Design and Development of a Lift for Bag Storage Area

By

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INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

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Design and Development of a Lift for Bag Storage Area

Major Project Report

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Mechanical Engineering
(DESIGN)

By

Ankit Jadav

(18MMED05)

Guided by,

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DEPARTMENT OF MECHANICAL ENGINEERING

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AHMEDABAD-382481

MAY 2020

Declaration

This is to certify that

a. The thesis comprises my original work towards the degree of Master of Technology in Design at Nirma University and has not been submitted elsewhere for a degree.

b. Due acknowledgment has been made in the text to all other material used.

-Ankit Jadav
(18MMED05)

Undertaking for Originality of the Work

I, Ankit R Jadav, Roll No. 18MMED05, give undertaking that the Major Project-1 entitled Design and Development of a lift submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Mechanical Engineering (Design) of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere, it will result in severe disciplinary action.

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Kalol, Gandhinagar.

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Abstract

In most of industries storage areas are provided for storing machines, its spare parts and other equipment. For storage industries built a big or small storage yards as per requirements. In most of cement industries it is require to store the empty bags for packing cement. J.K.Lakshmi Cement Ltd. is one of the major cement industry in India. In Gujarat there are two split grinding units built one unit is situated at Kalol, Gandhinagar and other is situated at Surat. These both plants are split grinding unit in which mixture of clinker and gypsum is grind in big ball mill. After grinding the final product (cement) is store in big silos. Cement is packed in bags by roto packer machine. For completing the dispatch requirements empty bags always to be shifted to the packer machine continuously. In Kalol cement plant there are two bag storage areas which are built above the packer machine area. For maintaining the stock bag lots are shifted to the storage areas from ground level. In this plant a hoisting lift (overhanging type lift) built for transfer the bag lot. In this system a trolley is lifted by a 440V 3-phase motor whose load carrying capacity is 1000 kg. According to safety rules for bag storage area more than 50V DC power supply is not allowed in bag storage area and another problem in the system is that the trolley is swinging due to wind while it is lifted which create unsafe condition.

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Chapter 1

Introduction

1.1 About J.K. LAKSHMI Cement Ltd.

J.K. Lakshmi cement Ltd. (JKLCL) is an ideal company of the renowned of J.K. Organization that is into cement business since 1982. The company produce cement of capacity 13.2 million MT per annum. The plant has certificate like ISO-9001, ISO-14001 and OHSAS-18001. It also maintains very high level standards in quality, equipment and safety fields. The plant has won number of national and international awards including Energy Efficiency Award-2008 awarded by the ministry of power, GOI and Three Leaves Award by CSE for state of art for pollution control technology.

J.K. Lakshmi cement Ltd. is a part of J.K. organization. In Gujarat they have two split grinding unit which are located in Kalol Gandhinagar and Surat. The mother plant of J.K. Lakshmi cement Ltd. is situated at Sirohi Rajasthan. In mother plant lime stone is heated about 1400˚C to 1800 ˚C for manufacturing the clinker which is main component of the cement. The clinker is transported to other split grinding plant for manufacturing the cement. In Kalol split grinding unit the main row material (Clinker) comes from mother plant and it will then grind in ball mill with other material (Gypsum and Fly ash). In this plant two types of cements are manufacture OPC (Ordinary Portland Cement) and PPC (Portland Pozzolana Cement).

1.2 Cement Manufacturing Process and Packing Plant

Cement manufacturing process starts with producing clinker by heating lime stone in long tube called kiln at 1400 ˚C to 1800 ˚C. Kiln is 12 feet in diameter and 500 feet in length. Clinker is produced at mother plant of JKLC, Siroh, Rajasthan. At Kalol plant, there is a split grinding unit, so clinker is used as a raw material at Kalol plant. Here clinker, gypsum and fly ash are mixed in required proportions and grinded to make final cement.

Process starts with truck tippler from where row materials are dumped into tunnels and fed into silos or hoppers through conveyor belts and bucket elevators. Clinker is fed into clinker silo, gypsum and fly ash are fed into hopers. Clinker can be taken into clinker hopper from clinker silo.

From the hopper adequate mixture of clinker and gypsum is fed into the ball mill through feed conveyor belt. Ball mill is a rotating device divided into two chambers. Each chamber consisting of small metal balls. First chamber consisting big size metal balls (60 mm to 90 mm Dia.). First chamber is called crushing chamber. The mixture of clinker and gypsum is crushed in this chamber first and then the mixture is moved to next chamber through the grid type of disk which allow the mixture to pass not the metal balls. Second chamber consisting smaller size metal balls (15 mm to 40 mm in Dia.). This second chamber is called grinding chamber. In this chamber the mixture is further grinded into powder form which is called cement. The ball mill has capacity of 75 TPH (Tone Per Hours).

In Kalol grinding unit, two types of cements are manufacture. OPC (Ordinary Portland Cement) and PPC (Portland Pozzolana Cement). OPC contain clinker and gypsum while PPC contain clinker, gypsum and fly ash.

From the ball mill material flows to the cyclone separator from where fine cement particles move forward into cement silos while coarse cement particles are fed back into the mill through reject belt for further grinding.

Cyclone separates cement material and air (which is given to maintain flow of material in the process). Cement material thus stored in cement silos through bucket elevators. There are two silos for OPC (Ordinary Portland Cement) and PPC (Portlan Pozzolana Cement). From cement silos, cement is filled in bags through roto-packers. Cement is also filled in big containers at bulk loading point for transported at big project location.

A roto packer is a roatating device which contains sprouts (nozzles) around it, on which empty cement bags are placed and filled with cement. There are two roto packers, one is of 12 sprouts and another is of 8 sprouts. From the roto packers cement bags moved to truck loaders where cement bags are loaded in truck. There are four manual truck loaders and one auto truck loader. Dispatch rate of manual truck loader is 2500 bags/hour and auto truck loader is 3200 bags/hour.

1.3 Existing Bag Lifting System

In the plant there are two bag storage area which are located above the packing plant at the height of 15 m. And both the storage area are aligned at right angle as shown in Fig. 1.1. The entry gates are also different for both storage area. Empty bags are first lifted from ground level to bag storage-1 by a trolley which is lifted by overhanging crane type system. In which crane hook is fixed with trolley as shown in Fig 1.2. Trolley is made by MS round pipes. The height, width and length of trolley is 1 m. This trolley can lift about 200 kg – 250 kg load at a time. At one time it can take up to 5-6 big bag empty bag lots and 8-10 small empty bag lots. A single small bag lot consists of 300 empty bags while a single big bag lot consists of 500 empty bags. Each small bag lot weighted up to 23 kg – 25 kg and big bag lot weighted up to 30 kg – 32 kg. The size and shape of bag lot and empty bags are shown in Fig 1.3.

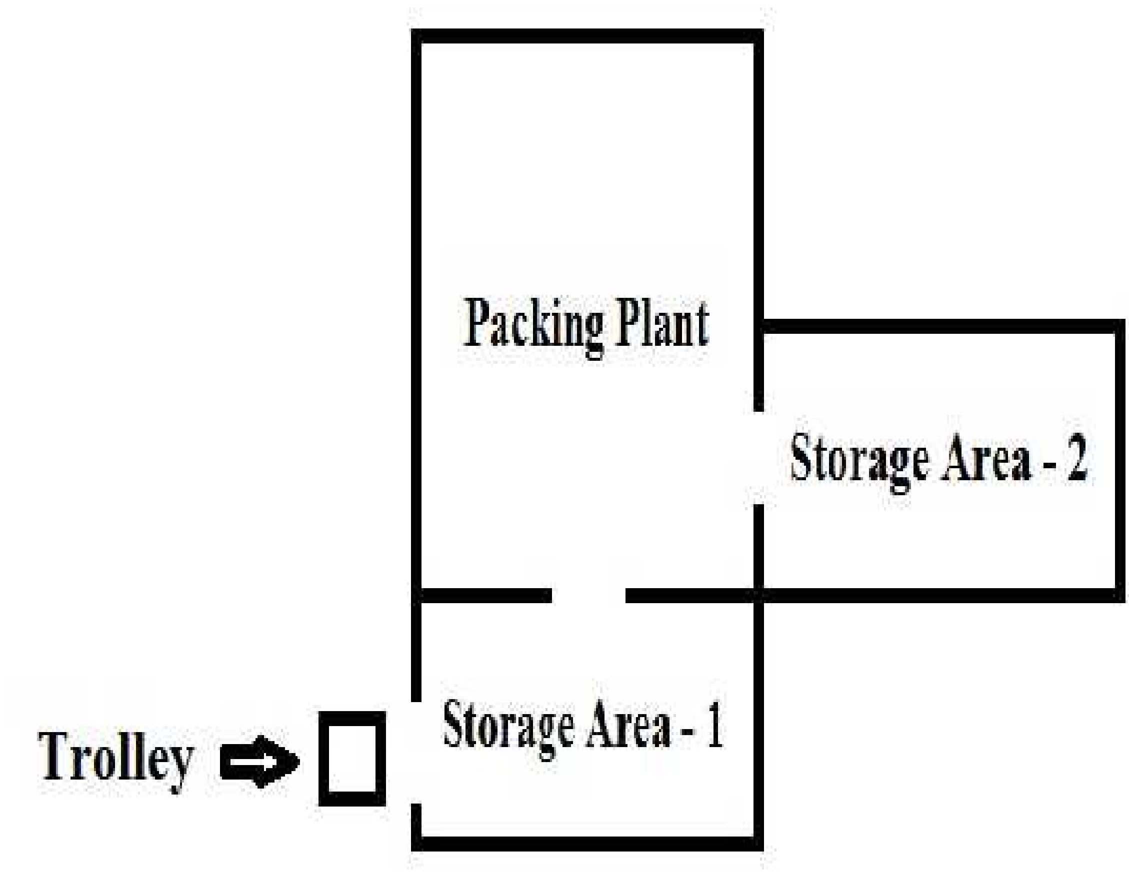


Fig. 1.1 Storage Area and Packing Plant

Fig. 1.2 Over Hanging Crane Type Trolley System

Fig. 1.3 Bag Lots Stacking in Bag Storage Areas

In this system the motor specifications are as follow.

Load carrying capacity :- 1 Tone

Height of lift :- 20 m

Hoisting speed :- 10 m/min

Traverse speed :- 1.8 m/min

Electric supply :- 3ϕ , 440 V

Horse power :- 5 H.P.

1.4 Problems in Existing Bag Lifting System

In current system main problems are as follow.

- Problem due to wind.
  - Due to wind the trolley swings which create unsafe condition at that location for workers and other equipment also.
  - Sometime this swinging of trolley damage the rope which is use to lifting the trolley. The swinging of trolley while lifting it creates uneven tension in the rope due to which motor needs to sustain uneven load also.

- Problem in transporting from one bag storage are to another.
  - In the plant there are two bag storage areas which are located above the packing plant for quick supply the empty bags to the packers. But these both storage areas are located at right angle to each other as shown in Fig. 1.1. Due to this type arrangement it is difficult to transporting from first bag storage are to other. And there are many pipe line connections given for packer requirement which are create problem during transporting the bag lots. Workers need to transfer each bag lot manually this is very time consuming.
- Problem due to electric power supply.
  - According to safety rules more than 50 V DC power supply is not allowed in the bag storage area because the bags get fire from small sparks also.

Fig. 1.4 Outside View of Bag Storage Area-1

Fig. 1.5 Gate Location of Bag Storage Area 1 and 2

1.5 Motivation

While the trolley from ground level to bag storage area-1 the swinging of trolley creates unsafe condition. It unsafe for workers doing their work below the storage area. Due to safety requirements more than 50 V DC power supply is not allowed in the bag storage areas because it create fire while sparking happened in the storage area. The workers get tired form sifting the bags from bag storage area-1 to bag storage area-2. While the trolley is lifted and the bag lots are sifted to bag storage area that time the labors at the ground level are free which is loss of man power time in the company.

1.6 Requirements for Bag Lifting System

Lifting system requires following to be adequate:

- A simple construction with higher load carrying capacity.
- Motor should be outside the bag storage area for safety purpose.
- Decrease or remove the swinging of trolley due to wind force.
- Easy transferring system which can transfer bag lots from bag storage area-1 to bag storage area-2 easy, faster and at low cost.
- More efficient and low cost system.
- Take care all other safety rules and regulations also.

1.7 Objective

- To design and fabricate a wheel mounted trolley, platform (carriage) and side support for lift at low cost and lesser weight with greater performance.

1.8 Methodology for Design The Lifting System

- To design a wheel mounted trolley which can carry more weight than existing system.
- To analyze the trolley for design load carrying capacity.
- To fabricate and test the trolley.
- To design a platform or carriage by which trolley can be lifted from ground level to bag storage are-1 first.
- To analyze the trolley for maximum carrying capacity.
- To fabricate and test the platform.
- To design side supports for decreasing or removing the swinging effect due to wind.
- To analyze the side supports against the bending due to its own self weight and maximum load due to wind.
- To fabricate and mount the side support.

Chapter 2

Literature Review

2.1 What is Elevator or Lift?

An elevator or lift is used as vertical transportation of goods as well as people among the floors in buildings. By pushing the switch or button a person can call the box which can transfer the goods or himself/herself from one floor to another. In fact, elevator or lift is mandatory for building which has more than four or five floors. For most of the people, an elevator offer ease as well as convenience, and also makes life easier for physically handicapped persons.

2.2 Different Types of Elevator or Lift

1. Cable driven or Traction Lift
2. Hydraulic Elevator or lift

2.3 Cable driven or Traction Lift

Traction lifts are the oldest and versatile type of lift. They basically consist of a cabin and a counterweight attached to separate ends of a cable which travel over a large pulley wheel or a large drum called sheave at the top of lift shaft. When the cabin goes up, the counterweight goes down and vice versa. The cable is driven by the electrical geared motor. This type of motor has high torque capacity.

More details of the cable driven or traction lift is mention in following research papers.

I. The Design of A One-Man Passenger Electric Elevator [3]

Abdulmalik , Ibrahim O, Akonyi, NasiruSule, Bolarinwa, Gabriel Oladeji, Chima, Lazarus Onyebuchi, Amonye, Michael C, Mgbemena, Chinedum Ogonna

The one-man Passenger electric elevator described in this paper is designed primarily to carry one person according to the specifications of the client. The electric elevator is moved by an electrically powered motor that drives hardened steel traction sheave over which the ropes are suspended. It has advantages over the staircase, ladder and the hydraulic elevators. This work is a reference design for a one-man passenger electric elevator for emergency exit in high buildings.

II. The Design and Structural Analysis of Platform Stair Lift Using Finite Element Method [1]

V. N. Chougule, B. N. Wadia, A. S. Kotecha, F. A. Phantaki

The foldable Platform lift is similar to a lightweight lifting rectangular platform that allows human to sit, stand or get their wheelchair on it anywhere on it in any suitable position. The traditional type of wheelchair is difficult to move through the inclined stairs due to its large size and rigid structure and thus, they are inappropriate for letting patients with inability to climb stairs using a wheelchair or any other source. Unlike the traditional wheelchair, it consists of a rectangular platform which enables patients with a wheelchair to use that platform to move through stairs and thus able to let patients with walking disability to move across stairs. The aim of this research paper is to focus on mechanical design of a model and finite element analysis (FEA) of the mechanism using CATIA software and ANSYS software. The present work, all the elements of the mechanism are designed under static load condition. The results of the FEA analysis indicate that the Platform Stair lift satisfies equilibrium and stability criterion and is capable of helping patients with walking disability move across the stairs.

III. Tall Buildings and Elevators: A Review of Recent Technological Advances [2]

Chimay J. Anumba

Efficient vertical mobility is a critical component of tall building development and construction. This paper investigates recent advances in elevator technology and examines their impact on tall building development. It maps out, organizes, and collates complex and scattered information on multiple aspects of elevator design, and presents them in an accessible and non-technical discourse. Importantly, the paper contextualizes recent technological innovations by examining their implementations in recent major projects including One World Trade Center in New York; Shanghai Tower in Shanghai; Burj Khalifa in Dubai; Kingdom Tower in Jeddah, Saudi Arabia; and the green retrofit project of the Empire State Building in New York. Further, the paper discusses future vertical transportation models including a vertical subway concept, a space lift, and electromagnetic levitation technology. As these new technological advancements in elevator design empower architects to create new forms and shapes of large-scale, mixed-use developments, this paper concludes by highlighting the need for interdisciplinary research in incorporating elevators in skyscrapers.

IV. Design and Construction of a Conventional Elevator [4]

S.K Bello, N.A Badiru

This paper is about the design and construction of an elevator. Elevator is a device that efficiently moves people or goods vertically between floors of a building, vessel, or other structures. They are generally powered by electric motors that either drive traction cables or counterweight systems like a hoist, or pump hydraulic fluid, to raise a cylindrical piston in the form of a jack. During the industrial era, the development of elevators was led by the need for movement of raw materials including coal and lumber from the hillsides. The technology developed by these industries and the introduction of steel beam construction worked together to provide the passengers freight elevators in use today. The construction and installation of other systems of elevator in existence are quite expensive compared to the conventional system. This research work was aimed at developing an elevator that does not use the hydraulic system but more to the conventional system in order to save cost in construction, installation and maintenance.

2.4 Hydraulic Elevator or Lift

Hydraulic elevators or lifts are powered by a piston that travels inside a cylinder. An electric motor pumps hydraulic oil into the cylinder to move the piston. The piston lifts the elevator cabin. This type of lifts or elevators are used extensively in buildings up to five or six stories high.

Following research paper gives some useful details about the hydraulic lifts or elevators.

I. Design and Analysis of Hydraulic Lift By FEA [5]

Sabde Abhijit Manoharrao, Prof. Jamgekar R.S.

A hydraulic pallet lift is a mechanical device used for various applications for lifting of the loads to a height or level. A lift table is defined as a scissor lift used to stack, raise or lower, convey and/or transfer material between two or more elevations. The main objective of the devices used for lifting purposes is to make the table adjustable to a desired height. A scissor lift provides most economic dependable & versatile methods of lifting loads; it has few moving parts which may only require lubrication. This lift table raises load smoothly to any desired height. The scissor lift can be used in combination with any of applications such as pneumatic, hydraulic, mechanical, etc. Lift tables may incorporate rotating platforms (manual or powered); tilt platforms, etc., as a part of the design. Scissor lift design is used because of its ergonomics as compared to other heavy lifting devices available in the market. The frame is very sturdy & strong enough with increase in structural integrity. A multiple height scissor lift is made up of two or more leg sets. As per the discussion with the concern person of DS Engineering, Pune, It is found that they are facing some problems regarding hydraulic scissor lift like job to be lifted are heavier which causes more deformations in hydraulic lift frame checking deformations & stresses induced in it is a major objective of this project.

Chapter 3

Concept Development

3.1 Existing System

As shown in fig. 1.2 current system is overhanging crane type lifting system. It consist mainly 4 components as follows.

1. Trolley
2. Motors
3. Hook
4. Wire Rope

1. **Trolley:** In the current system trolley is made from 40 mm round pipe. This trolley can lift up to 6 bag lot at a time. There is one square pipe is welded for attaching the hook with trolley for lifting it up. The maximum weight can be lifted by this trolley is 300 kg. The size of trolley is 1 m height, 1 m width and 1 m length. (Fig. 3.1)

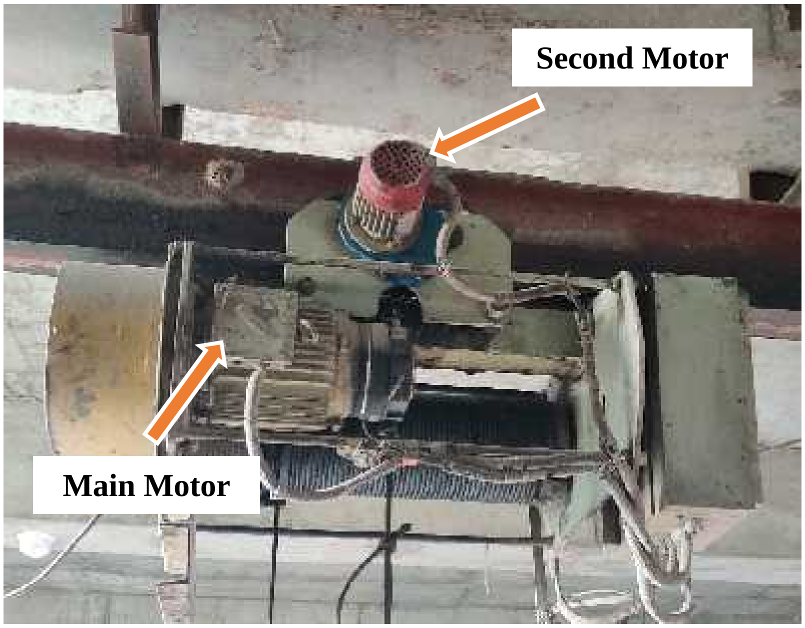
2. **Motors:** There are two motors mounted on the I-section beam which is attached on the roof. As shown in Fig. 3.2. Main motor is use to lift the trolley (with load) up and down. And another motor is use to move that trolley inside the bag storage area-1 first. Both the motors are operated on 440 V AC. The lifting capacity of main motor is 1000 kg.

3. **Hook:** For lifting the trolley hook is attached in the hole provided on the top of the trolley. The hook capacity is 1500 kg. A hook is mounted with pulley which is rolled over the rope. A hook may have one or more built-in pulley sheaves as a block and tackle to multiply the lifting force. (Fig. 3.3)

4. **Wire Rope:** Wire rope is winded on the drum which is mounted with main motor such that the over lapping of the rope can be avoided. In wire rope metal wire twisted into a helix forming a composite rope, in a pattern known as “laid rope”. Larger Diameter wire rope consists of multiple stands of such laid rope in a pattern known as “cable laid”. The strength of 3/8” wire rope is 6 tons (Stainless Steel). (Fig 3.4)

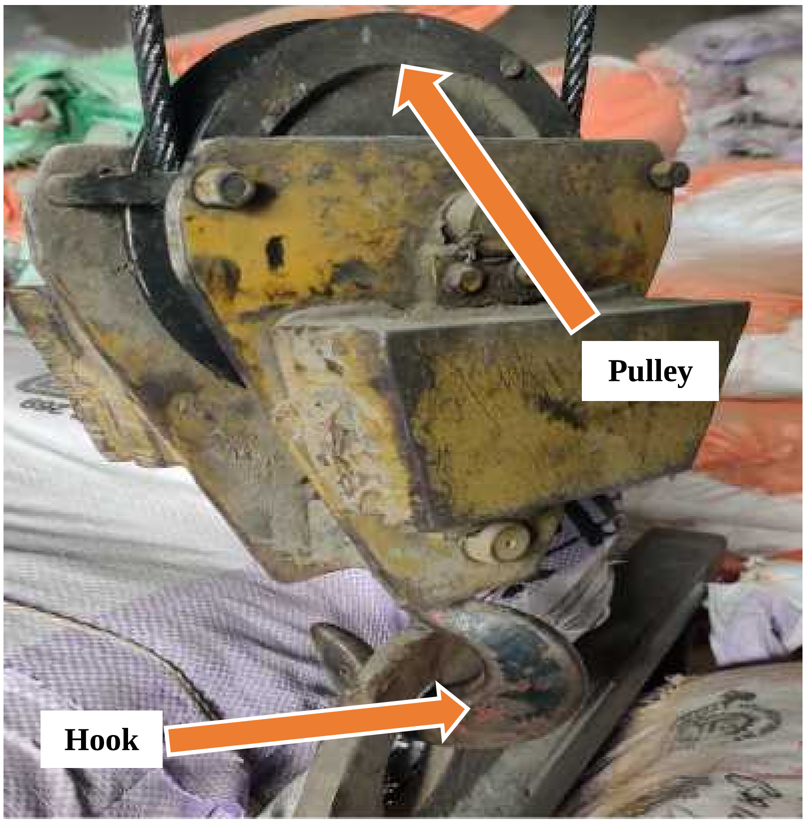
The pipe size is 40 mm and 3 mm thick.
Length of trolley: 1 m
Width of trolley: 1 m
Height of trolley: 1 m
Square pipe size is 50 x 50 mm and 6

Fig. 3.1 Existing Trolley



Main motor is used for lifting the load up and down.
Second motor is used to move whole arrangement left and right.

Fig. 3.2 Motor Arrangement in Existing System



The load carrying capacity of hook is 1.5 Tons.

Fig. 3.3 Hook and Pulley

The diameter of wire rope is 9.5 mm. (3/8” Wire rope).

Fig. 3.4 Wire Rope

3.2 Proposed System

Following are the concepts that will provide easy, safe and low cost arrangement for transferring the bag lots from ground to bag storage areas.

A trolley with caster wheel can easily transfer the bag lots from bag storage area-1 to bag storage area-2. Caster wheels are free to move in any direction on the ground. But breaking purpose rear wheels needs to be fixed in straight direction. Front wheels will guide the trolley in any direction on the ground. This will reduce the effort of the workers and man power or worker time also.

The platform or carriage is use to lift the trolley form ground level to bag storage area-1. The platform will remain outside of the storage area which will take whole attachment of motor outside also. For maintenance purpose motor attachment can be taken inside the bag storage area by unhook the platform. This will restrict the unsafe condition due to electric power supply.

Providing the side support or other arrangement to the platform for restrict the side moment of the platform due to the wind. The side supports will restrict four movement of the carriage. By this only up and down motion can be done. This will restrict the swinging effect due to wind and other forcing effects due to lifting the platform also.

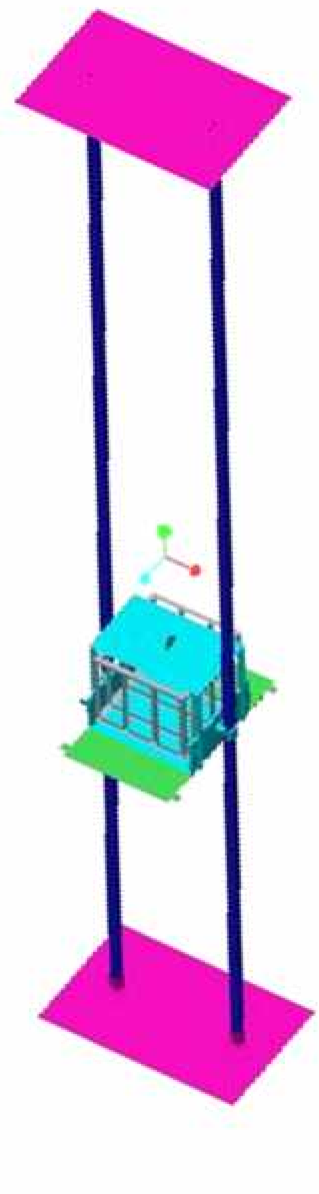


Fig. 3.5 Proposed System

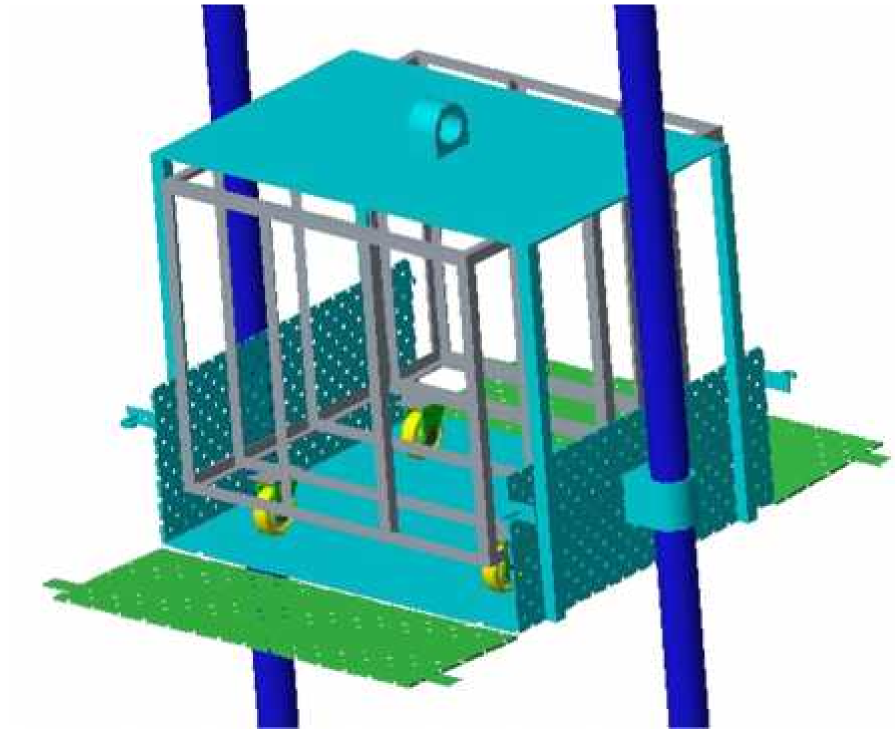


Fig. 3.6 Platform for Lifting The Trolley

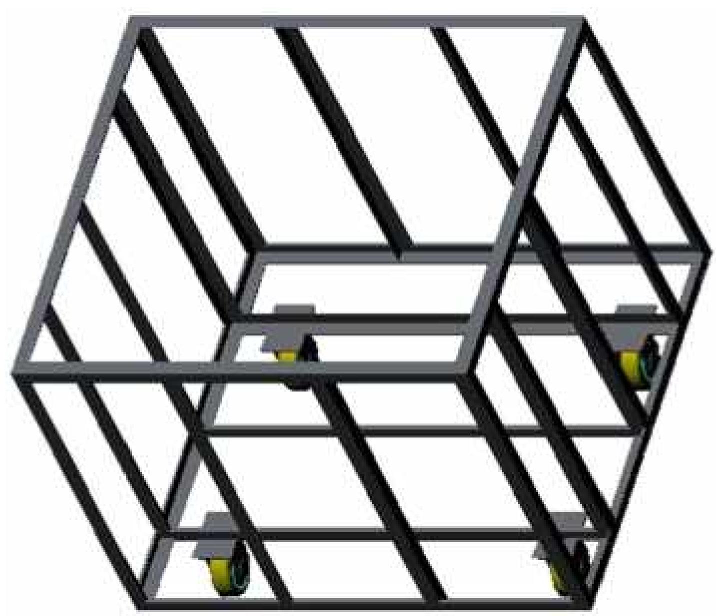


Fig. 3.7 Trolley with Caster Wheels

Fig. 3.8 Caster Wheel

Chapter 4

Design, Fabrication & Testing of Lift

Proposed system consists following parts or arrangement which should be design or selected.

1. Caster Wheels
2. Trolley
3. Platform or Carriage
4. Side Support

4.1 Selection of Caster Wheels

4.1.1 Requirements for Caster Wheels

Trolley is containing bag lots. One bag lot consist about 300 to 350 empty bags. Bag lot is weighted up to 28 kg to 30 kg. Trolley should consist 8 to 10 bag lots at a time which is weighted around 280 kg to 300 kg. The number of empty bags in the trolley will be around 3000 to 3500. For this purpose the capacity of caster should be more than 500 kg and trolley contain four wheels so that each wheel should have weight carrying capacity more than 125 kg.

Cater wheels require following requirements for batter performance.

- Weight carrying capacity for single caster wheel should be up to 150 kg.
- The wheel diameter is about 100 mm.
- The height of caster wheel from top plat to bottom surface is about 150mm to180 mm.
- Caster wheels should have in built breaking arrangement

4.1.2 Selection of Required Caster Wheels

For satisfying above requirement following type of caster wheels are available in standard size and weight carrying capacity.

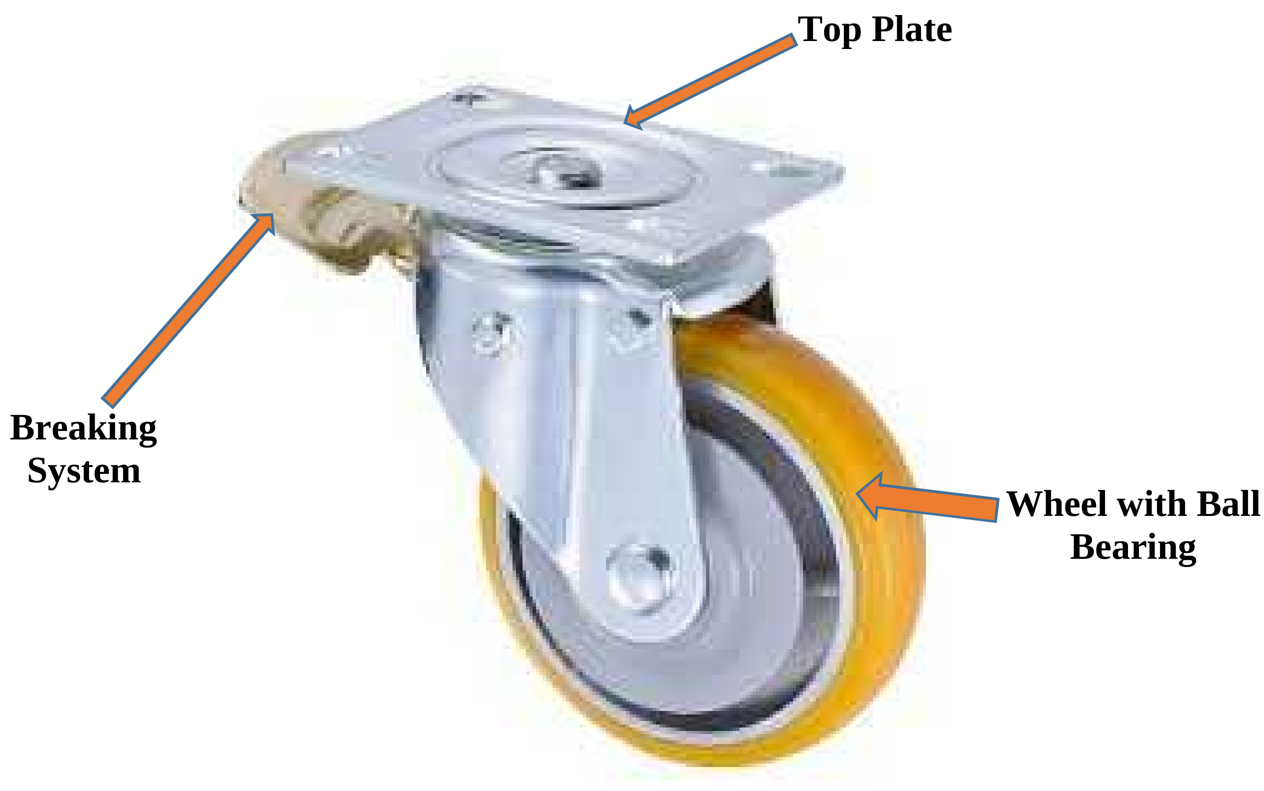


Fig. 4.1 Required Caster Wheel [6]

4.2 Design of Trolley

4.2.1 Requirements for Trolley

The trolley should contain up to 8 to 10 bag lots. The size of bag lot is 850 mm to 900 mm in length, 550 mm to 600 mm in width and 200 mm to 250 mm in height. (As shown in Fig. 4.2)

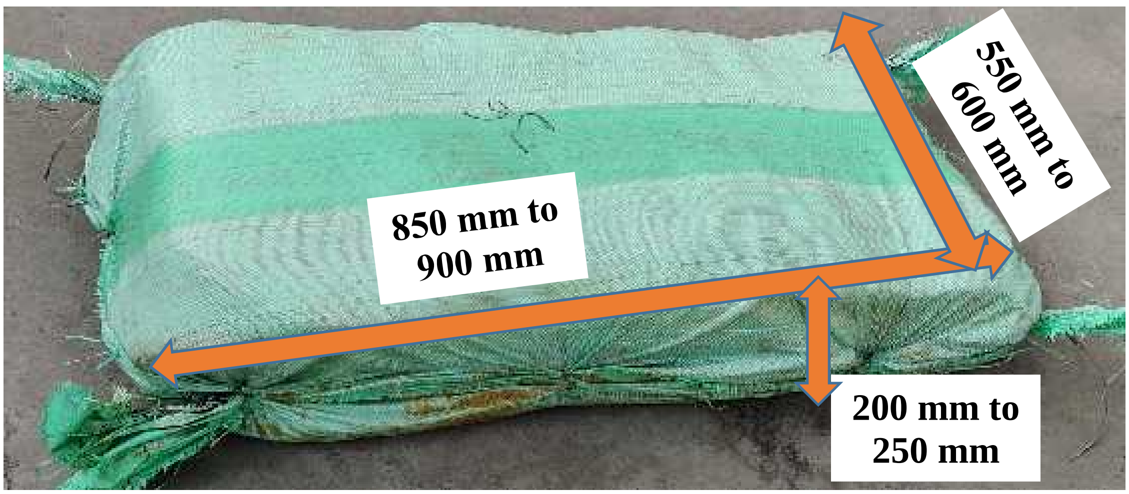


Fig. 4.2 Bag Lot Size and shape

For completing these requirements the size of trolley should be more than 900 mm in length, 900 mm in width and 900 mm in height. The trolley also should sustain more than 500 kg load. For this suitable section should be selected. And the trolley should be made such that it is easy to load it and unload it and it also should be easy to handle it.

4.2.2 Calculation for trolley

The best material for fabricate the trolley is mild steel because it is easy to operate different operation like welding, cutting, drilling and bending. The material property of mild steel is given below.

Density (ρ)	:- 7854 x 10^{-9} kg/mm^3
Ultimate tensile strength (σ_u)	:- 440 MPa
Yield tensile strength (σ_y)	:- 220 MPa
Modulus of elasticity (E)	:- 205 GPa
Bulk modulus (κ)	:- 140 GPa
Poisson ratio (ν)	:- 0.29

FOS = 8-9 (for lifting equipment)

For lifting equipment the factor of safety is taken as 8-9. So for light weight FOS will be 8.

Allowable stress $\sigma_a = \frac{\sigma u}{F} = \frac{440}{8} = 55$ MPa

Now, for vertical components

Load P=600 kg ≈ 6000 N

Minimum required cross section

$\sigma_a = \frac{P}{A} \Rightarrow A_r = \frac{P}{\sigma a} = \frac{6}{55} = 109.09\ mm^2 \approx 110\ mm^2$

Now check for Bending (For Horizontal Components)

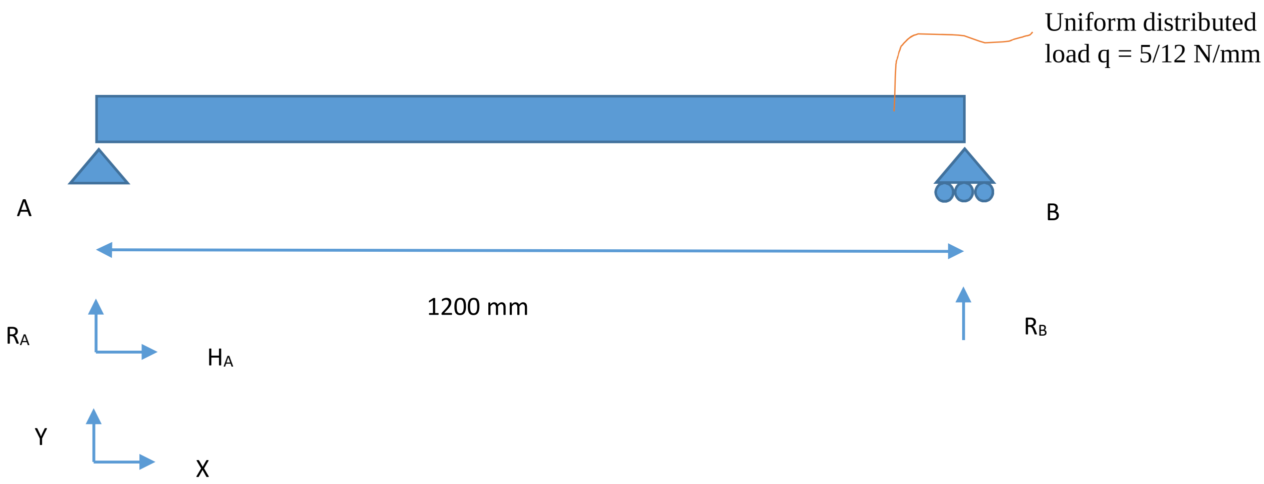


Fig. 4.3 Free Body Diagram of Horizontal Components

$M = \sigma \frac{I}{y}$ => $\frac{I}{y} = \frac{M}{\sigma} =$ section modulus

For finding the required section modulus first it is required to find maximum bending moment. For that reactions and equation of bending is required. For reactions

$\sum F_x = 0$

$\therefore H_A=0$

$\sum F_y = 0$

$\therefore R_A+R_B-q*1200=0$

$\therefore R_A+R_B=500$

$\sum M_A = 0$ CW=> +Ve & CCW=> -Ve

$\therefore q*1200*600- R_B*1200 = 0$

$\therefore R_B = 250$ N

$\therefore R_A = 250$ N

There is no any axial load so that there will not any axial load equation.

Equation for bending moment.

$M_{(x)} = R_A*x - (q*x^2)/2 = 250*x - 5*x^2/24$

x = distance in mm

Finding maximum bending M_{max}

$\frac{d(M(x))}{d} = 0$ => x=600 mm

$M_{max} = 75000$ N*mm

Now required section modulus

Required section modulus $= \frac{I}{y} = \frac{M}{\sigma} =$ 75000/55 = 1363.63 mm^3

Now checking for required minimum required cross section area and minimum required section modulus for different sections available.

4.2.3 Selection of Suitable Section for Trolley

For carrying this much load suitable material is mild steel. The suitable section for making the trolley are square pipe, round pipe, rectangular section, angle section (L-section), T-section and C- section. The best suitable section is angle section (L-section) for manufacturing the trolley because it will be low weight and it will easily available. Angle section will also provide compact design and more space than any other section with more stability and grater load carrying capacity.

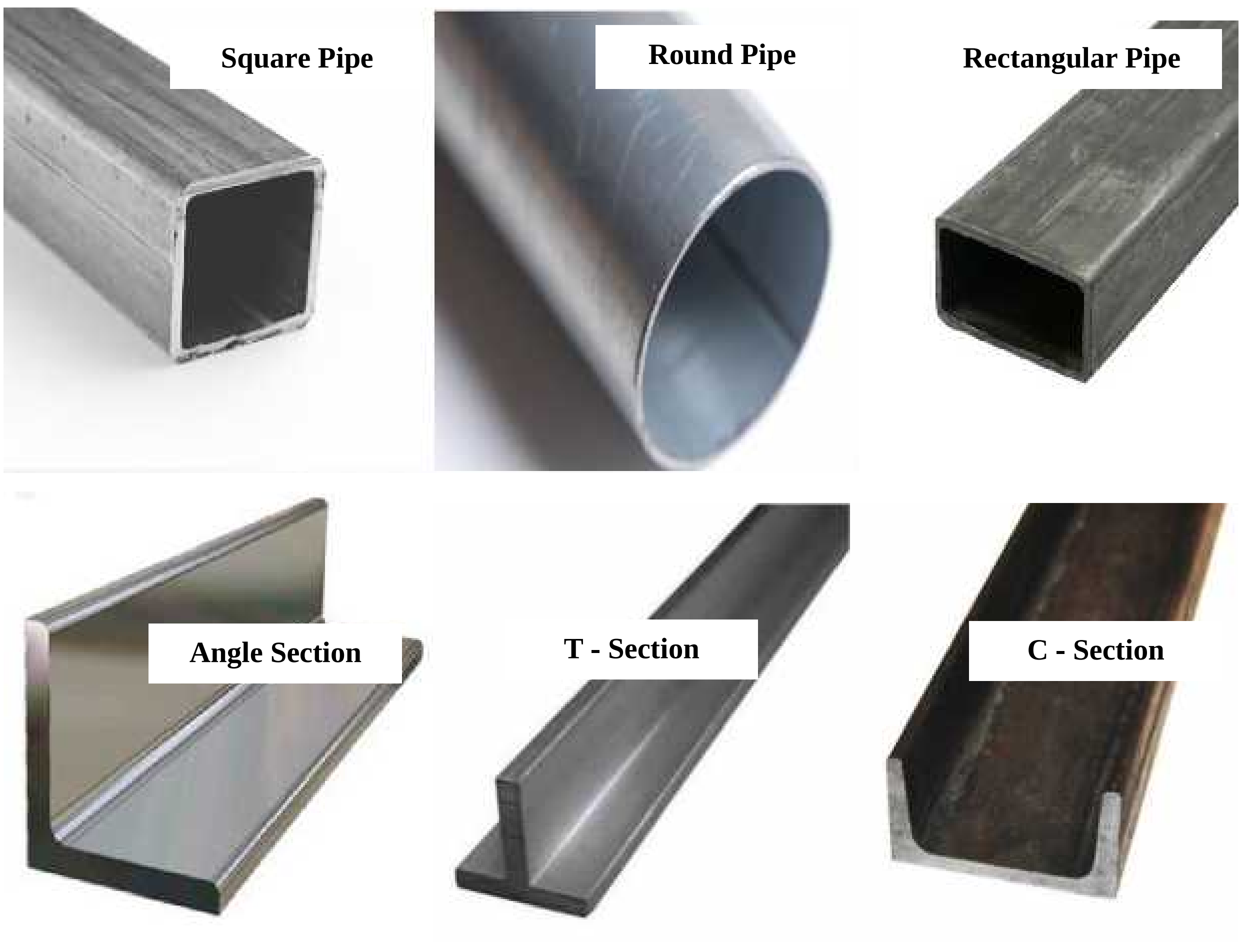


Fig. 4.4 Suitable Section for Trolley [7]

The angle section is best suitable section because if fabrication of trolley done by the square pipe, rectangular pipe, round pipe or C-type Section that time the size of trolley will increase. Here the length of the trolley should be 1200 mm excluding the thickness or width of the section. That's why these sections are not useful that much even though they have low weight and higher strength. T-type section is not suitable in the corner. The same size of T-type section and angle section have same strength and weight. That's why angle section is best suitable for fabricate the trolley.

The cross section and the section modulus of different size of the angle section is given in below table 4.1.

Table 4.1: Cross section, Section modulus and Weight for different angle section

Section	**Cross Section Area (mm^2)**	**Section Modulus(I/y) (mm^3)**	**Weight (kg/m)**
Angle section (35 x 35 x 3)	201	939.83	1.57
Angle section (35 x 35 x 4)	264	1220.94	2.03
Angle section (35 x 35 x 5)	325	1488.35	2.55
Angle section (37 x 37 x 3)	213	1054.83	1.67

4.2.4 Design of Trolley

As per requirement the size of trolley such that it can contain 8 to 10 bag lots for that if two bags are placed side to side then its length will be 1100 mm to 1200 mm and width will be 850 mm to 900 mm. From this data the best suitable length and width of the trolley will be 1200 mm excluding the thickness of the angle section. Now for stacking the bag lots it is require to put 4 to 5 bag lots in column. Here the total height require will be about 800 mm to 1000 mm so that the best suitable height of the trolley will be 1000 mm excluding the thickness of the angle section.

The final Size, material and section of the trolley is mention in bellow table.

Table 4.2: Dimensions & Material for Trolley

Length of Trolley	**:1200 mm**
Width of Trolley	:1200 mm
Height of Trolley	:1000 mm
Maximum weight carrying capacity of Trolley	:600 kg
Material of the section	:Mild Steel
Suitable section	:Angle Section (L-Section)

Fig. 4.4 shows the best suitable design for the trolley. The model is created in Creo parametric 3.0 software. The analysis is also done in the Creo simulation software. For analysis purpose the design is made from four different size of angle section for checking best suitable size according to total weight of trolley, availability, maximum stress and load carrying capacity.

For analysis in Creo simulation software it is need to give some constrain to the design. The bottom rectangular plates are fixed for analysis purpose. The load is consider as uniform distributed load on the trolley above the angle provided at the bottom rectangular plate. For batter check four different size of angle section are taken for the analysis. In the analysis only two parts are consider, one is maximum principal stress and other is maximum deflection. The result of four different section analysis is shown below and the data of the maximum deflection, maximum principal stress and weight is mention in the table below.

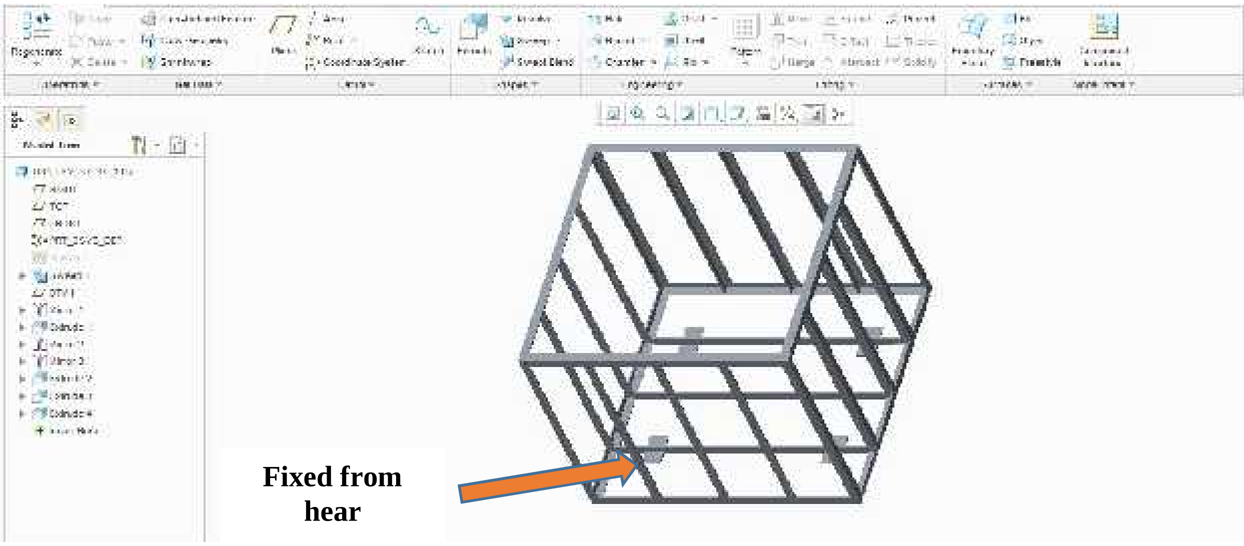


Fig. 4.5 Design of Trolley in Creo Parametric 3.0

The material properties for the mild steel is given below which is entered in the Creo simulation software for analysis purpose.

Table 4.3: Mild Steel Material Properties

Properties	
Density (kg/mm^3)	: 7854 x 10^{-9}
Ultimate Tensile Strength (MPa)	: 440
Yield Strength (MPa)	: 220
Poisson's Ratio	: 0.29
Young Modulus (GPa)	: 205
Thermal Expansion Coefficient (K^{-1})	: 12 x 10^{-6}
Thermal Conductivity (W/mK)	: 54
Specific Heat Capacity (J/g*K)	: 0.472

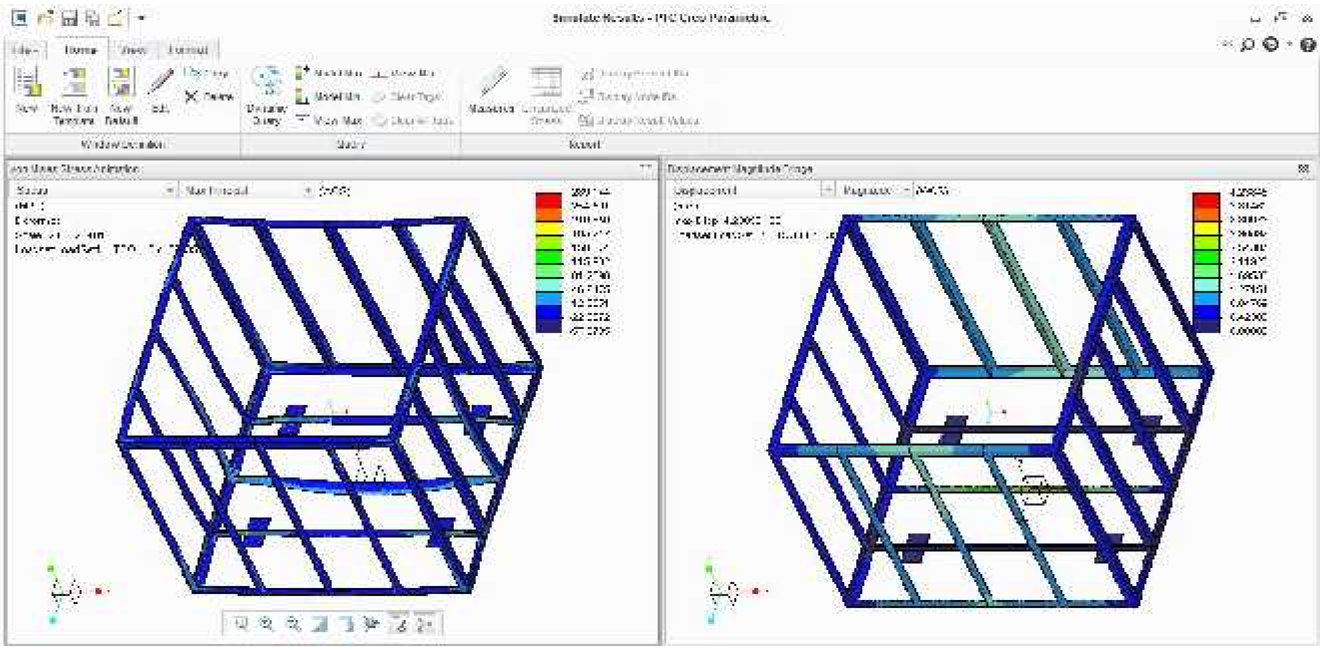


Fig. 4.6 Analysis of Trolley (35 x 35 x 3 mm Angle Section)

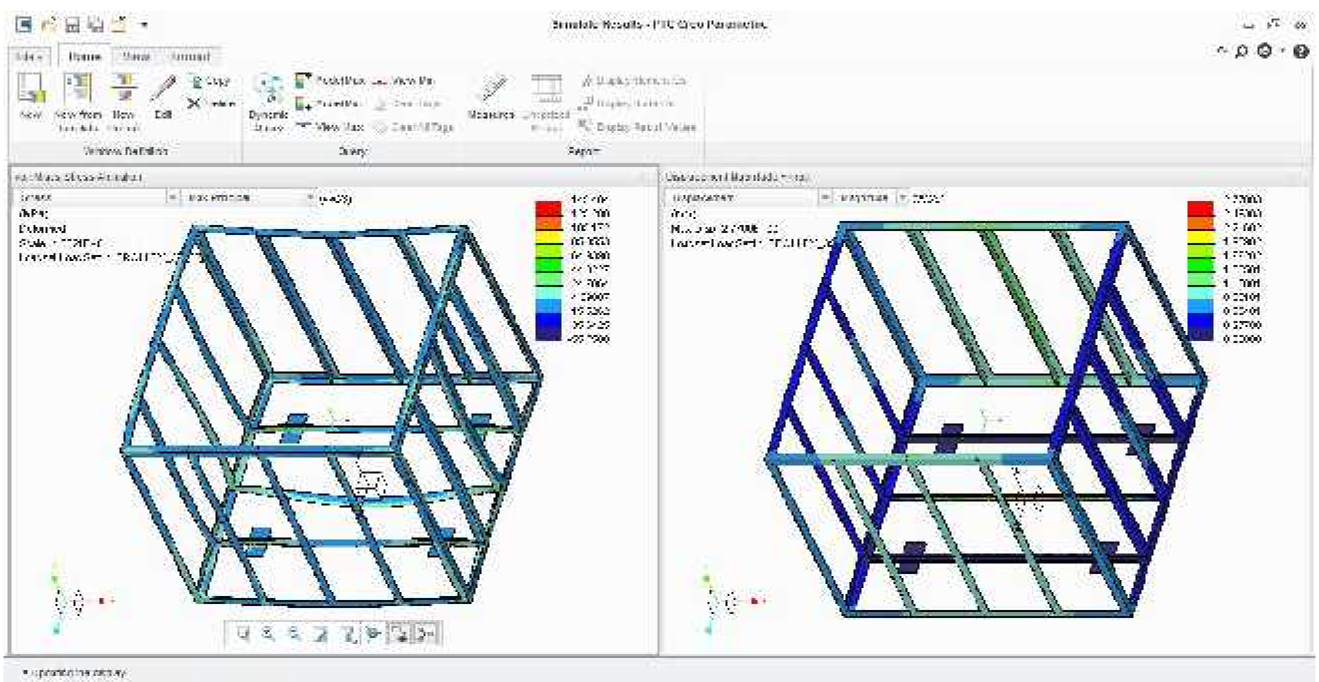


Fig. 4.7 Analysis of Trolley (35 x 35 x 4 mm Angle Section)

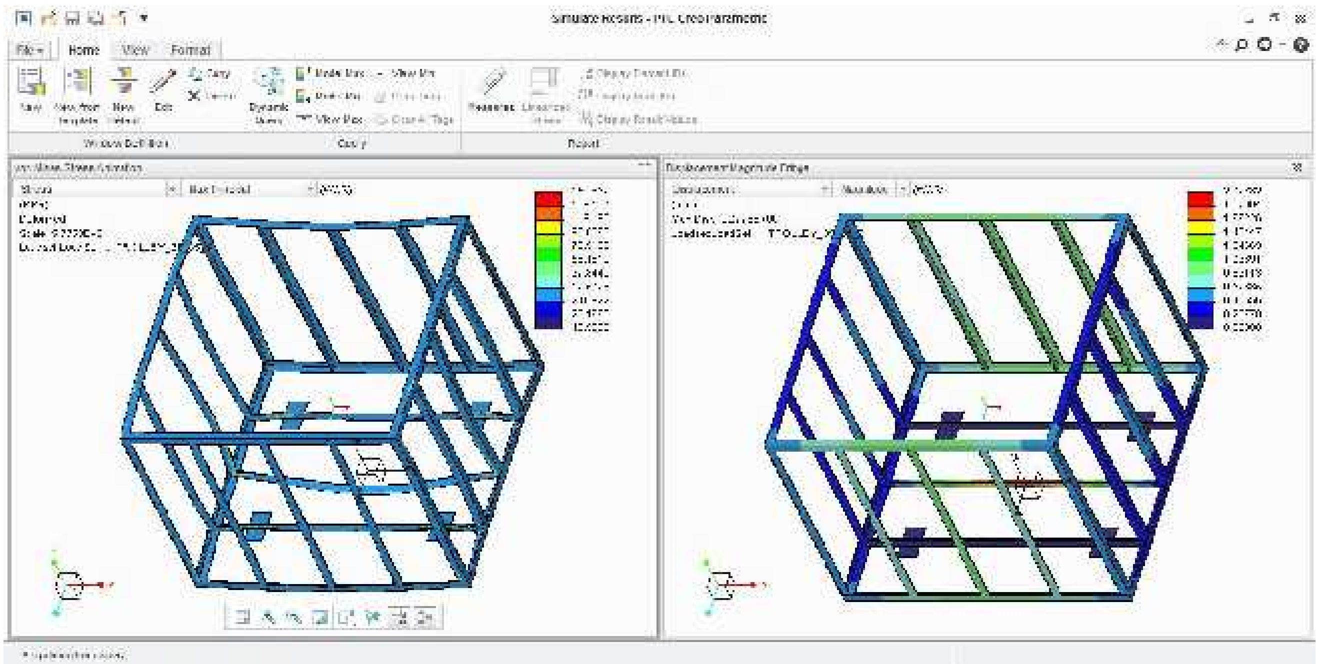


Fig. 4.8 Analysis of Trolley (35 x 35 x 5 mm Angle Section)

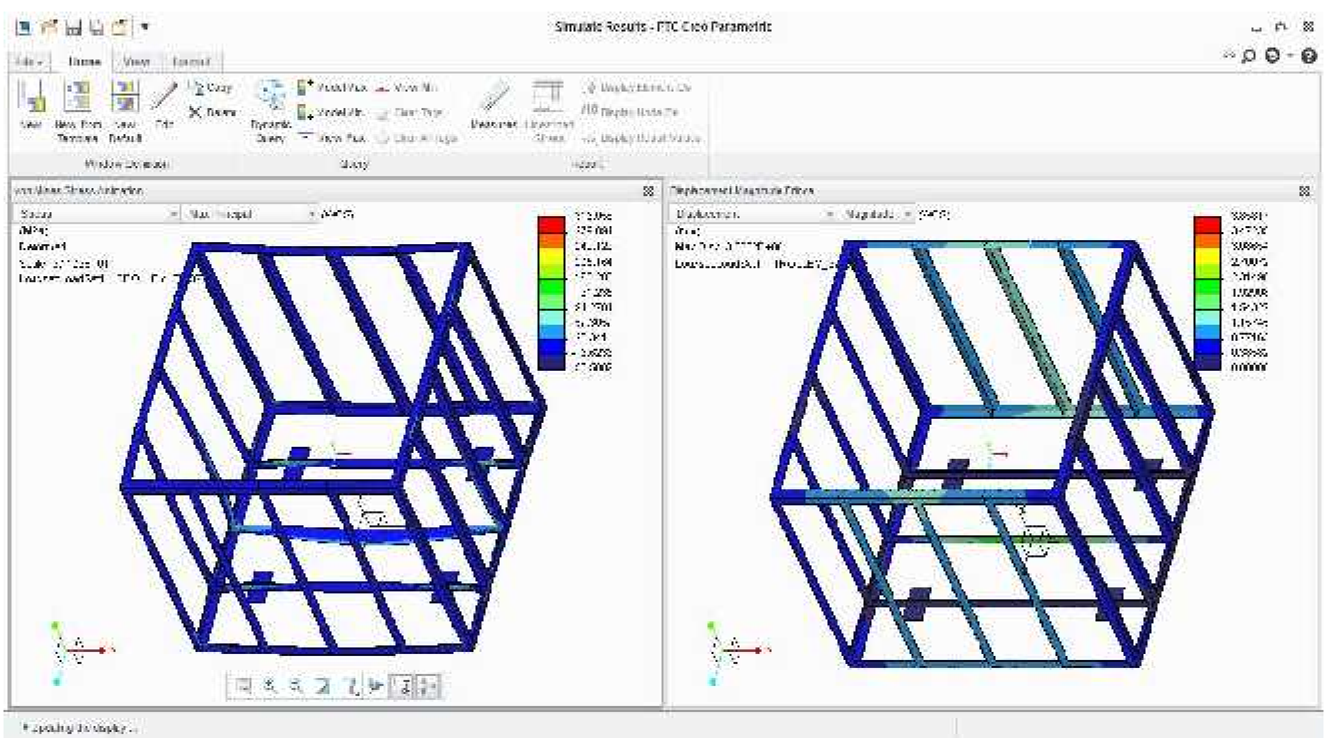


Fig. 4.9 Analysis of Trolley (37 x 37 x 3 mm Angle Section)

The maximum principal stress, maximum displacement and the total weight excluding the wheels of all four selected size of the angle section is given in below table.

Table 4.4: Analysis Result of Trolley

Section (L x L x t) mm	Weight (kg)	Maximum Principal Stress (MPa)	Maximum Displacement (mm)
35 x 35 x 3	46.5	289.144	4.238
35 x 35 x 4	58.6	145.404	2.770
35 x 35 x 5	70.2	159.867	2.077
37 x 37 x 3	48.7	252.77	3.855

The result shows that the angle section of 37 x 37 x 3 mm is best suitable for fabrication of trolley because it has low displacement under the load. Here induced stress is higher than 35 x 35 x 4 and 35 x 35 x 5 mm angle section and displacement is also higher but the trolley weight is less that's why 37 x 37 x 3 mm angle section is best.

The angle section lesser than this size are also available in market but their displacement will be higher and induced stress also will be higher so that they will not be selected. The grater then this sizes angle section leads to more weight so that sizes also will not be used.

Fig. 4.10 Trolley

4.3 Design of Platform or Carriage

4.3.1 Requirements for Platform or carriage

The platform or carriage should sustain total load of empty bag lots and trolley. Consider that the total load of bag lots and trolley will be 1000 kg and the size of the carriage should be such that the trolley can easily shifted into it.

4.3.2 Calculation for Platform or Carriage

The best material for fabricate the trolley is mild steel because it is easy to operate different operation like welding, cutting, drilling and bending. The material property of mild steel is given below. First calculating the required cross section and inertia of main horizontal component.

Density (ρ)	:- 7854 x 10^{-9} kg/mm^3
Ultimate tensile strength (σ_u)	:- 440 MPa
Yield tensile strength (σ_y)	:- 220 MPa
Modulus of elasticity (E)	:- 205 GPa
Bulk modulus (κ)	:- 140 GPa
Poisson ratio (ν)	:- 0.29

FOS = 8-9 (for lifting equipment)

For lifting equipment the factor of safety is taken as 8-9. So for light weight FOS will be 8.

Allowable stress $\sigma_a = \frac{\sigma u}{F} = \frac{440}{8} = 55$ MPa

Now, for vertical components

Load P=1000 kg ≈ 10000 N

Minimum required cross section

$\sigma_a = \frac{P}{A}$ => $A_r = \frac{P}{\sigma a} = \frac{1}{55} = 181.81\ mm^2 \approx 182\ mm^2$

Now check for Bending (For Horizontal Components)

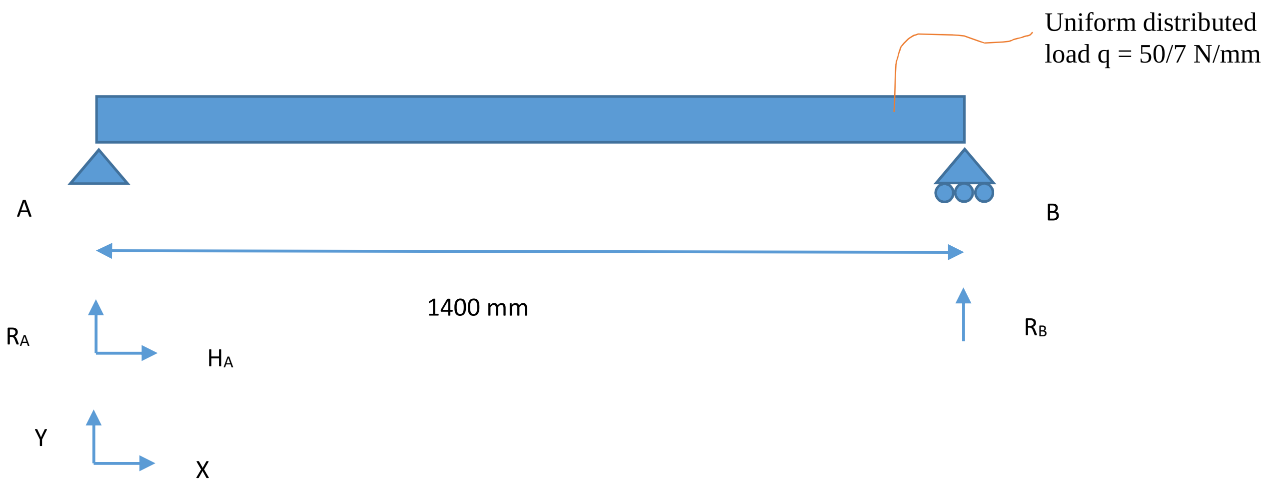


Fig. 4.11 Free Body Diagram of main Horizontal Component of Carriage

$M = \sigma \frac{I}{y}$ => $\frac{I}{y} = \frac{M}{\sigma}$ = section modulus

For finding the required section modulus first it is required to find maximum bending moment. For that reactions and equation of bending is required. For reactions

$\sum F_x = 0$

$\therefore H_A=0$

$\sum F_y = 0$

$\therefore R_A+R_B-q*1400=0$

$\therefore R_A+R_B=10000$

$\sum M_A = 0$ CW=> +Ve & CCW=> -Ve

$\therefore q*1400*700- R_B*1400 = 0$

$\therefore R_B = 5000$ N

$\therefore R_A = 5000$ N

There is no any axial load so that there will not any axial load equation.

Equation for bending moment.

$M_{(x)} = R_A*x – (q*x^2)/2 = 5000*x – 50*x^2/14$

x = distance in mm

Finding maximum bending M_{max}

$\frac{d(M(x))}{d} = 0$ => x=700 mm

M_{max} = 1750000 N*mm

Now required section modulus

Required section modulus $= \frac{I}{y} = \frac{M}{\sigma} =$ 175000/55 = 31818.18 mm^3

Now checking for required minimum required cross section area and minimum required section modulus for different sections available.

Now calculating the required cross section and inertia of other horizontal and vertical component of carriage.

Density (ρ)	:- 7854 x 10^{-9} kg/mm^3
Ultimate tensile strength (σ_u)	:- 440 MPa
Yield tensile strength (σ_y)	:- 220 MPa
Modulus of elasticity (E)	:- 205 GPa
Bulk modulus (κ)	:- 140 GPa
Poisson ratio (ν)	:- 0.29

FOS = 8-9 (for lifting equipment)

For lifting equipment the factor of safety is taken as 8-9. So for light weight FOS will be 8.

Allowable stress $\sigma_a = \frac{\sigma u}{F} = \frac{440}{8}$ = 55 MPa

Now, for vertical components

Load P=1000 kg ≈ 10000 N

Minimum required cross section

$\sigma_a = \frac{P}{A} \Rightarrow A_r = \frac{P}{\sigma a} = \frac{1}{55} = 181.81\ mm^2 \approx 182\ mm^2$

Now check for Bending (For Horizontal Components). There are total 10 horizontal components. So load per component will be 1000 N.

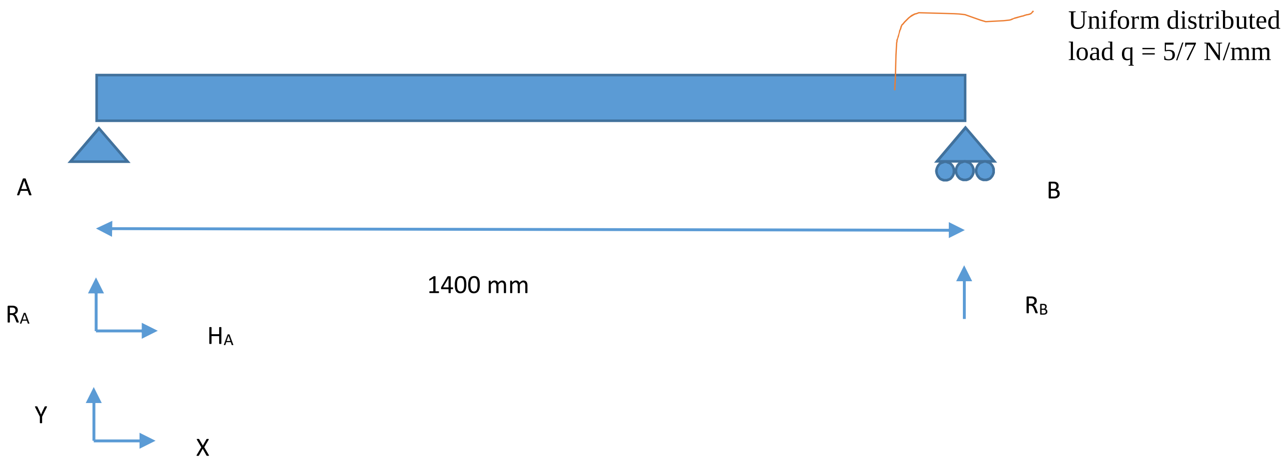


Fig. 4.12 Free Body Diagram of Horizontal of Carriage

$M = \sigma \frac{I}{y} \Rightarrow \frac{I}{y} = \frac{M}{\sigma}$ = section modulus

For finding the required section modulus first it is required to find maximum bending moment. For that reactions and equation of bending is required. For reactions

$\sum F_x = 0$

$\therefore H_A=0$

$\sum F_y = 0$

$\therefore R_A+R_B-q*1400=0$

$\therefore R_A+R_B=1000$

$\sum M_A = 0$ CW=> +Ve & CCW=> -Ve

$\therefore q*1400*700- R_B*1400 = 0$

∴ $R_B = 500$ N

∴ $R_A = 500$ N

There is no any axial load so that there will not any axial load equation.

Equation for bending moment.

$M_{(x)} = R_A*x - (q*x^2)/2 = 500*x - 5*x^2/14$

x = distance in mm

Finding maximum bending M_{max}

$\frac{d(M(x))}{d} = 0$ => x=700 mm

M_{max} = 175000 N*mm

Now required section modulus

Required section modulus $= \frac{I}{y} = \frac{M}{\sigma} =$ 175000/55 = 3181.81 mm^3

Now checking for required minimum required cross section area and minimum required section modulus for different sections available.

4.3.3 Selection of Suitable Section for Platform or Carriage

From above calculation the available section and their detail is shown in below table.

Table 4.5: Cross section, Section modulus and Weight for different Square Hollow Section

Section	Cross Section Area (mm^2)	Section Modulus(I/y) (mm^3)	Weight (kg/m)
Square Hollow Section (40 x 40 x 3)	444	5098.6	3.9
Square Hollow Section (80 x 80 x 5)	1500	35312.5	13.1

4.3.4 Design of Platform or carriage

The final Size, material and section of the trolley is mention in bellow table.

Table 4.6: Dimensions & Material for Carriage

Length of Trolley	**:1400 mm**
Width of Trolley	:1400 mm
Height of Trolley	:1400 mm
Maximum weight carrying capacity of Trolley	:1000 kg
Material of the section	:Mild Steel
Suitable section	:Square hollow section

Fig. 4.4 shows the best suitable design for the carriage. The model is created in Creo parametric 3.0 software. The analysis is also done in the Creo simulation software. For analysis purpose is to check total weight of carriage, maximum stress and load carrying capacity.

For analysis in Creo simulation software it is need to give some constrain to the design. The top square hollow section is fixed for analysis purpose. The load is consider as uniform distributed load on the carriage above the square pipes provided at the bottom. In the analysis only two parts are consider, one is maximum principal stress and other is maximum deflection.

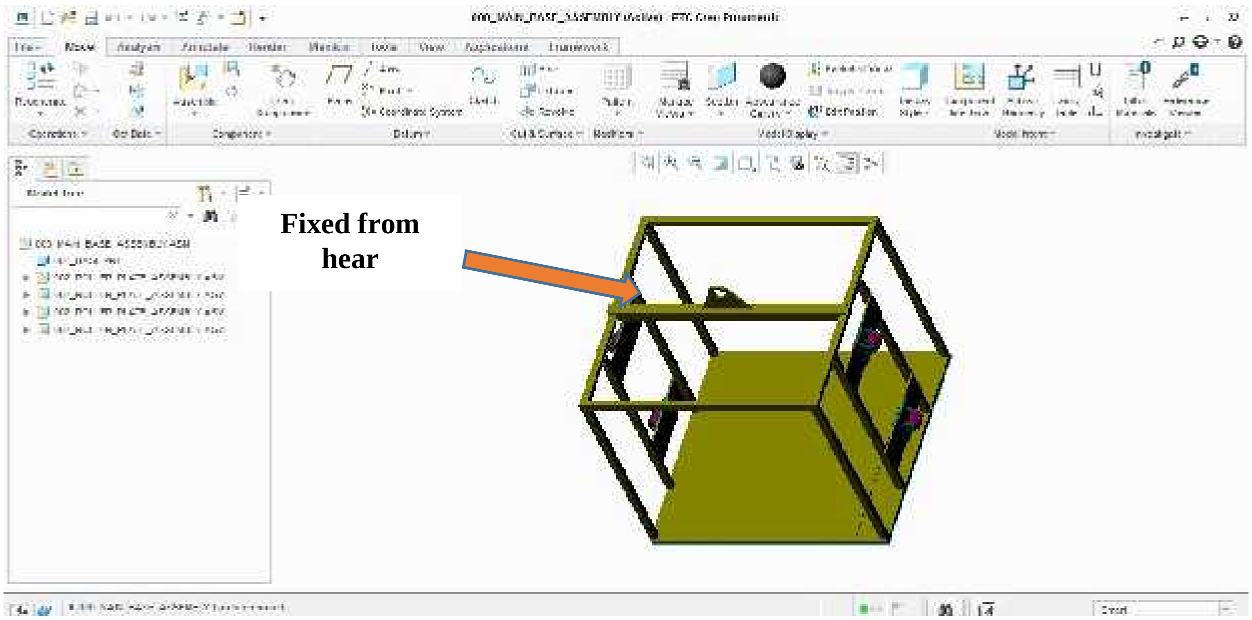


Fig. 4.13 Design of Platform or Carriage in Creo Parametric 3.0

The material properties for the mild steel is given below which is entered in the Creo simulation software for analysis purpose.

Table 4.7: Mild Steel Material Properties

Properties	
Density (kg/mm^3)	: 7854 x 10^{-9}
Ultimate Tensile Strength (MPa)	: 440
Yield Strength (MPa)	: 220
Poisson's Ratio	: 0.29
Young Modulus (GPa)	: 205
Thermal Expansion Coefficient (K^{-1})	: 12 x 10^{-6}
Thermal Conductivity (W/mK)	: 54
Specific Heat Capacity (J/g*K)	: 0.472

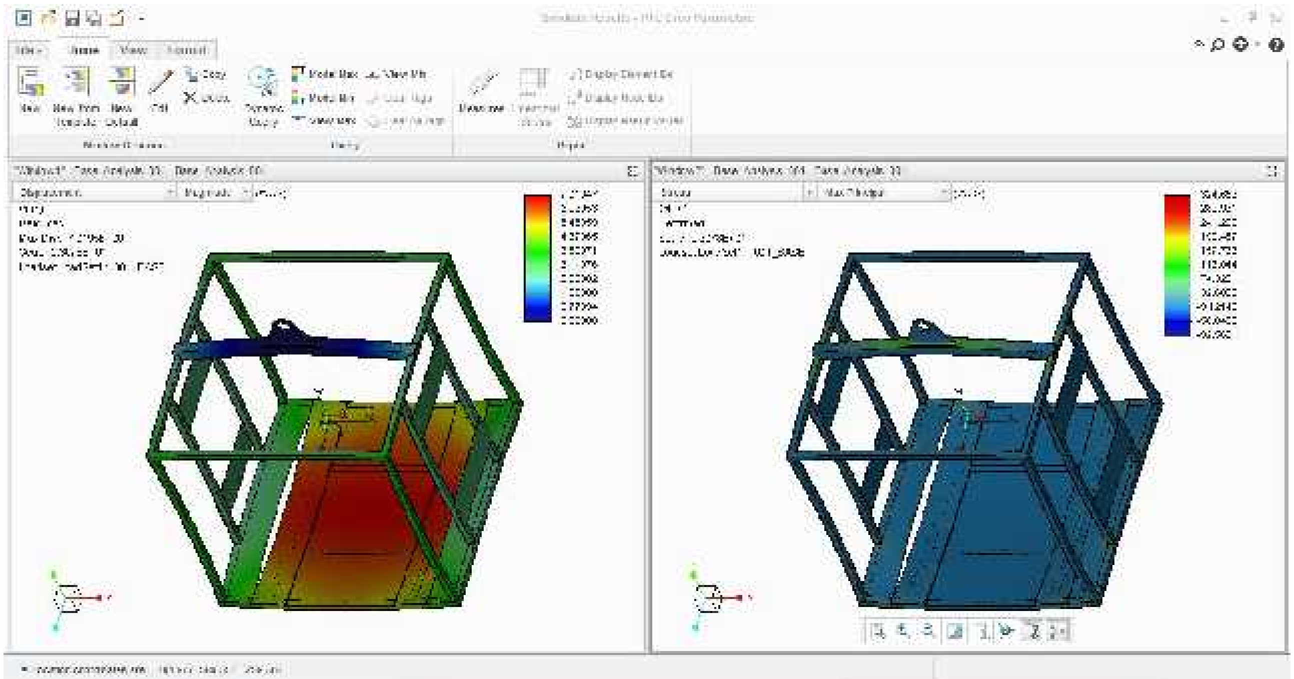


Fig. 4.14 Analysis of Platform or Carriage

The maximum principal stress and maximum displacement is 324.65 MPa and 7.09 mm respectively.

Chapter 5

Summary & Future Scope

5.1 Summary

For requirements of the company to transfer the bag lots to the bag storage areas it is require to fabricate the trolley with caster wheels. The size of trolley is such that it contain maximum bag lot at a time. The best caster wheels are 150 kg load carrying capacity wheels with breaking system in built. The best suitable section to fabricate the trolley is 37 x 37 x 3 mm angle section. The motor system remains as it is for lifting. Other parts to be fabricate are platform or carriage and side supports.

For easy transferring of trolley from ground level to bag storage area, it is require to fabricate a carriage which can easily transfer the trolley form ground level to bag storage area. The size of the carriage must be such that the trolley can easily move into it. The carriage must contain the rollers on its side, this will help the carriage against the swinging due to wind.

5.2 Future Scope

- The lift can be automated by changing some of its parameters.
- The lift can be for not only for empty bag lot transferring but also for transferring other goods also.
- The lift can be used as passenger lift or for emergency services also.

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