# A Review on Design and Fabrication of Affordable Lift for Built Home

[1]Thamme Gowda C S, [2]Dr. G B Krishnappa, [3]Yashas G, [4]Ujwal K N, [5]Vishal R, [6]Pavan D S

[1]Research scholar, Department of Mechanical Engineering, Vidyavardhaka College of Engineering, Mysuru, Karnataka, India

[2]Dean R&D and Professor, Department of Mechanical Engineering, VidyavardhakaCollege of Engineering, Mysuru, Karnataka, India

[3,4,5,6] Students of Mechanical Engineering, Vidyavardhaka College of Engineering, Mysuru,Karnataka, India

***Abstract*****:** Lift may be a very simple mechanical equipment used to raise elements or objects or load from ground level to a specific height to perform a particular work with maximum load capacity and minimum efforts of a worker. The objective of this work is to develop a mechanism for climbing up and down over stairs for aged and physically challenged people and easy mobility of the whole elevator. To achieve this, we require high strength materials, wheels, etc. All the researchers attempt to optimize these parameters according to the concerned requirements. This review paper is focused on the analysis of some research papers containing the entire study of components, selection of materials, and analysis of dimension of components. After the analysis of research papers, long term scope of the research was also suggested. This review paper focuses on the analysis of several research papers that explore the entire study of components, selection of materials, and analysis of dimension of components. It provides insights into current advancements in the field and evaluates different approaches to developing a stair-climbing mechanism for aged and physically challenged individuals.

## 1 INTRODUCTION

Disability is a part of the human condition. Almost everyone may be temporarily or permanently impaired at some point in life. More than one billion people in the world live with some form of physical or mental disability, of which nearly 200 million experience considerable difficulties in functioning. This is due to ageing population, as well as the global increase in chronic health conditions, such as diabetes, cardiovascular disease, and mental health disorders. In addition to that, a lot of people use wheelchair to overcome their disability in non-motion or who suffer difficulty in getting up and down stairs independently. People who have difficulties with walking activities need a mobile stairlift facility. However, the pitfalls of this facility are its high cost, independence of operation, installation to existing building and complexity of design.

Considering people with physical disorders, aged people and mobility of goods this study aims to design and develop of a mechanical stairlift system. The design highlights the mechanical configuration of the system and its control. Thus, aiding the above mentioned in developing a low-cost, mobilized and reliable electro-mechanical stairlift is a major contribution of the study. Besides, it facilitates their daily lives.

## 2. MATERIALS AND METHODS

This study presents a low-cost, automated portable lift that merges mechanical and electrical components for a seamless user experience. The system prioritizes safety and comfort while ensuring consistent and efficient operation. It is engineered to cater to a wide range of needs and preferences, with particular attention to safety measures for users. The following sections offer an in-depth analysis of the hardware module, detailing its design and functionality.

## 3 HARDWARE MODULE

The hardware module includes both mechanical and electrical components, which have been carefully selected based on the design requirements. The mechanical design encompasses the driving methods and rail systems, providing explanations for each choice and how they contribute to the overall functionality.

In the electrical design, the focus is on the lifting mechanisms and the selection of appropriate motors, taking into account their types and specifications. These aspects work together to ensure the lift operates efficiently and reliably while meeting the needs of the users.

## 4 MECHANICAL MODULE

The mechanical design of the platform encompasses several key considerations that must be addressed during the design process. These include selecting an appropriate driving method, crafting an efficient rail system, and conducting precise mechanical and power calculations for the actuators. Additionally, other mechanical components must be carefully integrated to ensure smooth and reliable operation.

Further, attention must be paid to factors such as weight distribution, load-bearing capacity, and the durability of materials. Proper alignment and fit of the various mechanical parts are crucial to guarantee seamless functionality. Each aspect of the design plays a vital role in achieving a safe, stable, and efficient platform for the user.

## 5 MECHANICAL DRIVING METHOD

Many mechanisms are used to convert rotational motion into linear motion, such as pullies, and sprockets with chain drives.

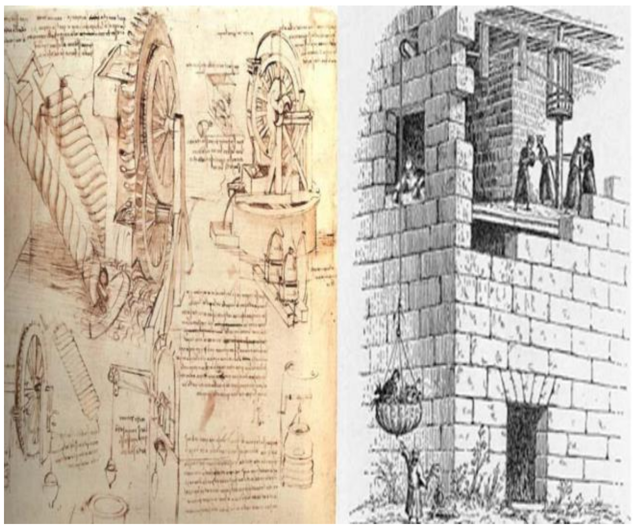


**Figure 1:** Early days of Elevator

## 6 Rail Design

Rail design in typical elevator systems, many designs fix the system on the existing building walls. The system was initially designed to examine design limitations. In the initial design, the rail consists of two straight twin I section steel railings, each with a length of 3657.6 mm. There were few limitations and therefore, the design was updated to C section railings and after considering few design calculations and limitations, the final length is designed to 48618 mm. Another challenge was the material selection of wheels since it had to withstand the total weight of the elevator as well as the external load added. To minimize the probability of failure due to frequent use of the load carrier, two stand rails with four rail wheels were recommended to support the system. Optimal distances between the support rails were determined and designed to be 1280.16 mm.

The calculations of the same is formulated below:

### Guide rail: C -section

Person weight = 120 kg = 1177.2 N
2-person weight = 240 kg =2354.4 N
=2354.4 N + 100 N
= 2454.4 N say 2500 N
consider the point load =2500 N
consider the material is mild steel
mild steel yield strength = 250 mpa (consider table 1.8 /page no 463 in design data hand book)

*Tensile strength = 432 - 510 N/mm2
* Yield stress = 245 mpa say 250 mpa
* Suggested uses: - general purpose-low stressed components
=σmax = $\frac{\sigma y}{FOS}$
*σmax = maximum normal stress
*σy = yield stress(N/mm2)
*FOS = factor of safety
σmax = $\frac{250}{3.5}$ = 71.4 N/mm2 say 75 N/mm2

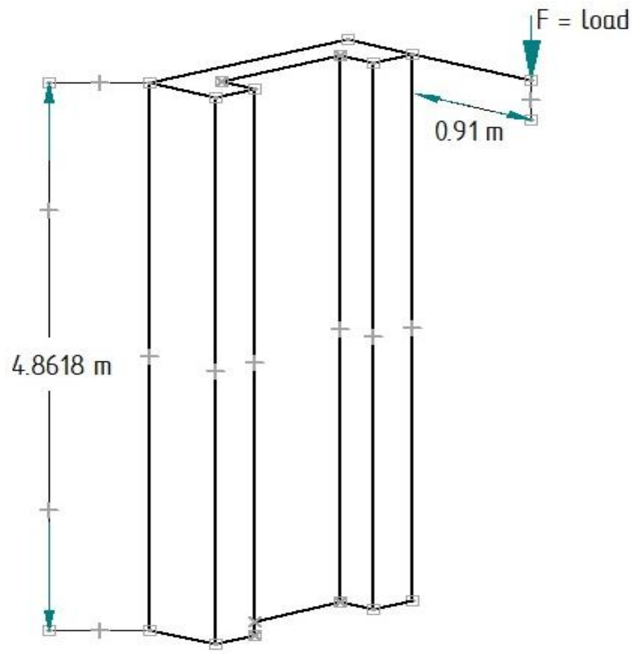



**Figure 2:** Guide rail: C -section

**Parameters need to be considered while Fabricating the Stair lift:**

- Weight of the platform
- Average weight to be lifted [180 – 200 kg]
- Platform dimensions [3*4 Ft.]
- Selection criteria for the selection of type of rope best suited for the stair lift and its strength and dimensional specifications.

**The main components involved in our project:**

- Metallic rope
- Guide ways
- Rollers
- Platform
- Electric motor

- Supportive frames [Mild steel]

Stress factor to be considered was calculated through the following:

### maximum normal stress

σmax = $\frac{F}{A} + \frac{Fe}{Z}$ (consider the equation no.1.10/page no 7 in design data hand book)
F = force N (kgf)
e = eccentricity, as force application (mm)
A = cross sectional area, mm2
Z = rectangular and polar moment of inertia respectively, mm4
Finding the cross-section area (A)?
(consider the table 1,3(a)type (d)/page no.12 in design data hand book)

### Data: - C – Section column

B =75 mm
b = 69 mm
H = 39 mm
$\frac{a}{2}$ = 3 mm
d = 5 mm
c1 = $\frac{aH^2 + bd^2}{2(aH + bd)}$
c1 = $\frac{9125 + 1725}{2(234 + 345)}$
c1 =9.36 mmc2 = H - c1
c2 = 39 - 9.36
c2 = 29.64 mm
h = c1- d =9.36 - 5
h = 4.36 mm
A = Bd + 2[(H-d)× $\frac{a}{2}$]
A = 75×5 + 2[(39-5)×3]
A = 579 mm2
Finding the Z =?
Z = I /C

Moment of inertia (I): -
I = $\frac{(Bc_1^3 - bh3 + ac_2^3)}{3}$
I = $\frac{(75\times 9.36^3 - 69\times 4.36^3 + 6\times 29.64^3)}{3}$
I = 70673 mm4
Z = $\frac{I}{c1}$ = $\frac{70673}{9.36}$ = 7550 mm3
Σmax = $\frac{F}{A} + \frac{Fe}{Z}$
Σmax = $\frac{2500}{579} + \frac{(2500*900)}{7550}$
Σmax = 302 N/mm2

The maximum normal stress (σmax) is 75 to 302 N/mm2 it is safe to design.

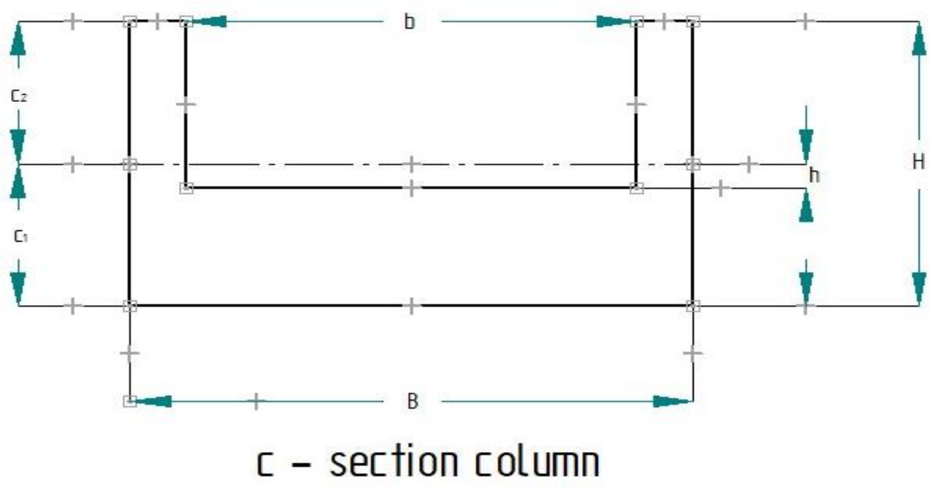



**Figure 3:** C – Section column

**Carrier (cantilever end load)**

Yield stress(σy) = 250 mpa

Factor of safety =3.5

Σmax = $\frac{\sigma y}{FOS}$

Σmax = $\frac{250}{3.5}$ =75 N/mm2

Σmax = 75 N/mm2

Σmax = $\frac{M}{Z}$ (maximum bending stress at point P)

M = bending moment-mm(kgf-mm)

Z = rectangular and polar modulus respectively, mm3

Σmax = $\frac{M}{Z}$

M = FL

Z = $\frac{bh^2}{6}$

Σmax =75 = $\frac{2500\times900}{(\frac{1280.16\times h^2}{6})}$

h2 = $\frac{2500\times900\times6}{(1280.16\times75)}$

h2 = 140.60 mm2

h =11.85mm say 12mm

The thickness of the carrier base is 12mm is safe to design.

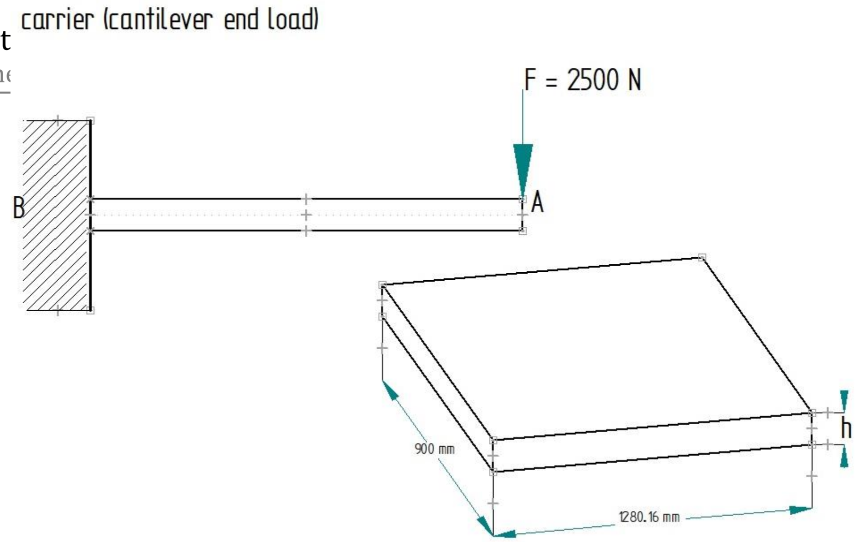



**Figure 4:** Carrier (Cantilever end load)

**Ropes: - calculation**

Design Data:

Standard designation is 6×19 rope

Application of 6×19 rope is a standard hoisting rope used for hoisting purposes in mines, quarries, cranes, dredges, elevators, tramways, well drilling.

Select a wire rope for a vertical carrier to lift of 2.5 KN form a depth 5 meter. A rope speed of 10 meter/min is to be attained in 50 seconds

Solution:

Data:

W =2.5 KN =2500 N

Depth = 5 meter

V = 50 m/min

T = 50 seconds

The following procedure may be adopted in selecting a wire rope for a vertical carrier.

Let us take a rope of type 6×19

Take the factor of safety as 7. since the design load is calculated by taking a factor of safety 2 to 2.5 time the factor of safety. Let us take the factor of safety as 15.

Design load for the wire rope

= 15×2.5 = 37.5 KN

= 37500 N

We find the tensile strength of 6×19 rope made of wire with tensile strength of 1600 MPA is 530d2(in NEWTON),Where 'd' is the diameter of rope in mm

530d2 =37500

d2 = $\frac{37500}{530}$

d2 = 70.75

d = 8.4 say 9 MM

We find that a 6×19 rope

Diameter of wire dw = 0.063d = 0.063×9 =0.5 mm

Area of rope A = 0.38d2 =0.38×92 = 31 mm

Now let us find out the various loads in the rope as discussed below.

We find that weight of the rope:

w= 0.0363d2 =0.0363×92 = 2.94 N/m

w = 2.94×5 = 14.7 N (depth = 5 m)

We find that diameter of the sheave (D) may be taken as 60 to 100 times the diameter of rope(d)
D = 100×9 = 900 mm

**Bending:**

$\Sigma b = \frac{E_r \times d_w}{D}$

$\Sigma b = \frac{84000 \times 0.5}{900}$ = 46 N/mm2

(taking Er =84000 N/mm2)

And the equivalent bending load on the rope

Wb = Σb×A

Wb = 46×31 = 1446 N

We know the acceleration of the rope and load

$a = \frac{V}{60t}$

$a = \frac{50}{60 \times 50}$ = 0.016 m/s2

additional load due to acceleration

$Wa = [\frac{(W + w)}{g}] \times a$

$Wa = [\frac{(2500 + 14.7)}{9.81}] \times 0.016$ = 4.10 N

We know the impact load during starting (when there is no slackness in the rope)

Wst = 2(W+w)

Wst = 2(2500+14.7) =5030 N

We know that the effective load on the rope during normal working (I,e, during uniform lifting or lowering of the load)

= W+w+Wb

= 2500+14.7+1446

= 3961 N

Actual factor of safety during normal working.

$= \frac{37500}{3961}$

= 9.46

Effective load of safety during starting

=Wst+Wb

= 5030 + 1446

= 6476 N

Actual factor of safety during starting

$= \frac{37500}{6476}$

= 5.79

Effective load on the rope during acceleration of the load

(I,e during first 50 second after starting)

= W+w+Wb+Wa

= 2500+14.7+1446+4.10

= 3965 N

Actual factor of safety during acceleration of the load

$= \frac{37500}{3965}$

= 9.45

Since the actual factor of safety as calculated above are safe, therefore a wire rope of diameter 9mm and 6*19 type is satisfactory.

Buckling Column: -

Consider column 39 mm×69 mm×23 Kg/m with thickness(t) 3 mm and thickness(t1)5 mm. The height of the column is 5 m and has load applied on to a pinned joint on top and is fixed at its base.

Data: -
Breadth = B =39mm
Width = D = 69mm
Thickness(t) = 3mm
(t1) = 5mm
Length = 5000 mm
Solution: -
End condition factor K =2.05 for one end fixed and another end pinned

Least moment of area l2 = $\frac{B^3-t}{6}+\frac{t_1^3-d}{12}$

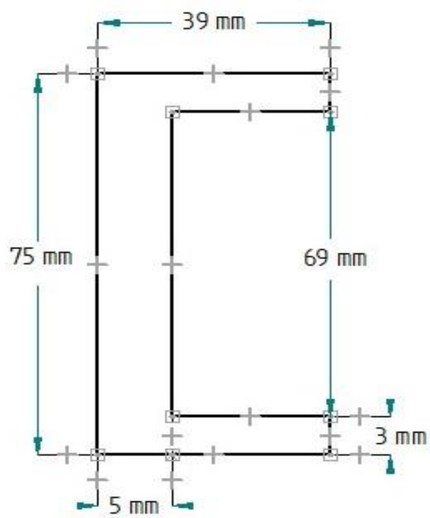
$$l2=\frac{39^3-3}{6}+\frac{5^3-69}{12}$$

l2 =9891 mm4
young's modulus for mild steel
E = 210000 mpa
Buckling load (P):

$$P=\frac{K\pi^2 El_2}{L^2}$$

$$P=\frac{2.05\times\pi^2\times210000\times9891}{5000^2}$$

P =1.68 KN =1681 N
The calculated buckling load was 1.68 KN.



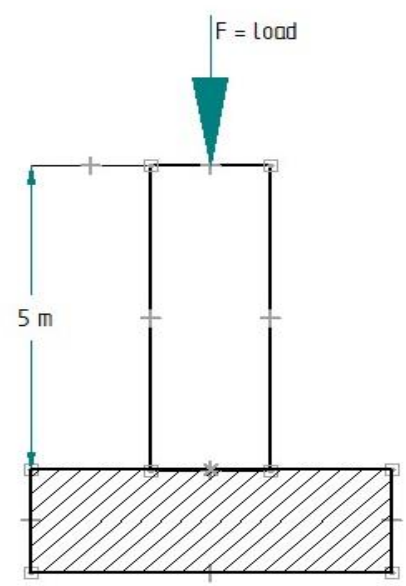




**Figure 5:** Bending

**Motor:**
The motor specification is one of the key factors that had to be considered to adhere the external load applied. According to the required load calculation, the following specification of the motor is proposed:

- 1 hp motor can pull up to 300Kg to 400Kg Maximum
- Input power 600W
- Frequency 50-60Hz
- Weight of the motor 11Kg

After formulating all the above design-oriented factors and the affordability factor the design, modelling and fabrication proposed and developed is reviewed here in the below shown images:

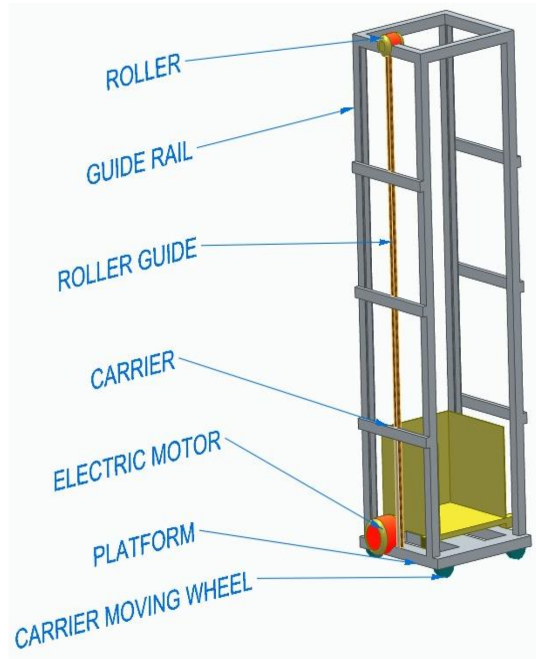
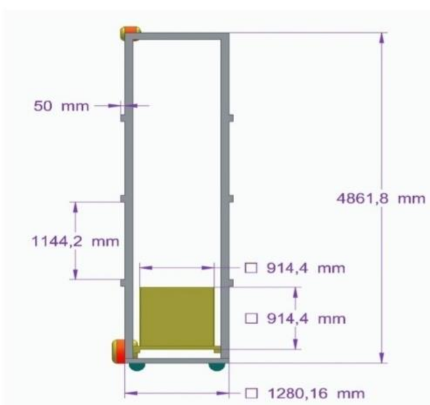
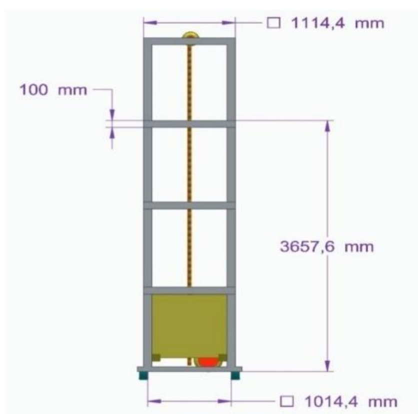


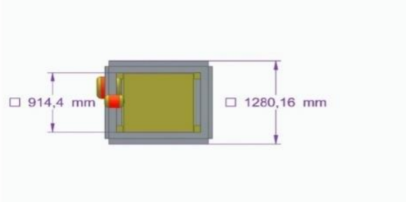

**Figure 6:** Our Solid Works Model




FRONT VIEW

SIDE VIEW




TOP VIEW

**Figure 7:** 3-D Dimensional View

## 7 Fabrication

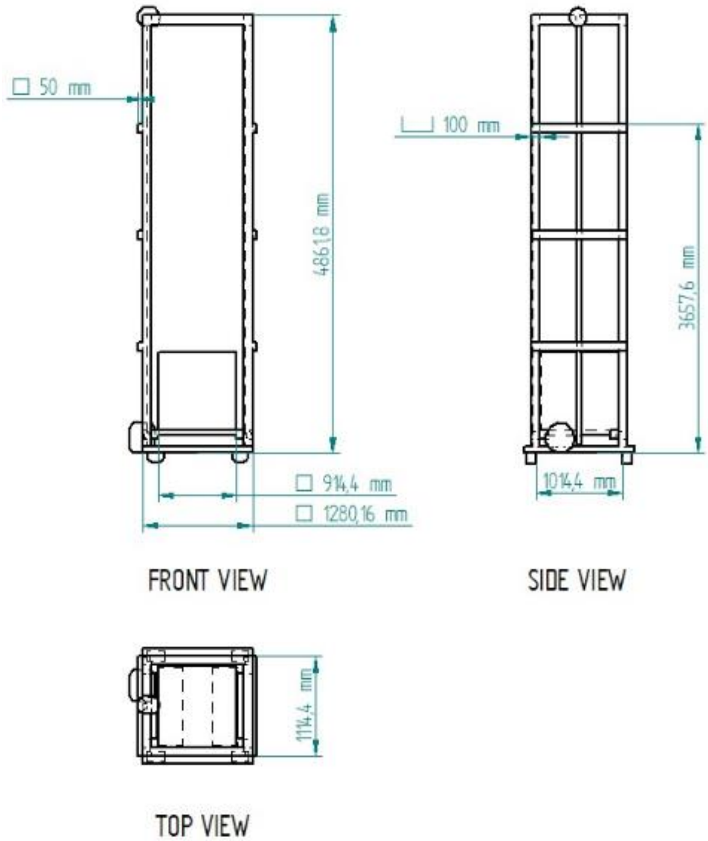



**Figure 8:** Draft Sketch

## 8 Literature Review:

Ahmed M. Salaheldin, Mostafa El-Mohandes Gandla and Neven Saleh [1]. In this study, a stairlift chair was designed and implemented to enable elderly and disabled people to climb and descend stairs. The design has been proposed based on electro-mechanical design. Both lifting and tilting mechanisms were designed and implemented in terms of hardware and software. The chair system was designed to carry a person weighing up to 100 kg. Several trials were made at different stages of fabrication to improve the system. The chair's characteristics in this context are that it is lightweight, comfortable, and inexpensive. Indeed, this study is considered a good solution for disabled people to facilitate their daily lives consistently.

Prof. Prashant Rahate, Nandkishor Gujwar, Megharaj Khorgade, Vaibhav Moundekar, Yash Gupta and Ajahar Mirza [2] The layout of the stair case is compact and for this reason is capable of flow approximately in nearly all of the stairs that we discover at institutions, offices, industries and additionally at a few homes. The layout is made very secure and there may be no hazard of failure of the body and wheels beneath Neath regular situations. The layout of the stair case is compact and for this reason is capable of flow approximately in nearly all of the stairs that we discover at institutions, offices, industries and additionally at a few homes. The layout is made very secure and there may be no hazard of failure of the body and wheels beneath Neath regular situations According to the checks conducted, the stair mountaineering stair case has a ability of wearing a load of 100kgs on flat surface. It has the capacity to ascend a flight of stairs of 40-diploma elevation wearing a weight of 55kgs. The layout of the stair case is compact and for this reason is capable of flow approximately in nearly all of the stairs that we discover at institutions, offices, industries and additionally at a few homes. The layout is made very secure and there may be no hazard of failure of the body and wheels beneath Neath regular situations.

Gaikwad Avinash , Bhalerao Sachin [3] Stair case lift can be adapted for its sheer use sim plicity and economy. During the test run of t his project, it was realized that it woul d capabl e of carry ing heavy l oad wi thout suffering any deform ation or l ocal fract ures i f i t woul d go into real world production at an i deal scale Therefore it can be widely used for hom e as well as industrial which ensures a promising future to the concept.

Suhas B. Bhalake, Amit Gade, AkankshaSonawale, Nilesh Bhapkar and RishikeshDhamane [4The natural frequency of lift should not be equal to the external excitation frequency hence no vibration in the lift. A portable work platform hydraulic scissor lift is designed for high load resistance. The hydraulic scissor lift is simple in use and does not require routine maintenance. The scissor lift reduces the complexities in a design and fabrication time was reduced. But the limitation of this lift is the initial cost. The design and fabrication of a portable work platform raised by a hydraulic cylinder were carried out meeting the required design standards. The portable work platform of a scissor lift is operated by a hydraulic cylinder which is operated by a motor.

Abhijaya Shrestha [5] The earliest forms of elevators were manually driven windlasses, animal-powered hoists, shaft ways seen in ancient Roman ruins and other vertical movement systems based on the simple machine - pulley. One could even argue that elevators were discovered when pulleys were. In mountainous landscapes like of Tibet, baskets drawn by pulley and rope are still used to vertically transport people, driven by a windlass and manpower. The definition of modern elevators more or less includes a mechanism to prevent the carriage from falling in the event the linkage or lifting means fail. Elisha Graves Otis invented such elevator safety device in 1853 when working in a factory and wondering how he could clean up better by moving the old debris to the upper levels of the factory. His safety device operated by causing a pair of spring-loaded dogs to engage the cog design of the guide rails when the tension of the hoisting rope was released. The definition of modern elevators more or less includes a mechanism to prevent the carriage from falling in the event the linkage or lifting means fail. Elisha Graves Otis invented such elevator safety device in 1853 when working in a factory and wondering how he could clean up better by moving the old debris to the upper levels of the factory. His safety device operated by causing a pair of spring-loaded dogs to engage the cog design of the guide rails when the tension of the hoisting rope was released.

Jürg Nipkow [6] There are high saving potentials in lift systems. Two major paths lead to higher overall efficiency: Lowering stand-by consumption, that should be addressed by the lift industry and demanded by the buyers' side . On the other hand, in an integral planning process of architect, planner, orderer and lift supplier the system should be optimized regarding design and technology to satisfy comfort, cost and energy requirements. Energy consumption and efficiency potentials of lifts.

Aaron Miller, Chris Engst , Robert B.Tate, Annalee Yassi [7] Introduction of ceiling lifts into long-term care facilities has positive reductions of patient handling injuries. Staff within the intervention facility did not find any significant differences between mechanical floor lifts and ceiling lifts in terms of risk for injury, but preferred to use the ceiling lifts for performing lifts and transfers of residents. When assessing the need for overhead lifting equipment, it is always necessary to assess the physical capabilities of the residents.

Ramiz Ahmed, Ramiz Ahmed, Nick Pusateri[8] Since we initially took advantage of using SOLIDWORKS software to test for failure under applied loading there was no need to do any real experimentation or building of a test rig. The purpose of using the software is to test the application in the analysis tool instead of buying a bunch of material to test with possible a wooden structure which is not a true or close representation of what is being considered to be built. After the prototype was built. It was lifted up and down using a hydraulic jack to check the performance in the loaded and unloaded conditions. We also tested the prototype in its fully extended and fully closed position to confirm the structure would work and take the applied loads under those conditions.

Gregory L. B. Sanz [9] I will start by saying that this thesis, and all that that entails, was very rewarding to me. Not only did I learn a great deal about the process of designing a useful device, but I also became inspired by the realization that there are many difficult tasks for which p ep-oý tch ~\ pLhC15 -,gJ56 proper inventions still do not exist. Moreover, in doing this thesis I learned just how hard it is to create a truly optimized device. Though my prototype does not seem to function without error, it is still a novel and sufficiently helpful device for my friend to use when moving things around his house. Were this prototype to go into mass production, the biggest change would be that the lift plate and the back support piece would be rolled and forged, respectively, and then welded together to form a single, stronger piece. Also, it would be ideal for the back support piece and sleeves to be made of a single forging.

M. Kiran Kumar, J. Chandrasheker, Mahipal Manda, D.Vijay Kumar [10] Portable work platform hydraulic scissor lift is designed for high load resistance. The hydraulic scissor lift is simple in use and does not required routine maintenance. Both the mild steel and aluminum alloys are good at their different aspects. Mild steel has greater durability strength and it is also cheap and easily available. As these properties plays an important role in designing scissor lift. So in designing scissor lift mild steel has greater importance.

Syed Faiq Irfan Sayed Azman [11] Loss of balance leads to the increasing numbers of stair falls experienced by elderly people. To help eliminate the hardships faced by elderly people from lack of balance, a portable small items stair-lift was developed. The prototype will have the ability to carry small items up and downstairs through the stair handrails. This reduces the risk faced by elderly people while going up and down. The key feature of this prototype is its portability, which differentiates it from other already available products in the market serving a somewhat similar purpose. The portable stair-lift is being controlled wirelessly through a developed user interface via Wi-Fi network. A live video streaming of the device view is also included which permits control for not only users nearby but even those away from home to help if in any case the people that are about to use it is incapable. Overall, this device will aid in increasing the safety aspects of stairs and promotes further advancement towards the quality of life in general.

## 9 Conclusion

This study developed a stairlift chair to assist elderly and disabled individuals in climbing and descending stairs. The design was based on an electromechanical approach, incorporating both lifting and tilting mechanisms in the hardware and software. The chair system was engineered to safely support a person weighing up to 100 kg.
Throughout the fabrication process, multiple trials were conducted to refine and enhance the system. The chair stands out for being lightweight, comfortable, and cost-effective, making it a practical solution for those in need of mobility assistance on stairs.

## Reference:

[1] “World report on disability,” Who.int, 2011. [Online]. Available: https://www.who.int/publications/i/item/9789241564182. [Accessed 27 April 2021].

[2] N. Saleh, M. Abdel Wahed, and A. M. Salaheldin, “Computer-aided diagnosis system for retinal disorder classification using optical coherence tomography images,” Biomedical Engineering / Biomedizinische Technik, vol. 67, no. 4, pp. 283-294, 2022.

[3] A. M. Salaheldin, M. Abdel Wahed, and N. Saleh, “Machine Learning-Based Platform for Classification of Retinal Disorders Using Optical Coherence Tomography Images,” in Artificial Intelligence and Sustainable Computing, Singapore, Springer Nature, 2022, pp. 269-283.

[4] N. Saleh and A. M. Salaheldin, “A benchmarking platform for selecting optimal retinal diseases diagnosis model based on a multicriteria decision-making approach,” Journal of the Chinese Institute of Engineers, vol. 45, no. 1, pp. 27-34, 2022

[5] H. Adel, M. Abdel Wahed, and N. Saleh, “A novel Approach for Improving Patient Flow in Emergency Department,” in 9th Cairo International Biomedical Engineering Conference (CIBEC), Cairo, 2018.

[6] N. Saleh, H. Adel, and M. Abdel Wahed, “Quality-driven framework for reducing patient waiting time in emergency department,” Journal of Engineering Research, vol. 9, no. 1, pp. 214-228, 2021.

[7] W. Sulistiyo and D. Sumarsono, “Optimization of a stair lift design to realize a safe transportation system for the elderly and the disabled when using stairs,” in conference on mechanical, infrastructure and industrial engineering, 2019.

[8] A. Gaikwad and J. K. , “Modeling and analysis of a staircase lift for material handling system,” International Journal of Innovative Research in Science, Engineering and Technology, pp. 2645-2649, 2013.

[9] T. C. Khidir, A. M. Ismael, and A. A. Abduljabbar, “Designing and analysing stair case lift system,” European Journal of Engineering and Technology, 2017.

[10] W. Akram and A. Getme, “Design Modification of Electro-Powered Chair with Staircase Climbing Ability,” International journal for scientific research & development , pp. 1317-1319, 2018.

[11] R. Kulkarni, B. Patel, C. Mulay, P. Musale, and R. Bhaskar, “Design of Stairlift for Curved Path,” International Journal of Current Engineering and Technology, 2018.

[12] M. Hirata, A. Setoyama, S. Adachi and H. Sakaniwa, “Attitude Control System Design of a Seated Stair Lift on a Single Rail by Using Two-Degrees-of-Freedom Control,” in The Proceedings of Conference of Kanto Branch, 2007.

[13] M. Smith, “Using the Building Regulations: Part M Access”, 2006.

[14] V. N. Chougule, B. Wadia, A. Kotecha, and F. A. Ph, “Design and Structural Analysis of Platform Stair Lift Using Finite Element Method,” IOSR journal of Engineering, pp. 10-17, 2018.

[15] American National Standards Institute, “Gear nomenclature, definition of terms with symbols,” Alexandria, Va. : American Gear Manufacturers Association, 2011, p. 72.