

DESIGN OF BAMBOO PRODUCTS

DIPLOMA PROJECT

SUBMITTED IN PARTIAL FULFILMENT OF
REQUIREMENT FOR THE POST-GRADUATE
DIPLOMA IN INDUSTRIAL DESIGN

DP/VIII/72/1979

BY

SATISH P. RAUT

INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY

POWAI, BOMBAY 400 076

1979

I. D. C Library
L. I. T. Bombay.

APPROVAL SHEET

DIPLOMA PROJECT ENTITLED
DESIGN OF BAMBOO PRODUCTS
BY SATISH P. RAUT IS APPROVED
FOR THE POST-GRADUATE DIPLOMA
IN INDUSTRIAL DESIGN

GUIDE

- *Sh. P. Raut*

CO-GUIDE

-

CHAIRMAN

-

Rama Shetty
7. 8. 79

EXAMINERS

-

*Dr. B. B. B.**GATEWAY TO KNOWLEDGE*

ACKNOWLEDGEMENT

MY SINCERE THANKS TO MY
GUIDE MR.A.G.RAO
FOR THE HELP HE GAVE DURING
MY PROJECT WORK.

CONTENTS		
1.	INTRODUCTION	1
2.	PROBLEM STATEMENT	3
3.	BAMBOO AVAILABILITY IN NATURE	4
4.	PROPERTIES OF BAMBOO	6
4.1	SHRINKAGE & MOISTURE ABSORPTION	7
4.2	INCOMPRESSION	8
4.3	INDIRECT TENSION	8
4.4	COLOUR AND TEXTURE	9
5.	PRESERVATIVE TREATMENT OF BAMBOO	11
6.	USE OF BAMBOO	13
6.1	HOUSEHOLD PRODUCTS - URBAN AREA	13
6.2	HOUSEHOLD PRODUCTS - RURAL AREA	14
6.3	BAMBOO FOR BUILDING CONSTRUCTION	15
7.	DESIGN HYPOTHESIS	17
8.	DESIGN APPROACH	18
9.	JOINING METHOD IN BAMBOO	19
10.	DESIGN DESCRIPTION	30
10.1	WALL CHAIR	30
10.2	BEACH AND GARDEN CHAIR	31
10.3	DINING SET	32
10.3.1	DINING TABLE	32
10.3.2	DINING CHAIR	33

1. INTRODUCTION

Bamboo is natural material available in large quantities in our country. Since very ancient times it is being used for building construction and for making many products. In recent times it has found 80% of Bamboo uses for paper making. The value realised for Bamboo in paper making is very low. In addition the private industry controlling the mills have indiscriminately destroyed the Bamboo resources, affecting the large number of Bamboo Craftsman traditionally dependant on Bamboo as raw material.

Bamboo, if used for products like furniture can get an enhanced value for the craftsman thereby increasing their self-employing opportunities. This would of course need structural support in marketing by the Government.

The recent stand taken by Mr. George Fernandes, Minister of Industry to make compulsory use of Bamboo furniture in government offices is a welcome impact

2

in this direction.

The design of product or furniture in Bamboo does not seem to have been tackled by professional designer so far. With this background in mind the present project on 'design of Bamboo furniture' has been tackled.

2. PROBLEM STATEMENT

Since the problem is essentially to create new market for bamboo, it was decided to explore the various joining methods in Bamboo for use in furniture and design. a set of furniture for restaurants, artist's/designer's use which has a high potential^{for} absorbing the new design at present.

3. BAMBOO AVAILABILITY IN NATURE

There are about 550 species (belonging to the tribe Bambuseae) unevenly distributed in various parts of the world. They are found in greatest abundance from India eastwards to Burma, China, Japan upto Korea. Asia alone accounts for nearly 320 species of which 136 species occur in India and 39 in Burma. South America accounts for 179 species and a few occur in South Africa, Madagascar and Australia.

Bamboo can grow almost anywhere from the sea level to the snowline. The plant attains maximum growth in the monsoon forests where pure stands cover vast stretches of land. In temperate regions and at high altitudes, they dwindle to the size of small shrubs. In India, West Bengal, Assam, North-Eastern Himalayas, the Western Ghats and the Andamans are particularly rich in Bamboo.

In size, Bamboo may vary from the small fishing tackle to towering pole as high as 36 meters or so, jointed and more frequently hollow and cylindrical, from within.

4. PROPERTIES OF BAMBOO

The high rate of growth of bamboo necessitates a great economy of material and energy. This is achieved by producing a hollow cylinder strengthened at nodes by horizontal portions. The material has a great deal of cellulose. Cellulose fibres are much longer than in other broad leaved trees and confer a very high tensile strength. Since there is a single ~~sprout~~ ^{stem} of growth, the material is entirely homogeneous with no heart wood and sap-wood; and no growth rings to introduce heterogenities.

The stem of bamboo is cylindrical in form. It has joints which close the cylindrical ^{stem} at intervals but there are no annual rings. The surface is hard and smooth and the stalk itself is light and resilient. There are strong vertical fibres so that the plant is difficult to cut horizontally but easy to split vertically. It is often cut into very thin strips for weaving baskets.

The typical properties of the Bamboos

1. Specific gravity	
before drying	1.05 to 1.19
2. Specific gravity	
after drying	0.31 to 0.41
2. Contractivity	
i) lengthwise	0.05%
ii) along width	0.77%
iii) thickness	1.36%
3. Absorptivity	15%
4. Compressive Strength	600 to 900 kg/cm ²
5. Tensile Strength	980 to 3406 "
6. Bending Strength	60.8 "

It is a very supple and elastic material. At the same time nature has not made bamboo to last for long, and it is highly susceptible to insect and fungal attacks.

4.1 SHRINKAGE AND MOISTURE ABSORPTION

Bamboo has a relatively high shrinkage factor, from the green to the seasoned stage. The shrinkage is much greater across the diameter than along the length of the culm. The age of the culm

and the season of the year in which it is at constitute the prime factors influencing the degree of shrinkage to be expected when a freshly cut column is seasoned. Many old culms in a bamboo grove have undergone considerable seasoning while standing.

4.2 IN COMPRESSION

Results of test made to determine the modulus of elasticity and unit compressive strength of bamboo in compression show that the samples, that had a length in relation to diameter in which cross bending or buckling did not occur. Average compressive strength of about 8000 pound/sq.inch and a modulus of elasticity of about 216000 pound/sq.inch.

4.3 INDIRECT TENSION

The maximum tensile strength of species when tested either with or without node, the maximum average tensile strength of species without a node shows a high value of 50,000 pounds/sq.inch and a low of 26000 pounds/sq.inch.

Generally the weaker part of the culm in tension is the node and the average value of all tension failures occurring at the nodes are considerably lower than the average for failures between nodes.

The strength of the culm^{at} the node varies greatly with the species of bamboo. The species and varieties which have a pronounced thickening and bulging of the side walls at the node show a corresponding weakness in tension at that point.

The average maximum tensile strength of all species and varieties is about 37,500 pound/sq.inch. between nodes and about 32,500 pound/sq.inch at the node. The maximum tensile strength at a node is about 49,500 pounds and the minimum about 18000 pounds/sq.inch.

4.4 COLOUR AND TEXTURE

Nearly all bamboos are green when fresh but some species have a beautiful golden colour with green strips. An occasional species has a near-black colour.

After being cut, fresh bamboo and in some cases where the culms age in the grove, the culm are seasoned as indicated by the golden brown colour of the stems.

the nodes, become helpful in the improvement of absorption.

Care must be taken that the bamboo culms for treatment are freshly cut, when the bamboo are dry it is practically impossible to get any preservative solution through the culms.

6. USE OF BAMBOO

6.1 HOUSEHOLD PRODUCT - URBAN AREA

Bamboo finds many applications in the household and in the implements of our daily use. Bamboo ladders and Bamboo legs for beds, stools and tables are in common use. Bamboos form convenient cylindrical vessels for storage bins and bamboo mats form domestic winnowers. Caps made of bamboo matting are used as protection against rain.

6.2 HOUSEHOLD PRODUCTS - RURAL AREA

Bamboos make staffs for ploughs and pipes for seed drills. Bamboo baskets are used to carry manure and fertilizers. Bamboo with its long cellulose fibres is an excellent raw material for the production of paper and synthetic fibres. Bamboos serve as fishing rods and as posts for fishing nets. They form rafts to ferry people across rivers and frameworks of small boats. Bows, arrows, snares and traps and our policeman's lathi are made of Bamboo. Bamboo pipes are used to pipe water in our north eastern hill states and in the construction of wells in Bihar. And Bamboo flutes -the basari of North and the Venu of the South- are our premier wind instruments.

6.3

BAMBOO FOR BUILDING AND CONSTRUCTION

Bamboo is easily the world's cheapest, most abundant and most easily worked construction material. It is believed that there have always been and still are more bamboo houses than of any other kind in the world.

As a construction material bamboo is used in full, in halves, as splinters as boards or as mats. It is also used in foundation, framing, flooring, walls, trusses, doors and windows. However, the ease with which bamboo splits vertically is a disadvantage as a building material in that it cannot take nail.

The smaller, lighter huts such as those of many tribals tend to be constructed almost entirely of bamboo.

The most exciting prospect in more sophisticated construction is of course that of bamboo reinforced cement concrete. The ultimate tensile strength of some species of bamboos in direct tension is about the same as that of mild steel.

Beams and slabs of a room 13 feet by 10 feet constructed in Manila in the Philippines, with bamboo splints as reinforcement, were still in excellent condition seven years after construction.

Bamboo is recommended as reinforcement for small buildings, kitchen tables, covers for septic tanks, shelves and pipes. There is certainly scope for bamboo in roles other than scaffolding in modern house construction.

7. DESIGN HYPOTHESIS

1. Design should reflect proper use of bamboo to achieve a true form-material relationship.
2. As bamboo cannot be bent easily like cane, a system of proper type of joints should be developed.
3. It should be possible to make the furniture out of hand tools and it should be within the skills of village craftsmen.
4. Ergonomical factors should be given due importance while designing the furniture.
5. Design should be elegant enough to prompt the uses in restaurants and hotels where 'novelty' is given high weightage.

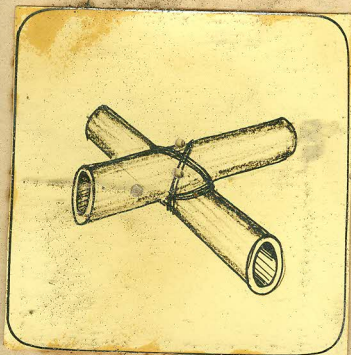
8 DESIGN APPROACH

Unlike cane bamboo cannot be bent to any required shape and used as successfully in furniture industry. Like steel, Bamboo too possesses a certain amount of resilience which is necessary to ensure comfort to the users.

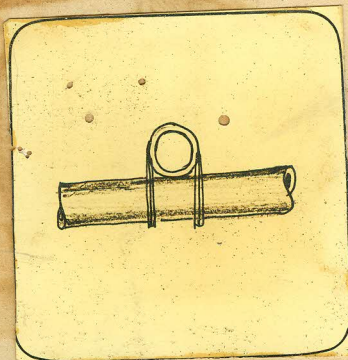
The limitation in ^{of bamboo} case is the in proper joining techniques available to the craftsman, therefore unless proper and elegant methods are found out, bamboo cannot be used successfully in furniture industry.

On the following pages, there is a brief discription of various joining method developed for furniture making.

9. JOINING METHODS IN BAMBOO



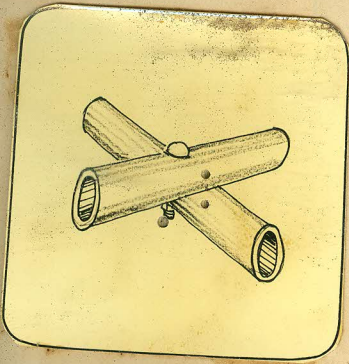
4



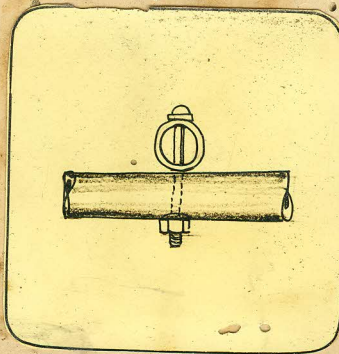
5

This joint is formed by keeping two pieces of bamboo overlapped (Fig. 4,5) and tightened with jute rope or metal wire. This joint is generally used in making scaffoldings and temporary structures. Problem with this joint is that it gets loosened after a prolonged use.

The above joint can be tightened with a nut and bolt instead of joining with rope. (Fig. 6,7)

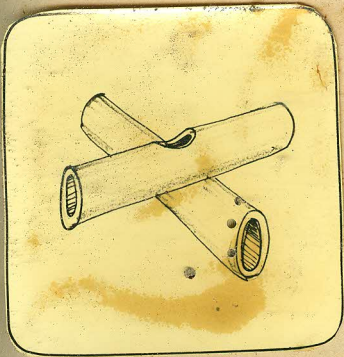


6

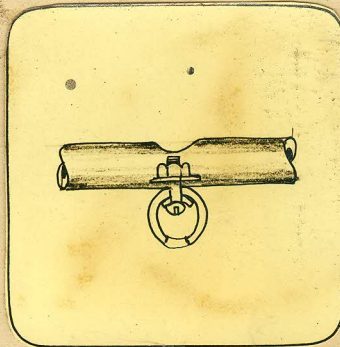


7

Bolt fastening gives more strength, with ease of working and time saving. This also provides folding facility and folding bamboo furniture can be made with this joint. In the above joint (Fig. 6,7) nut and head of bolt remaining outside causes inconvenience and is aesthetically not pleasing.

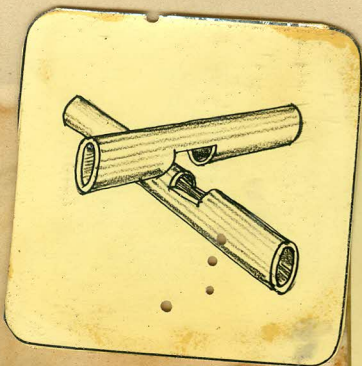


8

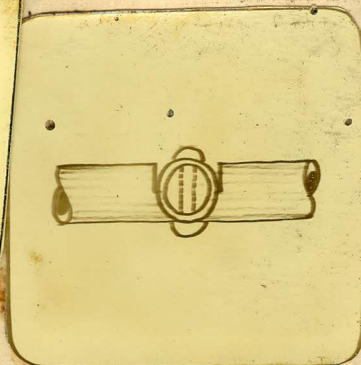


9

Nut and bolt can be hidden if two holes are drilled on opposite sides and only inside walls are used for fastening. By doing this load comes on inside walls only, making them weak. Additional metal plates can be put inside for making it stronger. (Fig. 8,9.)



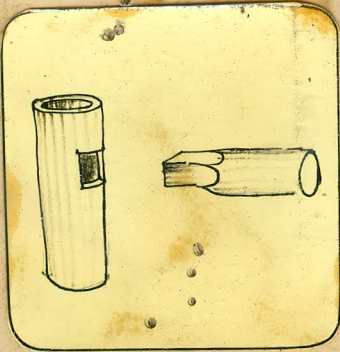
10



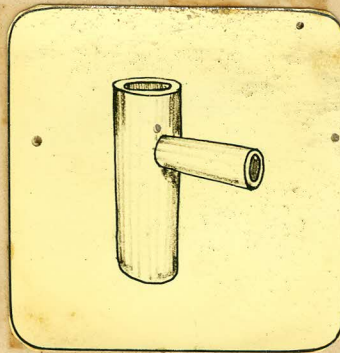
11

A slight improvement over the type of joint shown above is achieved by cutting a small segment equal to the width of the overlapping bamboo and then tightening it with rope etc. as usual. This prevents bamboo to slide over each other and joint is stronger

(Fig. 10, 11.)



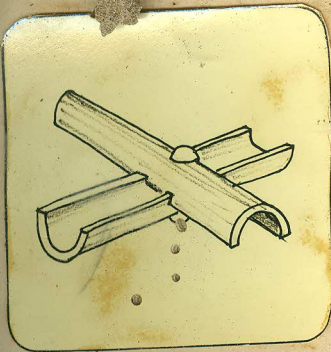
12



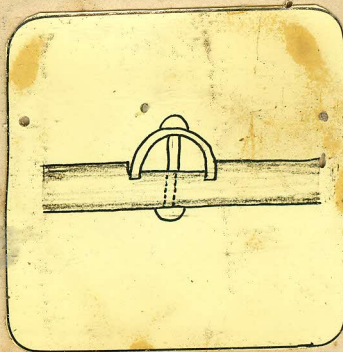
13

This type of joint is practised in ladder making. A hole is drilled or dug out with a chisel and bamboo cross member is then shaped, and inserted in the hole. Cross member bamboo is generally solid or of quite large wall thickness. This joint is generally nailed at the center but ^{nailing.} is not advisable as there are chances of splitting. (Fig. 12, 13)

This joining detail can be used in furniture making, if bamboo of sufficiently different diameters are used.



14



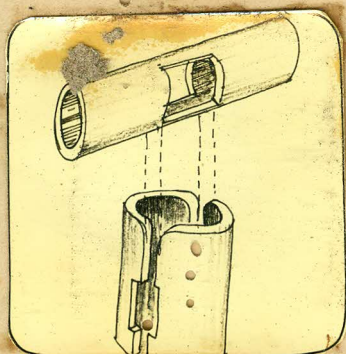
15

Split bamboo with notches made as shown can be joined face to face with rope or nut and bolt. This prevents them from sliding over each other. This also forms an aesthetically pleasing joint. (Fig 14,15)

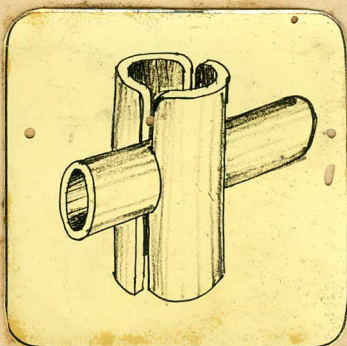
This can be further clamped to give an even load distribution. This also adds to the beauty of the joint. (Fig 16)



16



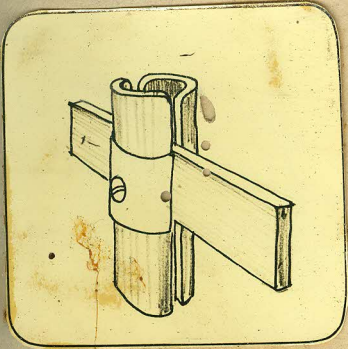
17



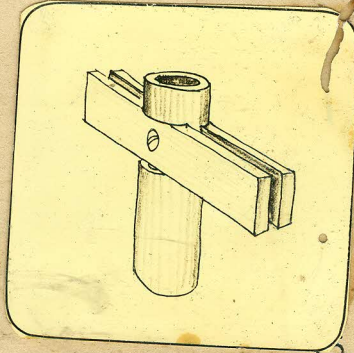
18

This joint is quite different from other types of joints as in this case three members are used to form a joint. The central member is whole bamboo with segments cutout on one end with under cuts as shown. Side members are half split bamboo with small notches which lock in the notches of the central member when slid side ways. This type of joint totally prevents side ways motion and also prevents rotation of side members around the central member. Considering a certain amount of play which might occur because of minor irregularities in cutting the notches. This joint can be further tightened with rope or with nuts and bolts. (Fig. 17, 18)

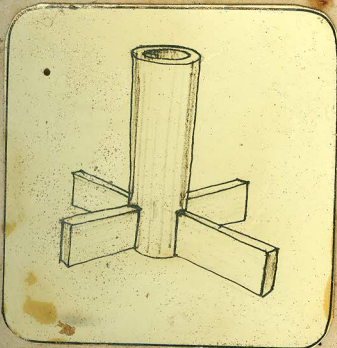
WOOD AND BAMBOO JOINTS



24

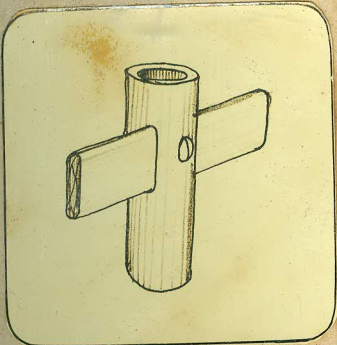


25

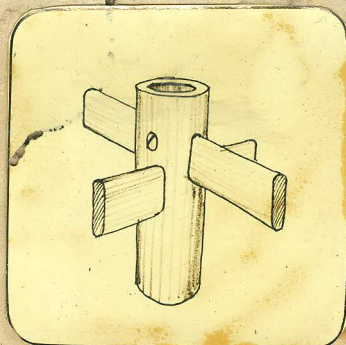


26

Various types of joints with bamboo and wood combination can be made by making rectangular notches in bamboo and inserting straight plywood or wooden pieces in several ways as shown.

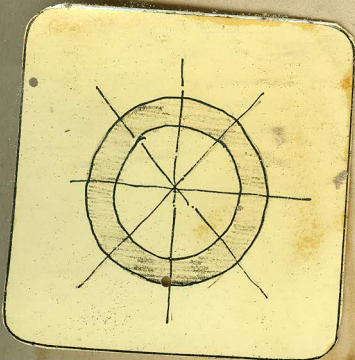


27

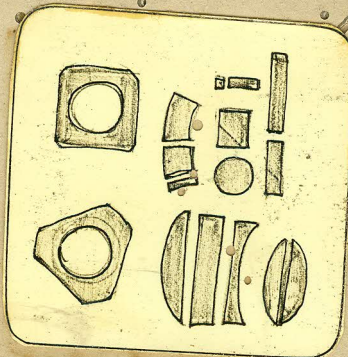


28

 BAMBOO SECTIONS



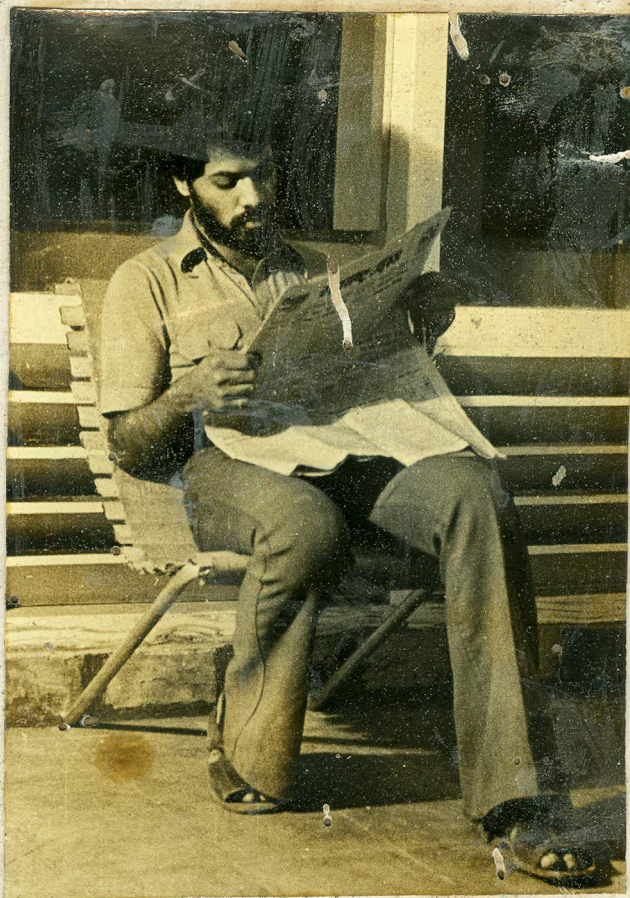
29.



30.

Different bamboo sections can be obtained by splitting bamboo in different ways. Later these split pieces can be ground for a good finish.

Sketches show how these sections can be obtained by splitting bamboo in various ways. The split pieces can be used for making seats, back rest, curtains, panneling, partition etc.



10. DESIGN DESCRIPTION

10.1. Wall Chair

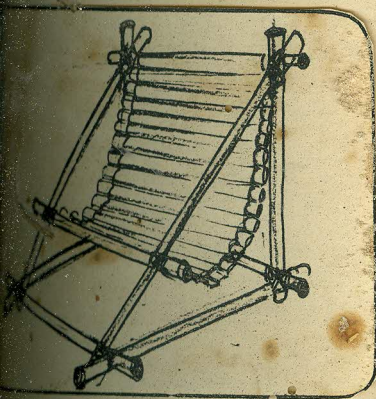
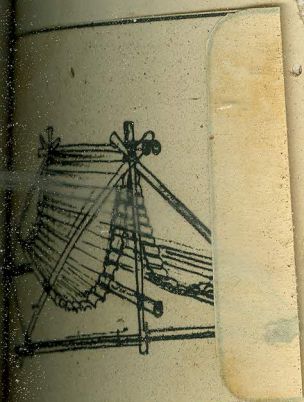
The chair has been mainly designed for 'waiting lounges' and where space is not sufficient to keep conventional type of chairs.

A jute cloth with sleeves sewn for accommodating bamboo splinters forms the main part of the chair. In one end-sleeve a bamboo piece is inserted, which can be hooked to the wall. A bamboo frame with one member inserted in the other end-sleeve functions as a structural support. This frame can be hooked on to the wall when the chair is not used. This chair can also be used as a 'piece of Paintings' when folded. Painting is done on the back side of the jute cloth.

Sag and height of the chair can be adjusted by inserting the member of the frame in suitable sleeve of jute cloth.

10-2. Beach and Garden Chair

On a fixed triangular frame (as shown in the sketch) jute cloth as used in the wall chair can be fixed at two ends of the frame to form a seat. Two or four such triangular frames can be fixed on rectangular or cross frame respectively to form the whole system. A small table made out of bamboo splinters fixed over a hollow bamboo frame can be fitted in the centre of the system if needed. The bottom square or cross frame gets submerged in the sand and provides the whole chair system a firm base. The chair being light in weight can be easily carried and kept at different places.





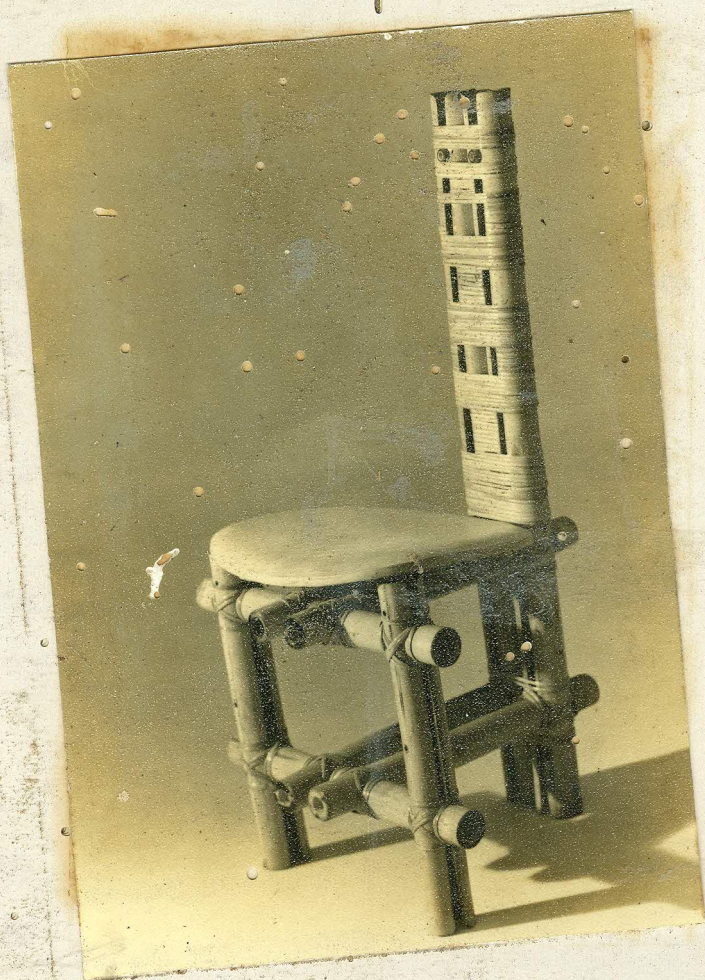
10.3. Dining Set

The Dining Set consists of one square bamboo table with a glass or bamboo-mat top and four chairs as shown in the photographs.

In both table and chairs, a special type of joint (described on page No. 25) is used. For tightening the joints, cane has been used. Other types of strings such as nylon and jute were also tried for the fastening joints. Cane was found most suitable as it belongs to the same class of material and matches with other parts of the furniture. Cane gives a clean and aesthetically pleasing look as well.

10.3.1 Dining Table

The table consists of two cross members placed over each other, supported by four vertical members using the joint explained earlier (Page. 25). These four vertical members protrude out above the top 'cross'. A glass sheet or a bamboo mat top can be placed over these four supports.



10.3.2 Dining Chair

In the chair also the same type of joint is used as explained earlier (page no. 25). This chair is three legged with the rear leg made out of two long bamboo pieces which also serve as back rest. Front leg-frame is jointed with the rear leg by means of two bamboo pieces, both at the top and at the bottom. This supporting structure employs a different kind of joint as explained on page no. 22.

Seat of the chair is made out of bent plywood sheet with leather cover. Coir can be used as a cushioning material. Between the plywood sheet and leather cover.

Cane which passes through the two holes drilled in the plywood sheet, fixes the seat with supporting frame.

Top portion of the rear leg above the seat level has been tied with cane to give it strength as well as an integrated look.

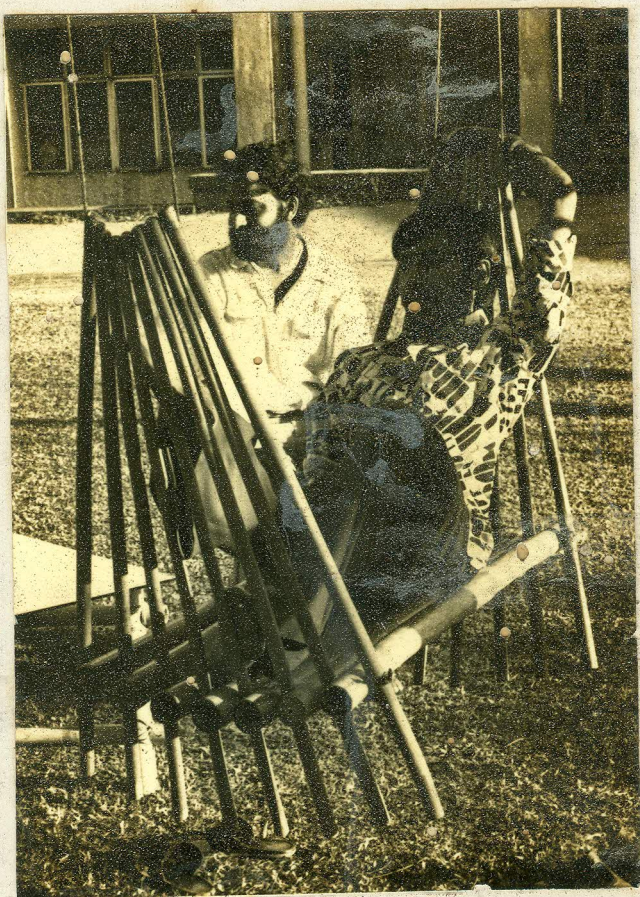


10.4. Relaxing Chair

This chair has been made out of bamboo pieces of approximately 20 mm to 25 mm diameter by arranging them alternately in a criss-cross fashion as shown in the photograph.

Angles of the chair have been ergonomically worked out to attain a comfortable posture.

After arranging all the pieces in the required angles, holes are drilled out at the junction. These junctions are then tied with the cane. Metal wire prevents sliding of bamboo pieces over each other, it also helps in positioning the pieces at correct place and hence fabrication becomes fast and easy.



10.5. Swing

Swing uses bamboos of two diameters, thicker ones which are around 50 mm in diameter form the seat part of the swing, while the other ones, which are around 20 mm diameter have been used to support and hang the seat part of the swing. This can also be used as back rest. Thicker and thinner bamboos have been placed alternately and a cable passes through the holes drilled at the ends of the bamboos. Cables also pass through holes at the free end of the hanging bamboos, forming loops which in turn can be tied with a tree branch in a garden or hooked on to a beam when taken inside.

Cable loops and supporting bamboos can be stretched wide open to form a relaxing swing bed. This swing can be folded and kept in a bundle ^{form} when not in use.



10.6. Centre Table

Centre Table uses type of joint explained on page no. 23 . It consists of two bamboo frame placed diagonally apart with common central members as shown in photograph. A bamboo mat top placed on the central square serves as table top. Bamboo mat is resin coated and hence can be easily cleaned.

11. COST OF BAMBOOS

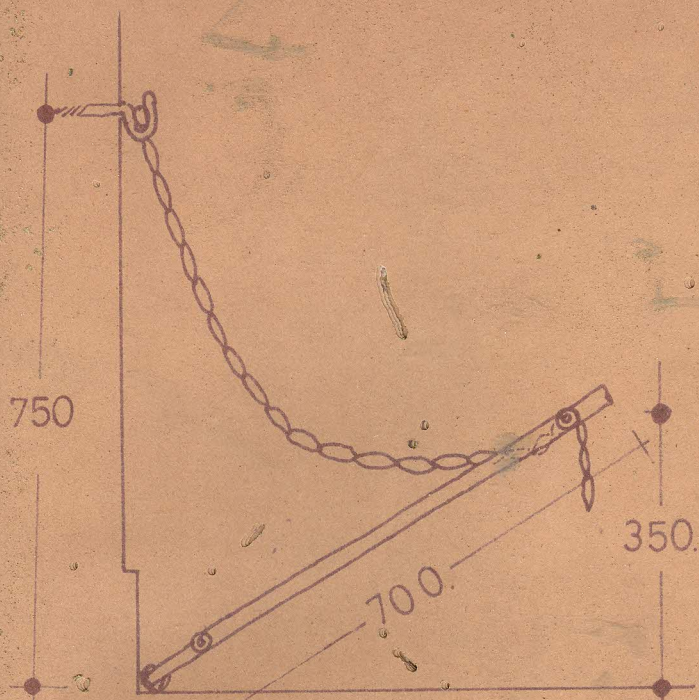
	Diameter of bamboo		Length	Cost of bamboo per 100 pieces
1.	Around	2 c.m.	5m to 6m	Rs.50 to Rs.100
2.	"	3 "	"	Rs.150 to Rs.250
3.	"	4 "	"	Rs.300 to Rs.350
4.	"	5 "	"	Rs.400 to Rs.500
5.	"	6 "	"	Rs.600 to Rs.700

TREATMENT COST

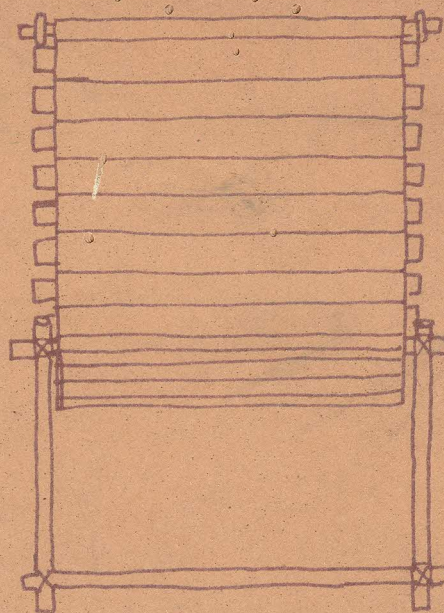
	Large size bamboo		Small size bamboo	
	One no. length 5to6m		10 no.length 5 to 6 m	
	Untreated	Treated	Untreated	Treated
Cost of Bamboo	Rs.1.00	Rs.1.50	Rs.5.00	Rs.7.00
Service Life	4 year	15 year	4 year	15 year

12. ADVANTAGES OF THE NEW DESIGN

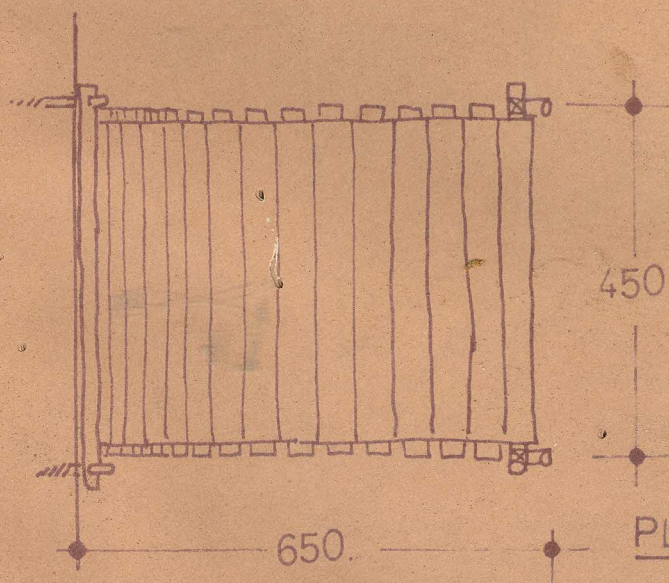
1. Bamboo is available in abundance and at a low price, hence low cost.
2. Furniture can be made with ordinary hand tools and production is easy and fast.
3. Natural colour and texture of bamboo is quite appealing and not other surface treatment is required. However, if needed it can be polished at a low cost.
4. Transportation problems are minimal as furniture can be easily dismantled and reduced in volume to occupy less space. Furniture can be easily reassembled at site.
5. Furniture is light in weight as bamboo has high strength to weight ratio.
6. Provides a good ventilation and therefore is very comfortable.
7. Exposed joints show simplicity of design.



SIDE ELEVATION.



FRONT ELEVATION.



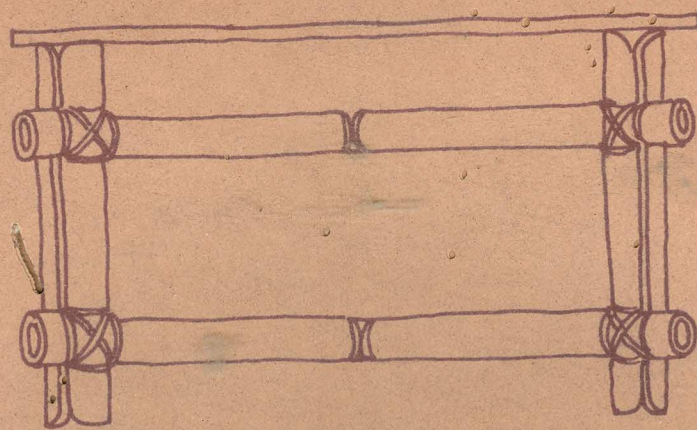
PLAN.

DESIGN OF BAMBOO PRODUCT.
WALL CHAIR

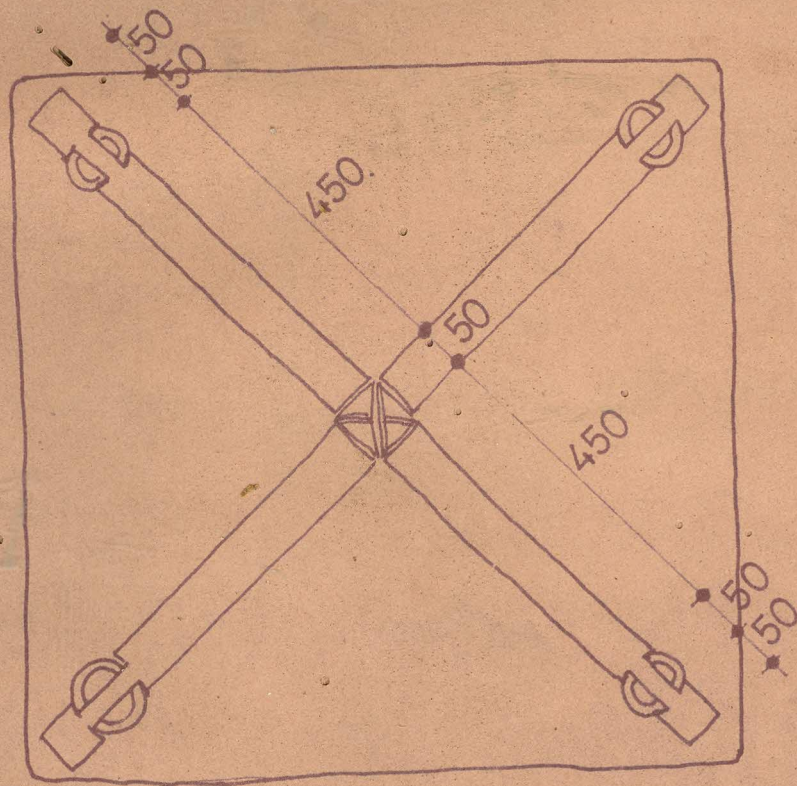
SCALE 1:10

DRG.NO.

1



ELEVATION.

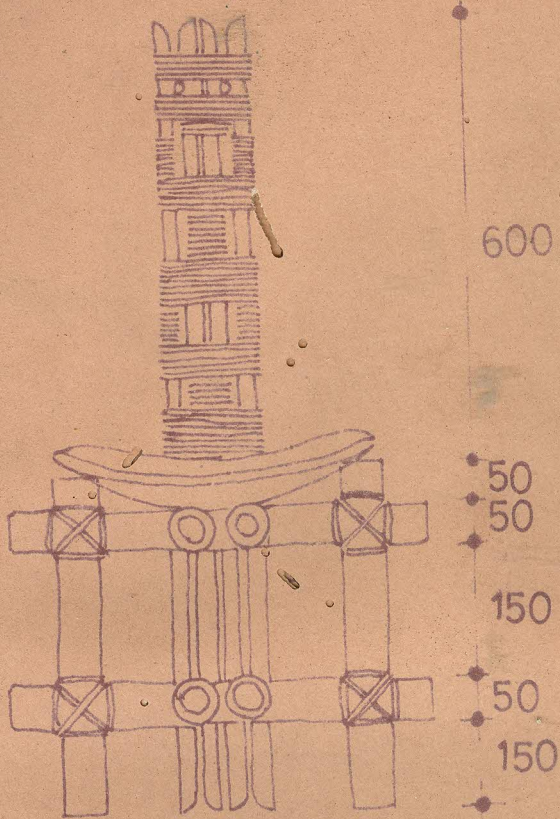


PLAN.

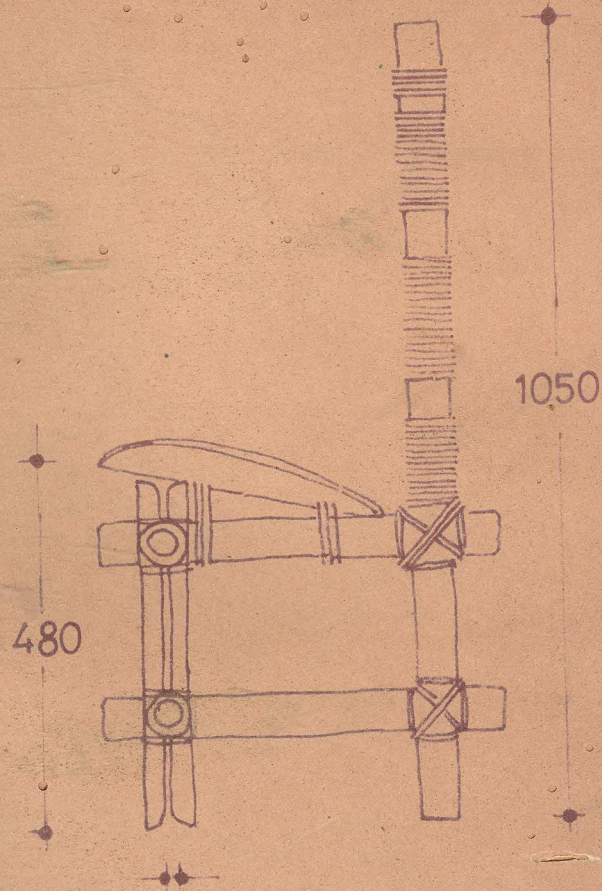
DESIGN OF BAMBOO PRODUCT.
DINNING TABLE.

SCALE 1:10.

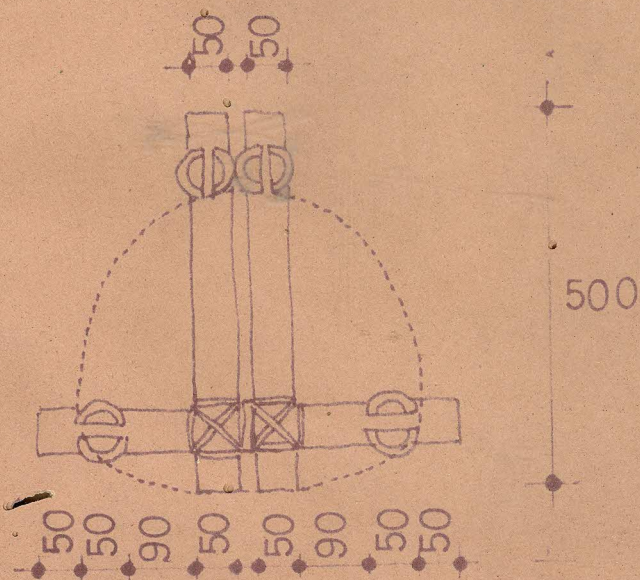
DRG. NO.
2



FRONT ELEVATION.



SIDE ELEVATION.

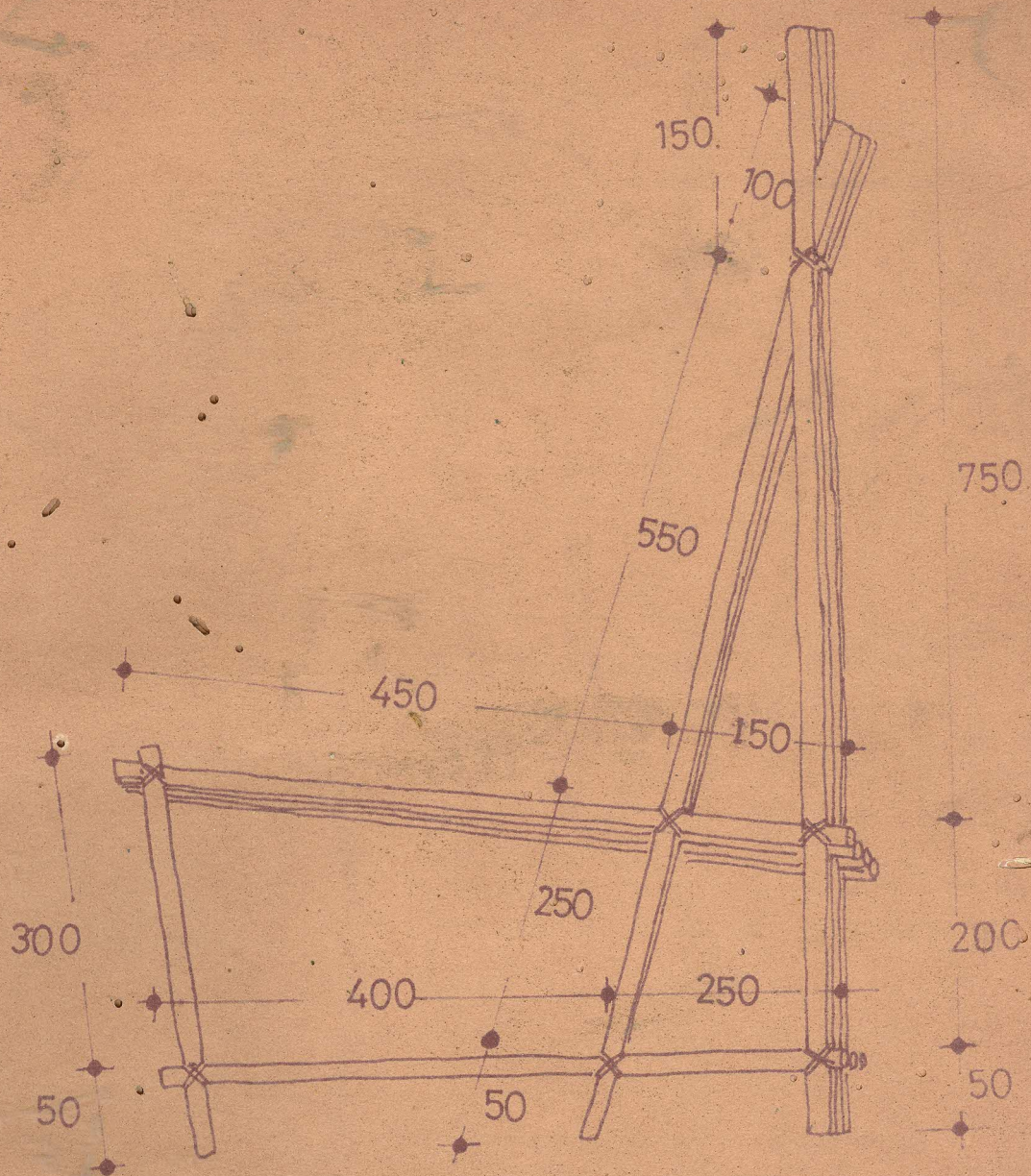


PLAN.

DESIGN OF BAMBOO PRODUCT.
DINNING CHAIR.

SCALE 1:10

DRG NO.
3

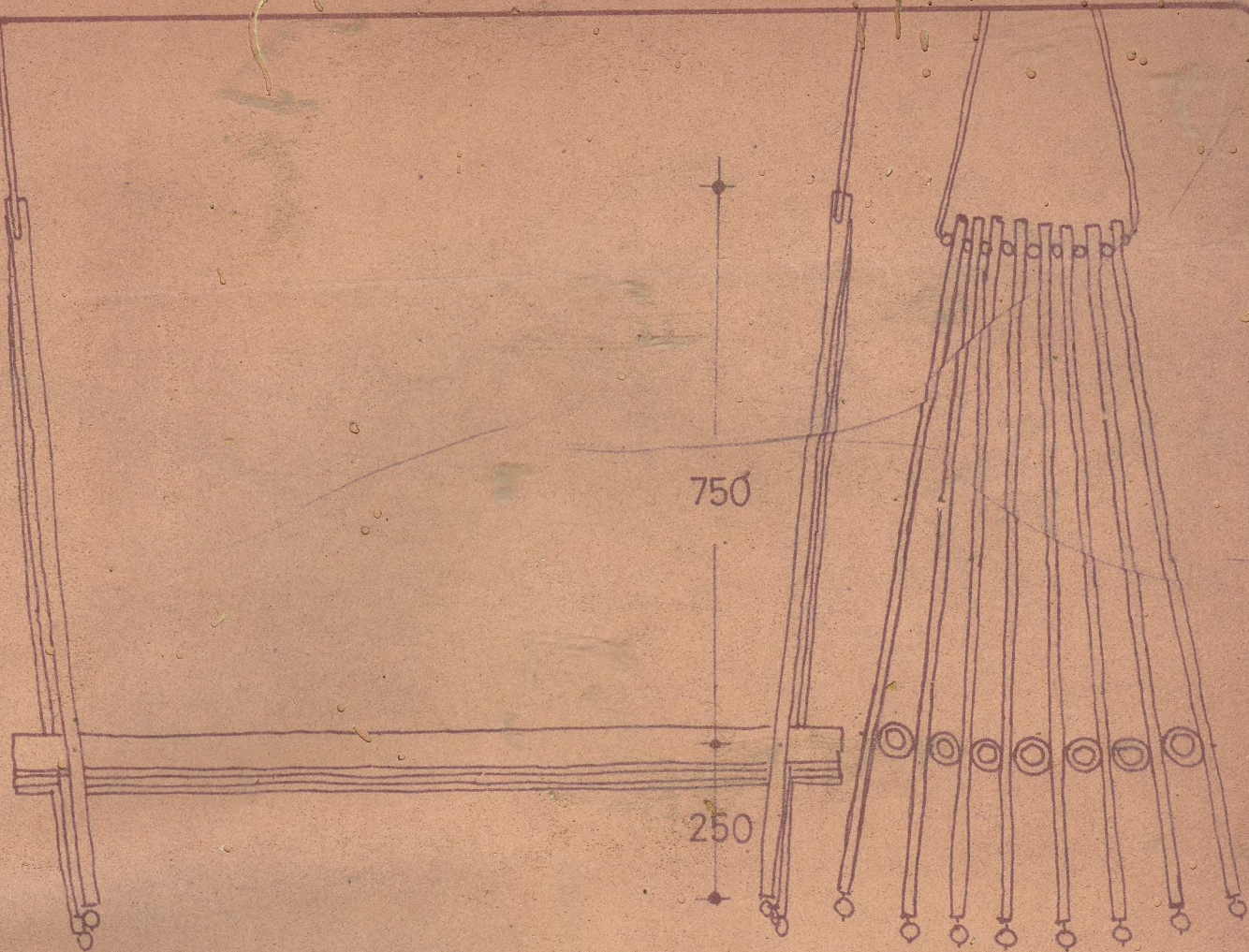


SIDE ELEVATION.

DESIGN OF BAMBOO PRODUCT
RELAXING CHAIR

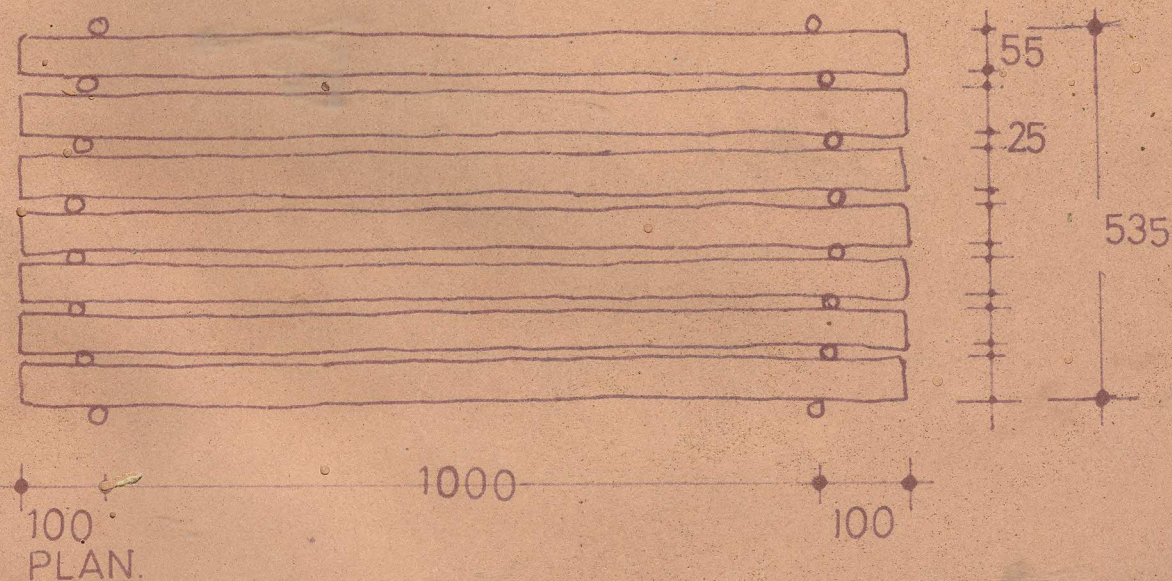
SCALE 1:75

DRG NO
4



FRONT ELEVATION.

SIDE ELEVATION.

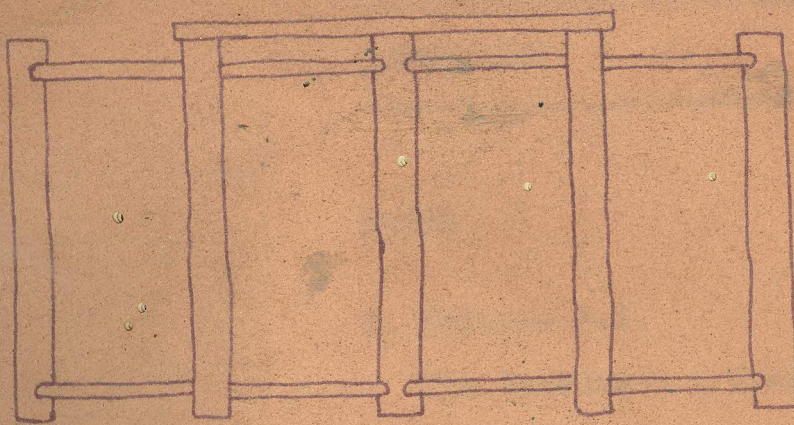


100
PLAN.

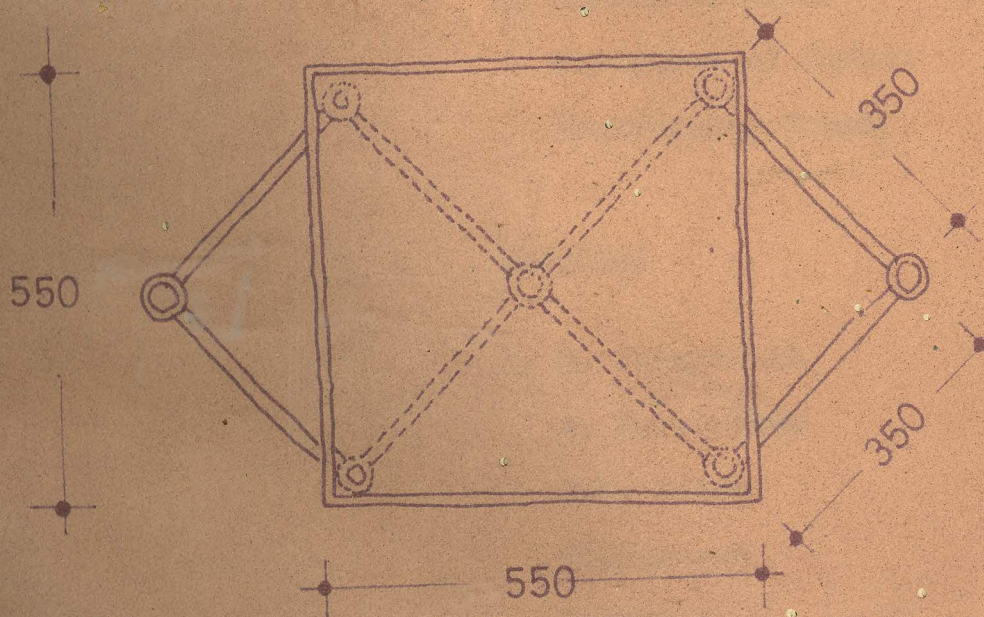
DESIGN OF BAMBOO PRODUCT
SWING

SCALE: 1:10

DRG. NO.
5



ELEVATION.



PLAN.

DESIGN OF BAMBOO PRODUCT
CENTRE TABLE

SCALE 1:10.

DRG. NO.
6

DP/VIII/72/1978

I. D. C Library

~~Library~~14. REFERENCES

BOOKS

1. McClure F.A.

The Bamboos - A fresh perspective
 Harvard University Press, Cambridge
 Massachusetts
 1966 edn.

2. Harumichi Kitao

Formation of Bamboo
 Shokokusha, Tokyo

ARTICLES

1. D. Harayanath

A. Burshotham

S.K. Sudan

Vidyasagar

Bamboo :

Indian forest bulletin No. 110, 1951

2. S.M. Vaid

Bamboo (in series - Let us grow
 more trees), Science Today March '78

3. Gadgil Madhav

Finished in 20 years - Bamboo
 Inside-Outside, Volume 2 No.3 1978