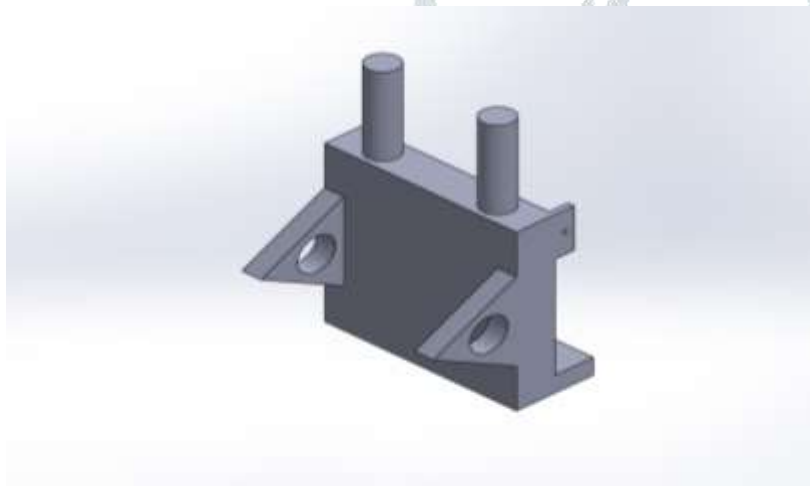


Fig. 1

The second main part is in staircase trolley is the spinner like structure which is attached with the shaft.

The dimensions for which the design is being made may be different from the other stairs so the dimensions of this part may be arbitrary and make it according to the staircase.



Fig. 2

On the edges of this the wheels are attached and in the middle the shaft is attached to it.

Wheels- The rotation of the shaft is only in that case when the trolley is on the stairs so the rotation of the shaft must be stopped when it is moving on the flat surface. So by just doing one simple thing the rotation of the shaft can be stopped i.e. by applying a breaking system in the wheel which is not on the surface and attached that with the cart for that purpose only just the holes are being made in the wheels so that the system work properly.



Fig. 3

To stop the reverse motion of the shaft the application of the mechanism which is used in the cycles. The shaft must not have back motion when it is on the stairs.

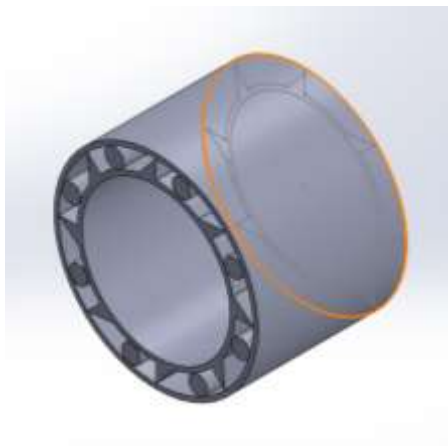


Fig. 4

In this the process is that when the trolley is being pulled it the rollers in between will rotate but when it will go in other direction the rollers will go on the inclined surface and it will stuck.

**Final Assembly-**

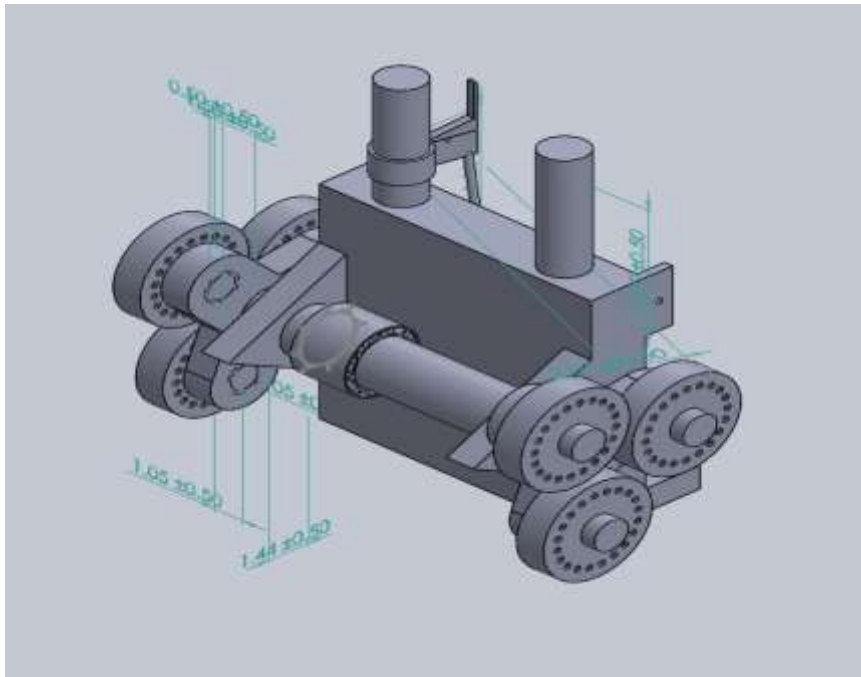


Fig. 5

**Analysis-** Material used in the wheel is the high carbon steel. The material used for antislippage mechanism is structural steel.

**DEFORMATION-**

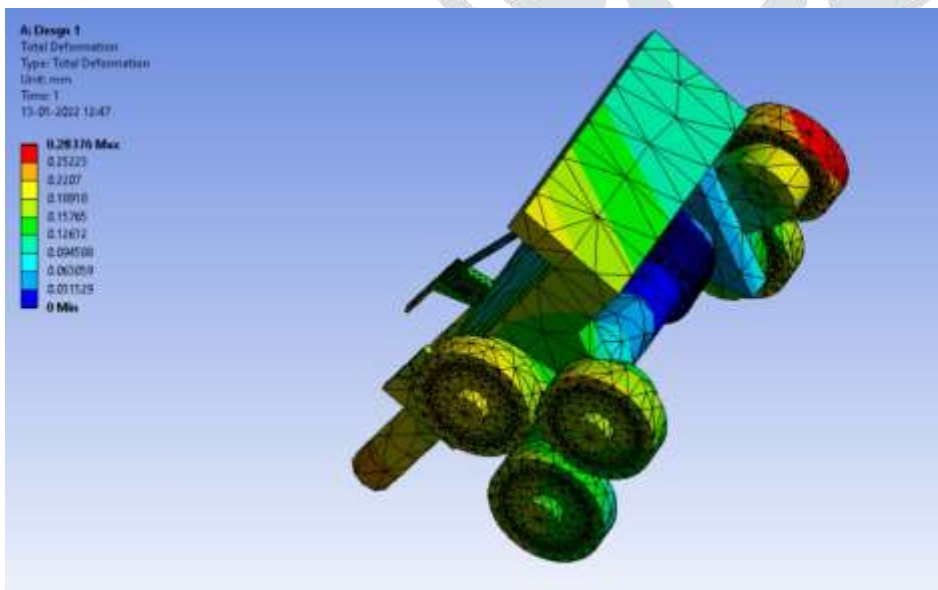


Fig. 6

## FACTOR OF SAFETY-

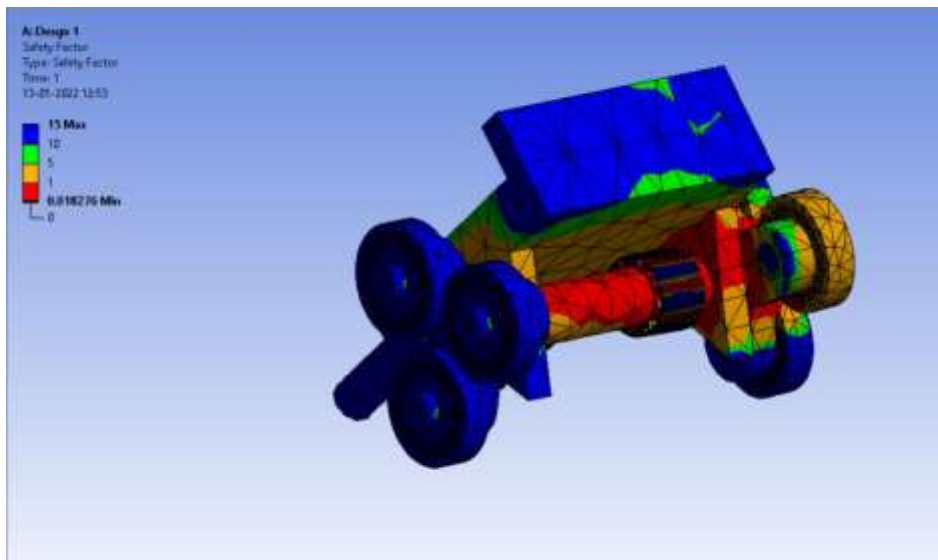


Fig. 7

**Result-** As this is the modern type of climber, the better results can be achieved by the less efforts. Here the comparison with other ones the tri-wheel set-up which is much effective and also this format of design gives the much more elegant way to look according to design as well as the adoptability in climbing the stairs. By this creation the transportation of the huge loads to the upper floors with minimal effort. It was found that the vehicle was moving well over the stair. It can move on flat surface uniformly at 20 rpm without any fluctuation. It was observed that there was very low noise and vibration over flat surface or stair. It was observed that the vehicle was disturbed when it faced the stair of different step sizes. This was because of the shape and size of the wheel frame.

**Conclusion-** The above work on fabrication design and analysis of stair climbing trolley is based on modeling made by solid works with accurate values and imported into ANSYS workbench for structural analysis and proper mesh. After performing the analysis design brought into practical working model successfully. The wheel attachment as proper gap with each other and there is no slip, 2sudden shock, wear and tear on other platform. The mechanism of transmission can carry heavy loads with less effort. The tri stair plate can weight itself to climb any height of stair with little tolerance using nut-bolt and adjustment mechanism with in less time more luggage can be moved to different locations with easy transportation. During the test run of this project, it was realized that it would capable of carrying heavy load without suffering any deformation or local fractures if it would go into real world production at an ideal scale. Though the initial cost of the project seemed to be higher but more accurate manufacturing would shorten this cost.