CONSTRUCTION OF FAN BEAM TELESCOPE

A Postgraduate Project Report submitted to Manipal University in partial fulfilment of the requirement for the award of the degree of

MASTER OF TECHNOLOGY
In
Astronomy and Space Engineering

Submitted by

KURAVI ARUNA

Under the guidance of

Ramesh Balasubramanyam		Sandra D'Souza
SUPERVISOR	**&**	**DEPARTMENT GUIDE**
Assistant Professor		**Senior faculty**
Department of Astronomy and Astrophysics (A and A),		**Instrumentation and Control Engineering (ICE),**
Raman Research Institute		**Manipal Institute Of Technology**

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

MANIPAL INSTITUTE OF TECHNOLOGY

(A Constituent College of Manipal University)

MANIPAL – 576104, KARNATAKA, INDIA

May 2011

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

MANIPAL INSTITUTE OF TECHNOLOGY

(A Constituent College of Manipal University)

MANIPAL – 576 104 (KARNATAKA), INDIA

Manipal

< 13-5-2011>

CERTIFICATE

This is to certify that the project titled "**CONSTRUCTION OF FAN BEAM TELECSOPE"** is a record of the bonafide work done by **KURAVI ARUNA** (*Reg. No. 090944007*) submitted in partial fulfilment of the requirements for the award of the Degree of Master of Technology (M.Tech) in **ASTRONOMY ANS SPACE ENGINEERING** of Manipal Institute of Technology Manipal, Karnataka, (A Constituent College of Manipal University), during the academic year 2010-11.

Dept Guide :-Sandra D'Souza
Project Guide

Prof. Dr. V. I George
HOD, ICE.
M.I.T, MANIPAL

ACKNOWLEDGEMENT

Implementing of any task would be incomplete without the mention of all the people without whom this endeavor would have been a difficult one to accomplish. Their constant encouragement, guidance and suggestions have been a source of inspiration to me. I take this opportunity to express my gratitude to all, who have played a role in shaping up this project. This project is dedicated to my parents without whom I could not have reached till here.

I am thankful to **Dr. Ramesh Balasubramanyam**, Radio astronomer in Raman Research Institute, Bangalore, my Guide for his support in my undertaking this project and also for the guidance and support which were instrumental in all the going stages of the project and without whom the project could not have been possible.

I express my sincere gratitude to the members of Mechanical Engineering Services (MES) at Raman Research Institute for all the manufacturing and assembly support. Especially, I wish to thank Mr. Shiva, Mr. Elumalai and Mr. Gopal for their active and enthusiastic participation. I also extend my sincere thanks to the chemistry department in the experimentation process and entire staff of the Raman Research Institute for their help and co-operation in my work.

I am thankful to P. Pandurangan, proprietor, Indo-Tech for their services in bending full lengths of rectangular aluminium sections to arcs of long radius of curvature to satisfactory accuracy. I especially appreciate the dedicated hard work put by Mr. Mahendra in this regard.
I thank all colleagues at the Molecular Astronomy Lab for providing a congenial, friendly and helpful environment.

KURAVI ARUNA

ABSTRACT

Construction of a radio telescope for the observation of radio waves (from 30kHz to 800GHz) is a powerful instrument for the astronomers to see celestial objects in the universe. Sub-millimetre wave band refers to wavelength between 300 micrometres to 3 millimetres .CAD software as mechanical structural designing is mandatory for an innovative idea to final application**. Construction of fan beam telescope** involved computer aided designing (CAD), Manufacturing, Measuring, Testing and validating. Three dimensional modelling and drafting are done in Auto desk inventor 2010.Construction involved selection of material, bill of materials, logistics followed by experimentation (testing, measuring, validating) in manufacturing process to satisfy the functionality based on the design. Measuring, testing and validating required computational analysis involved programing for solving mathematical calculations. Field work in dealing with workshop and manufacturing industries to get the job done was the crucial step.

Accuracy was one of the important factors for the construction of sub-millimetre wave telescopes. The required accuracy for the surfaces and their relative positioning is 10 microns. Since the fourth mirror is envisaged to have its own position control system, the accuracy on the structural elements need only be about 200 microns. M3 support frame and M3 moving frame form tertiary (M3) component have been manufactured after the experimentation. Construction of two major components tertiary (M3) and quaternary (M4) of the telescope was the objective but the M4 has been delayed due to technical reasons.M3 Panel back up profile manufacturing has been experimented and one test piece of panel back was manufactured.

Keywords: Sub-millimetre wave, Construction, CAD, Machining process, measuring, Testing and validating, experimentation, M3 construction, Panel back up experimentation.

LIST OF TABLES

LIST OF FIGURES

Contents

CHAPTER 1

INTRODUCTION

1.1. Introduction

Telescopes need paraboloidal reflectors to collect light. They are mostly alt-azimuth mounted. When the telescope moves in altitude the gravity on the supporting elements change in direction leading to change in deformation. This will lead to shape change. Minimizing such a shape change needs a backup structure. Many of the radio telescopes in the world today use homologous backup structure design, first realized by Robert Leighton at Caltech. In biology, homologous structures are structures that look different but have same embryonic origin eg. Front limb of a human, a cat, a bat and a whale. They change the shape according to the need but serve a similar purpose. A homologous backup structure too allows shape change of the reflector but keeping it to be a (and not the) paraboloid all the while. This means that the reflector always has a focus although this focal point shifts around with respect to the focal axis as the telescope moves in altitude. This restricted freedom reduces the backup structure weight as well as overall distortions allowing operating at higher frequencies. No further technical details of how to go about homologous design are publicly available.

1.2. Motivation

Sometime ago, Prof. B. Ramesh from Raman Research Institute, India, had proposed a new four mirror optics for telescopes [1]. This optical arrangement is completely new and no telescope using this optics exists today. Obviously, such a telescope needs a new structure design. Prof. Ramesh has undertaken the structure design and construction of a prototype telescope as a proof-of-concept. This is an on-going program that began in Mar 2008. This four mirror optical system can be thought of as two optical subsystems, each having a pair of mirrors, arranged back-to-back. The first pair containing the primary and secondary forms an `afocal compandor pair'. The third and fourth mirrors form the `fan-beam pair', which is a telescope in itself. A telescope is a complex system and takes substantial time and resources to design and develop. This M.Tech thesis deals with the development and construction of the fan beam telescope.

1.3. Organization of report

Acknowledgement

Abstract

List of figures

List of tables

Chapter 1 Introduction

Significance and motivation of the project on construction of Fan Beam Telescopes with a new design and concept proposed by B.Ramesh,Raman Research Institute, Bangalore

Chapter 2 Literature Review

This chapter gives an overview about the theory in truss frame structures ,relevant results from basic theory of deflections for beams, Software tools used for the developing the three dimensional detail design modelling ,construction material ,manufacturing process ,mechanical joint involved in fabrication and importance of measurements and qualification from construction point of view.

Chapter 3 Methodology

This chapter describes about the experimentation performed and implemented for the construction of M3 support frame and moving frame. The section gives the process of fabrication cycle dealing material selection and procurement, experimentation processes in joint frames ,bending methods and profile cutting and finally the methods and process developed for the construction of M3 support frame and M3 moving frame.

Chapter 4 Results and analysis

This chapter gives the results of the experiment of construction and qualification analysis of M3 support frame design and M3 moving basket. It gives the results obtained by experimentation and theoretical analysis of test frame from manufacturing point of view. Results and data input of radius curvature and surface undulations of bending measured using Radial measuring unit for the rails of m3 support frame are presented in this section. First order qualification results of M3 support frame and M3 moving frame.

Chapter 5 Conclusion and future scope

This chapter gives a brief summary of the work stated and experimental methods adopted ,its significance to complete fabrication cycle of tertiary(M3) component and stating the future work.

References

Annexures

CAD drawings:-Engineering drawings of test frame designs, support frame ,moving frame and templates

Project Details

CHAPTER 2

LITERATURE REVIEW

Introduction

The mechanical structure design has its basic theory related to the truss frame structures. The design is has to be evaluated both theoretically and practically. There are various tools which are used in order to evaluate the construction process to form the product are introduced. The subsequent sections in this Chapter deal with the following aspects:

2.1. Truss Frame structures: - This section introduces various truss frame structures [4] under use and their theoretical foundation for inter comparison.

For the practical implementation of the design following are the necessary steps:

2.2. Relevant results from basic theory of deflections: - Approximate load transfer and deflection calculations to be computed by using the results from basic theory of deflections [3] for structural elements to be used in the construction of a mechanical design are introduced.

2.3. Software tools: - Manufacturing of various elements need their detailed mechanical drawings to be made. Software tools help in this process. Also analysing measurement results and its presentation, on many occasions require software tools that can do statistical analysis and produce graphical out puts. In this section, we introduce all software tools in this project collectively.

2.4. Material selection: - This section gives an overview of grades of aluminium alloys [6], [4] and sheets. Also describes about the cross sections available and its usage based on the loading conditions. The mechanical properties and stress-strain graph of aluminium alloys is presented.

2.5. Manufacturing process:-Manufacturing process [6] are the critical in constructional process because the product to be transformed from the raw material requires appropriate selection of manufacturing process based on the selection of raw material, precision, availability of machines and cost. This section briefs about the general manufacturing process.

2.6. Mechanical joints: - The second phase of construction involves the assembly which directly relates to the rigidity of structure on application of external loads is the mechanical joint [6]. Therefore classifications of mechanical joints are described in this section.

2.7. Measuring and qualification:- Every manufacturing process has to undergo the quality control unit where the product obtained is tested for its dimensional quantities(design specifications) and these parameters are mathematically computed and verified for the tolerance limit to meet the functionality.

CHAPTER 2

LITERATURE REVIEW

2.1. Truss Frame Structures

A structure is composed of structural members fastened together by permanent joint or temporary joint is a way to resist change in the shape. Structures made up of chain of structural members where a minimum of three members connect form a joint are known to be frame structures. The arrangement of the elements in truss is to support larger load .The members in the truss are joined together by means pinned joint, bolts, rivets etc. Frame structures [4],[5] are widely used in the applications of building constructions, bridges, high ways, towers etc. Some of the truss frame structures are shown below

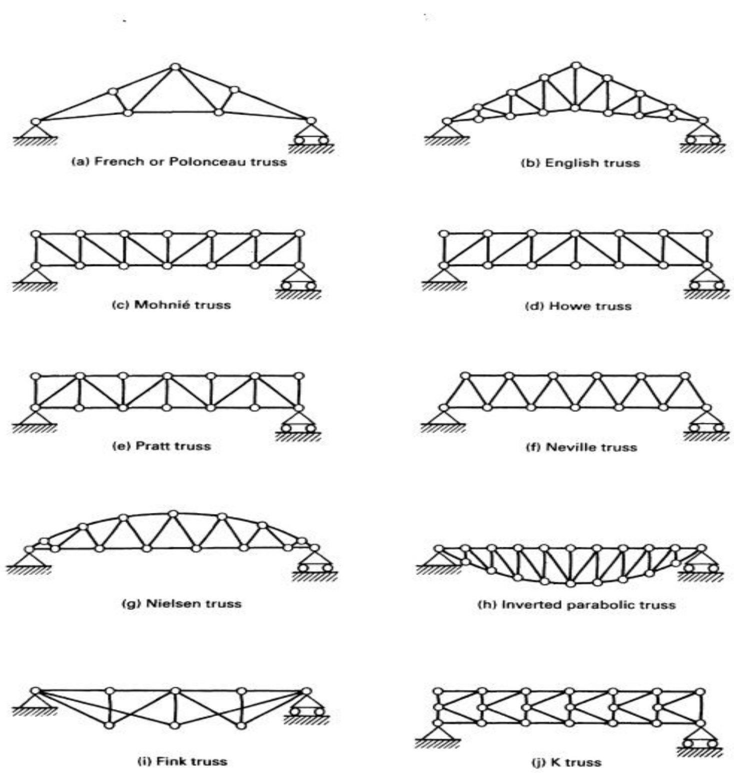


Fig1 Standard truss frame structures

These truss frame structures can be determinate or indeterminate based on the arrangement of its structural members.

2.1.1. Determinant and Indeterminate truss frame structure

A relation between the number of members 'm' and number of joints 'j' in a truss frame structure is $nj=m+r$ for determining whether a structure indeterminacy[3],[5], there fore

- If $nj<m+r$ there are more members than the independent equations so the truss is statically

indeterminate. Also if nj>m+r it's a statically indeterminate truss as all the forces in its members as well as in the reactions cannot be determined by using equilibrium equations.

- If nj=m+r, the number of members equal to than independent equations so the truss is statically determinate so all the forces in its members and reactions can be determined by using equilibrium equations.

There exist two kinds of stability in a truss frame structures depending on the determinacy conditions

Internal stability:-The number and arrangement of member is such that truss does change its shape when detached from a support.

External instability:-Instability due to insufficient number or arrangement of external support.

When m<nj-r, truss is internally unstable and m≥ nj-r, truss is internally stable provided it is geometrically stable.

Statically indeterminate structures in practice because they result in smaller stresses and greater stiffness (smaller deflections) and also introduce redundancy, which may insure that failure in one part of the structure will not result in catastrophic or collapse failure of the structure. The main disadvantages being self-strained due to temperature changes and fabrication errors.

The load bearing capacity of designed structured frame mainly depends on the distribution of load on application of external load. The forces experienced by a structure are classified as internal forces and external forces. These forces are due to various its change of its intermolecular structure of molecules, dead weight, environmental. The effect of the various kinds of loads leads to development of internal stress, deformations etc. The basic forces which act on the structure would be

- Tensile force:-A body subjected to two equal and opposite pulls inducing tensile stress and strain.
- Compression force:-A body subjected to two equal and opposite pushes inducing compressive stress and strain.
- Shear force:-A body subjected to two equal and opposite forces which act tangential to the resisting section inducing shear stress and strain.

2.1.2. Effect of the forces:-deformation

Deformation which is a change in the shape or size of an object due to an applied force. These deformations for beams and columns are calculated by the Simple bending theory [3],Euler's column theory, etc. Vibration is one effect which is caused because of the rotating components.

Any structure is essentially made up of only a small number of different types of elements:

- Columns:-Elements that carry only axial force - either tension or compression - or both axial force and bending (which is technically called a beam-column but practically, just a column). The design of a column must check the axial capacity of the element, and the buckling capacity.
- Beams: - An element in which one dimension is much greater than the other two and the applied loads are usually normal to the main axis of the element.
- Shells:-They derive their strength from their form, and carry forces in compression in two directions.

2.2. Relevant results from basic theory of deflections

Approximate load transfer and deflection calculations to be computed are based on the results from basic theory of deflections for structural elements are introduced below

2.2.1. Simple bending theory

Bending theory[3] relates the moment to the beam’s curvature, deflection and stress.

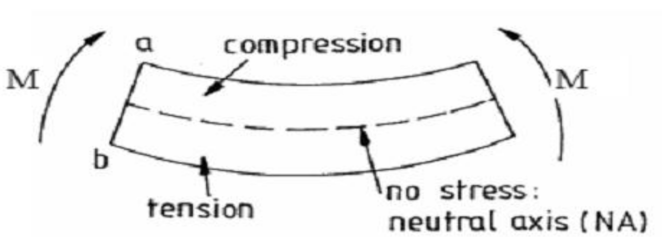


Fig 2 Beam subjected to bending moment

When a beam is subjected to a bending moment M :

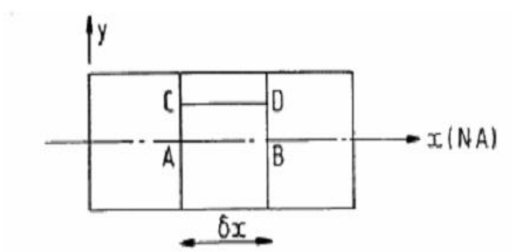


Fig3 Elemental part of beam

Consider a section of a beam subjected to pure bending:

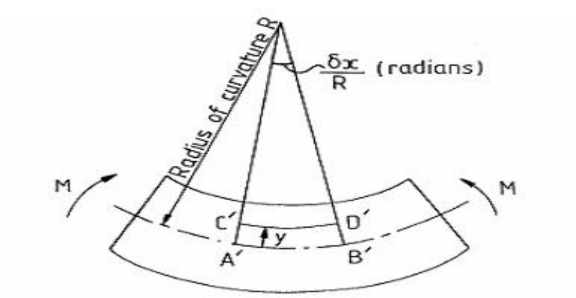


Fig 4 Elemental part of beam subjected to pure bending

AB=CD=A'B'=δx

C'D'=(R-y)(δx/R)

Strain in C'D'=(C'D'-CD)/CD= ((R-y)(δx/R) -δx)/δx

Hence strain distribution:

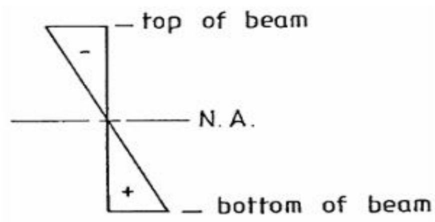


Fig 5 Strain distribution diagram

If linear-elastic: σ = Eε (Stress ∝ Strain)

Therefore

σ=-(Ey)/R

Hence stress distribution:

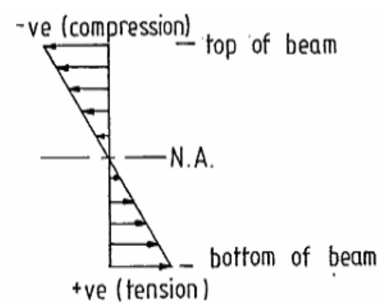


Fig 6 Stress distribution diagram

2.2.1.1. Neutral axis position

Considering beams that have symmetrical cross-sections about the axes i.e. rectangular and circular cross-section beams and I beams with flanges of equal size. For all beams of these types, the neutral axis is at mid height of the section. For beams that are not symmetric, the neutral axis position has to be calculated by considering the total axial force acting across the section, which is zero when there is pure bending.

2.2.1.2. Moment equilibrium

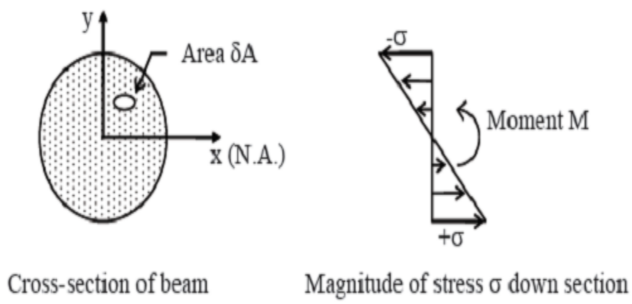


Fig 7 Stress distribution of a circular cross section

Axial force on area δa=σδa

Therefore moment of force on area about N.A=yσδA

Total moment M=-∫ yσδA

(Integral indicates integration over the whole area)

(-ve due to sign convention. +ve moment when there is a stress decrease in y direction)

$$\boxed{\frac{M}{I} = \frac{E}{R} = -\frac{\sigma}{y}}$$

2.2.1.3. Deflection of beams

The deformation of a beam[3] is expressed in terms of its deflection from its original unloaded position. The deflection is measured from the original neutral surface of the beam to the neutral surface of the deformed beam. The configuration assumed by the deformed neutral surface is known as the elastic curve of the beam. There are various methods of obtaining the deflection and one of them described below is double integration method.

1/R=M/EI

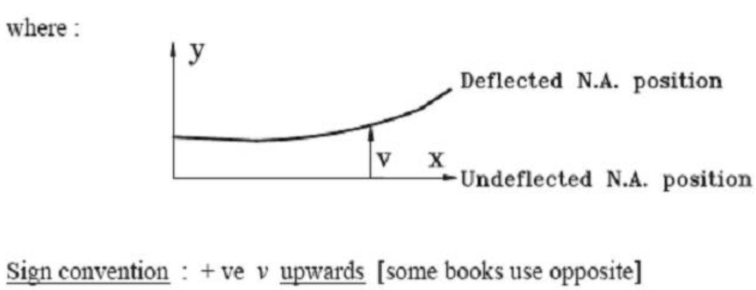


Fig 8 Deflection curve

small deflections are assumed such that 1/R=d2v/dx2

$$\therefore \ Beam\ curvature\ \frac{\partial^2 \vartheta}{\partial x^2} = \frac{M}{EI}$$

$$Beam\ slope\ \frac{\partial \vartheta}{\partial x} = \int \frac{M}{EI} dx$$

$$Beam\ deflection\ \vartheta = \int \left(\int \frac{M}{EI} dx \right) dx$$

$$Beam\ Moment\ M = EI \frac{\partial^2 \vartheta}{\partial x^2}$$

The above is the basic equation is used for various types of beam cases and the type of loading condition. Among them two which are used are mentioned below

Case A: Deflection of a simply supported beam with a centre load.

A simply supported beam AB of length L loaded with centre point load W as shown in the fig below

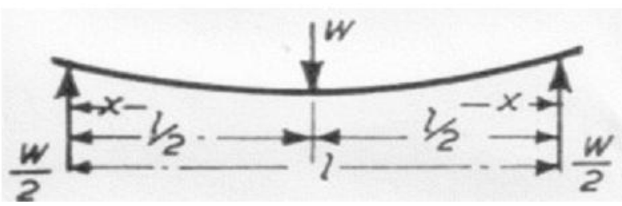


Fig 9 Free body diagram of simply supported beam with centre point load

Considering a section at distance x from point A such that x varies from 0 to L

Ra=Rb=W/2

Bending moment about this section is Mx=Ra*x=(W/2)*x

we also know that the bending moment equation is given by

$$Beam\ Moment\ M = EI \frac{\partial^2 \vartheta}{\partial x^2}$$

substituting M in the above equation and rearranging the terms we get

$$EI \frac{\partial^2 \vartheta}{\partial x^2} = \frac{W}{2} X$$

up on integration we get

$$EI \frac{\partial \vartheta}{\partial x} = \frac{W}{2} \times \frac{X^2}{2} + C_1$$

C1 is an integration constant whose value can be obtained by applying the boundary condition

at x=l/2,slope is zero(as maximum deflection is at centre where slope will be zero. On substitution we get

$$0 = \frac{W}{4}\frac{l^2}{4} + C_1$$

therefore

$$C_1 = -\frac{Wl^2}{16}$$

so the above is a slope equation from which we can find slope at any point on the beam, slope is maximum at A where x=0

$$EI\theta_A = -\frac{Wl^2}{16}$$

$$\theta_A = -\frac{Wl^2}{16EI}$$

since the load is applied symmetrically slope at A is equal to slope at B.

Up on integrating the slope differential equation we get the slope at any point as

$$EI\vartheta = \frac{W}{4}\frac{X^3}{3} - \frac{Wl^2}{16}X + C_2$$

C2 is an integration constant whose value is obtained by applying the boundary conditions as x=0 slope is zero, which implies that the second integration constant is zero, hence deflection is maximum at the centre at x=l/2

$$\vartheta = -\frac{Wl^3}{48EI}$$

Negative sign shows that deflection is downwards.

Case B: Deflection of a cantilever beam with an end point load.

Cantilever beam is a beam that is only supported on one of its ends. The beam bears a specific weight on its open end as a result of the support on its enclosed end, in addition to its structural integrity.

Consider a cantilever beam AB with an end point load W at point B as shown in the figure below.

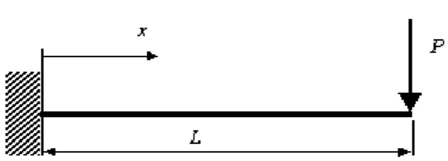


Fig 10 Cantilever beam with end load

Consider a section X at distance x from the point A. Then the bending moment at this section is given by Mx=-W(l-x)

Substituting in the bending moment equation we get

$$EI\frac{\partial^2\vartheta}{\partial x^2} = -Wl + Wx$$

up on integration

$$EI\frac{\partial\vartheta}{\partial x} = -Wlx + W\frac{x^2}{2} + S_1$$

further integration results in

$$EI\vartheta = -Wl\frac{x^2}{2} + W\frac{x^3}{6} + S_1x + S_2$$

where S1 and S2 are integration constants whose value is obtained by applying the boundary conditions. At x=0, deflection is zero, substituting these values in deflection equation we get S2 equal to zero. Similarly at x=0, slope equal to zero, substituting these values in slope equation we get S1 equal to zero. Therefore the slope equation becomes

$$EI\frac{\partial\vartheta}{\partial x} = -Wlx + \frac{Wx^2}{2}$$

Slope is maximum at the free end when x=l

$$\theta_B = -\frac{Wl^2}{2EI}$$

and defection equation

$$EI\vartheta_B = -W\left(\frac{lx^2}{2} - \frac{x^3}{6}\right)$$

hence maximum deflection at free end is at x=l

$$\vartheta_B = -\frac{WL^3}{3EI}$$

negative sign shows that deflection is downwards. There for a cantilever beam both slope and deflection are maximum at the free end.

2.2.1.4. Bending to radius of curvatures

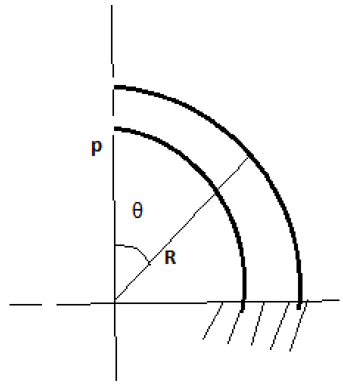


Fig 11 Free body diagram of a beam bent in arc of radius R

P= load in horizontal direction, O= Centre of the circle,Θ=Angle,R=Radius,M=Bending moment

Resolving the forces horizontally and vertically

$F_x= -P\cos\theta$:$F_y=P\sin\theta$

Bending moment about the fixed end is

$M= -PR\sin\theta$

Therefore by using simple bending theory we can find the stress

$f/y=E/R=M/I$

2.3. Software tools

2.3.1. Introduction

In the present day scenario engineering design processes is more inclined to prototyping in order to meet high requirements of performance, efficiency, concept, testing and cost. It is enabled by software available for different engineering domains which is essentially the pre requisite. Specialized soft wares tools are used for specific domain, for example Automobile, Aerospace, Mechanical, electrical, mechanical hydraulic and control, and every tool uses specific formats for the model representation. Following are the software used for in the project.

2.3.2. Autodesk Inventor 2010

Autodesk Inventor[6] provides a detail set of 3D mechanical CAD tools for producing, validating, and documenting a complete digital prototype. Prototyping helps to visualize, simulate, and analyse how a product or part works under real-world conditions before it is built. The software is enabled with various environment mangers that are user friendly. Auto Desk inventor 2010 version is being used for the design.

Autodesk Inventor 2010 has four basic modules namely part, assembly, drawing and presentation .Part has a two dimensional and three dimensional workbenches for designing any type of component as per the dimensions. These components are taken into the assembly module for assembly of all individual components to make a complete product using assembly tools. Machine drawings are done in drawing module contented with the drafting features for manufacturing process. Presentation module gives the exploded view of the component to make technical documentation (Technical publications). They also provide the basic as well as specified calculations of a structure. These files by default save in .ipt,.iam and .dwg extension but can be saved in other interface format like .IGES,.STEP,.dwf,.dwx etc extension to open in other software. By this it enables an interface to convert the file to same extension of CAM and used.

2.3.3. Autocad mechanical 2010

AutoCAD Mechanical[6] is a 2D mechanical design and drafting solution for engineers, designers, and manufacturers. It provides a numerous innovative 2D design features by tools as well as programing. It is a user friendly and a basic software enabled with command features to create any two dimensional complex curve. Auto cad is an inter phase software used in CAM for CNC machining, Laser cutting and many other. Since it's inter phase it can convert any file format to the CAM files. Autodesk inventor has a link of AutoCAD mechanical 2010 where the drawings files can be modified in the drawing workbenches for machining process.

2.3.4. Xmgrace

Xmgrace is two dimensional graph tool used for mathematical computations. It can be used from a point-and-click interface or scripted in the form of built-in programming language. It performs both linear and nonlinear least-squares fitting to arbitrarily-complex user-defined functions, with or without constraints. Other analysis tools include FFT, integration and differentiation, splines, interpolation and smoothing.

2.4. Material selection

Aluminium is third abundant metal available in earth's crust in the form bauxite ore. The application of alloys of aluminiumin[6] manufacturing technology is makeable. Depending on the strength and durability they have wide range of aluminium alloys .Aluminium Alloys can be divided into nine groups as listed below in the table.

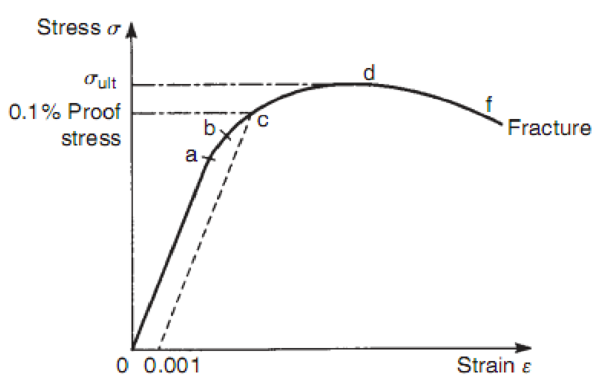
Designation	Major Alloying Element

1xxx	Unalloyed (pure) >99% Al
2xxx	Copper is the principal alloying element, though other elements (Magnesium) may be specified
3xxx	Manganese is the principal alloying element
4xxx	Silicon is the principal alloying element
5xxx	Magnesium is the principal alloying element
6xxx	Magnesium and Silicon are principal alloying elements
7xxx	Zinc is the principal alloying element, but other elements such as Copper, Magnesium, Chromium, and Zirconium may be specified
8xxx	Other elements (including Tin and some Lithium compositions)
9xxx	Research is still going on.

Table 1:-Grades of aluminium alloy

2.4.2. Stress and strain of aluminium alloys

Aluminium alloys are ductile materials, although their stress– strain curves[4] do not have the distinct yield stress of mild steel. A typical stress–strain curve is shown in Fig. The points ‘a’ and ‘b’ again mark the limit of proportionality and elastic limit, respectively, but are difficult to determine experimentally. Instead a proof stress is defined which is the stress required to produce a given permanent strain on removal of the load. In the figure below, a line drawn parallel to the linear portion of the stress–strain curve from a strain of 0.001 (i.e. a strain of 0.1%) intersects the stress–strain curve



at the 0.1% proof stress. For elastic design 0.2% proof stress, is taken as the working stress.

Fig 12 Stress- strain curve of aluminium alloy

Fracture of aluminium alloy test pieces results in the formation of a ‘double cup’ as shown in Fig. below, implying that failure was initiated in the central portion of the test piece while the outer surfaces remained intact. Again considerable ‘necking’ occurs. In compression tests on aluminium and its ductile alloys similar difficulties are encountered to those experienced with mild steel. The stress–strain curve is very similar in the elastic range to that obtained in a tensile test but the ultimate strength in compression cannot be determined in design its value is assumed to coincide with that in tension.

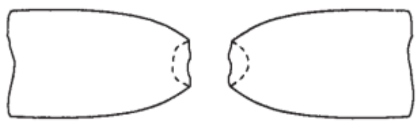


Fig 13 Double cup failure of an aluminium test piece

Aluminium alloys can suffer a form of corrosion particularly in the salt laden atmosphere of coastal regions. The surface becomes pitted and covered by a white furry deposit. This can be prevented by an electrolytic process called anodizing which covers the surface with an inert coating. Aluminium alloys will also corrode if they are placed in direct contact with other metals, such as steel. To prevent this, plastic is inserted between the possible areas of contact.

2.4.3. Cross sections

Materials are in general drawn into tubes(both solid and hollow) and sheets with varying cross sectionals shape[4] and chosen as per force requirements subjected.

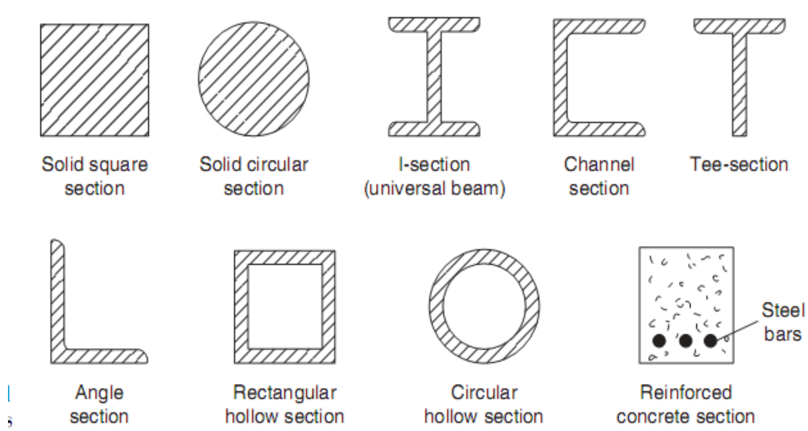


Fig 14 Structural element cross section

2.4.3.1. Solid sections

The solid square (or rectangular) and circular sections are not particularly efficient structurally. Generally they would only be used in situations where they would be subjected to tensile axial forces (stretching forces acting along their length). In cases where the axial forces are compressive (shortening) then angle sections, channel sections, Tee-sections or I-sections would be preferred.

I-section and channel section beams are particularly efficient in carrying bending moments and shear forces.

2.4.3.2Hollow sections

The rectangular hollow (or square) section beam is also efficient in resisting bending and shear but is also used, as is the circular hollow section, as a column. A Universal Column has a similar cross section to that of the Universal Beam except that the flange width is greater in relation to the web depth.

Concrete, which is strong in compression but weak in tension, must be reinforced by steel bars on its tension side when subjected to bending moments. In many situations concrete beams are reinforced in both tension and compression zones and also carry shear force reinforcement.

Other types of structural element include box girder beams which are fabricated from steel plates to form tubular sections; the plates are stiffened along their length and across their width to prevent them buckling under compressive loads. Plate girders, once popular in railway bridge construction, have the same cross-sectional shape as a Universal Beam but are made up of stiffened plates and have a much greater depth than the largest standard Universal Beam.

2.4.4. Sheet Metal

Sheet metal is simply metal formed into thin and flat pieces which can be cut and bent into a variety of different shapes[6]. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6mm (0.25in) are considered plates. There are many different metals that can be made into sheet metal, such as aluminium, brass, copper, steel, tin, nickel and titanium.

Sheet metal has applications in car bodies, airplane wings, medical tables, roofs for buildings and many other things. Sheet metal of iron and other materials with high magnetic permeability, also known as laminated steel cores, has applications in transformers and electric machines.

The four most common aluminium grades available as sheet metal are 1100-H14, 3003-H14, 5052-H32, and 6061-T6.

- **Grade 1100-H14** is commercially pure aluminium, so it is highly chemical and weather resistant. It is ductile enough for deep drawing and weldable, but low strength. It is commonly used in chemical processing equipment, light reflectors, and jewelry.
- **Grade 3003-H14** is stronger than 1100, while maintaining the same formability and low cost. It is corrosion resistant and weldable. It is often used in stampings, spun, mail boxes, tanks and fan blades.
- **Grade 5052-H32** is much stronger than 3003 while still maintaining good formability. It

maintains high corrosion resistance and weldability. Common applications include electronic chassis, tanks, and pressure vessels.

- **Grade 6061-T6** is a common heat treatable structural aluminium alloy. It is weldable, corrosion resistant, and stronger than 5052, but not as formable. Note that it loses some of its strength when welded.

2.5. Manufacturing process

Manufacturing is a process of building a product from raw material as per the engineering design data specifications using of machines and tools. Depending on the material properties, accuracy and design machining process varies with complexity. With the evolution of industrial techniques and increase in sophistication of customer demands, modern manufacturing processes came into existence and have evolved over a period of time which are CAM. Following are the basic manufacturing process [6] which are semi-automatic.

2.5.1. Cutting machines

The machine is hacksaw power belt driven unit for cutting long beams without the length being restricted to frame. A power hacksaw (or electric hacksaw) is a type of hacksaw that is powered either by its own electric motor or connected to a stationary engine.

2.5.2. Milling machines

A milling machine is a machine tool (end mill) used to machine solid materials. Milling machines are often classed in two basic forms, horizontal and vertical, which refer to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the work piece stationary as the drill moves axially to penetrate the material, milling machines also move the work piece radially against the rotating milling cutter, which cuts on its sides as well as its tip. Milling machines can perform a vast number of operations, from simple (e.g., slot and key way cutting, planing, and drilling) to complex. Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf.

2.5.3. Drilling machining

A drilling machines drills holes on the work piece. A radial arm drill press is a large geared head drill press in which the head can be moved along an arm that radiates from the machine's column. As it is possible to swing the arm relative to the machine's base, a radial arm drill press is able to operate over a large area without having to reposition the workpiece. The size of work that can be handled may be considerable, as the arm can swing out of the way of the table, allowing an overhead crane or derrick to place a bulky piece on the table or base. A vise may be used with a radial arm drill press, but more often the workpiece is secured directly to the table or base, or is held in a fixture.

2.5.4. Turning

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. On changing the orientation of the tool post and the tool taper turning, facing, parting and threading are performed on the work piece

2.5.5. Bending

Bending is a process by which metal can be deformed plastically and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change much. Bending usually refers to deformation about one axis. There are various types of bending methods used which vary as per the application and requirement.

2.5.5.1. Three Point Roller bending

Bending a piece of metal by placing the specimen in between three rollers which are in a
triangular shape. The shaft is powered by motor and a gear which makes the rollers to roll and compresses the specimen to follow the circular profile. This a general standard technique used for bending. Since the radius obtained from template bending has variations of radius more than 20mm.It undergoes the three point roller bending at very small regular steps to match with the arc of desired radius.

2.5.5.2. Template Bending:-The tube is bent by a combination of manual force and mild heating, held in position by clamps to avoid relaxation while cooling. A mild Steel strip of reasonable thickness is bent to radius of around (+5mm) is fixed along with the supports to the mild steel table by welding. Application of heat at the edges of the specimen by Qxyflame torch (blue flame). During application of heat for long distances, the uniformity of heating along the member should be maintained as the material becomes soft and can be bent by manual force by an iron rod at the other end to obtain the curvatures. Clamps are incorporated after manual force to the MS profile template. It is unclamped after some time so that the tube relaxes and attains the profile is obtained.

2.5.6. Water jet cutting

Water jet cutting is a process of slicing into metal or other materials (such as granite) using a jet of water at high velocity and pressure, or a mixture of water and an abrasive substance[6]. It is a preferred method, when the materials being cut are sensitive to the high temperatures generated by other methods. It has found applications in a diverse number of industries from mining to aerospace where it is used for operations such as cutting, shaping, carving, and raeming. The cutter is commonly connected to a high-pressure water pump where the water is then ejected from the nozzle, cutting through the material by spraying it with the jet of high-speed water. Additives in the form of suspended grit or other abrasives, such as garnet and aluminium oxide, can assist in this process.

2.6. Mechanical joints

2.6.1. Introduction

Joining of two or more structural elements is a fabrication process step to form a structured assembly product as per the assembly design. The kind of joining[6] depends on the assembly to satisfy the loading conditions subjected, relative motion of the element with respect to other ,properties of the structural members. There are three types of joining methods namely

- **Permanent joint:-**Any structure which once made cannot be disassembled involves permanent joints for example welding, soldering, brazing, moulding etc. Welded joints does not allow for easy disassembly as it uses filler material to form the joint by application of heat and pressure. Any type of welding on a material makes the material to lose its strength by 20% of its original strength. In case of aluminium its 40%. All kind of material don't allow welding because of its mechanical and thermal properties. They are resistant to all the three kind of loads ie axial, compression and shear.
- **Semi-permanent joints**:-An external member used for joining the structural elements such that it gives strength more than a temporary joint and weaker than permanent joint. They can be disassembled by damaging the external member used for joining. They are usually resistant to axial and compressive load except for the shearing for example riveted joints.
- **Temporary joints**:-An external member used for joining the structural elements such that it gives strength less than permanent and semi-permanent. The structure can be disassembled without damaging any structural element. They are usually resistant to axial, compressive load, shearing for example bolted joints. This type of joint allows the maintenance department to easily disassemble the joint when necessary.

2.6.2. Welding

Welding is a fabrication process that joins materials by melting the workpieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld.[6] This is in contrast with soldering and brazing , which involve melting a lower-melting-point material between the workpieces to form a bond between them, without melting the workpieces .Aluminium is the most difficult alloy to weld. Aluminium oxide should be cleaned from the surface prior to welding. Aluminium comes in heat treatable and non-heat treatable alloys. Heat treatable aluminium alloys get their strength from a process called aging which is significant as decrease in tensile strength can occur.

2.7. Measurements and qualification

In every field of engineering, measurement is the most important activity of obtaining and comparing physical quantities of real-world objects and events. [6]Established standard objects and events are used as units, and the process of measurement gives a number relating the item under study and the referenced unit of measurement. Measuring instruments are the means by which data is taken and computed to mathematical equations to the relations of numbers are obtained. All measuring instruments are subject to varying degrees of instrument error and measurement uncertainty. Scientists, engineers and other humans use a vast range of instrument units to perform their measurements.

CHAPTER 3

METHODOLOGY

Introduction

This chapter gives an overview of the methods adopted in the construction of the fan beam telescope**.**

3.1. Material selection and procurement:- This section gives is crucial step where the raw material was chosen and procured after the market survey.

3.2. Experimentation process

This section describes the theoretical and practical steps taken in the frame design, the type of bending method and profile cutting manufacturing.

3.2.1. Joint frame experimentation

3.2.2. Bending methods experimentation

3.2.3. Profile cutting manufacturing method experimentation

3.3. Construction M3 support frame:-This section gives an over view of the process and steps adopted for the fabrication of support frame.

3.4. Construction of M3 moving frame:-This section gives an over view of the process and steps adopted for the fabrication of Moving frame.

3.5. Fabrication panel back up:-This section gives a methodology of process adopted for construction of panel back up.

3.6. M4 construction:-This section deals with M4 construction delay and base frame assembly under construction.

CHAPTER 3

METHODOLOGY

3.1. Material selection and procurement

Aluminium is a light weight, corrosion resistant and easily machinable material than steel. It has two main limitations. Structural limitation being fatigue strength. Unlike steels, aluminium alloys have no well-defined fatigue limit, meaning that fatigue failure eventually occurs, under even very small cyclic loadings. This implies assessment of these loads and design is for a fixed life rather than an infinite life. Thermal limitation of aluminium alloys is their sensitivity to heat. Workshop procedures involving heating are complicated by the fact that aluminium, unlike steel, melts without first glowing red as such not suitable for welding. Aluminium welding reduces the strength of the material by 40% of its original strength. As a raw material aluminium has limitations but when these limitations formed in to appropriate structure can be overcome. Keeping the limitations in view the detail design construction is made to overcome. Commercial grade of aluminium 6061 series has been selected as the major raw material.

3.1.1. Cross section selection: - Rectangular, square and circular hollow sections were selected based on the type of joint selected, load and ease of processing.

3.1.2. Type of mechanical joint selected: - A combination of temporary and permanent joints were selected for the construction of mobile telescope. Bolted joints and welding were chosen to satisfy the functionality. Bolted joints were the most common element in construction process because joint will be designed such that the clamp load acting on the joint causes no relative motion in the joined members. One of the kind of bolted joint do not have a designed clamp load but relies on the shear strength of the bolt shaft. This may include clevis linkages, joints that can move, and joints that rely on a locking mechanism (like lock washer, cir-clips, thread adhesives and lock nuts).

Bolted type of joint design provides several properties:

- Greater preloads in bolted joints reduce the fatigue loading of the fastener.
- For cyclic loads, the fastener is not subjected to the full amplitude of the load; as a result, the fastener's fatigue life can be increased or—if the material exhibits endurance limit extended indefinitely.
- As long as the external loads on a joint don't exceed the clamp load, the fastener is not subjected to any motion and will not come loose, obviating the need for locking mechanisms.

The most common mode of failure is overloading: Operating forces of the application produce loads that exceed the clamp load, causing the joint to loosen over time or fail catastrophically.

Over-torquing might cause failure by damaging the threads and deforming the fastener, though this can happen over a very long time. Under-torquing can cause failures by allowing a joint to come loose, and it may also allow the joint to flex and thus fail under fatigue. Brinelling may occur with poor quality washers, leading to a loss of clamp load and subsequent failure of the joint. Other modes of failure include corrosion, and exceeding the shear stress limit. Bolted joints may be used intentionally as sacrificial parts, which are intended to fail before other parts, as in a shear pin.

Sheet:-Grade of 6061-T6 has been selected as the raw material for panels. The thicknesses selected are between 1 to 2mm for the panel back up.

Agricultural and Industrial Supplies, Bangalore was identified as reliable supplier. The required material was procured and transported using RRI vehicle.

3.2. Experimentation process

3.2.1. Joint frame experimentation

This was a significant step of testing the type of joint for the truss frame structure which involved a team work. It was an iterative process where more than 8 frames were designed in Autodesk inventor 2010 and were manufactured. Three main factors which were taken in to consideration for the joint frame experimentation were

- The available dimensional cross section of the material and thickness variations.
- The rigidity of joint (load bearing capacity, deflection and stability) and weight of the structural joint.
- The machining process feasibility, time consumption, workmen ship.

In the iterative process of fabrication inclined hole drilling was performed and process had consumed much of the time and change of drill bits and the joint which was connected using a combination of rectangular members and a circular member which was not rigid and allowed rotation even after using self-locking threading mechanism. A press fit joint was also fabricated which had not been qualified because three members were connected in such a way that increased its weight and required a careful work as even a small error would make it play. Two frames had been selected after the qualification. Refer three dimensional designing and engineering drawings, done in Auto desk inventor 2010 ,that are presented in Annexures(D1 to D10)

3.2.1.1. Manufacturing procedure adopted

The process is divided into two phases. The first phase involved the machining of the sub components as per the dimensions given in the engineering drawings. The second phase was the assembly procedure.

Phase 1

All the drawings were verified and raw material was made available.

Machining process:- Cutting, milling, facing, step bending, drilling

Procedure

- Marking the geometrical dimensions on the sections and cut the sections as per the dimensions required using chain saw cutting machines.
- Milling machine is used for milling the surfaces that cut.
- A special tool was made for step bending using which the two of the inclined member are step bent after the slot cutting is done providing rolled/curved edges so that metal does not shear at the corner.

Phase 2

Assembly

- Alignment of all the section members as per the design.
- Alignment the holes and put the bolts, nuts and fix is simultaneously for the rest of the structure.

3.2.1.2. Determinacy and indeterminacy of frame

The above frame was tested for point load of 25kg at three different points and the deflections were noted by using a dial gauge. The defection reading obtained was zero which confirmed our test frame structure design and manufactured.

Determinacy of the structure was calculated by using the formula

$m=2j-3$,(two dimensional truss frame)

From the design $m=5$ and $j=4$

On substituting on LHS we have

$= 2*4-3=8-3=5$

This satisfies the RHS where m=5.Therefore LHS=RHS. Hence the structure is statistically determinate structure and stable.

3.2.1.3. Load transfer calculations

Theoretical calculations are done for the 25kg centre load on the frame for the load transfer.

A mid load of 25 kgs is applied at the centre for a fixed supports as shown below

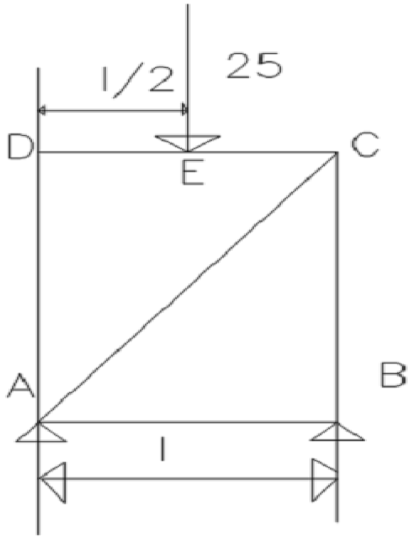


Fig 15 Free body diagram of a truss frame 1 subjected to centre point load.

By using the equilibrium equations we calculate the reaction forces.

$\sum Fy=0;Ray+Rby=25$

$\sum M=0; 25*a/2-Rby*a=0$

ie Rby =25/2=Ray=12.5

Consider the joint B

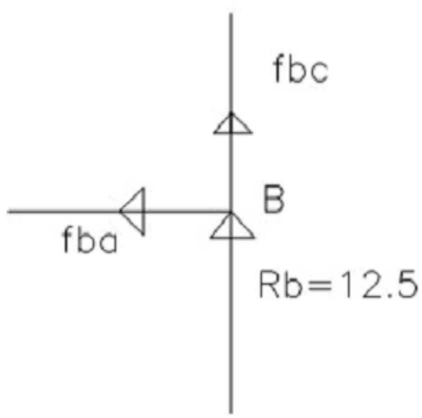


Fig 16 Free body diagram of joint B .

applying equilibrium equations

$\sum Fx=0; fba=0$

$\sum Fy=0;fbc+Rb=0$

fbc=-Rbc=-12.5

ie fab=0 and fbc=-12.5,negative sign indicates the direction is opposite.

Consider joint C

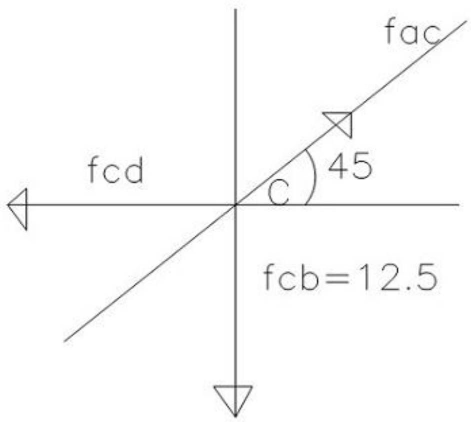


Fig 17 Free body diagram of joint C.

Applying equilibrium equations we get

$\sum Fy=o$; fac sin45-fcb=0

therefore fac=fcb/sin45=12.5√2

$\sum Fx=0$;fac cos(45º)-fcd=0

i.e fcd=fac cos (45º)=12.5

Consider the joint A

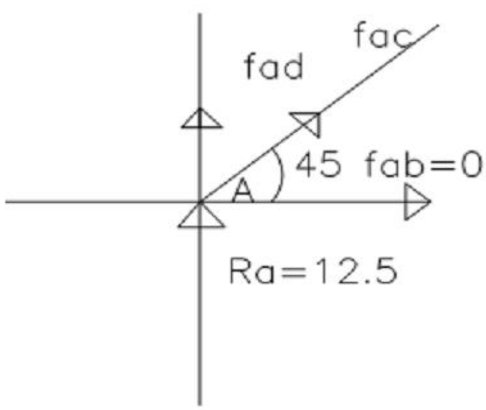


Fig 18 Free body diagram of joint A.

The only unknown quantity is fad. Apply equilibrium equation along y axis

$\sum Fy=0$; fad+Ra+fac sin (45º)=0

.fad=-Ra-fac sin(45º)=-12.5-12.5√2=-12.5(1-√2).Therefore the complete distribution of load in each member is shown below for the frame

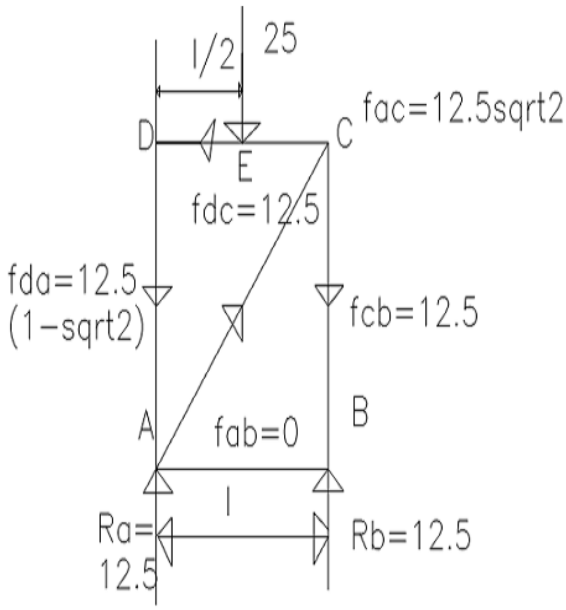


Fig 19 Free body diagram of complete frame with load distribution.

Now the first order bending of the frame was obtained by simplifying the frame to a simply supported beam with a centre point load. Then the deflection would be $WL^3/48EI$.

W=25*9.81=245.25N

L=500mm,E=70000N/mm^2

I=bd^3/12=27*52^3/12=316368mm

deflection = 245.25*(500^3)/48*70000*316368=8.58*10^{-9} mm.

Which means defection is negligible and it can with stand three times more than applied load of 25kgs.

Similarly second frame was also fabricated and its drawings are given in **ANNEXURES** .Since the frame involved only milling operation general steps of manufacturing were adopted.

3.2.1.4. Load transfer calculations for frame 2

Similarly for a second frame, theoretical calculations are done for the 25kg centre load on the frame for the load transfer.

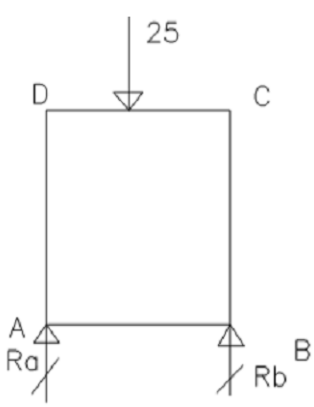


Fig 20 Free body diagram of truss frame 2 with centre point load.

A load of 25 kgs is applied at centre as shown above. By using the equilibrium equations we calculate the reaction forces.

$\sum Fy=0; Ray+Rby=25$

$\sum M=0;\ 25*a/2-Rby*a=0$

ie $Rby=25/2=Ray$

Consider the joint A

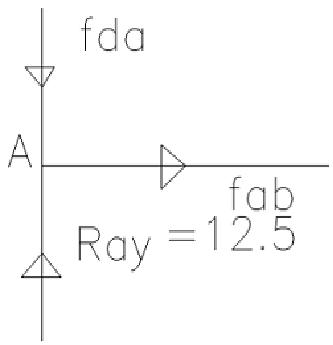


Fig 21 Free body diagram of joint A.

applying equilibrium equations

$\sum Fx=0; \sum Fy=0$

ie fab=0 and fda=Ray=12.5kgs,since the frame is symmetric about y axis and x axis

we have fda=fcb=12.5Kgs.

The load transfer in all the members is shown below

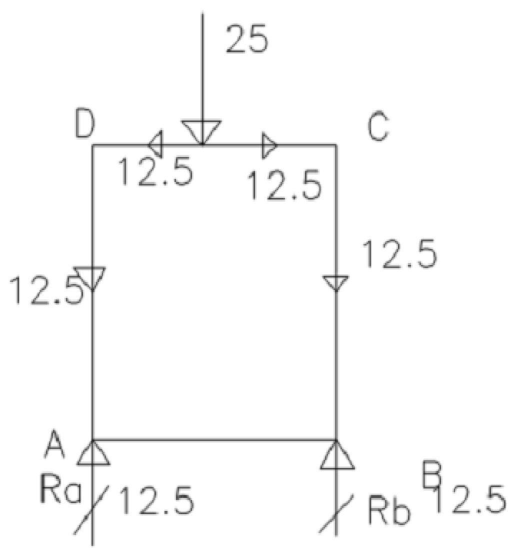


Fig 22 Free body diagram of complete truss frame 2 with load distribution.

So the deflection could be found by isolating the frame as simply supported beam with centre point load. Such that deflection is given by $WL^3/48*EI$. It will be same as the above of negligible deflection.

3.2.2. Bending methods experimentation

Long radius bending for aluminium hollow sections was the next critical step which involved bending industry survey .As process involved in the making top and bottom rail was long radius bending involved careful testing in terms of accuracy. The bending was performed at Indo tech industry by using their three point roller bending machine. In order to test the obtained radius of curvature and surface undulations, a one meter hollow rectangle section (52*27*3mm) was bent (Three point roller bending) to an inner radius of 2490 mm. With help of Radial Measuring Unit (RMU) readings were taken and computed the radius as 2522mm with surface undulations of 1.8 mm .Similar bending was performed on hollow rectangular section (52*27*2mm) of 500 mm long. In order to obtain the same curvature. They both were fixed together by end welding. But the process did not work out as they had buckled internally. So a aluminium rectangular section of (52*27)of 3mm wall thickness was chosen. The results from the bending experimental process was analysed and various opinions were taken which are as follows

- Change of the rollers on bending machine.
- A prototype of bending machine was proposed by my guide for the specified task.
- Reduction of speed and number of steps given as input on the three point bending machine.
- Template bending was suggested by Indo tech industries.
- Necessary steps were taken in the process to obtain the desired radius with minimum surface undulations by using a combination of template bending and three point roller bending.

3.2.2.1. Procedure and theory behind measuring the radius of curvature using Radial Measuring Unit.

To know the approximate radius and deflections along the length of the tube a Radial measuring unit is used. It measures the outages at the equal interval along the length using dial gauge. The radial measuring unit can measure up to 10mm depth. The centre of the arc, radius is approximated and arm and axial is adjusted. The adjusted radius of the arm, chord length of the arc is measured carefully and the readings are taken for the analysis.

Mathematical analysis

Chord of the circle=C

Radius of the circle=R

Angle=θ

$C=2*R\sin\theta$

From the above expression theta (θ) is calculated with chord length and radius as known parameters.

The equation of a circle assuming the centre to at origin is given by

$X^2+Y^2=R^2$

Such that $X=R*\cos\theta$

$Y=R*\sin\theta$

Assuming that there is a shift in the centre of the circle

Then equation of the circle becomes

$(X-Xo)^2+(Y-Yo)^2=R^2$

By using on nonlinear curve fitting technique [6] the given set of points are fit to a curve using least square principle

$L(X, Y, R) =\sum (sqrt ((X-Xo)^2+(Y-Yo)^2)-R)$

$dL/dR=-2\sum (sqrt ((X-Xo)^2+(Y-Yo)^2+2*n*R)$

$dL/dX=2*r\sum(X-Xo)/ \sum (sqrt ((X-Xo)^2+(Y-Yo)^2)-2*n*X+2*n*X0$

$dL/dY=2*r\sum(Y-Yo)/ \sum (sqrt ((X-Xo)^2+(Y-Yo)^2)-2*n*Y+2*n*Y0$

The above mathematical manipulation for a large set of points is done in shell scripting programing language with output of plots and transformations in Xmgrace.

3.2.3. Profile experimentation

The conceptual design of the panel back up to be in the form of criss cross with vertical members and longitudinal parabolic profile members was proposed by my guide. For the demonstration of the design of panel back to MES division at Raman Research institute, a transparency sheet of 200 microns provided with in between vertical members made up of sticks was made and longitudinal members of made of transparency sheet. It could retain the shape of the profile jig.

The actual panel back is to be made of thin aluminium sheets of 1mm thickness .The difficulty in the process was in obtaining the parabolic shape on a 1mm sheet with less cost, so chemical etching was tried out in RRI chemistry lab .A 1mm aluminium sheet clamped in between two M.S discs and bolted at the centre was immersed in to a an alkaline etching solution with 5% NaOH .Etching time was 3 hours and the solution had penetrated in between the disc and etched up to 2mm with very sharp corners. Then plastic tape was fixed and tested in the solution and it was found tape does not react with solution and seeps into as exposed time is more. So a transparency sheet was cut to disc dimension and the aluminium sheet of 1mm was placed in between transparency sheets and two circular discs. Then also the solution had penetrated in between the disc and etched up to 1.2mm with very sharp corners. Another attempt was with a combination of rubber sheet, transparency sheet cut to disc profile and aluminium sheet was placed and concentration was increased to 10% then also the solution seeped and etched up to 1mm with sharp corners. So the process was discarded as it took lot of time for etching, the solution used to turn black because of the type of aluminium material and more importantly was not satisfying our precision levels.

Since it did not work for circular profile it would not give for a parabolic profile. A modified design for the profile cutting machine using the milling machine was proposed by my guide and drafting was done by me but it could not be manufactured by our MES because it would take lot of time. So water jet cutting was suggested by them and the process took place.

3.3. Construction of M3 support frame

Group of people were involved in the construction of M3 support frame. This construction was planned and careful steps were followed to bring it to completion and qualification.

A combination of two test frame designed was used for the M3 support frame. This component of the telescope would form the basis of joint construction procedure for the rest of the components of 3meter sub millimetre wave telescope.

M3 support frame has following sub-components

- Top and bottom rail
- Interlinking U-support frame
- Inclined member

The process of theoretical analysis, construction and qualification form starts with the CAD designing of M3 support frame and the sub components.

CAD Designing and engineering drawings are to be referred in **Annexures (D11 to D20).**

The construction involved fabrication of individual components followed by individual qualification and finally assembled and verified.

3.3.1. Top and bottom rail

Material was procured and transported to Indo tech in the RRI vehicle.

Long radius bending of the top and bottom rail was first taken up and done at Indotech and procedure followed is briefed below

A 1:1 arc profile template of the radius desired were printed on A3 sheets, aligned carefully and fixed together. This was used as a reference to check if the arc is bent to the desired radius and accuracy. An M.S strip was nearly bent to the 1:1 arc profile template by using Three Point bending and then template bending was performed. Again work piece was matched to the 1:1 arc profile by giving a small step feeding in the three point bending method.

Total of six full lengths were bent, three of inner radius of 2080mm and rest of 2490mm.8 sets of data points were taken using the radial measuring unit among them four sets are presented in the result and analysis. The top two rails needed 1mm accuracy and were obtained to be around 1.2mm.

3.3.2. Interlinking U- frame

The second step involved in the construction of M3 support was fabrication of 12 sets of interlinking U frames and to be qualified. These frame were fabricated at Indo-Tech .Fabrication process is briefed below

3.3.2.1. Template preparation

In order to obtain same dimensional slot maintaining the constant distance between the slots a 1:1 paper templates were prepared, stuck and aligned. Since the vertical member had four different slots a complete three dimensional view 1:1 profile was made.

1:1 paper templates were fixed to the members after cutting it to required lengths. These templates were used as reference and the milling operation was performed. A wooden jig was made by sticking four wooden blocks properly sized, on a wooded board mounting them with proper separation, alignment and orthogonality among them. This reference wooden jig was used to make "identical" U frames by inter locking the members after appropriate slot cutting and machining. Holes were drilled in-suit to bind them into a set. Each set was given the numbered along with individual member before disassembly. All the engineering drawing are to be referred in the **Annexures (D20)**.

3.3.3. Inclined member

The third step involved in the construction of M3 support was fabrication of 26 inclined members. These frames were fabricated at RRIs Mechanical Engineering Services. Fabrication process is briefed below

As per the design inclined member had step bending on the both sides and ends so step bending technique tool was prepared by Mechanical Engineering Service workshop at Raman Research Institute. The machining process involved cutting, milling and step bending. For connecting each of the frames (side by side), a total of 28 inclined members are machined and step bent.

All the 26 inclined members were first cut to the desired length and 1:1paper templates were made and fixed with proper alignment. Taking the line on the template as the reference all the inclined members were step bent on both sides and both ends.

This completed the fabrication and qualification of individual components of M3 support frame. The next step was assembly.

3.3.4. Assembly of M3 support frame

The assembly process of M3 support frame was very critical and was done at Mechanical Engineering workshop, Raman Research Institute, Bangalore. The process took two days to complete the assembly and its mounting. M3 support frame has two frames. All the members were verified as per their dimensions and for the ease of marking the points,1:1 paper drilling templates were made, printed and stuck. Both bottom and top rails were cut as per the assembly drawings and tight fit joint was made by inserting wooden block. The distance between the two vertical members with in between the inclined member was fixed by making two 1:1 wooden triangular templates using engineering design. One was the upper triangle and other was lower triangle of frame. The members were inserted as per the numbering and in-suite drilling was done in order to maintain perpendicularity of the holes to be drilled and bolted. As paper templates were made for drilling the holes, it was easy to maintain the uniformity throughout the frame. An assembly drawing was made giving an idea how all the members are to be linked to form the frame.

After the completion of first frame all the top and bottom horizontal members were bolted as per their numbering and the second frame was placed to maintain the alignment and then only the process was repeated as for the first frame. All the bolted joints were tightened completing the construction of M3 support frame and mounted.

All the drawings including template and assembly to be referred **Annexures (D17 to 24)**

3.4. Construction of M3 moving frame

The next component to be constructed in fan beam telescope was M3 moving frame which is the moving component on the rails of M3 support frame. It construction cycle starts with fabrication and qualification of individual component followed by the assembly.

M3 moving frame basket has following components.

- Two frames with joining members as the columns.
- Wheel assembly.
- Panel back up.

This also involved a group of people which was planned and the construction was completed. The conceptual design of the moving basket was converted to detailed design using Auto desk inventor appropriate drawings were made for its construction. All drawings were made ready and material was estimated and procured. All the members were cut to length.

The process started with vertical and horizontal members which involved milling operation. So 1:1 paper printed template designs were made and fixed with care full alignment and numbered. The milling operation was performed taking them as the reference and were slot dimensions and distances among the slots were qualified using Vernier Callipers.

The process was followed by circular members which were bent to a radius of 904mm at Indo tech following the same process of top rail and bottom rail of M3 support frame. and 1:1 template verification was satisfied. The next component of M3 moving frame was inclined member.

8 inclined members in the frame had one step bend in which there was a bit modified and one side bending (4mm) was done instead of two sides on both the ends with templates as the references and the process as followed for the inclined members of the M3 support frame. The horizontal and arcs members were also step bent on a side with 1:1template reference lines.

All the engineering drawings including template and assembly to be referred **Annexures(D25 to 49)**

All the members were verified and assembly procedure was planned.

3.4.1. Assembly of M3 moving frame

The assembly procedure was done similar to that of M3 support frame. Wooden templates as reference for maintaining on spacing between the members were made and the members were adjusted and in-suit drilling was done and bolted. The interconnecting circular axle (brass plug inserted and 7mm threading for bolting) was made self-locking to main the distance.

After the frame was done we had identified an mistake, that the in between distance of the two M3 support frame was supposed to be 330mm but it was 288mm.So two major modifications had to be made; one on the arrangement of wheels of the wheel assembly and the second being on the panels. The outer end panels have to be of width 200mm and others one would be 250mm.

3.4.2. Axle wheel assembly

The component which makes the M3 moving frame move on the rails of the M3 support frame was Axle wheel assembly. Various designs of the wheel assembly were done and only one after the load testing was selected and fabricated to be installed to the frame. The axle is a hollow aluminium circular rod of 25 mm diameter with 2.5mm wall thickness of length 325mm.Brass plugs are exactly fitted and threading is done up to 7mm of diameter 16mm.The cushioning effect of spring is tested by using this kind of wheel arrangement. Two pairs of wheel assembly were made as per the engineering drawing after the verification of spring test. Drawings to be refereed in **Annexures (D45 to 49).** The moving frame was dissembled into two frames and the wheels were inserted and re assembled and all the bolts were tightened.

The m3 moving frame construction was completed and was mounted on to the M3 support frame.

3.5. Panel back up

The profile experimentation was done for the panel back up and water jet cutting process was experimented, so auto cad drawings were made using Auto cad 2010 as the software tool because water jet cutting CAM process. Its a program based drawing and implemented.

Command used:- pline x1,y1 x2,y2,...

The engineering were made for a parabola of focus 1700mm and width 800mm with 1 mm slots. Vertical members of length 250mm and height 60mm with slots of width 1mm and 50mm apart. In order to reduce the cost of machining process various processes have been tried out among them was chemical etching which did not give required result. As a set of experimentation one panel was machined with water jet cutting. There were many difficulties in the process which are as stated below

Water jet cutting has its smallest nozzle of which can cut 0.8 mm slot so for 1mm slot it has go twice to get the slot and during the second time it produces bur which does not give the exact width of 1mm on 1mm sheets. The assembly was done by fixing all of them as per the design give us the required criss cross structure for the panel back up and it will be cladded with a sheet on the top. Still the process of machining the back has not been finalized.

Another option was using 1mm sheet for the parabolic profile and 0.8mm sheet for the vertical member was also ruled out because the water jet cutting of 1mm slot on 0.8mm sheet causes the instability of sheet leading to vibration during the process, since the width and height is small it cannot be tolerate the vibrations and cause it produce zig-zagness in the slot.

Initially it was thought that a stack of 25 sheets fixed together as one workpiece would be used for cutting but the industry rejected that they would not do in that way as it will lead to tool breakage and it will have thermal effect in between the sheets. Still experimentation on that has to be done on milling machine using a very small diameter end mill.

Auto cad drawings to be referred in Annexures **(D50 and D51)**

3.6. M4 construction

The M4 component from manufacturing point of view is very straight forward because its a ladder structure with a box as a M 4 panel on the top which takes less than a week time. The construction of this member is not in process because of following reasons

- Any angular undulations which exceed more than 12 arc seconds of the moving frame motion on the support frame should be incorporated in the M4.
- The stability of the moving basket frame with the panels has to tested because the vertical distance between the two mirror is very critical from optical point of view.

So the base frame assembly has been initiated and is under construction. The conceptual design of the assembly is converted in to detail design, and are to be referred in **Annexures (D52-55).**

CHAPTER 4

RESULTS AND ANALYSIS

This chapter gives the results of the experiment of construction Truss frame design

4.1. Manufacturing process of test frame designs:-This section gives the results obtained for manufacturing process method adopted and is analysed.

4.2. Static indeterminacy:-This section gives the static indeterminacy of the two finalized test frame designs.

4.3. Over all load transfers in the frames:-This section gives the resultant free body diagram of the overall load transfer in the finalized frames.

4.4. Measurement and analysis of M3 support frame:-This section gives the results of the radius of curvatures and surface undulations of bent arcs and first order level deflection of the frames and is analysed.

4.5. Measurement and analysis of M3 moving frame:-This section gives the results of first order level deflection of the moving axle assembly of moving frames and is analysed.

CHAPTER 4

RESULTS AND ANALYSIS

4.1. Manufacturing process of test frame designs

Design 1 and 2

- The design and manufacturing was more flexible and logical.
- Machine process time was very small.
- Machine workmen requirement is also less and easy to handle.

4.2. Static indeterminacy

For the design 1 as the equation satisfied the condition of m=2j-3, the frame structure design is statistically determinate structure and stable.

For the design 2 as the equation was having the case m>2j-3, the frame structure design is statically indeterminate with degree of determinacy of 1. This indeterminacy shows us that the frame is not stable because the diagonal angle between the members can change it does not always remain constant.

4.3. Over all load transfer frames

4.3.1. Test frame design 1

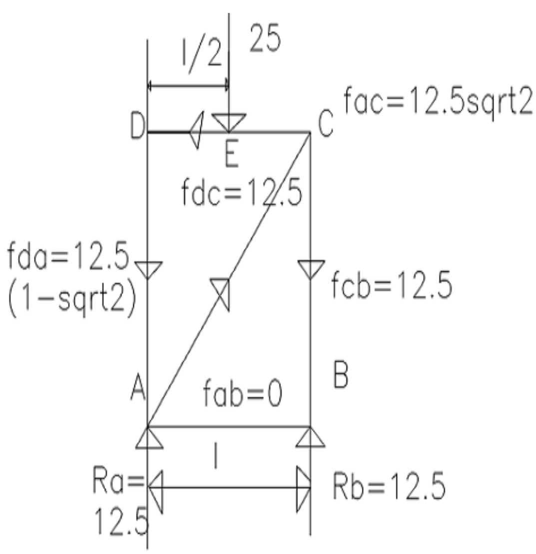


Fig 23. Free Body Diagram (FBD) of test frame design 1 showing load transfer distribution.

4.3.2. Test frame Design 2

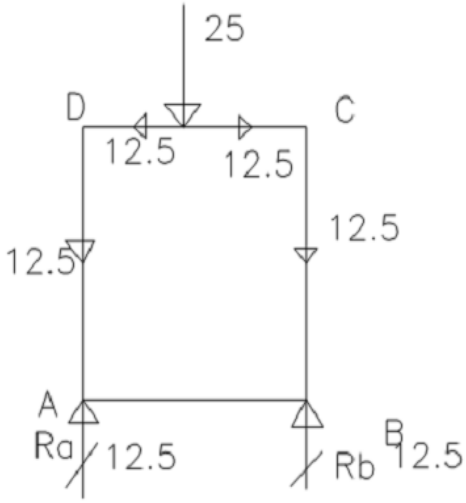


Fig 24 Free Body Diagram (FBD) of test frame design 1 showing load transfer distribution.

Now the first order bending of the frames can be obtained by simplifying the frames to a simply supported beam with a centre point load. Then the deflection will be WL3/48EI.

W=25*9.81=245.25N

L=500mm,E=70000N/mm²

I=bd³/12=27*523/12=316368mm

deflection=245.25*(500³)/48*70000*316368=8.58*10^{-9} mm.

Which means defection is negligible and it can with stand three times more than applied load of 25kgs .So from theoretical point of view, the frame when symmetrical extended on the both sides can take more load maintaining the strength and rigidity. So the construction was initiated.

The mechanical engineering workshop of Raman Research institute is equipped with the basic machine tools. The basic machining operations done in the construction of telescope involves cutting to length, facing, milling, threading, drilling, welding, turning and carpentry work.

Long radius bending and milling operations of interlinking frames was performed at Indo-tech, proprietor P. Pandiragan, Peenya industrial area, Bangalore.

4.4. Measurements and analysis of M3 support frame

The qualification of M3 support frame involved determination of radius of curvature and surface undulations of the arcs using RMU whose input and output are given below.

4.4.1. Determination of radius of curvature and surface undulations of bending

Rectangular section of(52*27)of 3mm wall thickness was chosen the necessary steps were taken in the process to obtain the desired radius with minimum surface undulations.8 sets of data points were taken from radial measuring unit among them four sets are presented here with computationally analyses.

4.4.1.1 ARC-1

Given input

Chord length= 2955mm,Radius =2090.5mm

Given below are the input data points in table 2

S.No	Radial Deflection in 10 micrometers
0	691
1	666
2	654
3	634
4	617
5	612
6	624
7	625
8	619
9	600
10	566
11	535
12	513
13	512
14	524
15	522
16	517
17	516
18	515
19	485

20	496
21	519
22	535
23	548
24	542
25	535
26	524
27	520
28	529
29	555
30	543
31	547
32	545
33	545
34	539
35	524
36	517
37	517
38	505
39	499
40	494
41	484
42	460
43	444

44	420
45	431
46	403
47	385
48	373
49	356
50	343
51	332
52	329
53	314
54	307
55	300
56	291
57	278
58	260
59	262
60	267
61	275
62	281
63	296
64	294
65	288
66	288
67	298

68	294
69	290
70	304
71	303
72	282
73	294
74	327
75	369
76	379
77	401
78	421
79	432
80	448
81	494
82	542
83	582
84	623

OUTPUT

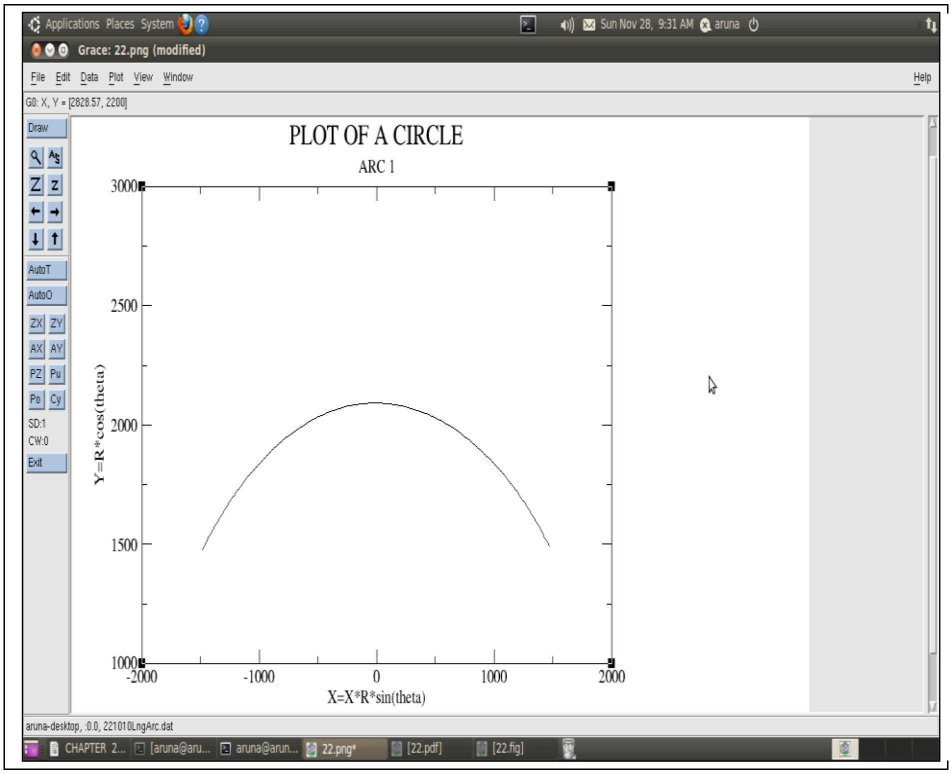


Fig 25 Plot of Circular Arc 1from the input data.

Fitting with formula: y = a0+sqrt (a1^2-(x-a2) ^2) (2910c)

Initial guesses:

a0 = 0;a1 = 2092;a2 = 0;Tolerance = 0.01

Relative error in the sum of squares is at most tol.

Computed values:

a0 = -2.15388, a1 = 2098.29, a2 = -2.43949

Correlation coefficient: 0.999979,RMS relative error: 0.000747172

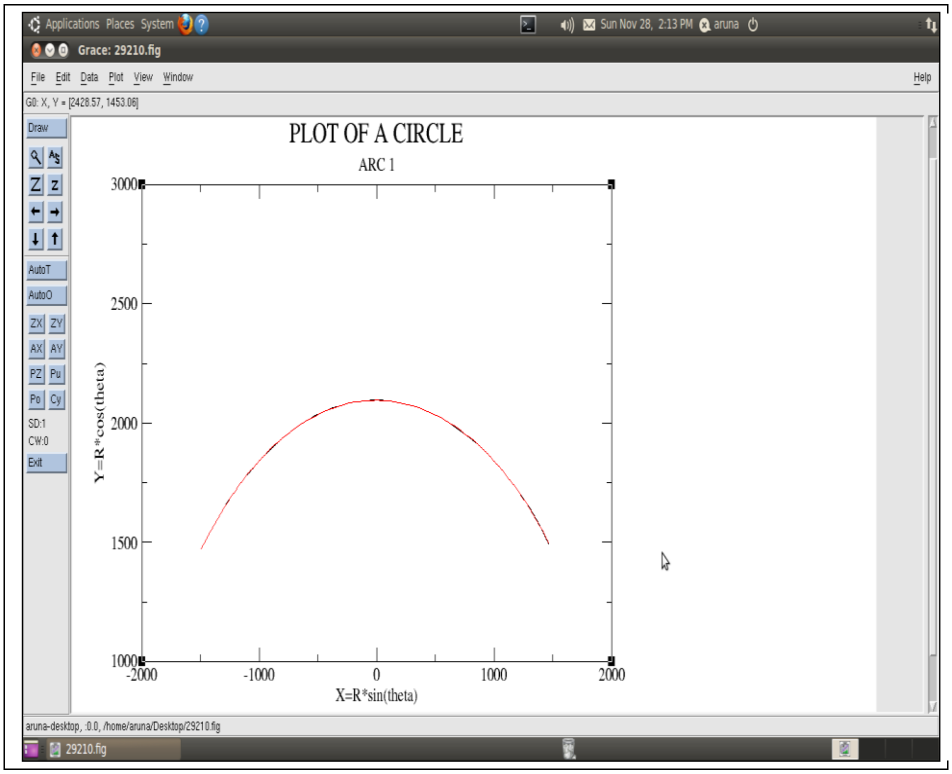


Fig 26 Curve fit for Circular Arc 1.

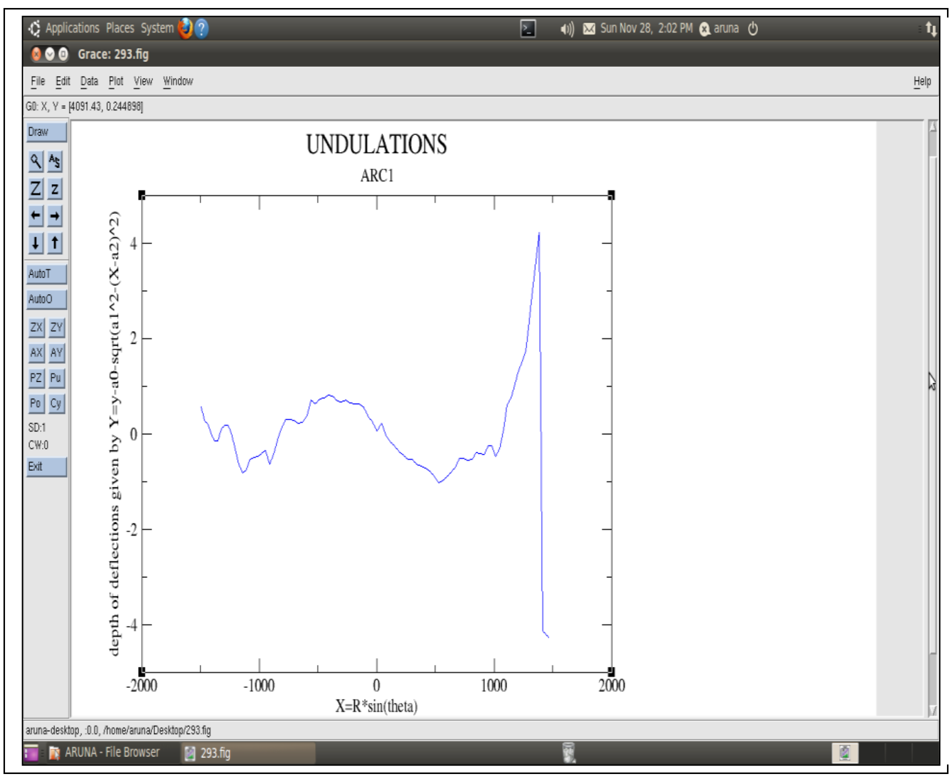


Fig 27 Surface undulations on circular arc 1.

4.4.2. ARC-2

Given input

Chord length= 2955mm,Radius =2088mm

Given below are the input data points in table 3

S.NO	Radial Deflection in 10 micrometres
0	847
1	849
2	851
3	862
4	854
5	845
6	866
7	876
8	882
9	867
10	853
11	825
12	790
13	738
14	743
15	760
16	748
17	749
18	757
19	756

20	732
21	744
22	781
23	768
24	785
25	835
26	845
27	840
28	854
29	870
30	860
31	854
32	871
33	889
34	905
35	915
36	921
37	909
38	871
39	873
40	853
41	842
42	816
43	792

44	765
45	736
46	735
47	731
48	720
49	694
50	656
51	624
52	601
53	569
54	529
55	468
56	422
57	430
58	435
59	422
60	492
61	372
62	338
63	309
64	319
65	309
66	299
67	285

68	210
69	216
70	223
71	216
72	201
73	265
74	245
75	235
76	238
77	242
78	224
79	201
80	185
81	168
82	146
83	190

OUTPUT

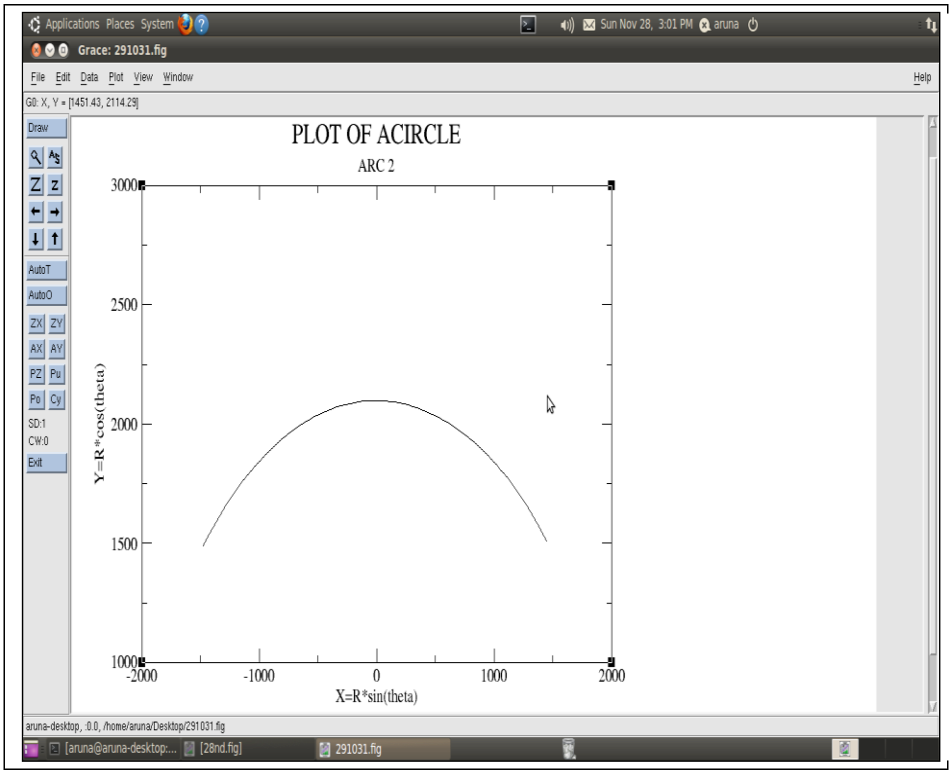


Fig 28 Plot of Circular Arc 2 from the input data.

Fitting with formula: y = a0+sqrt (a1^2-(x-a2) ^2) (29103rdarccenetr)

Initial guesses:

a0 = 0; a1 = 2100;a2 = 0;Tolerance = 0.01

Relative error in the sum of squares is at most tol.

Computed values:

a0 = 10.1681, a1 = 2087.87, a2 = -5.73232

Correlation coefficient: 0.999989,RMS relative error: 0.000452499

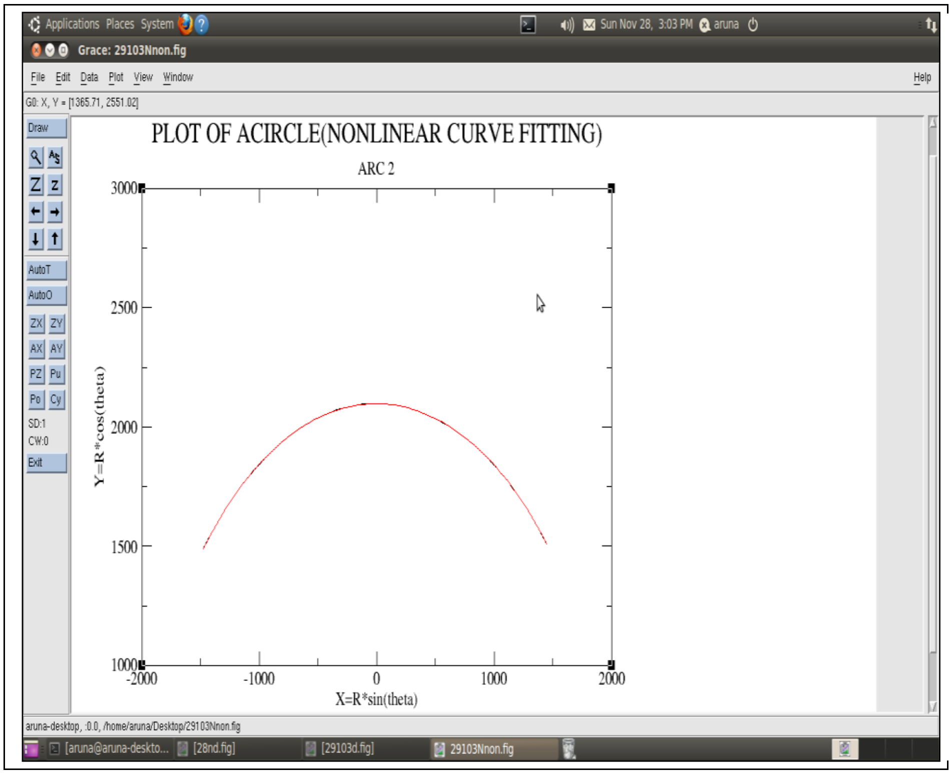


Fig 29 Curve fit for Circular Arc 2.

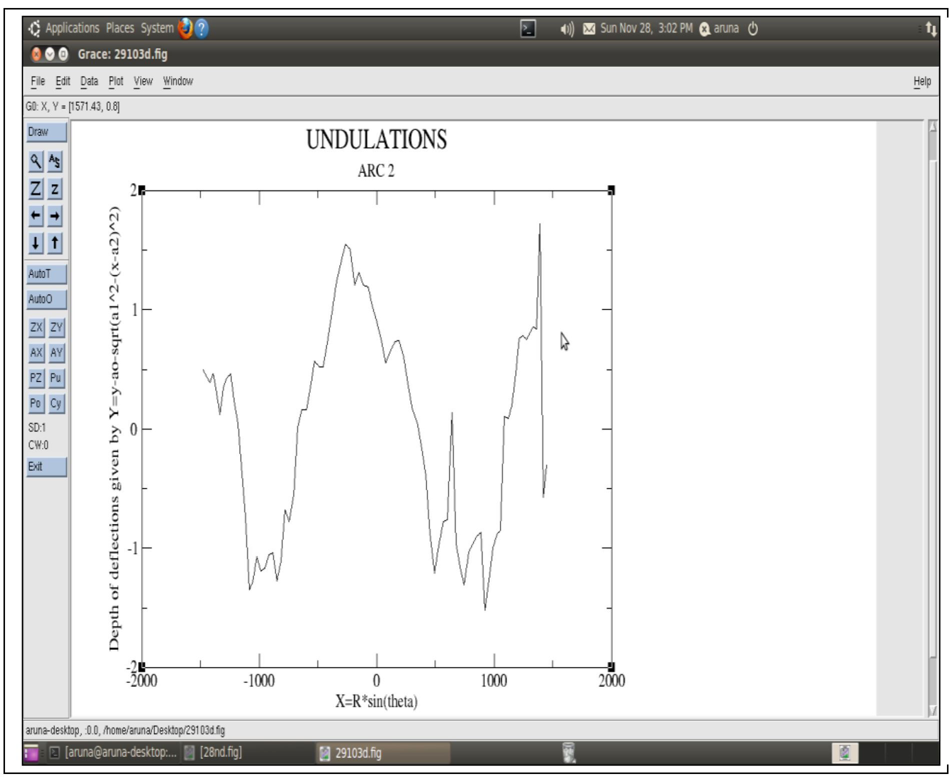


Fig 30 Surface undulations on Circular Arc 2.

4.4.3. ARC-3

Given input

Chord length= 2955mm, Radius =2088mm

Given below are the input data points in table 4

S.No	Radial Deflection in 10 micrometres
0	768
1	760
2	803
3	814
4	820
5	841
6	860
7	860
8	878
9	894
10	909
11	917
12	924
13	921
14	912
15	904
16	922
17	924
18	932
19	934

20	933
21	910
22	887
23	880
24	885
25	917
26	940
27	948
28	950
29	986
30	991
31	1010
32	1014
33	1014
34	996
35	996
36	993
37	982
38	990
39	990
40	986
41	964
42	961
43	957

44	947
45	945
46	960
47	958
48	954
49	960
50	960
51	945
52	946
53	964
54	966
55	956
56	945
57	937
58	929
59	932
60	930
61	917
62	901
63	888
64	886.7
65	848
66	832
67	835

68	820
69	803
70	789
71	766
72	754
73	735
74	747
75	740
76	742
77	741
78	726
79	726
80	712
81	718
82	738
83	760
84	760
85	718

OUTPUT

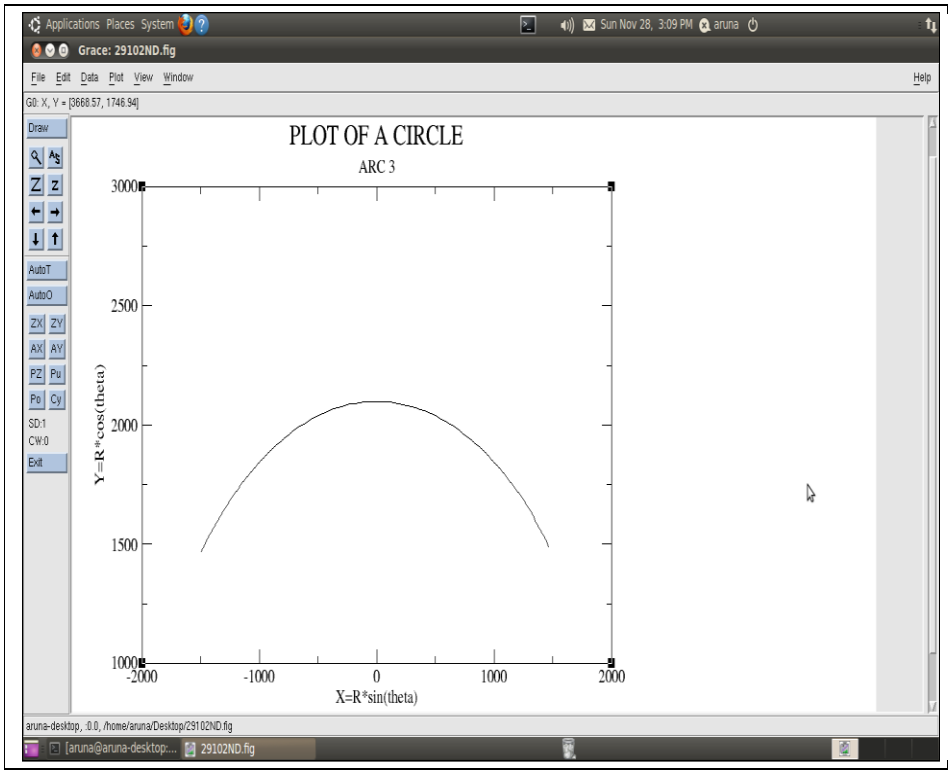


Fig 31 Plot of Circular Arc 3 from the input data.

Fitting with formula: y = a0+sqrt (a1^2-(x-a2) ^2) (29102c)

Initial guesses:

a0 = 0; a1 = 2100;a2 = 0;Tolerance = 0.01

Relative error in the sum of squares is at most tol.

Computed values:

a0 = 17.2813; a1 = 2082.87; a2 = -2.98224

Correlation coefficient: 0.999966,RMS relative error: 0.00096549

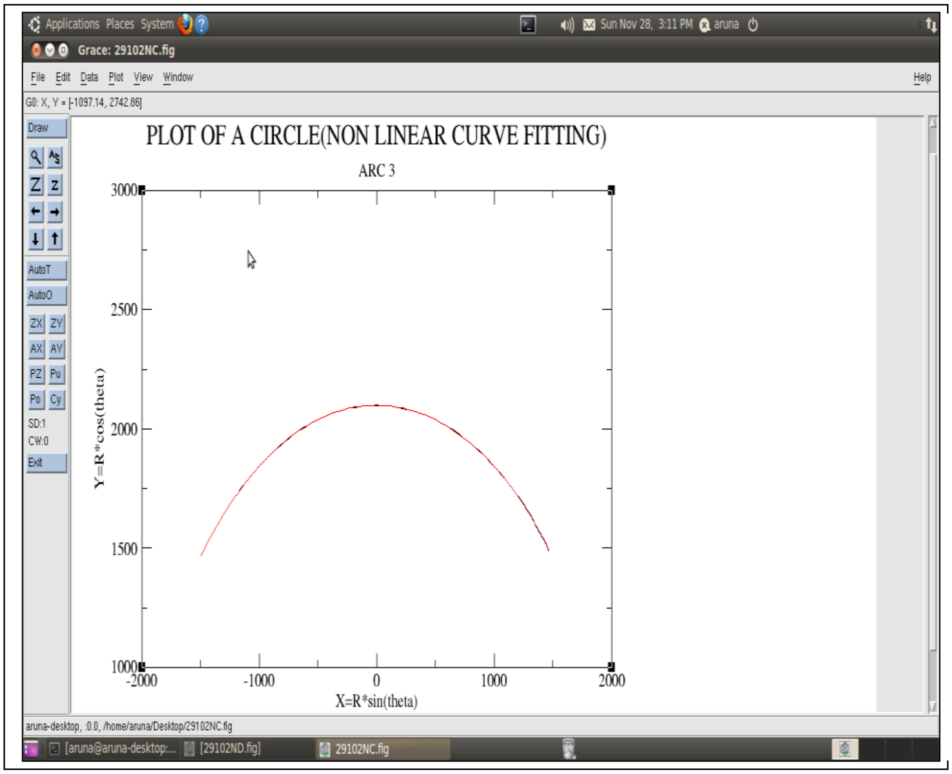


Fig 32 Curve fit on Circular Arc 3.

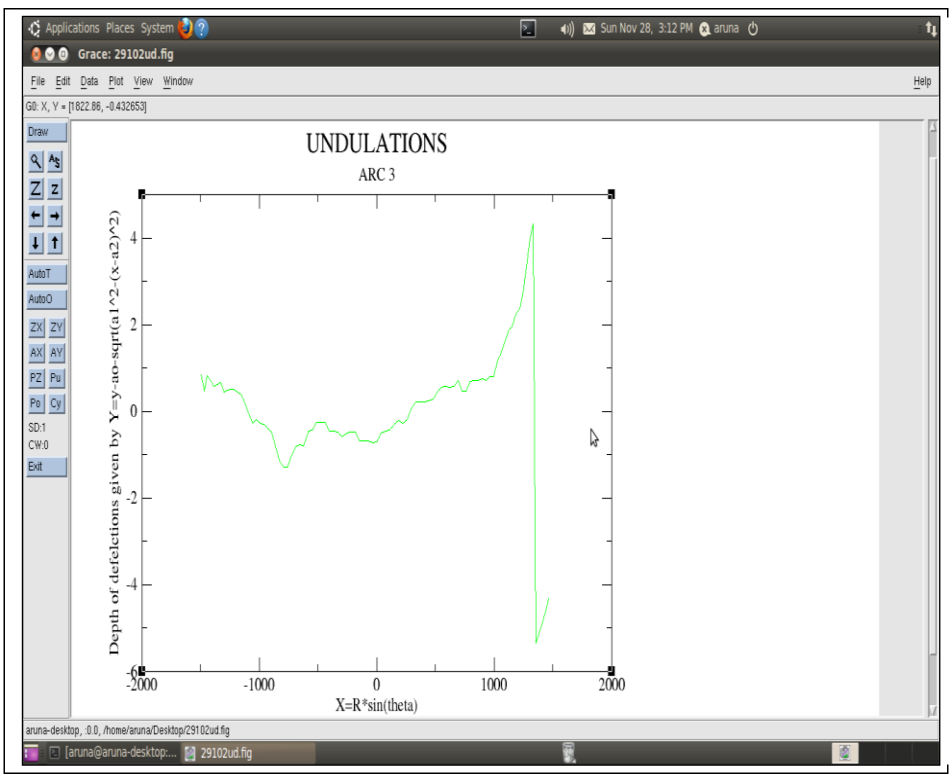


Fig 33 Surface undulations on Circular Arc 3.

4.4.4ARC-4

Given input

Chord length= 2955mm, Radius=2090.5mm

Given below are the input data points in table 5

S.No	Radial Deflection in 10 micrometres
0	554
1	567
2	573
3	585
4	599
5	644
6	665
7	680
8	682
9	678
10	675
11	680
12	698
13	732
14	758
15	782
16	795
17	794
18	795
19	825

20	878
21	894
22	922
23	925
24	932
25	935
26	933
27	964
28	978
29	994
30	998
31	999
32	1025
33	1028
34	1032
35	1046
36	1055
37	1049
38	1059
39	1071
40	1065
41	1069
42	1063
43	1050

44	1068
45	1052
46	1056
47	1055
48	1048
49	1046
50	1045
51	1057
52	1056
53	1058
54	1058.5
55	1059
56	1050.5
57	1046
58	1048
59	1052
60	1048
61	1049
62	1047
63	1024
64	994
65	989
66	964
67	938

68	915
69	893
70	838
71	868
72	848
73	844
74	845
75	799
76	755
77	719
78	634
79	620
80	599
81	563
82	550
83	599

OUTPUT

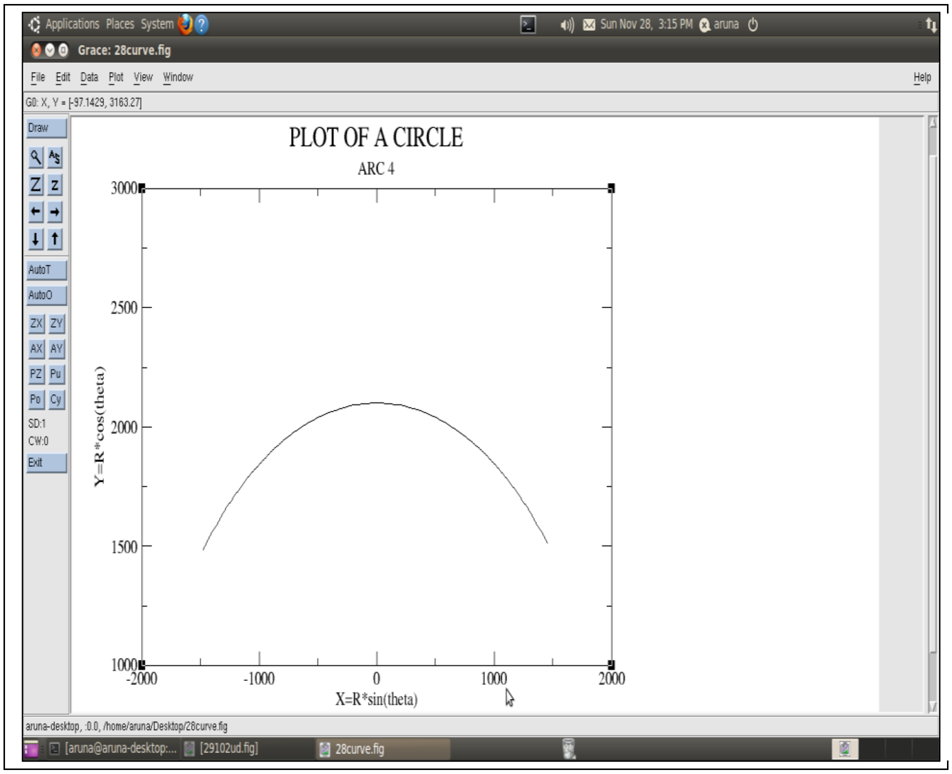


Fig 34 Plot of Circular Arc 4 from the input data.

Fitting with formula: y = a0+sqrt (a1^2-(x-a2) ^2) (28c.txt)

Initial guesses:

a0 = 0;a1 = 2100;a2 = 0;Tolerance = 0.01

Relative error in the sum of squares is at most tol.

Computed values:

a0 = 18.5131, a1 = 2082.71, a2 = 0.635706

Correlation coefficient: 0.999997,RMS relative error: 0.000256094

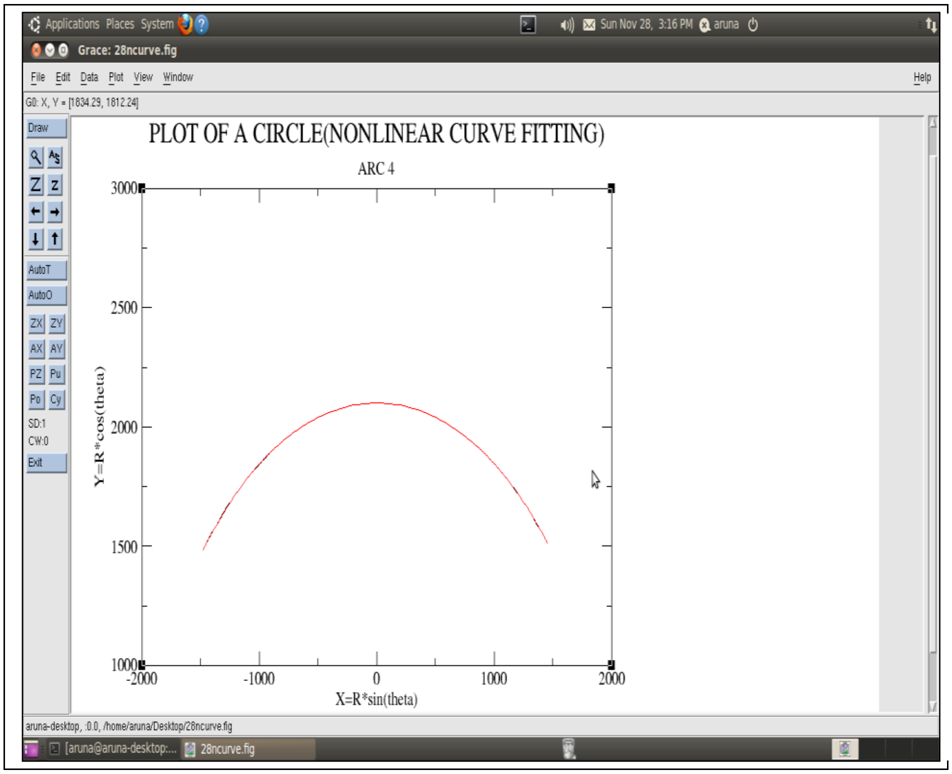


Fig 35 Curve fit on Circular Arc 4.

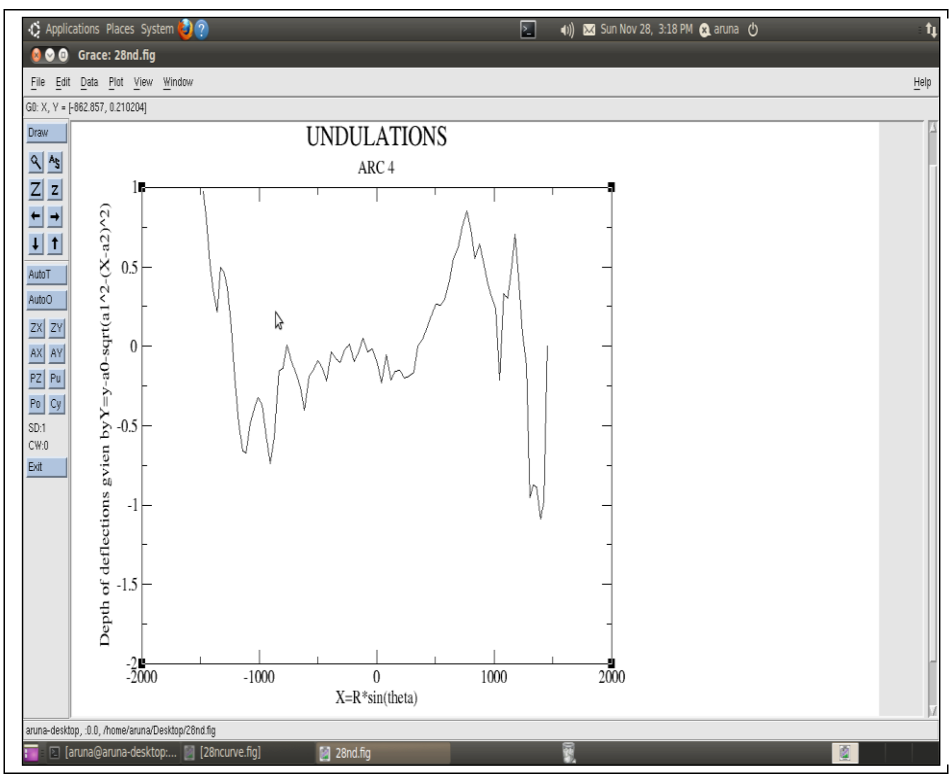


Fig 36 Surface undulations on Circular Arc 4.

By using a spirit level mounted firmly on an inter connecting member and it has been verified that the first order deflections were found to be negligible. The rigidity of the structure to bear more than 100 kgs was tested and the M3 support frame was qualified.

Hence from the results obtained in radius of curvature and surface undulations was analysed and qualified. Similarly the first order load testing results also were satisfactory and the M3 support frame qualified.

4.5. Measurement and analysis of the M3 Moving frame

The wheel assembly was experimented under 80kgs loading condition and was found to take the cushioning effect and was qualified.

After mounting the moving frame on the support frame the motion on the rails was tested without much drifting on the wheels. The frame has been qualified at the preliminary level .More elaborate measurements need to be done. Special jig incorporating displacements and angular probes is being prepared for their purpose. Once the jig is ready and qualified, elaborate measurements and final qualification of the M3 support frame and moving carriage will be undertaken.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

This chapter gives a summary of the work stated and methods adopted to complete.

5.1. Brief summary:-This section gives a general conclusion about the project.

5.2. Work conclusion:-This section gives conclusion about the experiments, process adopted, its significance and result analysis and outcome.

5.3. Future work:-This section gives the work going to be done in future which is about theoretical analysis of second order load transfer and deflection calculations of the M3 support frame.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. Brief summary

The constructions of fan beam telescope from the point of view of new structural frame design is a challenging, experimental and a learning process. Because of the development of the technology prototyping is the first step. My work was more involved in using of Auto desk inventor and Auto cad software for conversion of conceptual design of M3, profiles for the panels and base frame component. The work involves more Computer Aided Designing (CAD) for bring it to construction stage along with an exposure to industry and their skills, the importance of precision engineering and measurements. The engineering drawings which formed the basis for the experimentation and measurement in the construction of fan beam telescope. These experimentations and the procedure developed will form the basis for developing other components in the 3 meter sub millimetre wave telescope. I was involved in supervising the manufacturing, in taking measurements and its assembly. I actively participated in the during the entire fabrication cycle stage of most of the components. This also includes manufacturing of some tool jigs and systems.

World over telescopes are designed and many of them use frame structures for back up support. However, reports containing design, development and construction procedures and strategies are not available in the public domain. Therefore, undertaking this project provided me a great opportunity to learn how to develop components and how to work in a team of manufacturing unit.

5.2. Work conclusion

Using Auto desk Inventor 2010 detailed three dimensional designing of M3 component and base frame were produced for their manufacturing. In order to make the milling operation easy ,and qualification of the slots and uniformity in all the members, 1:1 templates preparation for interlinking U-frames, Inclined step bending members were necessary and was done using Auto desk inventor. The designing of all the test frames was done and tried out in the fabrication giving importance to the stability of the joint. Theoretical calculations on the load transfer and deflections gave us the first order approximations of the experimental test frames have been accomplished. Bending method experimentation was done as the design involved the long radius. The measurements of long radius curvature of the M3 support frame were taken using RMU and qualified.

M3 support frame:-The structure has been constructed, qualified and mounted.

M3 moving frame:-The structure has been constructed, qualified and mounted.

M3 panel:-The conceptual design of panel back up structure for the panel which is a criss-cross grid of plates has been demonstrated and a test piece was made by the method of water jet cutting process.

M4 component: - The base frame is under construction. Once this is completed, the M3 support frame will be mounted and accurate measurements for deformations will be made. Part compensation of these deformations may imply small shape change to the M4 mirror that has to be machined using a CNC lathe and therefore expensive. Hence, the fabrication of M4 mirror and its simple ladder support frame are delayed until the completion of base frame.

5.3. Future work

Theoretical analysis of second order load transfer and deflection calculations of truss frame structure is the next step. From theoretical point of view truss frame structure is to be analysed from the three dimensional point of view .It is a statically indeterminate braced beam structure[5] and three dimensional theory is more complex and requires more time.

REFERENCES

Journal / Conference Papers

[1] Balasubramanyam, R. , "A telescope made with cylinders - I. Some analytical results ",Monthly Notices of the Royal Astronomical Society, Volume 354, Issue 4, pp. 1189-1193. Bibliographic Code: 2004MNRAS.354.1189B ,2004

[2] Robert B. Leighton *"A 10 Meter Telescope for Millimeter and Submillimeter Astronomy"* Final Technical Report for NSF Grant 73-04908, 1978.

Reference / Hand Books

[3] Dr R.K Bansal, "A text book of Strength of materials ", Laxmi Publications Ltd,fourth Edition, 978-81-318-0814-6 .

[4] T.H.G.Megson, "Structural and stress analysis", Butterworth-Heinemanne,second Edition 2005, 9780750662215 .

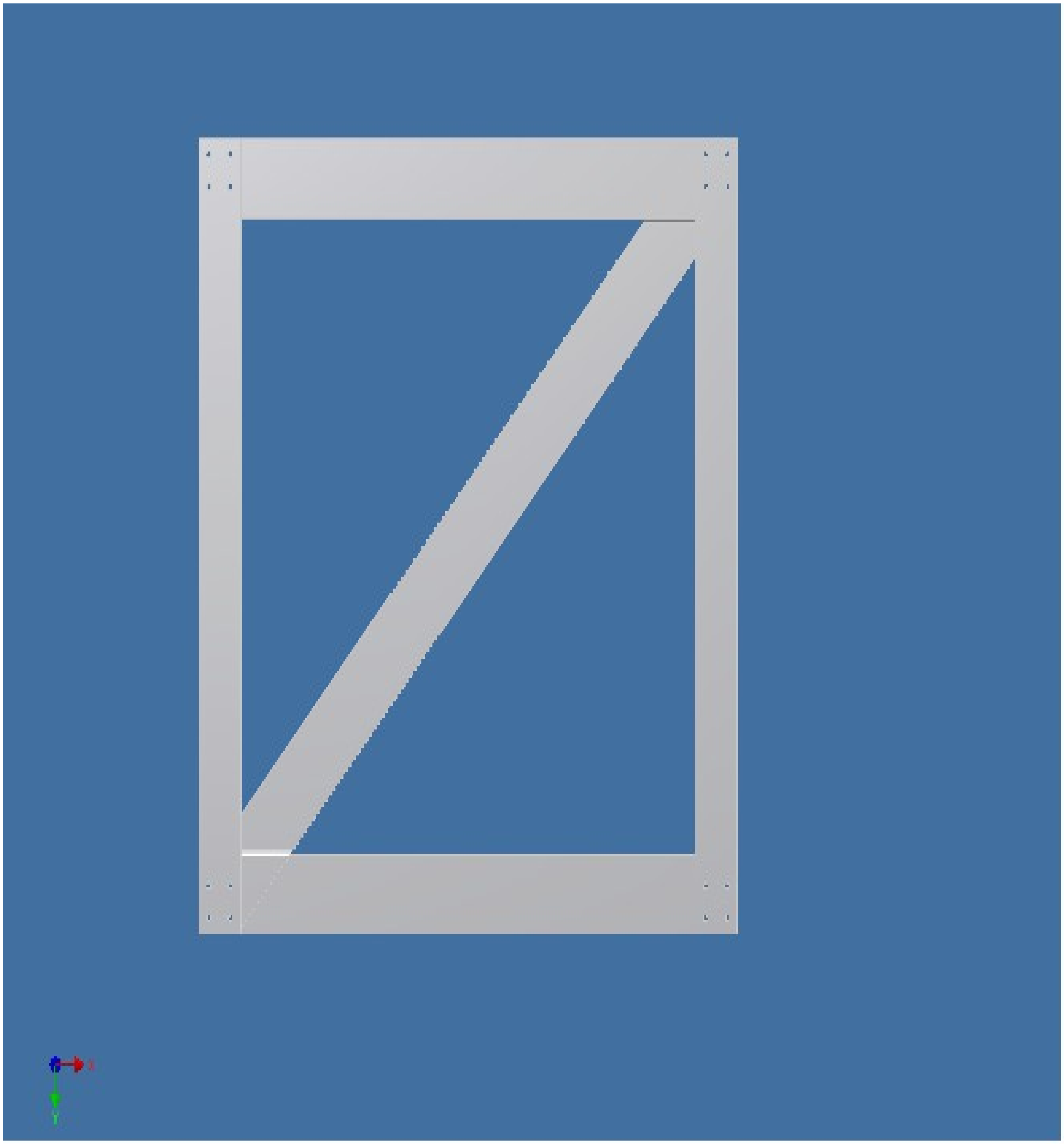
[5]Carepenteri,Alberto, "Structural mechanics-A unified approach",Spon press Publication , first Edition,jan 1997,0203474953

Web

[6] Aluminium alloys, manufacturing process, material properties of aluminium, measuring instruments etc, wikipedia

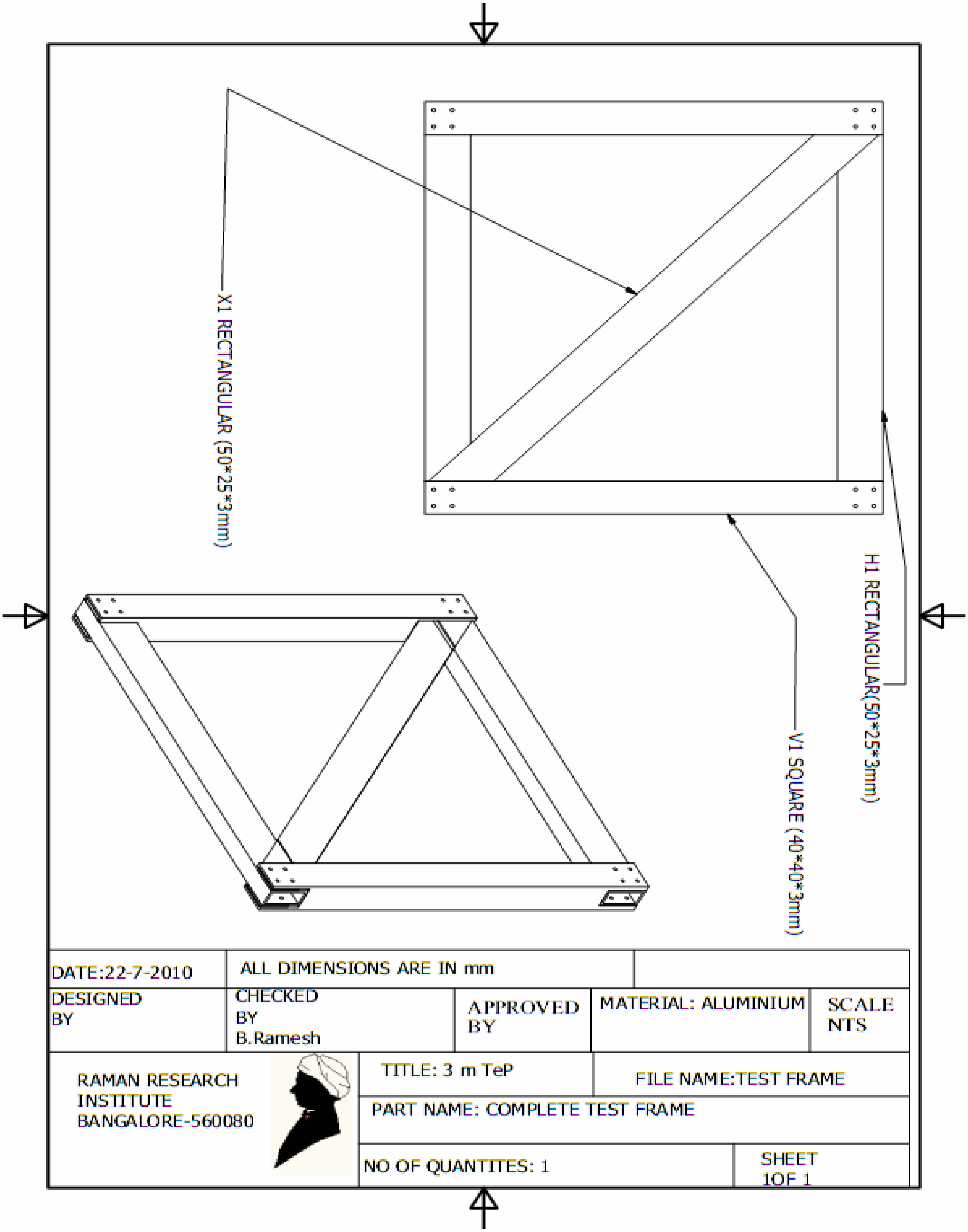
ANNEXURES
CAD DRAWINGS

TEST FRAME DESIGN 1

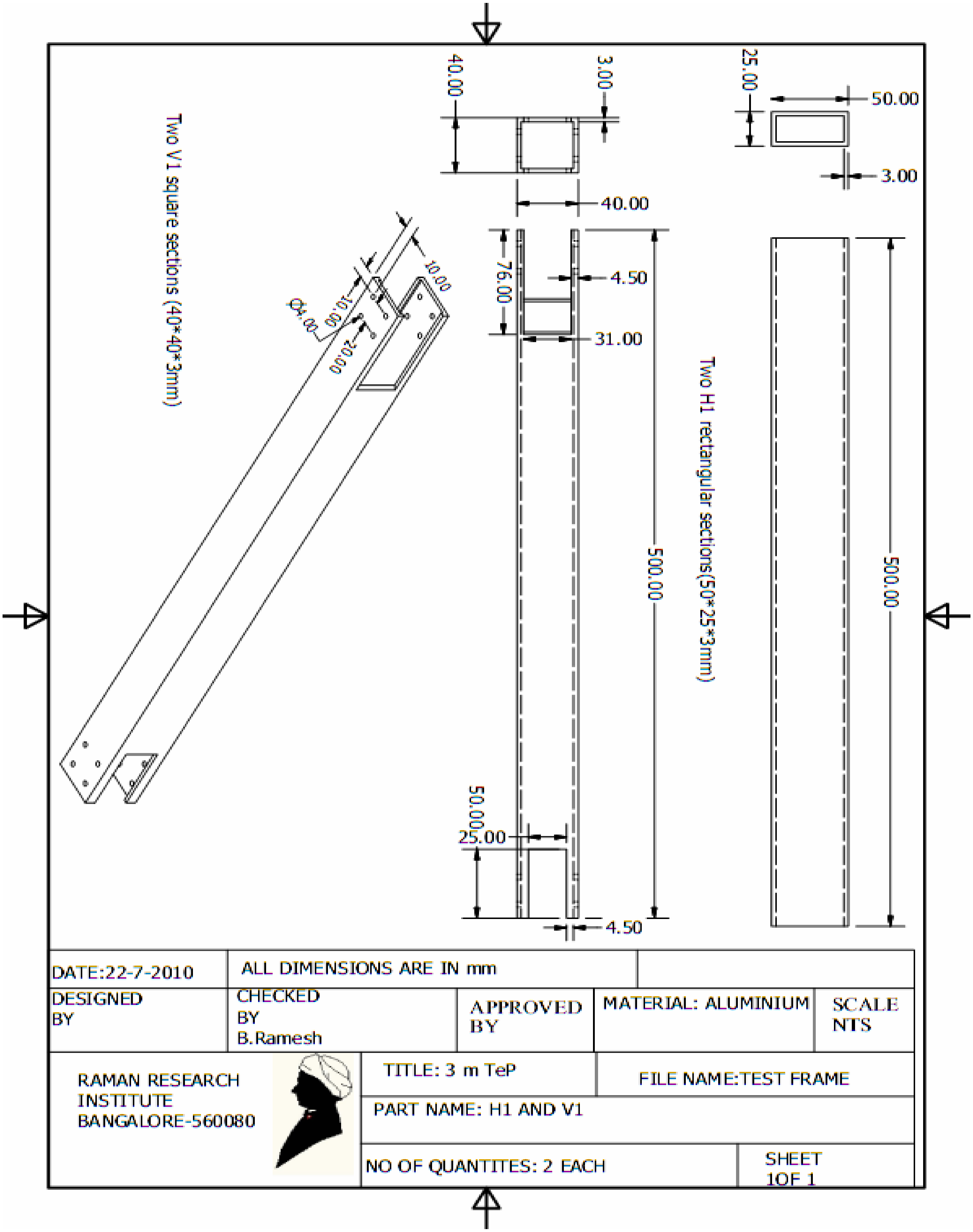


D1

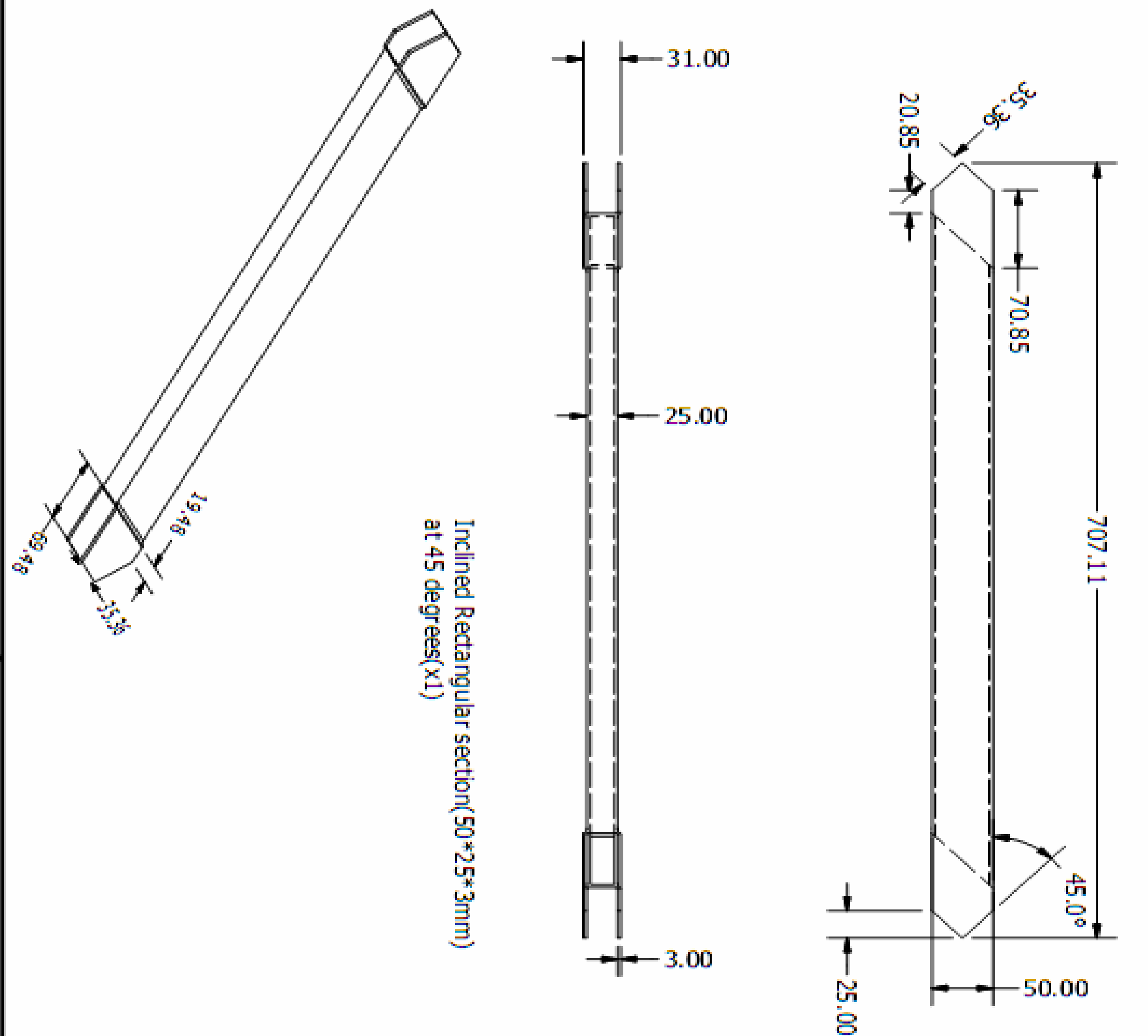
D2


X1 RECTANGULAR (50*25*3mm)
H1 RECTANGULAR(50*25*3mm)
V1 SQUARE (40*40*3mm)
DATE:22-7-2010
ALL DIMENSIONS ARE IN mm
DESIGNED BY
CHECKED BY B.Ramesh
APPROVED BY
MATERIAL: ALUMINIUM
SCALE NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080
TITLE: 3 m TeP
FILE NAME:TEST FRAME
PART NAME: COMPLETE TEST FRAME
NO OF QUANTITES: 1
SHEET 1OF 1

D2


Two V1 square sections (40*40*3mm)
Two H1 rectangular sections(50*25*3mm)
40.00
3.00
25.00
50.00
3.00
40.00
76.00
4.50
31.00
10.00
Φ4.00
10.00
20.00
500.00
500.00
50.00
25.00
4.50
DATE:22-7-2010
ALL DIMENSIONS ARE IN mm
DESIGNED BY
CHECKED BY B.Ramesh
APPROVED BY
MATERIAL: ALUMINIUM
SCALE NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080
TITLE: 3 m TeP
FILE NAME:TEST FRAME
PART NAME: H1 AND V1
NO OF QUANTITES: 2 EACH
SHEET 1OF 1

D3

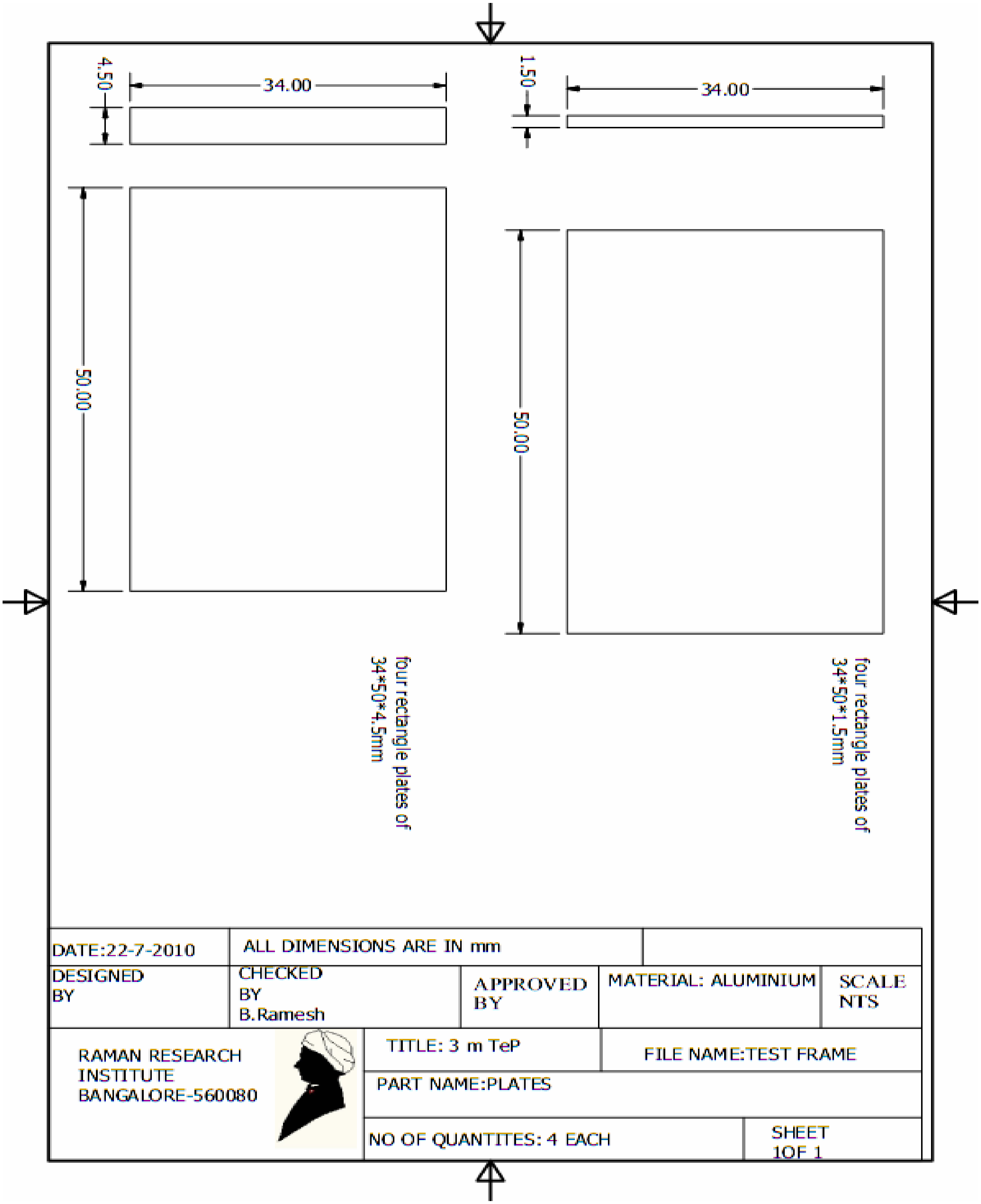


DATE:22-7-2010	ALL DIMENSIONS ARE IN mm			
DESIGNED BY	CHECKED BY B.Ramesh	APPROVED BY	MATERIAL: ALUMINIUM	SCALE NTS

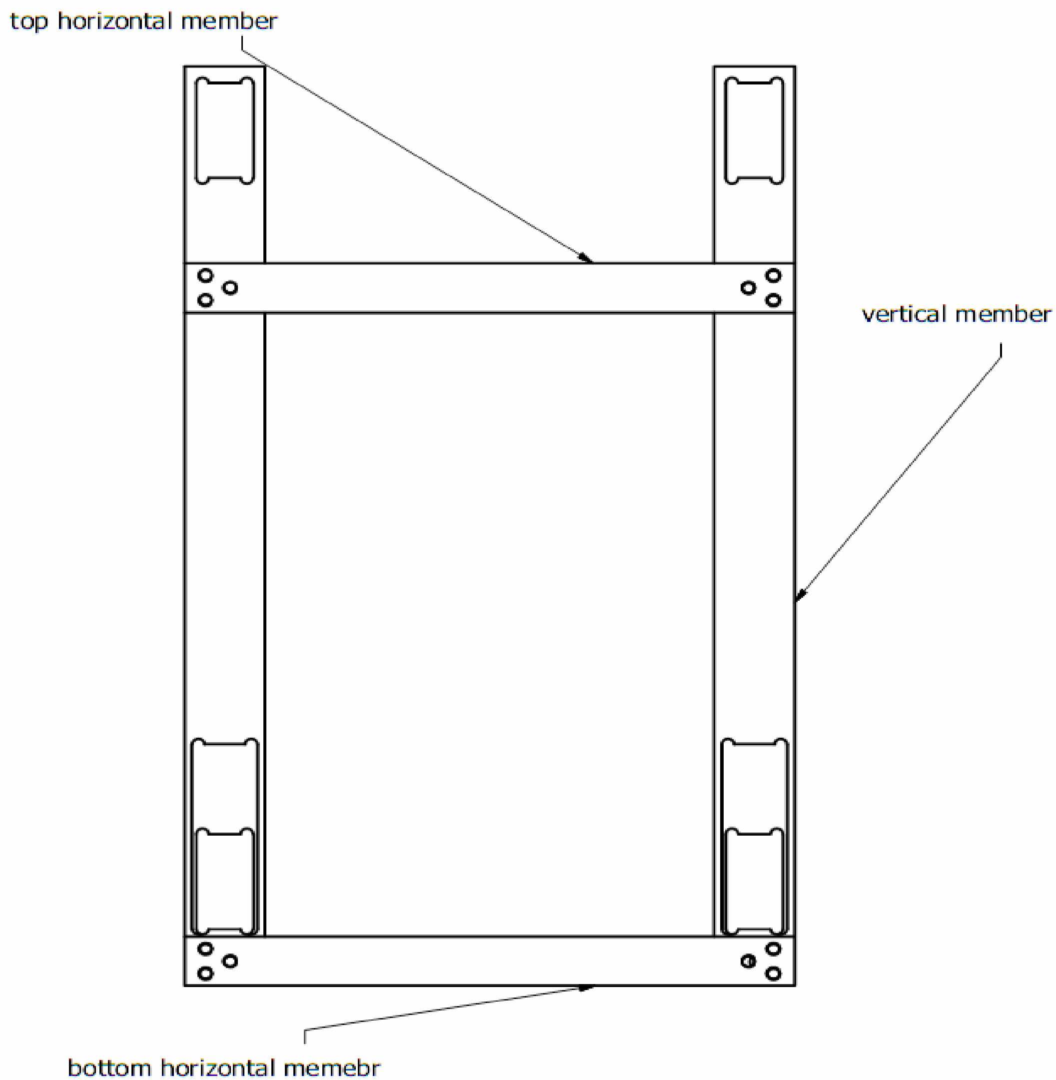
RAMAN RESEARCH INSTITUTE BANGALORE-560080

TITLE: 3 m TeP	FILE NAME:TEST FRAME
PART NAME:X1	
NO OF QUANTITES: 1	SHEET 1OF 1

D4

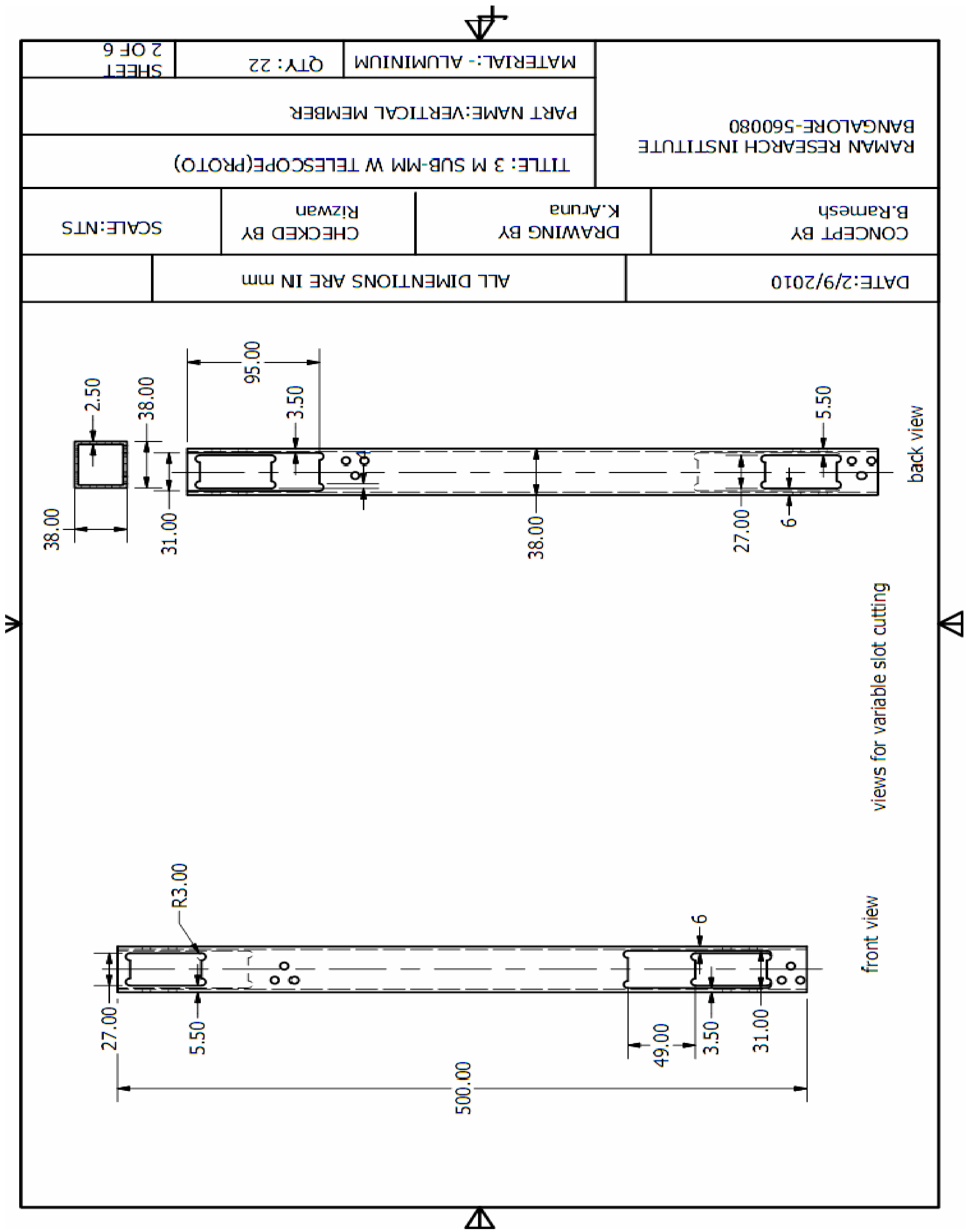

4.50
34.00
1.50
34.00
50.00
50.00
four rectangle plates of
34*50*4.5mm
four rectangle plates of
34*50*1.5mm
DATE:22-7-2010
ALL DIMENSIONS ARE IN mm
DESIGNED BY
CHECKED BY B.Ramesh
APPROVED BY
MATERIAL: ALUMINIUM
SCALE NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080
TITLE: 3 m TeP
FILE NAME:TEST FRAME
PART NAME:PLATES
NO OF QUANTITES: 4 EACH
SHEET 1OF 1

D5

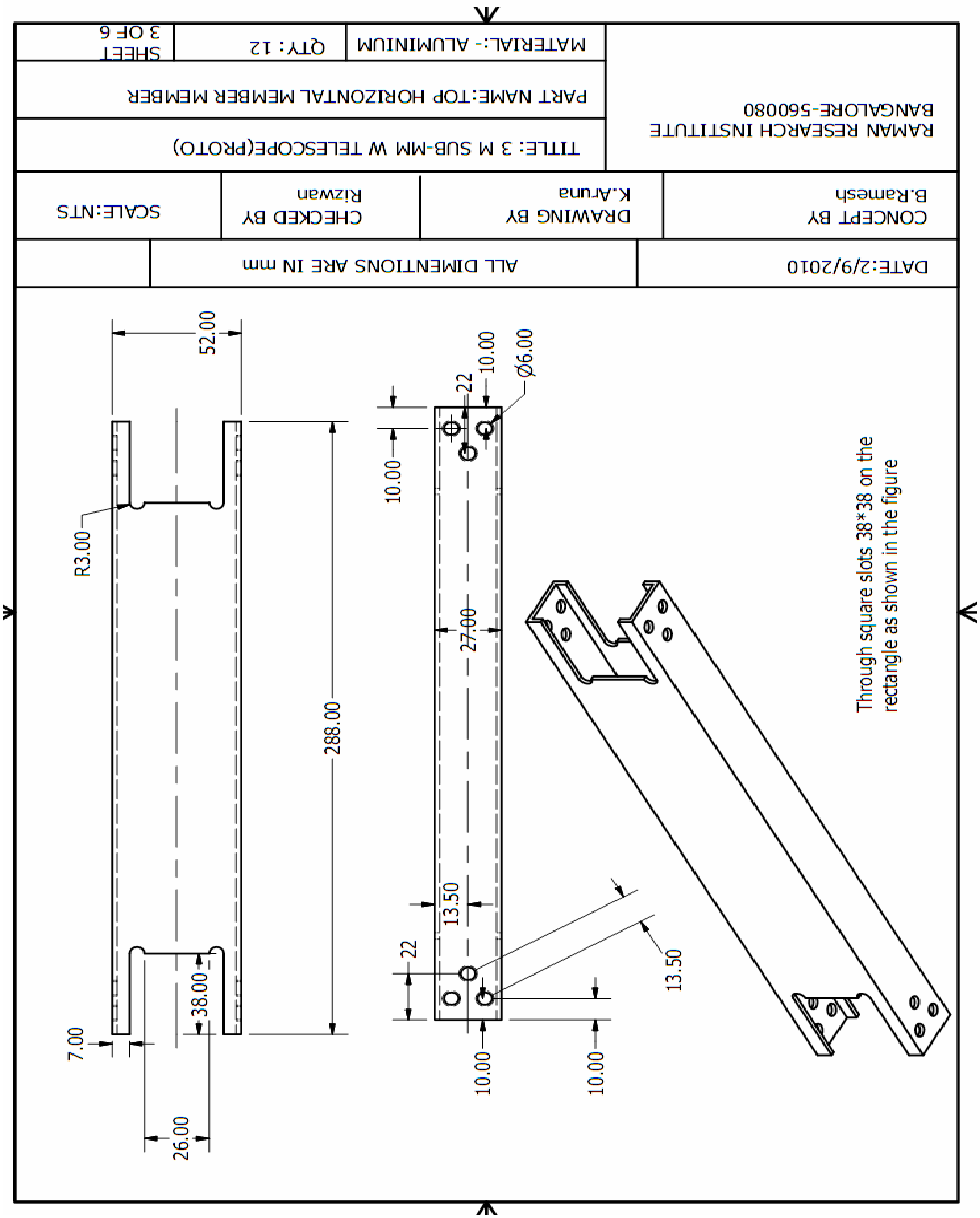


DATE:2/9/2010	ALL DIMENTIONS ARE IN mm		
CONCEPT BY B.Ramesh	DRAWING BY K.Aruna	CHECKED BY Rizwan	SCALE:NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080	TITLE: 3 M SUB-MM W TELESCOPE(PROTO)		
	PART NAME:FRAME ASSEMBLY		
	MATERIAL:- ALUMINIUM	QTY: 11	SHEET 1 OF 6

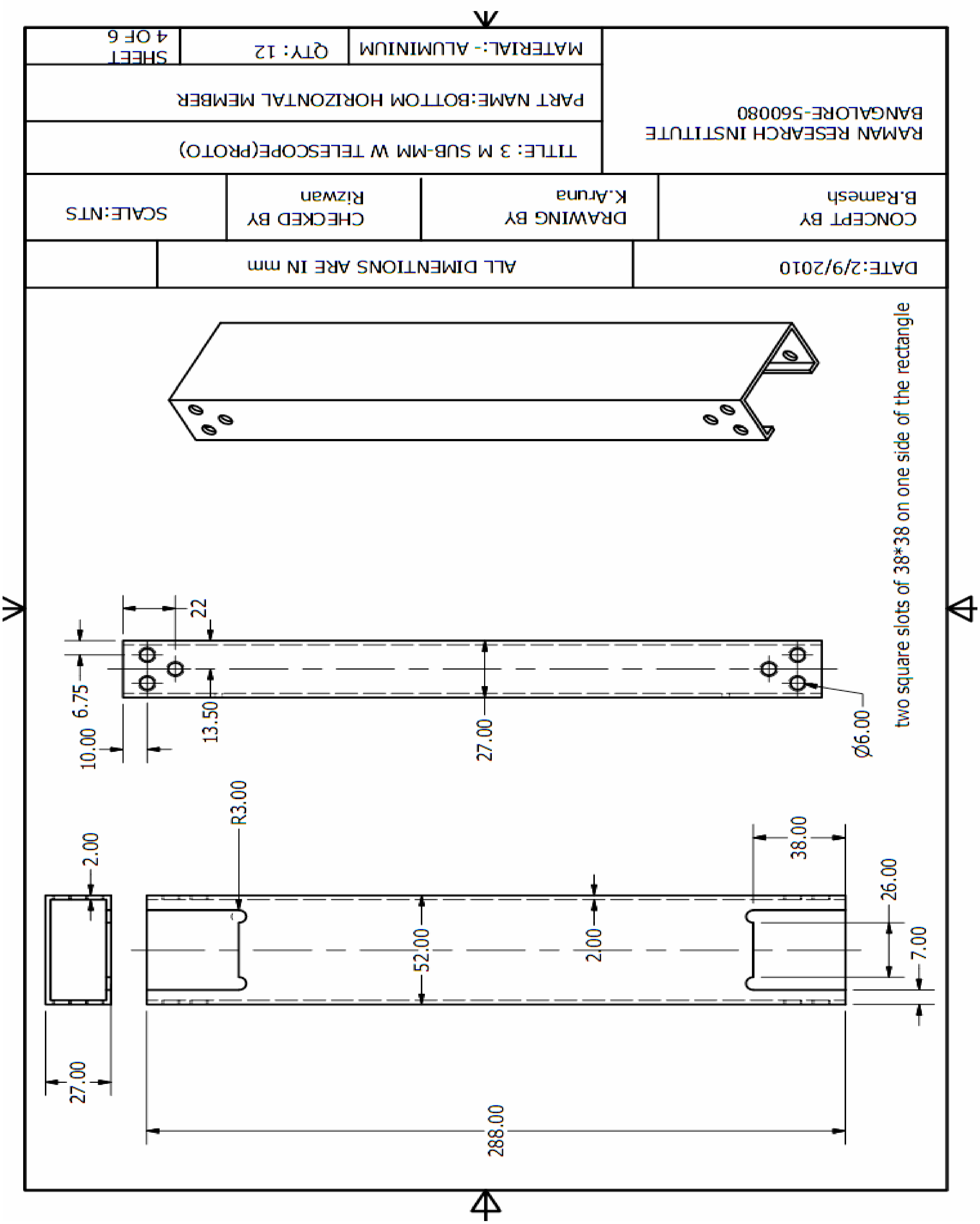
D6


MATERIAL:- ALUMINIUM
QTY: 22
SHEET
2 OF 6
PART NAME:VERTICAL MEMBER
TITLE: 3 M SUB-MM W TELESCOPE(PROTO)
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
CONCEPT BY
B.Ramesh
DRAWING BY
K.Aruna
CHECKED BY
Rizwan
SCALE:NTS
DATE:2/9/2010
ALL DIMENTIONS ARE IN mm
back view
views for variable slot cutting
front view
95.00
3.50
5.50
2.50
38.00
31.00
27.00
6
R3.00
49.00
500.00

D7

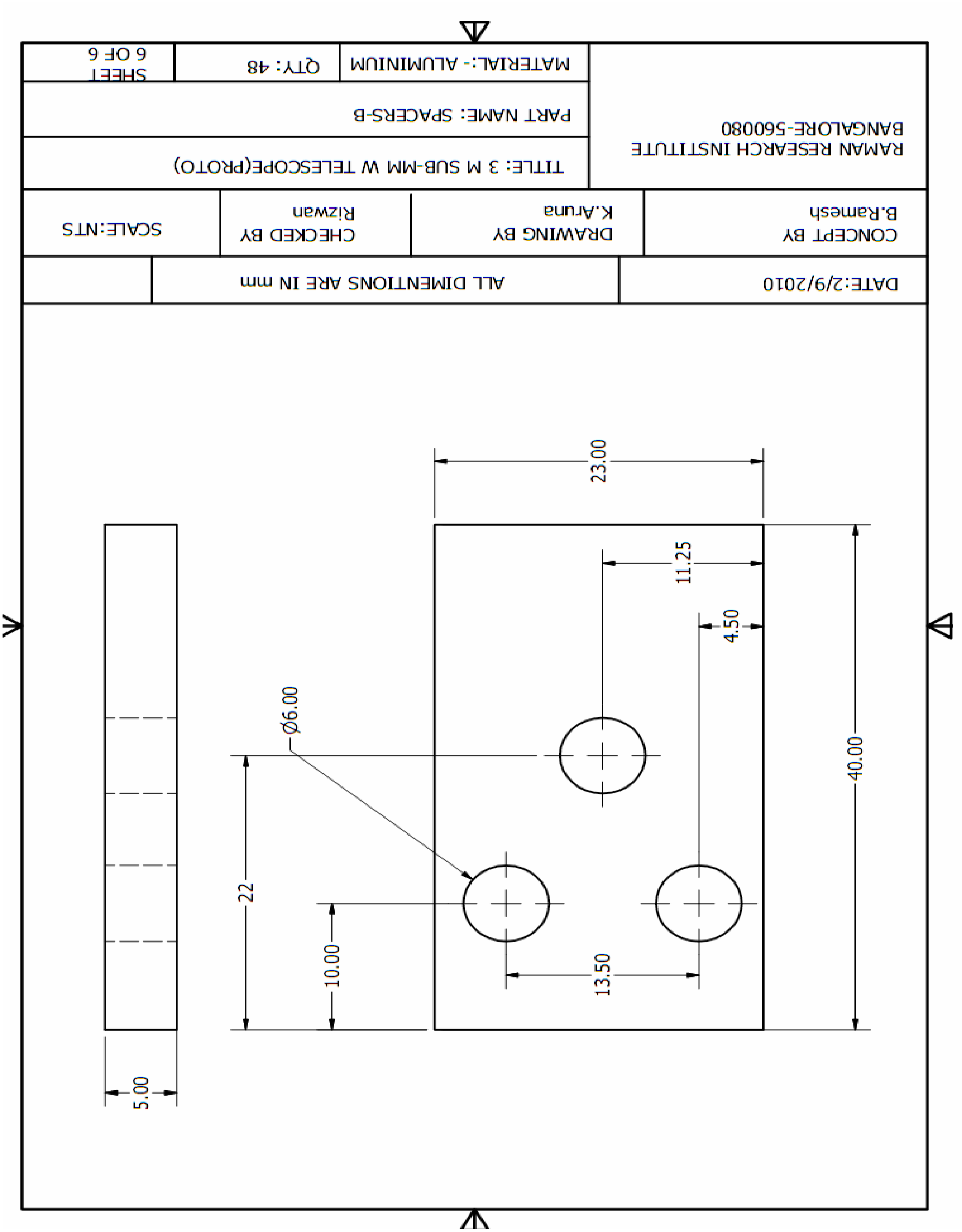

RAMAN RESEARCH INSTITUTE
BANGALORE-560080
MATERIAL:- ALUMINIUM
QTY: 12
SHEET
3 OF 6
PART NAME:TOP HORIZONTAL MEMBER MEMBER
TITLE: 3 M SUB-MM W TELESCOPE(PROTO)
CONCEPT BY
B.Ramesh
DRAWING BY
K.Aruna
CHECKED BY
Rizwan
SCALE:NTS
DATE:2/9/2010
ALL DIMENTIONS ARE IN mm
52.00
288.00
R3.00
7.00
38.00
26.00
10.00
22
Ø6.00
27.00
13.50
Through square slots 38*38 on the rectangle as shown in the figure

D8



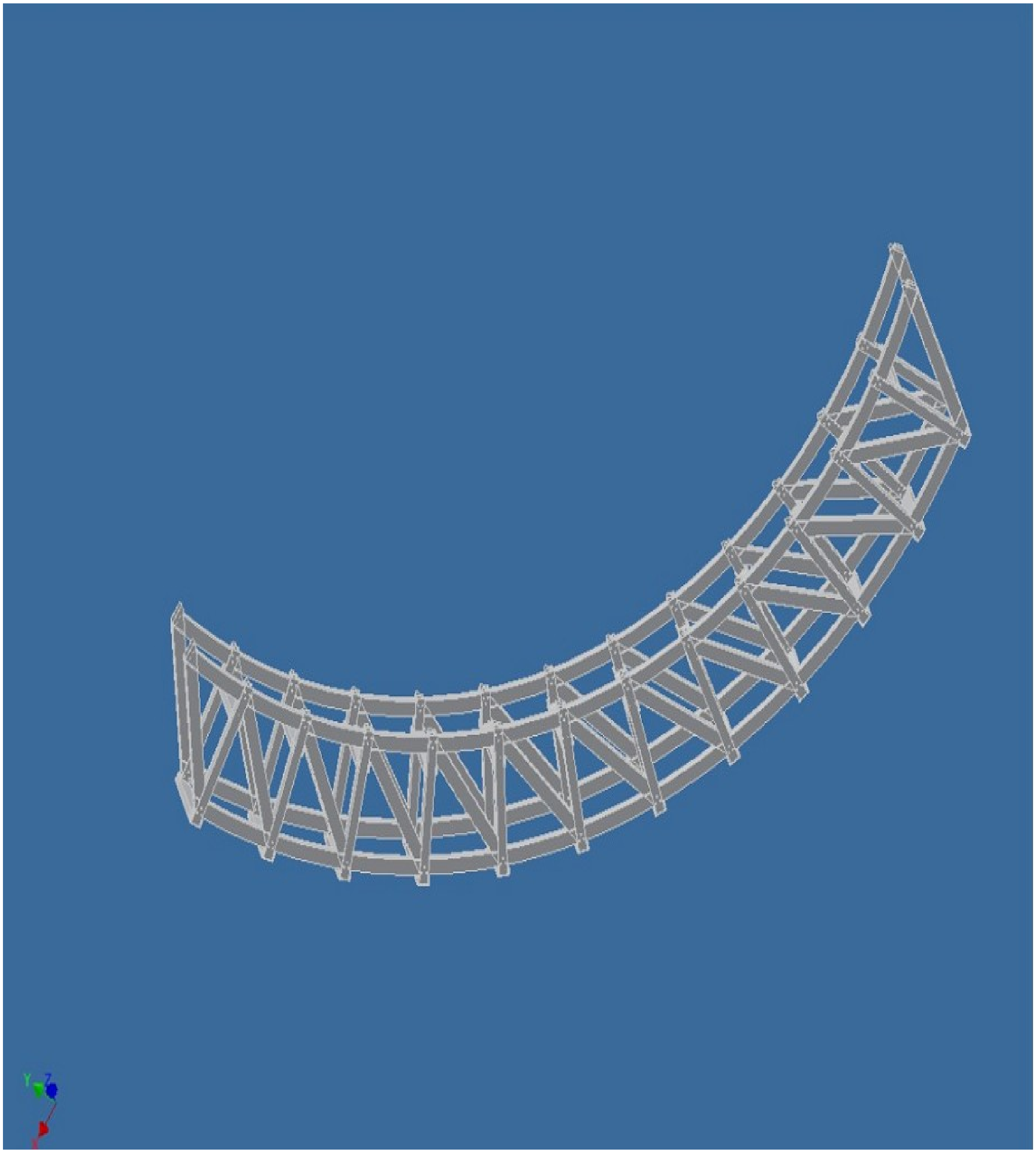
SHEET 4 OF 6
QTY: 12
MATERIAL:- ALUMINIUM
PART NAME:BOTTOM HORIZONTAL MEMBER
TITLE: 3 M SUB-MM W TELESCOPE(PROTO)
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
SCALE:NTS
CHECKED BY Rizwan
DRAWING BY K.Aruna
CONCEPT BY B.Ramesh
ALL DIMENTIONS ARE IN mm
DATE:2/9/2010
two square slots of 38*38 on one side of the rectangle
22
6.75
10.00
13.50
27.00
Ø6.00
R3.00
2.00
52.00
2.00
38.00
26.00
7.00
27.00
288.00

D9

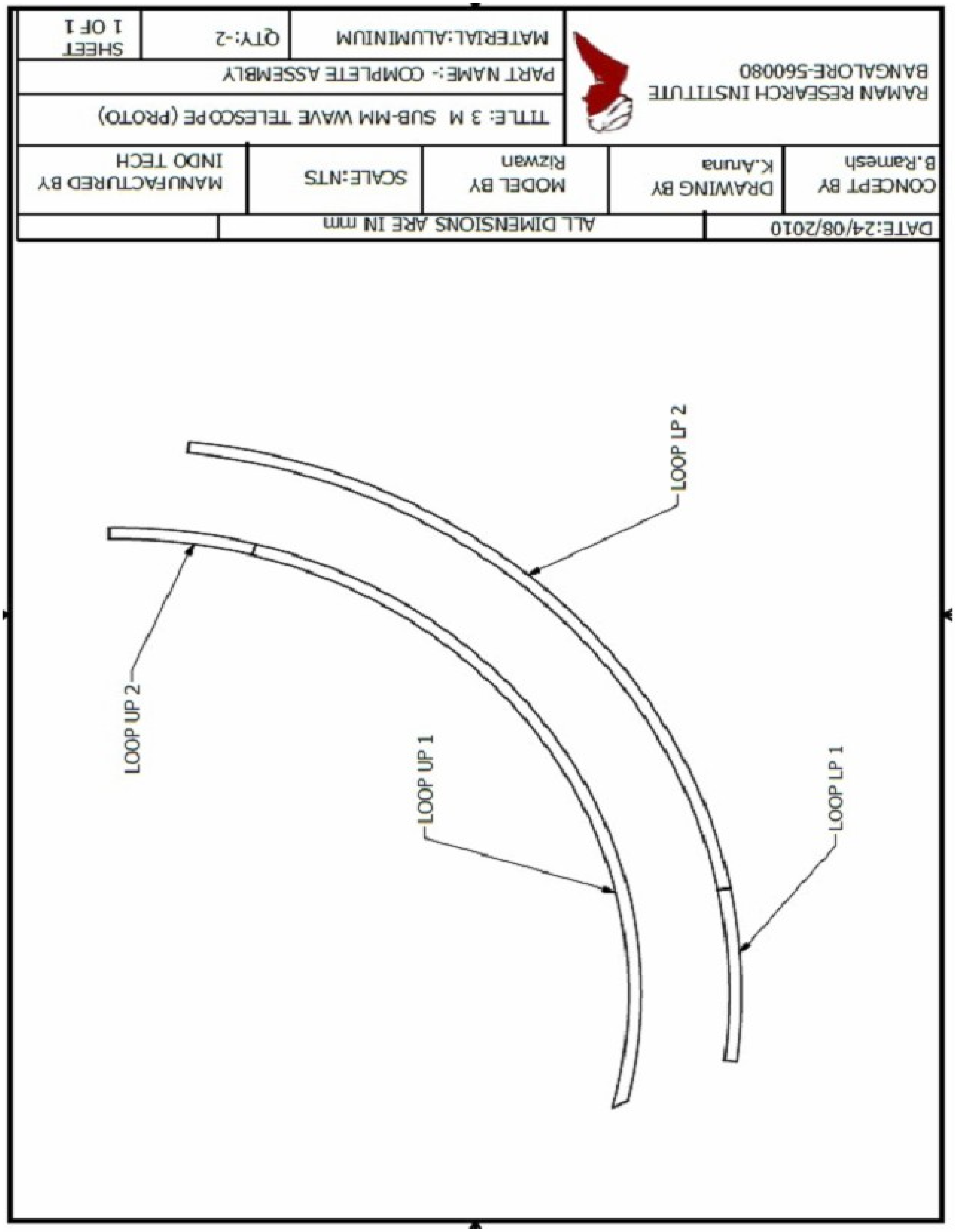

MATERIAL:- ALUMINIUM
QTY: 48
SHEET
6 OF 6
PART NAME: SPACERS-B
TITLE: 3 M SUB-MM W TELESCOPE(PROTO)
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
CONCEPT BY
B.Ramesh
DRAWING BY
K.Aruna
CHECKED BY
Rizwan
SCALE:NTS
DATE:2/9/2010
ALL DIMENTIONS ARE IN mm
23.00
11.25
4.50
40.00
Ø6.00
22
10.00
13.50
5.00

D10

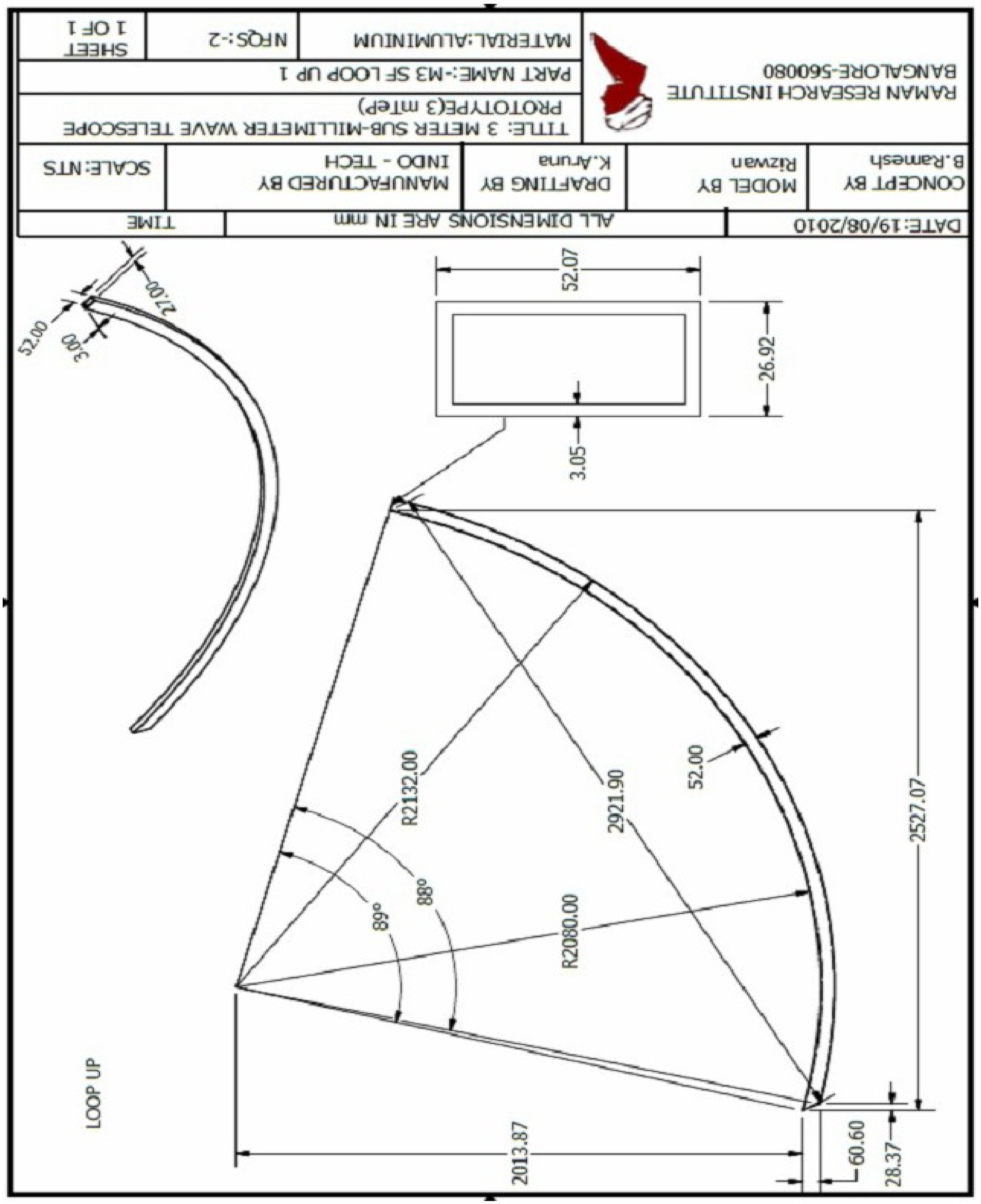
M3 SUPPORT FRAME



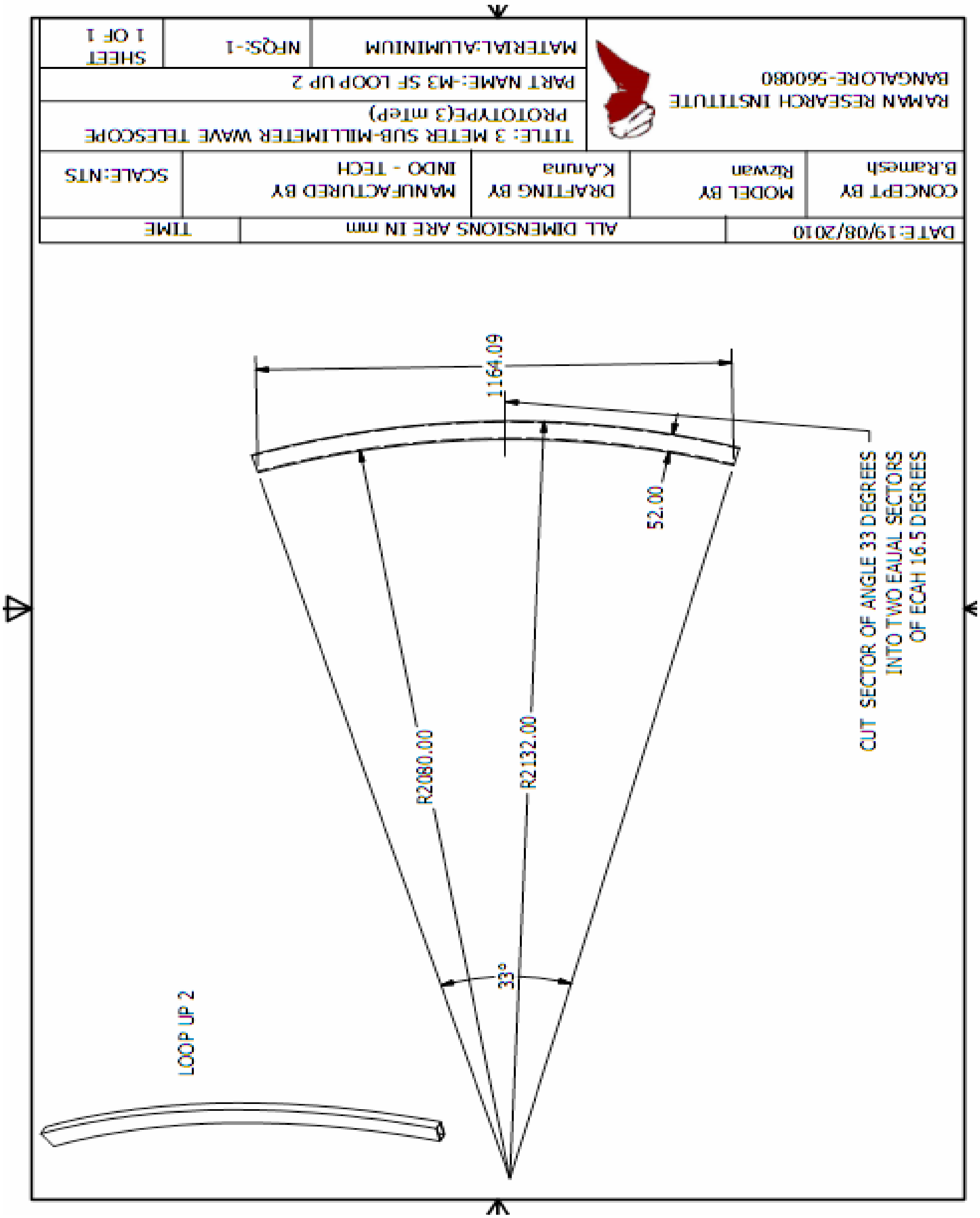
D11


RAMAN RESEARCH INSTITUTE
BANGALORE-560080
MATERIAL:ALUMINIUM
QTY:-2
SHEET
1 OF 1
PART NAME :- COMPLETE ASSEMBLY
TITLE: 3 M SUB-MM WAVE TELESCOPE (PROTO)
CONCEPT BY
B.Ramesh
DRAWING BY
K.Aruna
MODEL BY
Rizwan
SCALE:NTS
MANUFACTURED BY
INDO TECH
DATE:24/08/2010
ALL DIMENSIONS ARE IN mm
LOOP LP 2
LOOP UP 2
LOOP UP 1
LOOP LP 1

D12

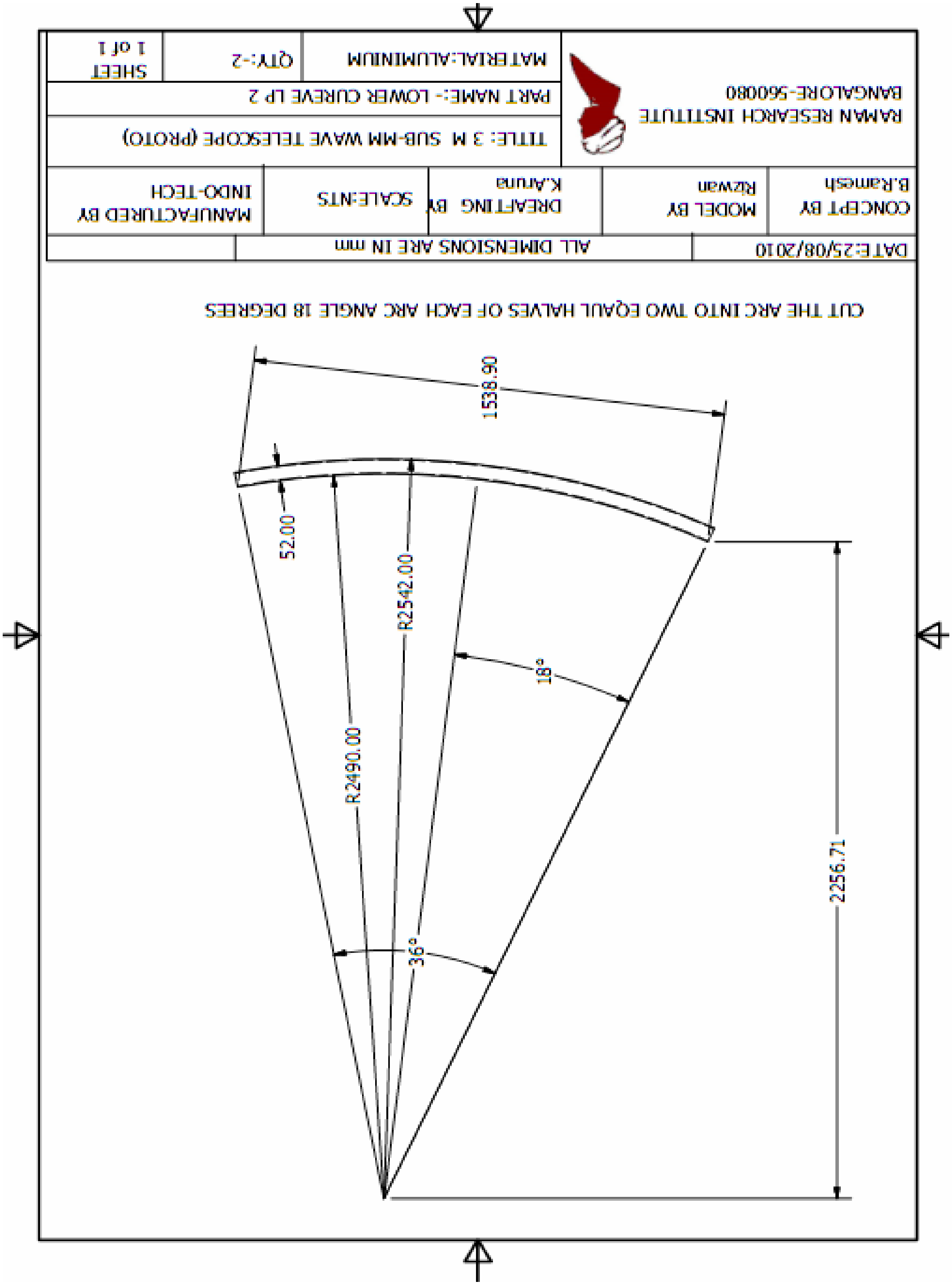

RAMAN RESEARCH INSTITUTE
BANGALORE-560080
MATERIAL:ALUMINIUM
NRQS:-2
SHEET
1 OF 1
PART NAME:-M3 SF LOOP UP 1
TITLE: 3 METER SUB-MILLIMETER WAVE TELESCOPE PROTOTYPE(3 mTeP)
CONCEPT BY
B.Ramesh
MODEL BY
Rizwan
DRAFTING BY
K.Aruna
MANUFACTURED BY
INDO - TECH
SCALE:NTS
DATE:19/08/2010
ALL DIMENSIONS ARE IN mm
TIME
52.07
26.92
3.05
27.00
52.00
3.00
R2132.00
2921.90
52.00
2527.07
89°
88°
R2080.00
LOOP UP
2013.87
60.60
28.37

D13

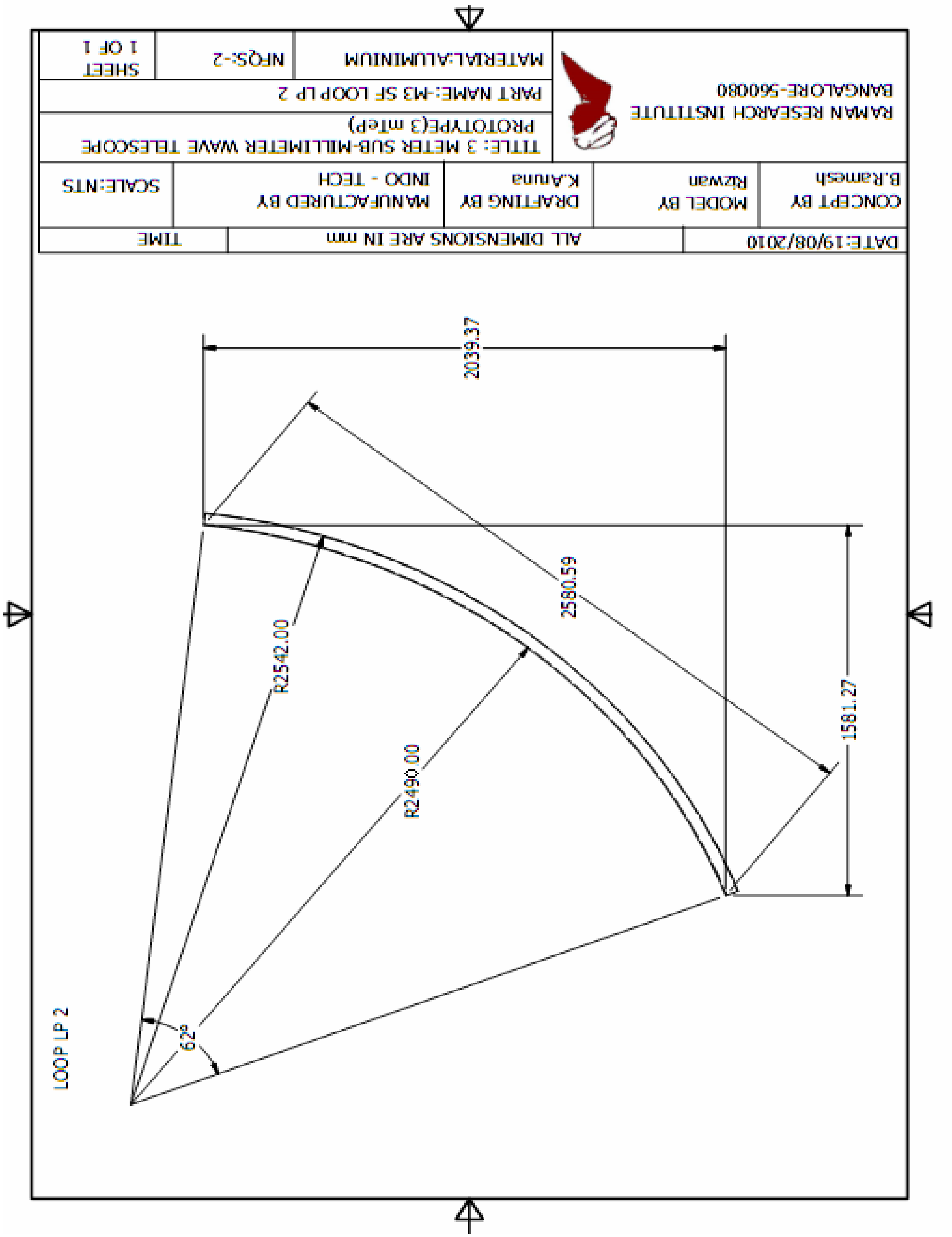


RAMAN RESEARCH INSTITUTE
BANGALORE-560080
TITLE: 3 METER SUB-MILLIMETER WAVE TELESCOPE
PROTOTYPE(3 mTeP)
PART NAME:-M3 SF LOOP UP 2
MATERIAL:ALUMINIUM
NFQS:-1
SHEET
1 OF 1
CONCEPT BY
B.Ramesh
MODEL BY
Rizwan
DRAFTING BY
K.Aruna
MANUFACTURED BY
INDO - TECH
SCALE:NTS
DATE:19/08/2010
ALL DIMENSIONS ARE IN mm
TIME
1164.09
52.00
R2080.00
R2132.00
33°
CUT SECTOR OF ANGLE 33 DEGREES
INTO TWO EAUAL SECTORS
OF ECAH 16.5 DEGREES
LOOP UP 2

D14

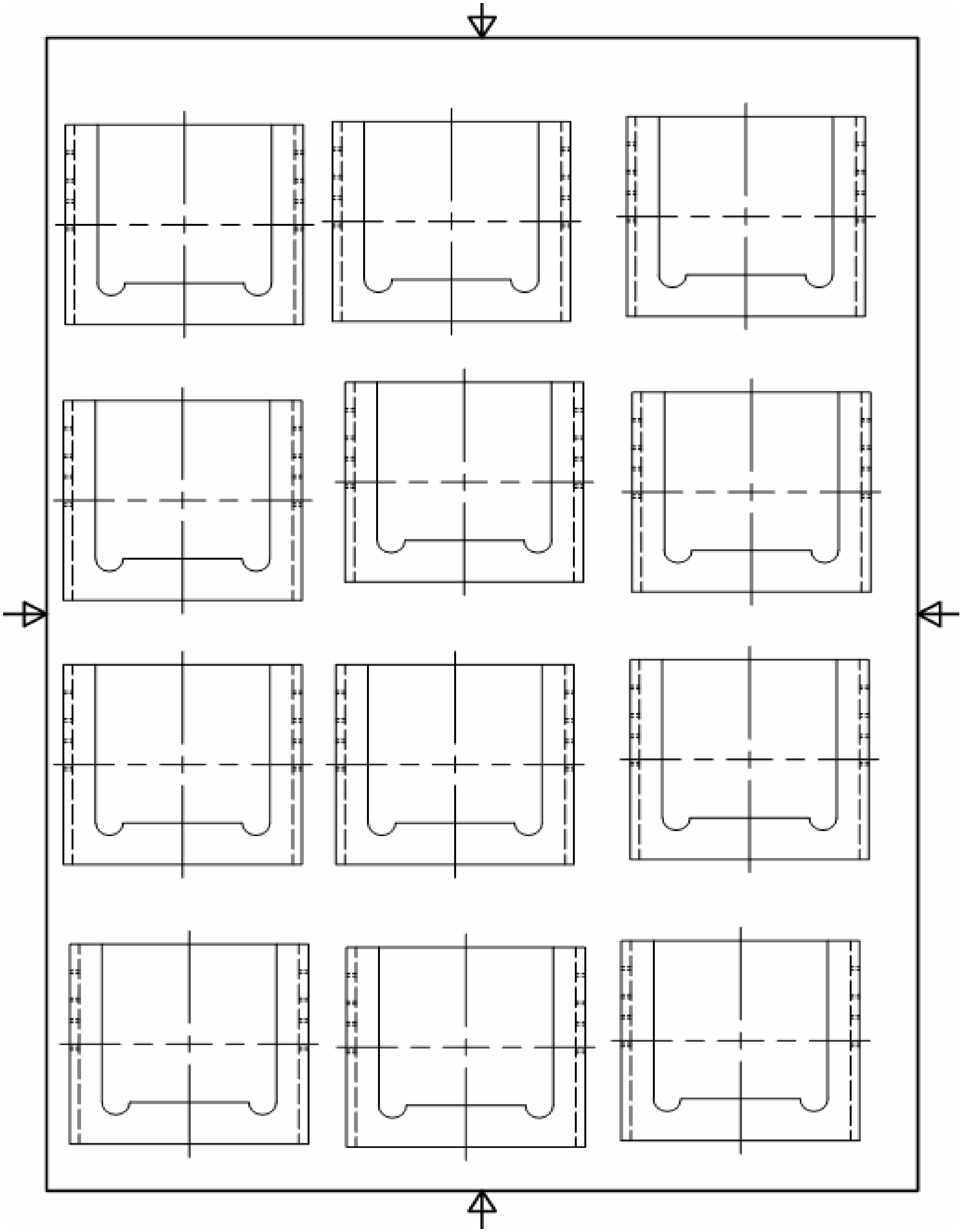

RAMAN RESEARCH INSTITUTE
BANGALORE-560080
TITLE: 3 M SUB-MM WAVE TELESCOPE (PROTO)
PART NAME:- LOWER CUREVE LP 2
MATERIAL:ALUMINIUM
QTY:-2
SHEET 1 of 1
CONCEPT BY B.Ramesh
MODEL BY Rizwan
DREAFTING BY K.Aruna
SCALE:NTS
MANUFACTURED BY INDO-TECH
DATE:25/08/2010
ALL DIMENSIONS ARE IN mm
CUT THE ARC INTO TWO EQAUL HALVES OF EACH ARC ANGLE 18 DEGREES
1538.90
52.00
R2542.00
R2490.00
18°
36°
2256.71

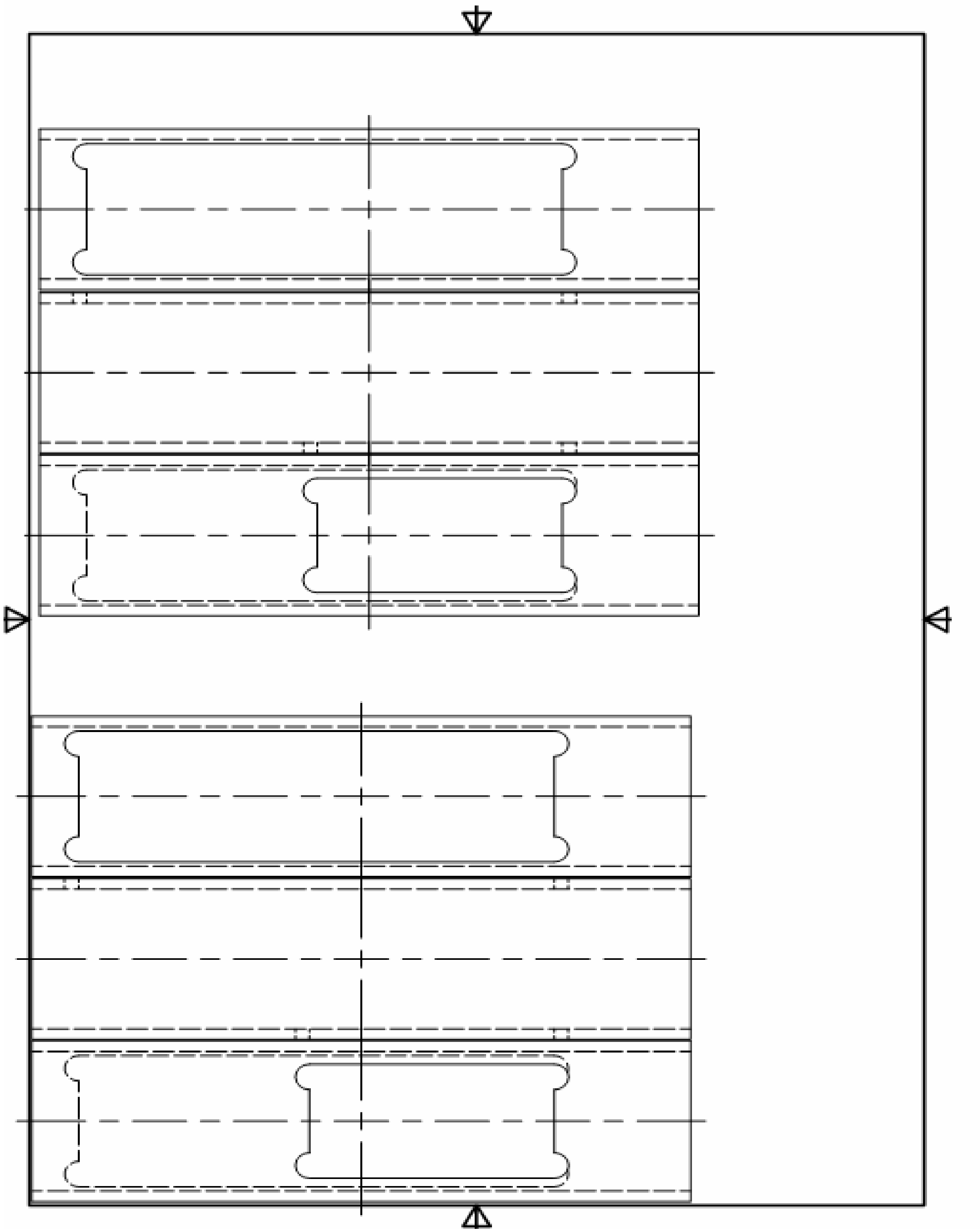
D15


RAMAN RESEARCH INSTITUTE
BANGALORE-560080
TITLE: 3 METER SUB-MILLIMETER WAVE TELESCOPE
PROTOTYPE(3 mTeP)
PART NAME:-M3 SF LOOP LP 2
MATERIAL:ALUMINIUM
NFQS:-2
SHEET
1 OF 1
CONCEPT BY
B.Ramesh
MODEL BY
Rizwan
DRAFTING BY
K.Aruna
MANUFACTURED BY
INDO - TECH
SCALE:NTS
DATE:19/08/2010
ALL DIMENSIONS ARE IN mm
TIME
2039.37
2580.59
R2542.00
R2490.00
1581.27
62°
LOOP LP 2

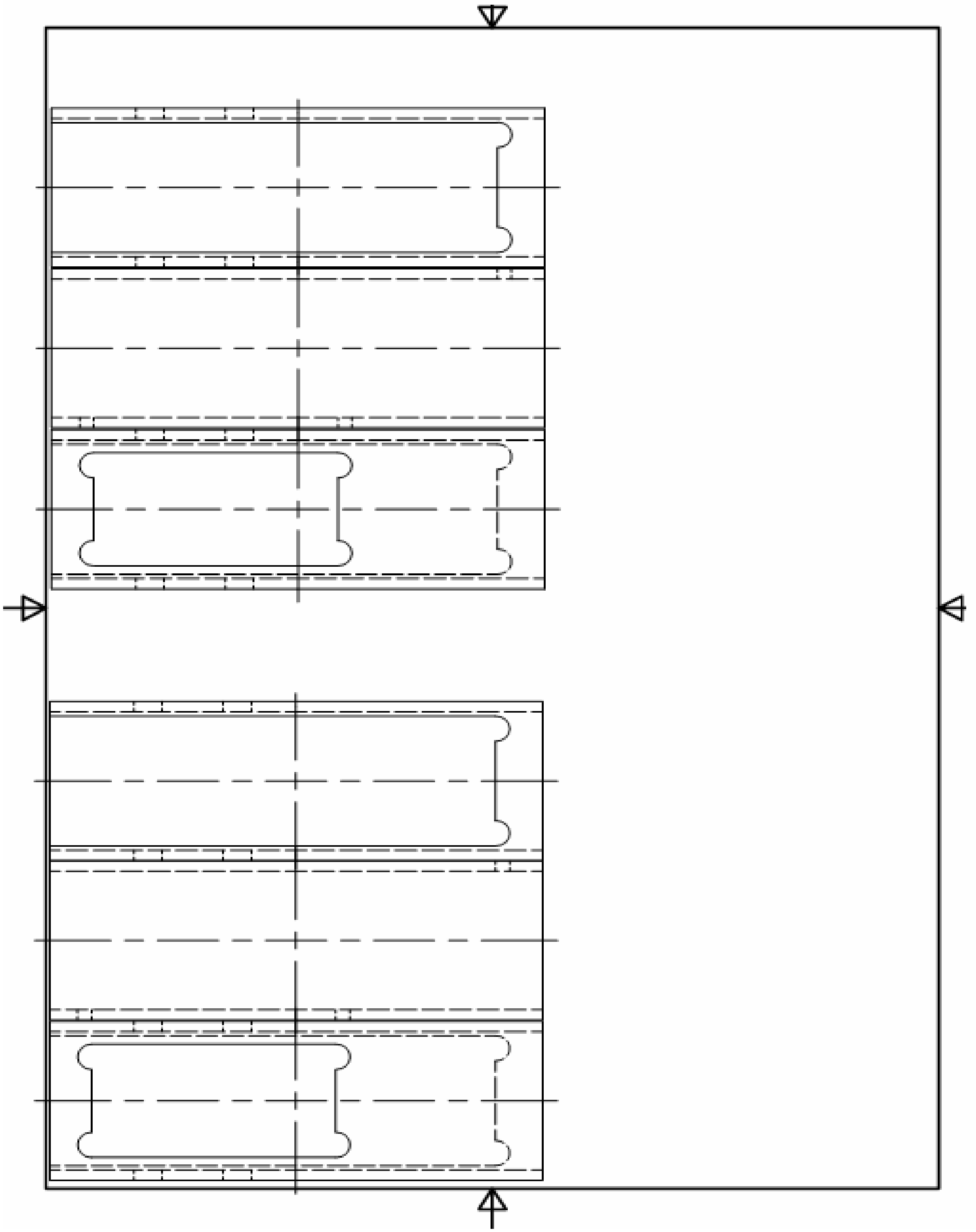
D16

INTERLINKING U FRAME 1:1 TEMPLATES

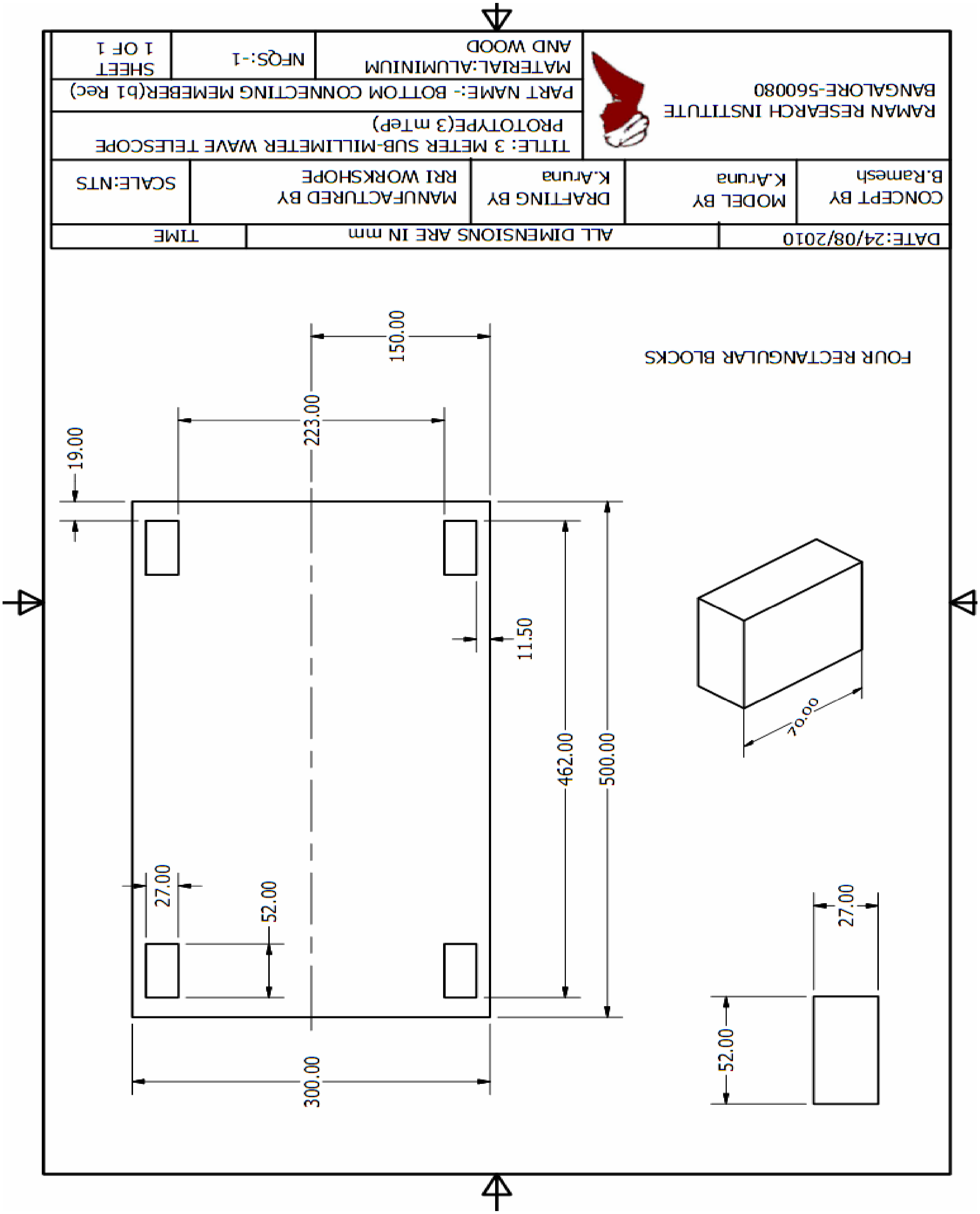




D18



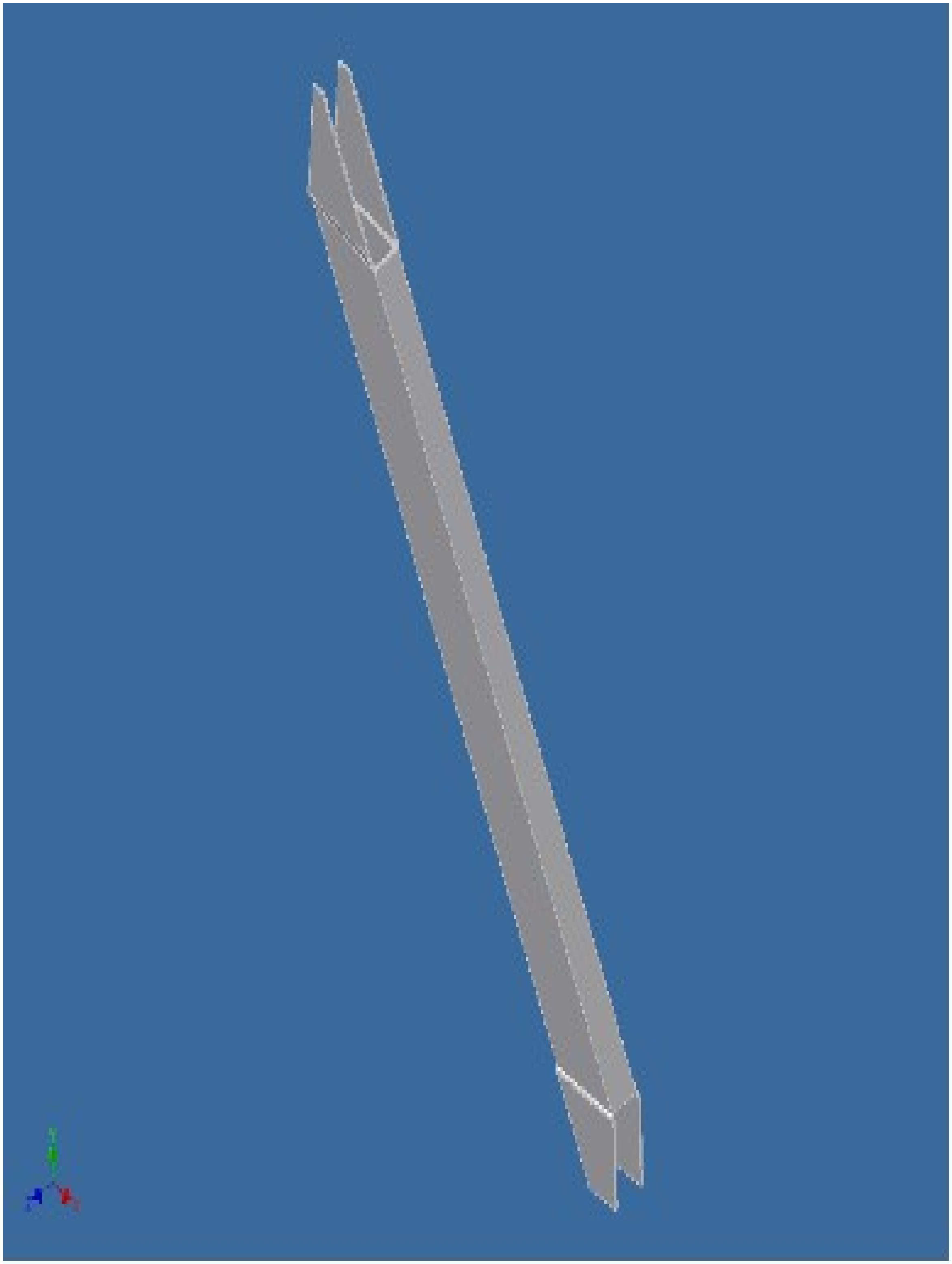
D19



RAMAN RESEARCH INSTITUTE
BANGALORE-560080
SHEET
1 OF 1
NFQS:-1
MATERIAL:ALUMINIUM
AND WOOD
PART NAME:- BOTTOM CONNECTING MEMEBER(b1 Rec)
TITLE: 3 METER SUB-MILLIMETER WAVE TELESCOPE
PROTOTYPE(3 mTeP)
CONCEPT BY
B.Ramesh
MODEL BY
K.Aruna
DRAFTING BY
K.Aruna
MANUFACTURED BY
RRI WORKSHOPE
SCALE:NTS
DATE:24/08/2010
ALL DIMENSIONS ARE IN mm
TIME
FOUR RECTANGULAR BLOCKS
150.00
223.00
19.00
11.50
462.00
500.00
27.00
52.00
300.00
70.00
27.00
52.00

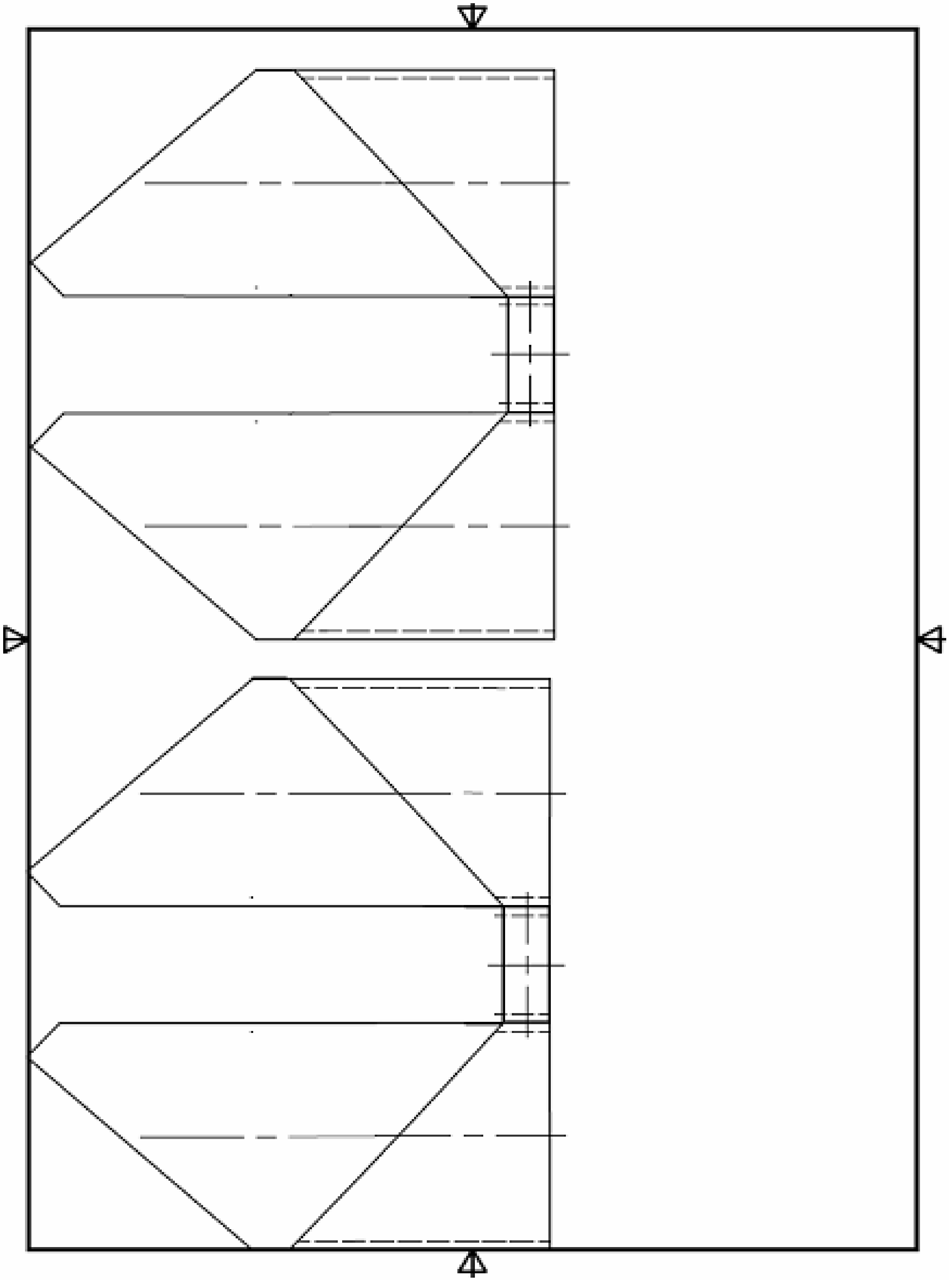
D20

INCLINED STEP BENDING MEMBER

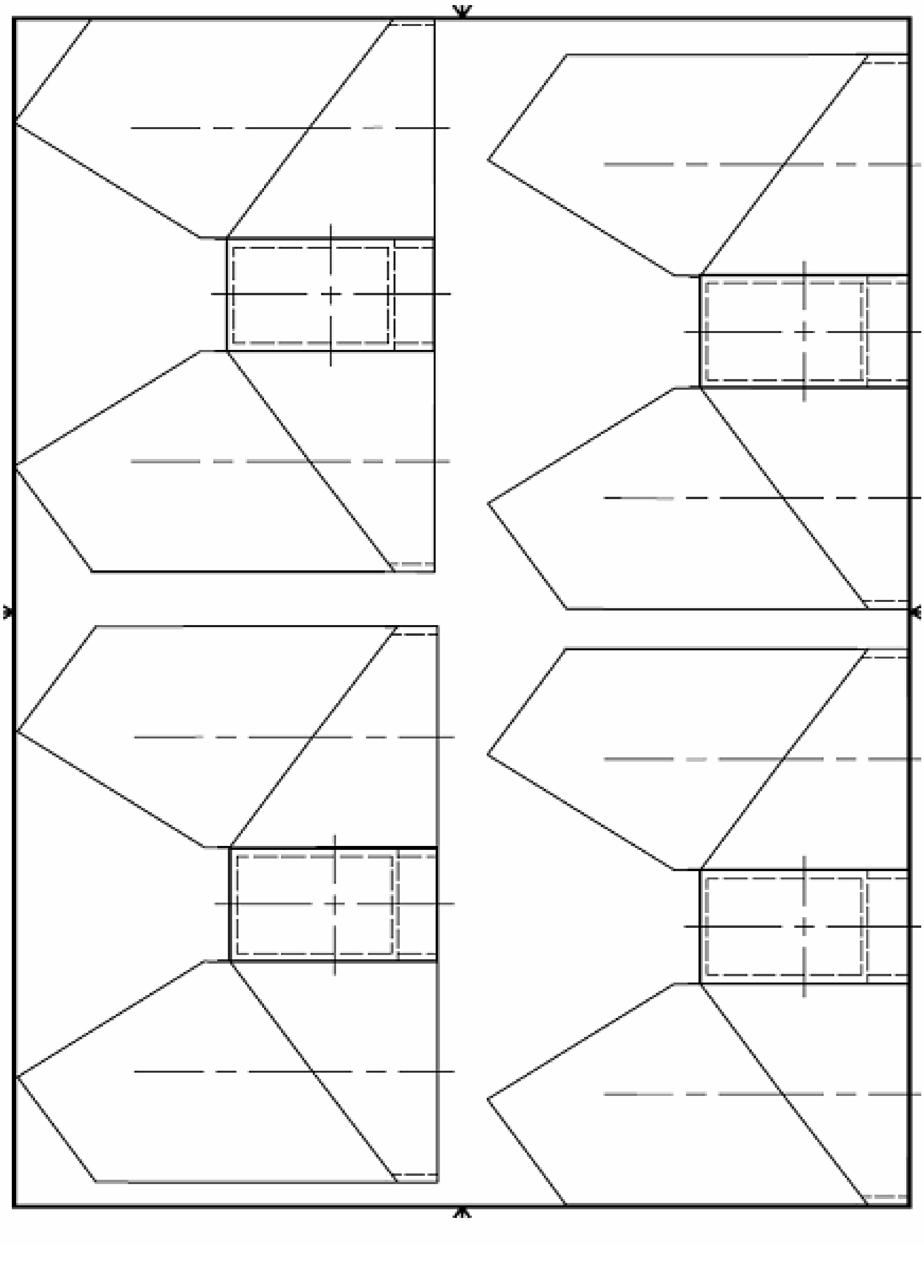


D21

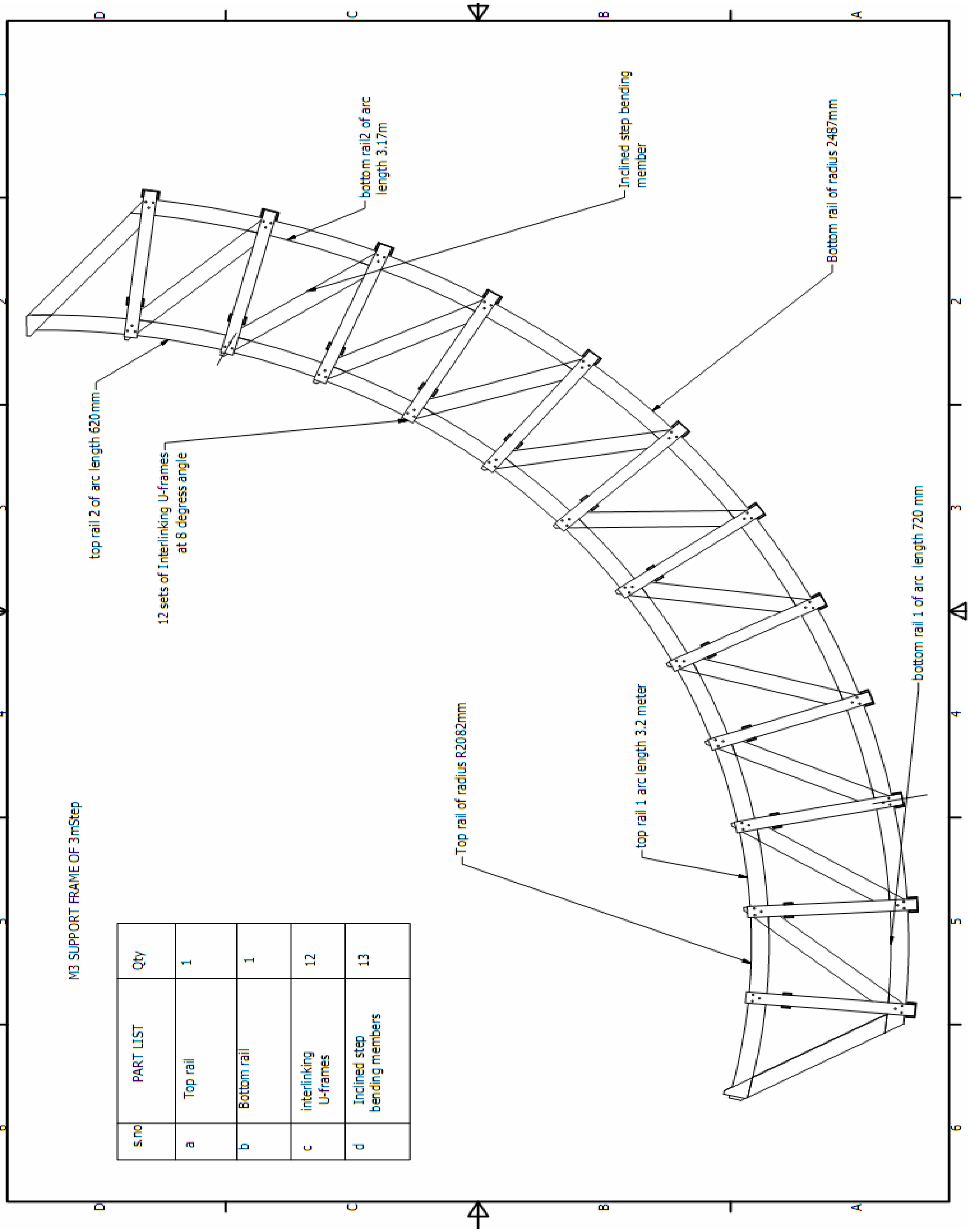
STEP BENDING TEMPLATES FOR M3 SUPPORT FRAME



D22

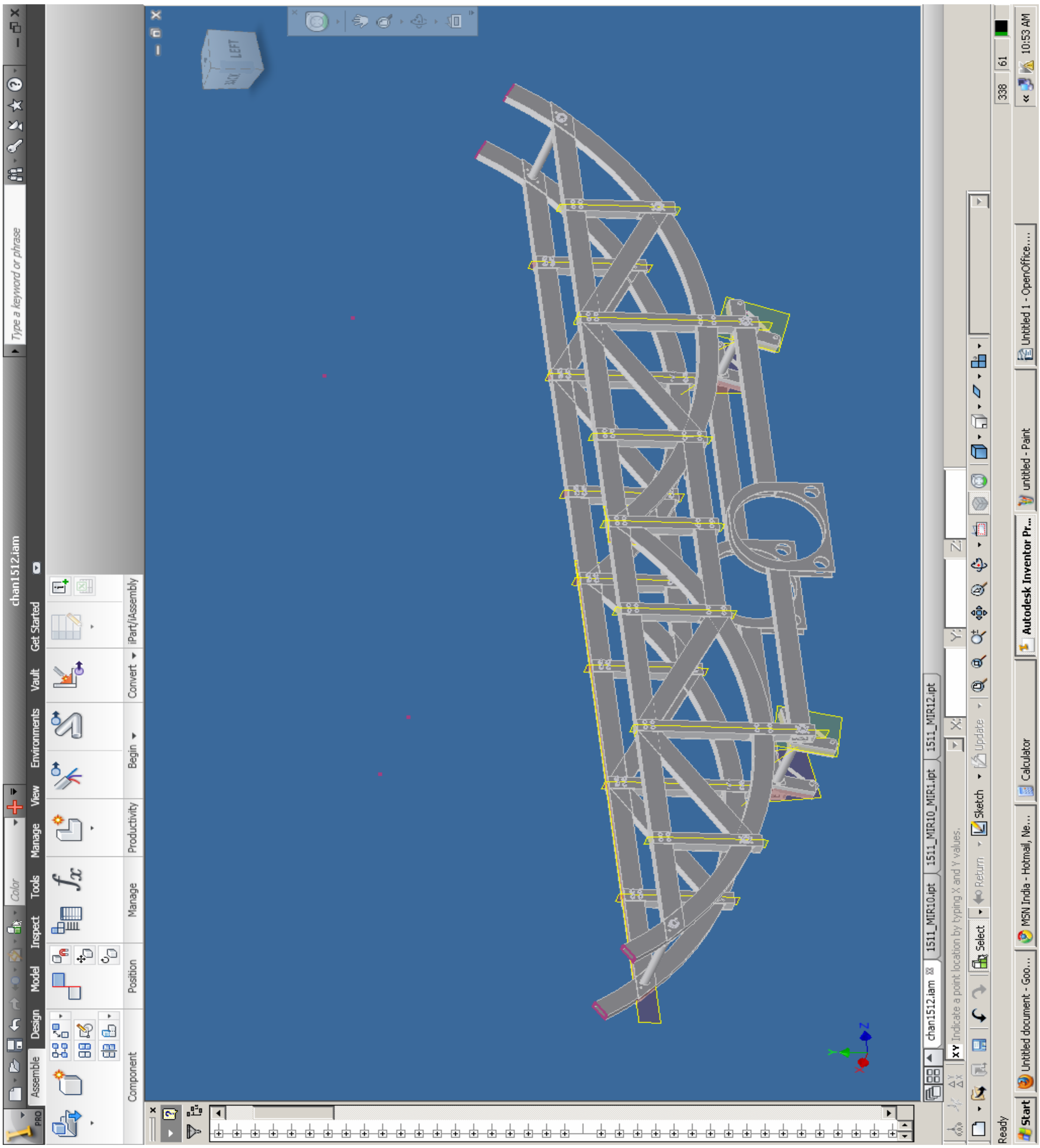


D23

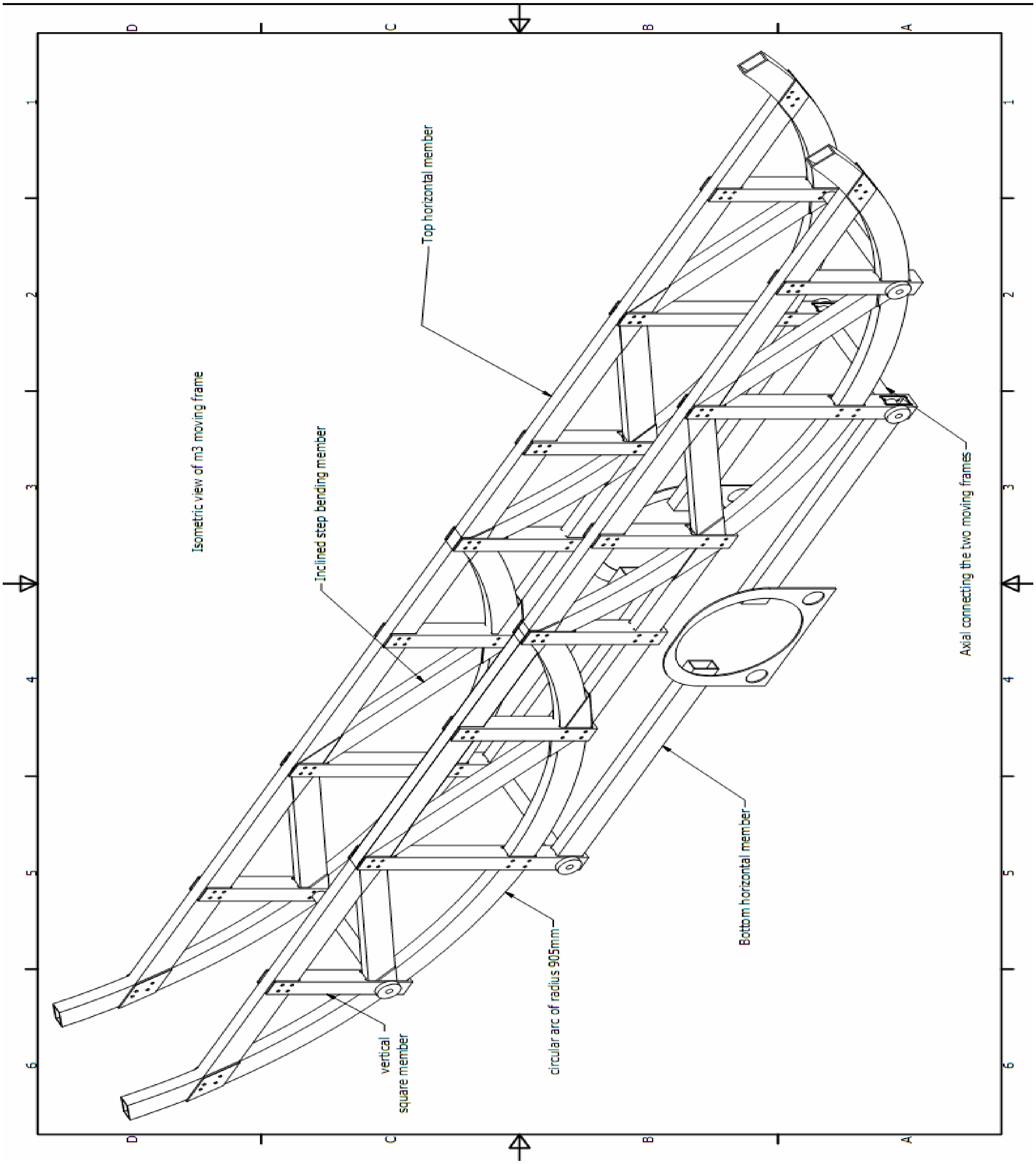

M3 SUPPORT FRAME OF 3mStep
PART LIST
s.no | PART LIST | Qty
a | Top rail | 1
b | Bottom rail | 1
c | interlinking U-frames | 12
d | Inclined step bending members | 13
bottom rail2 of arc length 3.17m
Inclined step bending member
Bottom rail of radius 2487mm
top rail 2 of arc length 620mm
12 sets of Interlinking U-frames at 8 degress angle
bottom rail 1 of arc length 720 mm
Top rail of radius R2082mm
top rail 1 arc length 3.2 meter

D24

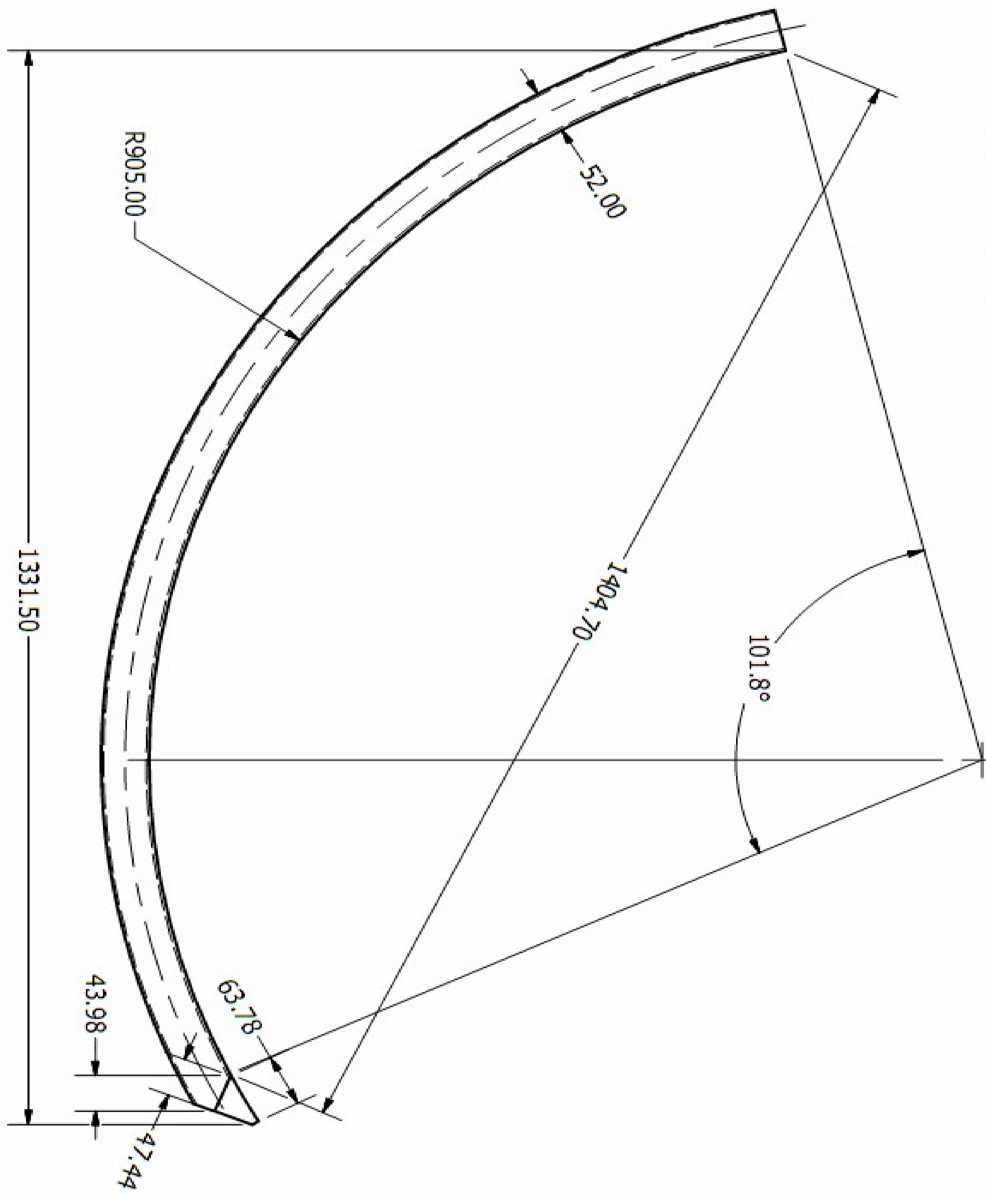
M3 MOVING BASKET



D25


Isometric view of m3 moving frame
Top horizontal member
Inclined step bending member
Axial connecting the two moving frames
Bottom horizontal member
circular arc of radius 905mm
vertical
square member

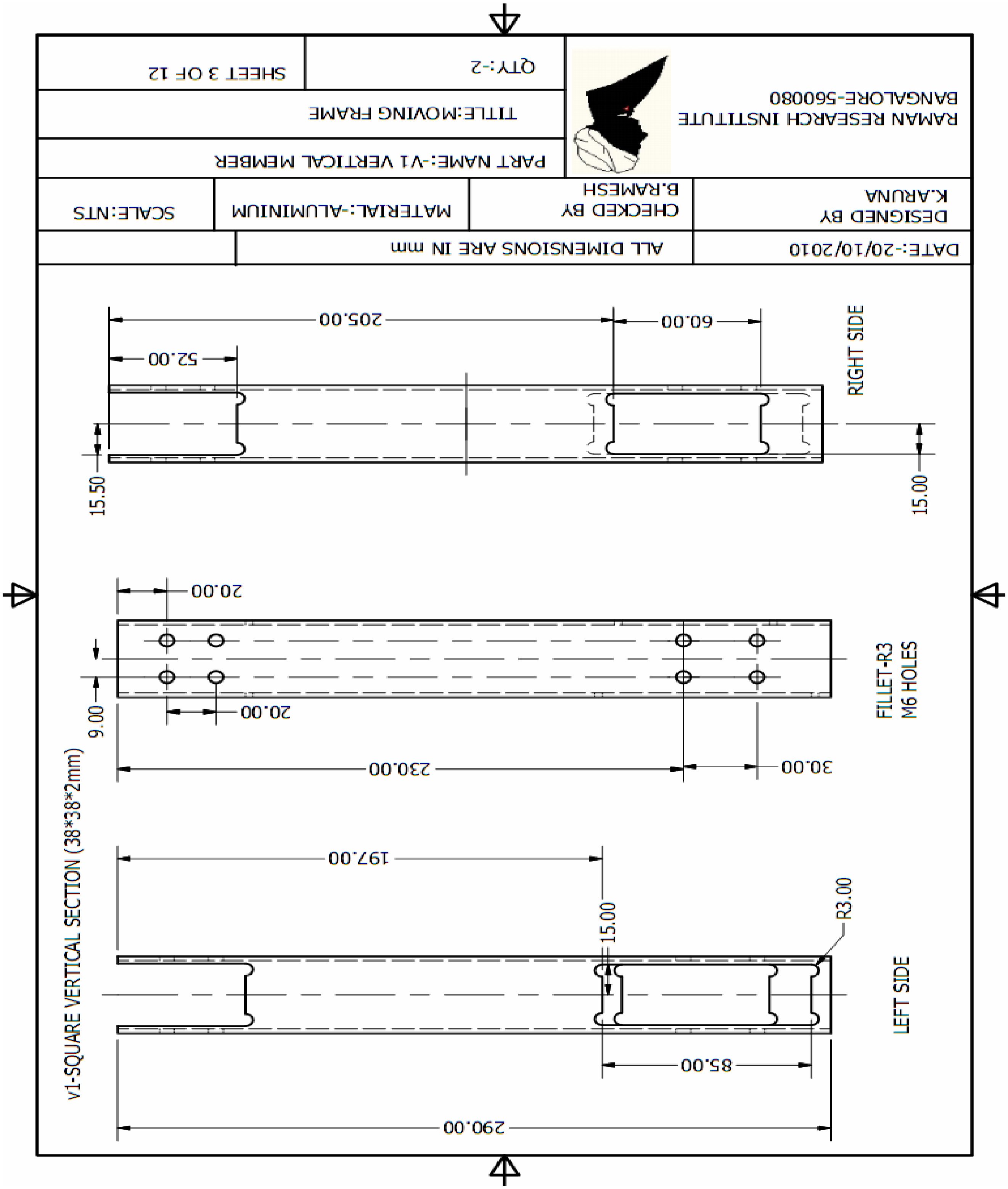
D26



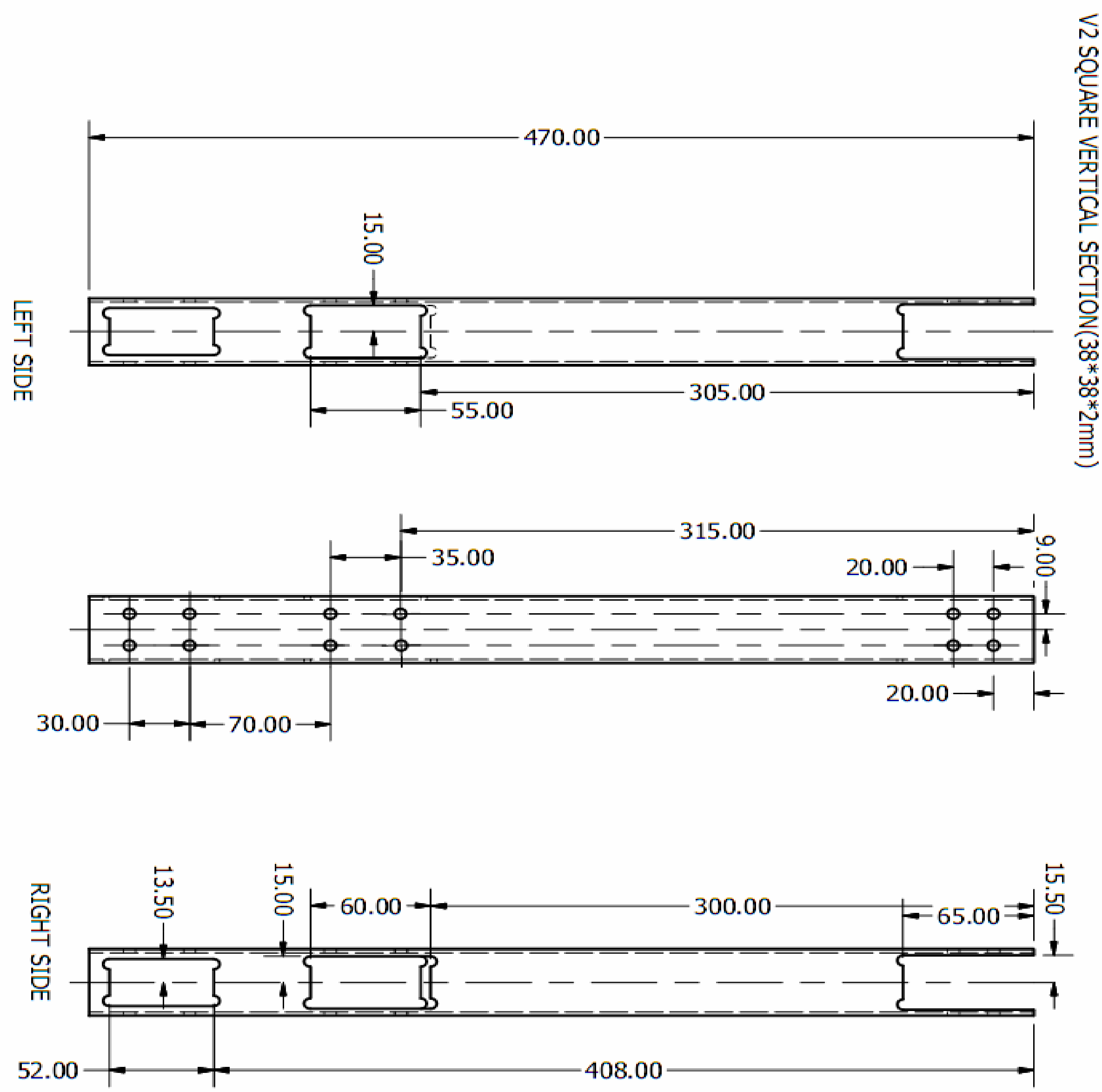
Rectangular section 52*27*3mm
Acuracyof arc deflectios-500 microns
Radius deflections- 5mm

DATE:-20/10/2010	ALL DIMENSIONS ARE IN mm		
DESIGNED BY K.ARUNA	CHECKED BY B.RAMESH	MATERIAL:-ALUMINIUM	SCALE:NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080	PART NAME:-A1 CIRCULAR ARC		
	TITLE:MOVING FRAME		
	QTY:-2	SHEET 2 OF 12	

D27

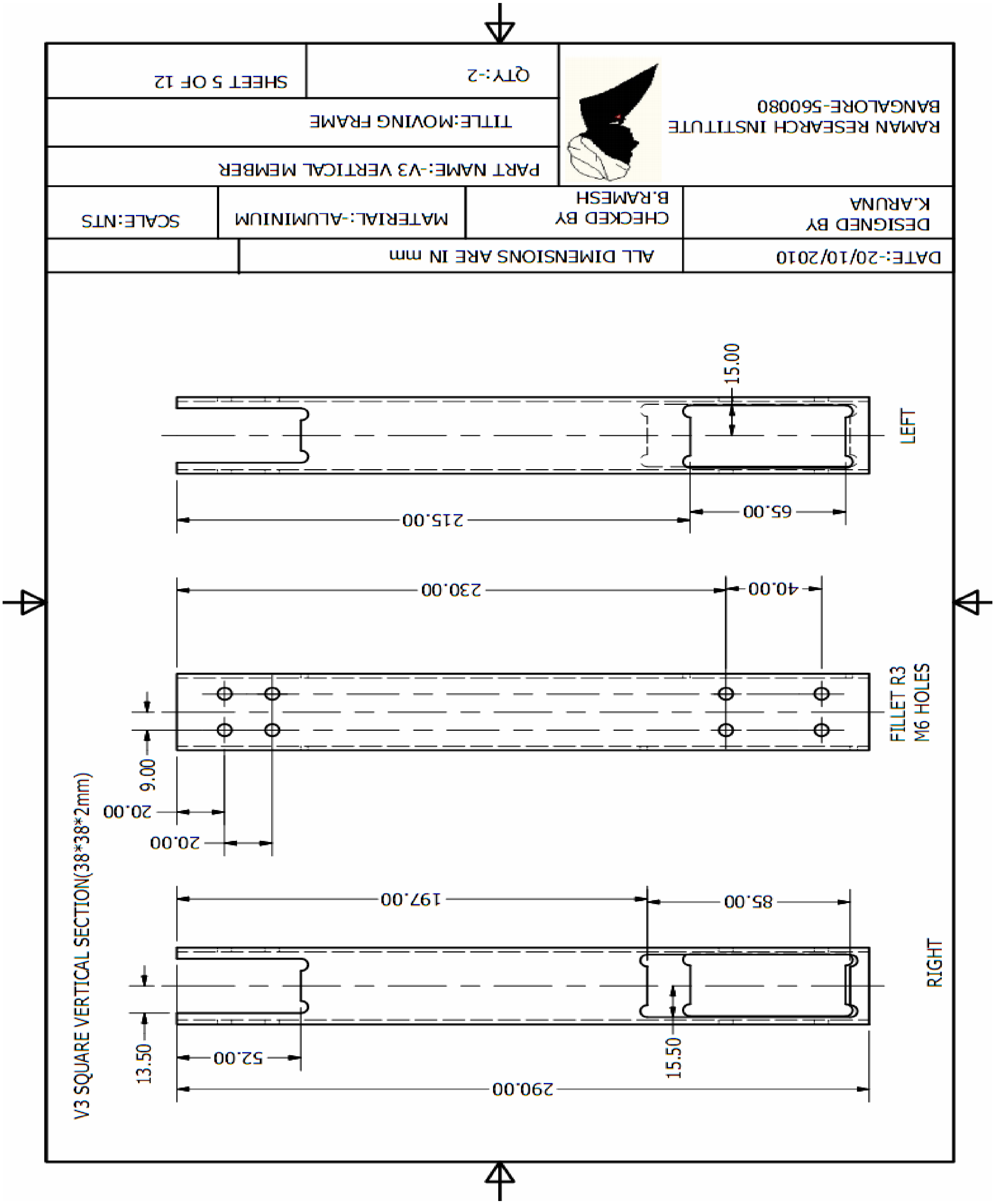

SHEET 3 OF 12
QTY:-2
TITLE:MOVING FRAME
PART NAME:-V1 VERTICAL MEMBER
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
SCALE:NTS
MATERIAL:-ALUMINIUM
CHECKED BY
B.RAMESH
DESIGNED BY
K.ARUNA
ALL DIMENSIONS ARE IN mm
DATE:-20/10/2010
RIGHT SIDE
FILLET-R3
M6 HOLES
LEFT SIDE
v1-SQUARE VERTICAL SECTION (38*38*2mm)
R3.00
205.00
60.00
52.00
15.50
15.00
20.00
9.00
230.00
30.00
197.00
85.00
290.00

D28

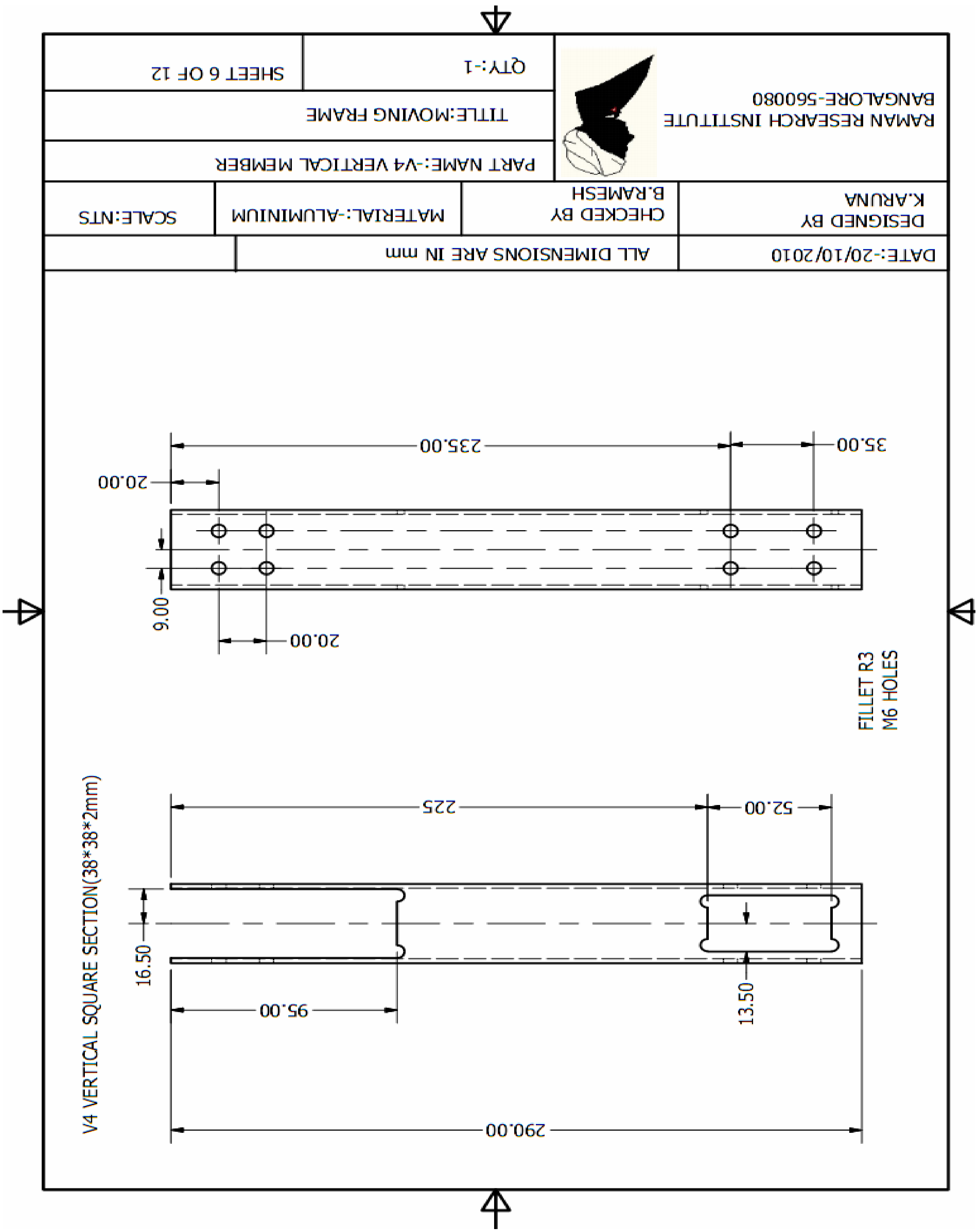


DATE:-20/10/2010	ALL DIMENSIONS ARE IN mm		
DESIGNED BY K.ARUNA	CHECKED BY B.RAMESH	MATERIAL:-ALUMINIUM	SCALE:NTS
RAMAN RESEARCH INSTITUTE BANGALORE-560080	PART NAME:-V2 VERTICAL MEMBER		
	TITLE:MOVING FRAME		
	QTY:-2	SHEET 4 OF 12	

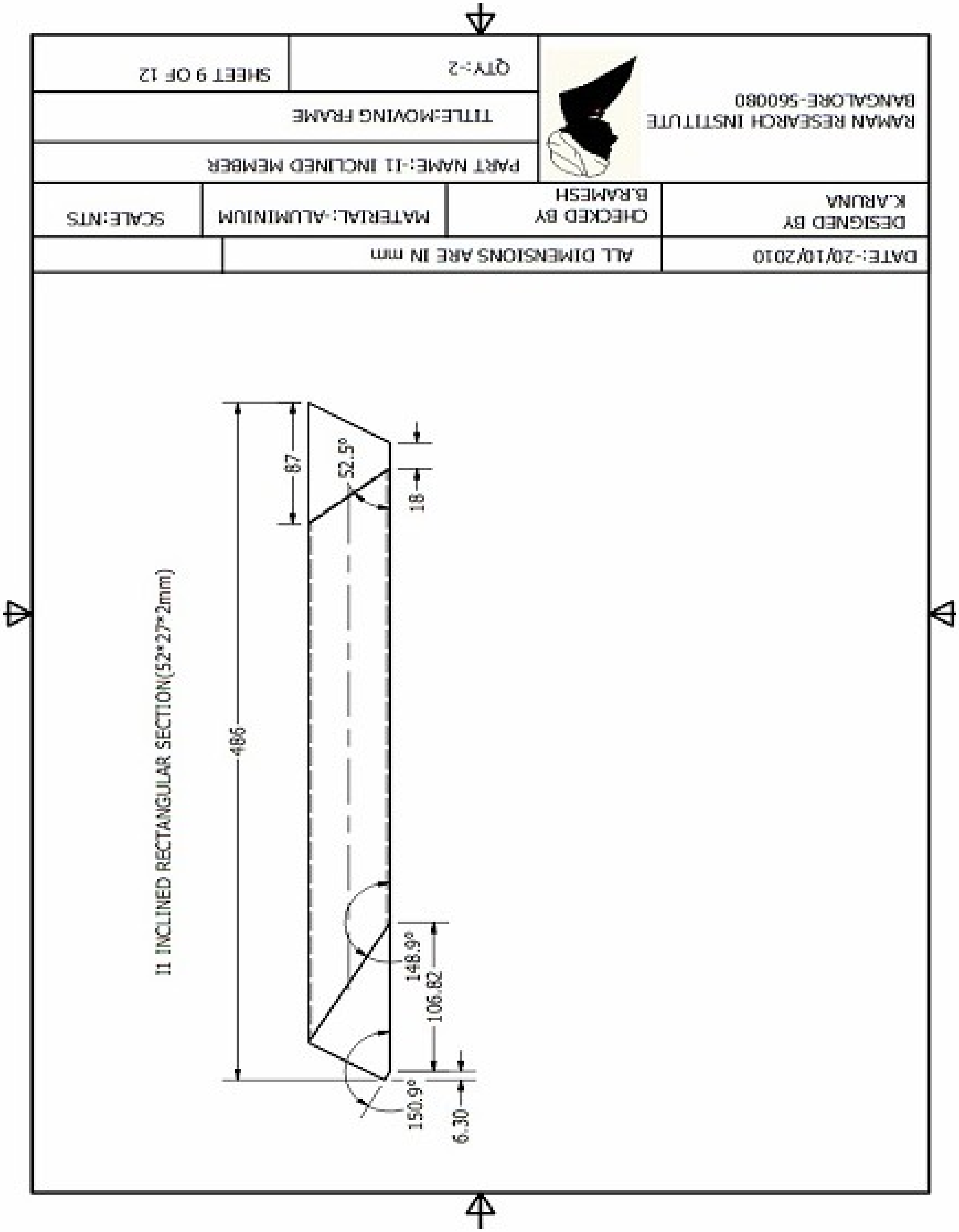
D29


SHEET 5 OF 12
QTY:-2
TITLE:MOVING FRAME
PART NAME:-V3 VERTICAL MEMBER
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
15.00
LEFT
215.00
65.00
230.00
40.00
FILLET R3
M6 HOLES
9.00
20.00
20.00
V3 SQUARE VERTICAL SECTION(38*38*2mm)
197.00
85.00
RIGHT
13.50
52.00
15.50
290.00

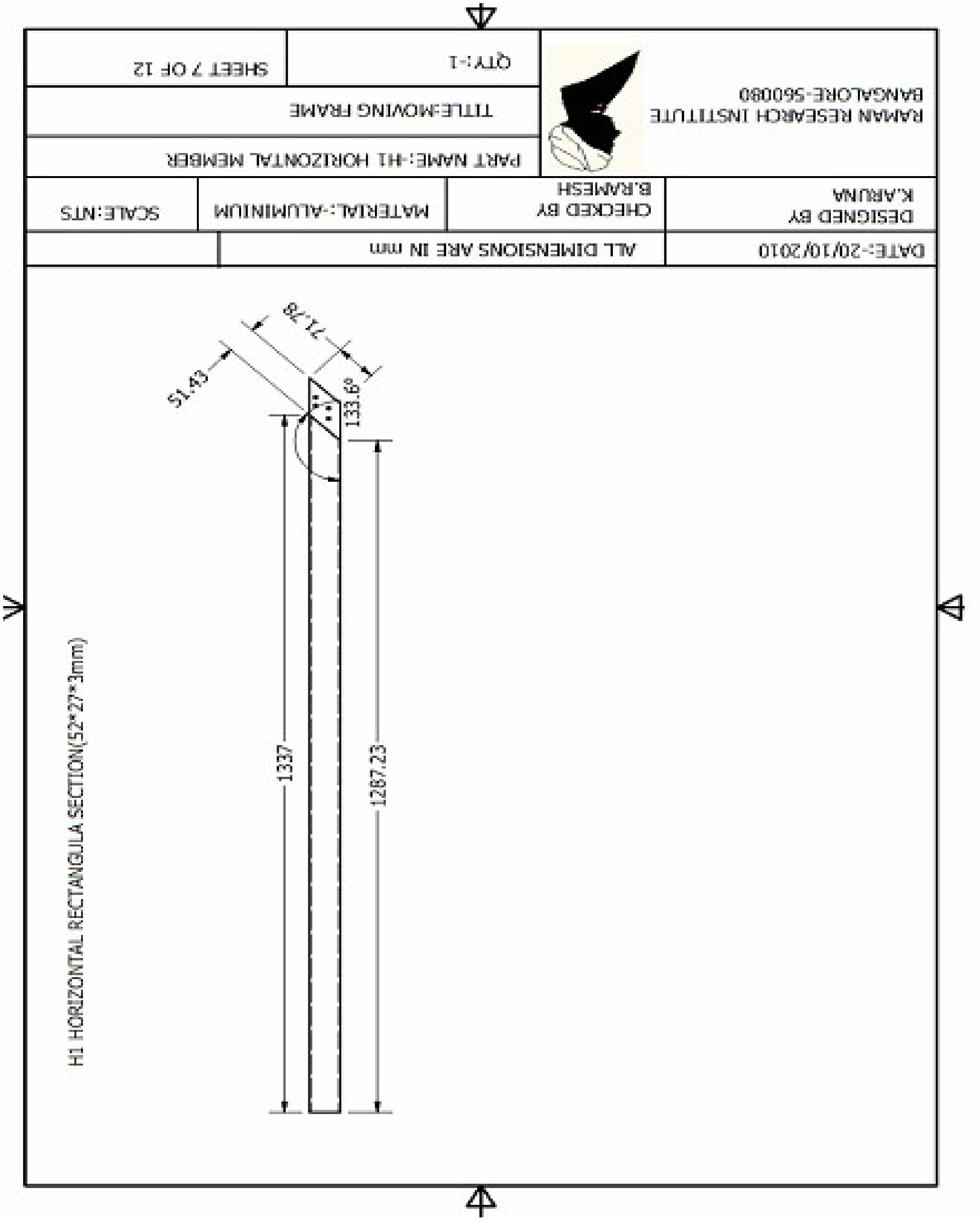
D30


RAMAN RESEARCH INSTITUTE
BANGALORE-560080
QTY:-1
SHEET 6 OF 12
TITLE:MOVING FRAME
PART NAME:-V4 VERTICAL MEMBER
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
35.00
235.00
20.00
9.00
20.00
FILLET R3
M6 HOLES
52.00
225
16.50
13.50
95.00
290.00
V4 VERTICAL SQUARE SECTION(38*38*2mm)

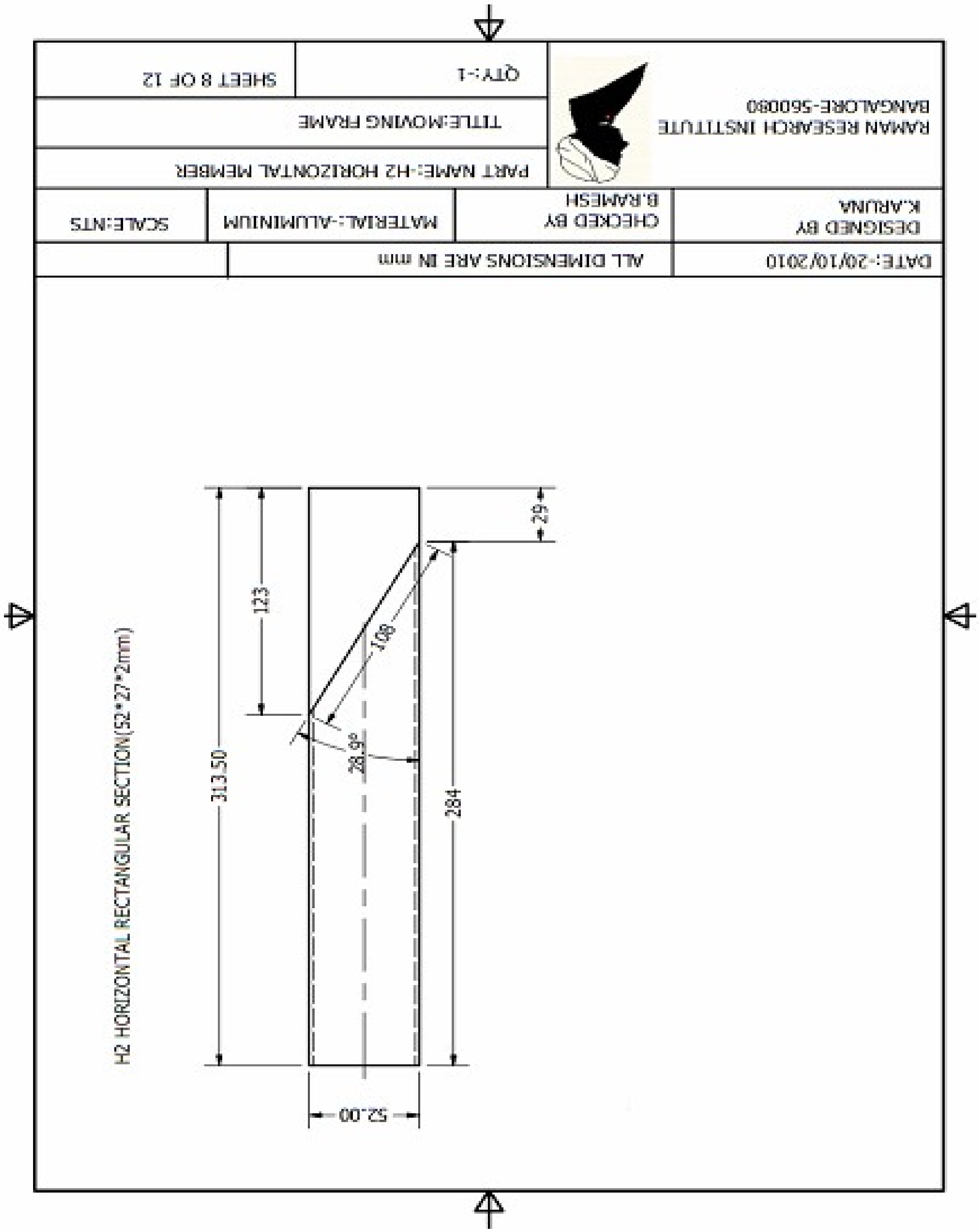
D31


RAMAN RESEARCH INSTITUTE
BANGALORE-560080
SHEET 9 OF 12
QTY:-2
TITLE:MOVING FRAME
PART NAME:-I1 INCLINED MEMBER
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
I1 INCLINED RECTANGULAR SECTION(52*27*2mm)
87
52.5°
18
486
148.9°
106.82
150.9°
6.30

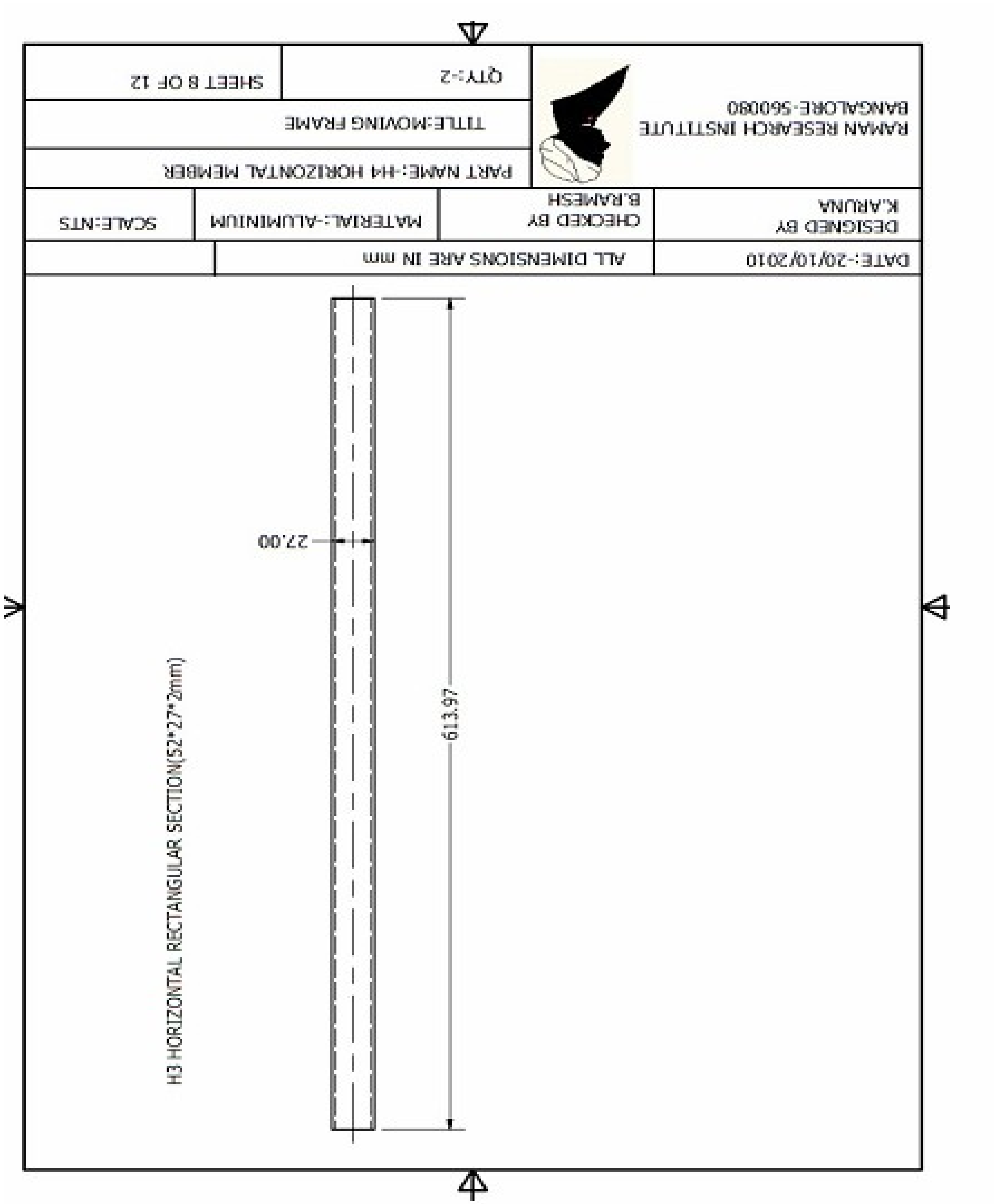
D32


SHEET 7 OF 12
QTY:-1
RAMAN RESEARCH INSTITUTE
BANGALORE-560080
TITLE:MOVING FRAME
PART NAME:-H1 HORIZONTAL MEMBER
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
71.78
51.43
133.6°
1337
1287.23
H1 HORIZONTAL RECTANGULA SECTION(52*27*3mm)

D33

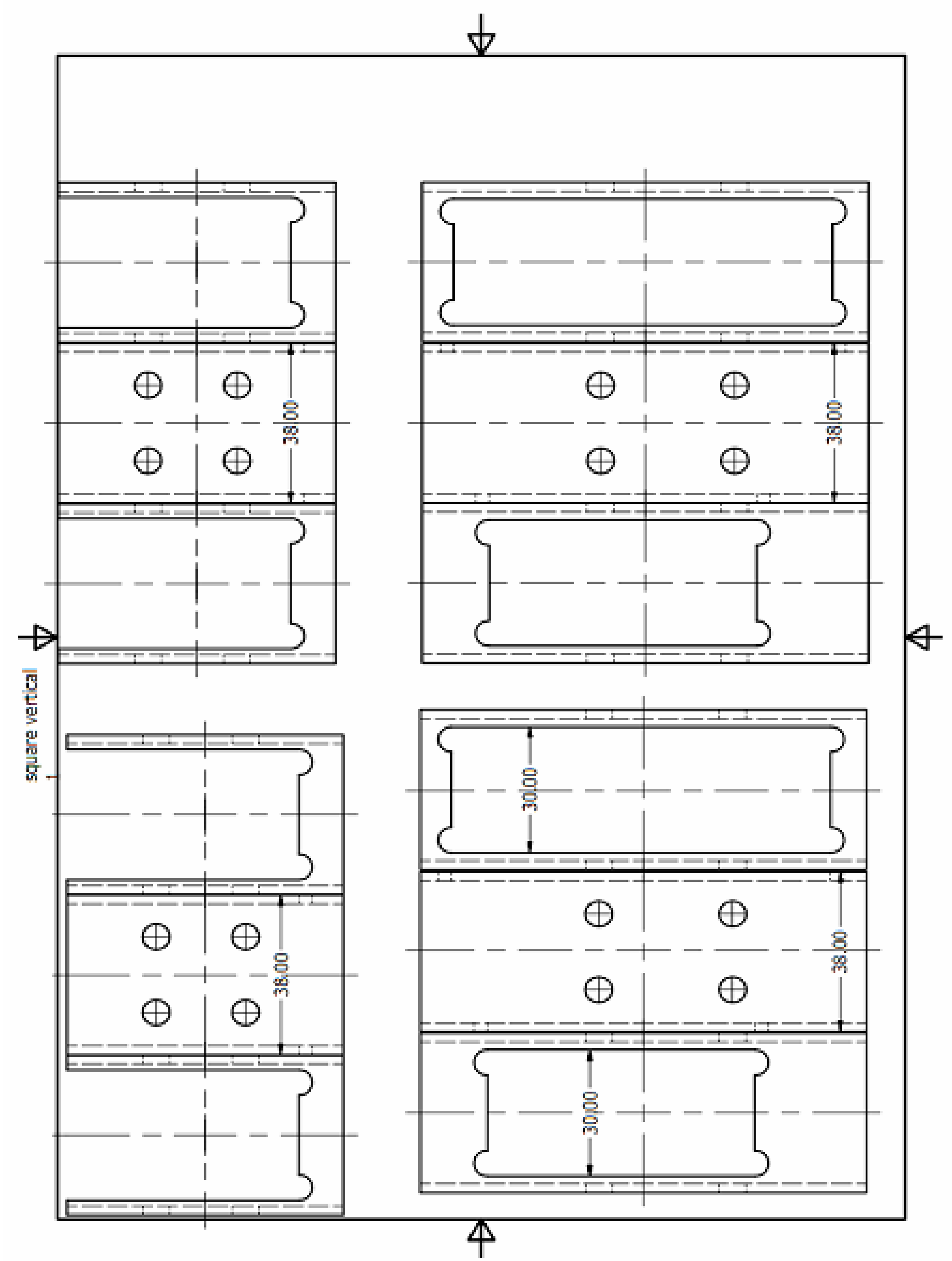

RAMAN RESEARCH INSTITUTE
BANGALORE-560080
QTY:-1
SHEET 8 OF 12
TITLE:MOVING FRAME
PART NAME:-H2 HORIZONTAL MEMBER
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
H2 HORIZONTAL RECTANGULAR SECTION(52*27*2mm)
313.50
123
29
108
28.9°
284
52.00

D34

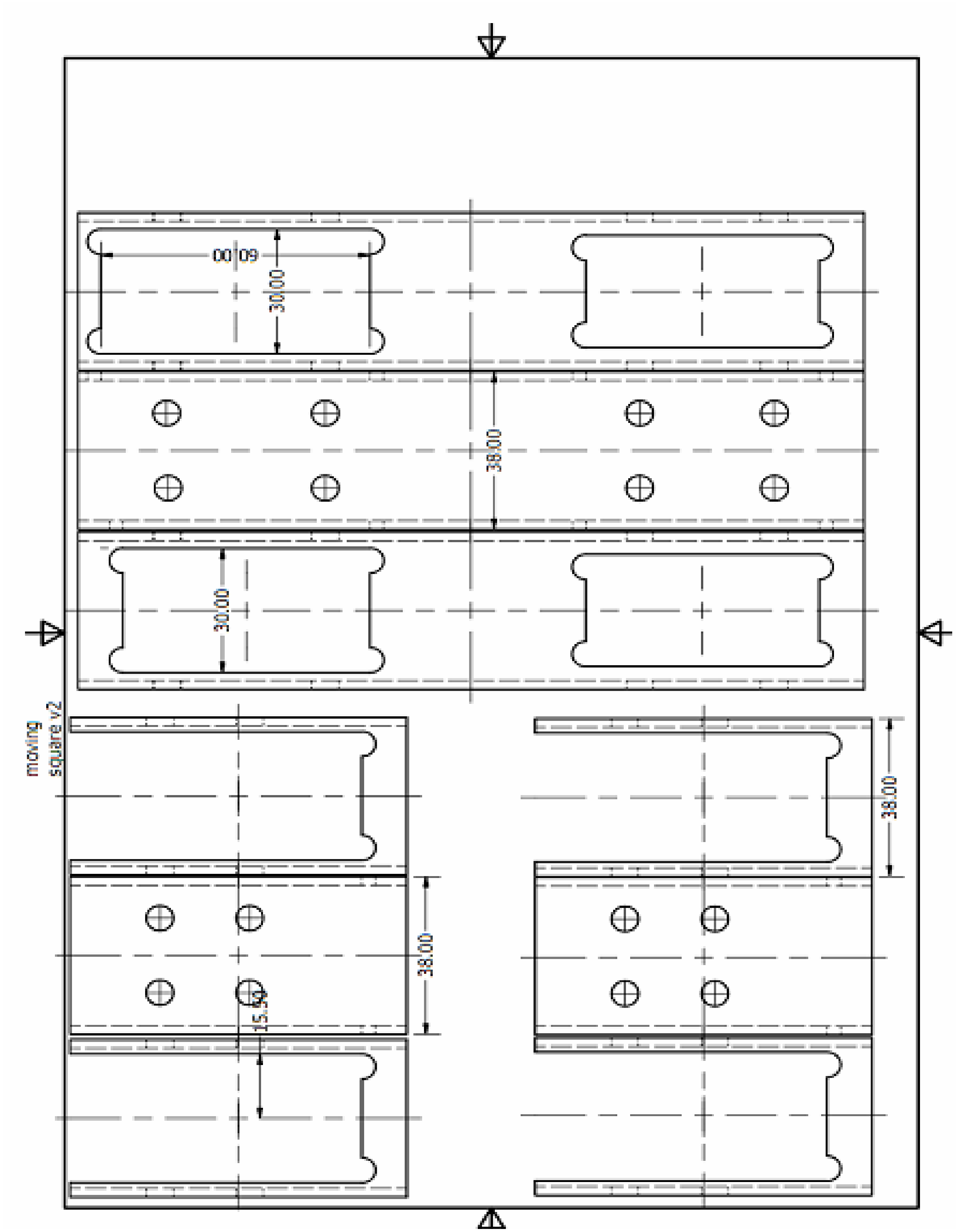

RAMAN RESEARCH INSTITUTE
BANGALORE-560080
QTY:-2
SHEET 8 OF 12
TITLE:MOVING FRAME
PART NAME:-H4 HORIZONTAL MEMBER
DESIGNED BY
K.ARUNA
CHECKED BY
B.RAMESH
MATERIAL:-ALUMINIUM
SCALE:NTS
DATE:-20/10/2010
ALL DIMENSIONS ARE IN mm
27.00
613.97
H3 HORIZONTAL RECTANGULAR SECTION(52*27*2mm)

D35

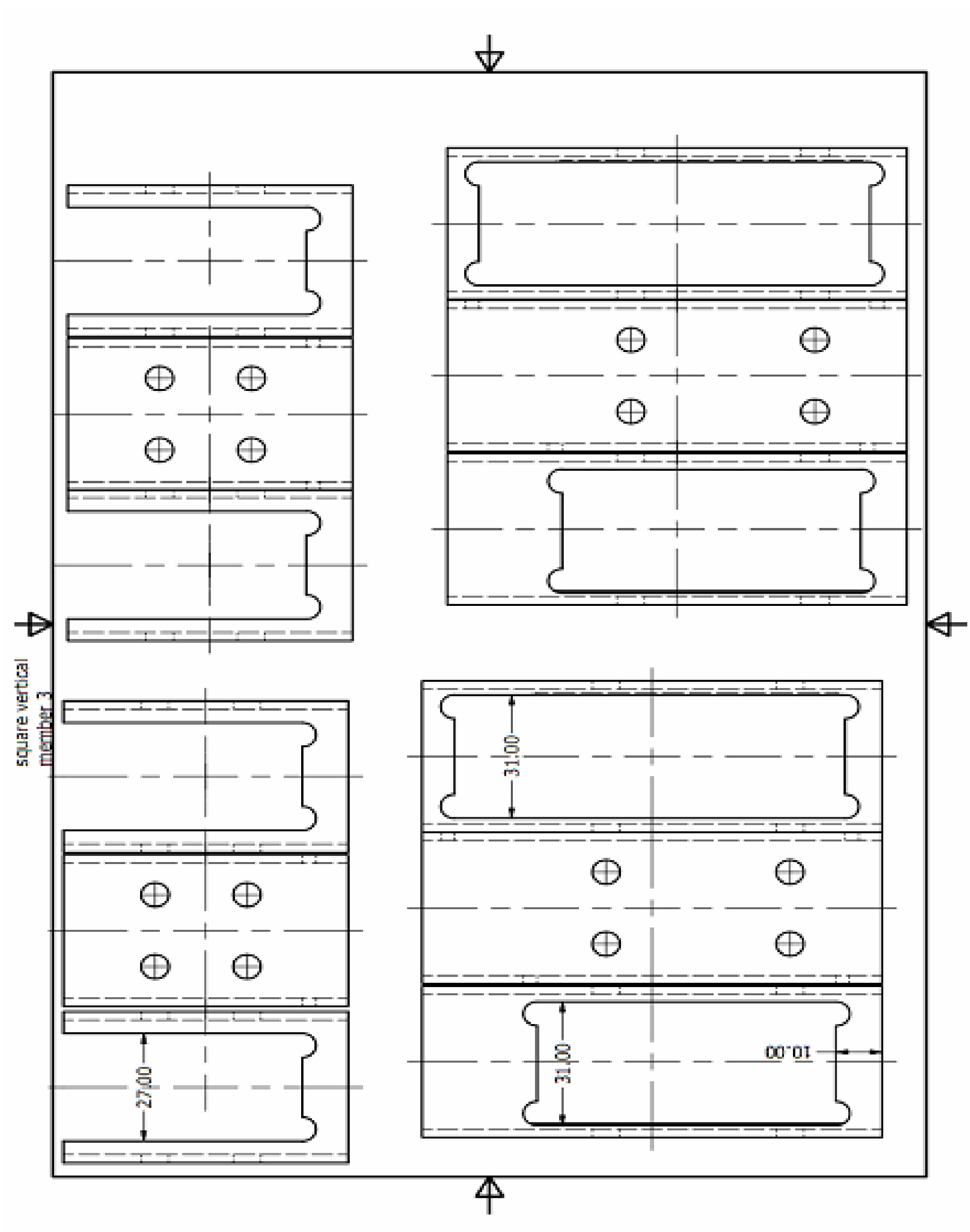
D36



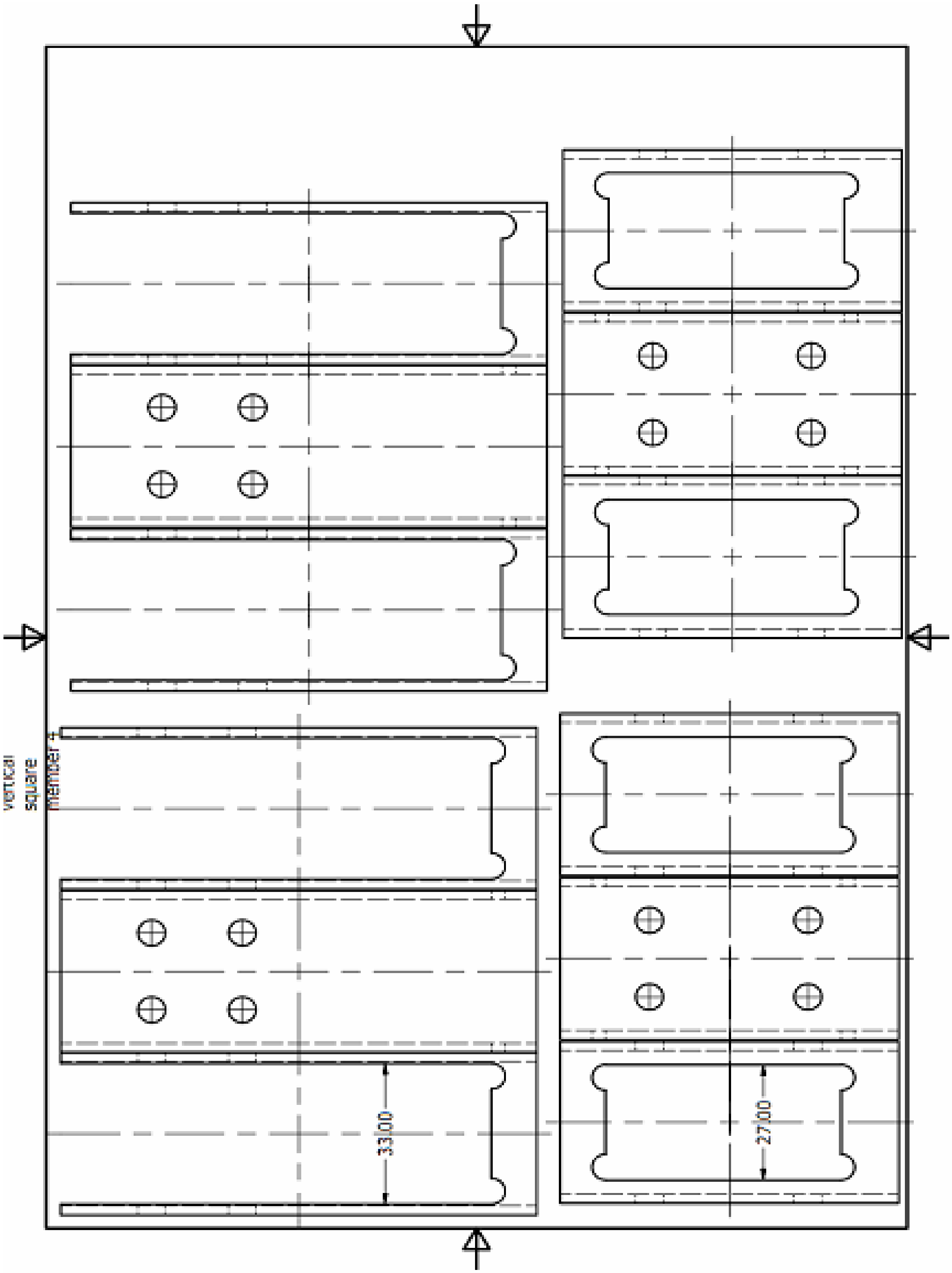
D36



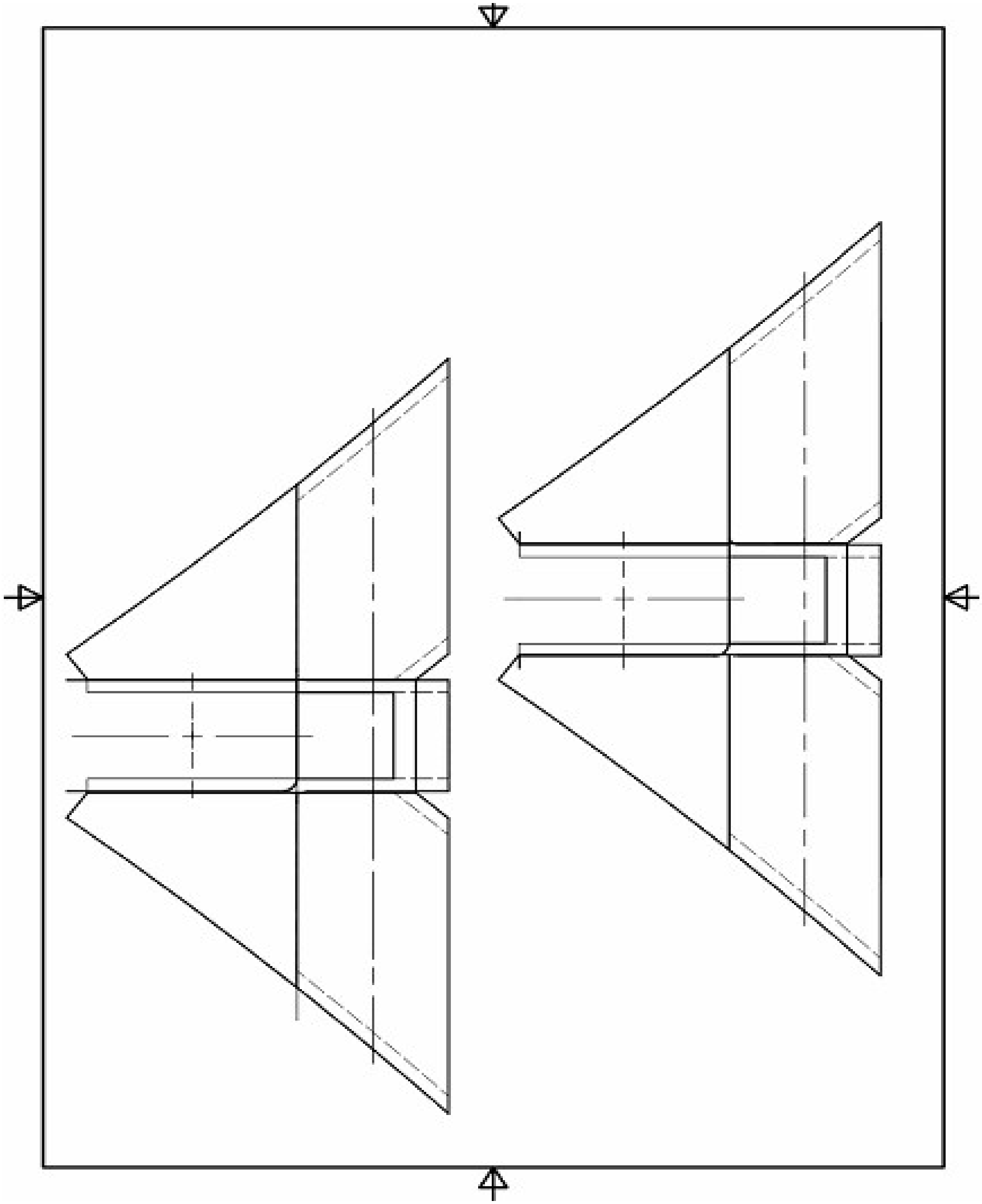
D37



D38

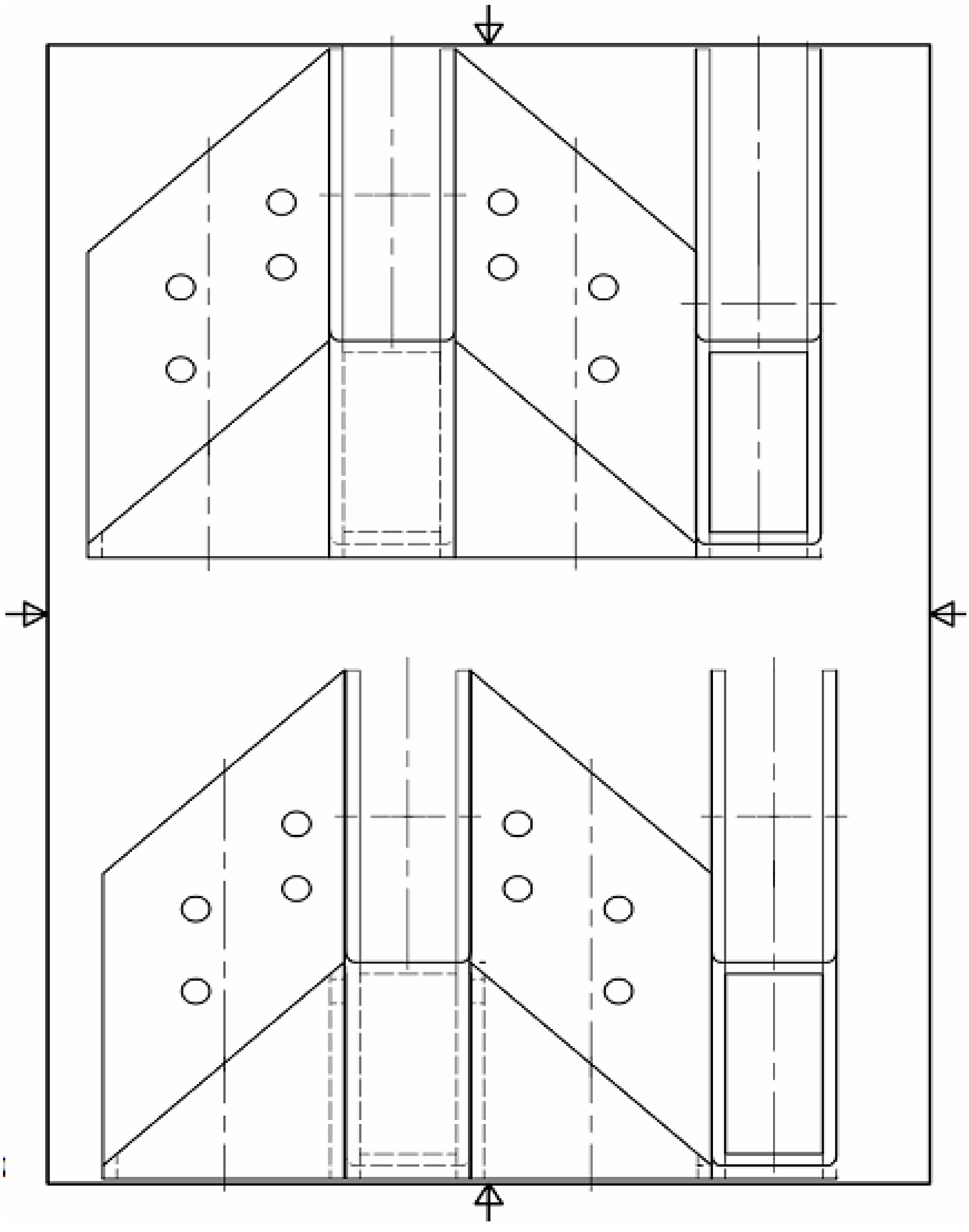


D39

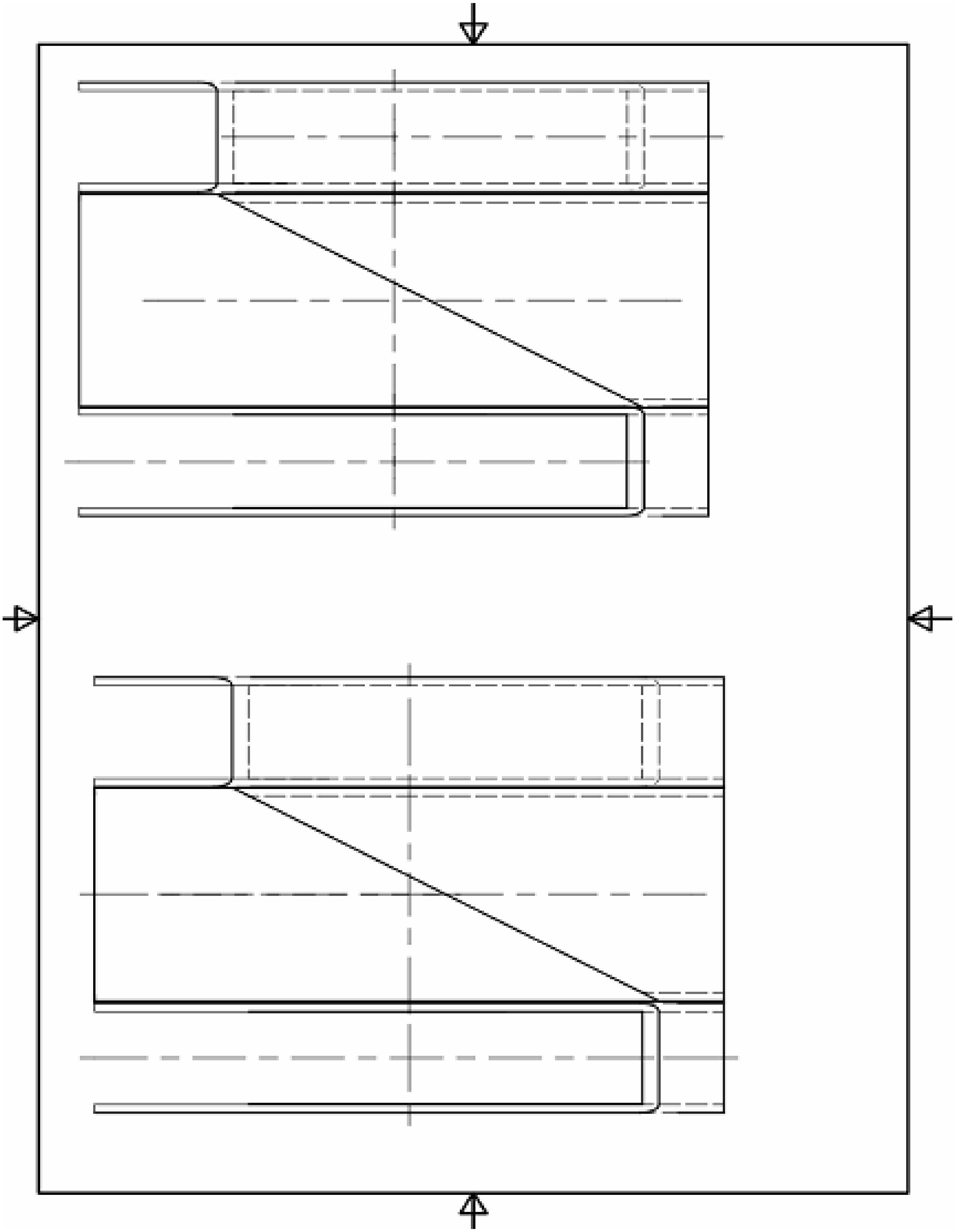


D40

D41

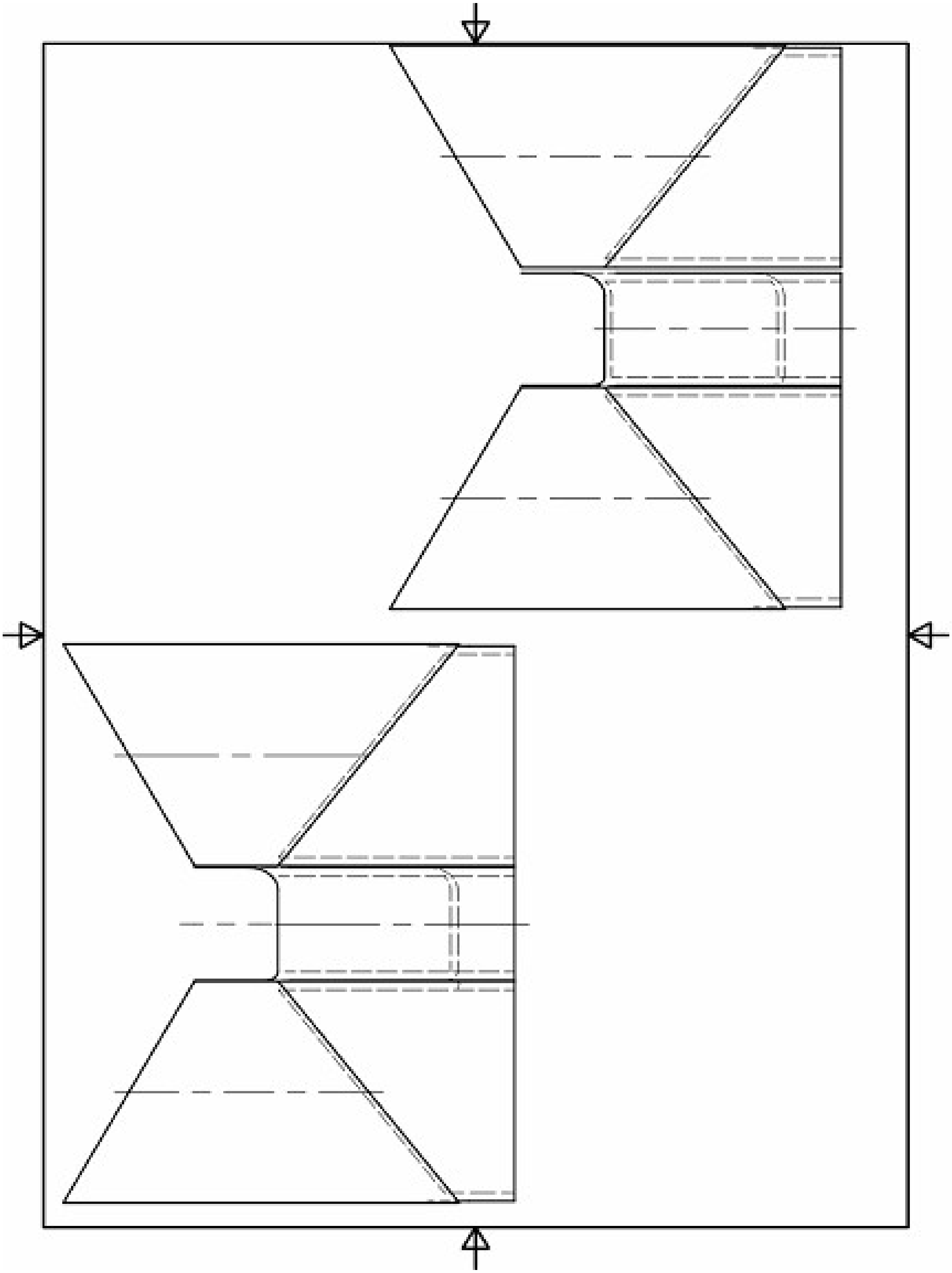


D41

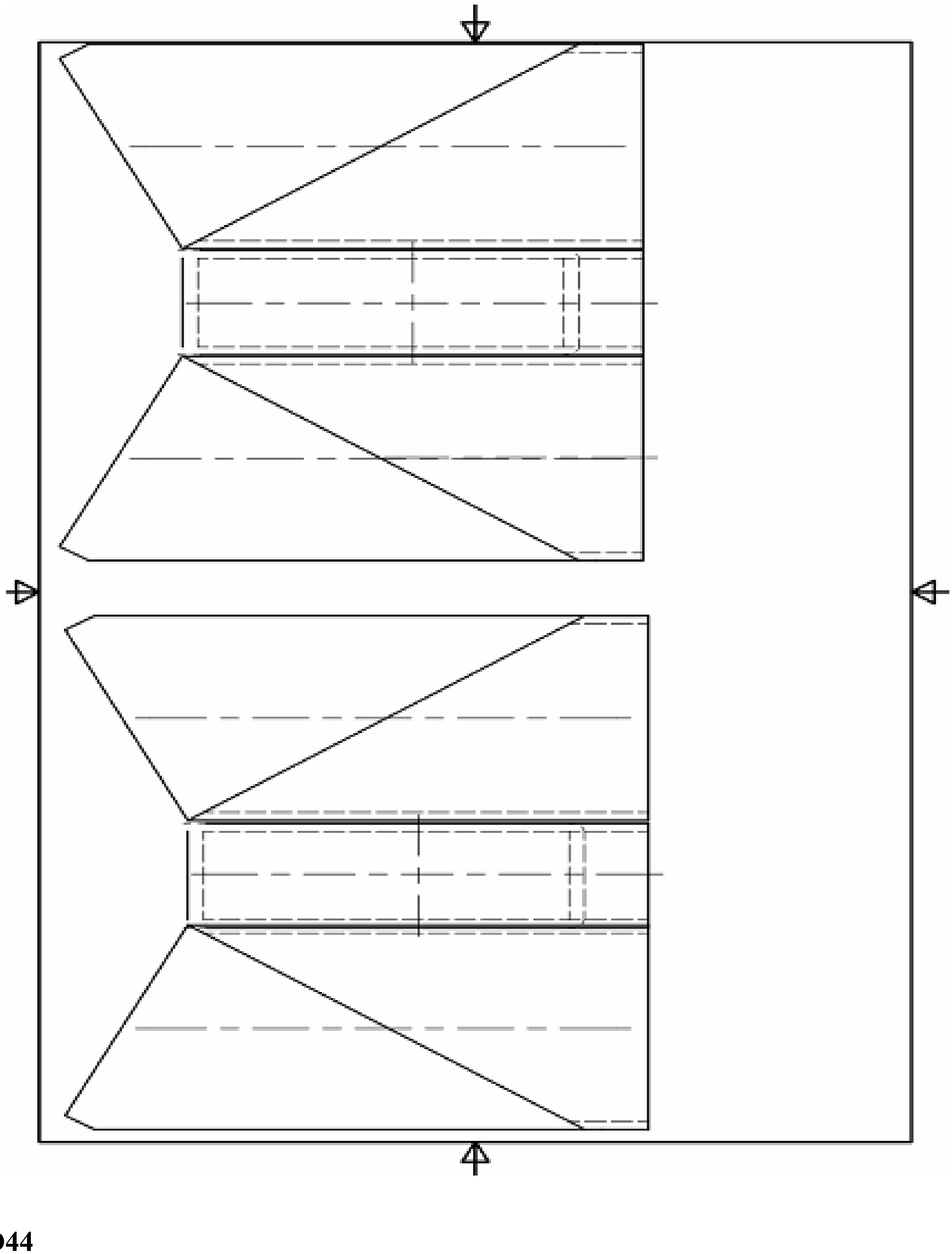


D42

D43

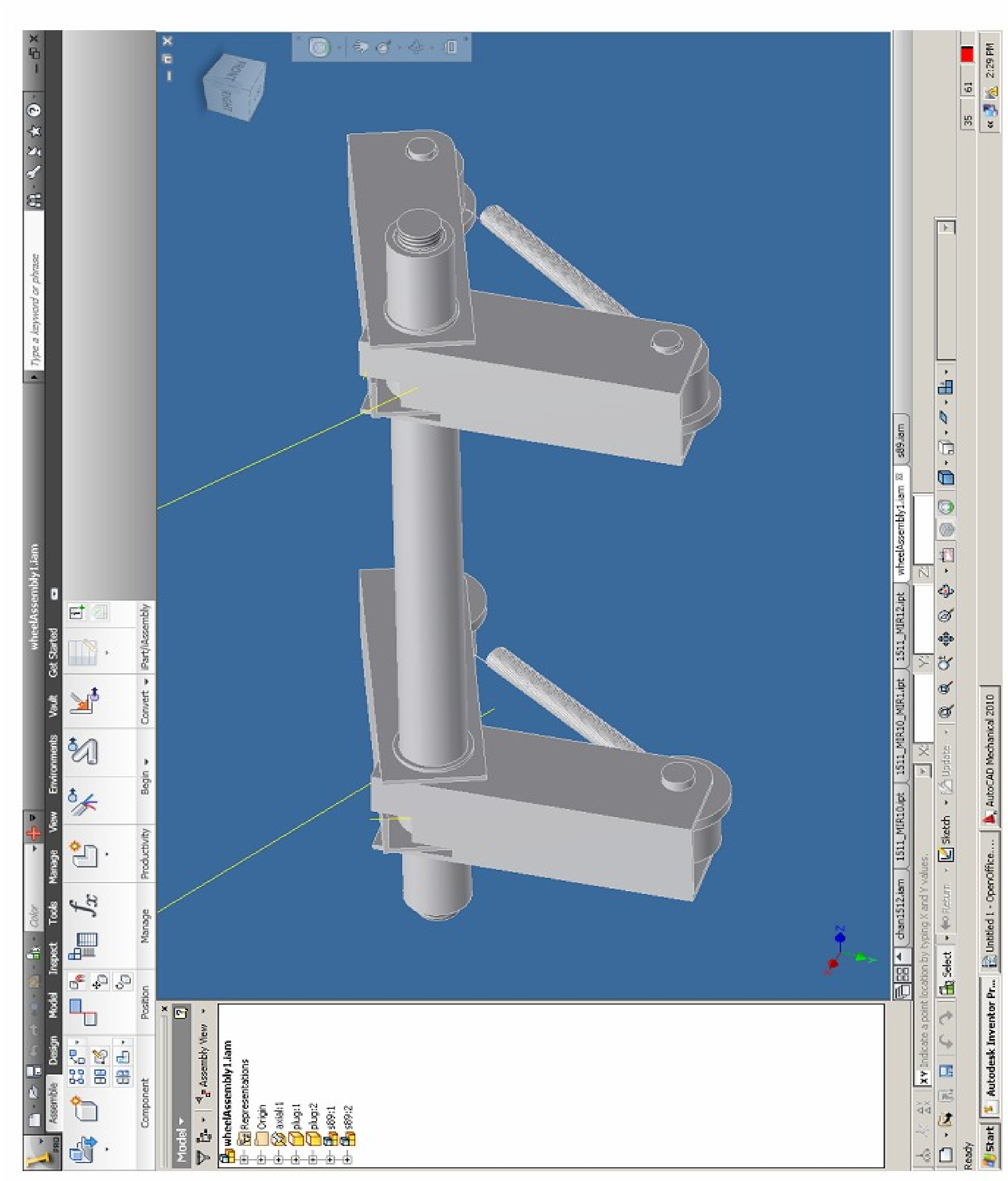


D43

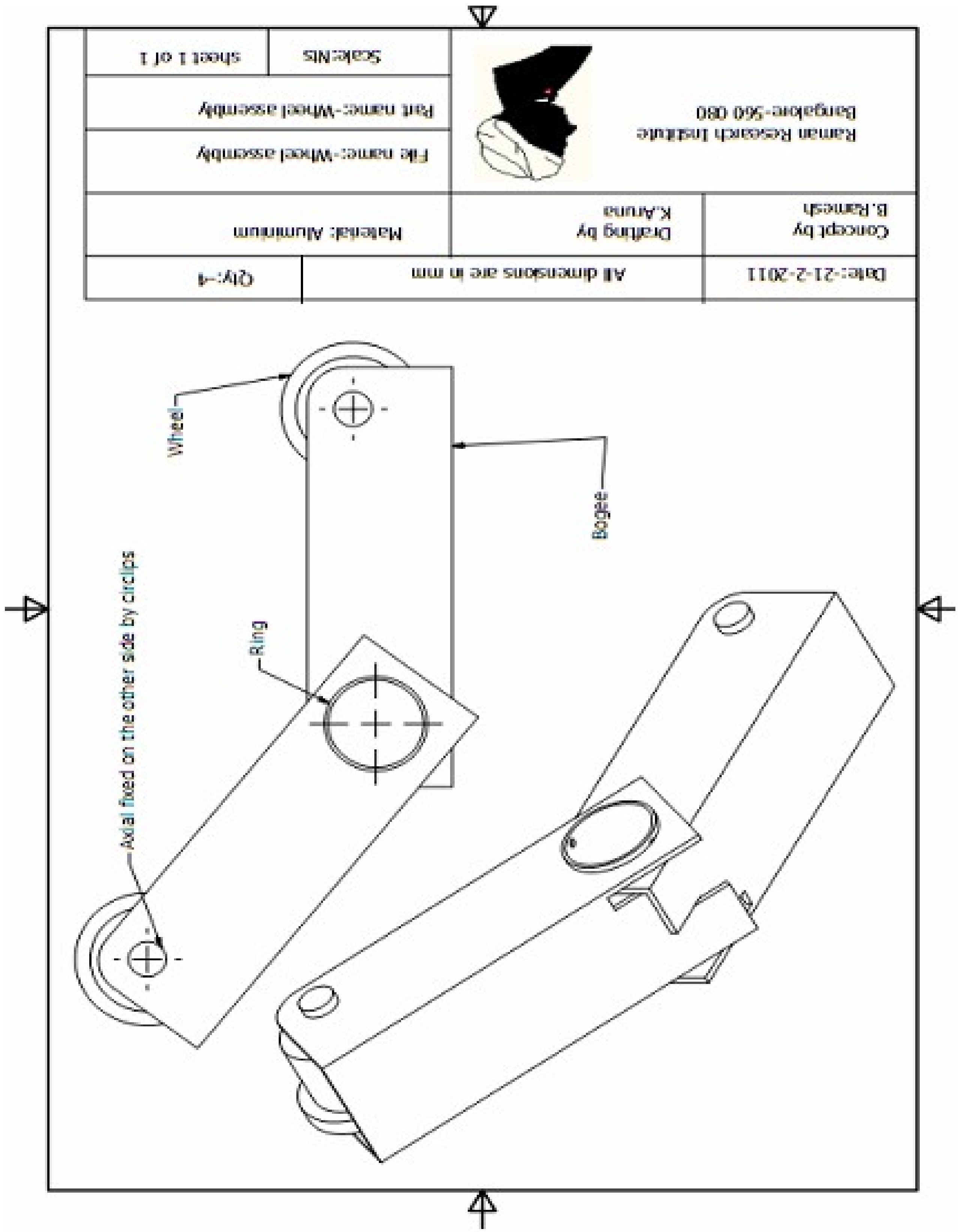


D44

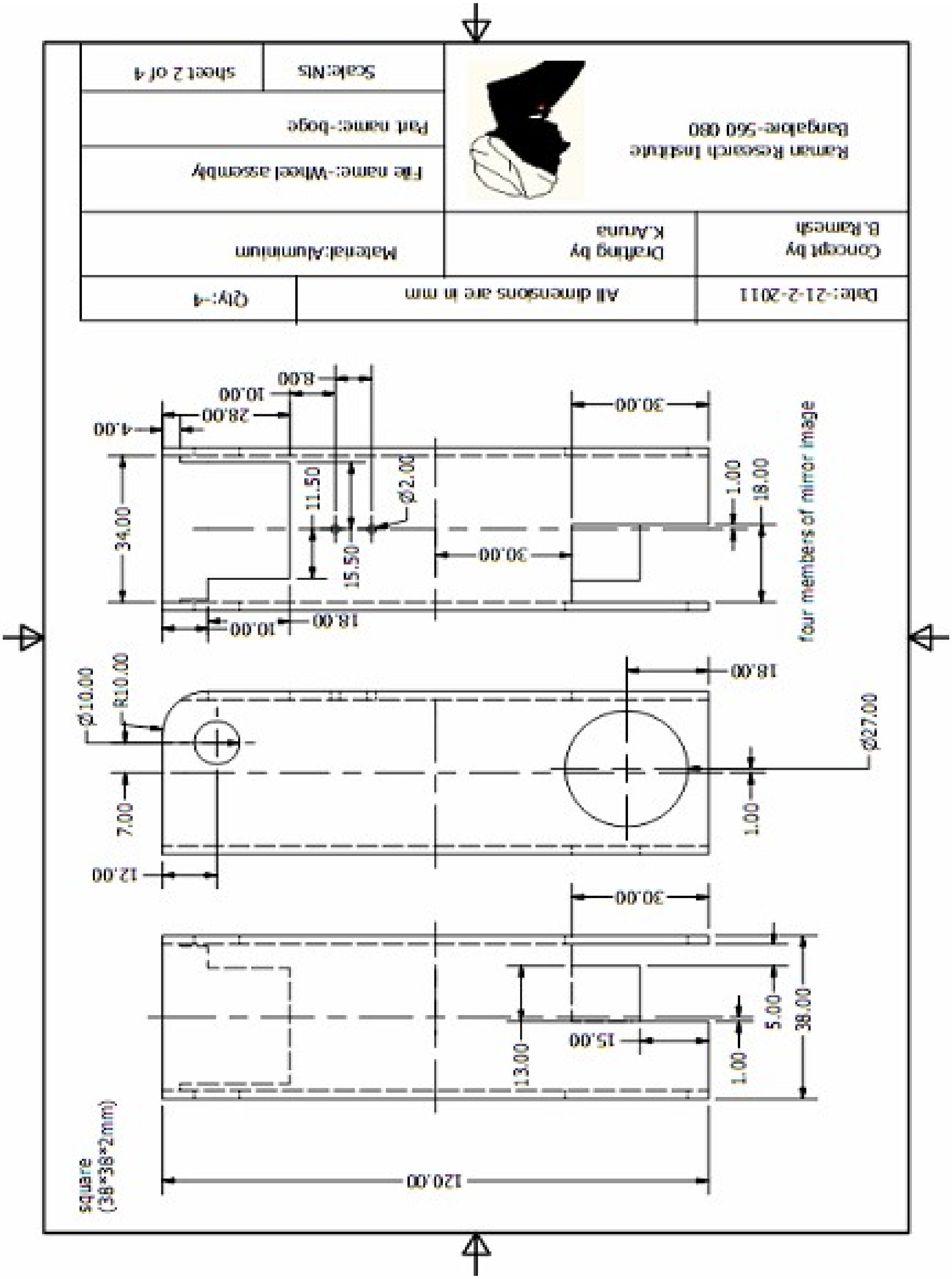
WHEEL ASSEMBLY



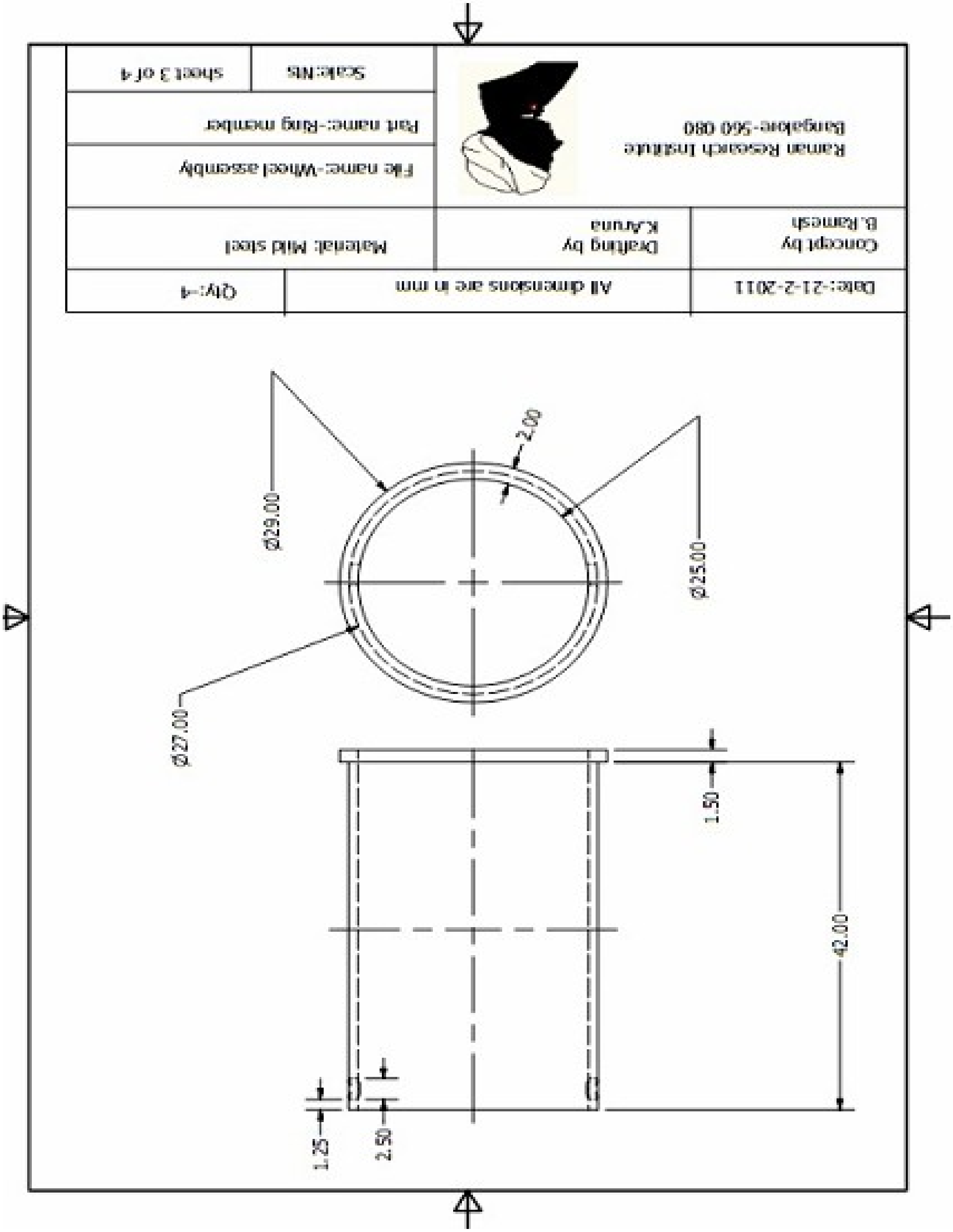
D45


sheet 1 of 1
Scale:Nts
Part name:-Wheel assembly
File name:-Wheel assembly
Raman Research Institute
Bangalore-560 080
Material: Aluminium
Drafting by
K.Aruna
Concept by
B.Ramesh
Qty:-4
All dimensions are in mm
Date:-21-2-2011
Wheel
Bogee
Ring
Axial fixed on the other side by circlips

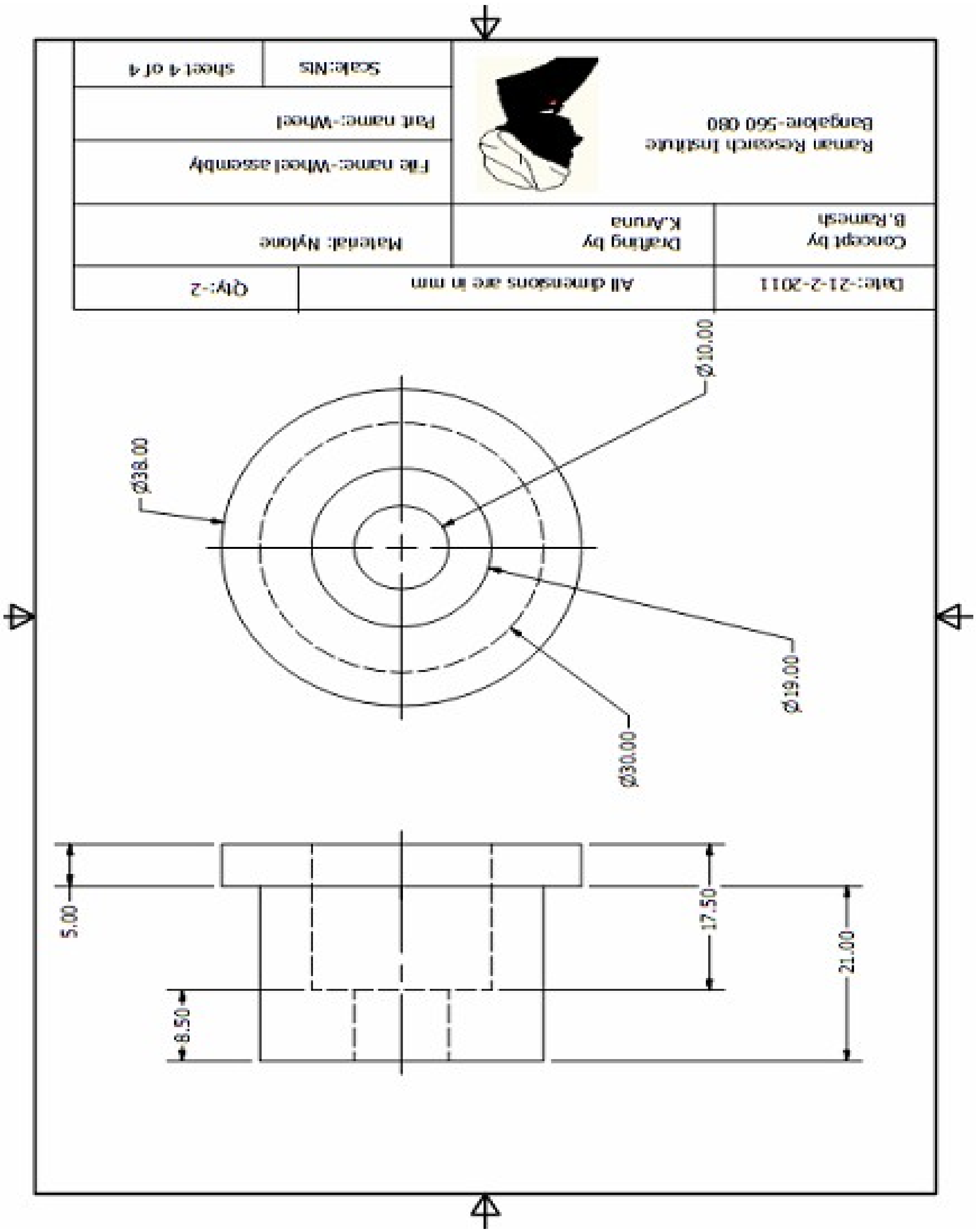
D46


sheet 2 of 4
Scale:Nts
Part name:-boge
File name:-Wheel assembly
Raman Research Institute
Bangalore-560 080
Concept by
B.Ramesh
Drafting by
K.Aruna
Material:Aluminium
Date:-21-2-2011
All dimensions are in mm
Qty:-4
four members of mirror image
square
(38×38×2mm)
120.00
30.00
15.00
13.00
1.00
5.00
38.00
12.00
7.00
R10.00
Ø10.00
Ø27.00
18.00
34.00
10.00
28.00
4.00
8.00
11.50
15.50
Ø2.00

D47

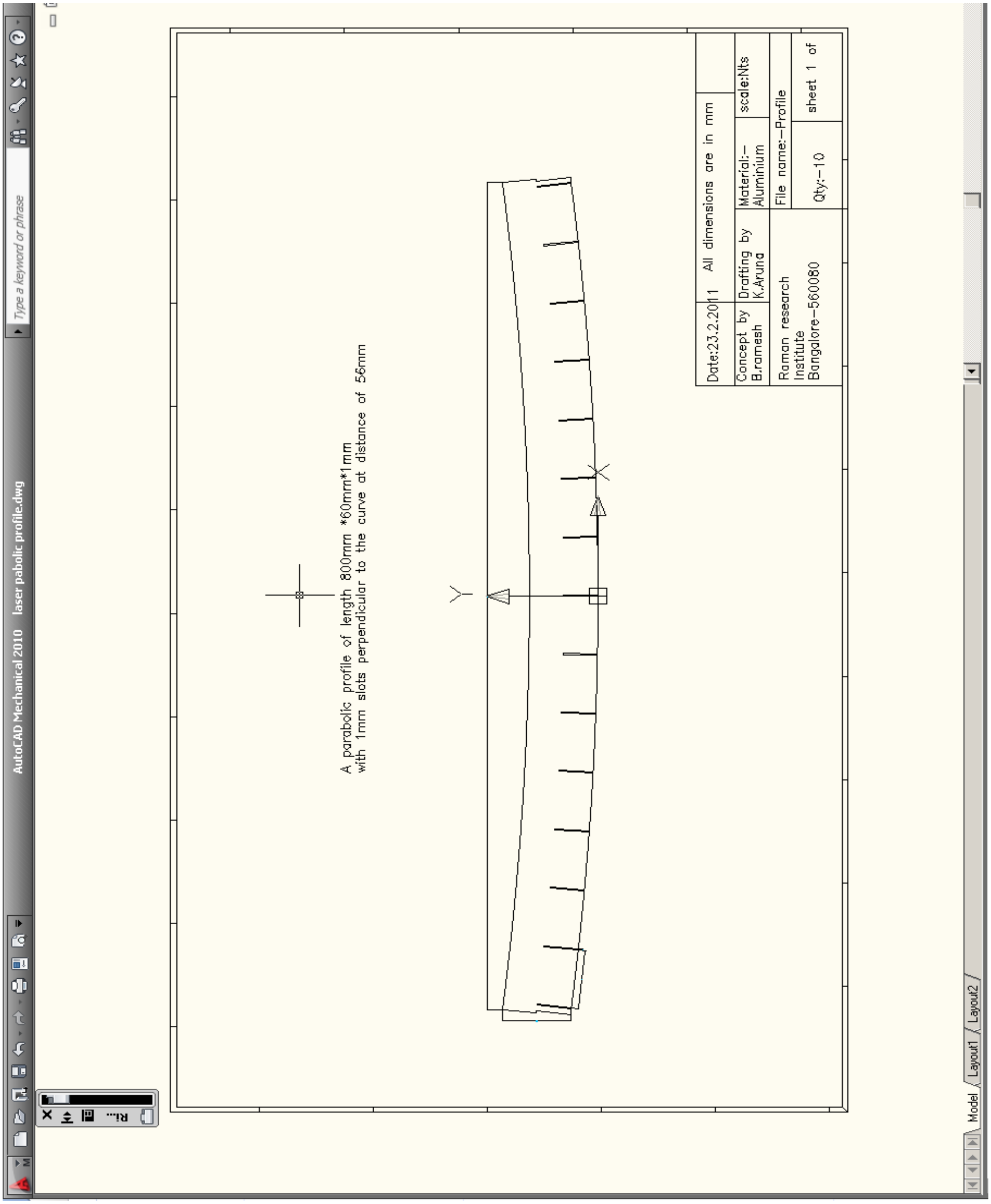

Raman Research Institute
Bangalore-560 080
File name:-Wheel assembly
Part name:-Ring member
Scale:Nts
sheet 3 of 4
Concept by
B.Ramesh
Drafting by
K.Aruna
Material: Mild steel
Date:-21-2-2011
All dimensions are in mm
Qty:-4
Ø29.00
2.00
Ø25.00
Ø27.00
1.50
42.00
1.25
2.50

D48

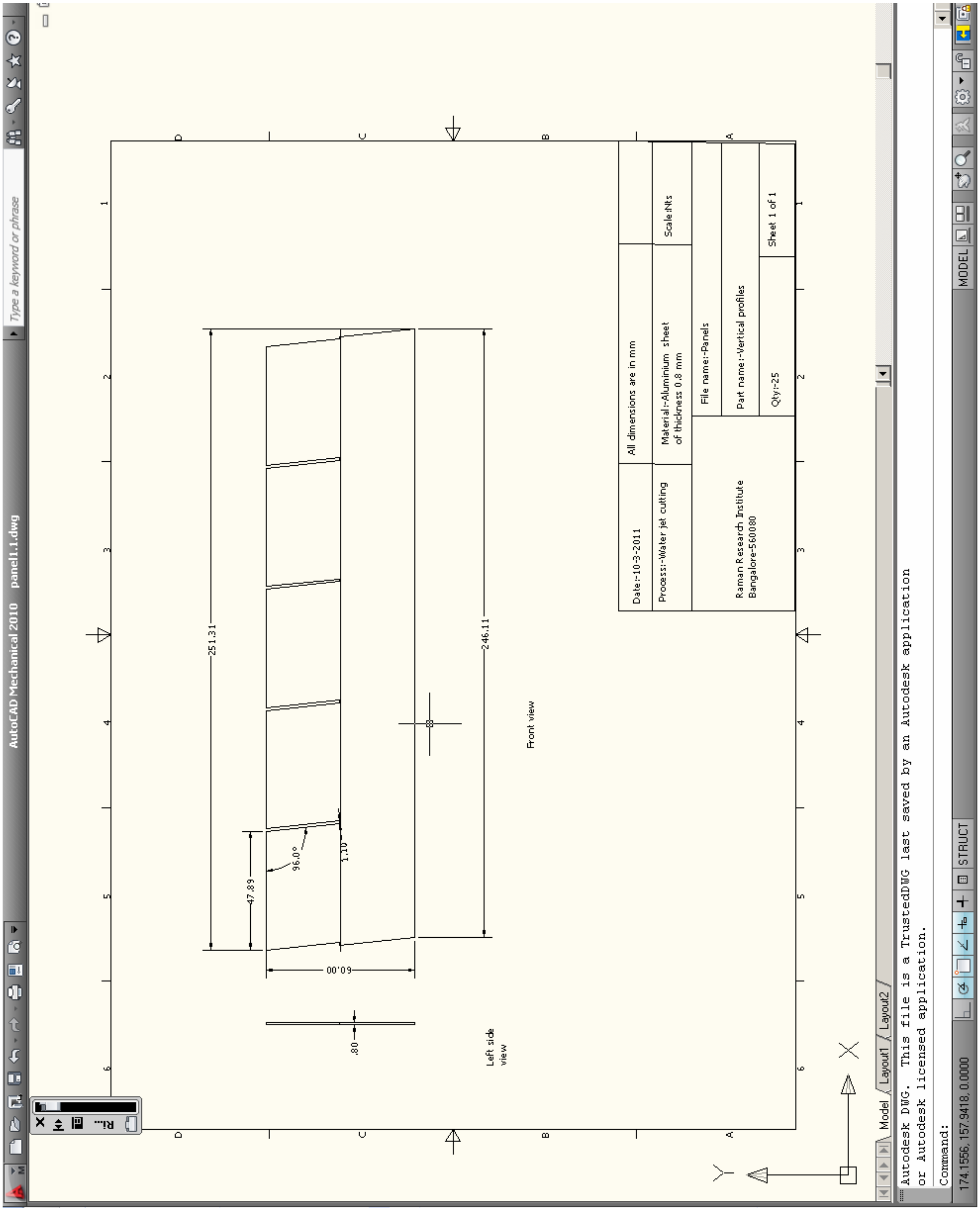

Date:-21-2-2011
All dimensions are in mm
Qty:-2
Concept by
B.Ramesh
Drafting by
K.Aruna
Material: Nylone
Raman Research Institute
Bangalore-560 080
File name:-Wheel assembly
Part name:-Wheel
Scale:Nts
sheet 4 of 4
Ø10.00
Ø38.00
Ø19.00
Ø30.00
5.00
17.50
21.00
8.50

D49

PANEL BACK UP AUTOCAD DRAWINGS

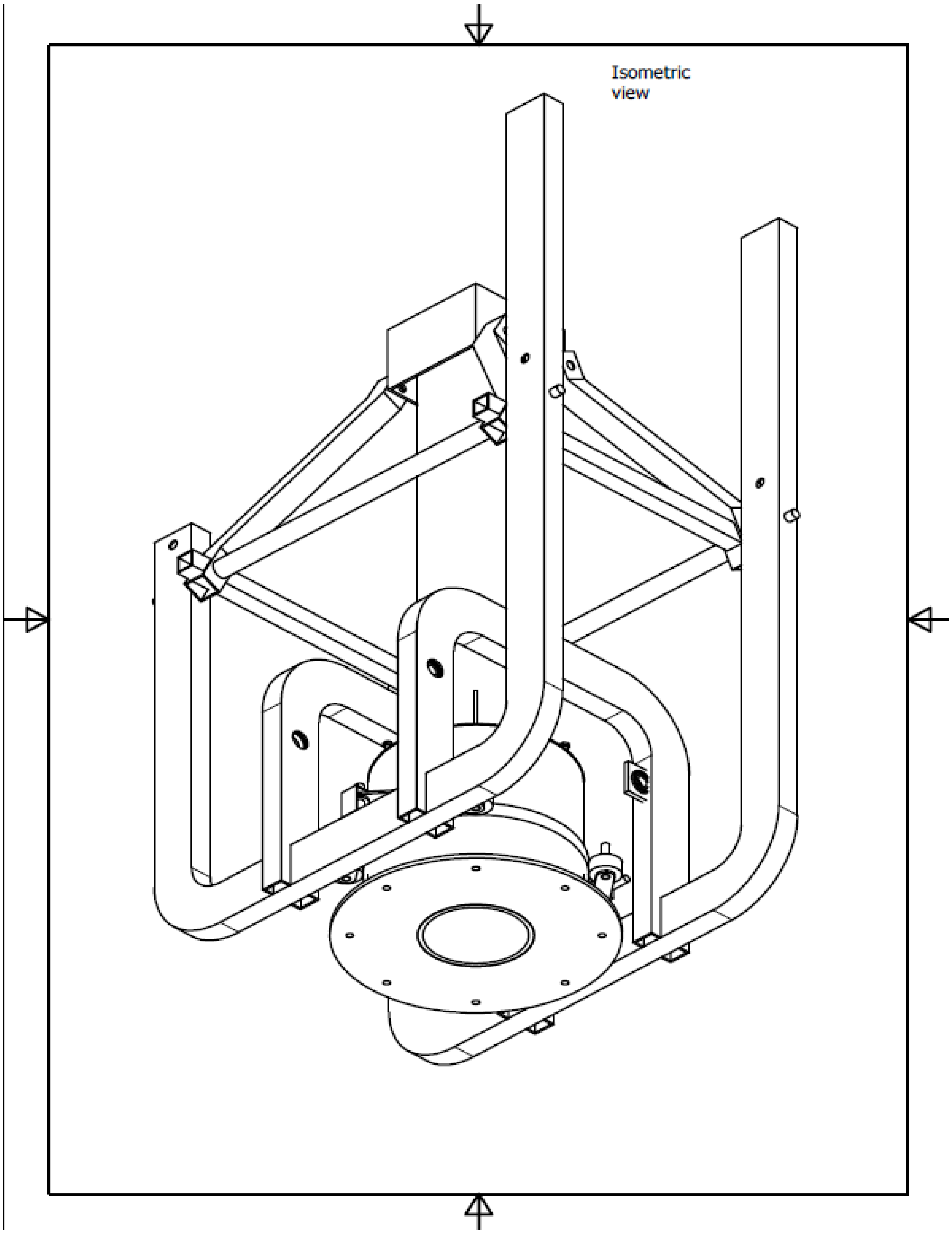


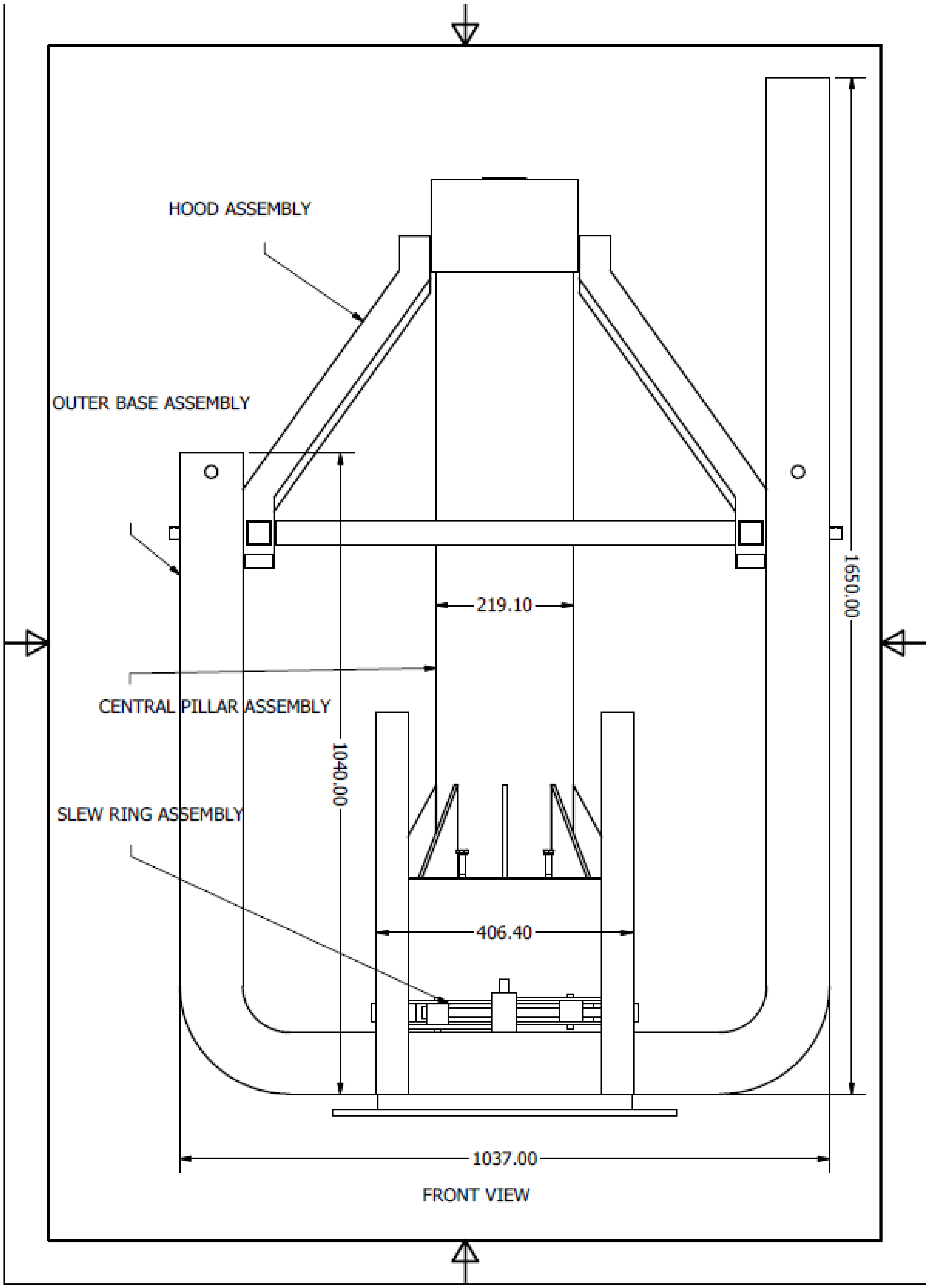
D50


AutoCAD Mechanical 2010 panel1.1.dwg
Type a keyword or phrase
251.31
246.11
47.89
96.0°
1.10
60.00
.80
Left side view
Front view
Date:-10-3-2011
Process:-Water jet cutting
All dimensions are in mm
Material:-Aluminium sheet of thickness 0.8 mm
Scale:Nts
File name:-Panels
Part name:-Vertical profiles
Raman Research Institute Bangalore-560080
Qty:-25
Sheet 1 of 1
Model
Layout1
Layout2
Autodesk DWG. This file is a TrustedDWG last saved by an Autodesk application or Autodesk licensed application.
Command:
174.1556, 157.9418, 0.0000
MODEL
STRUCT

D51

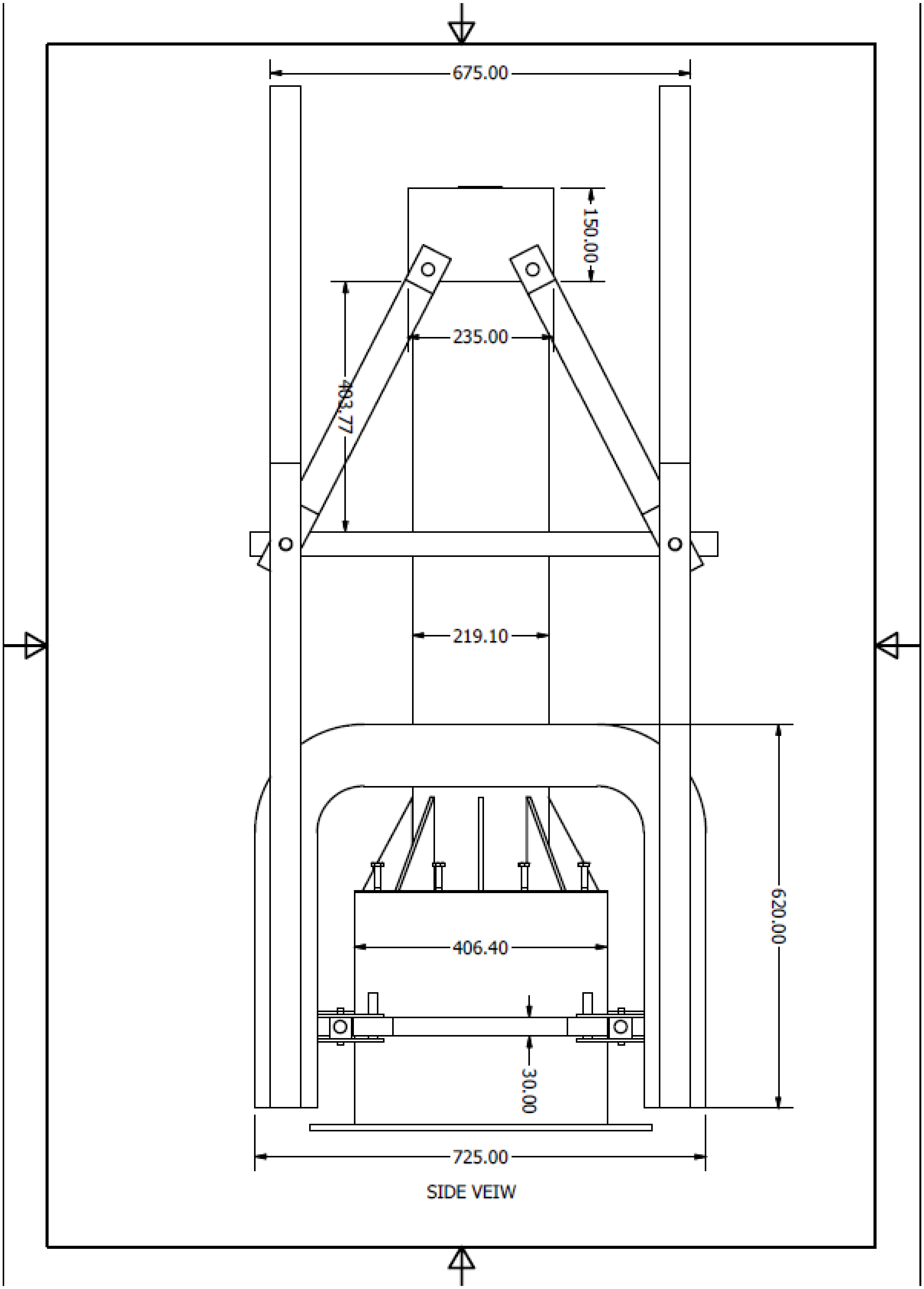
BASE FRAME ASSEMBLY




HOOD ASSEMBLY
OUTER BASE ASSEMBLY
CENTRAL PILLAR ASSEMBLY
SLEW RING ASSEMBLY
219.10
406.40
1040.00
1650.00
1037.00
FRONT VIEW

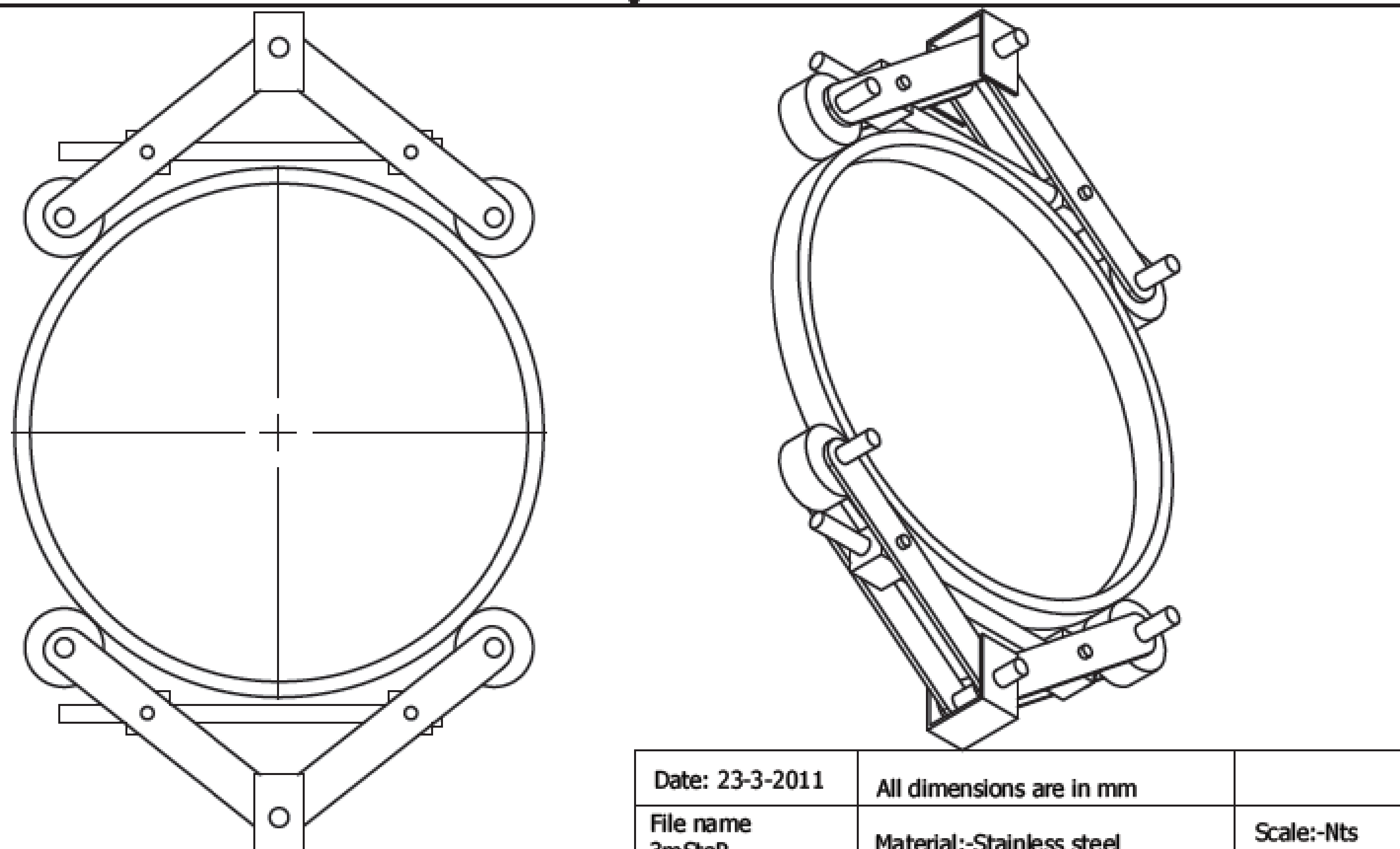
D53

D54



675.00
150.00
235.00
403.77
219.10
620.00
406.40
30.00
725.00
SIDE VEIW

D54



Date: 23-3-2011	All dimensions are in mm	
File name 3mSteP	Material:-Stainless steel	Scale:-Nts
Raman Research Institute Bangalore-560080	Title:- Central pillar assembly	
	Part name:-Slew ring	
		sheet 7 of 8

PROJECT DETAILS

Student Details			
Student Name	**KURAVI ARUNA**		
Register Number	909044007	Section / Roll No	7
Email Address	aero.aruna@gmail.com	Phone No (M)	8050112982
Project Details			
Project Title	**CONSTRUCTION OF FAN BEAM TELESCOPE**		
Project Duration	JUNE 2010 -May 2011	Date of reporting	01/06/10
Organization Details			
Organization Name	**RAMAN RESEARCH INSTITUTE**		
Full postal address with pin code	Raman Research Institute,C. V. Raman Avenue Sadashivanagar,Bangalore - 560 080 INDIA.		
Website address	www.rri.res.in		
Supervisor Details			
Supervisor Name	**DR.RAMESH BALASUBRAMANYAM**		
Designation	**Assistant Professor**		
Full contact address with pin code	DR.Ramesh Balasubramanyam,Department of astronomy and astrophysics ,Raman Research Institute,C. V. Raman Avenue Sadashivanagar,Bangalore - 560 080 INDIA.		
Email address	ramesh@rri.res.in	Phone No (M)	9449824176
Internal Guide Details			
Faculty Name	**Sandra D'Souza**		
Full contact address with pin code	Dept of Instrumentation & Control Engg, Manipal Institute of Technology, Manipal – 576 104 (Karnataka State), INDIA		
Email address			