A Project Report on

DESIGN AND FABRICATION OF PEEL STRENGTH MEASUREMENT MACHINE.

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CERTIFICATE

This is to certify that **Mr. Awale Shubham R., Miss. Chatur Gauri G., Mr. Shinde Deepak M., Mr. Shinde Dipraj S.** has successfully completed the Project Report entitled "**Design and Fabrication of Peel Strength Measurement Machine**" under my supervision, in the partial fulfilment of Bachelor of Engineering (Mechanical Engineering) of Savitribai Phule Pune University.

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ABSTRACT

The project mainly focuses on measuring peel strength of adhesive tapes. Peel strength is average force required to separate two bonded materials from one another. It is properly applicable to various industries such as aerospace, automotive, adhesives, packaging, biomaterials, microelectronics, etc. Peel test data is used to determine the quality of the adhesive joint. Peel tests are constant-speed tests in the tensile direction. In material testing, peel strength is calculated after measuring and averaging the load to peel the specimen and dividing the average load by unit width of the adhesive. Different adhesives are used for joining the different types of materials. The different types of peel tests available for investigating the adhesive strength are 90º, 135º, 180º and T-peel test. This project mainly focuses on 180º peel type test.[1]

Focal point of this study is to get precise reading by 180-degree peel strength measurement machine. In peel strength measuring machine the motor used is of low rpm which drives power screw with help of coupler. Rotational motion of leadscrew is converted into linear motion of table. Support rods supports table mounted on leadscrew and strength of adhesive tested with help of measuring gauge.

After successfully fabrication of peel strength measuring machine results obtained are nearly equal to standard value or range of standard values given by manufacturer. Results obtained by testing machine for Sellotape is 0.1042 N/mm at room temperature and standard value given by manufacturer is 0.0374 N/mm , for surgical tape value at room temperature obtained is 0.4782 N/mm and standard value is 0.345 N/mm , for masking tape value obtained at room temperature is 0.1658 N/mm and standard value is 0.11104 N/mm, for wire insulation tape result at room temperature 0.1609 N/mm and standard value is 0.16, for double sided tape values obtained at room temperature is 1.4266 N/mm and standard value is 1.1042 N/mm.

180-degree peel strength measuring machine can measure adhesiveness of tape applied on any surface with higher accuracy. It requires zero lubrication and maintenance cost is also low. Machine is cheaper in cost and quick operation.

1. INTRODUCTION

A project Peel Strength Measuring Machine is mainly focused on measuring the Peel strength of adhesive tapes. Peel strength is very important factor for any type of adhesive as it plays very important role for the selection of adhesive and as per the requirement parameter. Peel strength is generally used to measure the bond strength of a material, typically an adhesive. Peel strength is the average load per unit width of bond line required to separate bonded materials where the angle of separation is 180 degrees.[2]

Peeling tests are the practice of testing adhesion properties of film bonded to substrate, usually by tensile. The peel strength determines the adhesive strength (also called the adhesive fracture toughness). Physical testing of packaging products by peeling can tell us a lot about its properties and manufacturing process such as sealing consistency, bonding strength, adherence ability, cohesive properties of the interface, bond durability and other
parameters.[3]

There are two primary reasons for performing a peeling test:

i. Assessing the uniformity of the adhesion of a given type of pressure sensitive
ii. Distinguishing between acceptable and unacceptable criteria, by determining the adhesive strength range which is acceptable for consumer or for the purpose of the adhesive.

1.1 Overview

Industry which deals with adhesive tapes or gums needs such peel tester in their testing laboratory to measure the peel strength. Our group of 4 students show interest toward this topic. We had done research from various research papers and gone through various forums for the proper mechanism. We took guidance from our professors, finally we came up with simple mechanism, in which a motor drives a power screw due to which reciprocating action of table mounted on power screw takes place. On table we

adhere adhesive tape as per ASTM D3330 norms, one end of tape is adhered on table and one end will stick on arm of measuring gauge. Due to movement of mounting table tensile forces are developed between tape and the arm of measuring gauge which will be reflected in the dial of gauge and we get the value of Peel strength of adhesive tapes. For our project our main requirement is raw materials like A.C motor, power screw, thin aluminum sheets, angles, L clamp, limit switches and all this we brought from market and some are designed & manufactured by us.

1.2 Objective:

- To check and ensure quality of adhesive bond using 180 Degree Peel test.
- To check effect on peel strength of different types of adhesive tapes at different temperatures.
- To design and manufacture cost effective and modular peel strength testing machine with upgradable option using relatively low cost with simplicity in construction using readily available materials in workshops.
- To Assessing the uniformity of the adhesion of a given type of pressure sensitive adhesive interface, which indicates a bad adhesion and good adhesion between the adhesives and the adherents.

1.3 Problem Statement:

Currently industries are using the peel strength measuring machine which works on the mechanism of ‘90° peel test type A’ in which the complexity of the machine is very high which resulted in high cost of the machine. But as peeling angle increases the accuracy will also increases, so we are focusing on ‘180° peel test type B’ as per ASTM standard D3330.

On the other side, the solution that we have proposed based on the 180° peel strength mechanism which has reduced the machine complexity and resulted in economical peel strength measuring machine.

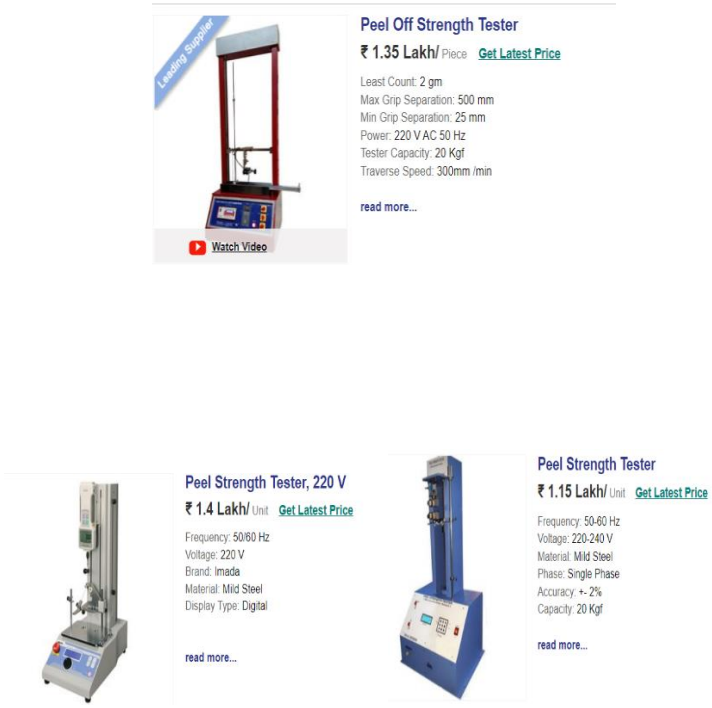


Fig 1.3.1. Existing Peel strength Tester

1.4 Scope of study

1.4.1) ASTM STANDARDS ASTM D3330/D3330M-04(2018) – Standard Test Method for Peel Adhesion of Pressure-Sensitive Tape.[1]

Peel strength

According to ASME (American Society of Mechanical Engineering) Peel strength or Peel Adhesion is defined as “The force per unit width required to break the bond between a tape and surface when it pulled back usually at 180 at standard rate and condition”

Pressure Sensitive:

A term commonly used to designate a distinct category of adhesive tapes and

adhesives which is dry (solvent free) form are aggressively and permanently tacky at room temperature and firmly adhere to a variety of dissimilar surfaces upon mere contact without the need of more than finger or hand pressure. they require no activation by water, solvent, or heat in order to exert a strong adhesive holding force towards such materials as paper, plastic, glass, wood, cement and metals.

They have sufficiently cohesive holding and elastic nature so that, despite their aggressive tackiness, they can be handled with the finger and removed from smooth surfaces without leaving a residue. General trade by leading tape manufacturer does not sanction extension of the term “pressure sensitive” to embrace tapes and adhesives merely because they adhere.

Common Peel Tests:

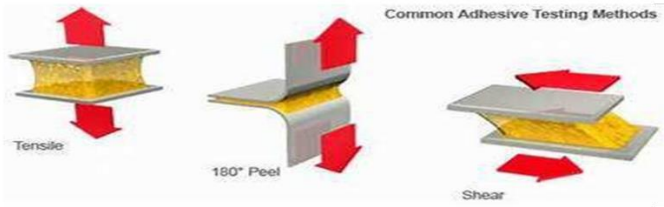
The most common types of peel tests for the measuring of adhesive strength are the T-peel, 90^o peel, and the 180 degree peel.

The T-peel test is a type of tensile test performed upon two flexible substrates that have been bonded together and placed into peel test grips such that one substrate sticks up and the other sticks down while the bonded area sticks out horizontally so that the entire setup forms a “T” shape.[1]

The 90^o test requires a 90^o peel test fixture to determine the adhesive strength between a flexible (tape) and rigid substrate (plate), where the plate lies horizontally with the gripped end of the tape sticking up perpendicular while the rest is bonded to the plate so that it forms an “L” shape.[1]

The 180 degree test is similar to the 90^o peel test except that the bonded area between the tape and plate is placed vertically between the peel test grips while the free end of the of plate is gripped by the bottom and the free end of the tape is gripped by the top so that it forms a tight “U” shape.[1]Fig.1.4.1 Common Peel

Adhesive tape



2. Literature Review

Peel strength is applicable to various industries including aerospace, automotive, adhesives, packaging, biomaterials, microelectronics, and more. Peel test data is used to determine the quality of the adhesive joint and, where applicable, provides information on the effects of processes.

Peel tests are constant-speed tests in the tensile direction. In material testing, peel strength is calculated after measuring and averaging the load to peel the specimen and dividing the average load by unit width of the bond line.

We had studied different research papers, Blogs, Textbooks for studying different aspects of peel test, different methods and ASTM Standards use for test. Following information gives idea about different aspects which we had studied:

2.1] Evolution:

1. Y . J . Awlekar et al [4] , Y. wang et al. [5] , G C kolleman et al [6], we got information about different effects of peeling angle on peel strength. We got information about different type of test available like T-type peel test. dead weight peel test, 180 degree peel test 90 degree peel test etc. Peel angle shows the peel force in peeling test. As peel angle increases peeling force decreases to some extent. Paper gives idea about different pattern different pattern formed during testing of specimen while fracture at different angle condition from referring to this 180o is best suitable method as it gives gradual shear resistance.

2. M V Borse et al [2], M D Toughness [7] we got to know Adhesive strength refers to the ability of an adhesive to stick to a surface and bond two surfaces together. It is measured by assessing the maximum tensile stress needed to detach or unstick the adhesive perpendicular to the substrate. To measure this adhesiveness there is a device called Adhesive Peel Tester. Peeling tests are the practice of testing adhesion properties of film bonded to substrate, usually by tensile. The peel strength determines the adhesive strength also called the adhesive fracture toughness. Physical testing of packaging products by peeling

can tell us a lot about its properties and manufacturing process such as sealing consistency, bonding strength, adherence ability, cohesive properties of the interface, bond durability and other parameters. This device covers the measurement of the peel adhesion of pressure sensitive tapes. Peel adhesion is the force required to remove a pressure sensitive tape from a test panel or its own backing at a controlled angle and at a standard rate and condition. A peel test is performed between two substances bonded together with an adhesive. The substrates may be both flexible or one may be flexible while other is rigid.

3. 180 Degree peel for Method B of ASTM D3330

ASTM D3330 Test Method B is very similar to Method A, but Method B measures the adherence of two layers of single-coated tapes to each other. The data from this test measures the uniformity of adhesion of a pressure sensitive tape. In this test a strip of tape is applied to a rigid substrate and then another strip of tape is applied to the backing of the first strip, then tested for peel adhesion.[1]

3.1] Method B Testing Procedure

For Method B, measure out several strips of the tape according to the standard. Now apply a strip of the tape to a rigid panel, such as the standard stainless-steel panel. Use a Test Resources Sample Roller to firmly apply the tape to avoid bubbles. Apply a second strip of the tape to the backing of the first strip on the test panel, taking care to align the edges of the second specimen with those of the strip in the test panel. Fold a tab of the tape and double back at an angle of 180 degrees. Next, clamp the substrate panel into the moveable jaw of testing machine and free end of tape into other jaw.

3.1.1] Procedure

According to ASTM, DESIGNATION D 3330/3330D-04 Around six Methodologies are given for the peel adhesion tests namely Type A, B, C, D, E, & F. From that we worked on Type A Method. Which is for single-coated tapes and assesses the peel adhesion at a 180 angle.[2]

3.1.2] Definition:

Peel adhesion or peel strength can be defined as the force required to remove pressure sensitive tape form a test panel or its own backing.

3.1.3] Significance:

In many applications the use of pressure sensitive adhesive tape depends upon adhesion strength or peel strength to give satisfactory performance. This property is also important in determining the uniformity of quality.

Equipment:

1.Peel strength measuring machine

2.Measuring gauge

3.Roller (4.5 lb.)

3.1.4] Test method.

1. Adhesion to steel:

Touch the one end of specimen or sample to the Steel plate. hold the other end of sample so that it does not make contact with other parts but is positioned is loosely above it. Roll the tape mechanically once each lengthwise direction using the roller to apply the tape to the steel plate. This prevents entrapment of air, between the adhesive and the steel plate should this occur, discard the sample. Where the width of sample is less than 1 in. prior to applying test sample, apply a strip or strips of the tape to give the equivalent width of 1 in. for rolling purpose. Prepare each sample individually and test immediately within one minute. (Longer dwell time will give the different result). Pass Roller over the tape around 5 times. [1]

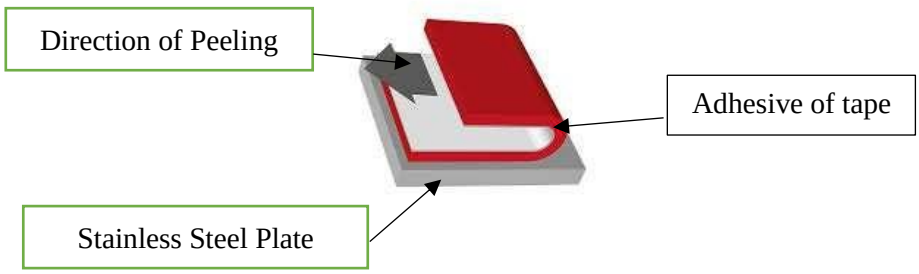


Fig. 3.1.4.1. Peel Adhesion at 180 angle.

2. Adhesion to backing:

Conduct the test for adhesion of a tape to its own backing. strips of the test under test to the lengthwise surface of cleaned surface. do not touch the backside of the strips. The sample on these strips taking care to align the edges, proceed the Steps as mentioned.[4]

2.2] DESIGN

1. We studied, ASTM D3330 is one of the more popular testing standards to determine the adhesive strength of pressure sensitive tapes. This unique standard consists of Methods A through F, identifying ways to measure peel adhesion with 180 degree and 90degree peel methods. Their test engineers are experienced with ASTM D3330 and information by them will guide us through the process. [1]

2. We had referred various formulas of safe design of power screw and also from the table we got suitable dimensions for power screw. [8],[9]

3.From paper of Yuvraj J A et al. [4] we studied; Different adhesives are used for joining the different types of materials. The different types of peel tests available for investigating the adhesive strength are 90º, 135º, 180º and T-peel test. This paper reviews the different peel tests available as well influence of other factors for determining of peel resistance between two materials. The investigation of adhesive strength helps to select a proper adhesive material for joining of two different materials. The paper briefs the effect of peel angle, different types of peel test.

4.We decided what will be suitable dimensions for bearing. The shaft diameter is 18 mm so we take suitable bearing dimensions from CatLog.[10]

2.3] TESTING AND VALIDATION:

1. we got info information about ASTM D3330 Test Method A which measures the peel adhesion of single-coated adhesive tape, when peeled at a 180-degree angle. The purpose of ASTM D3330 data results help assess the uniformity of adhesion for pressure sensitive tapes. The test materials consist of preparing several strips of tape to be tested and a hard substrate, such as a Stainless-steel plate. The tape is applied to the substrate with an even pressure using a handheld roller. The tape is then pulled from the plate at a 180-degree angle at a specified rate, and peel adhesion is measured.[1]
2. We got information about standard values of peel strength for masking tape of Asian paints which is 0.11104 N/mm and value obtained is 0.1628 N/mm.[11]

3. we got information about standard values of peel strength for Wire Insulation tape which is 0.16 N/mm and values obtain from our machine is 0.1609 N/mm.[12]

4.we got standard value of strengths of acrylic tape which is of 10mm,1inch and 3 inches which is 0.0374 N/mm and value obtained after testing on our machine is 0.102 N/mm which is matching to standard values. [13]

5. Standard value from 3M tape [14] for peel strength is 1.1042 N/mm and values obtained is 1.4266 N/mm.[36. Standard value for Mehta's Surgical Tape is 0.354 N/mm and values obtained from our machine is at 0.4782 N/mm.[15]

7. For Designation ID: D3330/D3330M_02'1 we got information about value of different values of peel strength for different materials.[1]

8. We got information about roughness value of Stainless Steel plate. For our machine superfinished plate is required which have surface roughness value is: 50 (+/- 25) nm.[16]

9. We had studied the effect of temperature on the strength of adhesive and we concluded that as temperature of plate increases capacity of peel tape is deceases.[17],[18],[19]

3. Methodology

3.1 Materails and its Specifications:

PSMM (Peel Strength Measurement Machine) consist of these main parts -

1. Driving motor
2. Power Screw
3. Coupler
4. Body or Frame
5. Supporting plates
6. Table Mounting
7. Limit switches
8. Toggle switch
9. Supporting bars

3.1.1) Driving Motor:

· In PSMM motor which is used has low rpm (about 60 rpm) and High torque (about 3.7 kg-cm) which is bi-directional and having voltage capacity of 230 V.

· Motor is driven by electrical means and which rotates power screw, through the flexible coupling.

· With the help of toggle switch we can change its direction of rotation [8]

AC 220V 60RPM A60KTYZ Gear-Box Electric Synchronous Gear Motor Speed Reducing

Specifications:

Output RPM: 60 rpm

Stall Torque: 3.7 Kg/cm

Stall Current: 750 - 800 ma

Motor body Length: 75mm

Motor Body Diameter:35mm

Material: Cast Iron

Shaft diameter: 6mm

Working Voltage: 12V

Motor Available in market and its Specification

3.1.2) Body or Frame:

The body which is used is mainly of M.S angles and fastened by welding which is in cuboid shape. Having dimensions of 600*300*200mm

· All the components are enclosed in it and it is covered with thin aluminium sheets which helps to keep all components safe from dust.

3.1.3) Coupler:

· Coupling is used to transmit the power or torque or rotating action from one shaft to another shaft either they are concentric or eccentric.

· For this purpose, we use universal joint which acquire diameters of motor shaft and power screw.

· This is flexible type of coupling made up of cast iron having main function is to minimize eccentricity.[19]

- Type- Single Joint Universal Coupling
- Material- Stainless Steel

3.1.4) Lead Screw and Nut:

· Power screw & nut which we design and manufacture having length of 400 mm and having standard pitch of 2mm

· Power screw transmit the power from motor to the table and which converts rotating motion to reciprocating, and due to bi-directional motion of motor, to and fro motion take place.

· Proper Dimensions of power screw are discussed further.[5],[2]

3.1.5) Table mounting and Stainless-Steel Plate:

· The reciprocating motion of table mounting is takes place due to power screw which is driven by motor. Arrangement of nut and lead screw will convert rotating motion to reciprocating motion. As Lead screw rotates Nut will move linearly.

· On table, mounting is provided for mounting of steel plate on which tape is to be adhered. Between Nut and steel plate Mounting material id provided.

· A material used for the mounting is polypropylene fibre, we used it due to light in weight and it have easy for machining operations on which we can mount steel plate.

3.1.6) Supporting Plates:

· Two supporting Plates are used.

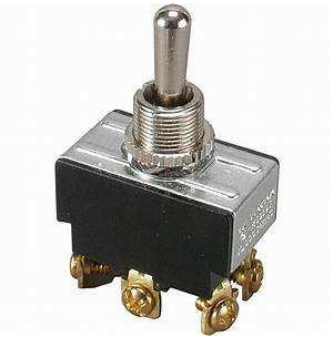
· One of them is used as dead supporting plate which actually didn't have any function and the plate which at the end side is used to support end of power screw.

· Generally, it's of aluminium sheet.

3.1.7) Toggle Switch:

· Toggle switch is used is of On-Off-On type.

· It helps to obtain bi-direction of motor.



3.1.8) Limit Switches:

· Limit switch is mounted at, at most and at least positions of table mounting. Generally it is roller type.

· Limit switch is used to stop the motor, when table strikes on limit switch the supply of current will stop due to this motor stops rotating.

3.1.9) Supporting bars:

· Supporting bars are used to support the table mountings.

· Sliding option of table is take place on this bar.

3.1.10) Bearings:

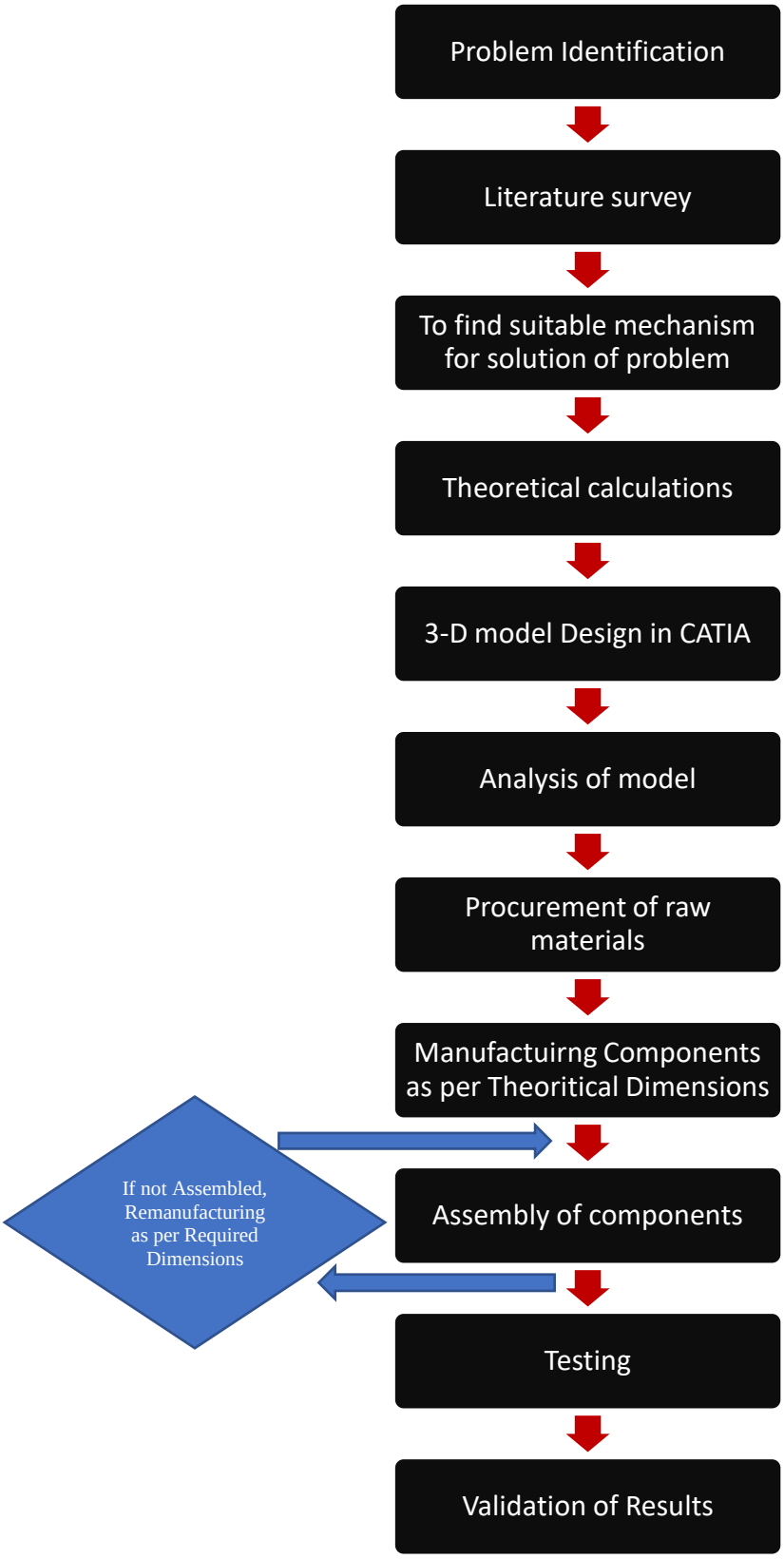
- Nowadays, bearings are one of the most commonly used machine parts because their rolling motion make almost all movements easier and they help reduce friction.
- We use two roller bearings to support power screw and make effective relative motion between power screw and hosing of bearings.

- Bearing consist of two parts- Housing which is made up of cast iron and roller which is made up of chromium steel.
- Proper dimensions of bearing are discussed further. [10]

3.2 Working of Experiment:

- For this setup we require Low speed Bi-Directional AC motor. And we will design Power screw for suitable load application.
- When we put the toggle switch on ON position the anti-clockwise motion of shaft of motor will take place.
- This motion will transmit to power screw through coupler.
- Due to this, reciprocating motion of table is take place and table slides over the supporting bar.
- When table reach at left most position, it actuates the limit switch and due to this motor will stop and toggle switch gets in OFF position.
- When we put the toggle position at second on position the clockwise motion of motor take place and due to this table mounting slides back.
- On table, we will mount stainless steel plate on which we have to adhere adhesive tape of which we have to measure peel strength.
- We are going to adhere adhesive tape as per ASTM standards. One end of adhesive tape is connected to peel measuring gauge.
- As table will move leftward, resistance will offer by adhesive tape, this resistance will indicate by measuring gauge and we will get reading for that one.

3.3 Process Flowchart-



4. Result and Discussion.

4.1 Theoretical Calculations for Design:

By analyzing all related articles and research paper we finally conclude with required analytical calculations and decide the all specification of parts for doing optimum design of Peel Strength Testing Machine. For this by calculating power requirement for prime mover we select other parts of machine-like pitch of power screw, bearings, etc. After concluding with all the setup, we take many readings on different adhesive tapes for gathering final results.[2]

Nominal diameter.	**Major Diameter**		**Minor diameter**	**Pitch**	**Depth of thread**		**Area of core (Ac) mm 2**
	Bolt	**Nut**			**Bolt**	**Nut**	
d1	d	D	dc	p	h	H	Ac
14	14	14.5	12	2	1	12.5	113
16	16	16.5	14				154
18	18	18.5	16				201
20	20	20.5	18				254

For our design, taking its compactness in size and working load of max. 20 kg in consideration we had chosen 24mm as Nominal dia. For square thread shaft. And as per IS:4694-1968 dimensions (all are in mm) are-

Nominal dia. = 18

Major dia. = 18 (for bolt), 18.5 (for nut)

Minor dia. = 16

Pitch = 2

Depth of thread = 1 (for bolt), 1.25 (for nut)

Coefficient of friction (for mild steel bolt and Nut) (tan ∅) = 0.09

….. [as per ref. mentioned textbook 4]

As per ASTM D3330 Standards peeling should be done with max. velocity of 300 mm/min, so

V = 300mm/min

So, this will be standard data, as we require low speed motor which carry max 20kg load, so we are estimating motor specifications as per follow-

W= 20kg = 20 x 9.81 N = 196.13 N

Motor Speed (N) = $\frac{\text{velocity of nut}}{\text{Pitch of screw}} = \frac{120}{2}$ = **60 rpm**

Angular speed (ω) = 2π x $\frac{60}{60}$ = 6.28 rad/s

$\tan\alpha = \frac{\text{Pitch}}{\pi \times \text{Dai.of screw}} = \frac{2}{3.14 \times 18}$ = 0.03539

So, force required at circumference of the screw (P)

$$P = W\tan(\alpha+\phi) = W\left[\frac{\tan\alpha+\tan\phi}{1-\tan\alpha\cdot\tan\phi}\right]$$

P= 24.6713 N

Torque of motor (T) = P x radius of power screw = 24.6713 x 9

= **222.041 N-mm**

=22.634Kg-mm

≈ **2.263kg-cm**

Power of Motor (P) = (ω) x (T) = 222.041 x 6.28 = 1394.423 W

= 1.3945 kW≈ 1.5 kW

This parameter we had calculated for Electric Motor for our requirement, and from these specifications available electric motor in market is-

Speed	60 RPM
No Of Phase	Single Phase
Country of Origin	Made in India
Torque	7 Kgcm
Voltage	240 V
Current	125 mA

Parameters of Power Screw-

By considering desired dynamic load, static load and motor rpm we design the power screw of following parameters.

Material used – Stainless Steel

Major diameter – 18mm

Minor diameter- 16mm

Pitch – 2mm

Length -500mm

Thread Type- acme Thread

Thread angle-29

Parameters of Bearing-

By considering desired dynamic and static load considerations and considering nominal dimeter of power screw (15mm) we use bearing including following specifications [From Ref No.10]-

- Part no- UCP202 (Metric Series Two Bolt Pillow Block)
- Bearing type – Extended inner race with set screws
- Dynamic Load Rating (Cr) -12,843 N
- Static Load Rating (Cor)- 6,668 N

- Shaft Dia.-15.000 mm
- Weight (g) 635.00 grams
- Material Used – Cast iron housing and Chrome steel bearing

Parameters of Universal Joint-

By considering eccentricity between motor shaft and power screw and different dimeters of both we prefer universal joint having flexibility up to $45^0$and including following parameters. [19]

- Type- Single Joint Universal Coupling
- Material- Stainless Steel
- Min. Torque- 5.5Nm

4.2 2D Diagram of setup

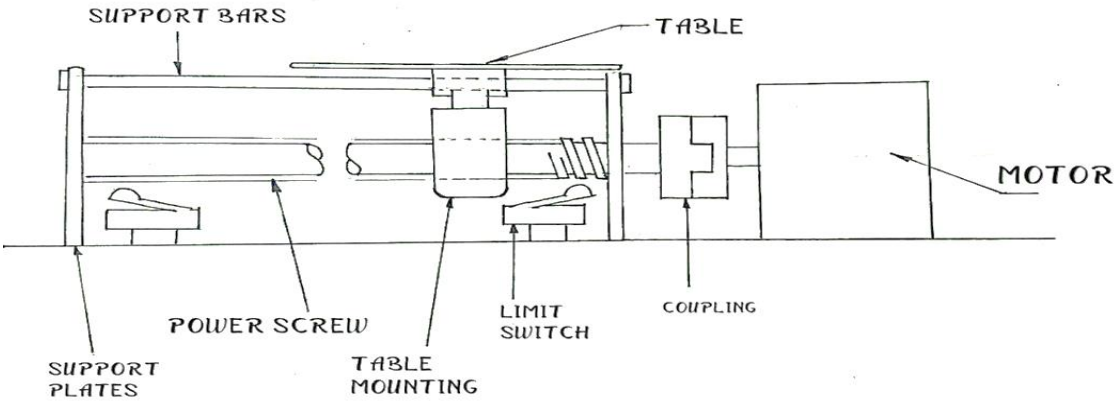


Fig.4.2.1 AC Motor.

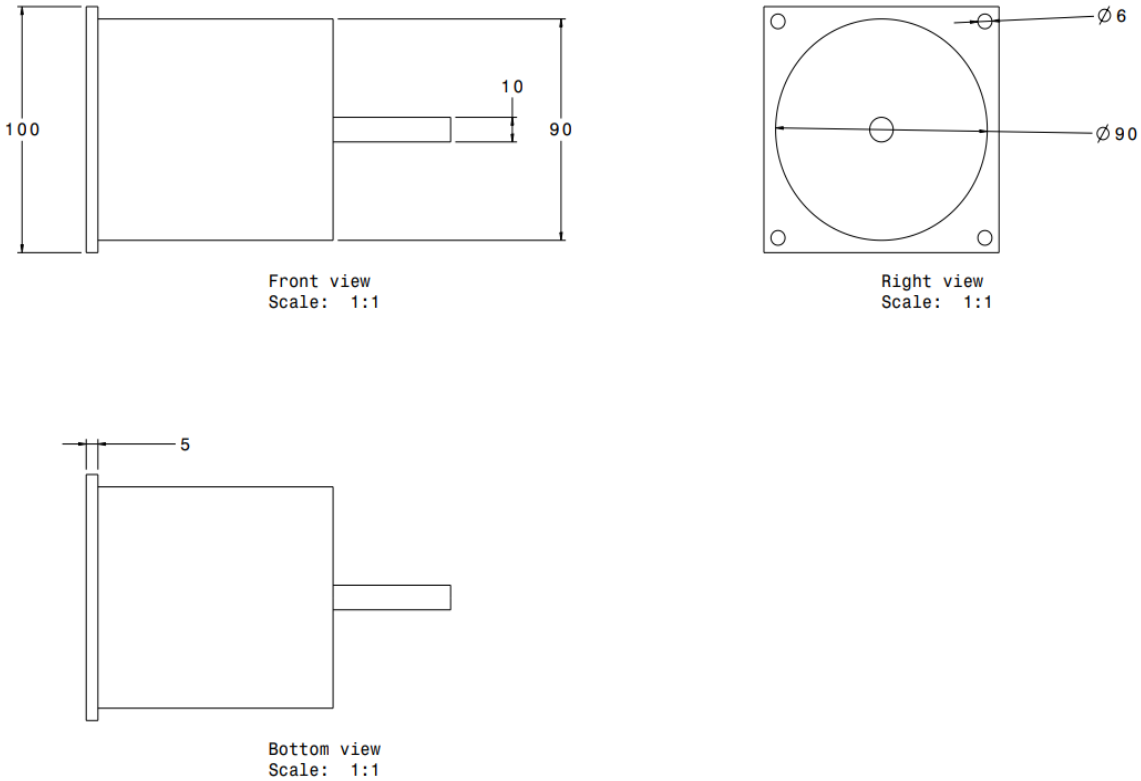


Fig. 4.2.2 Lead Screw

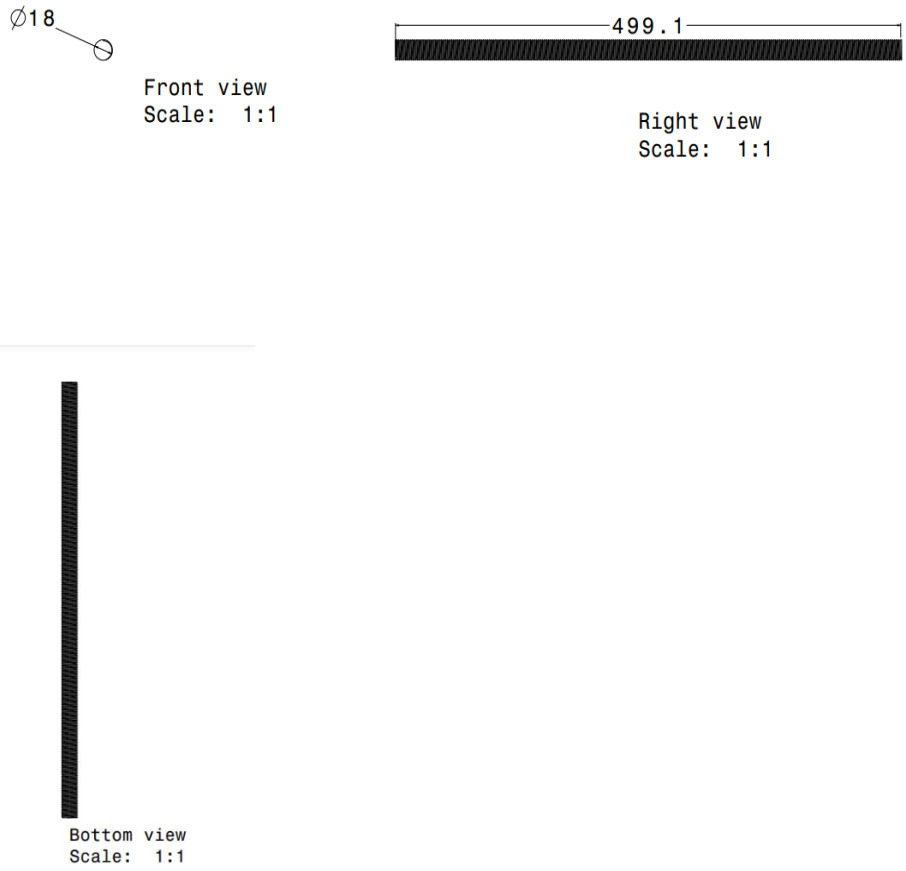


Fig.4.2.3 Bearing

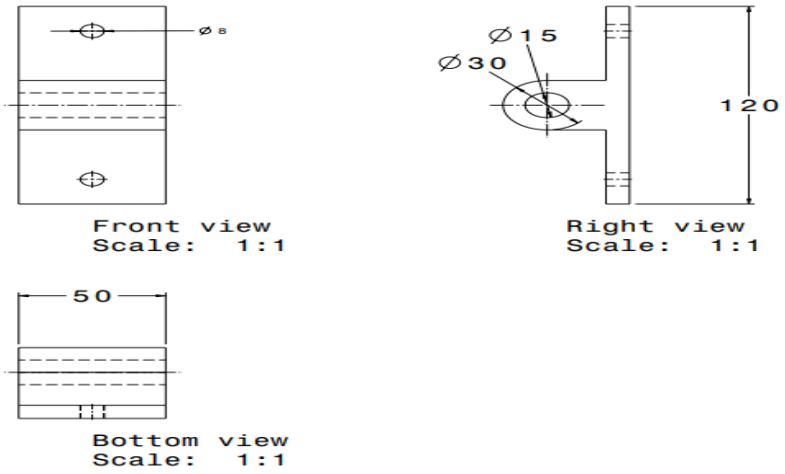


Fig. 4.2.4 Universal Joint

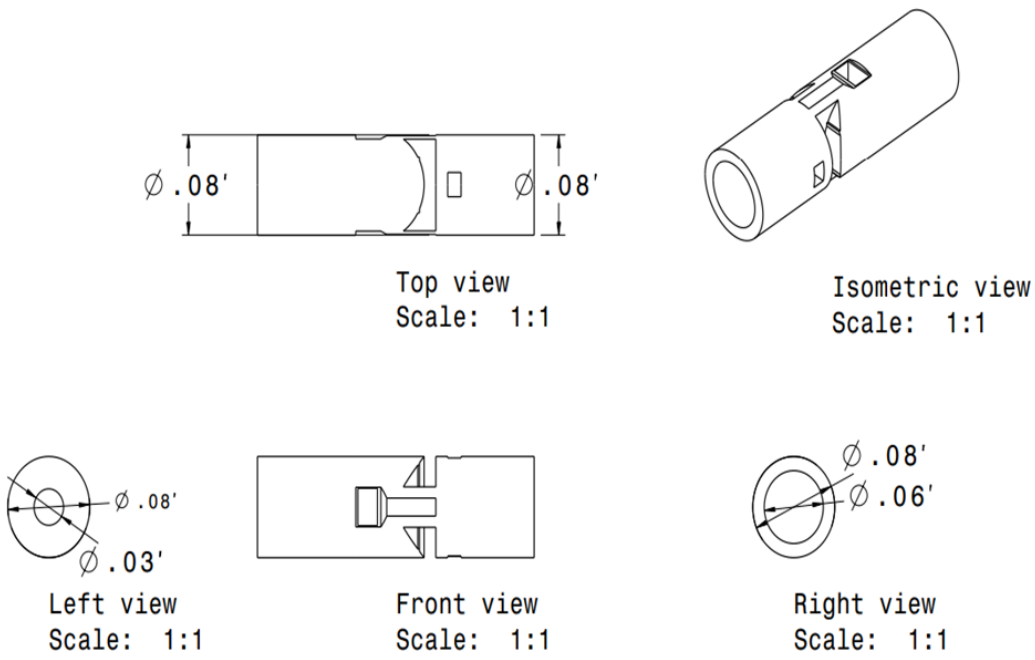


Fig 4.2.5 Support rod Cover

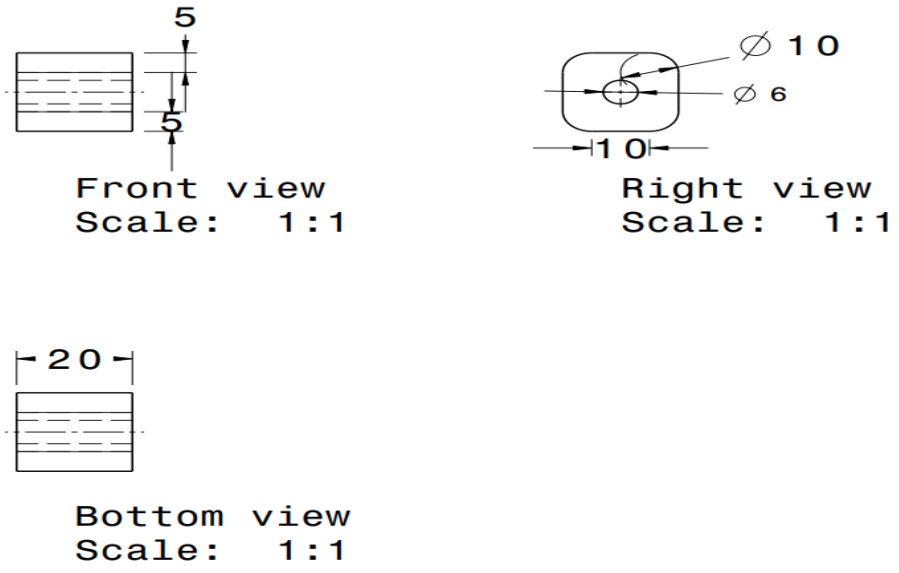
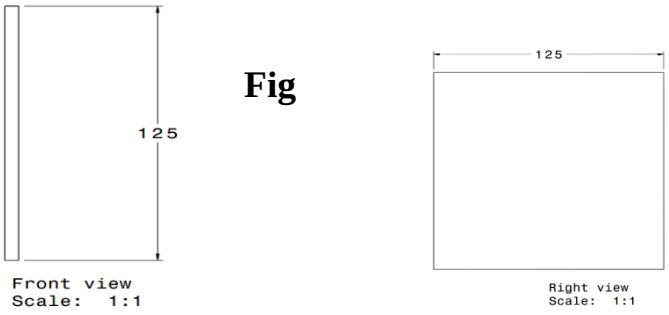


Fig 4.2.6 Testing Panel.



Fig

4.2.7 Support rod.

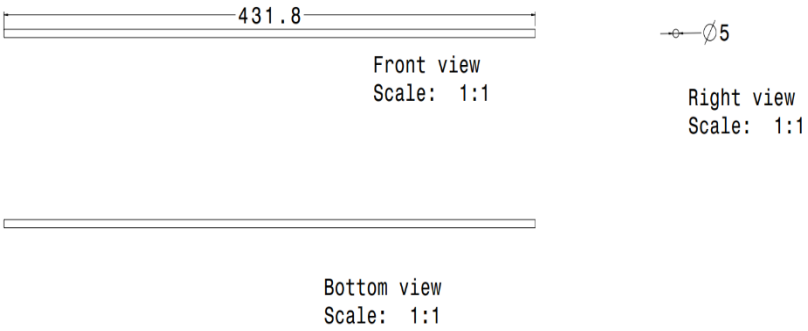
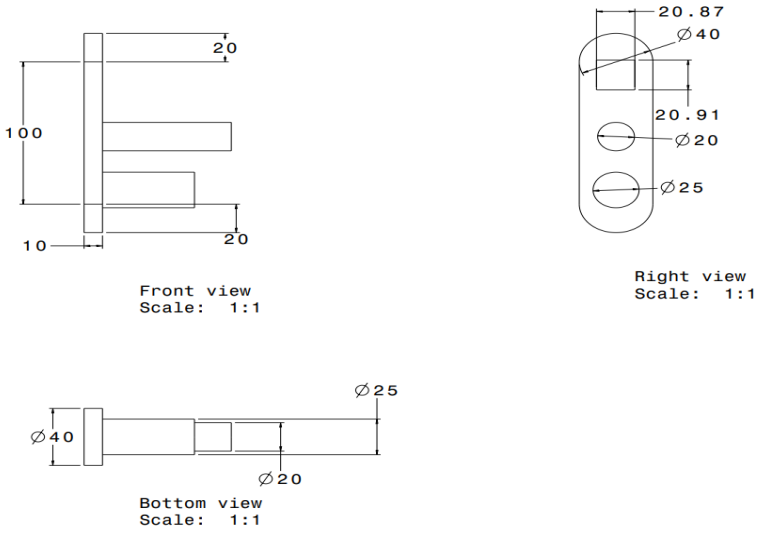


Fig 4.2.8 R-C Series.



4.3 3-D Model Design in Catia

Fig.4.3.1 Isometric view

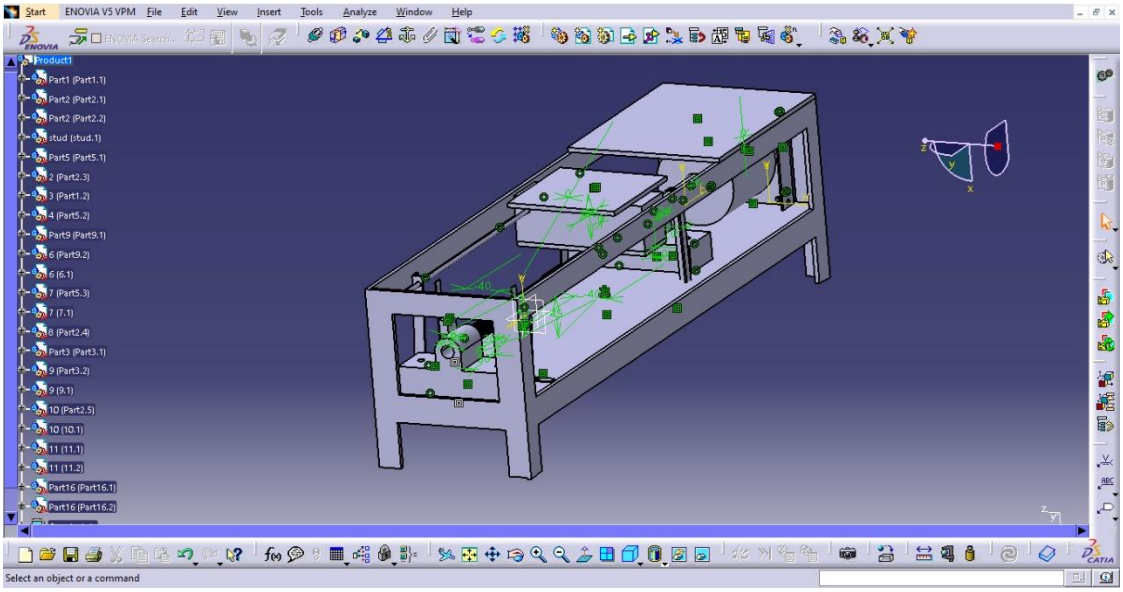


Fig.4.3.2 Side View

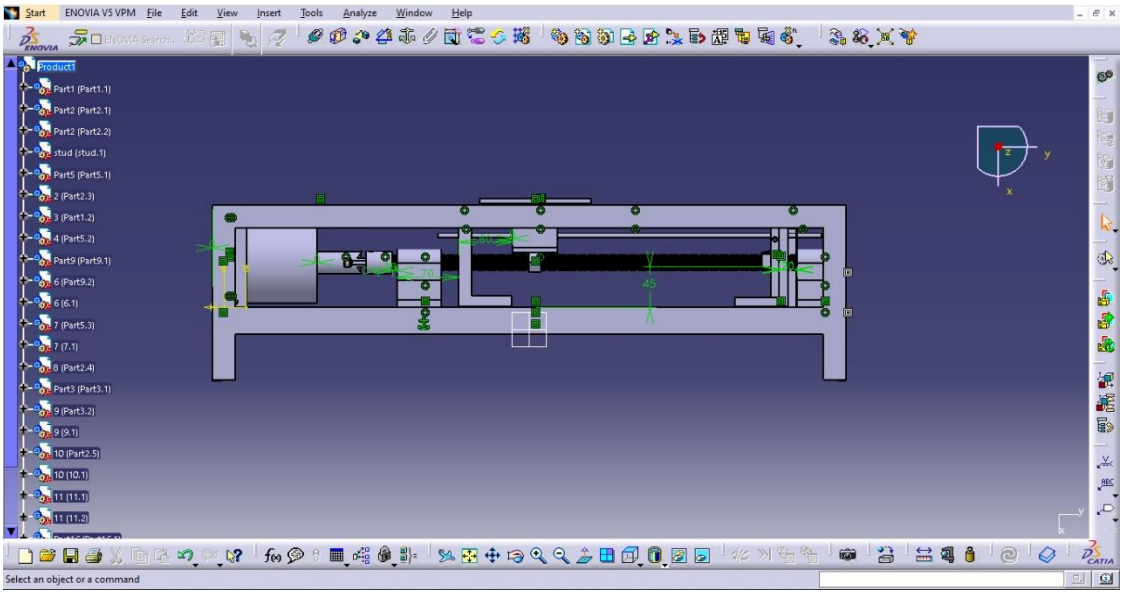
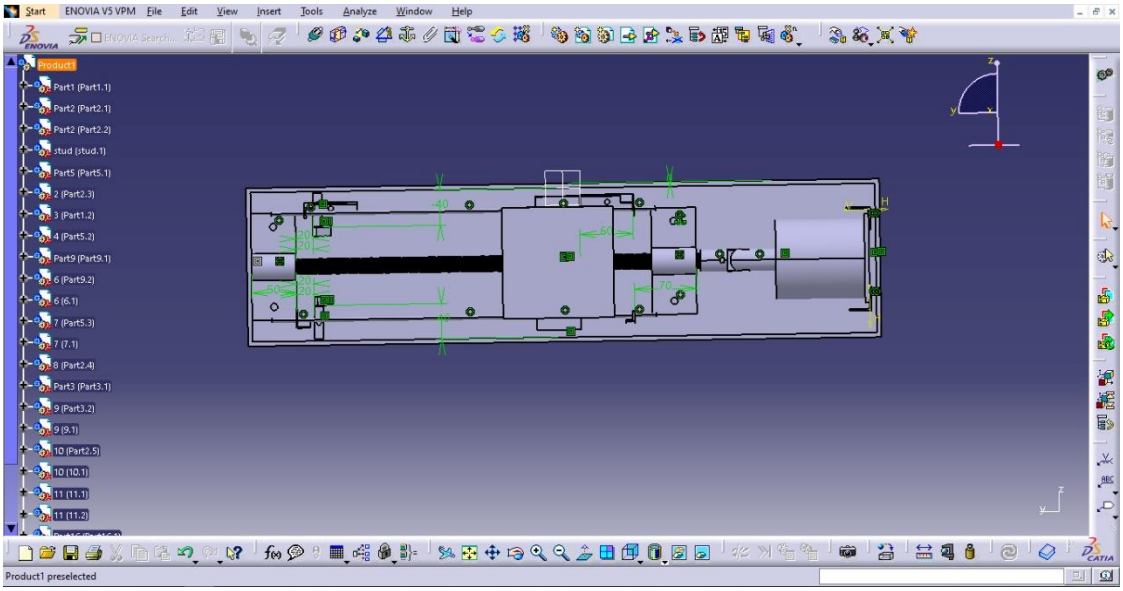
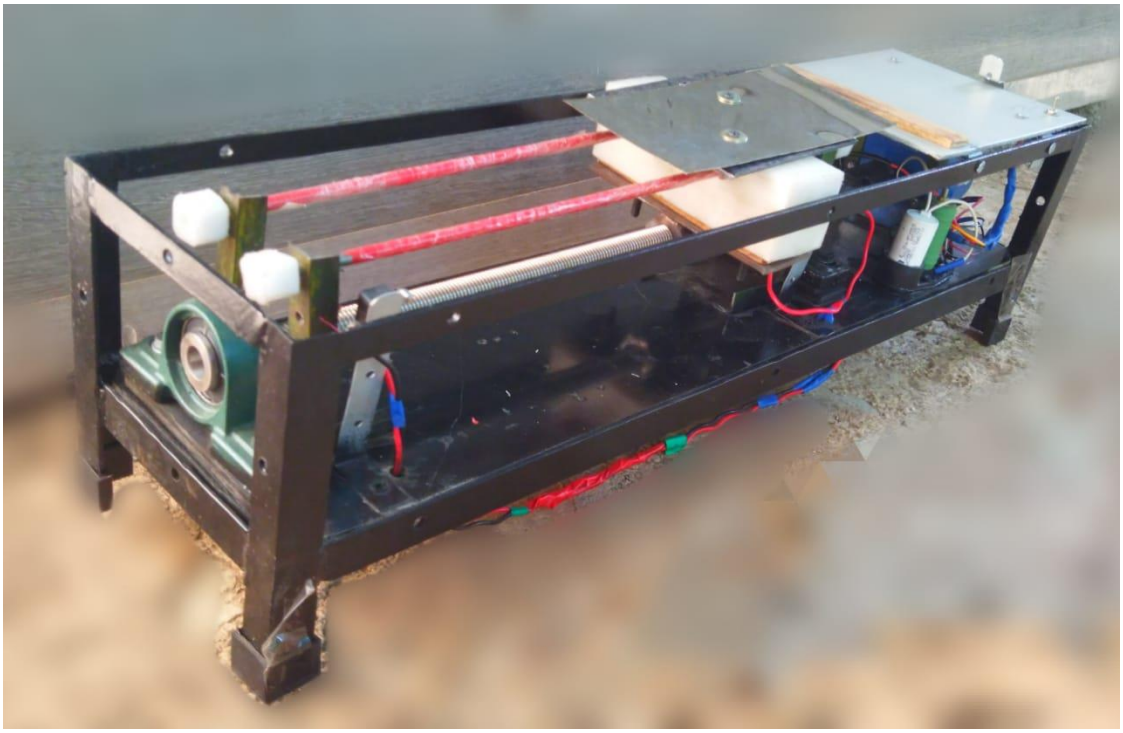
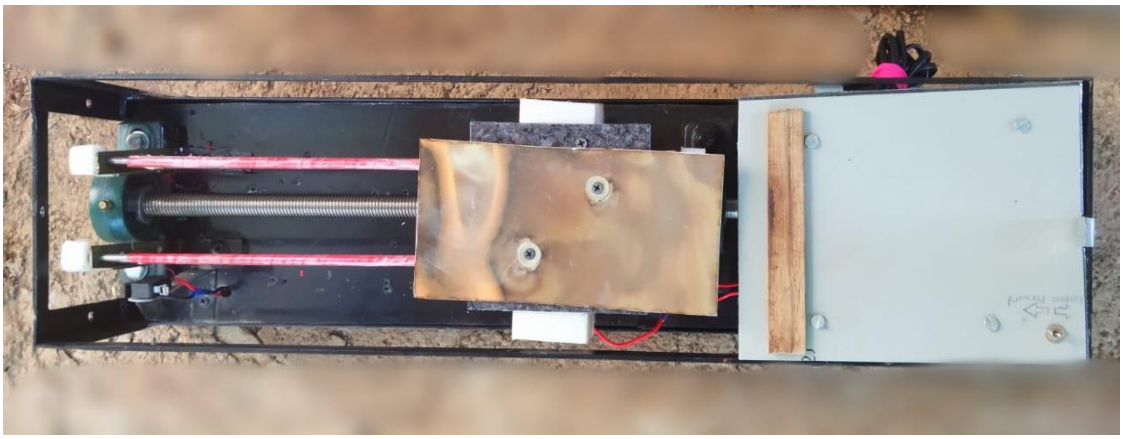


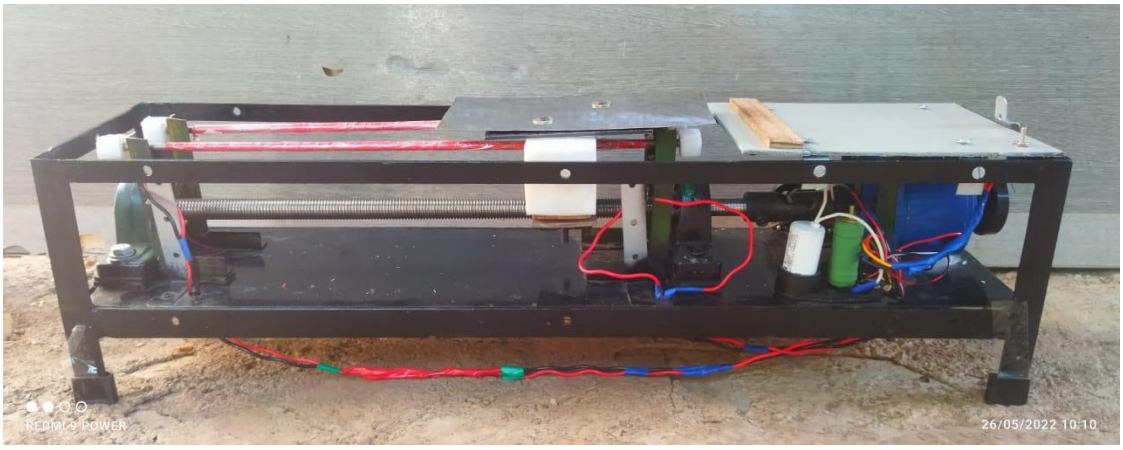
Fig.4.3.3 Top View.



4.4 Actual Prototype.






26/05/2022 10:10

4.5 Standard readings given by manufacturer: -

Any company follows same ASTM standards for testing peel strength where length kept as constant i.e., 300mm where width is variable. And all tests are done in Controlled atmospheric room temperature i.e., 22-24^{o}c.

Sr. No.	Manufacturer Company	Type of adhesive tape	Standard reading (Min.)
1.	Asian paints Pvt. Ltd [11]	Arbo or Masking tape	320gm/25mm
2.	Pidilite Pvt. Ltd (Steelgrip) [12]	Wire Insulation tape	150gm/10mm
3.	Mehta's surgical Pvt. Ltd [15]	Surgical tape	650gm/25mm
4.	Wonder tape 555 [13]	Transparent acrylic tape (10mm)	90gm/25mm
5.	Wonder tape 555 [13]	Transparent acrylic tape (1 inch)	180gm/25mm
6.	Wonder tape 555 [13]	Transparent acrylic tape (3 Inch)	275gm/ 25mm
7.	3M Adhesive. [14]	Double sided foam Tape	1407 gram/ 12.5mm

4.6 Observation tables using stainless steel panel

For detail study we tested adhesive tapes at different temperature to study behaviour of adhesive with respect to temperature since this tests are done in summer where room temperature was 35 to 37 degrees Celsius. Length for all types of adhesive tapes is kept constant i.e 50 mm where width is variable.

1. **Mehta's Surgical Tape-**

Parameters- Length =50mm, width = 25mm

Observations are converted from gram to Newton. (grams/1000*9.81) = Newtons e.g., Std. range is 650gm = 650/1000*9.81 = 6.3765N.

Sr no	Standard range (Min. in N/mm) [15]	Below R.T (19.3 C) in (N/mm) (σ =0.176)	At R.T (35.8 C) in (N/mm) (σ =0.0423)	Above R.T (61.2 C) in (N/mm) (σ = 0.0915)
1	0.25506	0.47	0.27	0.106
2	0.25506	0.52	0.304	0.107
3	0.25506	0.47	0.31	0.117
4	0.25506	0.66	0.32	0.127
5	0.25506	0.7	0.34	0.121
6	0.25506	0.74	0.34	0.128
7	0.25506	0.97	0.35	0.104
8	0.25506	0.913	0.38	0.113
9	0.25506	0.82	0.38	0.119
10	0.25506	0.78	0.413	0.127
Avarage in (Newton/mm)	0.25506	0.7043	0.3407	0.1169

Calculations-

For Mehta's Surgical tape. (25mm)

Width = **25 mm**

Standard given by manufacturer = 6.3765 N/ 18mm = **0.354N / mm**

Average recorded load (At Room Temp. 35.8 ^{o}C) = **8.609 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{8.609 \text{ Newtons}}{18 \text{ mm}}$

= 0.4782 N/mm.

Average recorded load (At Below Room Temp. 19.3^{o}C) = **17.71 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{17.71 \text{ Newtons}}{18 \text{ mm}}$

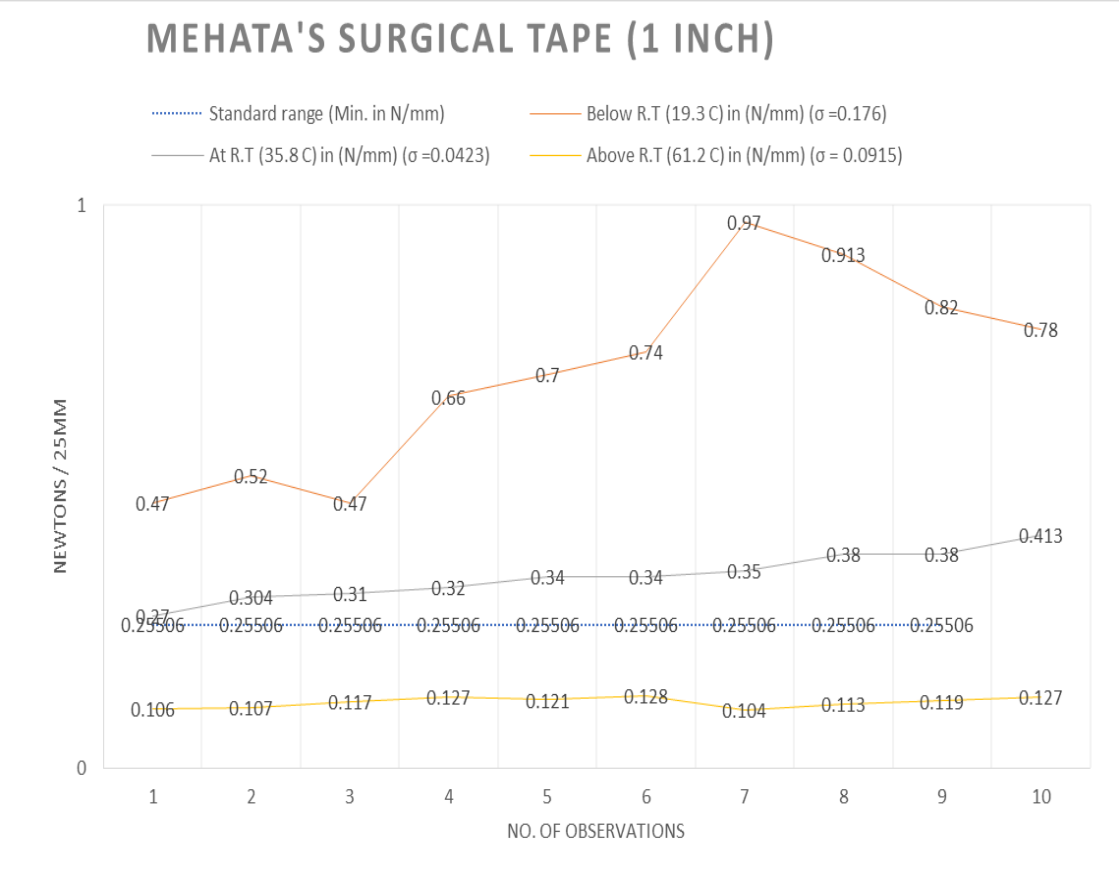
= 0.9838 N/mm.

Average recorded load (At Above Room Temp. 61.2^{o}C) = **2.938 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{2.938 \text{ Newtons}}{18 \text{ mm}}$

= 0.1632 N/mm



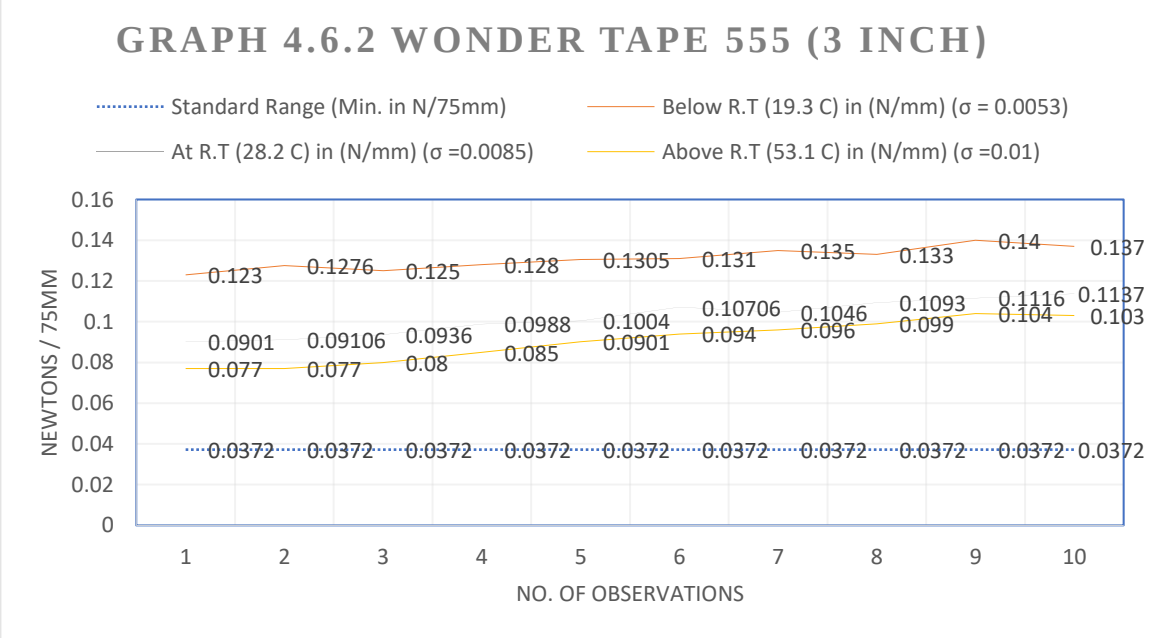
Graph 4.6.1 Mehata's Surgical Tape

2. Wonder tape 555 (3 inch)

By Ref. [13] Standard range is given 270 to 300gm/ 50mm from that we taken average 270+300/2 = 285gm/75mm

which is equal to - 285/1000*9.81 = 2.79585 Newtons

Sr no	Standard Range (Min. in N/mm) [13]	Below R.T (19.3 C) in (N/mm) (σ = 0.0053)	At R.T (28.2 C) in (N/mm) (σ =0.0085)	Above R.T (53.1 C) in (N/mm) (σ =0.01)
1	0.0372	0.123	0.0901	0.077
2	0.0372	0.1276	0.09106	0.077
3	0.0372	0.125	0.0936	0.08
4	0.0372	0.128	0.0988	0.085
5	0.0372	0.1305	0.1004	0.0901
6	0.0372	0.131	0.10706	0.094
7	0.0372	0.135	0.1046	0.096
8	0.0372	0.133	0.1093	0.099
9	0.0372	0.14	0.1116	0.104
10	0.0372	0.137	0.1137	0.103
Avarage in (Newton/mm)	0.0372	0.13101	0.102022	0.09051



Calculations-

For Wonder tape 555. (75mm)

Width = **75 mm**

Standard given by manufacturer = 2.7985 N/ 75mm = **0.0374N / mm**

Average recorded load (At Room Temp. 27.8 ^{o}C) = **7.653 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{7.653 \text{ Newtons}}{75 \text{ mm}}$$

= 0.102 N/mm.

Average recorded load (At Below Room Temp. 18.5^{o}C) = 9.846 **N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{9.846 \text{ Newtons}}{75\text{mm}}$$

= 0.13128N/mm.

Average recorded load (At Above Room Temp. 52.5^{o}C) = **6.8199 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{6.8199 \text{ Newtons}}{75\text{mm}}$$

= 0.0903 N/mm.

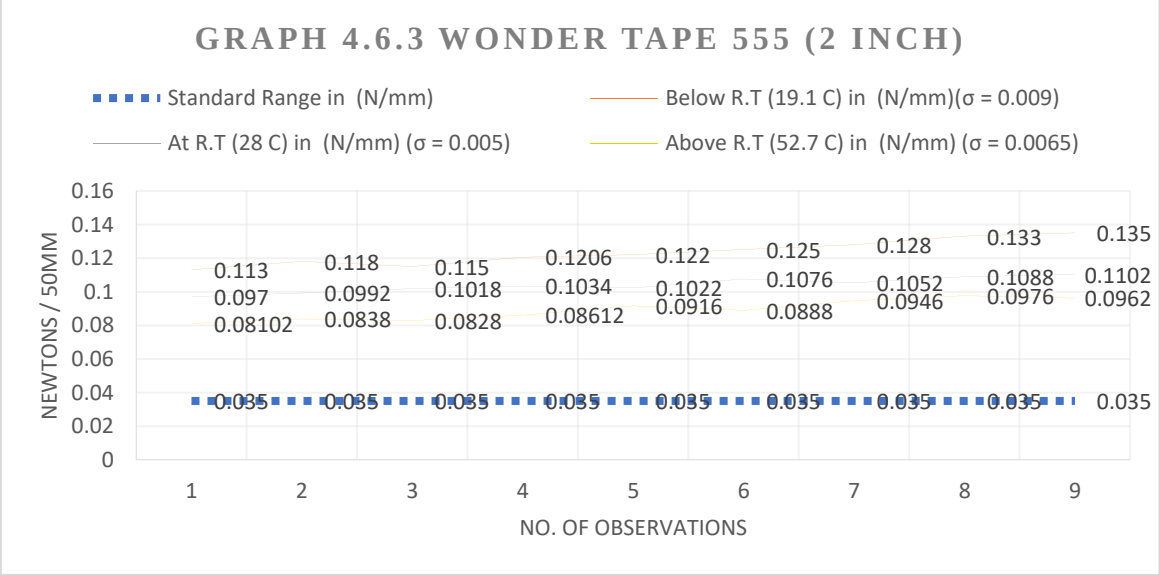
3. Wonder tape 555 (2 inch)

Parameter- Length=50mm, width=25mm

According to Ref. [13] Standard range is given 160-200gm/ 50mm from that we taken average 160+200/2= 180gm/50mm.

which is equal to - 180/1000*9.81 = 1.7658 Newtons

Sr no	Standard Range in (N/mm)[13]	Below R.T (19.1 C) in (N/mm) (σ = 0.009)	At R.T (28 C) in (N/mm) (σ = 0.005)	Above R.T (52.7 C) in (N/mm) (σ = 0.0065)
1	0.035	0.113	0.097	0.08102
2	0.035	0.118	0.0992	0.0838
3	0.035	0.115	0.1018	0.0828
4	0.035	0.1206	0.1034	0.08612
5	0.035	0.122	0.1022	0.0916
6	0.035	0.125	0.1076	0.0888
7	0.035	0.128	0.1052	0.0946
8	0.035	0.133	0.1088	0.0976
9	0.035	0.135	0.1102	0.0962
10	0.035	0.14	0.1128	0.099
Avarage in (Newton/mm)	0.035	0.12496	0.10482	0.090154



Calculations-

Width = **50 mm**

Standard given by manufacturer = 1.7658N/ 50mm = **0.035316N / mm**

Average recorded load (At Room Temp. 28 ^{o}C) = **5.241 N**

Now,

Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{2.8968 \text{ Newtons}}{50\text{mm}}$

= 0.10482 N/mm.

Average recorded load (At Below Room Temp. 19.1^{o}C) = **6.2605 N**

Now,

Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{6.2605\text{Newtons}}{50\text{mm}}$

= 0.12521 N/mm.

Average recorded load (At Above Room Temp. 52.7^{o}C) = **4.5077 N**

Now,

Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{4.5077 \text{ Newtons}}{50 \text{ mm}}$

= 0.090154N/mm.

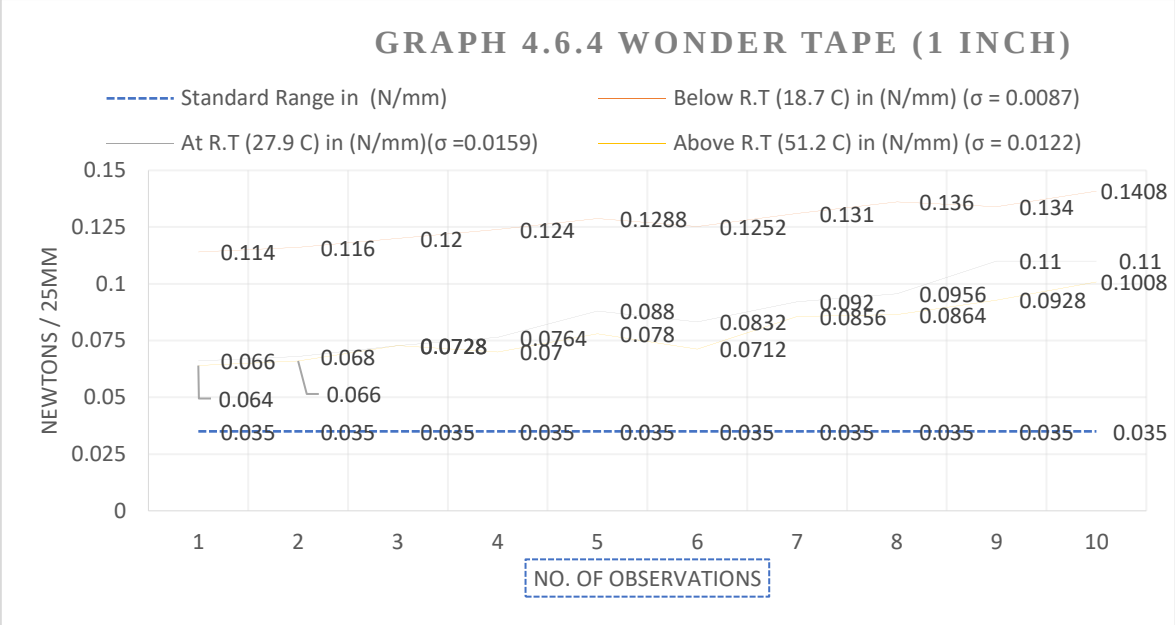
4. Wonder tape 555 (1 inch)

Parameter- Length=50mm, width=75mm

According to Ref. [13] Standard range is given 80-100 gm/ 25mm from that we taken average 80+100/2 = 90gm/25mm.

which is equal to - 90/1000*9.81 = 0.8829 Newtons

Sr no	Standard Range in (N/mm)[13]	Below R.T (18.7 C) in (N/mm) (σ = 0.0087)	At R.T (27.9 C) in (N/mm) (σ =0.0159)	Above R.T (51.2 C) in (N/mm) (σ = 0.0122)
1	0.035	0.114	0.066	0.064
2	0.035	0.116	0.068	0.066
3	0.035	0.12	0.0728	0.0728
4	0.035	0.124	0.0764	0.07
5	0.035	0.1288	0.088	0.078
6	0.035	0.1252	0.0832	0.0712
7	0.035	0.131	0.092	0.0856
8	0.035	0.136	0.0956	0.0864
9	0.035	0.134	0.11	0.0928
10	0.035	0.1408	0.11	0.1008
Avarage in (Newton/mm)	0.035	0.12698	0.0862	0.07876



Width = **25 mm**

Standard given by manufacturer = 0.8829 N/25 mm = **0.0353N / mm**

Average recorded load (At Room Temp. 27.9 ^{o}C) = **2.144 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{2.144 \text{ Newtons}}{25 \text{ mm}}$$

= 0.08576 N/mm.

Average recorded load (At Below Room Temp. 18.7^{o}C) = **3.1839N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{3.183 \text{ Newtons}}{25\text{mm}}$$

= 0.12732 N/mm.

Average recorded load (At Above Room Temp. 51.2^{o}C) = **1.9689 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$$= \frac{1.9689\text{Newtons}}{25\text{mm}}$$

= 0.07947 N/mm.

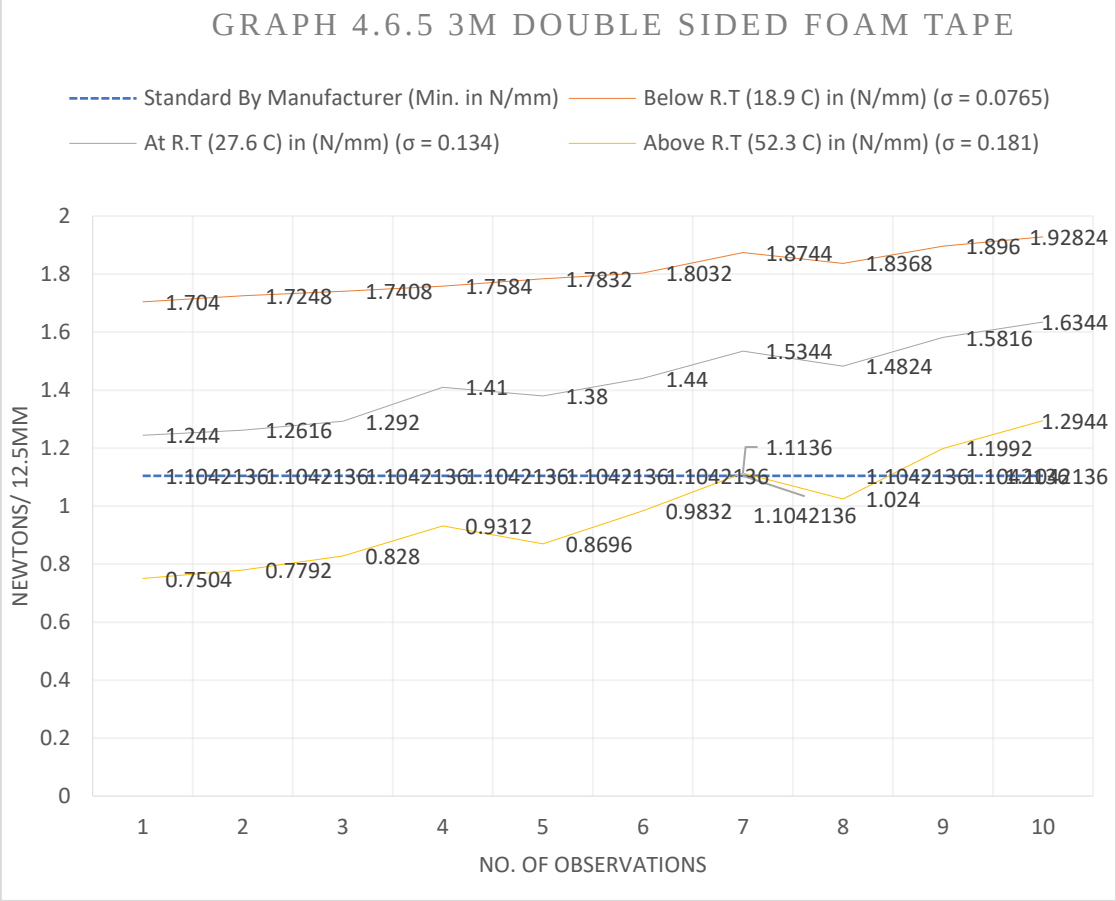
5. 3M Double sided acrylic foam tape (12.5mm).

Parameter- Length=50mm, width= 18mm

According to Ref. [14] for 3M Double sided acrylic foam tape standard given by manufacturer is 1407gm/12.5mm.

which is equal to - 1407/1000*9.81 = 13.80 Newtons.

Sr no	Standard By Manufacturer (Min. in N/mm)	Below R.T (18.9 C) in (N/mm) (σ = 0.0765)	At R.T (27.6 C) in (N/mm) (σ = 0.134)	Above R.T (52.3 C) in (N/mm) (σ = 0.181)
1	1.1042136	1.704	1.244	0.7504
2	1.1042136	1.7248	1.2616	0.7792
3	1.1042136	1.7408	1.292	0.828
4	1.1042136	1.7584	1.41	0.9312
5	1.1042136	1.7832	1.38	0.8696
6	1.1042136	1.8032	1.44	0.9832
7	1.1042136	1.8744	1.5344	1.1136
8	1.1042136	1.8368	1.4824	1.024
9	1.1042136	1.896	1.5816	1.1992
10	1.1042136	1.92824	1.6344	1.2944
Avarage in (Newton/mm)	1.1042136	1.804984	1.42604	0.97728



Width = **12.5 mm**

Standard given by manufacturer = 13.80267 N/ 12.5mm = **1.1042N / mm**

Average recorded load (At Room Temp. 27.6 ^{o}C) = **17.8328 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{17.8328 \text{ Newtons}}{12.5 \text{ mm}}$

= 1.4266 N/mm.

Average recorded load (At Below Room Temp. 18.9^{o}C) = **22.56239 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{22.56239 \text{Newtons}}{12.5 \text{ mm}}$

= 1.80499 N/mm.

Average recorded load (At Above Room Temp. 52.3^{o}C) = **12.216 N**

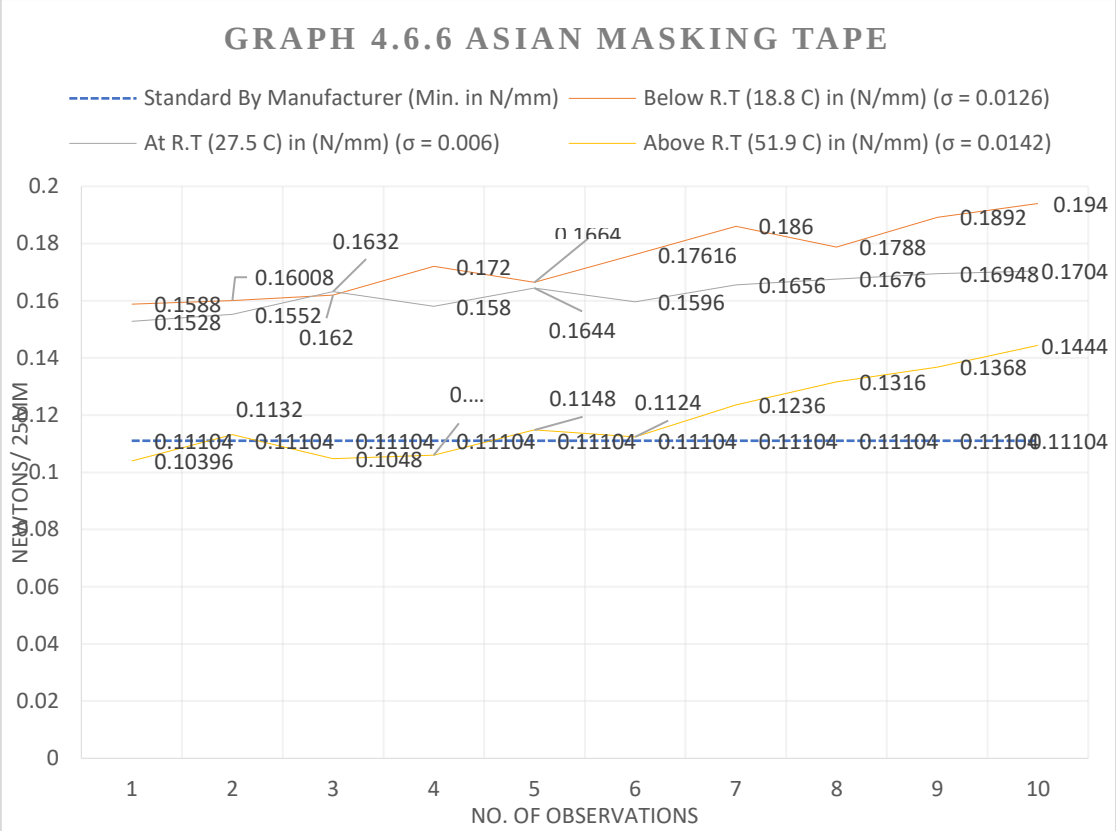
Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{12.216 \text{ Newtons}}{12.5\text{mm}}$ **= 0.97728 N/mm.**

6. Asian Masking Tape. (1Inch)

According to Ref. [11] Standard reading given by manufacturer is 283gm/ 25mm. which is equal to - 283/1000*9.81= 2.776 Newtons.

Sr no	Standard By Manufacturer (Min. in N/mm)[11]	Below R.T (18.8 C) in (N/mm) (σ = 0.0126)	At R.T (27.5 C) in (N/mm) (σ = 0.006)	Above R.T (51.9 C) in (N/mm) (σ = 0.0142)
1	0.11104	0.1588	0.1528	0.10396
2	0.11104	0.16008	0.1552	0.1132
3	0.11104	0.162	0.1632	0.1048
4	0.11104	0.172	0.158	0.106
5	0.11104	0.1664	0.1644	0.1148
6	0.11104	0.17616	0.1596	0.1124
7	0.11104	0.186	0.1656	0.1236
8	0.11104	0.1788	0.1676	0.1316
9	0.11104	0.1892	0.16948	0.1368
10	0.11104	0.194	0.1704	0.1444
Avarage in (Newton/mm)	0.11104	0.174344	0.162628	0.119156



Width = **25 mm**

Standard given by manufacturer = 2.776 N/ 25mm = **0.11104N / mm**

Average recorded load (At Room Temp. 27.5 ^{o}C) = **4.07 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{4.07 \text{ Newtons}}{25 \text{ mm}}$

= 0.1628 N/mm.

Average recorded load (At Below Room Temp. 18.8^{o}C) = **4.36N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{4.36 \text{ Newtons}}{25 \text{ mm}}$

= 0.1744 N/mm.

Average recorded load (At Above Room Temp. 51.9^{o}C) = **2.98 N**

Now, Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

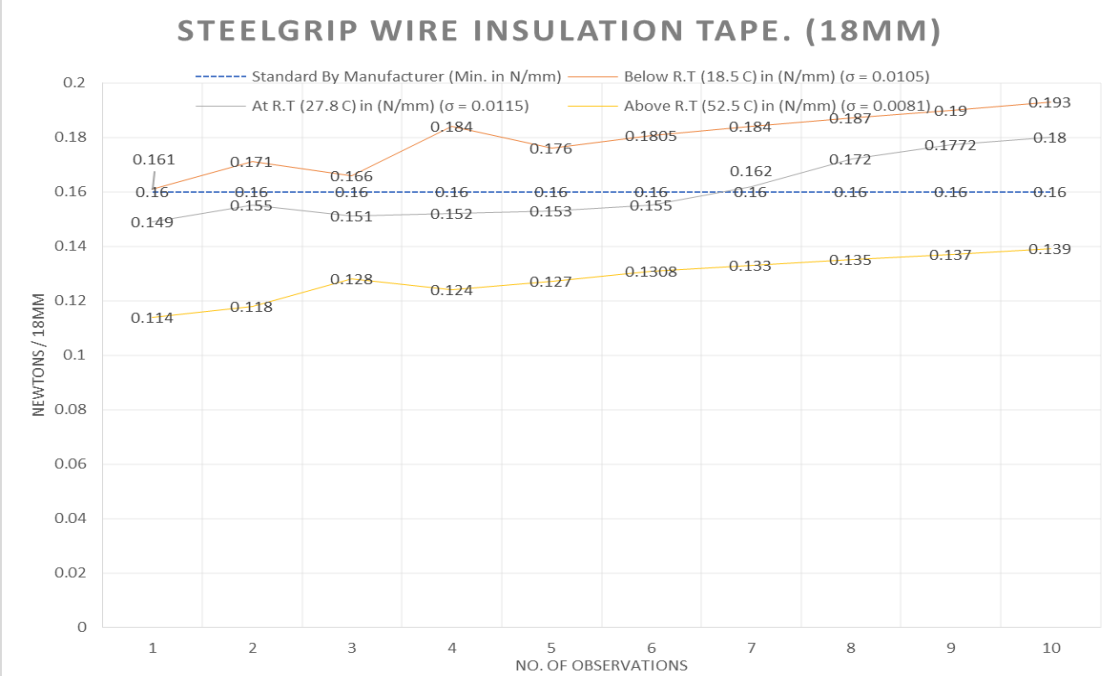
$= \frac{2.98 \text{ Newtons}}{25 \text{ mm}}$

= 0.1192 N/mm.

7. Steelgrip Wire Insulation tape. (18mm)

According to Ref. [12] Standard reading given by manufacturer is 1.6N/10mm for 10mm = 1.6 N **.** thus, for 18mm = 2.88 N / 18mm

Sr no	Standard By Manufacturer (Min. in N/mm)[12]	Below R.T (18.5 C) in (N/mm) (σ = 0.0105)	At R.T (27.8 C) in (N/mm) (σ = 0.0115)	Above R.T (52.5 C) in (N/mm) (σ = 0.0081)
1	0.16	0.161	0.149	0.114
2	0.16	0.171	0.155	0.118
3	0.16	0.166	0.151	0.128
4	0.16	0.184	0.152	0.124
5	0.16	0.176	0.153	0.127
6	0.16	0.1805	0.155	0.1308
7	0.16	0.184	0.162	0.133
8	0.16	0.187	0.172	0.135
9	0.16	0.19	0.1772	0.137
10	0.16	0.193	0.18	0.139
Avarage in (Newton/mm)	0.16	0.17925	0.16062	0.12858



Graph 4.6.7 Steelgrip wire insulation tape.

Width = **18 mm**

Standard given by manufacturer = 2.88 N/ 18mm = **0.16N / mm**

Average recorded load (At Room Temp. 27.8 ^{o}C) = **2.8968 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{2.8968 \text{ Newtons}}{18 \text{ mm}}$$

= 0.1609 N/mm.

Average recorded load (At Below Room Temp. 18.5^{o}C) = **3.229 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{3.229 \text{ Newtons}}{18 \text{ mm}}$$

= 0.1793 N/mm.

Average recorded load (At Above Room Temp. 52.5^{o}C) = **2.319 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{2.3190 \text{ Newtons}}{18 \text{ mm}}$$

= 0.1288 N/mm.

4.6.1 Results of testing.

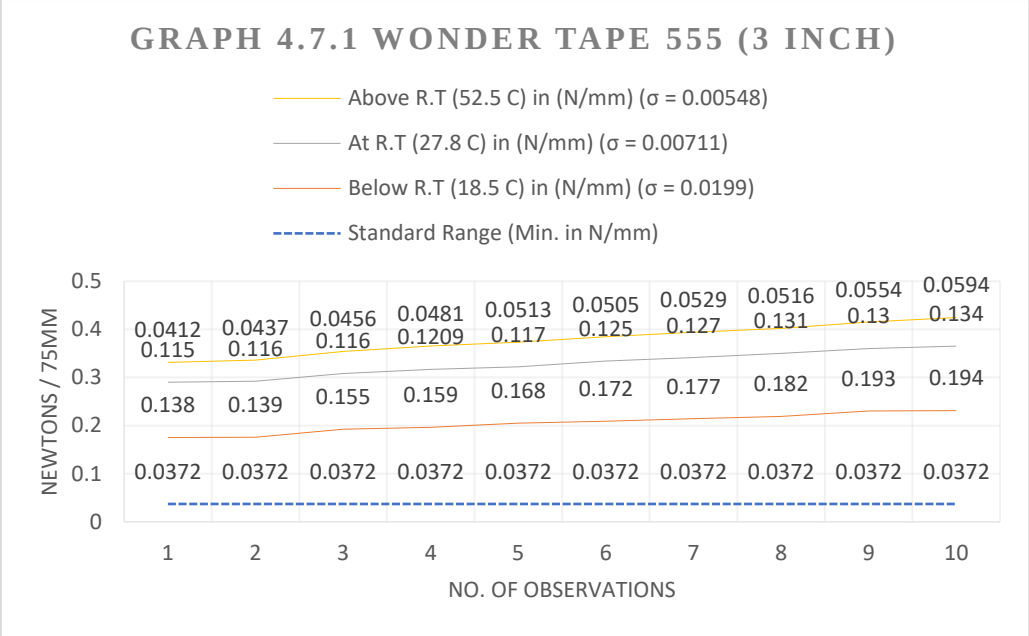
After performing standard test on different adhesive tapes by peel testing machine we conclude with following sample results -

Calculated Peel strength for	Standard Value given by Manufacturer.	At Room Temp	At Below Room Temp.	At Above Room Temp.
1. Mehta's Surgical tape. (1 Inch)	0.354 N/mm.	0.4782 N/mm.	0.9838 N/mm.	0.1632 N/mm.
2. Wonder tape 555 (3 Inch)	0.0374 N/mm.	0.102 N/mm.	0.13128 N/mm.	0.0903 N/mm.
3. Wonder tape 555 (2 Inch)	0.0353 N/mm.	0.10482 N/mm.	0.12521 N/mm.	0.090154N/mm.
4. Wonder tape 555 (1 Inch)	0.0353 N/mm.	0.1158N/mm.	0.12732 N/mm.	0.07947 N/mm.
5. 3M Double sided Acrylic Foam tape. (12.5 mm)	1.1042 N/mm.	1.4266 N/mm.	1.80499 N/mm.	0.97728 N/mm.
6. Asian Masking tape. (1 Inch)	0.11104 N/mm.	0.1628 N/mm.	0.1744 N/mm.	0.1192 N/mm.
7. Steel grip wire insulation tape. (18mm)	0.16 N/mm.	0.1609 N/mm.	0.1793 N/mm.	0.1288 N/mm.

4.7 Observation table using Aluminum composite panel

1. Wonder Tape 555 (1 Inch)

Sr no	Standard Range (Min. in N/mm)[13]	Below R.T (18.5 C) in (N/mm) (σ = 0.0199)	At R.T (27.8 C) in (N/mm) (σ = 0.00711)	Above R.T (52.5 C) in (N/mm) (σ = 0.00548)
1	0.0372	0.138	0.115	0.0412
2	0.0372	0.139	0.116	0.0437
3	0.0372	0.155	0.116	0.0456
4	0.0372	0.159	0.1209	0.0481
5	0.0372	0.168	0.117	0.0513
6	0.0372	0.172	0.125	0.0505
7	0.0372	0.177	0.127	0.0529
8	0.0372	0.182	0.131	0.0516
9	0.0372	0.193	0.13	0.0554
10	0.0372	0.194	0.134	0.0594
Avarage in (Newton/mm)	0.0372	0.1677	0.12319	0.04997



Sample Calculations-

Width = **75 mm**

Standard given by manufacturer = 2.7985 N/ 75mm = **0.0374N / mm**

Average recorded load (At Room Temp. 27.8 ^{o}C) = **7.653 N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{9.2645 \text{ Newtons}}{75 \text{ mm}}$$

= 0.1235 N/mm.

Average recorded load (At Below Room Temp. 18.5^{o}C) = 9.846 **N**

Now,

$$\text{Peel strength} = \frac{\text{Average load recorded}}{\text{Width}}$$

$$= \frac{12.6051 \text{ Newtons}}{75\text{mm}}$$

= 0.1680 N/mm.

Average recorded load (At Above Room Temp. 52.5^{o}C) = **6.8199 N**

Now,

Peel strength = $\frac{\text{Average load recorded}}{\text{Width}}$

$= \frac{3.75\ 4\ \text{Newtons}}{75\text{mm}}$

= 0.050 N/mm.

4.8 Comparison Chart

Panel Used -	At Room Temp.	Below Room Temp.	Above Room Temp.
Using Stainless steel panel	**0.102 N/mm.**	**0.13128N/mm**	**0.0903 N/mm.**
Using Aluminum Panel	**0.1235 N/mm**	**0.1680 N/mm**	**0.050 N/mm**

From Above table we can conclude that, as roughness changes peel strength will also change according to that. Here stainless steel has higher surface finish [16] as compared to aluminum panel [20]. Hence Peel strength on Stainless steel panel is less as compared to aluminum composite panel.

We can conclude that, as surface roughness increases strength require for peeling also increases. And Vise-versa.

4.9 Gantt Chart

		MONTHS								
Sr. No	**Activity**	**Sept. 2021**	**Oct. 2021**	**Nov. 2021**	**Dec. 2021**	**Jan. 2022**	**Feb. 2022**	**Mar. 2022**	**Apr. 2022**	**May 2022**
1	Search of topic									
2	Selection of topic and study of research papers.									
3	Finalizing project topic									
4	Literature review									
5	Finding dimensions of components.									
6	Calculations for actual design of components									
7	Design of components in Catia V5									
8	Assembly of components									
8	Finalizing and procurement of components									
9	Starting manufacturing									
10	Assembling the manufactured components									
11	Testing and validation of model									
12	Final report									

- Milestone 1: Search for topic
- Milestone 2: Finalizing project topic
- Milestone 3: Calculations for actual design
- Milestone 4: Design in Catia V5
- Milestone 5: Completed Manufacturing
- Milestone 6: Testing and validation
- Milestone 7 : Final Report

5. Conclusion

1. By performing peel test at different temperature results obtained are:
   i. For 3M Double sided acrylic tape [14] Standard value is 1.1042 N/mm, value at room temperature is 1.4266 N/mm, Value below room temperature is 1.80499 N/mm and Value above room temperature is 0.97728 N/mm.
   ii. For Wonder tape 1 Inch [13] standard value is 0.0353 N/mm, Value at room temperature is 0.1158, value below room temperature is 0.12325 & value above room temperature is 0.07947.

   Similarly, from other reading we can conclude that:
   - As temperature increases strength required for peeling adhesive is decreases.
   - Temperature is inversely proportional to peel strength.[17][21]

2. By performing peel test at different surface finish i.e., on steel plate and aluminum sheet: [22]
   i. Using Stainless steel panel value at room temperature is 0.102 N/mm, value of peel strength below room temperature 013128 N/mm, above room temperature 0.0903 N/mm.
   ii. Using Aluminium composite panel value at room temperature 0.1235 N/mm, Value below room temperature 0.1680 N/mm and value above room temperature 0.050 N/mm.
   - As surface roughness increases value strength required for peeling is also increases
   - Surface roughness is directly proportional to peel strength.

3. After performing peel test on different adhesive tapes by peel strength measuring machine , we can conclude that highest peel strength required is for 3M double tape which is nearly 1.4266 N/mm at room temperature
4. Currently industries use 90-degree peel strength measuring machine for finding peel strength of different adhesive [23] which is quite expensive we introduced totally new idea of 180-degree peel strength measuring machine with fabrication in affordable range and gives precise reading.

6. Recommendations

- When a manufacturer think about peel testing, that costly about 1.5 lac machines came in mind, but this machine became so useful in that manner. If this machine is used it is possible to obtain accuracy at low cost about 10k. And if we use digital gauges, it will cost up to 45-50k (Depending on precision of digital gauge) and hence in Future we can improvethe accuracy of this, using digital measuring gauge.

- The single-coated tapes and assesses the peel adhesion at a 180 degree angle. (ASTM D3330 /3330D-04) evaluates the force required to the progressively separate two bonded, flexible adherents. Variations in test specimen preparation such adhesive curing, adhesive thickness, adherents and conditioning provides insight for optimization in processes and application.

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