International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 14 (2015) pp 34084-34088

Design and Analysis of Low Cost Lift System for Disabled Citizens at Railway Stations

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ABSTRACT
This paper is a documentation of an attempt to provide a lower cost solution for people with mobility impairment or senior citizens to move from one platform to the other in railway stations. Based on this need, three different design concepts were proposed for a load capacity of 600kg. The concept that had a low cost of development was then taken up for detailed design and various critical components were validated. Overall design of the lifting mechanism of a low cost lift system for people with mobility impairment in railway stations has been was simulated to authenticate its working.

KEYWORDS; lifting mechanism; low cost;

I. INTRODUCTION

As per the latest data available; of the total population in India 5-6% are disabled[1]. But they are not very apparent in the general public nor have attracted any attention to their special needs in transportation infrastructure of the country. The existing build environment in India at micro and macro level is not designed to cope with the needs of the physically challenged people[2]. These limitations are usually unnoticed by the majority of population or conveniently overlooked by authorities. A lot of efforts are made so far in this regard; still the challenge of providing transportation of such disabled group at various social places is persistent. Product designers and mechanical engineers share the responsibility in solving such societal requirements.

It has been noticed that in a routine life of a normal citizen, steep vertical stairs of foot over bridges or subways in railway stations create mobility challenges to aged and disabled people[2]. For a normal person this challenge is not felt. However, a person who had met with an accident and had a fracture would have experienced this temporary disability. Pregnant ladies and the aged also undergo this trouble, either to travel across the length of the platform or while moving from one platform to another. They struggle to move from one platform to another safely with and without help from others[2]. It is also a big challenge to those accompanying such persons to take them from one platform to another. We have seen that on various occasions, the disabled person is carried up the stairs along with the wheel chair. This is a tough task to everyone involved especially when the feet over bridges are mostly 20 feet high. By installing escalators and elevators, the authorities have taken some effort to provide solution to this problem, but again escalators are not helpful to physically challenged people who are on wheel chairs. Moreover they are not available in all stations. In this project a cost effective solution is envisaged by installing a mechanical system on one side of the *existing* over bridge. The system is designed to enable easy operation by any person to take themselves and their luggage to their destination platform and from platforms to outside the railway station. The emphasis here is to use the existing structure and provide a low cost lifting device in stations that are not equipped with the usual elevators.

II. METHODOLOGY

A. MODELLING OF THE LOW COST LIFT SYSTEM

Fig.1 3D view of model 1

Three different possible concepts of the system were solid modelled and simulated using software. The device works based on mechanical advantage principle. Rope, drum, reduction gearbox and motor are the common components used in all three designs. The volume of cabin to be lifted was decided based on the height to be reached while the width was decided to accommodate one person on a wheel chair.

MODEL 1

The first concept consist of parts like, I section, C-sections, rollers, motor, reduction gear box, rope drum, wire rope , speed governor and a cabin as shown in Fig. 1. The two C-sections act as rail over which four rollers are mounted and subsequently a cabin was attached on the rollers. At the top portion of the cabin a steel wire rope was attached with the help of a hook.

Then the other end of the steel wire rope was wound on a rope drum. Then a reduction gearbox and a motor was attached to it, that was kept at the roof position of the over bridge fastened to a cantilever structure. Mechanical speed governor was used for safety considerations.

MODEL 2

In this design both vertical and horizontal movement was made possible where a single cabin was used to move from one platform to the other as shown in Fig. 2. The components and lifting mechanism are almost similar to the former concept**.** It comprises of eight rollers and two motors. The second motor provides the horizontal motion of the cabin through I- section placedat the roof position of the over bridge. C section acts as rail through which the cabin moves both in vertical and horizontal direction

Fig. 2 - 3D view of model 2

Fig.3 3D view of model 3

MODEL 3

Here a single I section acts as rail to which a chair or small sized cabin is mounted on I section through four rollers as shown in Fig. 3. The lifting mechanism is similar to the above described proposals. The user must be capable of fastening himself with the chair and later release himself once he reaches the top or bottom. It requires a platform for mounting on and off from it. The cost of the system was reduced by thereduction of material. The cabin was lifted from the ground level to a platform adjacent to the main channel.

B. CHOOSING THEMODEL FOR FURTHER DESIGN AND CALULATIONS

Among the three concepts model 1 was selected for detailed design and its various critical components were validated.Theselection was based on the basis that there are no civil structuralalterationsrequired for its installation, while the total device is low cost, low on power requirements, less bulkiness and has less maintenance requirements. It has simpler installation procedure and can be of industrial use too. This proposal is feasible in almost every railway station that has more than one platform and in which the user can move across platform along with his wheel chair. There is no need of an extra platform for mounting on and off from the system. Model 2 is not viable in railway stations having multiple platforms. It becomes more intricate and costly. In model 3 the assistance of wheel chair is not possible for the person. It requires an extra platform for mounting on and off from the system.

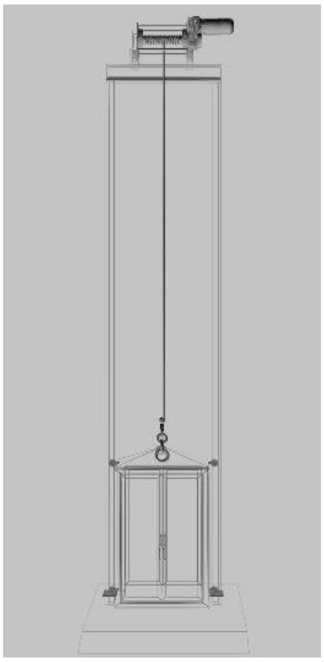


Fig.4 Front view

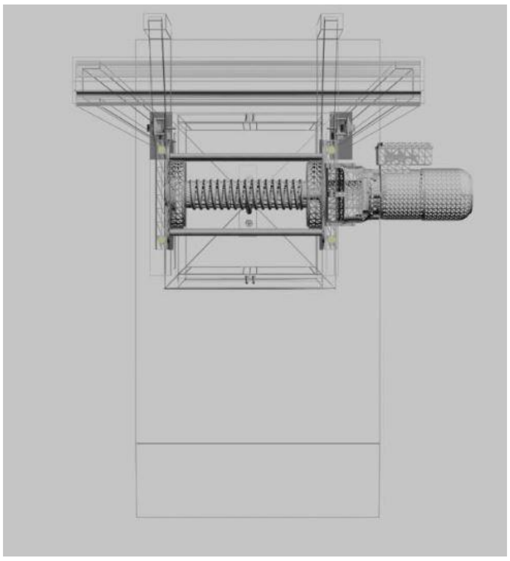


Fig. 5 Top view

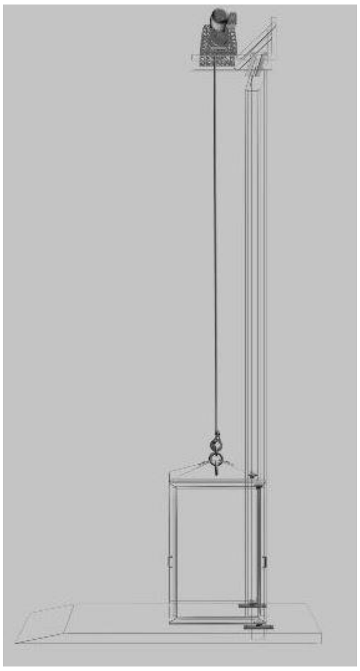


Fig. 6 Side view

Wireframe drawings of lifting mechanismof model 3Fig. 4, 5,6

The volume of the whole mechanism of lifting occupies 1220mm×1220mm×9000mm (length*breadth*height) only. The cabin has a dimension of 1220mm×1220mm×2500mm. The type of steel wire rope for the mechanism was selected to be as 6×37 considering a dead weight of 600kg[3]. The diameter of the steel wire rope was chosen as 12mm from calculations[4]. The corresponding rope drum diameter is taken to be 230mm.The lifting height was fixed as 6500mm. The time taken to reach the lifting height was set at 20secs. The corresponding lifting speed was calculated as 19m/min. The energy supplied to the rope drum per minute was calculated to be 114×10^3 N-m/min[5]. The power supplied to the rope drum was obtained as 1.9kW[6]. By considering 80% efficiency of the rope drum the power of the motor was determined as2.375kW. The speed of the rope drum is 165.217 rad/min.

III. RESULTS AND DISCUSSION

A. SIMULATION OF THE SYSTEM

The solid model was exported from 3D software to MSC ADAMS^{TM}. The joints were assigned appropriately to all parts based on the motion required[7]. A cable system was created by considering the dimensions of rope drum and wire rope[8]. Initially the cabin was assumed to be at bottom position (Fig.7).When the torque is applied on the rope drum, the cabin starts to move upward (Fig. 8, 9) the extent to which the cabin has to move with respect to time was allocated to the cable system. The simulation was carried out and the mechanism was successfully tested for its performance.

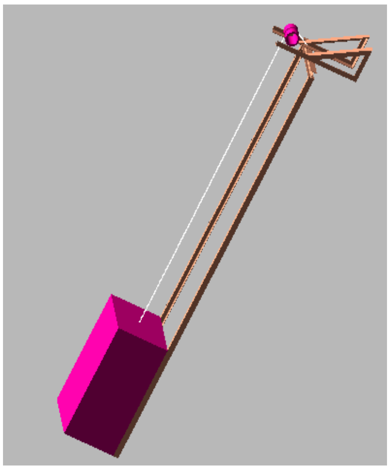


Fig.7 Bottom position of cabin

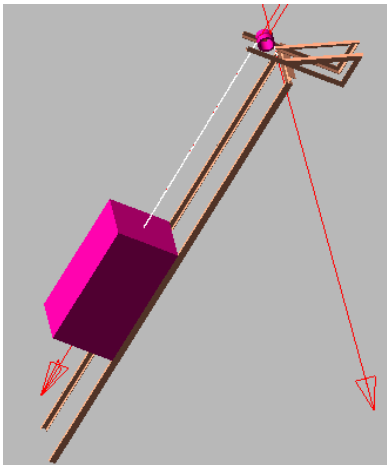


Fig.8 intermediate positionof cabin

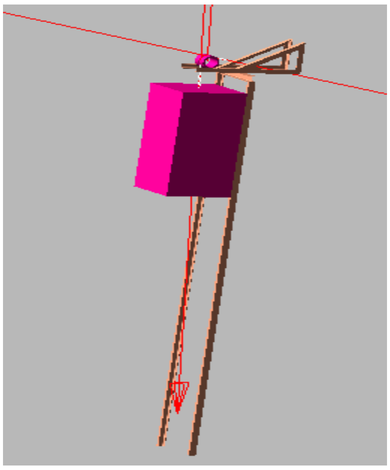
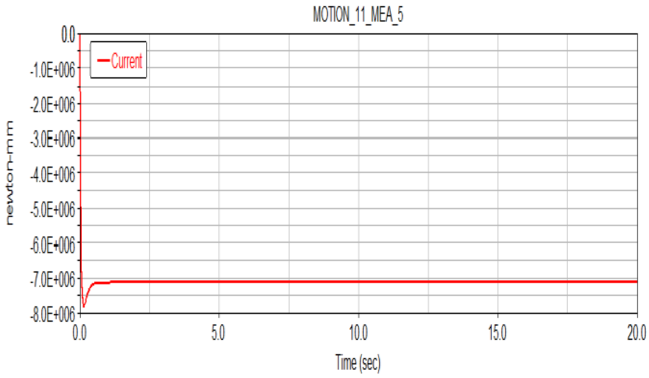


Fig.9Top position of cabin



Torque vs time plot Fig.10

The torque required on the rope drum was measured after simulation. The torque desired to lift the load was plotted against time. At the initial stage the torque on the rope drum is obtained as zero then it increases to a peak value to overcome the inertia effect. After that it reaches to a constant value. The inference of the simulation is shown in the Fig.10.

B. STRESS ANALYSIS OF CRITICAL PARTS

The critical parts of system were identified as the structure and hook. In order to evaluate the stress and deformation acting on them, a FEM based analysis software was used[9]. The material was considered to be steel.

B1. STRESS AND DEFORMATION ON THE STUCTURE

The structure was modeled and meshed and the calculated load of 9000N was applied to it. The results obtained based on analysis shows that the stress concentration and deformation are high at the end portion of the structure as shown in the Fig (11, 12) respectively [9].

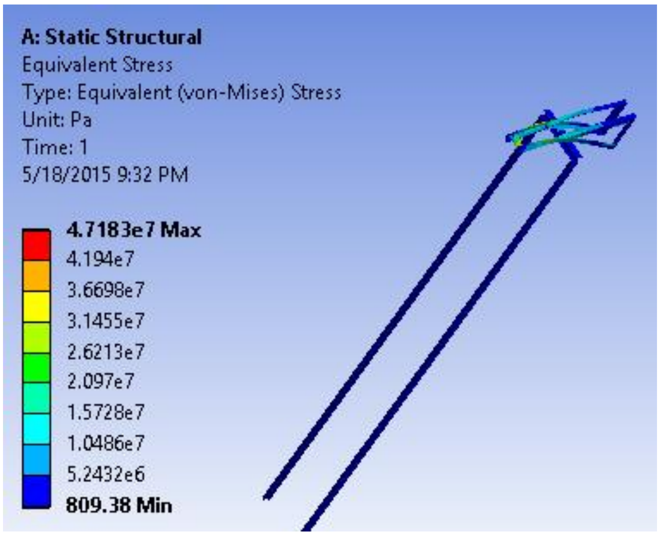


Fig.11 Von-Mises stress on the structure

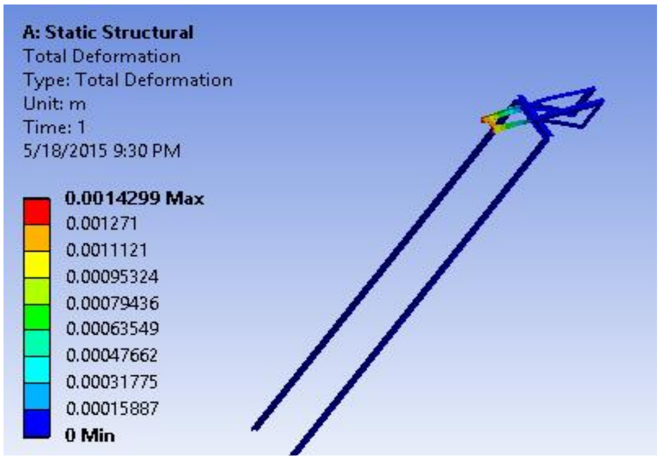


Fig.12 Deformation on the structure

B2. STRESS AND DEFORMATION ON THE HOOK

The hook was designed and meshed and the dead weight of 600kg was applied to it[10]. The results obtained based on the analysis of hook shows that the stress concentration is high at the intrados than the extrados. The deformation is high at the tip portion of the hook[9]. They are as shown in the Fig. 14 and 15 respectively.

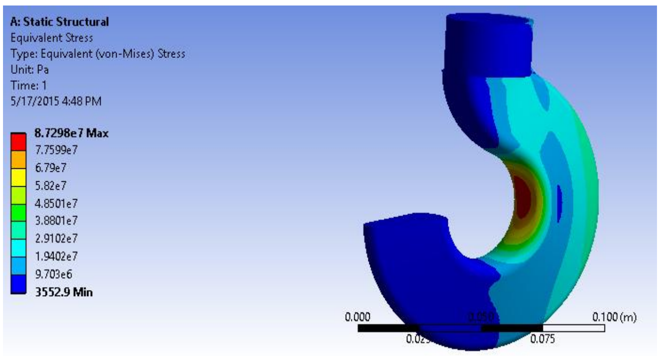


Fig.14Von-Mises stress on the hook

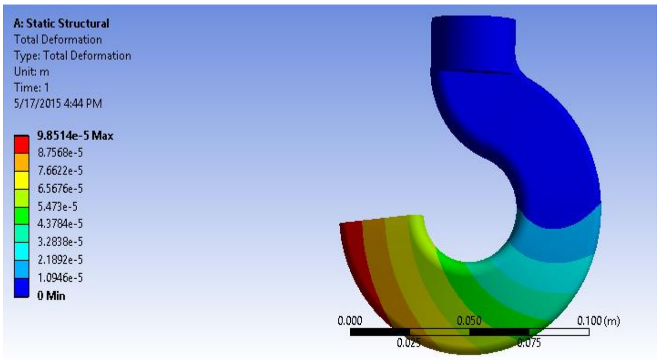


Fig.15Deformation on the hook

IV. COST BREAK DOWN OF A SINGLE LIFTING MECHANISM

The cost of materials is equipped based on the present market value. The cost per unit can be again considerably reduced by mass production of the system.

Table 1 A rough estimate of cost of materials

Sl No.	Item	Quantity	Cost /unit	Total cost In Rs.
1	Wire rope hoist	1	30000	30000
2	Cabin	1	20000	20000
3	Rollers	4	750	3000
4	C-Channel	20 meter	450	9000
5	I-Section	1.5 meter	800	1200
6	Electrical components (with safety)			20000
7	Other requirements (nuts ,bolts, cement)			6000
	Total			89200/-

IV. CONCLUSION

The objective to provide a low cost lifting mechanism to move the disabled from one platform to another was met in this work. Three concepts were conceived and the best among them was modeled and the mechanism was simulated to authenticate its working. Then deformation and stress analysis of the structure and hook was carried out and their outcomes are presented. The cost of the proposed device is around Rs.90,000/- which on lot production will reduce considerably to around 60% of this cost.A further study on alternate material will lower the cost still further.

V. REFERENCES

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