

**TRANSFER OF SOME SELECTED
WOOD PROCESSING TECHNOLOGIES
TO WOOD USING INDUSTRIES IN KERALA**

T. K. Dhamodaran

P. K. Thulasidas

**Division of Forest Utilisation
Kerala Forest Research Institute
Peechi – 680 653, Kerala, India**

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KFRI Research Report No.

Transfer of some selected wood processing technologies to wood using
industries in Kerala

(Final Report of Project KFRI 355/2000)

T. K. Dhamodaran

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ABSTRACT OF THE PROJECT PROPOSAL

1. Project Number: KFRI 355/2000
2. Title of Project : Transfer of some selected wood processing technologies to wood using industries in Kerala
3. Principal Investigator: T. K. Dhamodaran
4. Associate Investigator: P. K. Thulasidas
5. Objectives: To popularize---
 - i. The use of solar kiln for timber drying
 - II. Ammonia plasticization technique for the manufacture of bent wood articles
 - iii. Ammonia fumigation technique for imparting desired surface colour/shade and
 - iv. Preservative treatment for increasing the durability of timber for the promotion and sustenance of wood-based industries in the State.
6. Funding Agency: STEC (present KSCSTE), Government of Kerala
7. Budget Outlay: Rs. 1.41 Lakhs
8. Duration: April 2000- September 2001
9. Programme Outline: - Conduct “Wood Technology Clinics” in 6 selected Districts of Kerala where wood industry is concentrated
 - Conduct required maintenance and upgradation for the facilities and equipments installed at KFRI, Peechi in order to keep the system alive for the benefit of entrepreneurs.
 - Conduct “Open House” Programme in order to familiarize with the installed facilities and equipments, for the benefit of the interested participants of the Technology Clinics
 - Publish necessary Promotional Literature for circulation among the participants of the Technology Clinics and Open House Programmes
 - Provide appropriate scientific/technical input to potential entrepreneurs in order to start new units.

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ABSTRACT

Transfer of appropriate technologies for product diversification and value-addition is vital for the sustenance of wood-based industries in Kerala. Support from the Indian Council of Forestry Research and Education (ICFRE) has resulted in an earlier project for transferring a package of technologies; solar kiln for economical drying of timber, plasticizing wood with ammonia gas for the manufacture of bent wood articles, liquor ammonia fumigation of wood for improved surface colour – by way of installing the facilities and equipments at KFRI, conducting Wood Technology Clinics at selected Districts of the State where wood industries are concentrated and by conducting Open House Programmes for the benefit of the interested participants of the Technology Clinics and by publishing promotional literature. As a follow-up action of the above project, it was planned to conduct more Wood Technology Clinics to a wider audience. The installed facilities and equipments (solar kiln, ammonia plasticization unit, ammonia fumigation chamber and wood treatment facilities) were maintained for demonstration to the participants of Open House programme or for interested general visitors. Eleven Wood Technology Clinics were conducted at seven selected Districts of Kerala where wood industries are concentrated. The course curriculum was so designed to disseminate the details of the techniques among the wood industries, technologists, students, end-users/consumers, entrepreneurs, and other interested public. Promotional Literature (KFRI Information Bulletin) was prepared and circulated to the participants and other interested persons. The Wood Technology Clinics were organized with the help of the respective District Industries Centre and the audience comprised supervisory, managerial staff and workers of wood-based industries, engineers, technocrats, professional consultants, representatives of trade organizations, NGOs, end-users, students and other interested general public. The techniques were transferred through interactive lectures, demonstrations, slide shows, etc. Open House programme was also arranged for the benefit of the interested participants of the Technology Clinics, which further offered opportunity to the prospective entrepreneurs for familiarizing the installed facilities and equipments. Appropriate scientific/technical inputs were also provided to potential entrepreneurs in order to start new units.

The message of product diversification for better profit through the adoption of the available technologies for value-addition was popularized and the wood-based industries in the State as well as new entrepreneurs were benefited by this action research project supported by State Committee for Science, Technology and Environment (STEC) of the Kerala Government.

1. INTRODUCTION

Timber is a major industrial raw material for construction, furniture and panel works. Wood-based industries have a significant role in the industrial economy of Kerala. Efficient utilization of available secondary timbers and wood from non-conventional sources is the need of the hour and it calls for value-addition techniques for better profit. Product diversification is another option for the revival of sick units. Upgradation and renovation of existing technologies and introduction of new technologies are vital for the sustenance of wood industries in the State. It is in this context, the Kerala Forest Research Institute has successfully implemented the first phase of an action research programme to transfer some selected wood processing technologies to wood using industries in Kerala (Gnanaharan and Dhamodaran 2001). Popularization of cost effective timber drying by the use of solar kiln, ammonia plasticization of wood for bent wood articles, ammonia fumigation of wood for improved surface colour/shade, and preservative treatment techniques for improved durability are identified as some of the thrust areas where tested technologies are available for immediate transfer to wood using industries in the State. Necessary facilities and equipments were installed and a limited number of Wood Technology Clinics, Open House programme, and circulation of promotional literature were conducted as the means for transfer of technology. As the feed back from this work necessitated continuation of the programme as a second phase of the earlier project to address a wider audience.

With the support from the Science, Technology and Environment Committee (STEC) (at present KSCSTE) of the Kerala Government, an action research programme was undertaken to popularize: the use of solar kiln for drying timber, ammonia plasticization technique for the manufacture of bent wood articles, ammonia fumigation technique for imparting desired dark colour/shade, and preservative treatment techniques for increasing the durability of timber – by way of conducting more Wood Technology Clinics in selected Districts of Kerala where wood industries are concentrated, maintaining the installed facilities and equipments at KFRI for conducting Open House Programme for the benefit of interested participants of the Technology Clinics and new entrepreneurs, circulation of promotional literature, etc. Also it was envisaged to provide appropriate scientific/technical input to potential entrepreneurs in order to start new units.

2. STATE OF ART

Preservative treatment and seasoning (drying) are the primary concerns in any programme for effective utilization of wood. Increased durability and dimensional stability are the value-addition factors that can be achieved through this preliminary processing. Product diversification is a tool for better profit and can be effected through adoption of novel techniques. Use of curved wood in furniture, housing, sports goods, boats, ships and in several decorative and utility products is much prevalent and better price fetching from ancient days onwards. Cutting, sawing and shaping of wood to required curvature becomes uneconomical from the point of view of the more material requirement and wastage. Bending wood after plasticizing it with vapor ammonia is an economical substitute process from the product diversification point of view. It is more economical and easy to handle compared with the traditional steam bending process. Further, steam bending has the limitations such as the quality and number of bents that can be made, the achievable minimum radii of bent and requirements of costly equipments like boiler which necessitates much safety precautions too. The unpleasant light surface color of some of the secondary species can be modified to desired darker shades by ammonia fumigation technique.

2.1. Preservative treatment

Non-durable timbers require treatment with preservative chemicals to increase their service life. Many secondary species and non-conventional timbers such as rubber wood, coconut wood, bamboos, etc. available in plenty in the State are generally non-durable. Research in the Kerala Forest Research Institute (KFRI) led the widespread acceptance of compounds of low mammalian toxicity such as boric acid and borax for the protection of perishable timbers in Kerala (Dhamodaran and Gnanaharan 1994, 2005 a & b, 2006, Gnanaharan 2000, Gnanaharan and Dhamodaran 1989, Gnanaharan *et al.*1983). Even though Forest Research Institute (FRI), Dehra Dun, India suggested ammonical copper arsenite (ACA) to be suitable for treating timber in the rural areas (Dev *et al.* 1991, 1993), these were not popularized in Kerala due to reasons of non-availability of arsenical compounds to rural folk and its eco-unfriendliness. Copper – chrome – arsenate (CCA), Copper – chrome – borate (CCB), boric acid and borax remains the sole wood preservative chemicals under use and vacuum-pressure impregnation (VPI) process is adopted as the method for commercial scale treatment of perishable timbers for various end-uses in Kerala.

Different aspects of preservative treatment need to be disseminated among wood-based industries. The finer details of the treatment such as choosing the right chemical and concentration of treatment solutions; effect of moisture content, treatment schedule, and thickness of sizes in maintaining dry salt retention (DSR) specifications, etc. need to be conveyed. Besides, there is a strong need for creating awareness on preservative treatment among the wood users.

2.2. Solar Drying of Timber

Timber needs to be properly dried for insuring dimensional stability before putting into use. The cost of drying timber depends on the method employed. Steam heated and electrically heated dry kilns remains the principal commercial seasoning methods in the wood-based industries in the State. Negligence in strictly following proper drying schedules results in wastage of wood due to development of drying defects and wastage of energy. While the cost of air-drying timber is the least, it has disadvantages like longer time to dry, no control over drying leading to development of serious drying defects and the consequent high wastage due to rejects. Also, the possibility of bio-degradation due to the attack of bacteria, fungi, insect borers, termites, etc are all a natural part of the air drying system. While kiln drying can reduce the drying time considerably and can have better control over drying conditions for reduced development of drying defects, it is expensive as it involves artificial heating. Use of solar energy as a heat source is a partial solution to make drying cost effective. Use of specially designed Glass House type solar kiln can have better control over the air drying conditions, and the air drying time can also be reduced considerably, depending on the species and thickness of sizes. Solar kiln can also be economically used as a pre-drier where kiln drying is unavoidable. Use of solar kiln is not in practice in the State of Kerala.

The Forest Research Institute (FRI), Dehra Dun has set up a solar kiln of the '*Green House*' design in the 1970's and over the years a number of modifications have been done on the kiln (Sharma *et al.* 1972). The Central Building Research Institute (CBRI), Roorkee, also has done work on solar kiln (Singh and Gupta 1990). Later, Plumptre (1983 and 1985) reviewed various solar kilns and brought out a manual (Plumptre and Jayanetti 1996) which deals with research work done and in progress on solar drying of timber.

The Glass House type FRI solar kiln can be effectively utilized for reducing the energy requirements for drying timber. Kiln design can be appropriately modified depending on the geographic location, for tapping more heat from the sun by selecting the roof slop. Kiln conditions can be controlled by the use of vents. Humidity can be controlled by vents, water spray and fan. Air circulation can be ensured by another fan. Efficient recovery of solar heat can be made use of by black body radiation principle, using black painted corrugated GI/aluminum baffles.

2.3. Wood Plasticization and Bending Techniques

Ammonia, with its hydrogen bonding efficiency, acts as a weak solvent for the constituents of wood and enable it to swell and soften. A great deal of fundamental work has been carried out to study the possibility of using ammonia as wood plasticizing agent including its after-effects on various wood properties (Davidson and Baumgardt 1970, Bariska and Schuerch 1977). A relative vapor pressure of 5.2 kg/cm² was suggested as ideal for the treatment. Davidson (n.d) reported about the significance of 10-20% moisture content in wood for accelerating the ammonia absorption at room temperature.

Timbers such as *Dalbergia sissoo*, *Gmelina arborea*, *Terminalia myriocarpa*, *Amoora rohtiuka* and *Toona ciliata*, *Acrocarpus fraxinifolius*, *Mangifera indica* and *Grevillea robusta*, *Morus alba*, *Populus deltoides* and *Tectona grandis* etc. are successfully bent by ammonia plasticization. (Sharma *et. al.* 1979, 1988; Pandey *et. al.* 1991). They detailed about the radius of bent that can be made, the treatment conditions, etc. Cross sections of 13 mm thickness were bent to 37 mm minimum radius by ammonia plasticization. Rubber wood strips of up to 50 mm sections could be successfully bent (Rao *et. al.* 1993). Pandey and Rao (1995) bent 13-25 mm thick wood strips from six species by ammonia plasticization to a radius of 100-175 mm by using 5 kg/cm² pressure.

Pandey (n.d) gave all the required details about the technique of wood plasticization for making bentwood furniture. The ammonia treated plasticized wood can be bent to desired shape by applying the end-pressure required to obtain compression and prevent tensile failure. End-pressure can be applied by the use of metal strap with end blocks and L- clamps. Bending to the required shape can be done with the help of appropriately shaped wooden moulds fixed in thick wooden work bench/table. The bent piece must be held in its bent shape until it has dried or set properly (till the gas is completely escaped) or by keeping the bent

wood in slightly elevated temperature in a heating chamber. This ammonia plasticization and bending techniques can be used in the production of curved components for furniture, fancy items such as walking sticks, trays, peg tables, chairs, etc.

2.4. Ammonia fumigation and coloring of wood

For furniture and other decorative items, surface appearance of timbers is of great importance. Improving surface appearance/color of some secondary species may fetch higher prices and to achieve this, ammonia fumigation technique can be employed as an economical method. The tannin in wood reacts with ammonia vapor forming ammonium tannates, which are rich reddish/yellowish brown in color. Exposing the finished articles (before polishing) to ammonia fumes from liquor ammonia was found effective in bringing out the characteristic hue and prominent surface figures in tannin rich woods (e.g. oak, eucalypts, acacia, teak, *Dalbergia sissoo*, etc.). Apart from the tannin-ammonia reaction, the possibility of reaction with resinous substances in coniferous timbers with ammonia, leading to the formulation of darker colored compounds are noticed in comparatively tannin free pines (e.g. Chir pine – *Pinus roxburghii*).

Badoni (1987) reported about the prospect of ammonia fumigation of some Indian timbers for improved surface color. The requirements are an air-tight fumigation chamber of appropriate size and trays to keep liquor ammonia. 10 mm thick samples of *Terminalia procera* were darkened throughout their thickness, samples of silver oak showed characteristic violet tinges over its surface, where as *Eucalyptus tereticornis* showed marked color and grain development resembling walnut wood by exposure to ammonia vapor for 6-12 hours. Timbers like *Dalbergia sissoo* and *Tectona grandis* (Teak) showed further improvement in appearance after fumigation. In species like *Hopea* and *Anogeinsus latifolia*, varying degree of color in heartwood can be harmonized in shade after ammonia fumigation. Badoni *et al.* (1990a) recorded the color improvement in 51 Indian timbers. Regardless of the natural wood color, final color attained after ammonia fumigation in many wood species studied approached very close to the natural shade of teak. For timbers that are not rich in tannin (e.g. softwoods and plain looking timbers like poplars, rubber wood, mango, etc. and sapwood of many species) modified treatment in which fumed articles are swabbed-dipped in bark extracts) /tannin (e.g. *Terminalia elata* solution to obtain teak/walnut type hues with prominent surface figures is recommended (Badoni *et al.* 1990b). To overcome the problems during polishing due to the ammonia vapor emission from the fumigated timber, drying the

treated timber under high humidity conditions or a mild acid (e.g. 1% sulphuric acid solution) treatment followed by wiping with water are suggested. Ammonia fumigation is reported to be effective in protecting rubber wood from the attack of wood borer *Stronatum barbatium* (but ineffective for surface color improvement) and *Lyctus* in silver oak (Badoni 1990a).

3. Activities

The following facilities and equipments available with the Institute were properly maintained and utilized for the purpose of demonstration:

Sl. No.	Name of Facility/Equipment
1	Wood preservation facilities (Vacuum- pressure impregnation and diffusion treatment facilities)
2	Solar Kiln
3	Ammonia plasticization equipment
4	Ammonia fumigation chamber

The **preservative treatment facilities** consists of a vacuum-pressure impregnation (VPI) pilot plant for pressure treatment (Fig.1); and half cut oil drum for non-pressure diffusion treatment. The treatment cylinder was of 0.3 m in diameter and 2.0 m in length. The VPI system permits the application of an initial vacuum followed by the application of desired pressure for the desired duration so as to achieve the required retention. In the non-pressure, dip diffusion treatment, required retention is achieved by dipping the material in the preservative solution for long time. More details are given in the promotional literature published as KFRI Information Bulletin No. 15 (Appendix 1).

Fig. 1 VPI Pilot Plant

The **Solar Kiln** was made in glass panels framed with CCA treated rubber wood. (Fig.2). The angle of roof was 0.9 times the latitude. The external dimensions of the kiln were 3.7 m (L) x 2.3 m (H) at south wall and 3.0 m (H) at the north wall. The solar kiln was oriented in the North-South direction to trap maximum solar radiation during day time. The design details and the method of operation of a model solar kiln with 7.1 m³ capacity are given in Appendix 2.

Fig.2. Solar Kiln

The **ammonia plasticization equipment** consists of a 1500 mm x 150 mm cylinder of 10 mm thickness made of mild steel, and provided with two inlets and one outlet, with stainless steel valves and a pressure –cum vacuum gauge (Fig.3). One of the inlets is connected to a

vacuum pump and the other to a commercial ammonia gas cylinder through a pressure-regulating valve. The outlet provided at the bottom of the cylinder

Fig. 3

Ammonia Fumigation Chamber

is connected to water reservoir by hose for absorbing ammonia gas discharged from the cylinder after the treatment.

Moulds, flexible metal straps and L-clamps (Fig. 4) were used for manual bending of the plasticized wood strips. The method of operation of the equipment is detailed in the KFRI Information Bulletin No. 15 (*see* Appendix 2). Fig. 5 shows an example of bentwood furniture.

Fig. 4 Moulds, flexible metal straps and L-clamps furniture

Fig. 5 Example of bentwood

The **ammonia fumigation chamber** made with treated rubber wood and plywood had a dimension of 1.2 m x 1.85 m x 1.05 m, capable of holding real sizes of furniture for fumigation (Fig. 6). The air-tight chamber contained a wooden platform with holes of 50 mm x 50 mm below which liquor ammonia could be placed in plastic trays. The door was provided with a glass panel for viewing the color changes. The details on method of operation are given in the KFRI Information Bulletin No. 15 (*see* Appendix 2).

Fig. 6 Ammonia fumigation chamber

Fig. 7 shows an example of the desired darker shade obtained in *Eucalyptus* wood by ammonia fumigation.

Fig. 7 Handicraft made with untreated & ammonia fumigated Eucalyptus wood

Wood Technology Clinics in different Districts were planned and were organized through the District Industries Centre (DIC) (*see Appendix 3*) of the concerned District as a means for transferring the technologies to the end-users.

Open House programme was planned as a follow up to the interested participants of the Technology Clinics and other interested entrepreneurs and the public (*see Appendix 3*). Live demonstrations of the selected techniques were made in this occasion and the participants/entrepreneurs were convinced about the strength of the technologies for industrial application.

KFRI Information Bulletin No. 15, “*Some selected wood processing techniques*” was reprinted for the purpose of using as **Promotional literature** (*see Appendix 2*) and was circulated among the end-users for the disseminating the information.

Information about the Technology Clinics and Open House Programme were reported to the Press and news published in popular newspapers (*see enclosure for paper cuttings*).

11 Technology Clinics were conducted in 7 selected Districts followed by the Open House Programme at the Institute (*see appendix 3 & 4*). The curriculum of the Wood Technology Clinic is given in Appendix 5. Prospective entrepreneurs and the active participants of the Technology Clinics were given further opportunity to familiarize with the installed equipments and facilities at KFRI. The equipments and techniques were demonstrated to the participants.

Also, appropriate scientific/technical inputs were provided to potential entrepreneurs visiting the Institute in search of more details on the technologies transferred (*Agencies to be contacted for equipments, fabrication, installation and rectification works are given in Appendix 6*). This is expected to help them to start new units.

4. Conclusion

The Wood Technology Clinics facilitated the transfer of technologies for value-addition and product diversification for the sustenance of the existing wood-based industries and for potential entrepreneurs. Organizing the Technology Clinics through the active involvement of the respective District Industries Centre facilitated the participation of various wood-based industries in the seven selected Districts, *viz.*, Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram, Thrissur, and Pathanamthitta. The installed equipments and facilities at KFRI created an opportunity to the public for convincing the scope of the selected wood processing techniques. Demonstration of the techniques through Open House Programme created opportunity to the interested participants of the Technology Clinics and potential entrepreneurs to familiarize the technologies. Many rubber wood processing units established in the State are now convinced about the various aspects of preservative treatment in relation to the quality of treated wood. They have been trained in the use of appropriate concentration of treatment solutions required to achieve desired dry salt retention (DSR) levels in the treated wood at the time of treatment, thickness of wood, impregnation schedule and desired DSR levels. Also, they have been exposed to the drying of timber using solar kiln, steps to be taken while drying timber in order to reduce defects and rejects, installation and fabrication of solar kiln, etc. The possibility of product diversification was appreciated by the existing wood-based industries for their sustenance. Much interest was raised among the wood-based industries about the scope of ammonia plasticization for bent wood furniture and ammonia fumigation for imparting dark color/shades while using secondary species. The promotional literature (KFRI Information Bulletin NO. 15) served as a valuable handbook for the industries. Future efforts need to be concentrated on the improvement and appropriate modification of the equipments and facilities for economizing the system. The following points emerged as immediate priorities for future research in this line, which include: the use of improvised fans, dehumidifier, solar cells, etc in the solar kiln; a system for effective recycling of the used ammonia vapor in the plasticization and fumigation equipments, etc. Also, the possibility of combining the ammonia plasticization unit with fumigation unit needs to be looked into, as both the treatments use ammonia. The spent ammonia vapor from the plasticizing unit can be considered as a source of ammonia for fumigation treatment.

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6. APPENDICES

Appendix-1

KFRI Information Bulletin No. 15. Some selected wood processing techniques

(in Malayalam; “Chila theranjedutha thadisamskarana samkethikavidyakal”)

Appendix-2a

DESIGN AND INSTALLATION DETAILS AND METHOD OF OPERATION OF THE SOLAR KILN

1. SPECIFICATION

This kiln is designed for 7.1m³ charge capacity, manual stacking, solar heated, compartment type kiln with side mounted (reversible air circulation) internal fan. It can be worked as a recirculating air kiln with partial air venting in the normal manner or as a single pass forced air pre-dryer with solar heat.

2. SITE & LAYOUT

The kiln is to install on an 8.4 x 6.0 m concrete platform raised at least 15 cm above the surrounding ground level, at a site that provides maximum exposure to the sun. The long axis of the kiln is to be oriented east-west and the slope of the roof inclined towards the south, since our country lies in the northern hemisphere. As a rough rule, the kiln should be removed at a minimum distance of twice the height of any trees or buildings which is likely to cast a shadow on it.

3. GENERAL DESCRIPTION

The kiln has a wood-frame super structure consisting of 15 x 5 cm wall pillars and roof studs placed on 0.95 m apart centers (Drawing Fig. 2b). The wall pillars have been erected on a 15 x 10 cm wooden foundation having its 10 cm side half grouted in to the concrete platform. The northern wall of the kiln is sheathed with 9 mm thick shuttering grade plywood and all other walls are covered with double layer of clear transparent glass sheathing, 5.5 mm thick clear transparent glass sheets on the out side and 4.00 mm thick clear transparent glass sheets on the inside separated by an air gap of about 37 mm by means of wooden spacer strips. The inner glass sheathing is fixed in sections, to permit subsequent replacement of any punctured or photo-degraded section without dismantling other sections.

4. CHARGING AND INSPECTION DOORS

The kiln is provided with double door 2.06 x 1.90 m high for charging of timber and an inspection door 0.56 x 1.90 m high for taking out kiln samples periodically for weighing. Stacking is done manually inside the kiln. The doors may be located either in the eastern or western wall. They are of wood frame construction covered on both sides with glass sheets to permit easy replacements of sheathing in the event of damage during stacking and unstacking. In the northern wall, a 1.21 x 0.60 m plywood- door is provided (for lubricating the fan bearings and also for adjustment of baffles necessary for operation of the kiln at a forced air pre-dryer) (Drawing Fig. 4b).

5. ROOF OF THE KILN

The kiln roof is to be tilted towards the south at a suitable angle by adjusting the height of the northern wall, but keeping the height of the southern wall fixed at 2.28 m. **The tilt angle should be 0.9 times the latitude of the place where the kiln is to be erected for maximum absorption of solar radiation in year-round use** (at Peechi the angle of tilt with the horizontal is 9.27° , as the latitude is 10.3° N).

6. DIMENSIONS & CHARGING CAPACITY OF THE KILN

The kiln measures externally 5.76 m long x 3.66 wide x 2.28 m high at the southern wall and 3.48 m high at the northern wall. The charging capacity of the kiln will of course, depends on the thickness of the timber to be dried and that of the crossers used for stacking the materials. In the following estimate, the basis of calculations is -

Length of solid materials in the stack = 5.46 m

Width of solid materials in the stack = 1.53 m

Height of the stack excluding empty = 1.70 m

Stacking capacity of 2.5 cm thick planks stacked with 2.5 cm thick x 3.0 cm wide crossers = 7.1 m^3

The stacking capacity will be more with thicker stack and 2.5 cm is stacked on 2.5 cm thick crossers.

7. CORRUGATED HORIZONTAL GI SOLAR ABSORBER

Inside the kiln, a black painted V-corrugated GI solar absorber measuring 5.46 m long x 2.14 m wide is installed horizontally along the entire length of the kiln at a height of 1.90 m above the floor, leaving clear gaps of 0.61 m along the northern and southern walls. This solar absorber also acts as a false ceiling to provide a cross channel above the stack, for return of air from the exit to the entering air side of the stack for recirculation.

8. VERTICAL FAN PARTITION

A vertical partition of 9 mm plywood, 9.90 m high and 5.46 m long, spans the entire length of the kiln and extends from the floor to the false ceiling on its north side. A 0.61 m wide plenum gap is thus provided between the fan partition and the northern wall. The plywood partition bears two 100 cm diameter holes for the fans, having their centers at a distance of 1.36 m from the two inner ends of the four foundation frame and raised to mid height of the partition.

9. FANS

Two propeller fans of reversible type, 0.9 m in diameter having 12 blades are mounted in fan housings with their shafts supported cross-wise to the length of the stack horizontally in bearings mounted on two angle iron pedestals (Drawing Fig. 8) grouted in to the concrete platform. The shafts are taken out through the plywood northern wall and driven at 550 RPM 2 HP reversible electric motor individually. The fans should preferably be cast aluminum alloys.

10. EXHAUST AND FRESH AIR INTAKE VENTS

The moist air is exhausted out of the kiln and fresh air is taken in through eight, 30 x 60 cm vents, four in the northern wall and four in the southern wall at the floor level.(Drawing Fig. 4 & 9). The hinged cover provided on each vent is manually adjusted for controlling the humidity of the air in the recirculating air system (Drawing Fig. 1A)

11. VENTS AND BAFFLES FOR SINGLE PASS FORCED AIR DRYING SYSTEM

Two 1.30 m high x 0.90 m wide openings with removable covers are provided directly at the back of the two fans in the N-plywood wall. To convert the circulating air system in to the single pass forced air drying system, the covers on the N-wall openings behind the fans are removed. The 0.61 m wide northern side plenum space is blocked all around these two openings by means of baffles described below so that the fans exhaust the entire air leaving the stack through the openings in the northern plywood wall without its re-entering the stack as in the recirculating system (Drawing Fig. 1A). The baffles around each fan consist of two vertical 0.61 m high and one horizontal 1.26 x 0.61 m framed GI sheet panels hinged to the vertical fan partitions (Drawing Fig. 4a). The two vertical panels are kept flush with the vertical fan partition and the horizontal panel flushes with the false ceiling when the kiln is worked as recirculating air system. When swung out in to the northern side plenum gap, the three panels block the plenum gap all around the northern wall opening behind each fan and isolate the discharge of the northern side from the rest of the kiln thus preventing recirculation of the discharged air. Four additional 30 x 60 cm vents are also provided in the northern wall just above the level of false ceiling (Drawing Fig. 4b) for intake of fresh air, when the kiln is to be worked as a single pass forced air dryer.

12. OPERATION

i. Single pass forced air drying system

To work the kiln as a single pass forced air dryer with solar heat, close all the eight bottom vents at the floor level and open all the four upper vents in the northern wall. The northern wall openings behind the fans are uncovered and the hinged baffle (three for each fan) is swung out to block the plenum gap around both northern wall openings. The fans are driven so as to discharge air on the northern side (Drawing Fig. 1B). Fresh air is thus continually sucked through the upper vents in to the space over the false ceiling before entering the stack on its south side, and is finally exhausted from the northern wall openings in a single pass.

ii. Recirculating air system

For operating as a recirculating kiln, the removable covers of the northern wall openings are replaced to close the openings and the hinged baffles are swung back into their normal positions. The four upper vents in the northern wall are closed. The eight bottom vents are used to regulate the humidity inside the kiln (Drawing Fig. 1A).

The following operating procedures are recommended for solar drying of various species and thickness of timber.

Species & Thickness	Kiln operation procedure
Sections up to 62 mm thickness of non-refractory species like mango (<i>Mangifera indica</i>), Sal (<i>Shorea sp.</i>) (Sapwood), gamari, garuga (<i>Garuga pinnata</i>) (Sapwood), Chir (<i>Pinus sp.</i>), and semul, etc.	Forced air pre-drying from green to 40% moisture content. Working the kiln round the clock, followed by solar drying in the recirculating air kiln system with partial air venting during daylight hours only.
Planks up to 38 mm thickness of moderately refractory species like haldu (<i>Haldina sp.</i>), teak (<i>Tectona gradnis</i>), and sissou (<i>Dalbergia sissou</i>), etc.	<p><u>From green to 40% moisture content:</u> Solar drying in the recirculating air system with partial air venting during daylight hours and forced air pre drying during the night.</p> <p><u>Below 40% moisture content:</u> Solar drying in the recirculating air kiln system with partial air venting during daylight hours only.</p>
Thicker planks or scantlings/ farming sections of the above mentioned species and all thickness and sections of refractory species, sal, bijasal, laurel and jamun.	Solar drying in the recirculating air kiln system with partial air venting during daylight hours only (direct from the green condition). Relative humidity during the first 2-3 days of drying should not be allowed to fall below 60% and the water spray humidifier should be used to maintain it.

13. DRYING CAPACITY

The kiln takes about 18 days to dry 2.5 cm thick planks of furniture class of woods like teak & sissou. Hence the kiln can dry 88.5 m³ of seasoned timber per annum, during 9 clear months of the year reckoning 25 working days per month.

14. ELECTRIC MOTORS

The kiln requires two electric motors each of 2 HP, 14440 RPM for 3 phase, 440 VAC, complete with starters and reversing switches. In operation the actual power consumption for each fan does not exceed 1 KW when pans of aluminium construction are adopted.

15. HUMIDIFIER

A 'DOCTIARE' AL' spinning disc humidifier with 3/4 HP motor starter for 3 phase 440 VAC, capable of evaporating 10 American gallons of water / hr is installed in the northern side plenum space at the level of the solar absorbing false ceiling near the east or west end wall . A water supply connection at tap pressure is required to be made to the humidifier. A GI barrel attachment with a set of two strips and gap type screens (Drawing Fig. 3 b. ii) is mounted on the humidifier easing to filter out the spray. The spray can be operated manually by means of its starter as and when kiln humidity need to be raised.

16. CURVED G.I. BAFFLES

Two blackened, suitably curved baffles of 1 m wide, mounted and running along the length of the kiln at the roof - to- the northern wall and roof- to -the southern wall edges for smoothly guiding the air circulation where the air stream suffers bends (Drawing Fig. 8).

17. KILN INSTRUMENTS AND LABORATORY EQUIPMENTS

For finding the dry and wet bulb temperatures inside the kiln and for testing the moisture content of wood and for determining the rate of drying of timber in the kiln charge the following equipments are essentially required:

1. Set of mercury hygrometers (glass), (range 20⁰ - 100⁰ C) one for the north side and the other for the south side of the stack.
2. One physical balance to weight up to 250 g with a sensitiveness of 5 g.
3. One set of weights from 5 g.
4. One balance with a weighing capacity up to 10 kg.
5. One set of weights from 1 gm to 5 kg.
6. One electric drying oven for drying small samples of wood for moisture determination which can be maintained at a constant temperature of 100⁰ C.
7. An electric Moisture Meter for ready testing of final moisture content attained.

Two distant recording instruments for recording the dry and wet bulb temperatures in the kiln are also desirable.

18. OPERATING ROOM

The concrete platform may be walled on the northern side with GI or cement asbestos sheets to protect the motors, reversible switch starters, temperature recorders etc. against rain.

19. RELIEF OF CASEHARDENING STRESS

For timber to be used for precision jobs, residual stress at the end of solar drying should be relieved. For satisfactory relief of stress, however, the timber moisture content should first be reduced below 15%. After all kiln samples have been dried below the desired final moisture content, all the air vents are closed and the kiln is worked as a recirculating air system with the humidifier worked continuously so as to attain a high humidity of 90% or more. Thereafter, the humidifier is worked only to maintain this humidity. At the end of the day the fans and the humidifier are stopped and the air vents are left closed to retain the moisture inside the kiln and to allow the timber to absorb moisture at its surface, which helps to relieve stress. If needed the procedure is repeated next day also till stress is completely relieved. The time required for high humidity treatment depends upon the thickness and refractoriness of the stock; thick and refractory timber needing longer periods.

LIST OF MATERIALS AND EQUIPMENT REQUIRED FOR 7.1 m³ SOLAR KILN.

Please note that the drawings and sizes of structural members have been calculated specifically for 20° north latitude. For other latitudes, the sizes of structural members would need to be recalculated. And will differ slightly as the tilt of the roof will have to be changed depending upon the latitude of the locality. Angle of tilt of the roof to the horizontal = 0.9 x latitude

I. Masonry

Cement: 30 bags, Bricks: 2000 Nos. For cement platform: 8.4 m x 6.0 m; Boulders: 5 m³.

II. Fashioned timber sizes

SL No	Section (cm x cm)	Length (m)	Quantity	Description	Fig. ref.
1	15 x 10 Sal (<i>Shorea sp.</i>)	3.66, 6.06	2 each	Foundation frame to be grouted into cement platform.	2b
2	15 x 5 Sal	2.38, 3.0 & 3.0	7 each	N & S-wall pillars & roof studs, with 15 x 13 mm rebates on either side along with edge face.	3b, 2b (i) & (ii)
3	5 x 5 Sal	2.0, 3.0, & 3.0	2 each	E & W wall pillars as above.	2b
		0.69	1 each	Cross braces for E & W side pillars with 15 x 13 mm rebates on either side along one edge face.	2b 3b (i)
		2.37	2 Nos.	“	
		3.46 5.86	3 Nos. 4 Nos.	“ Cross braces for roof studs and S-wall pillars as above.	
4	5 x 5 Sal	5.86	2 Nos.	Longitudinal joining member for (i) roof N-wall , (ii) roof to S- wall, suitably grooved and shaped on diagonally opposite edges to be flush with the roof and two walls.	3b (i) 2b
5	10 x 3.7 Teak	1.9	6 Nos.	Vertical door members	3a & 2b
		0.56	3 each	Horizontal door members	“ “
		1.02 1.05	11 running m.		
6	3.7 x 1.3 Teak			Beading fixed on door frames to provide rebate seating of doors	4a
7	7.6 x 5 Sal	5.46	2 Nos.	Horizontal frame members for partition. Vertical frame members for above.	“
		1.95	7 Nos.		
8	7.5 x 2.5 Teak	0.76	20 Nos.	Frame members for hinged doors and horizontal N-side plenum 4(a) to convert kiln to forced air dryer.	4a
		1.95 m 1.27	8 Nos. 4 Nos.	“ “	4a 4a
9	5 x 1.5 Teak	5.76	4 Nos.	Longitudinal members for fixing GI air baffles.	2a

10	5 x 2.5	5.76	1 No.	Longitudinal horizontal bracing members for N-wall pillars.	-
11 2.5 cm thick Sal (<i>Shorea sp.</i>) or Bijasal (<i>Pterocarpus marsupium</i>) planks 3.30 M long to cover floor area of kiln 3.36 x 5.46 M.					

III. Plywood BWR shuttering grade (9 mm thick)

Sl. No.	Items	Quantity	Description	Figure Reference
1	1.82 m x 0.92 m sheets	12 Nos.	For sheathing	4b
2	1.82 m x 0.92 m sheets	2 Nos.	For fan partition	4a
3	1.82 m x 0.92 m sheets	4 Nos.	For fan partition	4a

IV. Glass

Clear glass sheet 5.5 mm & 4 mm thick (total quantity (i) 50 m² 5.5 thick & (ii) 50 m² 4 mm thick

SL.No.	Items (cm x cm)	Quantity (Nos.)
1	91 x 93	24
2	110 x 91	6
3	91 x 76	
4	111 x 91	2
5	32 x 77	8
6	19 x 11	1
7	119 x 77	1
8	111 x 104	1
9	104 x 77	1
10	111 x 58	1
11	77 x 58	1
12	104 x 77	2
13	77 x 73	2
14	73 x 77	2
15	73 x 111	2

V. G.I. Sheets, angle iron, etc.

SL. No.	Item	Quantity	Description
1.	2.44 x 1m. G.I Sheet.	8 Nos.	For V-corrugated solar absorbing false ceiling
2.	50 x 50 x 6 mm angle iron	16 m.	For V-corrugated solar absorbing false ceiling
3.	40 x 40 x 6 mm angle iron	10.5 m.	For V-corrugated solar absorbing false ceiling
4.	2.44 x 1m. 24 GI sheets		For N- & S - side air baffles hinged doors and covers in N-side plenum to convert kiln and to forced air drier, and filter attachment for humidifier
5.	Channel strips folded from G.I. sheet in 1 m lengths.	180 no.	For mechanical sealing of edges of glass panels on roof and walls against leakage.
6.	(i) U-shaped sponge rubber beading	50 kg	Available with M/s. Satyam Rubber Udyog, Plot NO. 56, Sector No.6, Faridabad, Haryana
7.	L-Shaped flat iron brackets , 24 x 15 x 5 cm., 6 mm thick with holes for fixing bolts and screws	40 no	For fixing the vertical wall pillars to the foundation frame
8.	Felt	1.5 kg	For door gaskets
9.	Wood wool boards 2.5 cm thick 2' x4' size	30 no	For insulating the north plywood (from inside)

VI. HARDWARE

1. Bolts, nuts and washers: 9 x 60 mm (30 Nos.), 9 x 75 mm (60 Nos.) & 9 x 150 mm (12 Nos.)
2. Bolts, nuts & Washers: 15 x 450 mm with 100 mm plates welded by the ends (12 Nos.).
3. Screws: 12.5 mm (80 Nos.) & 7.3 mm (1000 Nos.) with washers (1000 Nos.). 35 x 8 mm (200 Nos.). 25 x 6 mm (100 Nos.) 20 x 5 mm (100 Nos.)
4. Nails: 10 cm, 5 cm, 4 cm (No.14) & 2 cm (No. 17) 1 kg each and blue shoe tacks 1.8 cm (1 .25 kg.) & 5 cm (5 kg)
5. Tower bolts: 10 cm x 15 cm (12 each), hinges: 5 cm (24 Nos.) & 15 cm (9 Nos.) . Gate hooks: 15 cm (30 Nos.) & Door handles: 10 cm (24 Nos.), Tower bolts 7.5 cm (24 Nos.), Parliament hinges 10 cm (4 Nos.)
6. G.I. pipes: 1.5 x 100 cm & G.I. Bend: 1.5 cm (1 each and polythene pipe 12 mm x 3 mm).
7. Roof leak stop (5 kg), Paint brushes (2 Nos.), Black board paints (4 lit), Turpentine (5 lit), Pliobond (500 cm), Welded mesh 2.5 x 7.5 x 92 cm, 1 roll of 15 meter A1 Angle 2.5 x 2.5 x 360 cm (4 Nos.) and 2.5 x 1.25 x 360 cm (12 Nos.).

VII. EQUIPMENT

1. Propeller fans: (2 sets) 12 bladed, reversible types, 91 cm diameter, 550 RPM. in aluminium construction with 122 x 5 cm shafting, complete with pedestals, ball bearings, plumber blocks, pulleys and V-belts.
2. Electric motors: 2 HP, 1440 RPM for 3 phase, 440 V/AC with starter and reversing switch. 2 sets for driving the fans.
3. Humidifier: DOCTAIRE 'AL' Brand, Spinning disc type, capable of evaporating 10 American gallons of water hr., complete with 3/4 HP motor and starter for 3 phase 440 V/AC.
Suppliers: M/s. C. Doctor & Co. Pvt. Ltd., Bank of Baroda Building, Gandhi Road, Ahmedabad., New Durga Bhavan, 36/10 Jhandewalan Extension, New Delhi – 110055.

(Appendix -2b)

Drawings of the Solar Kiln

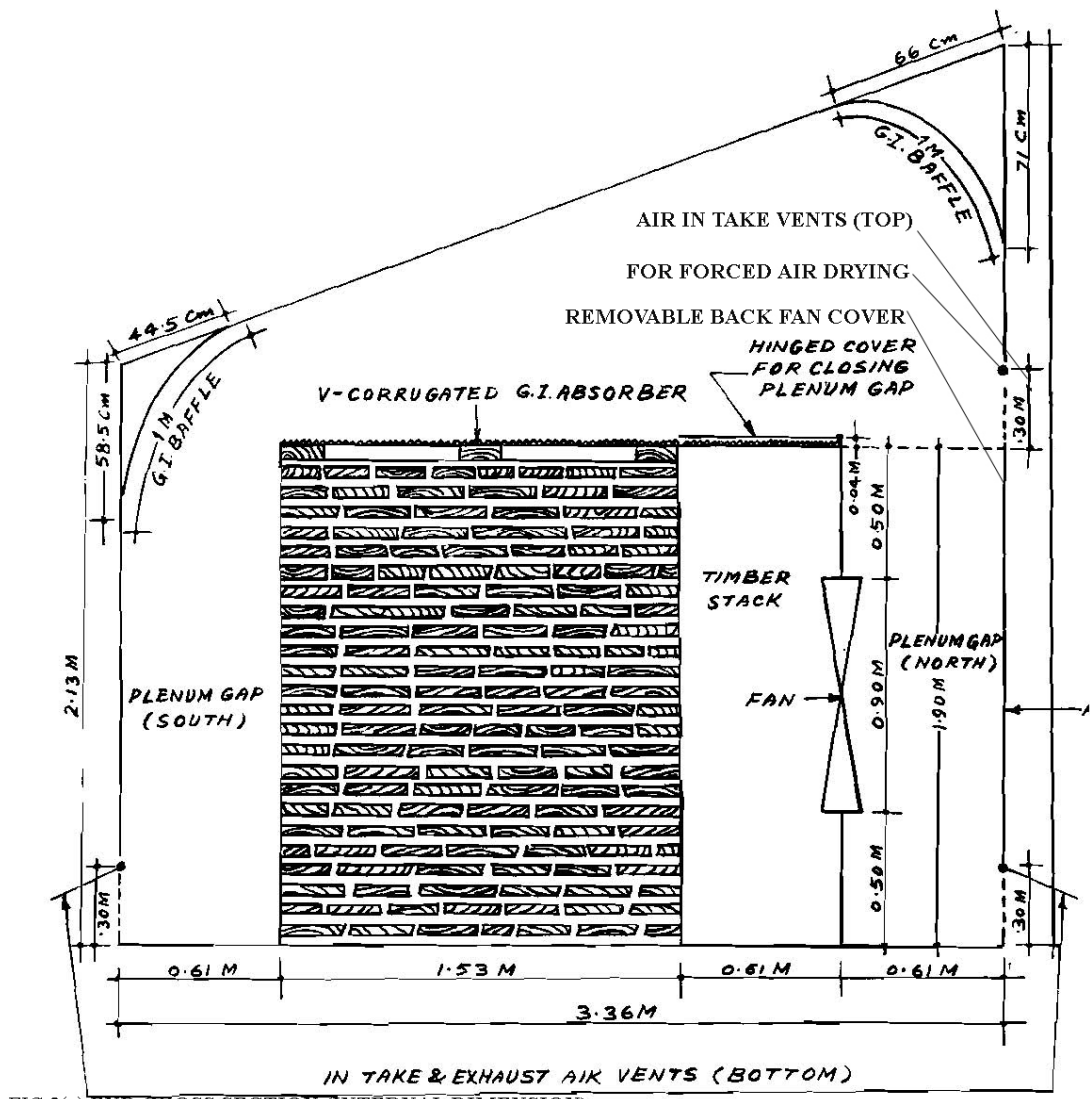


Fig. 2 (a). End cross section (internal dimensions)

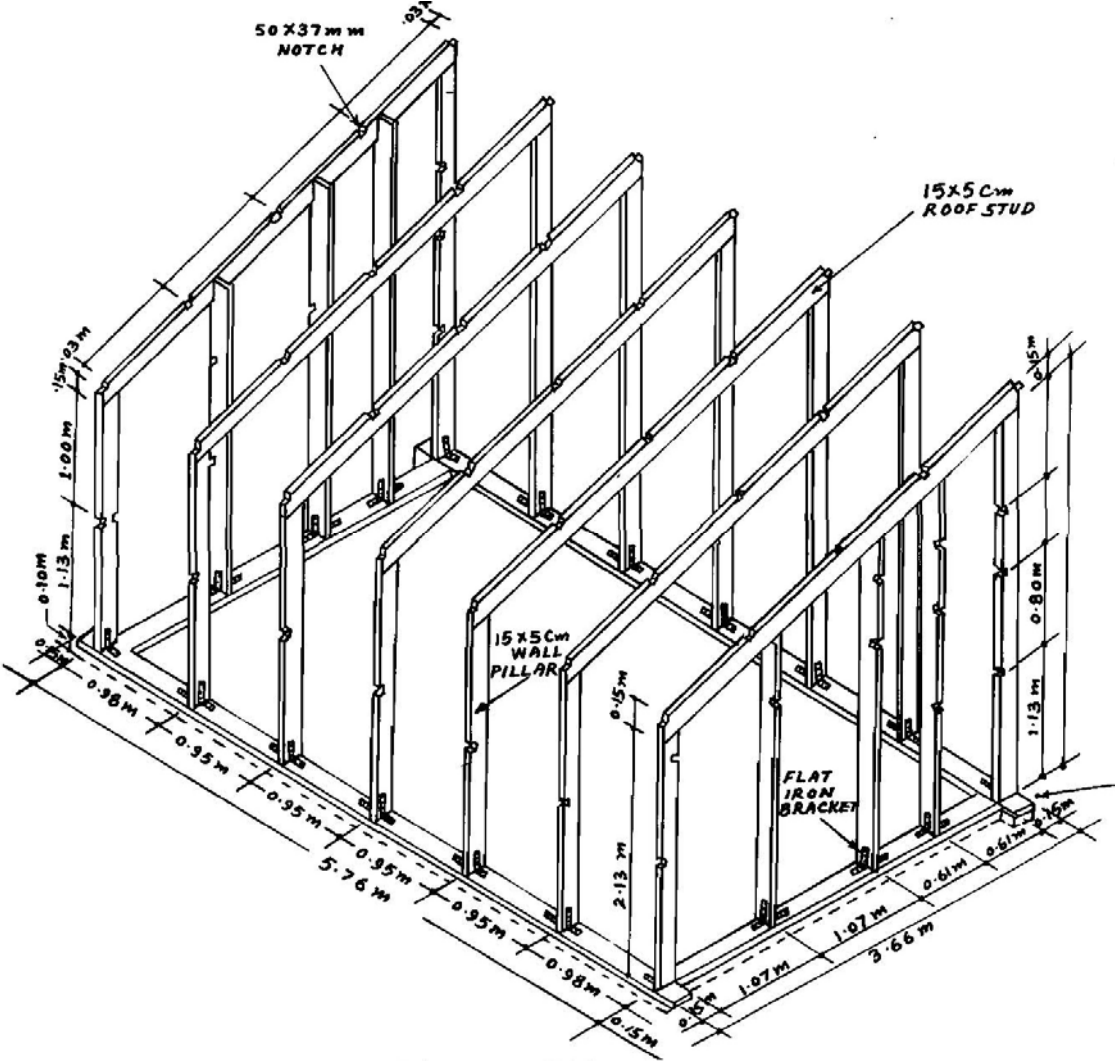


Fig. 2 (b). Wood frame super structure

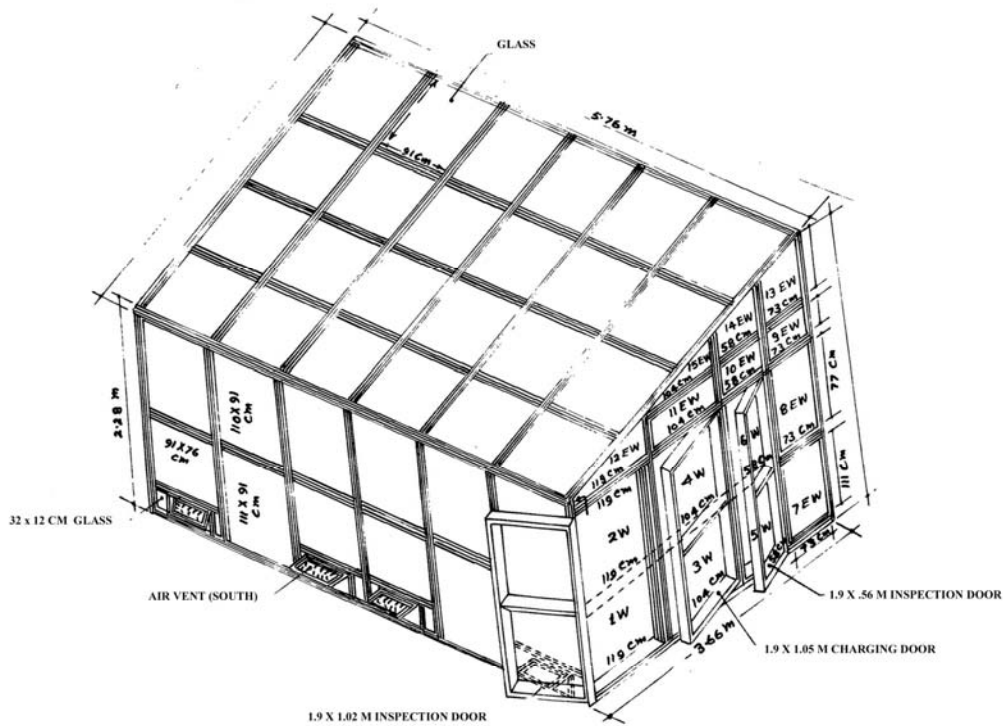


Fig. 3 (a). Isometric view showing charging & inspection doors, air vents and glass sizes

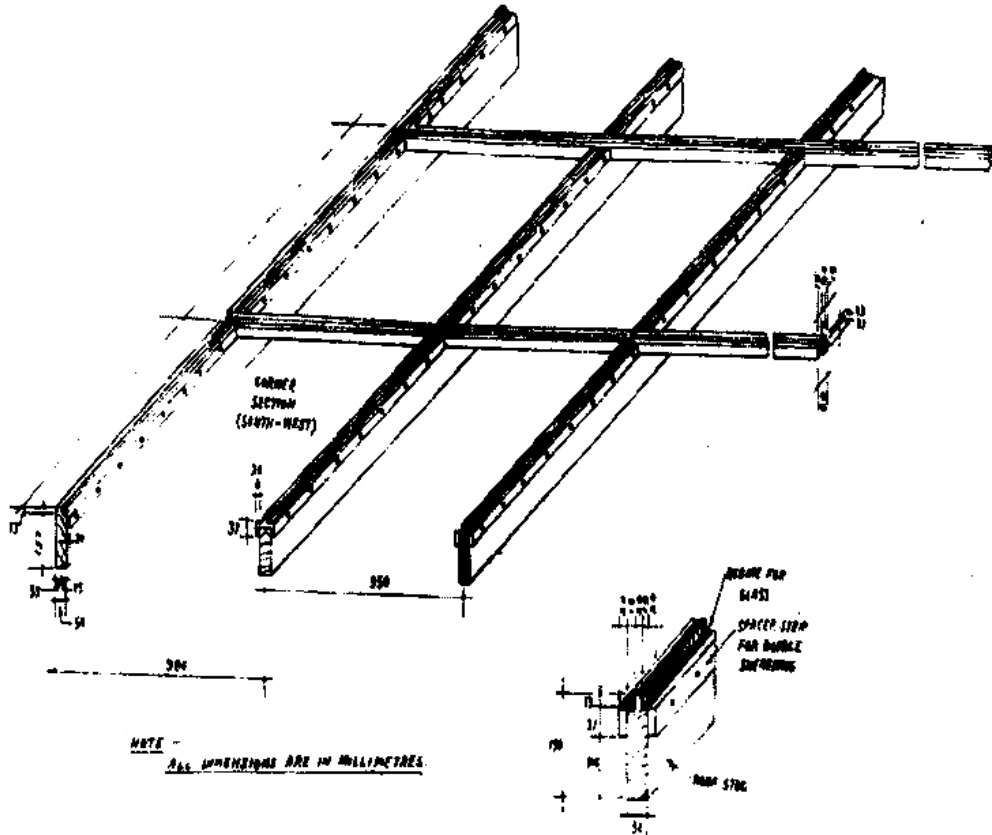
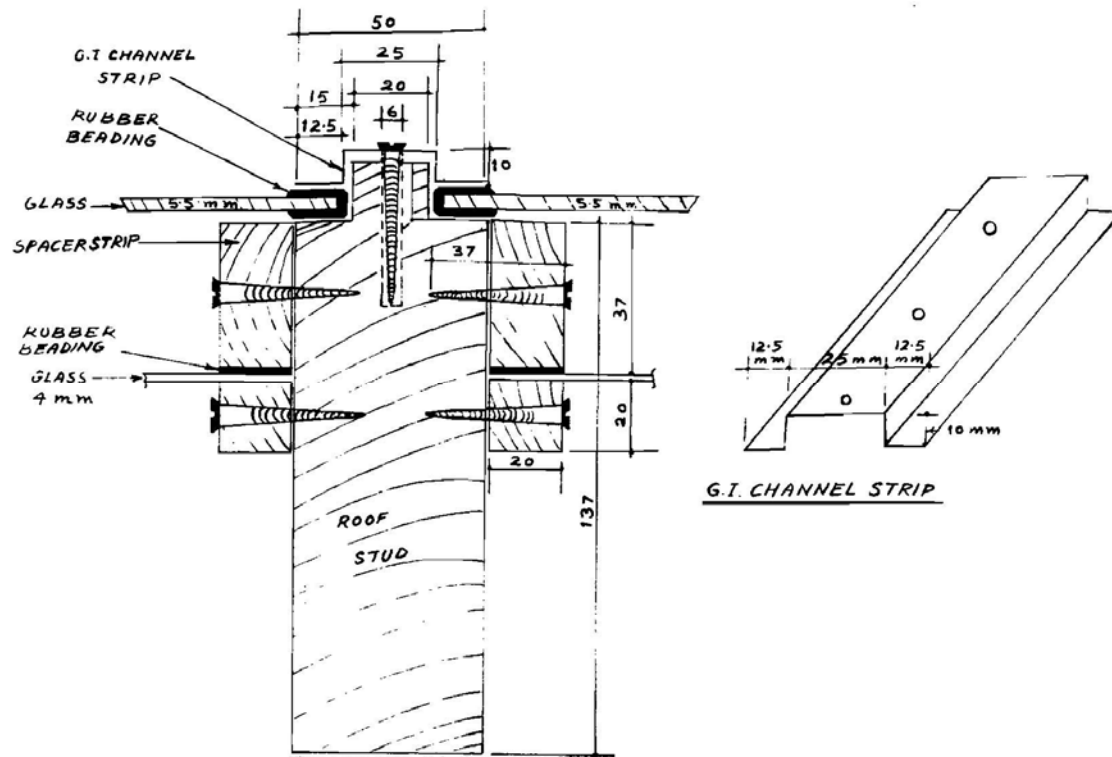


Fig. 3 (b) Roof frame for fixing glasses



NOTE: All dimensions are in millimeters

Fig. 3 (c). Details of fixing double sheathing to studs & pillars

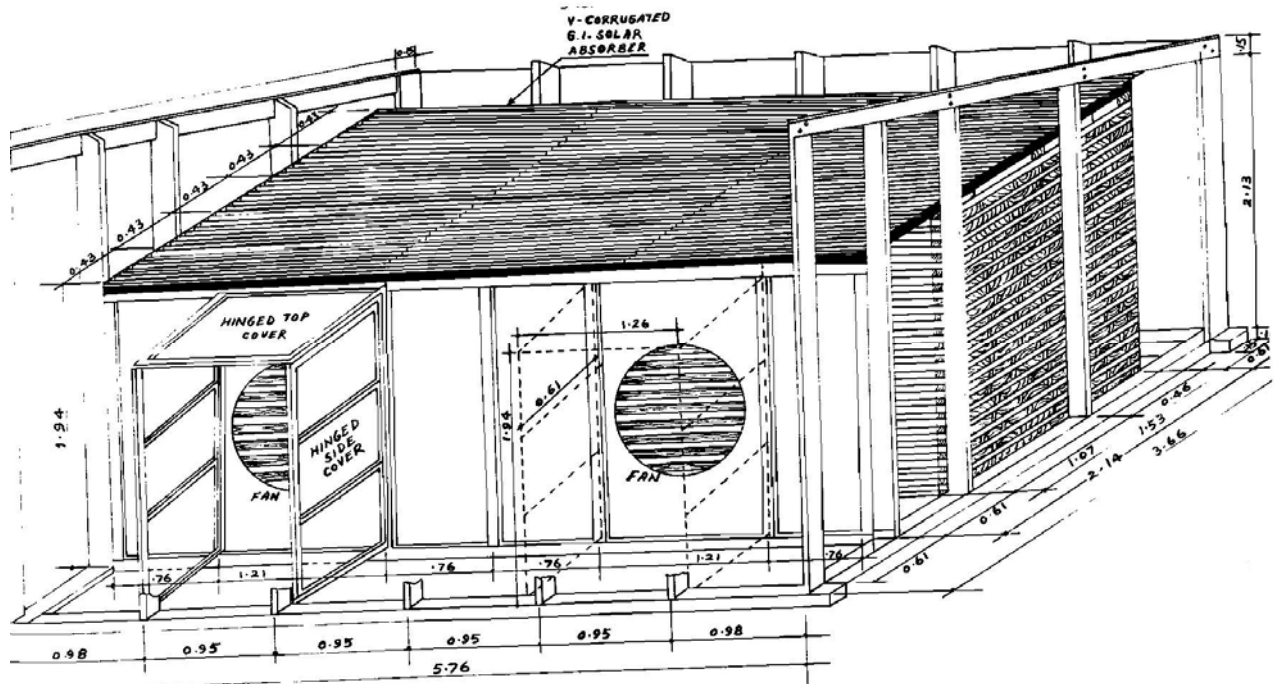


Fig. 4 (a). Inside view from north showing top & side hinged covers for fans to convert kiln to single pass forced air dryer

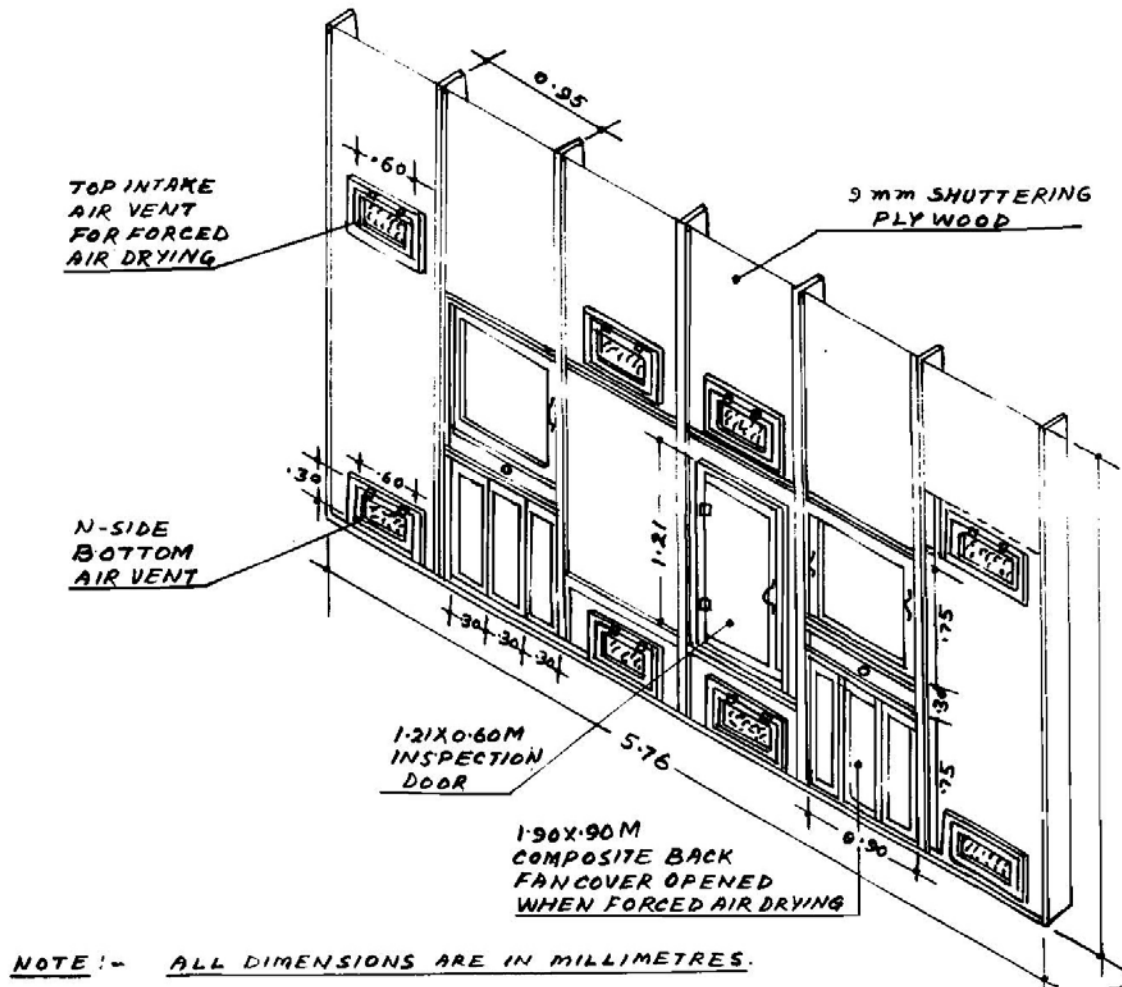


Fig. 4 (b). N-wall plywood sheathing showing air vents & back fan covers for converting kiln to forced air dryer

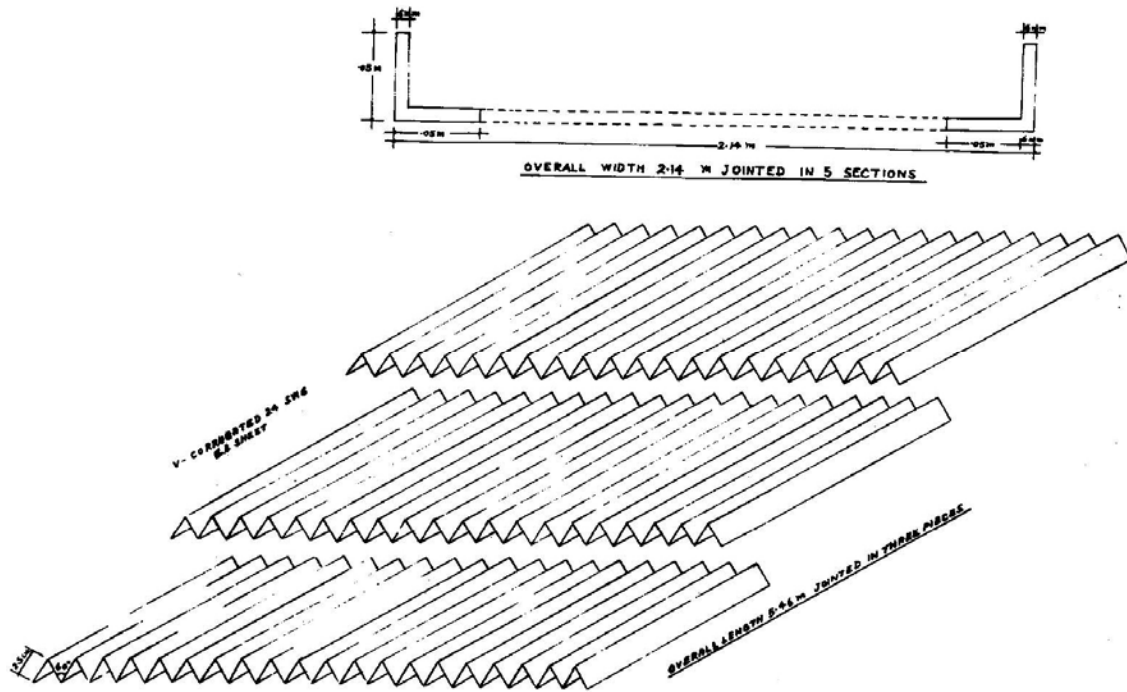


Fig. 5 (a). V –corrugated G I solar absorbing false ceiling

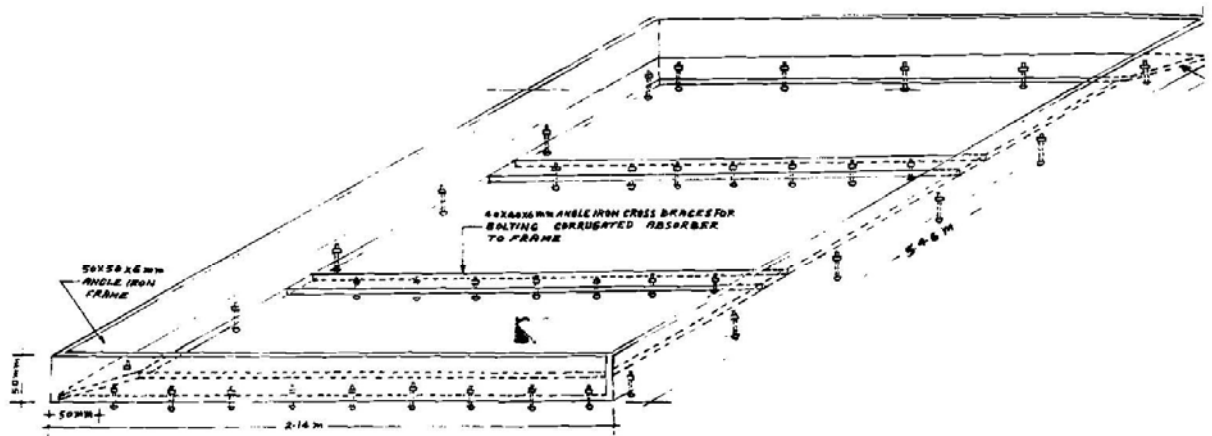


Fig .5(b). Angle iron cross braces for supporting the v-corrugated G I solar absorbing false ceiling

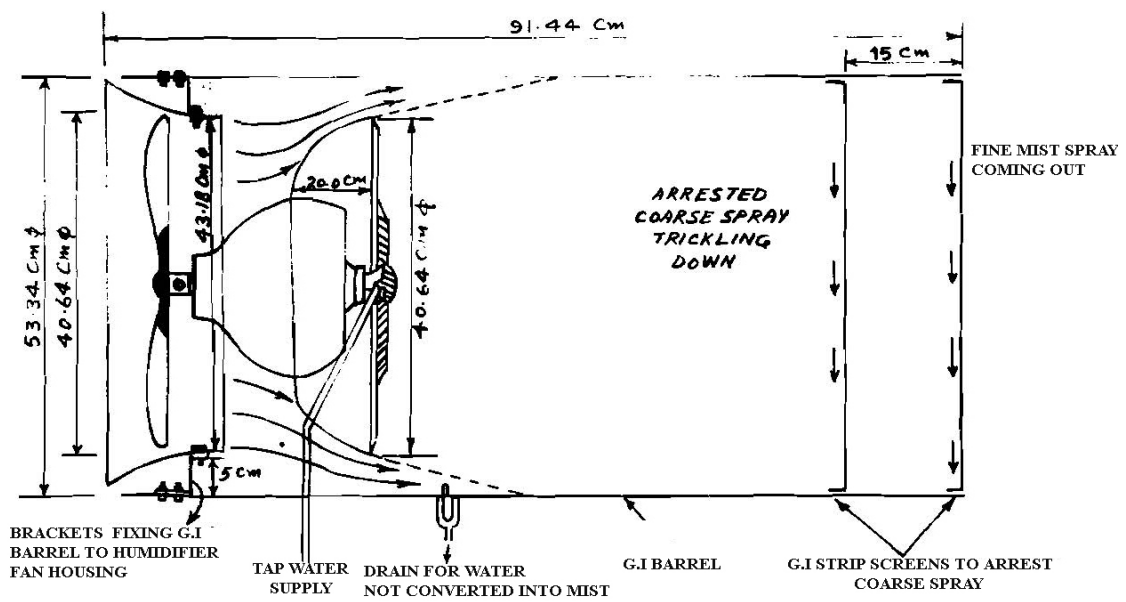


Fig . 6 (a). Bahnsen spinning disc water spray humidifier with G I barrel attachment

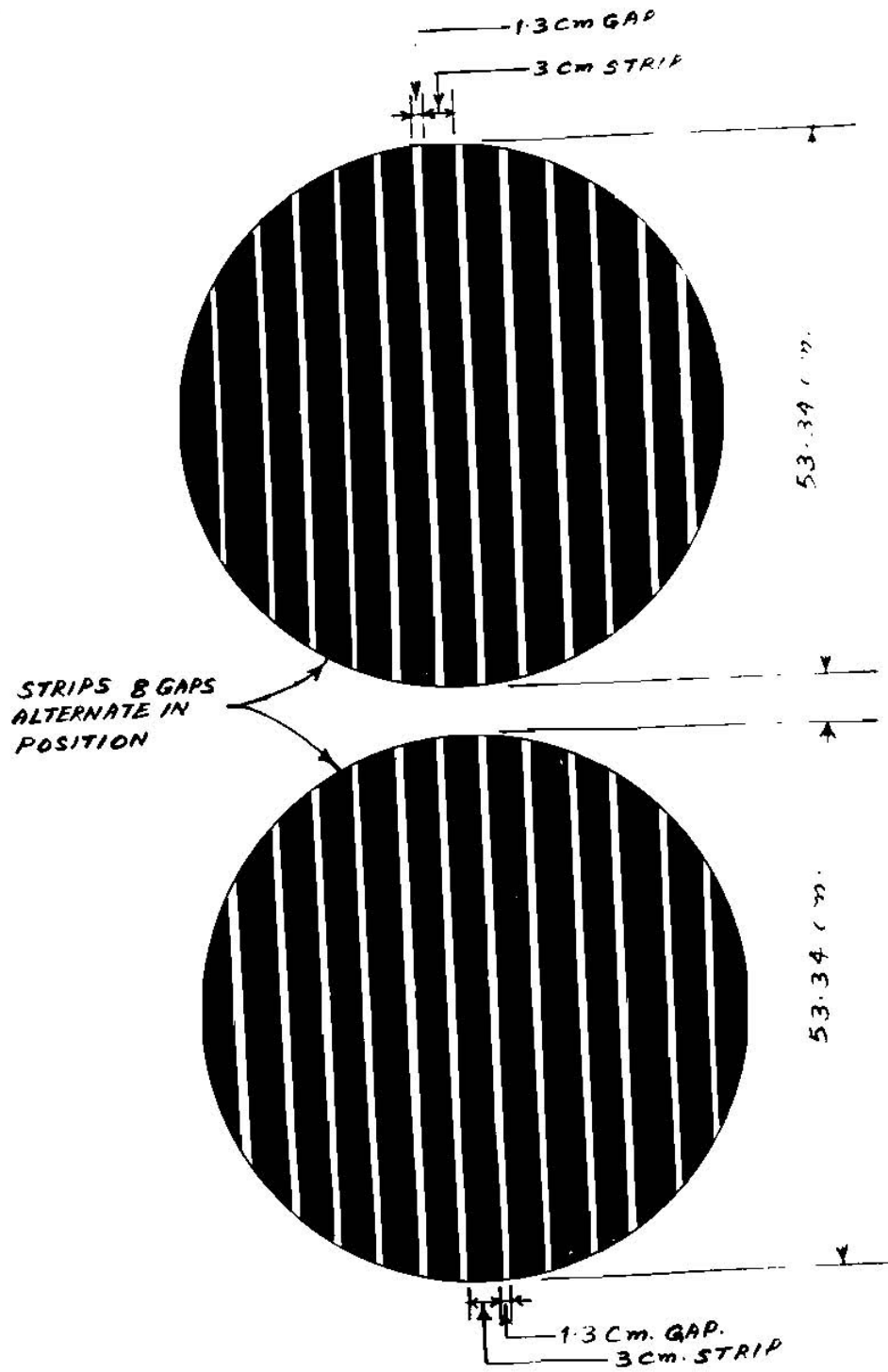
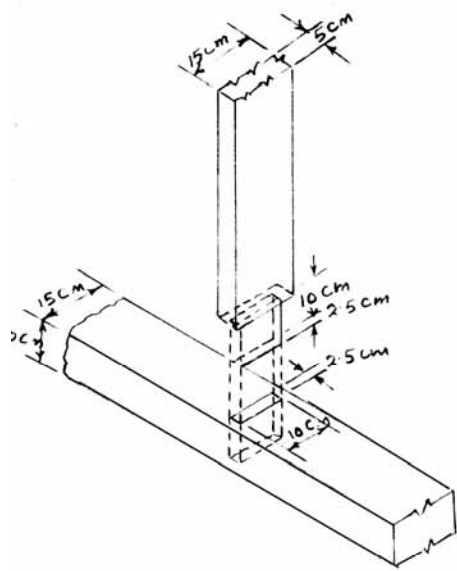
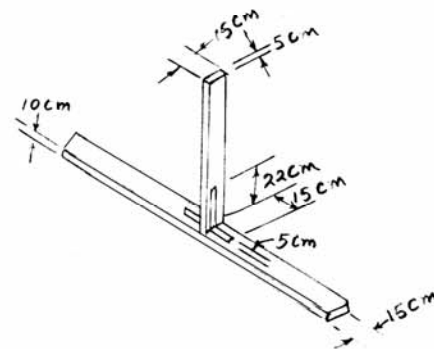
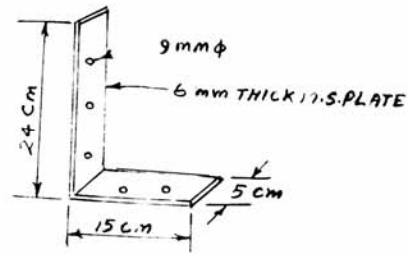


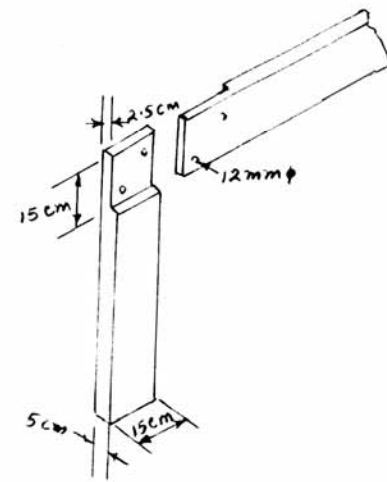
Fig. 6 (b). Strip screens for arresting coarse droplets of the water spray humidifier



FOUNDATION FRAME TO PILLAR JOINT



L-SHAPED MS. BRACKETS
FIXED TO FOUNDATION FRAME
& PILLARS



WALL PILLARS-TO-ROOF
STUDS JOINT

Fig. 7b.

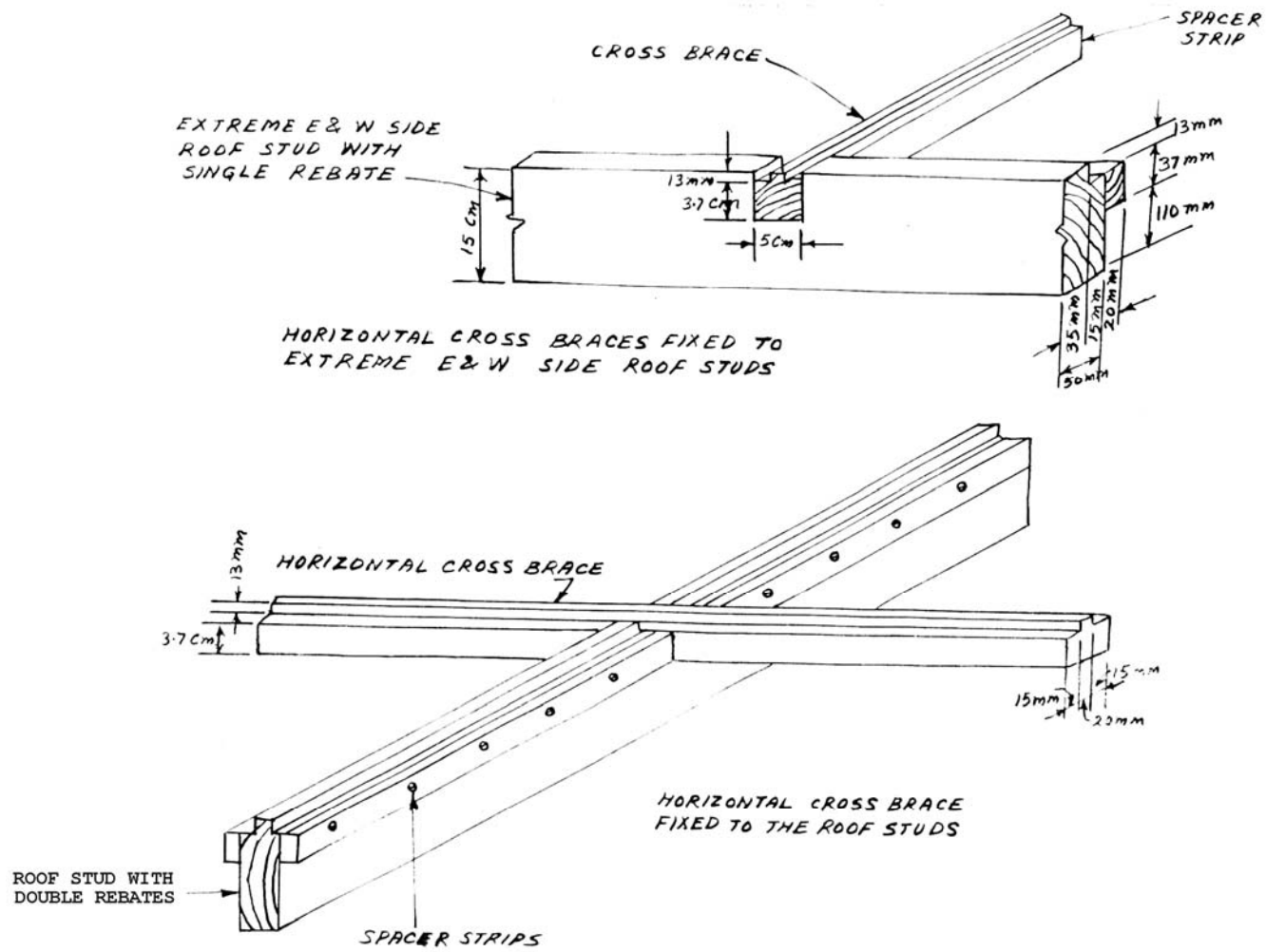
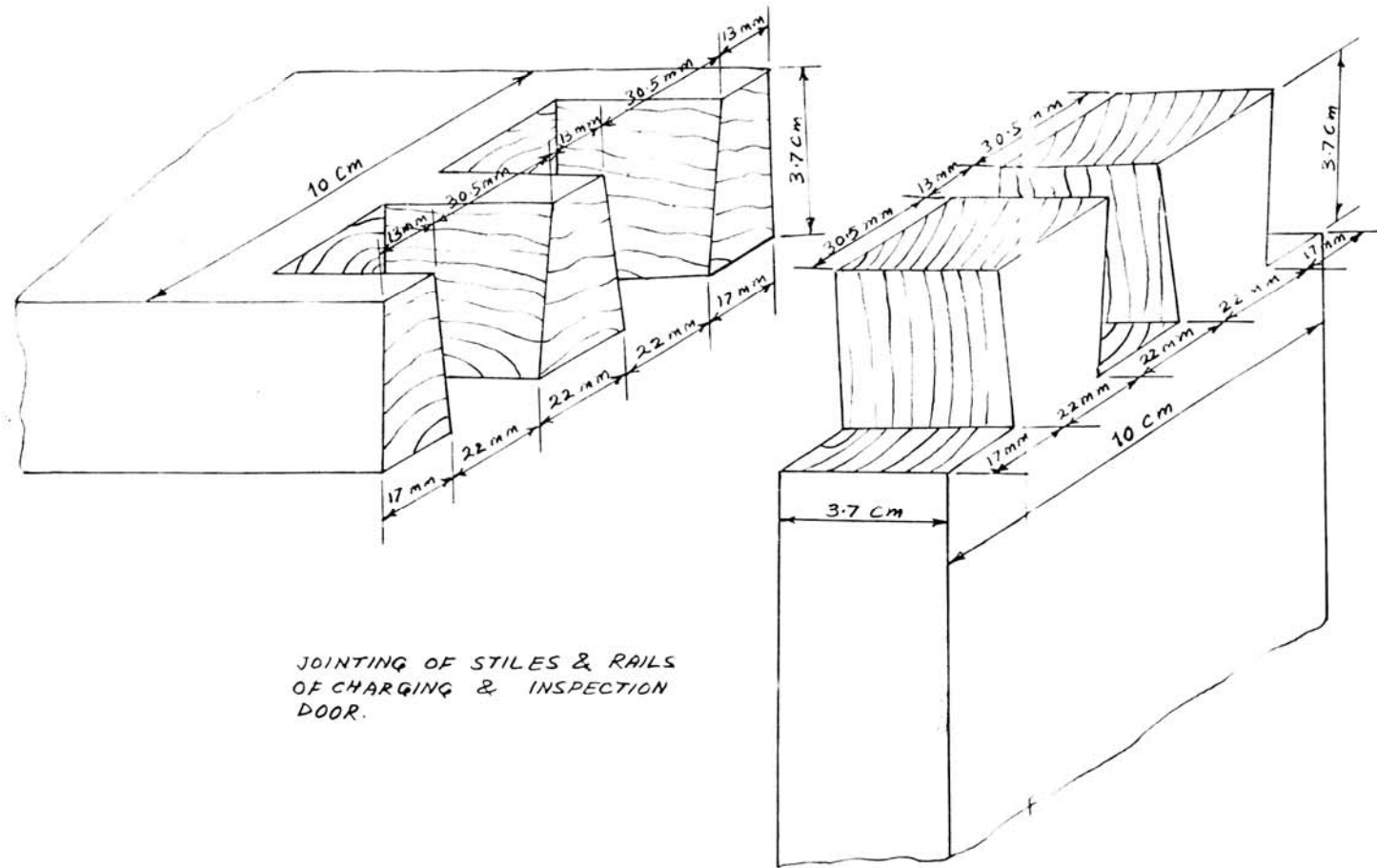
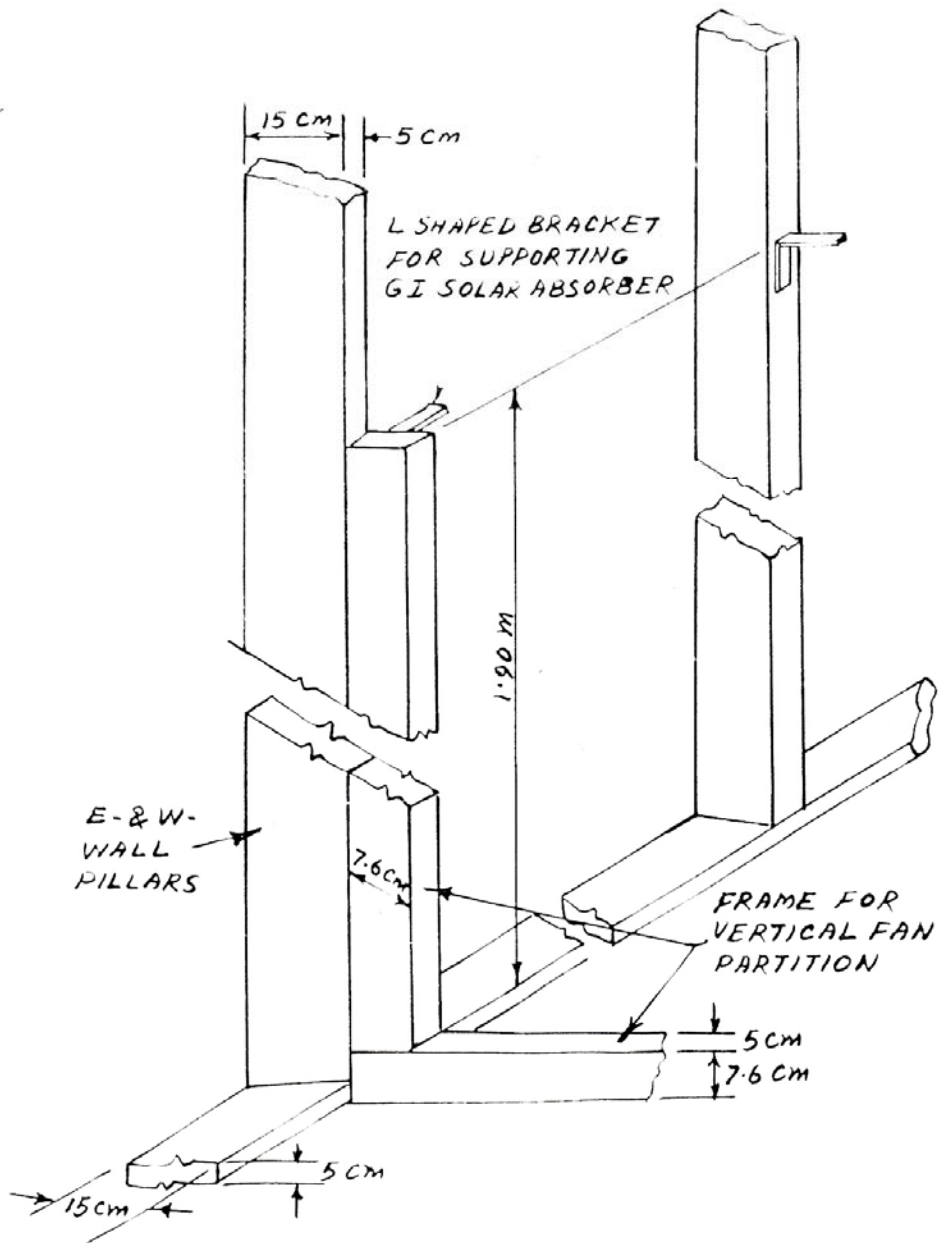


Fig. 7f.



JOINTING OF STILES & RAILS
OF CHARGING & INSPECTION
DOOR.

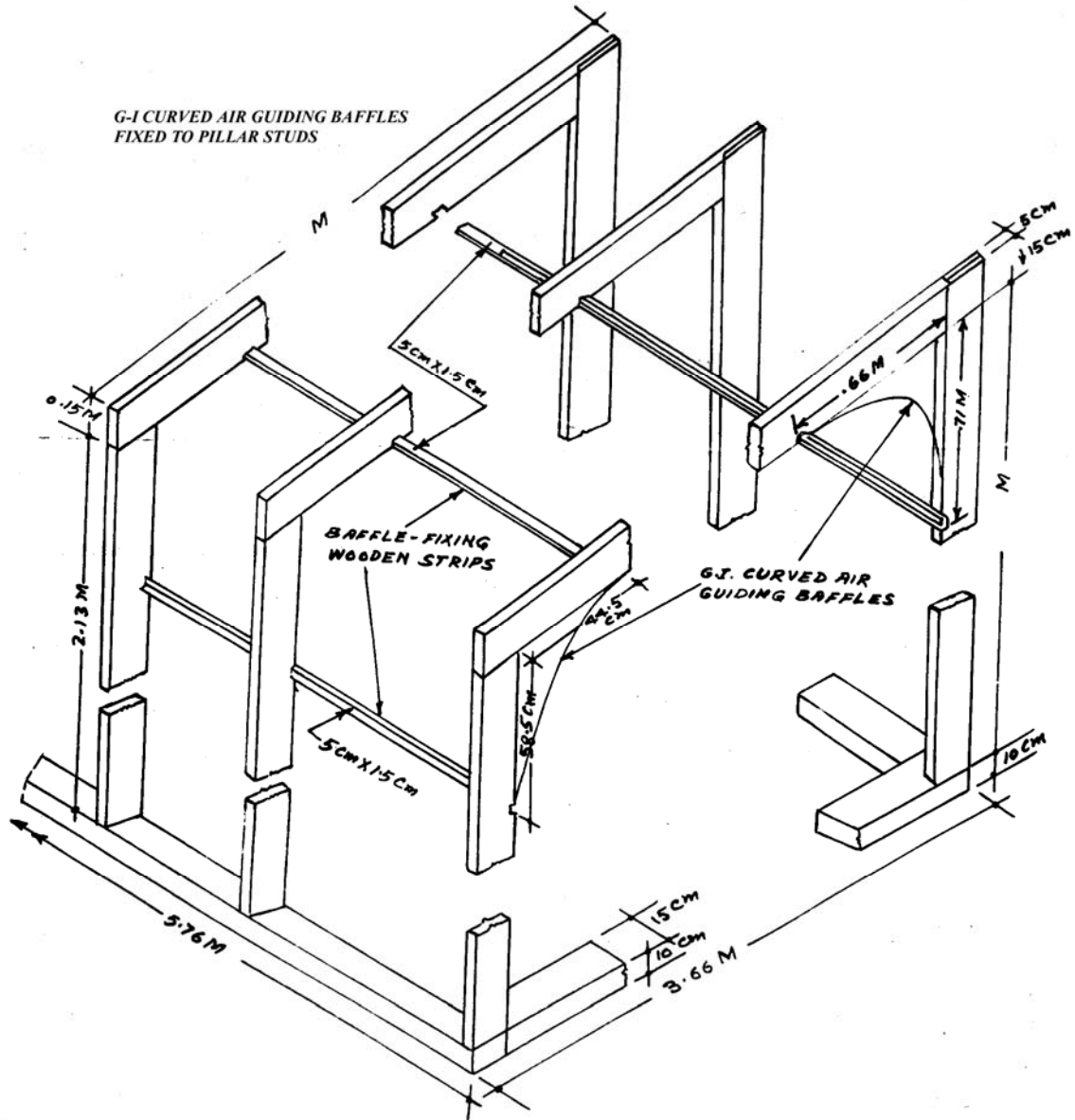
Fig. 7i.



E & W WALL PILLARS WITH SUPPORTS FOR SOLAR ABSORBER & ATTACHED FRAME FOR VERTICAL FAN PARTITION

Fig. 7j.

Fig. 8 a. DESIGN OF AIR GUIDING BAFFLES, AIR VENTS, BACK FAN COVERS FOR FORCED AIR DRYING



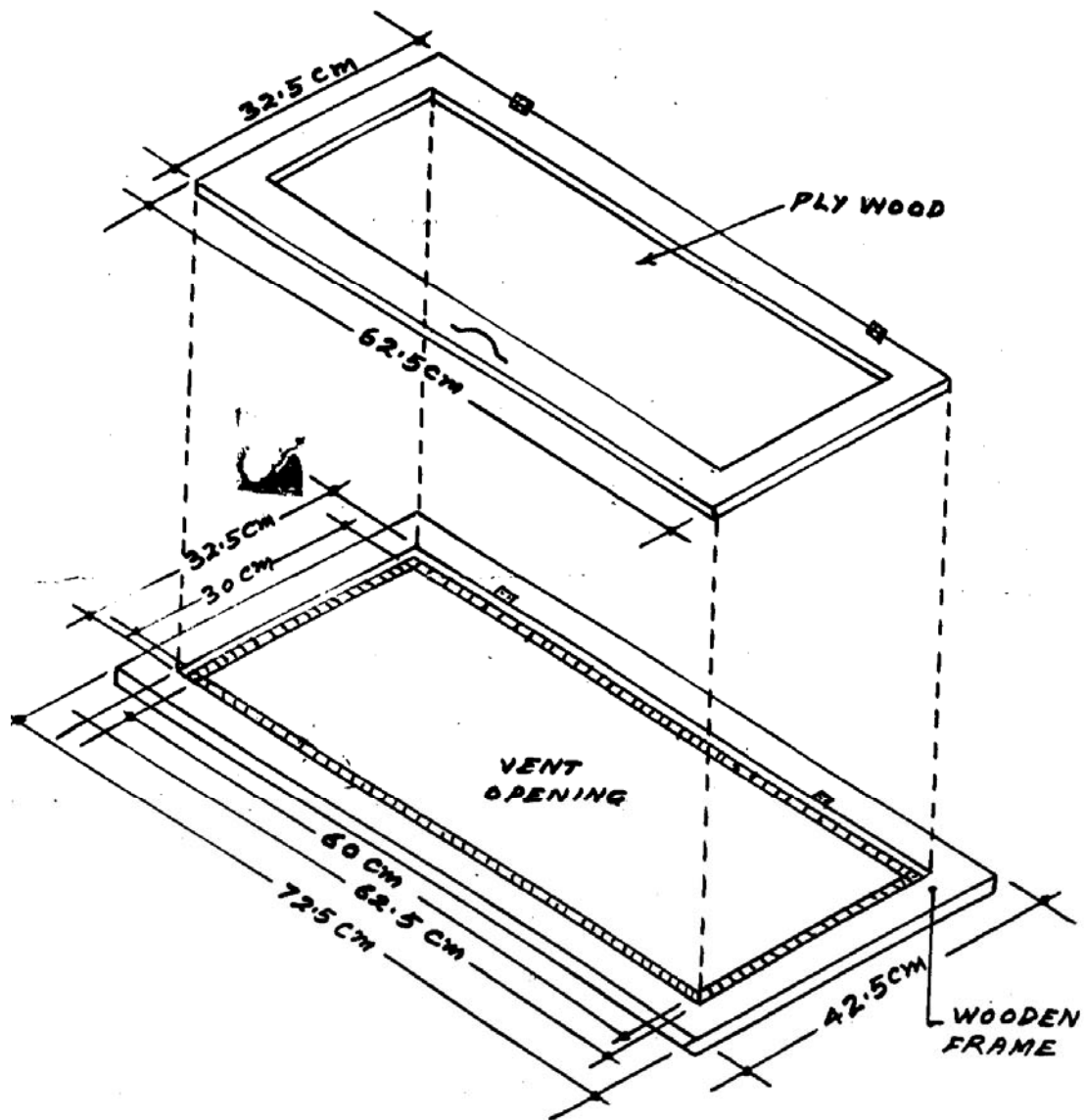


FIG. 8b VIEW OF ADJUSTABLE AIR VENT & ITS FRAME

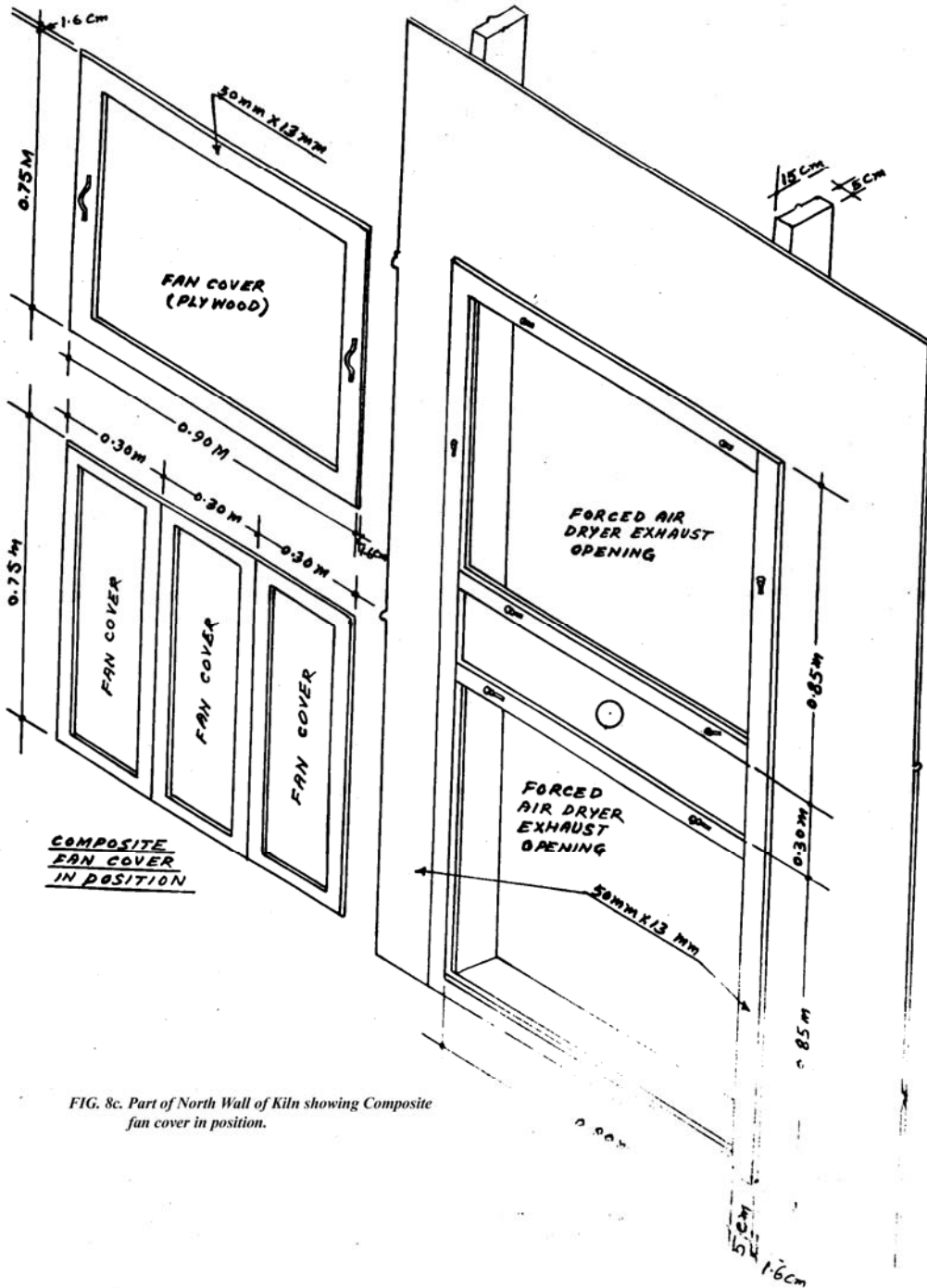


FIG. 8c. Part of North Wall of Kiln showing Composite fan cover in position.

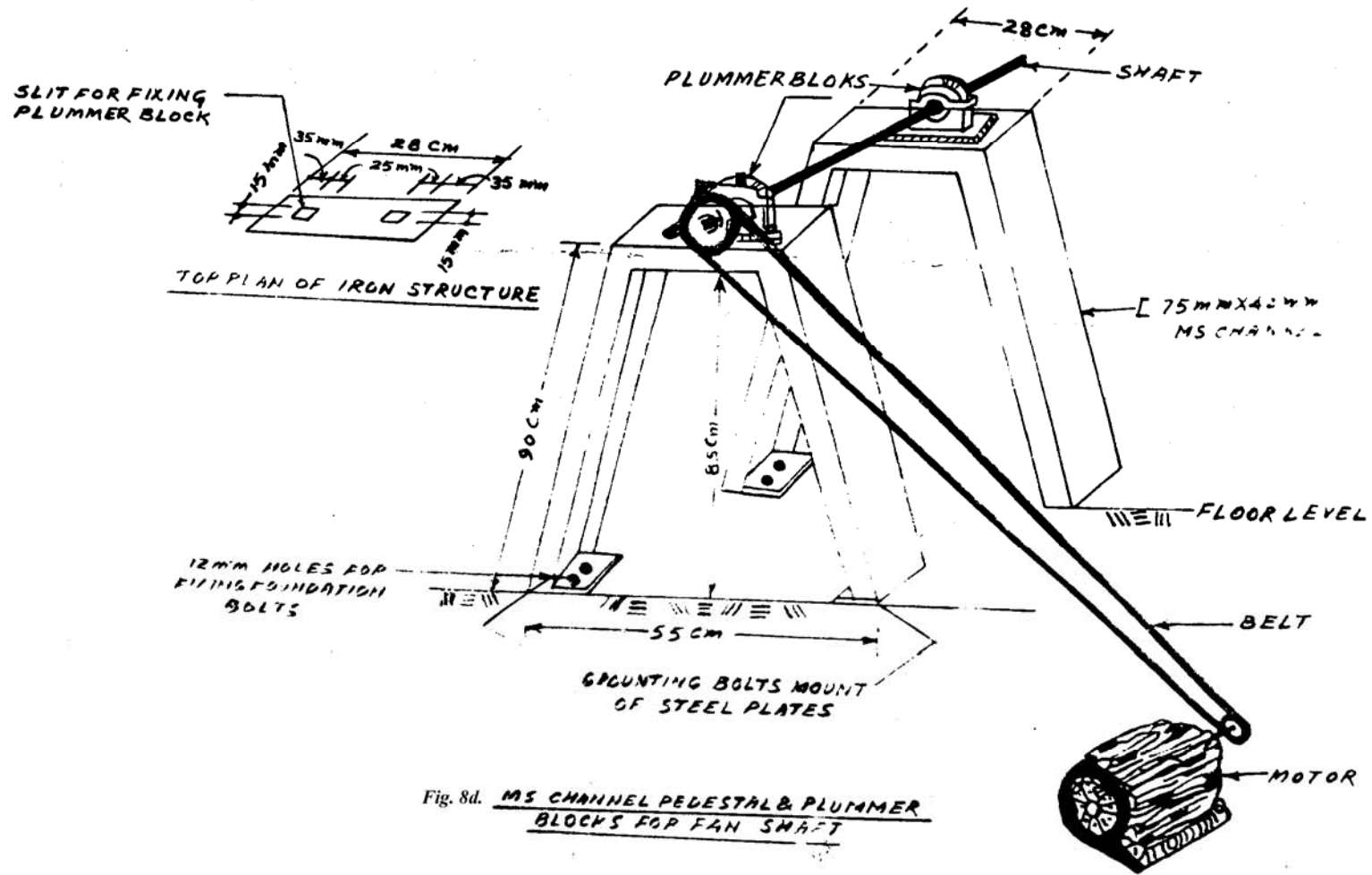


Fig. 8d. MS CHANNEL PEDESTAL & PLUMMER BLOKS FOR FAN SHAFT

Appendix-3

List of Wood Technology Clinics and Open House Programme

Sl. No.	Agency & Address	Date	No. of participants
1	District Industries Centre (DIC), Kasargod	08-12-2000	31
2	DIC, Kannur	07-12-2000	40
3	DIC, Kozhikode,	18-01-2001	33
4	DIC, Wayanad	02-02-2001	29
5	DIC, Malappuram	14-12-2000	23
6	DIC, Thrissur	06-02-2001	49
7	DIC, Pathanamthitta	19-12-2000	57
8	Sri Vyasa N. S. S. College, Wadakanchery	08-01-2001	50
9	Government Polytechnic, Kannur	01-02-2001	30
10	Cherpu Carpenters Co-operative Society, Perumbillissery, Thrissur	06-02-2001	35
11	St. Alloysius College, Elthuruth, Thrissur	03-11-2003	40
12	Open House Programme, KFRI, Peechi, Thrissur	23-02-2001	32

Appendix – 4

List of Participants in the Wood technology Clinics & Open House Programme

i. 07-12-2000, DIC - Kannur

1. Abdul Hameed.C, M.D, Nas Wood Industries Mill Road, Valapattanam, Kannur.
2. Abdul Jaleel,K.P. Jas Ply woods, Kannur.
3. Abdul Nazar.U.M.P, Hanzon Wood Industries, Kannur.
4. Abdul Rasheed T.P. High Tech Wood Industries, Taliparambu, Kannur.
5. Abdul Sathi .K.S Century ply woods, kannur.
6. Abdulkhadar.M.V, Manager, A.K Plywoods, Cherukunnu, Kannur.
7. Abooshyak B.P,Elerte Board Wood, Kannur.
8. Abubakker Haji,M. , Crust Wood Industries Valapattanam Kannur.
9. Ashruf.C.K,Keys White Wood Industries, Kannur.
10. Balakrishnan.V.V, IEO, Thaliparampu. Kannur.
11. Faisal ,V. Manager, Varnoly Plywoods, Kannur.
12. Fisal K.S. Nobel Ply woods, Kannur.
13. Gopinath.K, Century ply Wood, Kannur.
14. Hamed,K.K, H.M.K.Wood Industries, Pappinissery, Kannur.
15. Hameed.P.K, Manager, Prime Veners& wood industries,Kannur.
16. Haneefa.T.V, Primveenex ,kannur.
17. Ismail V.K.P. Secratery Timber Merchant Association Valapattanam, Kannur.
18. Majeed. P.V. Paul Mount Woods, Kannur.
19. Marshab.C.P, Manager, Prime Veners& wood industries, Kannur.
20. Mohamadali,K.S. Prestige Boards (P)Ltd Valapattanam, Kannur.
21. Mohanan.T.P, Trend Wood Tech., Kannur.
22. Moossankutty.O, Crust Wood Industries, Thaliparamp Kannur.
23. Muhamadkutty.V.K, Click Boards, Kannur.
24. Muhammadali.K.C, Manager, District Industry Centre Kannur.
25. Musthafa,K.L. Keapey Wood Industries, Kannur.
26. Muthalil Hagi, K.P. Rubeena Timbers,Valapattanam, Kannur.
27. NarayananA.P, Noble plywood, Kannur.
28. Prabhakaran.K, IEO, Payyannur, Kannur.
29. Rajeevan.M. Mahadeva Wood industries, Pappinisery, Kannur.
30. Rajesh.N.V, Prestige Board (p) ltd, Kannur.

31. Raveendran.M.V, Manager, Naas Woods& Boards, Uliyil P.O. Kannur.
32. Rishal Rahaman, Jet Boards,Kannur.
33. Sreedharan Namboodiri, IEO, Irikkur, Kannur.
34. Sreedharan.P.P, IEO, Kuthuparambu,Kannur.
35. Thomas.K.John, Manager, Prestige Boards (p) ltd Baliapatam, Kannur.
36. Ummelly,B.P. Wooden Boards, Valapattanam, Kannur.
37. Velayudhan.V.V, Industries Extension officer, Kannur.
38. Vijayan.N.S, Maanager, Sunlight Boards (p) ltd.Baliapatam, Kannur.
39. Yadeenathin.M, Sivananda Wood Industries Karunathur.
40. Youseph.C Aslan ply woods, Kannur.

ii. 08-12-2000, DIC - Kasaragod

1. Abdual Latheef, Crescent Wood Industries, Nileswar, Kasaragod.
2. Aboobakker.V.K.Aakash Fire Works P.O.Badidoka, Kasaragod
3. Akbarali.M. Sidhi Vinayrks Timber Industries,Kallian Road Junction,Chemmittam Valyl.
4. Ammalukutty.P. Assistant District Industries Officer, Kasaragod.
5. Balakrishnan Nair. K. IEV. Kasaragod.
6. Balakrishnan.C.K. Jawar Furnitur Industries, Chettumkuzhi,P.O.Vadyauagod, Kasaragod.
7. Chandukutty.K.P.Ramnagar Wood Works,Anandashrama, Kasaragod.
8. George Nidhiy St:Mary's Wood Industries, P.O.Padannlal, Kasaragod.
9. George Thava, Manager DIC, Kasaragod.
10. Ibrahim Moidhair, MIKA Industries, P.O.Madhur, Kasaragod.
11. Ilyas.K.P. Unitech Boards,Soorambial,Ednad P.O. Kasaragod
12. Mohamad U.B. Manpo Wood Industries, Udyawer Manjestive, Kasaragod.
13. Mohanan.V.C. Unitech Boards,Soorambial,Ednad P.O. Kasaragod.
14. Muhamad Hanneefa, Three Star Wood Industries, Mailaty, P.O.Chaukky, Kasaragod.
15. Nassir Hussan Anwar,Cords Polytechs Pvt LTD, Vidyanagar, Kasaragod.
16. Naveen Kumar. N. Teeh. Supervisor DIC, Kasaragod.
17. Nayok.S.V. Poudavolly,Karatvayal, Konbaga Kasaragod.
18. Padmanabhan.K. Manager DIC Kasaragod.
19. Padmarajan.A.K. Kuttikkol Vanpreya Enterprieses, Kuttikkol .P.O. Chengala.Kasaragod

20. Philip.M.J. St:Mary's Wood Industries, , P.O.Padannlal, Kasaragod
21. Prabhakaran.M. Lekha Woods, Kasaragod
22. Prakasan.K.P. Unitech Boards,Soorambial,Ednad P.O. Kasaragod.
23. Raghavan.P. Chaithadukam Enterpries, Munnad, Badidoka, Kasaragod
24. Ramesh. Kouvllapurayill. Ramnagar Wood Works,Anandashrama, Kasaragod
25. Sasidaran.P.J. Capital Furniture, Challanad P.O. Kasaragod.
26. Shulthib.V.P. Alfa Furniture, Trikaripur, Kasaragod.
27. Unni Krishnan Nair, National Wood Products, Kunjathur, Thalappady. Kasaragod.
28. Valsalan P.SCI, DIC, Kasaragod.
29. Varadarja Shenoy.M. Vimal Plast-Tech B5, Industial Estate, Vidyanagar, Kasaragod
30. Yoosef.M. Unitech Boards,Soorambial,Ednad P.O. Kasaragod.
31. Ravindran.K. Associated Rubber Kumhaugad.

iii. 14-12-2000, DIC - KSSIA Malappuram

1. Abdul Karieem.K, ADIO, DIC, Malapuram.
2. Abdul Youseph, Classic Wood Crafts, Wendoor, Malapuram
3. Aboobach Athikkal, Edavanna, Malapuram.
4. Ahmad Iqubal., Basheena Timbers, Thachode, Malapuram.
5. Ali. K.P.M., Kuttur Wood Industries, Malapuram.
6. Anilkumar.P.N, Industries Officer, Vzhikadav Block, Malapuram.
7. Augusteen.P.Y, IEO, Malapuram.
8. Hamza.N, IEO PMNA Block, Malapuram.
9. Haneefa. K. V, K.V. Furnitures Palliyangadi,Anakkayam, Malapuram.
10. Jafar.A Kottakkal Wood Complex, Kottakkal, Malapuram
11. Krishnakumar. Iqulal Wood Industries, Thachode, Malapuram.
12. M/S Continental Wood Industries, Kunnamangalam, Edavanna.P.O, Malapuram.
13. Mohamad Youseph.A. Kolar Plastic Industries, Anakkayam, Malapuram
14. Mohammad. P.V, ADIO, Perinthalmanna,Malapuram.
15. Musthafa. P, MAB Rubber Crafts, Malapuram.
16. Radhakrishnan. T. Rajesh Furniture, Thiruvvale, Malapuram.
17. Rosamma. P.T, DIC, Malapuram.
18. Santhi.V.T ,IEO, Manchery, Malapuram.
19. Shukum.K.A.Zodic Wood Works 4th Gate ,Bare P.O. Kasaragod
20. Simon Zacharia, Technical Supervisor, DIC Malapuram.

21. Sreedharan. V, Union Wood Industries, Malapuram.
22. Surendran. M. Rajadani Furniture Pathiriyal, Malapuram.
23. Veerankutty. K, ADIO, Malapuram.

iv. **19-12-2000, DIC- Pathanamthitta**

1. Abdul Jameel. P.A, ADIO Thiruvalla, Pathanamthitta.
2. Abraham. K.C, Kangurthara, Mangady, Thiruvalla, Pathanamthitta.
3. Aby Philip. Essec Industries, Kidangannur. P.O, Thiruvalla, Pathanamthitta.
4. Ajith. K. Thomas, Kannankuzhy,Ranni, Pathanamthitta.
5. Alex palanila, PASSS Pazhakulam Pathanamthitta
6. Alexander Chacko, Ethil House, Niraman West.P.O, Niraman, Pathanamthitta.
7. Alexander. M. C, Profession Tool Tech, Kuttada, Thiruvalla, Pathanamthitta.
8. Anilkumar.V. PASSS Kadampanad Pathanamthitta
9. Anish. S, The Tool Tech, Ramanchira, thiruvalla, Pathanamthitta.
10. Babu. P.V, Manager DIC,Pathanamthitta.
11. Baiju Joseph Thomas, Alco aluminum, Ramanchira, Thiruvalla, Pathanamthitta.
12. Bhattathiri. T. A. N, Manager,DIC, Pathanamthitta.
13. Chithamberan. D, General Manager, DIC, Pathanamthitta.
14. Devadasan. L, Manager,DIC, Pathanamthitta
15. Divakaran. V. N, Thiruvalla, Pathanamthitta.
16. Emmanuel Mathew,Thiruvalla, Pathanamthitta.
17. George. K. I, ADIO Pathanamthitta.
18. Gopinathan. V, Industries Extension Officer, Kulanada, Pathanamthitta.
19. Haneefa, DIC, Pathanamthitta.
20. James. K.M, Industries Extension Officer, Palakuzhy, Pathanamthitta
21. John Koppan. O. K, Kulanada, Thiruvalla, Pathanamthitta.
22. John mani. C, Victory Timbles, Chungapra. P. O, Pathanamthitta.
23. Justin, PASSS Pazhakulam Pathanamthitta
24. Krishnakumar. S, Kailas, Karma Wood Thadiyoor.P.O., Pathanamthitta.
25. Krishnankutty. A, Thiruvalla, Pathanamthitta.
26. Kuriakose, Italia Mosaice, Thiruvalla, Pathanamthitta.
27. M/S Thressy Wood Furniture Industries, Variapuram, Elanthoor East. P.O, Pathanamthitta.

28. Madhu. P. T, Pulayamkunnel, Karikkattur, Thiruvalla, Pathanamthitta
29. Malesh. S, Thiruvalla, Pathanamthitta.
30. Manoj Varghees, Alfa Furniture Mart , Kidangannor. P.O, Thiruvalla, Pathanamthitta.
31. Mathew George, Sunny vihar, Omallur. P.O, Pathanamthitta.
32. Mathew Philip, Sunny Vihar, Anallur, Pathanamthitta.
33. Mli Reju, Secretery PASSS Pazhakulam Pathanamthitta
34. Muralidas, Vasthusilpa Industries, Kangeetukara, Ayiroor, Pathanamthitta.
35. Presannakumar. V, Industries Extension Officer, Parakode Block, Pathanamthitta
36. Radhakrishna Pillai. R, Industries Extension Officer, Adoor, Pathanamthitta
37. Raichal Kuruvila, Industries Extension Officer, Koipuram, Pathanamthitta
38. RajeeveKumar. A. C, Thiruvalla, Pathanamthitta
39. Raju Kumar.R.S. PASSS Pazhakulam Pathanamthitta
40. Raju.V.K. PASSS Ezhukulam Pathanamthitta
41. Reji. K. B, Charutha Handi Crafts, Kunmbalampoika. P. O, Pathanamthitta.
42. Revisanker. C. V, Victory Service, Valcicos, Pathanamthitta.
43. Sabherankutty. K, Poabs, Timber Products(Pvt.)LTD. Thiruvalla, Pathanamthitta.
44. Sadanandan. V, Industries Extension Officer, Elanthoor, Pathanamthitta.
45. Sanilkumar. S, Sanil Sadanam, Wood caruing, Padiyali.P.O, Thiruvalla, Pathanamthitta.
46. Siresh. M. D, Indira Engineering Works, Vellankulam, Pathanamthitta.
47. Sivaraman Achery, PASSS Pazhakulam Pathanamthitta
48. Sreedarakurap. B, Industries Extension Officer, Ranni, Pathanamthitta
49. Sreekumar, PASSS Adoor Pathanamthitta
50. Sunny Joseph, Charuvila Puthanveedu, Kuttada. P. O, Pathanamthitta.
51. Tharakan. K, Italia Mosaice, Thiruvalla, Pathanamthitta.
52. Thomas Mathew, Industries Extension Officer, Thiruvalla, Pathanamthitta
53. Treesamma James, Industries Extension Officer, Mallepally, Pathanamthitta
54. Udayakumar. D, Thiruvalla, Pathanamthitta
55. Vimal Thorish. I. R, Guristicks, Chengannur, Pathanamthitta.
56. Vinodkumar. K, Cable Network Space Media, Kidangannur. P.O, Thiruvalla, Pathanamthitta
- 57 Wilson. L, ADIO, Adoor, Pathanamthitta.

v. 18-01-2001, DIC- Kozhikode

1. Abdul Latheif. M, IEO KGM, Kozhikode.
2. Abdul Mgeed, Parakkatt, West Mankure, Kozhikode.
3. Ajayan. T. R, Kuzhikodukudy, Kokkaloor. P. O, Kozhikode.
4. Alevi. M. T, ADIO, Koylandy, Kozhikode.
5. Ashikumar. K. C, Varikodi, Kizhakkumury. P.O, Kakkodi, Kozhikode.
6. Baby Ashitha, Janatha Road, Badakara 5, Kozhikode.
7. Bindu, Puthanpurayil, Bindu Wood Craft Centre, Eramalu. P. O, Badakara ,
Kozhikode.
8. Chandukutty. M, Haritha Nagar, Chuvarambalam. P. O, Kozhikode.
9. Dhamodaran. A, ADIO, Kozhikode.
10. Drina Sajith, Daffodil Complex, Cunnathpalam, Kozhikode 14.
11. Fransis Nilson. C. U, IEO, Cholary, Kozhikode.
12. Gopalan. K. M, Badakara 5, Kozhikode
13. Harshan. T, Anand Vihar, Nellyod, Kozhikode
14. Jayananthkumar. K, Bhaskaran & Sons, Timber Merchant, Puthiyakave,
Kozhikode 4.
15. Krishnamurthy. M, Fama Boards & Plywoods, Jayanthy Road, Kozhikode
16. Kunjikannan. I. K, IEO, Thodour, Kozhikode.
17. Marakkar. N. C, Kolathara. P. O, Kozhikode
18. Mohanan. K, Vadakkumpattuthazha, thiruvod. P. O, Naduvannur, Kozhikode.
19. Moithutty T.K, IEO, Koylandy, Kozhikode.
20. Nambeesan. T. N, ADIO , Kozhikode.
21. Narayanan. E, IEO, Kakkad, Kozhikode.
22. Narayanan. M, Freeman, Kannan Wood industries, Koylandy, Kozhikode
23. Presanna. C . Kutty, Haritha Nagar, Chuvarambalam. P. O, Kozhikode
24. Rajan. A, Manager, DIC, Kozhikode.
25. Rajeshkumar. A. I, Arikkarakandi, Thalayadu. P. O, Unnikulam, Kozhikode.
26. Sajith. R. J, Daffodil Complex, Cunnathpalam, Kozhikode 14.
27. Sakeer Husain. M. K, Alfa Opticals, S. M . Street Kozhikode.
28. Salim. M, Technical Supervisor, DIC, Kozhikode.
29. Shamsudheen. K. P, IEO, Perampira Block, Kozhikode.
30. Somanathan. T, IEO, Pantheleyei, Kozhikode.
31. Sulfiker. N. M, Free Wood Creations, Nallalam. P. O, Areekad, Kozhikode.

32. Sumangala. T, ADIO, DIC, Kozhikode.
33. Vishnunambuthiry. A, IEO, Balussery, Kozhikode.

vi. 02-02-2001, DIC-Wayanad

1. Abdul Raafi, The Glory Wood Industry, Maun Road, Meenangadi,Wayanad..
2. Abdulkhaderkutty.E, A.D.I.O DIC.Muttill, Wayanad.
3. Balakrishnan, Forenew, The Glory Wood Industry, wayanad.
4. Balan Nair.K.P, Sai Kripa, Puzhamudi.P.O, Kalpatta (via),Wayanad..
5. Biju.P.P, Poyikkunnel.House, Edawalia.P.O, Mananthavady (via), Pathirichal, Wayanad.
6. Damodharan.K, ADIO, Taluk Industries Office, Mananthavady,Wayanad..
7. Devadas.P, Wayanad Wood Works, Thundery, Kalpatta,Wayanad.
8. Devasia.M.C, Molekunnel.House, Thavinbal.P.O.,Wayanad.
9. Easudas.M.S, Sandhya Nivas, Vellamunda.P.O, Wayanad..
10. Gopalan.V.P, Frinds Furniture, Kallody.P.O, Mananthavady Wayanad..
11. Harikuttan.K.V, I.E.O. Sulthan Bathery Block, Wayanad.
12. Ibrahim.V, Vaisaal, Ambalakkad, Wayanad.
13. Johney.P.G, Seleel Furniture, Dwaraka, Wayanad.
14. Manual.V.V, Puthussery, Sulthanbathery, Kuttayard Road, Wayanad.
15. Murukan.K, Thachan Furniture mart, Court Gate, Puthankunnu.P.O, Wayanad.
16. Musthfa Kamal, Sonia Furniture, Anjukunnu, Wayanad.
17. Nasseer, Glory Wood Industry, Pachikkal, Kurvani.P.O. Wayanad.
18. Pavithran.K.P, New Touch Interior, Town Hall Road, Mananthavady, Waynad.
19. Sajeevkumar.V.S, Valiyaparampil House, Poomal, Sulthanbathery, Wayanad..
20. Santhoshkumar.K.T, Kuttikattil.House, Seethamound, Pulpally,Wayanad.
21. Sreedharan.M.R, Sandhya Nivas, Vellamunda.P.O. Wayanad.
22. Sreedharan.P, Puthiyodhar. House, Vellamunda.P.O, Wayanad..
23. Sujathan.P, Rajadhani Furniture, Pulpally, Wayanad.
24. Ummar.N.K, Naikkutty.P.O, Sulthanbathery, Wayanad..
25. Unnikrishnan.M.S, M/S Wood Work's, Police Station Road, Bathery, Chungam.
26. Unnikrishnan.P.M, Industries Extension Officer, Kalpetta Block, Wayanad..
27. Varghees.N.A, Sonia Furniture Anjukunnu, Wayanad.
28. Varghese, Paulson Wood Craft, Karani.P.O. Meenangadi, Wayanad.
29. Vijayakumar.P.C, P.C.Wood Work, Pallikkunnu.P.O.,Wayanad.

vii. **06-02-2001, DIC-Thrissur**

1. Abdul Aneez.M, IEO, Cherpu Block, Thrissur.
2. Appu.K.Kurakam, Thrissur.
3. Chandran.M.K, Perumpillissery, Thrissur.
4. Chandran.M.V, Abhi Nivas, Kolazhy, Thrissur.
5. Chandran.T.A.Urakam, Thrissur.
6. Dharmapal.V.K, Cherpu, Thrissur.
7. Gireesan.E.V, Edakkunni.House, Thaikkattussery.P.O, Ollur, Thrissur.
8. Gopalan.P.V.Urakam, Thrissur.
9. Gopi.K.B. Urakam, Thrissur.
10. Govindan.M.V. Urakam, Thrissur.
11. Jose Raphel.A, Alapadan. House, Cheroor.P.O, Thrissur.
12. Jose.K.A C/o Taaj Timber Trader, Cherpu, Thrissur.
13. Joshy.A.J, A.J.J Wood Industries, Alapaate Poovathingal House,
Thaikkattussery.P.O.
14. Kunjiveelu.M.I, Mullakkal. House, Poothrakkal.P.O, Cherpu, Thrissur.
15. Kunju.P.V.Urakam, Thrissur.
16. Lohidashan.V.K.Urakam, Thrissur.
17. Lula.P.G, Secretary, Co-operative society, Cherpu, Thrissur.
18. Madhavan.T.K. Urakam, Thrissur.
19. Mani.K.A. Urakam, Thrissur.
20. Mary Paul. N. ADIO, Thrissur.
21. Mijo.C.N, Chempil House, Avannisery P.O. Thrissur.
22. Mohanan.K.N, Keetiparampil. House, Arattupuzha, Thrissur.
23. Mohanan.P.S Urakam, Thrissur.
24. Pius.E.K, Elavathinkal. House, Cheroor.P.O, Thrissur.
25. Praveen.T.N, Thekkoot.house, Chathakudam, P.O.Vallachira, Thrissur.
26. Radhakrishnan.T.N. Urakam, Thrissur.
27. Raghavan.T.I, Thekkoot.house, Chathakudam, P.O. Vallachira, Thrissur.
28. Rajan.K.S. Urakam, Thrissur.
29. Ramachandran V.S. Urakam, Thrissur.
30. Rappai.C.I, Chemmanda, Urakam, Thrissur.
31. Ravi.M.S. Urakam, Thrissur.
32. Ravindran.T.S, Thekkemeppulli. House, Perinchery.P.O, Thrissur.

33. Sajitha.P, Secretary, Co-operative society, Cherpu, Thrissur.
34. Sankaran.K.A.Urakam, Thrissur.
35. Sathyan.M.U, Madathiparampil. House, Kolazhi, Thrissur.
36. Shaiju.K.J, Kidangan House, Anchery.P.O,Thrissur.
37. Sivadas.K.S. Urakam, Thrissur.
38. Sivaraman.T.C. Urakam, Thrissur.
39. Subakan.K.K, Oorakam,Thrissur.
40. Subash.C.K, Chirukandath.House, Enamakal,Thrissur.
41. Subramaniam.T.N.Urakam, Thrissur.
42. Sundaran.K.K. Urakam, Thrissur.
43. Suresh.P.K, Oorakam, Thrissur.
44. Thomas.P.O.Urakam, Thrissur.
45. Thomas.P.P, Surendra Saw Mills, Cherpu P.O, Thrissur.
46. Tony.T.A, Thattil Iyyu. House, Avannisery.P.O, Ollur, Thrissur.
47. Unnichekkann.K.R, Kottekkattu.House, Cherussery, Thaikkattussery.P.O. Thrissur.
48. Unnikrishnan.V.K. Urakam, Thrissur.
49. Vijayan.P.K, Porathala.House, Avannisery. P.O, Ollur, Thrissur.

viii. 08-01-2001, Sri Vyasa N. S. S. College, Wadakanchery

Students of B. Sc. Chemistry and Botany & Teachers of both the Departments participated.

ix. 01-02-2001, Government Polytechnic, Kanur-7

Students and Staff of the Diploma Course on Wood and Paper Technology participated.

x. 06-02-2001, Common Facility Service Centre, Cherpu Carpenters Co-operative Society, Perumbillissery, Thrissur

About 30 members (wood workers) of the Society participated.

xi. 03-11-2003, St. Alloysius College, Elthuruth, Thrissur

Students of B. Sc (Chemistry) and Staff of the Chemistry Department participated.

Open House Programme (23-02-2001)

1. Abhishek.T.S, Thalachira.House, Pyyavoor.P.O, Kannur.
2. Arun. K.M, Arunand,Nettur.P.O, Thalassery, Koduvaly.

3. Bijith.T, Kodallur.House, P.O.Nanichery, Prassinikadavu, Kannur.
4. Biju.K, Prabhalayam.House, Mayyil.P.O, Kannur.
5. Brijesh.O.P, Ramanilayam, Kanjirangad.P.O,Kannur.
6. GirishKumar.P, Divyiaragam, Ottachimakul, Pookode, Pattam, Thalassery.
7. Hareeshkumar.P.P, Padinjerepurayil.House, Thaliparambu.P.O,Kannur.
8. Jabir.K.V, SK.House, Uliyil.P.O, Mattannur, Kannur.
9. Jithin.C.V, Mantody.House, Perunthattil.P.O, Thalassery.
10. Linesh.C, Lakshmi.Nivas, Ponnad.P.O, Iritty.
11. Linishmon.K. Guest Lecture , Govt PolyTech. Kannur.
12. Maneesh.A.V. Achamveetile,Nadapuram.
13. Midhun.K, Kattery.House, Thottada.P.O, Kannur.
14. PratheeshBabu.C.P, Nichiyodi, Padiyoor.P.O, Kannur.
15. Ragesh.C.P, PK.House, Mananthen.P.O, Koothuparampu, Kannur.
16. Rajeesh.A., Aroth house, P.O. Chirakal, Pallikulam, Kannur.
17. Rajkamal.P. Shamrock,Edathile Temple,P.O.Nettur, Thalassery.
18. Ranjith.P, Morooha.P.O, Kannur.
19. Ratheesh.C.P, Chamavaliyaparambath.House, Nadaparambu, Kozhikode.
20. Roshin.K, Anandabhavan, Vadakkumpadu.P.O, Thalassery.
21. Sahher.I, VP.House, Koorara,P.O, Panoor, Mokery.
22. Saneesh.K, Sunil Nivas, Mayyil.P.O, Kannur.
23. Saneesh.Mathew, Thuppalanjyil.House, Nellikutty.P.O, Kannur.
24. Sannesh.M.P, Parammal.House, Chirakkal.P.O, Puthiyathara, Kannur.
25. Sanoj.M.V, Kadaleseveram.House, Palayodu, Keezhallur.P.O, Kannur.
26. Shaji.K, Sheeba.Nivas, Knnandiparambu.P.O, Kannur.
27. ShebinKumar.E.P, Erinjikkal.House, Kadachira.P.O, Kannur.
28. Sijimon Abraham, Muruttupoovathinkal.House, Iritty, Velimanam.P.O, Kannur.
29. SirajudheenKutty.P.C, Shufnas,Kottakkal.P.O, Calicit.
30. Sreejith.C. Chingan House, Kannadiparambu, Kannur.
31. Sunesh.P, Parakka.House, Chirakkal.P.O, Kadalayi, Kannur.
32. Vijesh.E. Erayeentavia, Edachery,Kacheri, Kozikode.

- A batch of 34 students of the 2nd year Wood & Paper Tecghnology Diploma Course and 3 Teachers from the Government Polytechnic College, Kannur, visited the facilities on 22 – 01-2004.

Appendix-5

Curriculum of the Wood Technology Clinic

Preservative treatment of wood for improved durability

Natural durability – need for protection – bio-deterioration – bacteria, fungi, insects/borers, termites, marine borers, and weathering – application of preservative chemicals – methods of treatment – Indian and International Standards – Dry salt retention (DSR) recommendations, optimization of treatment conditions – effect of concentration of treatment solution, moisture content of wood at the time of treatment, thickness of sizes, treatment schedule and duration etc on DSR, quality checks, consumer rights, etc.

Timber drying – Use of Solar Kiln

Importance of using dried timber – Principles of timber drying – drying with reduced defects – advantages of solar drying over air/kiln drying – design and structure, operation, schedules, etc.

Ammonia Plasticization and bending techniques

Theory of wood plasticization – steam plasticization versus ammonia plasticization – advantages and disadvantages – equipment for vapor phase ammonia plasticization – its operation – manual bending of the plasticized wood – use of clamps, flexible metal straps, wooden moulds, etc. – curing bent items – care and safety while using ammonia – bentwood furniture.

Ammonia fumigation

Ammonia fumigation for improved surface color – theory, effect of tannin content, species, density, thickness of sizes, exposure duration and intensity of color/shade – examples and applications.

Appendix-6

Agencies for equipments, installation and rectification works

Sl. No.	Name & Address of the Agency	Description
1	Kartar Engineering Works 16, Industrial Estate, Yamuna Nagar 135 001 N. R. Jadadhri, Haryana	1. Fan & Motor assembly for Solar Kiln 2. Wood Plasticization plant
2	C. Doctor & Co. Pvt. Ltd. 10, Cowley Brown Road, R. S. Puram Coimbatore 641 002 Tamil Nadu	'Doctaire' brand Humidifier for Solar Kiln
3	Shivam Rubber Mohana Road, Ballabgarh 121 004, Haryana	Rubber beadings for the wooden framework of Solar Kiln
4	WoodTech Industries 294/IX, Pullur P. O., Kallettumkara, Irinjalakuda Thrissur 680 683, Kerala	Fabrication & Installation of Solar Kiln
5	Geo Refrigerations VII/403, East Surya Gram Thrissur 680 005, Kerala	Rectification works of the Ammonia Plasticization plant

Enclosures
(Newspaper Clippings)

List of Newspaper clippings enclosed

Sl. No.	Name of Daily	Date
1	Mathrubhumi	06-02-2001
2	Mathrubhumi	02-02-2001
3	Mathrubhumi (<i>news in separate page</i>)	02-02-2001
4	Malayalamanorama	22-01-2001
5	Desabhimani	04-01-2001
6	Malayalamanorama	17-12-2000
7	Mathrubhumi	17-12-2000
8	Uttaradesom	07-12-2000
9	Uttaradesom	01-12-2000
10	Uttaradesom	01-12-2000
11	Malayalamanorama	03-12-2000

Newspaper Clippings

