DESIGN AND DEVELOPMENT OF FLOATING BACKPACK

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE DEGREE OF

Bachelor of Engineering
In
Mechanical Engineering

<u>Submitted By</u>

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[2022-23]

Progressive Education Society's

Modern College of Engineering, Pune

C E R T I F I C A T E

This is to certify that the project work (402051) report entitled

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Has Successfully Completed By

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In the partial fulfilment of degree of

BACHELOR OF MECHANICAL ENGINEERING

In

SAVITRIBAI PHULE PUNE UNIVERSITY

Under the guidance of

PROF. Dr. M. M. KAWADE

During the Academic Year 2022-23

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ACKNOWLEDGEMENT

We would like to express special thanks of gratitude to our project guide DR. Prof. M. M. Kawade as well as our principal Prof. Dr. Mrs. K. R. Joshi who gave us the golden opportunity to do this wonderful project on the topic “DESIGN AND DEVELOPMENT OF FLOATING BACKPACK”.

Secondly, I would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame

Lastly, I like to thank all my supporters who have motivated me to fulfil their project before the timeline.

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ABSTRACT

A suspended-load backpack is a device that is designed to capture the mechanical energy created as a suspended backpack load oscillates vertically on the back during gait. The objective of the current study was to evaluate the effect of a suspended-load backpack system on selected temporal and kinetics parameters describing gait. The purpose of this project is to design and development of floating bag. Our project proposes to design a backpack that permits the load to move relative to the wearer during walking and running so that the large movements between the load and the wearer of the backpack reduce the fluctuations of vertical motion of the load with respect to ground. Because the hip (and thus the pack body) goes up a down a good deal during walking, a large relative movement between the wearer and the load reduces the absolute excursion of the load. This movement may be, in turn, transferred to a motor through, for example, a rack and pinion gear, to convert the mechanical movement to electrical or mechanical energy. Such movement of the suspended-load relative to the wearer also reduces the forces on the wearer's body while walking or running, thus reducing the likelihood of orthopaedic injury. The suspended-load backpack includes a suspension system having a first portion connected to shoulder straps directly or through an interface and a second portion connected to the pack body and a compliant mechanism that permits the second portion of the suspension system and the pack body to move up and down relative to the first portion of the suspension system in accordance with a gait of the wearer of the backpack.

KEY WORDS: suspended-load, Floating bag, backpack, fatigue

1. INTRODUCTION

1.1 BACKGROUND

In Indian army, load carriage is an unavoidable part of field operations which is the reason why soldiers often make use of a military backpack. Infantry soldiers usually carry loads weighting more than 30% of their body weight. When the soldier carries a certain weight, his energy expenditure increases, which causes a reduction in performance.

The transported load has a movement similar to the vertical displacement of the centre of mass of the soldier while walking. This leads to a significant increase in the acceleration forces generated by the action of said load on the body which explains the increase in energy expenditure.

FIGURE 1. CONVENTIONAL ARMY BAG [6]

1.2 PROBLEM DEFINATION

Damage to muscle and the Skelton is the frequent consequence of carrying heavy backpacks and occupational gear on our backs. It also damages the nerves that travel through neck and shoulders, it causes major damages, change in posture when carrying heavy load, Heavy load, causes red marks on the shoulders.

1.3 SCOPE

The scope of work shall include the following:

1. LITERATURE REVIEW/SURVEY
2. DESIGN AND DEVELOPMENT OF FSMO
3. DESIGN OF FRAME
4. DESIGN OF MECHANISM
5. SELECTION OF MATERIAL AND CONFIGURATION
6. PROCUREMENT
7. FABRICATION
8. ANALYSIS
9. FIELD TRIALS

1.4 OBJECTIVES

The objective of this project is to develop a load carriage system that suspends the load and reduces its vertical displacement.

There will be the reduction in both the vertical excursion of the load and in the total vertical ground reaction force when carrying a load with the developed prototype, with respect to the conventional military backpack and will help military forces to transport supplies, equipment, personal items, ammunition and clothing in training or field operations.

This backpack is based on suspended load technology which reduces the vertical movement and forces generated by the load on the carrier leading to energetic benefits. It dramatically reduces the impact forces during locomotion, even permitting running comfortably with heavy loads.

1. Muscle fatigue due to prolonged use of conventional backpacks
2. Reduces the endurance capabilities
3. More chances of injuries such as stress fractures, knee pains and backpain
4. Rucksack palsy (Rucksack palsy is a traction or compression injury to the brachial plexus, caused by the shoulder straps of the rucksack. The patient presents with paresthesia, paralysis, cramping with pain, and muscle weakness of the upper limb).

1.5 SIGNIFICANCE

- Increase endurance capability
- Carry surplus amount of ammunition, ration etc.
- Less fatigue to soldier
- Reduces injuries in shoulders and backbones.

FIGURE 2. SIGNIFICANCE

1.6 FIELD APPLICATIONS

A suspended-load backpack designed to permit the load to move relative to the wearer during walking and running so that the large movements between the load and the wearer of the backpack reduce the fluctuations of vertical motion of the load with respect to ground. Because the hip (and thus the pack body) goes up a down a good deal during walking, a large relative movement between the wearer and the load reduces the absolute excursion of the load. Such movement of the suspended-load relative to the wearer also reduces the forces on the wearer's body while walking or running, thus reducing the likelihood of orthopaedic injury. Thus, this modified backpack can be extensively used in long marches, prolonged standing duties, trans border patrols etc.

1.7 ORGANISATION OF THESIS

Chapter 1: Introduction

A brief introduction of the problem of carrying heavy loads, faced in present time by a soldier in Indian Army deployed impartially over the vast subcontinent. This chapter covers a basic overview of the project and how we plan to design the modified backpack so that the force (on human body) due to it can be reduced significantly.

Chapter 2: Literature Survey

A detailed preliminary study of various patents and designs made by scientists all over the world was carried out. Basic designing methods & ideas were selected after detailed study and chosen to best suit our project. Cost analysis techniques and software best suited to our requirements were also selected on the basis of these research papers.

Chapter 3: Morphology of Design

This chapter covers the morphology of various materials used in the project and reasons why they were selected. We have used steel as the base material for making our first prototype so as to check our mechanism incorporating suspended load technology. Then, we moved on to make our final prototype using Al metal so as to reduce the weight of our prototype.

Chapter 4: Design and Fabrication

The main design details and calculations are covered in this chapter. Each individual part was designed, fabricated and assembled to for the final finished product. The design processes and methods are explained here.

Chapter 5: Conclusion

The benefits, problems faced and future scope of the project are covered briefly in this chapter.

Chapter 6: References

Reference papers and research theses’, websites and books referred to us during the scope of the project which helped us understand the theories and develop the project successfully.

2. LITERATURE SURVEY

The comprehensive methodology for the design is based on system engineering design and analysis approach. While giving due importance to the design procedure, the analysis of different methods and procedures were undertaken to design a reliable model for reducing the force exerted by the bag on human body. A number of research papers and analytical documents were referred to which formed the basis of our model. Some of these papers are as follows:

Laurence C Rome, Andy L Ruina et al. [1] shows a suspended-load ergonomic-backpack has been developed that dramatically reduces the dynamic forces on the body (e.g., 82-86%) and consequently reduces the metabolic rate for carrying the load (e.g., by 40 W for a 60 lb load), providing the ability to carry significantly greater loads for the same metabolic cost (5.3 Kg more). The suspended-load ergonomic backpack of the invention can be used to transport loads more quickly and more comfortably at running speeds—in contrast with a conventional backpack were running with a heavy load is essentially impossible.

Camilla Perez, Evan Campo et al. [2] shows that in military life, load carriage is an unavoidable part of field operations which is the reason why soldiers often make use of a military backpack. Infantry soldiers usually carry loads weighting more than 30% of their body weight. When the soldier carries a certain weight, his energy expenditure increases, which causes a reduction in performance. The transported load has a movement similar to the vertical displacement of the centre of mass of the soldier while walking. This leads to a significant increase in the acceleration forces generated by the action of said load on the body which explains the increase in energy expenditure. The objective of this project was to develop a load carriage system that suspends the load and reduces its vertical displacement. Results show a reduction in both the vertical excursion of the load and in the total vertical ground reaction force when carrying a load with the developed prototype, with respect to the conventional military backpack.

Joseph J Knapik, Katy L Reynolds, Everett Harman et al [3] reviewed historical and biomedical aspects of soldier load carriage. Before the 18th century, foot soldiers seldom carried more than 15 kg while on the march, but loads have progressively risen since then. This load increase is presumably due to the weight of weapons and equipment that incorporate new technologies to increase protection, firepower, communications, and mobility. Research shows that locating the load centre of mass as close as possible to the body centre of mass results in the lowest energy cost and tends to keep the body in an upright position similar to unloaded walking. Loads carried on other parts of the body result in higher energy expenditures: each kilogram added to the foot increases energy expenditure 7% to 10%; each kilogram added to the thigh increases energy expenditure 4%. Hip belts on rucksacks should be used whenever possible as they reduce pressure on the shoulders and increase comfort. Low or mid-back load placement might be preferable on uneven terrain but high load placement may be best for even terrain.

Deepti Majumdar, Madhu Sudan Pal, Dhurjati Majumdar et al. [4] shows the importance to evaluate the kinematic responses to existing load carriage operations and to provide guidelines towards the future design of heavy military backpacks (BPs) for optimising soldiers' performance. Kinematic changes of gait parameters in healthy male infantry soldiers whilst carrying no load (NL) and military loads of 4.2-17.5 kg (6.5-27.2% body weight) were investigated. There were increases in step length, stride length, cadence and midstance with the addition of a load compared to NL. These findings were resultant of an adaptive phenomenon within the individual to counterbalance load effect along with changes in speed. Ankle and hip ranges of motion (ROM) were significant. The ankle was more dorsiflexed, the knee and hip were more flexed during foot strike and helped in absorption of the load. The trunk showed more forward leaning with the addition of a load to adjust the centre of mass of the body and BP system back to the NL condition. Significant increases in ankle and hip ROM and trunk forward inclination (> or =10 degrees) with lighter loads, such as a BP (10.7 kg), BP with rifle (14.9 kg) and BP with a light machine gun (17.5 kg), may cause joint injuries. It is concluded that the existing BP needs design improvisation specifically for use in low intensity conflict environments.

Joseph F Seay et al. [5] Studies into the biomechanics of load carriage have documented motion-related differences such as increased step rate, decreased stride length, and more trunk lean with increases in pack-borne loads. However, there is a paucity of literature on the relationship between load carriage and biomechanical mechanisms of overuse injury. Findings of recent studies will be presented, which add mechanistic information to increased stresses on the lower extremity. This was particularly true at the knee, where in one study, peak knee extension moment increased 115% when carrying a 55 kg load (0.87 ± 0.16 Nm·kg^{-1}) vs. no external load (0.40 ± 0.13 Nm·kg^{-1}). Efforts to model injury mechanisms require continued biomechanical measurements in humans while carrying occupationally relevant loads to be validated. Specifically, imaging technologies (e.g., bone geometry scans) should be incorporated to produce higher fidelity model of the stresses and strains experienced by the load carrier. In addition to laboratory-based biomechanics, data are needed to further explore the mechanistic relationship between load magnitude and injury; to this end, wearable sensors should continue to be exploited to accurately quantify biomechanical stresses related to load carriage in the field.

Narendra Kurnia Putra, Suprijanto, and Andar Bagus Sriwarno et al. [6] proposed dynamic modelling and simulation of the suspended-load backpack to obtain optimal suspension parameters and reducing effect of ground reaction force. In this research, backpack designed with configuration of common spiral spring and clock spring which the spring stiffness could be changed trough addition and subtraction of spring. There are many methods to obtain suspension parameter of backpack design such as mechanical vibrator which is classified as advance technology method and also expensive in research cost. Because of that, this research objective is to obtain the optimal suspension parameter through simpler and low-cost way.

Renee L. Attwells, Stewart A. Birrell, Robin H. Hooper and Neil J. Mansfield et al. [7] have worked on influence of carrying heavy loads on posture, movement and gait. Studies in the literature mainly concentrate on physiological effects, with few biomechanical studies of military load carriage systems (LCS). This study examines changes in gait and posture caused by increasing load carriage in military LCS. The four conditions used during this study were control (including rifle, boots and helmet carriage, totalling 8 kg), webbing (weighing 8 kg), backpack (24 kg) and a light antitank weapon (LAW; 10 kg), resulting in an incremental increase in load carried from 8, 16, 40 to 50 kg. A total of 20 male soldiers were evaluated in the sagittal plane using a 3-D motion analysis system. Measurements of ankle, knee, femur, trunk and craniovertebral angles and spatiotemporal parameters were made during self-paced walking. It is concluded that the head functions in concert with the trunk to counterbalance load. The higher muscular tensions necessary to sustain these changes have been associated with injuries.

3. MORPHOLOGY OF DESIGN

Morphology of design refers to the study of the chronological structure of design projects. The following phases are usually involved in any design project. To give the project a particular form and structure, and before we started with the actual design, we carried out preliminary studies regarding material property, material selection and design aspects of the raw material which we will use to construct the project, the construction of the project includes the structure of frame, pulleys, shaft, springs, bolts and elastic rope.

To begin with, we started to select the raw materials for making the frame for our mechanism as it is the most crucial part of the project on which all the other components are supposed to be mounted. We then came to the pulleys which is mounted on the immovable frame. Then we attached the movable frame with the immovable frame with the help of elastic rope which enables the up and down motion of the backpack.

In this section we shall see the detailed study, on the basis of their properties, of the material used to design the frame and mechanism.

3.1 COMPONENTS

3.1.1 FRAME

The initial investigation of the frame, on our part, dealt with the materials with which it would be made. At first, we decided that the frames will be made of mild steel. But mild steel would not be feasible due to its weight constraints. Thus, we had to change the material of the frames. After some study and help from our guide, we came to the conclusion that aluminium will be used to make the frames.

Why Aluminium is feasible?

1. Aluminum has a lower density than any other commercial metal
2. It has excellent resistance to corrosion
3. It can be cast, machined and molded quickly.

Temper	Specified thickness mm		Tensile strength R_m MPa		Yield strength $R_{p0,2}$ MPa		Elongation min. %		Bend radius[a]		Hardness HBW[a]
	over	up to	min.	max.	min.	max.	$A_{50\,mm}$	A	180°	90°	
O	≥ 0,4	1,5		150		85	14		1,0 t	0,5 t	40
	1,5	3,0		150		85	16		1,0 t	1,0 t	40
	3,0	6,0		150		85	19			1,0 t	40
	6,0	12,5		150		85	16			2,0 t	40
	12,5	25,0		150				16			40
T4	≥ 0,4	1,5	205		110		12		1,5 t[b]	1,0 t[b]	58
	1,5	3,0	205		110		14		2,0 t[b]	1,5 t[b]	58
	3,0	6,0	205		110		16			3,0 t[b]	58
	6,0	12,5	205		110		18			4,0 t[b]	58
	12,5	40,0	205		110			15			58
	40,0	80,0	205		110			14			58
T451	≥ 0,4	1,5	205		110		12		1,5 t[b]	1,0 t[b]	58
	1,5	3,0	205		110		14		2,0 t[b]	1,5 t[b]	58
	3,0	6,0	205		110		16			3,0 t[b]	58
	6,0	12,5	205		110		18			4,0 t[b]	58
	12,5	40,0	205		110			15			58
	40,0	80,0	205		110			14			58
T42	≥ 0,4	1,5	205		95		12			1,0 t[b]	57
	1,5	3,0	205		95		14			1,5 t[b]	57
	3,0	6,0	205		95		16			3,0 t[b]	57
	6,0	12,5	205		95		18			4,0 t[b]	57
	12,5	40,0	205		95			15			57
	40,0	80,0	205		95			14			57

TABLE 1. MECHANICAL PROPERTIES OF ALUMINIUM

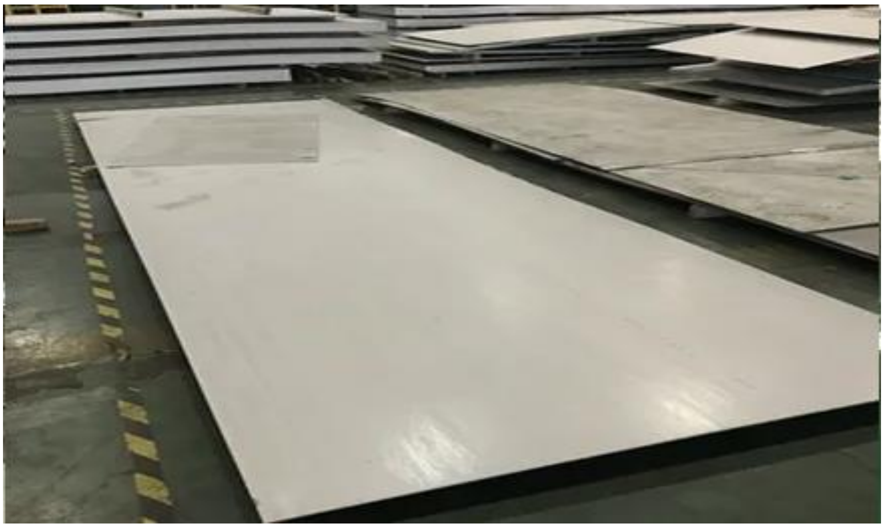


FIGURE 3. ALUMINIUM PLATES FOR FRAME

FIGURE 4. ALUMINIUM SHAFTS

3.1.2 Fasteners (nut and bolt):

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction, a slight stretching of the bolt, and compression of the parts to be held together.

FIGURE 5. NUT BOLTS

Bolts use a wide variety of head designs, as do screws. These are designed to engage with the tool used to tighten them. Some bolt heads instead lock the bolt in place, so that it does not move and a tool is only needed for the nut end.

The first bolts had square heads, formed by forging. These are still found, although much more common today is the hexagonal head. These are held and turned by a spanner or wrench, of which there are many forms. Most are held from the side, some from in-line with the bolt.

3.1.3 Pop rivet:

FIGURE 6. POP RIVET

A rivet is a permanent mechanical fastener. Before being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite to the head is called the tail. On installation, the rivet is placed in a punched or drilled hole, and the tail is upset, or bucked (i.e., deformed), so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place. In other words, pounding creates a new "head" on the other end by smashing the "tail" material flatter, resulting in a rivet that is roughly a dumbbell shape. To distinguish between the two ends of the rivet, the original head is called the factory head and the deformed end is called the shop head or buck-tail.

3.1.4 Linear-motion bearing:

FIGURE 7. LINEAR-MOTION BEARING

A linear-motion bearing or linear slide is a bearing designed to provide free motion in one direction. There are many different types of linear motion bearings. Motorized linear slides such as machine slides, X-Y tables, roller tables and some dovetail slides are bearings moved by drive mechanisms. Not all linear slides are motorized, and non-motorized dovetail slides, ball bearing slides and roller slides provide low-friction linear movement for equipment powered by inertia or by hand. All linear slides provide linear motion based on bearings, whether they are ball bearings, dovetail bearings, linear roller bearings, magnetic or fluid bearings. X-Y tables, linear stages, machine slides and other advanced slides use linear motion bearings to provide movement along both X and Y multiple axis.

3.1.5 Nylon pulley:

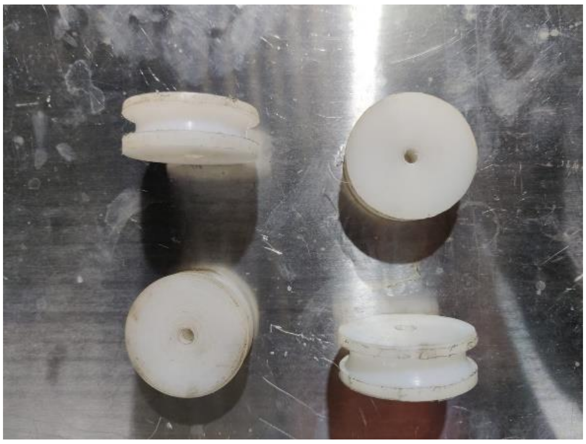


FIGURE 8. NYLON PULLEY

A pulley is a grooved wheel that holds the cable, rope, or wire on a pulley system. The pulley is situated on an axle or bearing within the pulley, and an operator can adjust the amount of force and direction necessary for lifting. The pulley's movement helps reduce friction and wear on the rope or cable. Pulleys can be found in forklifts, cranes, cable stranding machines, and wire drawing machines.

Nylon is a popular material for pulleys because of its durability and versatility. In fact, nylon pulleys offer a number of advantages over their metal counterparts. Learn more about the benefits and applications of pulleys.

Industrial nylon pulleys offer many benefits, especially compared to metal pulleys:

ADVANTAGES

Lightweight construction: Compared to metal pulleys, nylon pulleys are much lighter, reducing the overall weight of the system without compromising durability.

Longer cable/rope life: Nylon pulleys are more elastic and allow a larger contact surface area between the groove and the rope or cable, distributing the load more evenly and reducing stress. As a result, the entire system benefits from reduced maintenance and cost savings.

Reduced operating costs: Because nylon pulleys last longer than metal pulleys, they do not need to be replaced as often. Facility managers can also order lubricated grades of nylon pulleys, eliminating the need to purchase and apply lubrication separately.

Increased load capacity: Nylon flexes under the weight of the rope, increasing the contact area and load capacity of the pulley.

Corrosion resistance: Unlike metal, nylon is a chemically resistant material that will not rust or corrode.

3.1.6 Elastic rope:

FIGURE 9. ELASTIC ROPE

Elastic shock cord, or bungee cord, has a multi-stranded rubber core covered by a synthetic or cotton jacket. A standard bungee cord has a stretch factor of 100 to 125 percent when stretched to its ultimate break. The assemblies can be made with hooks, terminal fasteners, loops, rings, and other hardware. Bungee Cords are typically made using synthetic or natural rubber. The elastic part of the cord is covered by a braided material, and this braided material is typically made up of either nylon, polypropylene, polyester, or cotton. These fabrics have different advantages depending on the application of the bungee cord. The polypropylene material is better suited for outdoor use, and the nylon bungee cord performs well in marine applications. Nylon performs well in marine-based applications because it absorbs moisture better than cotton and polypropylene.

3.1.7 Camouflage bag-pack:

Militia Camouflage Army Travel Bag / Tracking Bag designed for Military/Army/Special Forces use, Militia 65L Rucksack is a tough light weight rucksack with plenty of compartments to carry essentials. It has a Stock cord attachment on the top hence more compartment to add extra bit.

Compartments:

1. Top Cap section with zipper (Ideal for handy items like mobile charger, sunglasses, medicines, etc.)
2. Main Upper Compartment
3. Main Lower Compartment - Separate bottom opening to be used for storing dirty clothes, emergency items or shoes
4. Spacious deep pockets on each side
5. Mesh pockets on each side
6. Laptop/File Compartment
7. Front main Pocket

Capacity: 65 Liters

Additional features:

- Easy Detachable Bag
- Fiber padding in the back along with lightweight aluminum strips provides a strong internal frame
- Extra soft breathable cushioning on the back provides easy air flow while walking for long hours
- 8 Utility straps to wrap additional items (sleeping bag, mat, camping equipment) on the sides, bottom and top
- Elastic cords and hooks on the day pack to hold mountaineering gear and additional emergency items
- Double layered strong fabric at the bottom provides durability for rough usage and carrying excess load
- Plastic padding on the bottom protects from rough terrain

Rain cover: Included in the bottom pocket

Usage: Ideal for mountain climbers, long duration hikes lasting more than 15 days and for carrying luggage on motorcycles and cars.

Load Management:

- Torso adjustment straps to fit multiple physiques
- Four load setting pulls on the shoulder straps
- Flexible and movable waist strap to fit below the pelvis area

Product Details	
SIZE	26 inches
WATER PROOF	Yes
CAPACITY	65 L
COMPARTMENTS	1
MATERIAL	Polyester
WITH RAIN COVER	Yes
NUMBER OF POCKETS	4
PATTERN	Solid
DIMENSIONS	W x H; 14 x 26 inch
DEPTH	6.5 inch
WEIGHT	1500 g

TABLE 2. PRODUCT DETAIL

FIGURE 10. CAMOUFLAGE ARMY TRAVEL BAG

3.2 CAD MODEL

PROCEDURE

- The entire model has been designed with the help of designing software solid works.
- With the help of colour feature the colours are given to the entire model.

Figure- Cad model of the assembled project is designed on Solidworks 2022 software.

3.2.1 SOLID MODELING

The entire model has been designed with the help of designing software solid works.

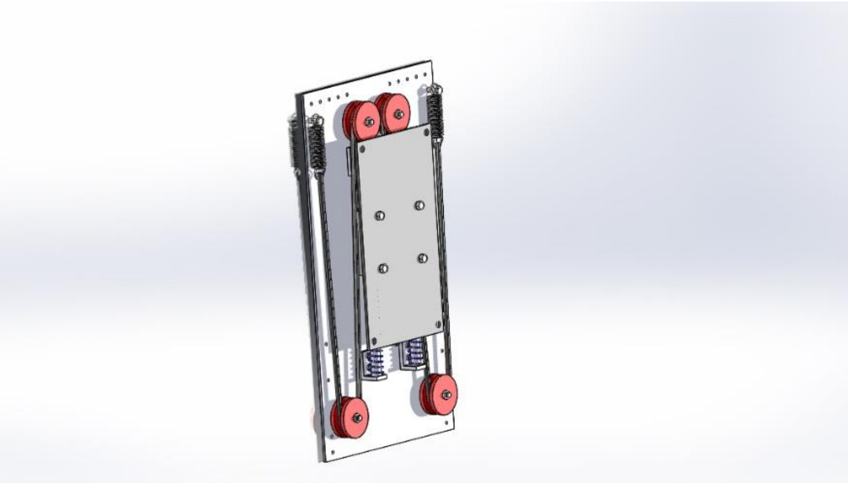


FIGURE 11. ASSEMBLY OF FLOATING BAG

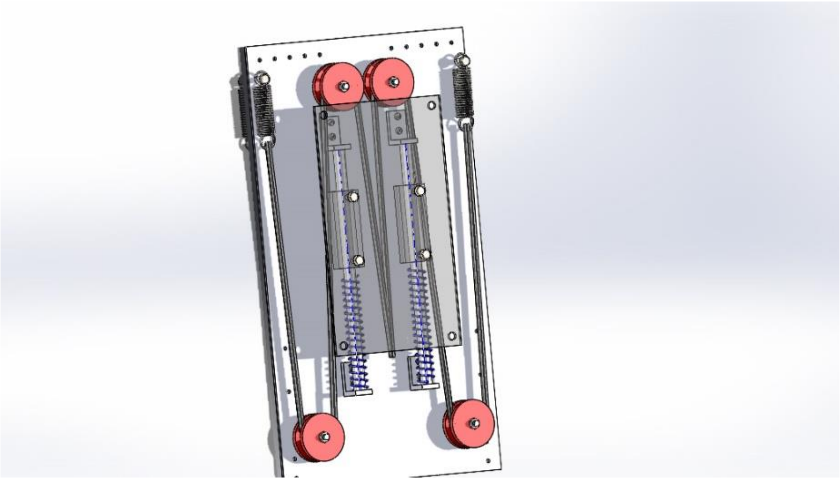


FIGURE 12. MECHANISM VIEW

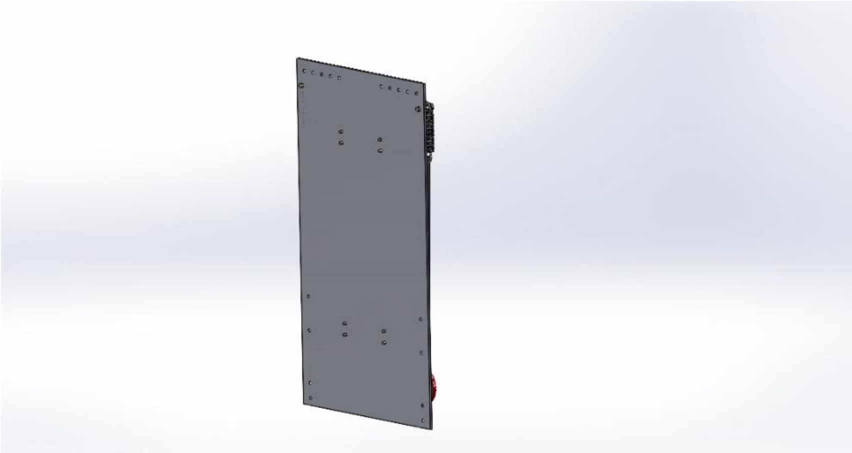


FIGURE 13. BACK VIEW

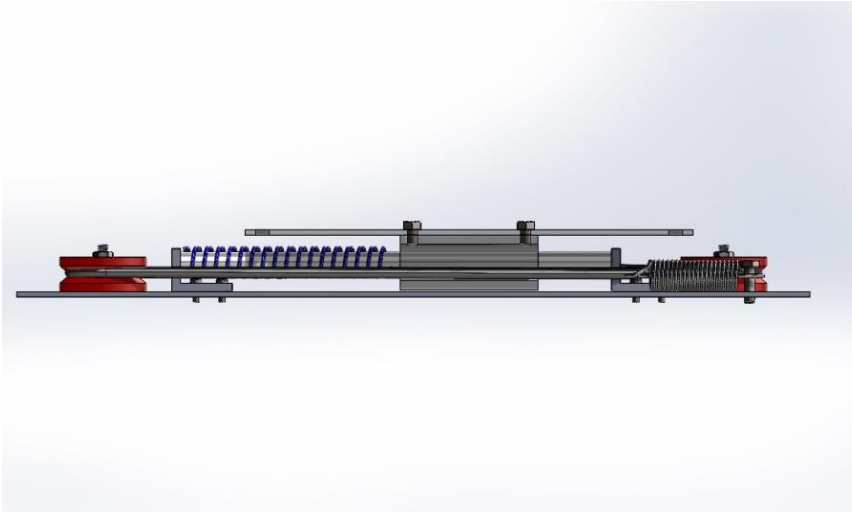


FIGURE 14. SIDE VIEW

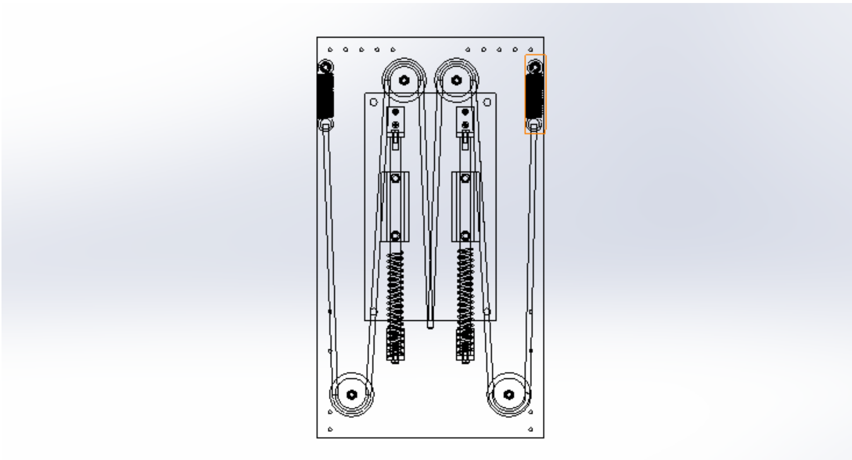


FIGURE 15. WIREFRAME VIEW

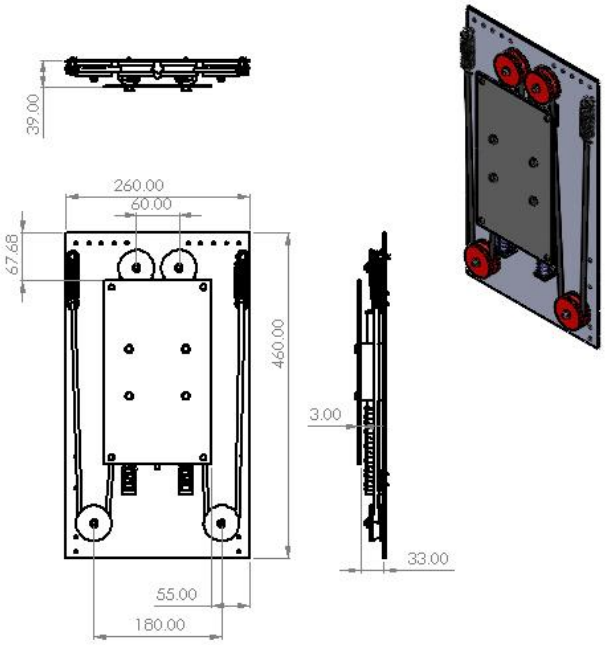


FIGURE 16. DRAFTING OF BAG-PACK

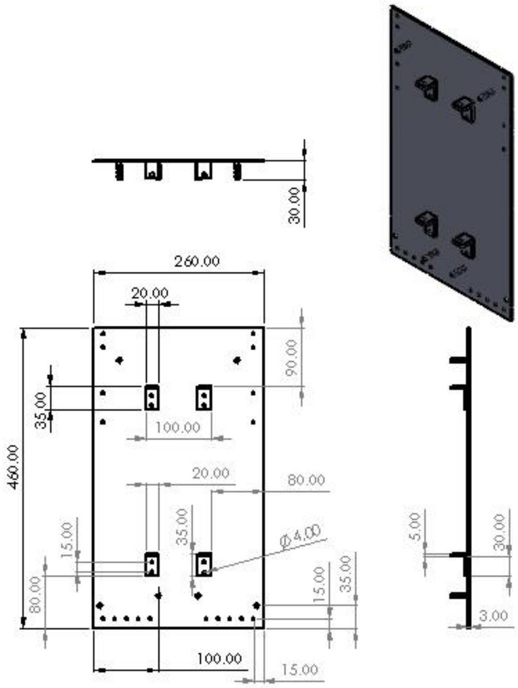


FIGURE 17. MAIN PLATE

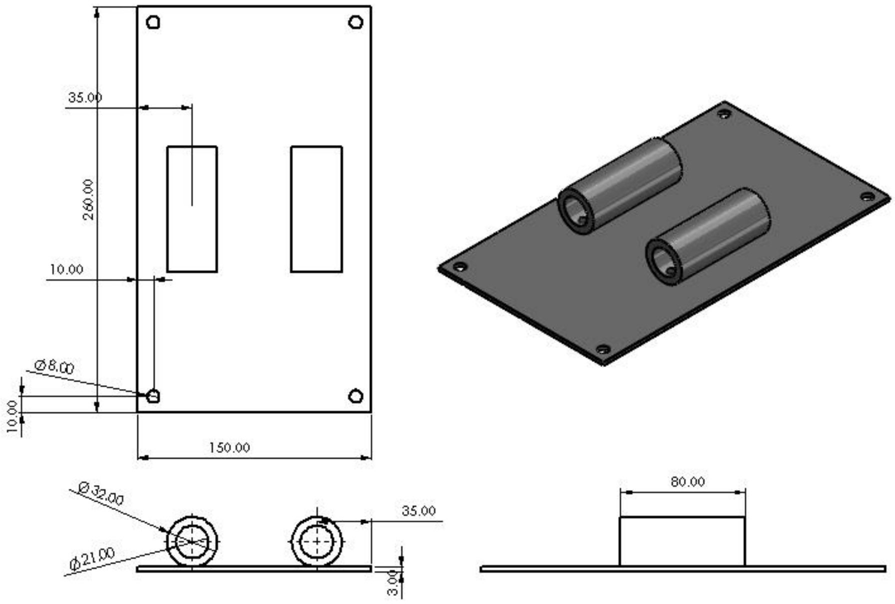


FIGURE 18. FRONT PLATE

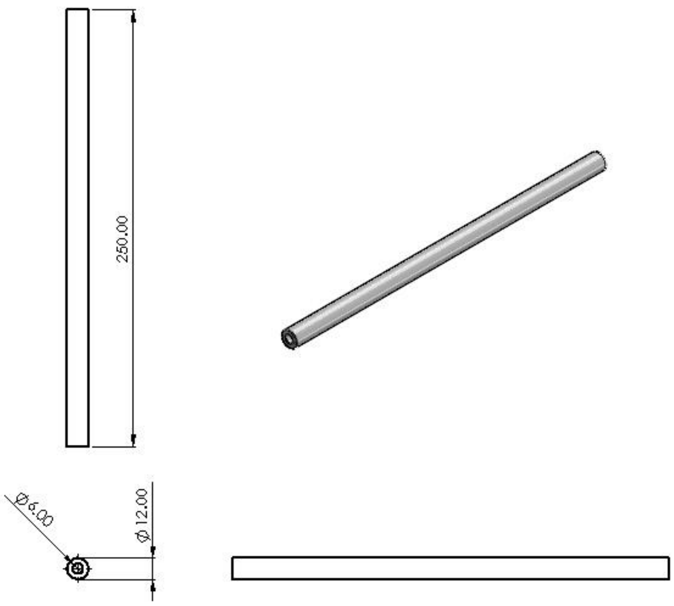


FIGURE 19. ROD

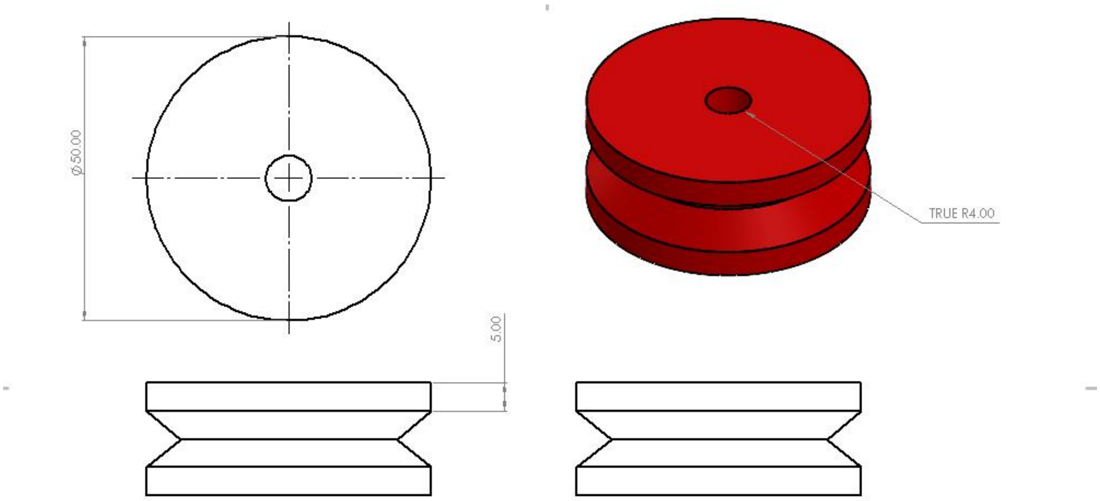


FIGURE 20. PULLEY

3.2.2 STRESS ANALYSIS

Sr. No.	Properties	Values	Unit
1.	Elastic Modulus	69000	N/m^2
2.	Poisson's Ratio	0.33	N/A
3.	Shear Modulus	27000	N/m^2
4.	Mass Density	2700	kg/m^3
5.	Tensile Strength	68.9356	N/m^2
6.	Compressive Strength		N/m^2
7.	Yield Strength	27.5742	N/m^2
8.	Thermal Expansion Coefficient	2.4e-05	/K
9.	Thermal Conductivity	200	W/(m·K)
10.	Specific Heat	900	J/(kg·K)
11.	Material Damping Ratio		N/A

TABLE 3. PHYSICAL PROPERTIES OF ALUMINIUM ALLOY

SIMULATION ANALYSIS OF MECHANISM

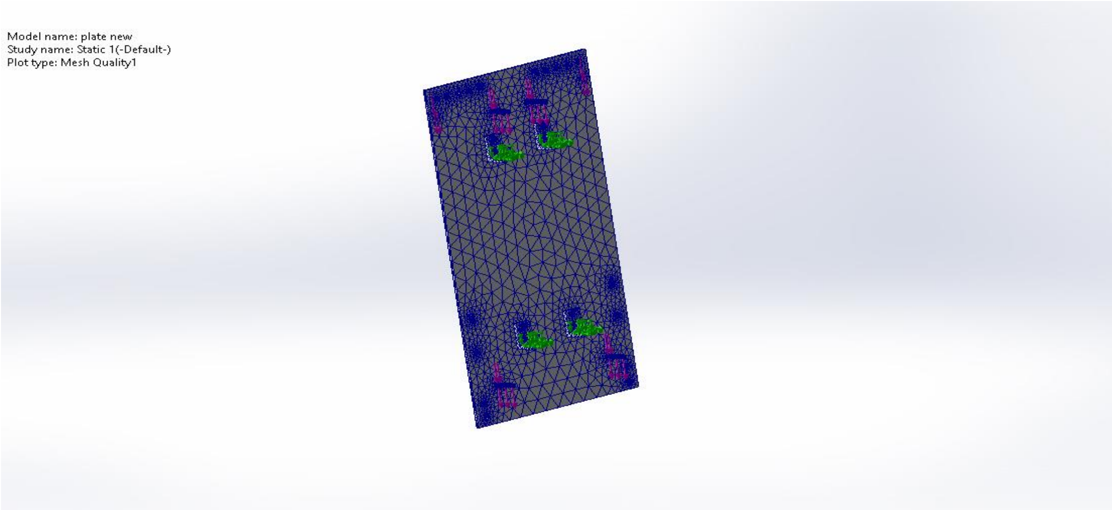


FIGURE 21. MESHING OF MAIN PLATE

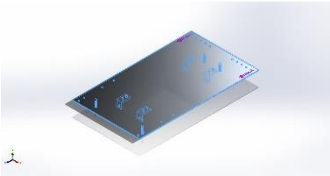
Document Name and Reference	Treated As	Volumetric Properties
Cut-Extrude4 	Solid Body	Mass:1.02901 kg Volume:0.000381114 m^3 Density:2,700 kg/m^3 Weight:10.0843 N

TABLE 4. SOLID BODIES STUDY

3.3 MATERIAL PROPERTIES

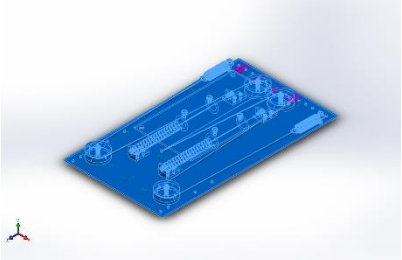
Model Reference	Properties
	**Name:** 1060 Alloy **Model type:** Linear Elastic Isotropic **Default failure criterion:** Max von Mises Stress **Yield strength:** 2.75742e+07 N/m^2 **Tensile strength:** 6.89356e+07 N/m^2 **Elastic modulus:** 6.9e+10 N/m^2 **Poisson's ratio:** 0.33 **Mass density:** 2,700 kg/m^3 **Shear modulus:** 2.7e+10 N/m^2 **Thermal expansion coefficient:** 2.4e-05 /Kelvin

TABLE 5. MATERIAL PROPERTIES (FINAL PROTOTYPE)

3.3.1 Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 1 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**0.0095371**	**0.0199607**	**200.005**	**200.005**
Reaction Moment (N·m)	**0**	**0**	**0**	**0**

TABLE 6. MATERIAL PROPERTIES (FINAL PROTOTYPE)

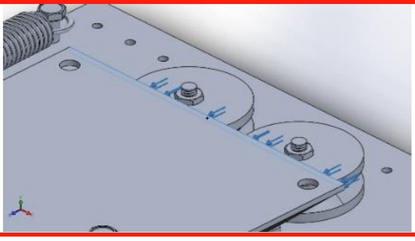
Load Name	Load Image	Load Details
Force-1		**Entities: 1 face(s)** **Type: Apply normal force** **Value: 200 N**

TABLE 7. MATERIAL PROPERTIES (FINAL PROTOTYPE)

Interaction Information

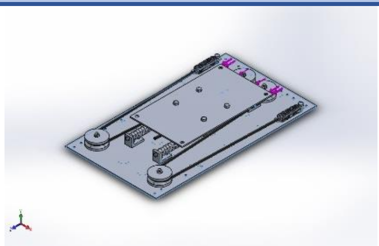
Interaction	Interaction Image	Interaction Properties
Global Interaction		**Type:** Bonded **Components:** 1 component(s) **Options:** Independent mesh

TABLE 8. INTERACTION INFORMATION

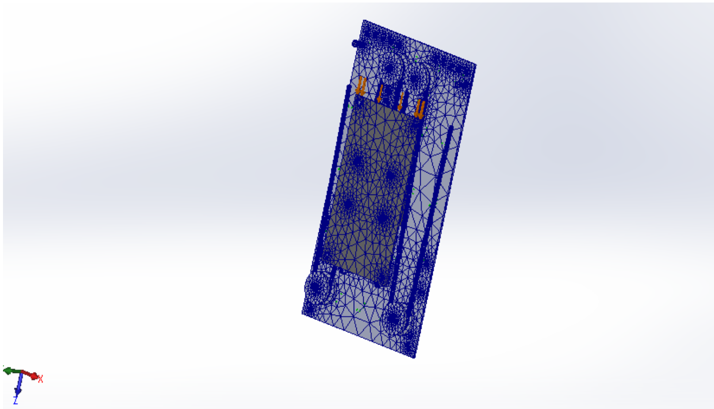


FIGURE 22. MESHING OF MECHANISM

3.3.2 Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Blended curvature-based mesh
Jacobian points for High quality mesh	16 Points
Maximum element size	33.2013 mm
Minimum element size	1.66006 mm
Mesh Quality	High
Remesh failed parts independently	Off

TABLE 9. MESH INFORMATION

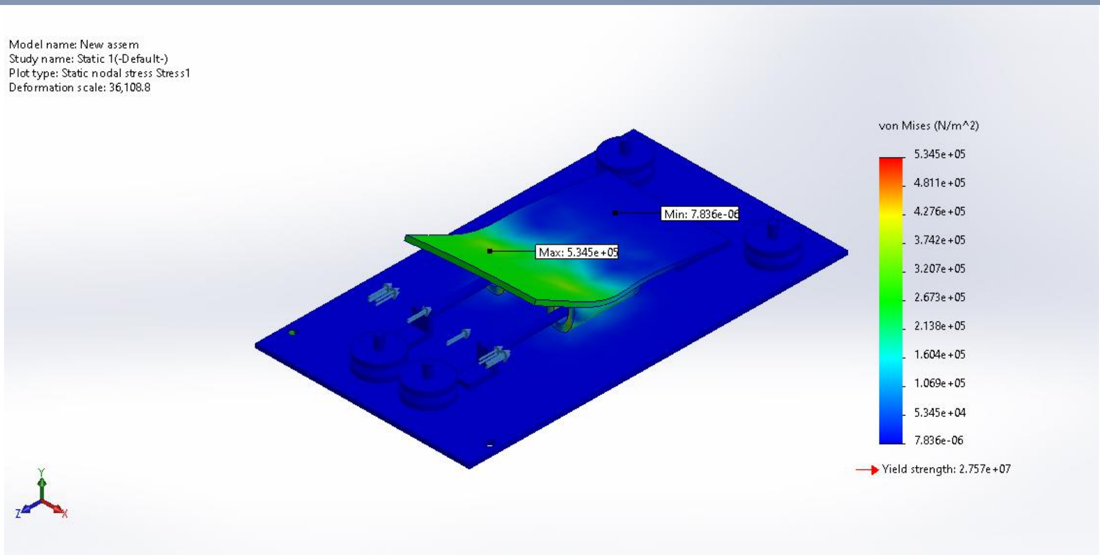
3.3.3 Mesh information – Details

Total Nodes	40194
Total Elements	19416
Maximum Aspect Ratio	16.613
% of elements with Aspect Ratio < 3	89.3
Percentage of elements with Aspect Ratio > 10	0.314
Percentage of distorted elements	0
Time to complete mesh(hh;mm;ss):	00:00:20

TABLE 10. MESH INFORMATION - DETAILS

3.3.4 STUDY RESULTS

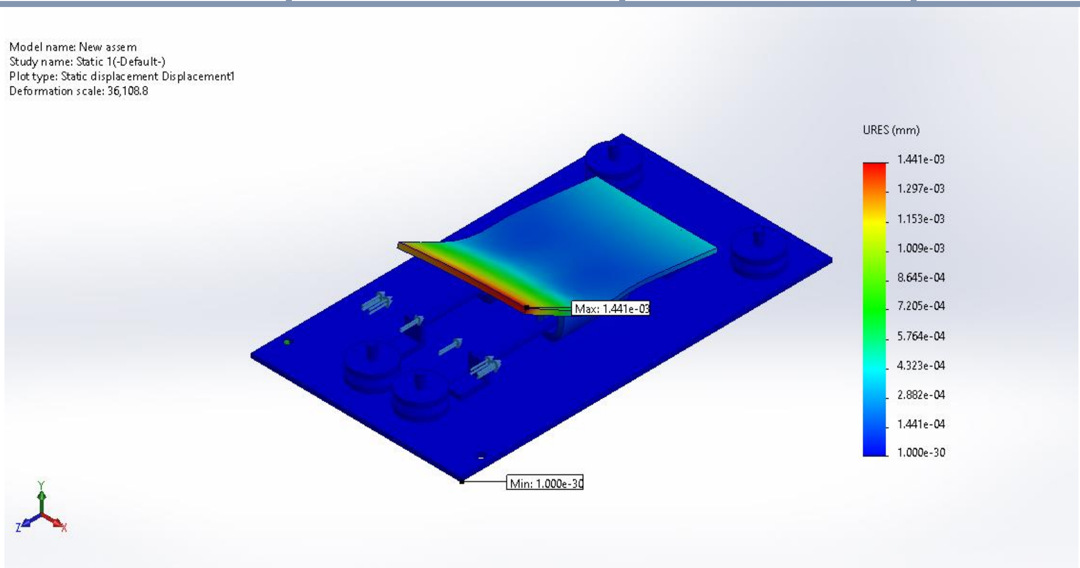
Name	Type	Min	Max
Stress1	VON: von Mises Stress	7.836e-06N/m^2 Node: 33702	5.345e+05N/m^2 Node: 8464



New assem-Static 1-Stress-Stress1

FIGURE 23. STRESS ANALYSIS

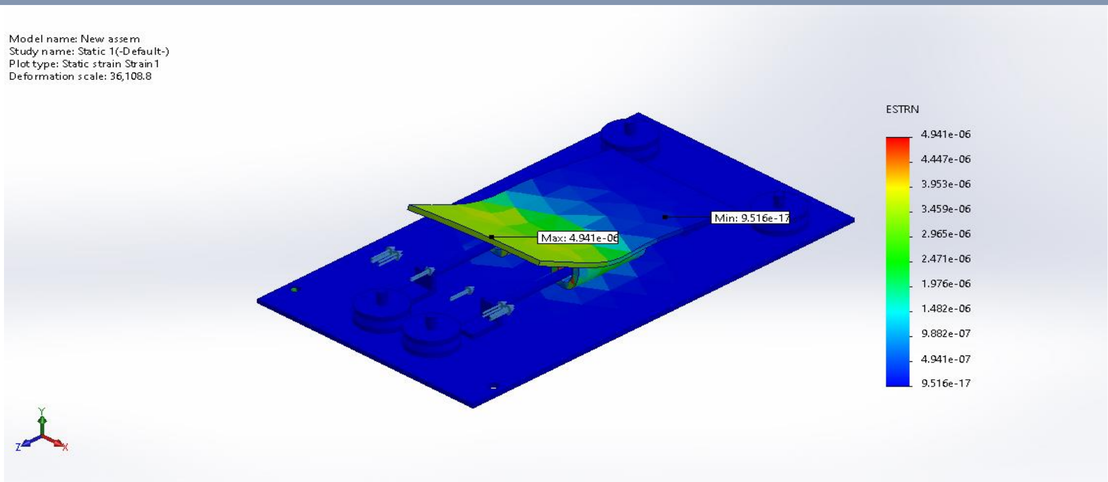
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 41	1.441e-03mm Node: 7201



New assem-Static 1-Displacement-Displacement1

FIGURE 24. STRAIN ANALYSIS

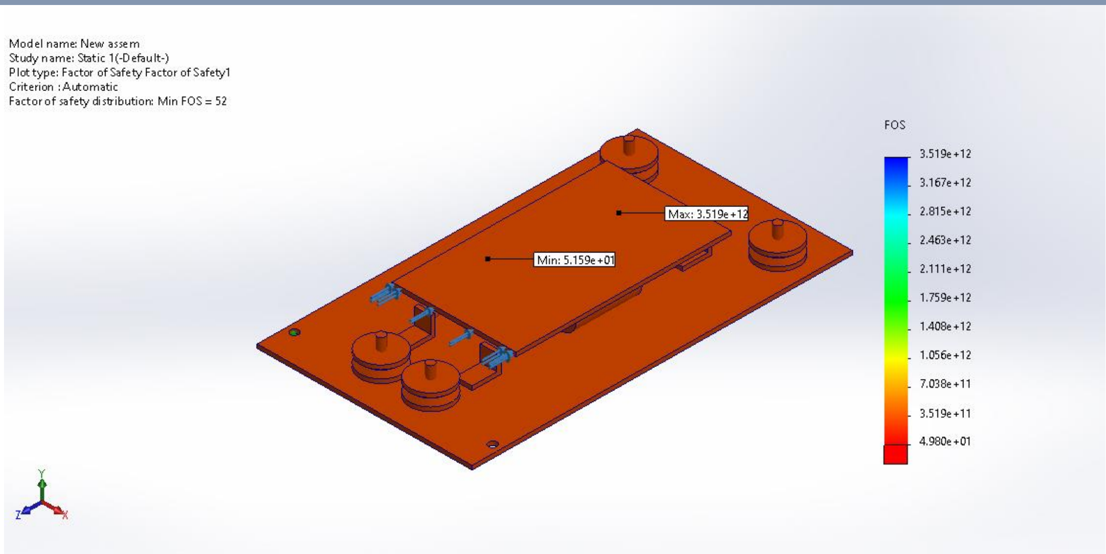
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	9.516e-17 Element: 19285	4.941e-06 Element: 3955



New assem-Static 1-Strain-Strain1

FIGURE 25. DISPLACEMENT ANALYSIS

Name	Type	Min	Max
Factor of Safety1	Automatic	5.159e+01 Node: 8464	3.519e+12 Node: 33702



New assem-Static 1-Factor of Safety-Factor of Safety1

FIGURE 26. FACTOR OF SAFETY

3.4 SUMMARY

Hence, we, from this initial investigation, decided the material with which the structure of the frames and the mechanism shall be made. The frame and mechanism are made of Aluminium. The composition of the materials, the physical properties and the mechanical properties of each of the materials was discussed in detail while comparing each of them to materials of different grade so that it could be determined which material is best suited for the project.

4. DESIGN AND FABRICATION

4.1 MOROPHLOGY

Designing in engineering is to formulate a plan or the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

For our project, we have designed frame, shaft, spring, pulley and bolt.

Design considerations for above parts are as per design data handbook:

- **PULLEY**
  a. Diameter of pulley is chosen to have desired velocity ratio.
  b. Alignment should be perfect.
  c. Should have good friction and wear characteristics.

- **ROD**
  a. Power should be fully transmitted.
  b. Deflection should not be there.
  c. Should withstand torsional stress.

- **ELASTIC ROPE**
  a. Should transmit maximum power
  b. Should not wear out easily
  c. Should not loose tension with time

- **SPRINGS**
  a. Tension should be maintained
  b. Alignment of spring with pulleys
  c. Springs should have sufficient strength.

- **BOLT**
  a. Should provide connection between mechanism and bag
  b. Should withstand stresses

4.2 DESIGN OF ROD

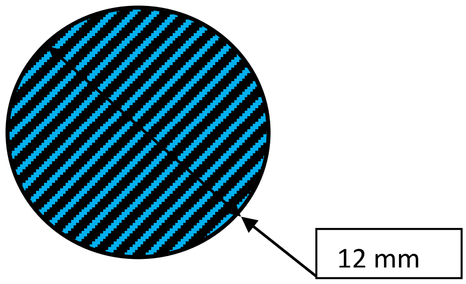
Let us design the bag for weight of 20 kg maximum

Length of rod = 250 mm

Now, rod will fail under bending

Weight on each shaft be 10 kg = 100 N say.

Two set of bearings are used so



W=10 kg= 100 N

For simply supported beam

M= W X L / 4

The rod diameter = 12 mm

M = 100 x 250/4 = 6250 N-mm

$Z= \pi/32 \times d^3$

$Z= \pi/32 \times 12^3$

Z= 169.668 mm^3

σ_b(induced)= M/Z = 6250/169.668 = 36.83 N/mm^2

As induced bending stress is less then allowable bending stress i.e., 68.9 N/mm^2 design is safe.

Name:	1060 Alloy
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	2.75742e+07 N/m^2
Tensile strength:	6.89356e+07 N/m^2
Elastic Modulus:	6.9e+10 N/m^2
Poisson's ratio:	0.33
Mass density:	2,700 kg/m^3
Shear modulus:	2.7e+10 N/m^2
Thermal expansion coefficient:	2.4e-05 /Kelvin

4.3 DESIGN OF SPRING

The spring is used to absorb the shock load of bag partially. we select spring with inner diameter 15 mm due to size restriction of rod.

Di = 15 mm

For average service life = 545 N/mm².

Wire diameter = 1.8 mm

Outer diameter of spring = Di + 1.8 x 2

Do = 18.6 mm.

Calculating the load bearing capacity of spring

Spring index = C = Do/d = 18.6/1.8= 10.33

C = 10.33

FIGURE 27. SPRING

Wahls factor

K = [4C – 1 / 4C-4] + (0.615 / C)

K = 40.32/37.32+(0.615/10.33)

K = 1.08+0.05 = 1.13

For C =10.33 K= 1.13

Now to find 'P',

Shear stress = $\frac{8\ K\ P\ Do}{3.14\ d3}$

$$P = \frac{545 \text{ x } 3.14 \text{ x } 1.8\text{x}1.8\text{x}1.8}{8\ x\ 1.13.18.16}$$

P = 58.84 N

P = 5.99 kg

This is the force applied by single spring we are using 2 springs hence maximum 12kg load will be applied by spring.

4.4 SELECTION OF PULLEY

Pulley of diameter 50 mm is used

FIGURE 15. PULLEY

4.5 MODULUS AND NATURAL LENGTH

Elastic strings are strings which are not a fixed length (they can be stretched). Some strings are stretcher than others and the **modulus** (or modulus of elasticity) of a string is a measure of how stretchy it is. The modulus is measured in newtons.

The length of an elastic string which does not have any forces acting upon it is known as the **natural length** of the string. If a string has been stretched, then the **extension** is how much longer the string is as a result of being stretched. Note that the extension = length of the string - natural length.

4.6 Hooke's Law

Hooke's law states that the tension in an elastic string (or spring), T, is found using the following formula:

$$T = \frac{\lambda x}{l}$$

where l is the modulus of elasticity of the string, x is the extension of the string and l is the natural length of the string.

A string with modulus (of elasticity) 0.5 N has a natural length of 100mm. What is the tension in the string when its length is 0.65 meter?

$$T = \frac{0.5 \times 550}{2} = 137.5N$$

So, the tension in the string is 137.5 N = 14 kg

4.7 DESIGN OF BOLT

Bolt is to be fastened tightly also it will take load due to rotation. Stress for C-45 steel. Std nominal diameter of bolt is 5.5 mm. From table in design data book, diameter corresponding to M6 bolt is 6 mm

FIGURE 29. BOLTS

Let us check the strength: -

Also, initial tension in the bolt when belt is fully tightened.

20 kg load is acting on nut bolt = 200N

P = 200 N is the value of force

P = 200 N

Also,

$P = \Pi /4\ dc^2 x\ \sigma$

$\sigma = \frac{200 \times 4}{3.14 \times (5.5)^2} = 8.42\ N / mm^2$

The calculated σ is less than the $\sigma_{tensile}$ and σ_{shear} (135 N/mm2) hence our design is safe.

5. COST ESTIMATION

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product. These expenses take into a consideration all expenditure involved in a design and manufacturing with all related services facilities such as pattern making, tool, making as well as a portion of the general administrative and selling costs.

PURPOSE OF COST ESTIMATING:

1. To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
2. Check the quotation supplied by vendors.
3. Determine the most economical process or material to manufacture the product.
4. To determine standards of production performance that may be used to control the cost.

<u>BASICALLY, THE BUDGET ESTIMATION IS OF TWO TYRES:</u>

1. Material cost
2. Machining cost

MATERIAL COST ESTIMATION:

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components.

These materials are divided into two categories.

1. Material for fabrication:

In this the material in obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.

2. Standard purchased parts:

This includes the parts which was readily available in the market like Allen screws etc. A list is forecast by the estimation stating the quality, size and standard parts, the weight of raw material and cost per kg. For the fabricated parts.

MACHINING COST ESTIMATION:

This cost estimation is an attempt to forecast the total expenses that may include to manufacture apart from material cost. Cost estimation of manufactured parts can be considered as judgment on and after careful consideration which includes labour, material and factory services required to produce the required part.

PROCEDURE FOR CALCULATION OF MATERIAL COST:

The general procedure for calculation of material cost estimation is

1. After designing a project, a bill of material is prepared which is divided into two categories.
   a. Fabricated components
   b. Standard purchased components
2. The rates of all standard items are taken and added up.
3. Cost of raw material purchased taken and added up.

LABOUR COST:

It is the cost of remuneration (wages, salaries, commission, bonus etc.) of the employees of a concern or enterprise.

Labour cost is classifying as:

a. Direct labour cost
b. Indirect labour cost

DIRECT LABOUR COST:

The direct labour cost is the cost of labour that can be identified directly with the manufacture of the product and allocated to cost centres or cost units. The direct labour is one who counters the direct material into saleable product; the wages etc. of such employees constitute direct labour cost. Direct labour cost may be apportioned to the unit cost of job or either on the basis of time spend by a worker on the job or as a price for some physical measurement of product.

INDIRECT LABOUR COST:

It is that labour cost which cannot be allocated but which can be apportioned to or absorbed by cost centres or cost units. This is the cost of labour that doesn't alters the construction, confirmation, composition or condition of direct material but is necessary for the progressive movement and handling of product to the point of dispatch e.g., maintenance, men, helpers, machine setters, supervisors and foremen etc.

5.1 EXPENSES

The expenses are also mainly divided into direct and indirect labour expenses.

1. **Direct expenses**

The expenses which can be directly cragged on cost of particular product are called direct expenses.

2. **Indirect expenses**

The expenses that cannot be charged directly on the cost of particular product are called indirect expenses.

PROCEDURE OF COSTING

Actual expenditure incurred in various departments for costing collects different items. The expenditure is categorized under the following main heads. All the expenses made by an industry may be group into various components of cost.

The various components of cost are under:

It should be noted that it is cumulative as shown. This system is used in most of modern industries irrespective of their size. It is because this type of classification is very helpful in analysing cost compounds according to modern management techniques.

(a) Prime cost

It is also referred as direct cost and is comprised of the direct material cost, direct labour cost and direct expenses incurred on the manufacturing of product.

Prime cost =Direct material cost + Direct labour cost + Direct expenses

(b) Factory cost

It is also referred as works cost and is comprised works overhead.

Factory cost = Prime cost + Factory over head

(c) Office cost

It is also referred as production cost of manufacturing; cost is comprised of factory cost and administrative over heads or office on cost.

Office cost = Factory cost + Administrative over heads

(d) Total cost

It is also referred as ultimate cost or gross cost and is comprised of the Office cost and selling and distribution overhead

Total cost = Office cost + Selling and distribution overhead

(e) Selling price

When profit or loss of organization is added / subtracted to the total cost of the product we get selling price.

Selling price = Total cost + Profit or loss

(f) Market price

It is also referred as catalogue price or list price some percentage of discounts is always allowed to the distributors, when this discount to the distribution is added to the selling price, we get market price.

Market price = Selling price + Discount to the distributors

Machines & equipment's required

Required machine tools

- Lathe machine
- Welding machine
- Hacksaw machine
- Grinding machine
- Drilling machine
- Slotting machine

Required tools /equipment's

- Hacksaw blade
- Spanner set
- Hammer
- Drill bit
- Fasteners
- Welding electrodes
- Centre punch
- Measure tape
- Chisel
- Single point cutting tool

- Steel rule
- Rough, smooth file

The total labour cost is calculated on the basis of wages paid to the labour for 8 hours per day.

Cost estimation is done as under

Cost of project = (A) Material cost + (B) Machining cost + (C) Labour cost

(A) Material cost is calculated as under:

1. Raw material cost
2. Finished product cost

1. Raw material cost:

It includes the material in the form of the Material supplied by the “Steel authority of India limited” and ‘Indian aluminium co.,’ as the round bars, angles, square rods, plates along with the strip material form. We have to search for the suitable available material as per the requirement of designed safe values. We have searched the material as follows: -

Hence the cost of the raw material is as follows: -

SR NO	PART NAME	MATERIAL	QUANTITY	COST
1.	SPRING	SS	4 NOS	1800
2.	PULLEY	NYLON	4 NOS	1200
3.	SHAFT	AL	500 MM	250
4.	LINEAR BEARING	STD	2 NOS	800
5.	ALUMINUM PLATE	AL	0.2 SQM	900
6.	STRING ROPE	STD	1 NO	100
7.	BAG	STD	1 NO	2250
8.	PLY WOOD	WOOD	1 NO	550
9.	NUT BOLT WASHER M 10	MS	20 NOS	20
10.	MISCELLINOUS	-	-	500
TOTAL				**8570**

TABLE 11. RAW MATERIAL & STANDARD MATERIAL (AS PER 1 BAG)

B) DIRECT LABOUR COST: -

SR. NO.	OPERATION	HOURS	RATE / LABOUR	AMOUNT
1	Turning	5	150	750
2	Drilling	7	100	700
3	Grinding	3	60	180
4	Tapping	3	40	120
5	Cutting	8	40	320
6	Assembly	2	100	200
7	Painting	2	100	200
Total				**2470/-**

TABLE 12. LABOUR COST

INDIRECT COST

Transportation cost = 500/-

Coolant & lubricant = 100/-

Drawing cost = 500/-

Project report cost = 2000/-

TOTAL INDIRECT COST = 2100/-

5.2 TOTAL COST

Raw Material Cost + STD Parts Cost + Direct Labour Cost +Indirect Cost

Total cost of project is done in table

TOTAL COST	AMOUNT
A	8570
B	2470
C	2100
Total cost of project	**13140**

TABLE 13. FINAL COST

5.3 MACHINING OPERATIONS

5.3.1 ABRASIVE SAW

An abrasive saw, also known as a cut-off saw or metal chop saw, is a power tool which is typically used to cut hard materials, such as metals. The cutting action is performed by an abrasive disc, similar to a thin grinding wheel. Technically speaking this is not a saw, as it does not use regularly shaped edges (teeth) for cutting. The abrasive saw generally has a built-in vice or other clamping arrangement, and has the cutting wheel and motor mounted on a pivoting arm attached to a fixed base plate.

FIGURE 30. ABRASIVE CUTTING MACHINE

They typically use composite friction disk blades to abrasively cut through the steel. The disks are consumable items as they wear throughout the cut. The abrasive disks for these saws are typically 14 in (360 mm) in diameter and 7⁄64 in (2.8 mm) thick.

5.3.2 DRILLING MACHINE

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips (swarf) from the hole as it is drilled. Exceptionally, specially-shaped bits can cut holes of non-circular cross-section; a square cross-section is possible.

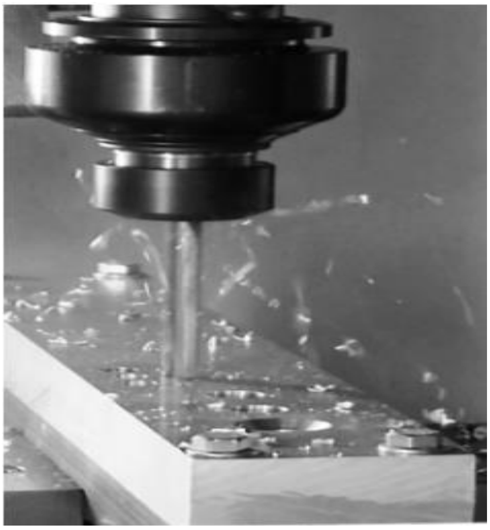


FIGURE 31. DRILLING OPERATION

5.3.3THREADING OPERATION

Taps and dies are tools used to create screw threads, which is called threading. Many are cutting tools; others are forming tools. A tap is used to cut or form the female portion of the mating pair (e.g., a nut). A die is used to cut or form the male portion of the mating pair (e.g., a bolt). The process of cutting or forming threads using a tap is called tapping, whereas the process using a die is called threading. Both tools can be used to clean up a thread, which is called chasing.

FIGURE 32. TOOLS USED FOR THREADING AND TAPPING

5.3.4 GRINDING OPERATION

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). The terms are usually used in separately in shop-floor practice. Lapping and sanding are subsets of grinding.

FIGURE 33. GRINDING OPERATION

6. RESULTS

Field Trials is an integral part of a project. It not only gives the idea of the working condition of the project, but we also come to know about the problems in the model and the errors that have been made so that they can be rectified.

- Shocks & Jerks are absorbed by helical compression spring up to 12kg load.
- Floating bag mechanism increases the endurance capability of body.
- Eliminates backpain and knee injury, increases overall physical activities performance.

6.1 TRIAL

We conducted the trial of the project at the college ground. All the members of the syndicate were present and the trial was done in the presence of our guide.

Condition:

A. WALKING WITH THE TRADITIONAL BACKPACK USED BY SOLIDERS
B. WALKING WITH THE FLOATING BACKPACK (PROTOTYPE)

Result:

1) FAST RUNNING BY INDIVIDUALS IN COMPARE WITH TRADITIONAL BACKPACK
2) EASY JUMPING AND FIELD MOVEMENTS.
3) INCREASE IN INDIVIDUALS’ PERFORMANCE AND JERKS ARE REDUCED.

7. CONCLUSION

7.1 CONCLUSION

1. Our product is going to cater the physiological and muscoskeletal problems faced by a soldier on duty.
2. It helps in long marches with less stress on body, also reducing chances of injury from too much strain on back, neck or knees.
3. In future this can further be enhanced to small scale electricity generation and casualty evacuation.

7.2 FUTURE SCOPE

- Due to time constraints and dearth of manpower and technology, we have made a very basic model. Given more time and resources, we may be able to improve upon the project even further. Some of the future scopes that we thought of, which could be added to the basic model, to improve the its efficiency and further decrease human efforts.
- Weight reduction can be done more by using different lightweight materials i.e., Kevlar and composite materials.

  Small scale electricity can be generated by converting mechanical energy to the electrical energy.
- This energy is can be utilized for charging small batteries.
- Extra arm can be provided to hold weapon in firing position during long marches.

7.3 FINAL PROJECT

FIGURE 34. FINAL PROTOTYPE

FIGURE 35. GROUP PHOTO

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