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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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DP/ID/SER.A/110
13 December 1977
English

DEVELOPMENT OF THE FURNITURE AND JOINERY INDUSTRIES
AND CREATION OF A CENTRE*
DP/YUG/73/006
YUGOSLAVIA

Technical report: Prefabricated wooden housing
and glued laminated timber construction

Prepared for the Government of Yugoslavia
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of C.R. Francis, registered civil engineer

United Nations Industrial Development Organization
Vienna

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Explanatory Notes

Reference to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in Yugoslavia is the dinar (Din). During the period covered by the report, the value of the dinar in relation to the United States dollar was $ US 1 = 18.00.

The following abbreviations are used in this report:

BiH	Republic of Bosnia and Hercegovina
R-O	Radna Organizacija (A self managed group of co-operative units)
Glulam	Glued laminated timber
Prefab	Prefabricated

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ABSTRACT

The consultant, an expert in the design of wooden buildings spent 2 1/2 months in Yugoslavia from 1 September 1977.

His mission was to advise the ŠIPAD factories on improvements to the design and construction of the prefab wooden buildings at present produced in BiH and to advise R-O Krivaja on the design of a factory for the production of glulam.

The expert's principal recommendations to the factories producing non specialised components were:

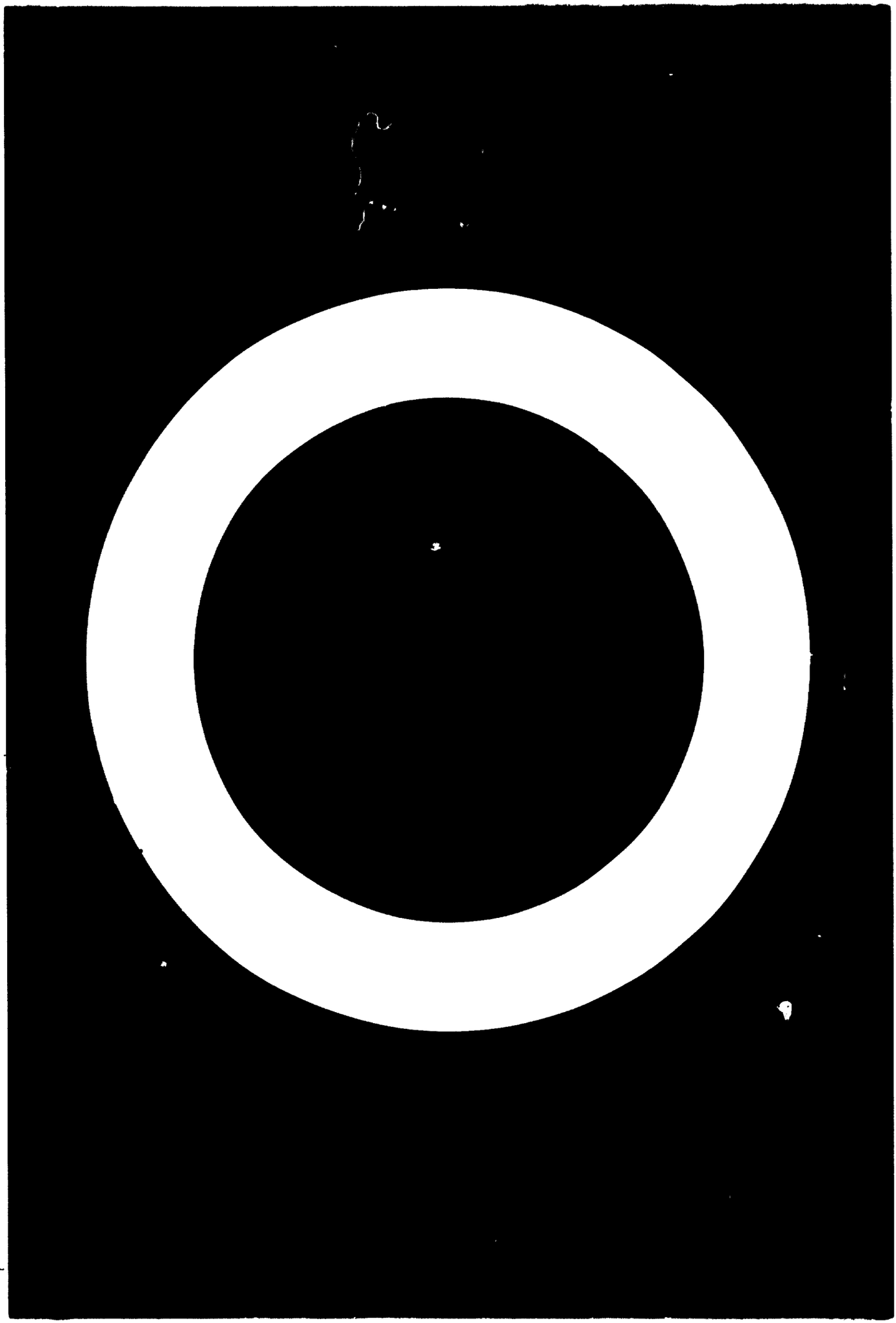
1. Increase the size of tne panels being produced.

2. Adopt stud frame construction as a basis of building design.

3. Construct suspended floors from joists and particleboard.

4. Manufacture roof trusses with toothed plate connectors.

He advised the R-O producing a specialised system building on design details, and prepared a design for a glulam factory to the parameters supplied.



CONTENTS

ANNEXES

INTRODUCTION

The expert's mission was part of the larger project "Centre for the Development of the Furniture and Joinery Industries, Sarajevo" (DP/YUG/73/006). The project was submitted by the Government of Yugoslavia in December 1973 and approved by the United Nations Development Programme (UNDP) and the executing agency, the United Nations Industrial Development Organisation (UNIDO), in August 1974. It was scheduled to start on 1 Setpember 1974 and to last for three years and four months. The UNDP contribution was $555,000 and the contribution of the Government of Yugoslavia was Din 19,247,900.

The long range objectives, as set forth in the project document were to enable the furniture and joinery industries (which includes the wooden house industry) initially in the Republic of Bosnia and Hercegovina (BiH) and later in all of Yugoslavia, to make a greater contribution to the economy of the country and to increase their participation in domestic and foreign markets. Immediate objectives were to help the industries to increase the value of the products, to improve quality, to reduce costs of production, to design new products and to forecast market requirements and adapt production accordingly.

It was originally planned that during his 2 1/2 month stay in Yugoslavia from 1 September 1977 the expert should be assigned to the ŠIPAD Design Centre. For various reasons this was not possible and a small separate office was established with UNIDO experts under the supervision of SIPAD Kombinat the administrative branch of ŠIPAD.

A counterpart engineer Mr. Nikola Stanivuković was assigned to the project, but through illness was not available for the second part of the project where the expert was advising and discussing problems at the factories. However, detailed discussions were held with the factory staff at the factories visited and the expert considers that most of the technical advice offered has reached the right quarters.

ŠIPAD the counterpart agency is an integrated corporation of woodworking industries with more than 120 factories in BiH, employing some 55,000 persons and covering the complete range of wood processing industries from forestry. sawmills, pulp and paper production, wood based panels (plywood, particle board, fibreboard), joinery and prefabricated houses, furniture etc.

The principal aim of BiH in the development of this sector is to double the production of furniture and to treble that of joinery within five years, increasing the work force from 6,000 to 9,000 persons in the furniture industry and trebling it to 4,500 in the joinery industry. At present ŠIPAD accounts for 80 percent of the total forest in the Republic and produces 85 percent of the manufactured ("finished") wood products. The supply of raw materials is adequate since one third of the country's total forest resources are located with BiH and the forest will remain as one of the principal sources of raw material.

Two thirds of the total are broad-leaved species, mainly beech and one third are conifers with firs, pines and spruce predominating.

The expert was initially recruited by UNIDO as a Cpnsultant in Glued Laminated Timber Construction, (glulam) however, due to a revision of the development programme by ŠIPAD the project title was changed to Consultant in Timber Engineering (Prefabricated Houses) for which the expert was equally well qualified.

The job description (Annex I) was only a guideline and during a pre-mission briefing in Vienna the expert was instructed to change, if necessary, the duties outlined therein, after obtaining the approval of the National Project Director.

In the event the expert advised in both fields, pre-fab houses for ŠIPAD and glulam for Krivaja.

During the first three weeks the expert toured extensively through BiH visiting four factories engaged in production of prefab buildings and glulam and various construction sites where prefab buildings were in the course of erection. He also visited the trade fair at Zagreb on 5th and 6th September where several prefab buildings manufactured by ŠIPAD and other manufacturers were on display.

From 3rd October to 18th October the expert worked mostly at OOUR Bosna at Ilijaš, advising on two storied timber construction. From 19th October to 4th November the expert worked advising OOUR Krivaja on glulam factory design and for the remainder of the time at OOUR Janj at Donji Vakuf. The expert made a two day visit to Belgrade on 26th and 27th September and conferred with the Engineering Division of OOUR Javor.

There were effectively four small projects combined in the expert's visit, consequently the remainder of this report is divided into sections, each with its own findings and recommendations. Many of the problems are similar at different factories so there is some repetition from section to section. A fifth section deals with prefabricated roof trusses where the problems and solution are common to all production units

R-O "Javor"

Findings

ŠIPAD manufactures wall and floor elements for a steel framed system called MDO-12 at a small factory on the outskirts of Sarajevo. The steelwork is manufactured in Slovenia by another company. The system is sophisticated with emphasis on quick erection and disassembly for re-use. Therefore no major changes are possible without major re-design. The system fulfills its function adequately.

The factory near Sarajevo is cramped and inefficient. Plans have already been made to move the panel construction to a new factory and expand the joinery manufacture section into the space vacated by the panel manufacture.

The Chief Architect described the problem they were having with wooden framed ceiling panels bowing in cold weather. These panels are insulated with polyurethane foam foamed in place in the space of honeycomb paper. It appeared from the description and detailed examination of samples that this bowing may be due to the cellular thermal insulation containing a temperature gradient which would produce a relative humidity gradient in the air round the framing timbers. This appeared to be the only technical problem they had which was described to the expert.

Recommendations

No major change in design of wall or floor panels is necessary or desirable.

The problem of the bowing of ceiling panels can possibly be solved by substituting reflective insulation for cellular insulation. The engineering department of ŠIPAD should conduct experiments using aluminium foil as produced for the cigarette industry. This foil appears quite suitable for the purpose and is produced in Yugoslavia. The foil would serve as both a vapour barrier and insulation and should therefore be placed on the lower warm side of the panel. Technical data on reflective insulation is being made available by the author to the engineering department and its advice should be followed on number of reflective surfaces for the degree of insulation required.

The inefficiency and occasional lack of dimensional accuracy of production at the existing factory should be avoided at the new factory by:

1. Maximum use of power tools, including :

   Nailing guns
   Pressure glue spreaders
   Powered screwdrivers

2. Provision of heavy duty jigs with mechanical or pneumatic locating clamps.

3. Use of roller conveyors for transport of partly finished components from one work station to the next.

4. Design of access for the forklift truck handling of raw materials and finished components.

The expert was not consulted on detailed design of the new factory, therefore these recommendations can only be made in general terms.

R.O. "JANJ" Donji Vakuf

The expert was able to spend only a short period at this factory. The interest here was advice on development of their prefabricated building system. The staff had prepared an agenda for the expert and work was able to proceed quickly. The agenda is attached as Annex II.

The expert prepared notes on Items II and III of Annex II. and this was translated and read by the "Janj" staff. These notes are attached as Annex III.

Findings

R.O. "Janj" prepares designs for a wide range of building types, as can be seen from Annex II. They wish to maintain this production, but also to penetrate the family housing market. Present two storey designs are based on a steel frame and a concrete first floor. They wish to eliminate both of these in favour of all-wood based construction.

There is market resistance to prefabricated family housing. This is due in varying degrees to:

Roof Style. The traditional roof has a steep pitch with ceramic tile covering and is frequently hipped.

Modular construction restricts flexibility in layout.

The numerous vertical joints detract from the appearance.

Windows are separated by the panel sides.

Construction is limited to a single storey **under the present system and the present building regulations.**

Recommendations

A market survey should be undertaken in all of the building fields in which "Janj" is interested. Planning for change of construction type should be based on the results of this survey.

The expert's opinion is that the present system of panels 122 cm wide is satisfactory for

Worker's accommodation on building sites.

Offices

Schools and kindergartens

Hospitals

For restaurants, family houses and any other buildings where appearance is important, the present system is not satisfactory for the reasons listed in "Findings". A larger wall unit must be designed and the disadvantages associated with this must be accepted. These disadvantages can largely be overcome by tight production planning.

A prefab floor panel should be designed along the lines of the sketches provided by the expert to R.O. BOSNA.

A wider wall panel should be designed. The design for this should be based on an authoritative stud frame building code. R.O. "Janj" should liase with R.O. Bosna where the expert has given instruction to the technical staff and where various information pertaining to stud frame construction is now held. For house construction the main limitations are weight and size. The weight problem is largely due to the thickness (8-10 mm) of the asbestos cement board used for exterior cladding. There is a wood-fibre reinforced asbestos cement board available. This board combines light weight with considerable toughness. Its surface is very similar to ordinary asbestos cement board and will take the same finishes. It has the advantage that it can be fixed with nails and does not require screws.

ŠIPAD should investigate the possibility of having this board manufactured in Yugoslavia. Preliminary contract is being arranged by the expert.

For family houses the height of the panels is such that transport of long lengths of walls is possible. The major limitation is handling. Janj should redesign the panels to take advantage of this, particularly if the light weight asbestos cement board is available.

For buildings where a floor to ceiling height greater than 2.4 m is required panels of a width not greater than the road transport limits should be designed. For these the present connection system between panels is suitable.

Fabrication Methods

The wall panel manufacturing operation should be equipped with nailing guns and roller convezors. This would greatly improve efficiency. These items are portable and can therefore be used on any size of panel. Heavy rigid jigs with mechanical or pneumatic locating clamps should be installed to improve dimensional accuracy and also to speed production.

If floor panel construction is started then either shadow lines or laser lines should be provided to help the workers to correctly position nails on interior joists.

Exterior finish of Existing Buildings

After erection the asbestos cement panels are sprayed with a thin covering of rough textured plastic finish. This is not thick enough to completely fill joints between covering sheets and the "prefabricated" appearance remains. "Janj" should investigate the economics of reverting to two coats of stucco, the traditional finish of brick buildings to improve the appearance of prefabricated buildings. Note should be taken that stucco will cover wide gaps, therefore a lower standard of workmanship will be acceptable with stucco than with the sprayed plastic.

"KRIVAJA" Zavidovići

At the request of Mr. L. Lesić, engineer and scientific consultant to "Krivaja", the expert prepared a design for a new factory for the manufacture of glued laminated timber (glulam). The proposed site was shown to the expert.

The production capabilities required are:

Annual volume	3000 m^3 to 4000 m^3
Maximum straight glulam member size	40 m x 1.8 m x 40 cm
Average straight glulam member size	20 m x 1.0 m x 16 cm
Proportion of curved members	20%

Mr. Lesić provided the format in which he wished the design report to be prepared. This is the format in which project proposals are prepared in Yugoslavia.

The Yugoslav report format and the expert's drawings and design report are attached as Annex IV.

The expert also wrote, on behalf of Mr. Lesić to specialised machinery manufacturers, for budget prices of suitable machines to assist in preparing cost estimates.

R-O "BOSNA"

The expert spent two weeks at this factory. The main interest was to investigate the possibility of building two storey buildings in prefabricated timber construction.

Mr. F. Savarić, Technical Director, assigned Mr. A. Mujalo engineer and Mr. M. Cabrilo, technician to this project.

It was agreed that architectural drawings of a modest two storied house would serve as a suitable case study. Two approaches were taken, use of the prefabricated panels now manufactured at Ilijaš and stud frame construction.

Prefabricated Construction

Analysis of the framing members only of the prefabricated panels showed that they would be overstressed in two storey construction. This analysis had already been undertaken by Mr. Mujalo and was confirmed by the expert. An analysis of the panel as a composite structure with finite rigidity of the fastenings between the particle board skin and the frame showed that the panels have ample strength. Some of the material properties required for this analysis were not available and conservative estimates of these were made. However, they remain estimates and should be determined experimentally. Then the calculations should be reworked using these values.

Stud Frame Construction

The expert drew the framing members of the main elements of the case study house in stud frame construction on the basis of the revision of the New Zealand light timber construction code. This happens to be the code with which the expert is most familiar, however, as was explained it is generally similar in its requirements to other codes for stud frame construction in low density soft woods.

Mr. Čabrilo prepared further detailed drawings from which quantities could be taken off and which could also be used as construction drawings for the main framework of the house.

Stud Frame Construction

The expert prepared explanatory notes on the stud frame system with emphasis on prefabrication, economics and minimisation of waste through best layout of framing members. He also discussed with Mr. Mujalo the basis on which engineering calculations should be based for various framing members. Since light frame building is not practised in Yugoslavia there are no standard timber sizes or grades for this purpose. Decisions will have to be made on these dimensions, species and grades to tie in with existing sawmilling practice and also to provide masimum economy in construction. These matters are well beyond the scope of the expert's brief and indeed could form the basis of a complete project in themselves. **This could be covered in a six weeks' assignment by a specialist.**

Existing Fabrication Methods

The existing premises are cramped and inadequate. Operations are carried out in one large building, one small one, a lean-to shed and in the open. Storage of new materials and finished components is in the open.

The floor is too uneven to allow the use of wheeled trolleys and there is a minimum of paving in the outside areas. Consequently a large amount of labour is used to carry materials and components around. There are no power tools in use, all nailing and screwing having to be done by hand. Jigs and nailing tables are worn and too light.

Housekeeping is poor and waste, stocks of components of various types and current work accumulates round operators reducing their efficiency.

All locating is manual and there is no firm clamping of material on jigs.

The type of roof truss manufactured is structurally inefficient. It would appear that its design has been dictated by the use of wire nails for fastening. For the large forces involved in roof trusses, very large quantities of nails are required to safely transfer these forces. A partial analysis of some of the roof truss joints indicated that the number of nails used is insufficient to supply the safety factors required for full design load to be carried. The use of hand nailing as the only fastening for wide span trusses is uneconomical in mass production. The jigging and component cutting system are both inaccurate and lead to difficulties and inaccuracies in site erection.

The type of trucks used for transport limit the size of component which can be carried. Consequently roof trusses are made in two halves for site jointing so that road loading limits are not exceeded. This leads to extra expense on the building site and also to further constructional inaccuracies.

Recommendations

1. Existing Panel Construction

The Yugoslav building regulations do not allow strength of the skin in stressed skin construction to be taken into account. If Ilijaš wish to pursue two storey construction using their existing panels which I consider the best solution to their immediate requirements, then they should assemble evidence that the panels are in fact amply strong.

This evidence should be based on calculations supplemented by material properties determined by test as outlined above, and a component testing programme in accordance with an authoritative timber engineering code. Suitable codes would be NZS 3603 (in course of publication) or BSCP 112. The expert has no doubts that the panels would satisfy the requirements of either of these when loaded with the local live and snow loads.

The method of calculation of this type of construction is fully described in a US Department of Agriculture Forest Service Research Paper FPL 152 "Composite Beams - Effect of Adhesive of Fastener Rigidity" by F. W. Knenzi and T. L. Wilkinson (1971) a copy of which has been left with Mr. Mujalo.

2. Stud Frame Construction

The quantity estimates prepared by Mr. Mujalo indicated that the stud frame house should be competative with existing prefabricated construction. It is therefore recommended that further work should proceed as follows:

(a) Finished dimensions of timber to be used should be decided.

(b) The sizes of sheets of particle board and gypsum board to be used should be selected (Sheet sizes of particle board vary from factory to factory).

(c) The drawings should be reworked to minimize both waste and timber content, based on these dimensions.

(d) The quantities of materials should be re-estimated and costed compared with the cost of a similar house built from the existing panels.

A firm decision on whether to proceed with construction of houses of this type or an exploratory model can be made at this stage.

If the decision is made to proceed at least a construction engineer and preferably also a foreman should undertake a study tour to countries where stud frame construction is traditional. These countries include Australia, Canada, New Zealand, U.S.A. In all of these a high standard of skill and workmanship can be observed on any building site employing this form of construction.

Basic data for a single case has been provided with typical details and translation of the most important parts of a set of stud frame building regulations. If this form of construction is to be pursued a structural engineer fluent in English (note that all the countries referred to above are English speaking) shoudl be assigned to study building regulations and practices and their backgrounds and to prepare similar documents for Yugoslavia. The various parts of such regulations which require computation e.g. floor joist and rafter tables, stud sizes etc. should be prepared to suit Yugoslav timber properties loadings and architectural requirements.

The engineer should also advise on the introduction of suitable handtools for the carpentry. The traditional Yugoslav hand tools, particularly hammers, saws and measuring equipment are not appropriate for efficient production and modern pattern tools should be introduced.

Carpentary Skill

The level of carpentary skill on the construction sites needs to be improved both to raise the structural and finish qualities of the buildings and to reduce erection times. This improvement in skill is required at the tradesman level, amongst workers who are leading hands or working foremen. This elvel of worker is difficult to train in formal sessions since he is generally unaccustomed to formal education and worker to worker contact and demonstration is the best way to transfer such skills as in the apprenticeship system. Unfortunately at this level language problems are at their most seyere and would inhibit any training scheme involving tradesman experts coming to Yugoslavia to operate a training scheme. A training scheme in Yugoslavia is impractical in any case since there is no suitable construction carried on to provide on-the-job training, which the expert considers is what is required.

A solution to this problem would be to arrange training employment with nationals of the "stud frame" Pacific Rim countries mentioned above who are of Yugoslav origin and who still speak Serbo Croat. There are several such ethnic enclaves in these countries and it should be possible with the assistance of the Yugoslav Ambassador and Consuls to locate suitable building firms who would be prepared to assist in a training scheme on the basis of short adult apprenticeships. Presumably such arrangements would have to be made on a Government to Government basis. It is recommended that investigations into the feasibility and costs of such a programme should be initiated as soon as possible and if found to be practicable, the programme should be instituted.

ROOF TRUSS MANUFACTURE

Findings

Three of the four factories visited were engaged in the manufacture of roof trusses. These were all of the same type, manufactured from several layers of 15 x 2.5 cm timber, fastened by hand nailing. The profile was of the type where the bottom chord projects over the exterior wall to form both the ceiling plane and the external soffit, meeting the rafter at the eaves.

In all factories the jigging and nailing tables were old, inaccurate and subject to considerable bounce. Although some factories were better than others, the cutting of the components was generally inaccurate, with variations of several degrees in angle cuts and also variations of length. of components. This resulted in adjustments at the jig table and variations in size of finished trusses. In turn difficulty was experienced at the building sites from this cause, various adjustments having to be made to produce a true roof.

The trusses were all made in two halves for transport. The explanation for this was that transport as a single component would violate the road loading regulations. As far as the expert could see, transport was by the conventional four wheel short wheel base truck which is in general use in Yugoslavia. This type of vehicle is not suitable for carrying roof trusses.

All the fabricating operations were very labour intensive partly because of the poor layout of the various operations involved and partly from the labour content inherent in the numerous wooden components and nails.

Recommendations

A system of toothed plate connected roof trusses should be introduced. This would lead to economy through:

Reduction in labour content

Reduction in timber content

Improvement in dimensional accuracy of finished trusses through the use of jigs designed by toothed plate connected roofing systems manufacturers.

Although not studied in depth it appears that Yugoslavia produces galvanised steel sheet of a quality suitable for the manufacture of toothed plate connectors and also already has presses suitable to stamp the plates. It is therefore recommended that negotiations should commence with licensors of toothed plate systems for the manufacture in Yugoslavia of the plates and manufacture of roof trusses to the system.

The licencing agreement should provide for:

Supply of dies or die designs,

Training of engineers in the design of plate connected trusses,

Design of a factory ,

Manufacture of specialised production machines,

Training of production operators,

Institution of quality control measures,

Provision of a design service'

Marketing assistance,

A list of addresses of companies manufacturing toothed plate connectors is attached as Annex V.

One medium sized roof truss factory could supply the whole of the present requirements of Bih. This would be much more efficient than construction of a separate factory at each present truss manufacturing location, but would require co-operation between the present factories. As an interim measure and until a centralised factory is operating, it is possible to manufacture toothed plate connected trusses by hand on a concrete floor. The precision of these trusses is not as good as those manufactured in a jig with a press and more labour is required, but even this relatively primitive method is more efficient and produces a better article than the present methods of hand nailing.

Suggestions on the requirements for such a small hand operated plant have already been made to SIPAD: A supply of plates should be arranged and production of trusses on a pilot basis should commence as soon as possible. A sketch of the required equipment is attached as Annex VI.

The profile of the trusses should be changed so that the bottom chord intersects the rafter at the external wall and a dropped soffit should be constructed back from the end of the rafter. The advantages of the construction are:

Reduction in size of triangulated area, resulting in a saving of timber and weight.

Elimination of an area of external wall on both sides of the building which at present required cladding and finishing.

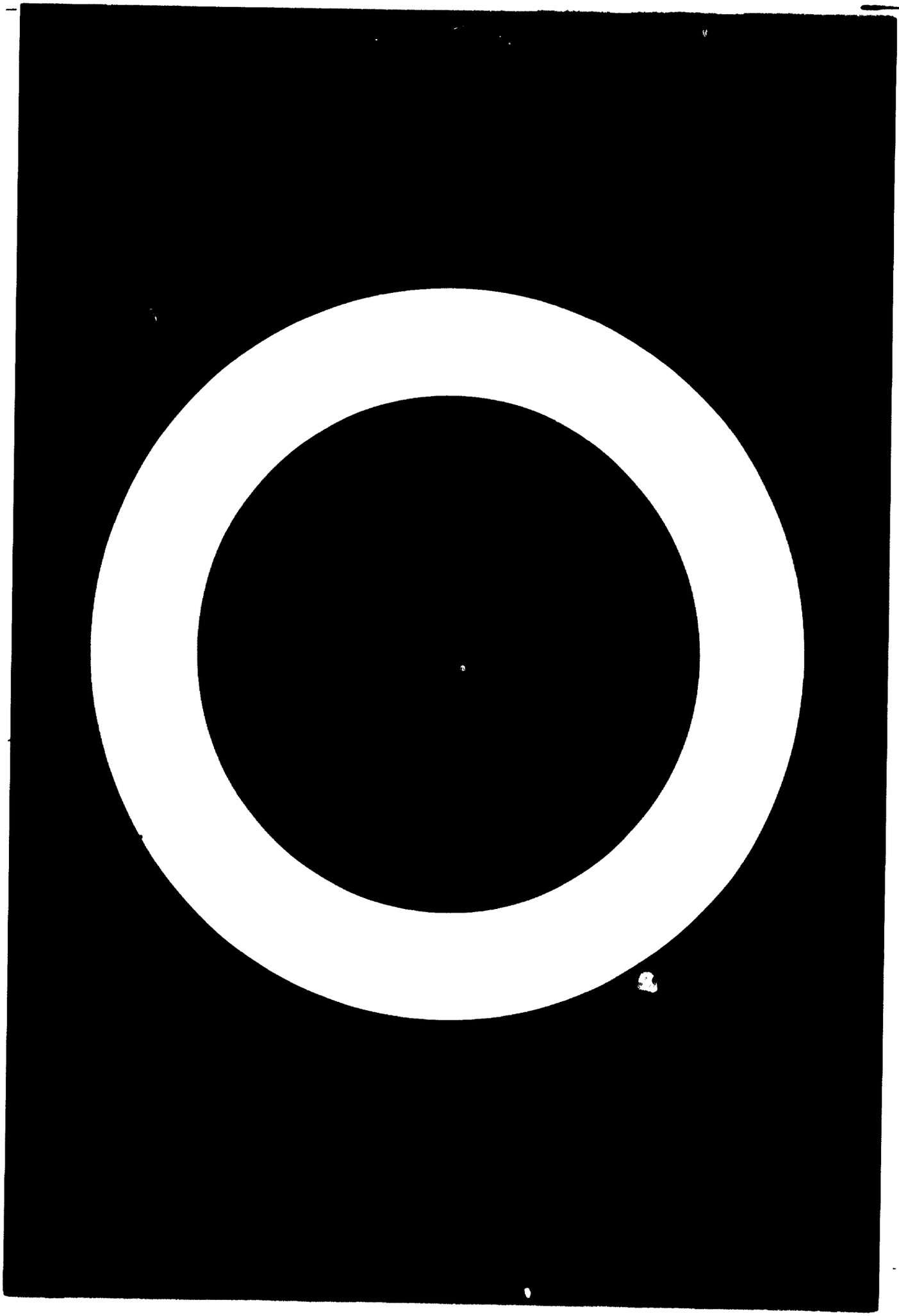
Improved weather protection to the heads of windows and doors. The sketch attached as Annex VII shows the present and recommended profiles of the end of the trusses.

A study should be made of the Yugoslav road transport regulations to determine the maximum size components which can be legally carried over various routes. A study of available trucks should also be made to determine their suitability for this purpose.

A study should also be made of the possibilities of using purpose made truck and trailer unit for the transport of trusses. It should be noted that a 2,4 m. wide load of 12 m. long trusses would weigh less than 5 tons therefore very powerful and heavy transport is not required, the limitations being on volume rather than weight. In some countries a light pick-up truck towing a pole trailer is used for the transport of trusses and a similar vehicle could be appropriate for BiH. Such a specialised vehicle would not be economic for the several small factories described above unless the prime mover had other functions, but a specialised vehicle equipped with a light crane could be justified for a centralised factory.

At present factory built roof trusses are confined to prefabricated buildings. There is a large potential market for roof trusses in traditional brick housing which is largely owner built. The exact size of this market was not determined, but it was obvious to the expert on his travels through BiH that there is considerable house building proceeding.

It is recommended that once experience in design of tooth plate connected trusses is gained, this market should be penetrated by means of advertising, addresses to local groups and site visits. Compared with the traditional roof construction at present in use, this would result in houses which are structurally sounder and therefore a better lending risk and also cheaper, which would be to the economic advantage of the country as a whole.



ANNEX I

27 July 1977

JOB DESCRIPTION

DP/YUG/73/006/11-03/M/Rev.1

Post Title:	Consultant in Timber Engineering (Prefabricated Housing)
Duration:	Three months
Date Required:	1 September 1977
Duty Station:	Sarajevo with travel in the Republic of Bosnia and Herzegovina
Purpose of Project:	To assist the development of the Furniture and Joinery Industries of Bosnia and Herzegovina.
Duties:	The expert will be attached to the ŠIPAD Design Centre which will eventually form part of the Centre for the Development of the Furniture and Joinery Industries which is being created with UNDP/UNIDO assistance. The expert will be responsible to the Centre's Director and will, in collaboration with the Design Centre's Yugoslav staff and staff from the factory being assisted, working on improvement of production of elements and prefabricated wooden houses to be produced by ŠIPAD, and Krivaja, Specifically the expert will be expected to:

1. Develop a system of moble wall panels (partitions) for prefabricated wooden houses and introduce it in cases where classical building methods are used. This wall panel would be built in both facade and partition walls so that flexible inside arrangement of rooms, would be possible. The solution should mostly be based on the use of wood and wood based panels.

2. Improve the panel system of building prefabricated houses with the basic construction made of wood: specially in the following respects

- universality of sizes and forms
- facade bases and materials
- thermal and hydro insulation
- Protection against rotting and fire
- factory building of installations, etc.

3. Suggest methods of reduction of production costs and assembling of prefabricated houses.

4. Eventually develop new preliminary solutions for assembling and disassembling of prefabricated houses, to achieve the maximum economy, specially with respect to transport and erection of the houses.

5. Recommend methods for increasing the size of the houses (and their elements) presently produced.

6. Recommend methods for applying glued constructions in the building of multistorey houses.

7. Train counterparts in the above duties.

The expert will also be expected to prepare a final report, setting out the findings of his mission and his recommendations to the Government on further actions which might be taken.

Qualifications: Wood technologist, civil engineer or architect with considerable experience in the design and production of timber engineered constructions, specially prefabricated housing.

Language: English, French acceptable; German an asset.

Background Information: The furniture and Joinery Industries of Bosnia and Herzegovina contribute about 8 percent to the Republic's gross national product, and represent over 4 per cent of its exports. An ambitious 5-year development plan is being implemented to double the production of furniture to attain DIN 2,000 million and increase the work force from 6,000 to 9,000 persons. This plan calls for an investment of DIN 800 million. Joinery production will increase from DIN 200 million to DIN 650 million and the work force will treble to attain 4,500 persons. Investment of DIN 950 million are foreseen for Joinery plants (US$ 1=17.5 Din) ŠIPAD, a co-operative integrated Forest Industry Organisation consisting of 126 factories and employing 55,000 persons, accounts for 65 per cent of sawmilling and 85 per cent of the final products of the Wood Industries of Bosnia and Herzegovina.

The Government of Bosnia-Herzegovina and the IPAD organization have decided to create a "Centre for the Development of the Furniture and Joinery Industry" to cater for the 38 existing Furniture and Joinery plants within the organization, and have requested UNDP/UNIDO assistance in the development of this industrial sector and the establishment of this Centre. It is to have the following departments: technology; quality control; production and organisation; design; marketing; documentation.

ANNEX II

WORK PROGRAMME OF U.N. EXPERT FOR PREFABRICATED HOUSES IN R.O. "JANJ", DONJI VAKUF

I-. Introduction to accepted and completed solutions of prefab houses in R.O. "Janj", Donji Vakuf.

For discussion on this matter "Janj" will prepare solutions of further buildings.

Buildings for accommodation of workers on building sites.

Business premises

Restaurants

Schools and kindergartens.

Hospitals

Family houses

Container houses

"Janj" will also prepare drawings - details of particular objects:

Facade elements (joints and details)

Interior partitioning walls (joints and details)

Roof trusses

Joinery (sections and details)

II Main ways of development in prefabricated housing based on materials of low specific weight.

Advantages and short comings of certain systems.

Trends in technical development of prefab housing in the world.

Advantages and shortcomings of prefab housing in comparison with classical systems.

Geographical spread of prefab housing in the world and factors that influence acceptance of the building system.

III Line of direction for future development of prefab housing in R.O. "Janj", Donji Vakuf.

Suggestions for solutions of buildings mentioned under Item I.

Suggestions for solutions of construction of joints and details mentioned under Item I.

Conclusions

ANNEX III

R.O. "Janj" - NOTES ON EXPERTS AGENDA

Two approaches:

1. Small modular elements - as done at Donji Vakuf

   Advantages: Standard units
   Units may be stockpiled in advance of orders
   Minimum of detailing for individual buildings
   Minimum of production supervision
   Easy handling

   Disadvantages: Flexibility is limited by module size and type.
   Numerous joints - extra work, possibility of cumulative errors
   Uniformity of appearance due to repetition of spacings and details in various buildings.

2. Large special purpose elements

   Advantages: Flexibility in planning
   Minimum of erection work
   More factory finishing since joint area is relatively smaller and less connections
   Pre-wiring and pre-plumbing is possible.

   Disadvantages: Larger number of types of units if general building is to be done
   Stockpiling not economic to any extent
   Mechanical handling essential
   More detailing required
   More factory supervision required.

Information Sources

I am not aware of any specialised journal on prefab housing. Most systems are patented and therefore details are not widely published.

Occasional references to systems are made in building and real estate journals, also exhibitions are held. Manufacturers brochures may be interesting. It is often difficult for a competing organisation to get these. Writing as a private individual will sometimes get results when brochures are refused an organisation.

Prefab Housing contrasted with Classical Methods

Prefab. Advantages, compared with Classical:

Short design and quotation times
Short erection time, particularly if made from stockpiled units.
Requires a minimum of skill on site

Disadvantages:

Appearance may not be acceptable
Price is frequently higher since factory overheads are loaded on to labour cost
Modular system may not permit layout that customer wants.
Building is delivered as a unit. This requires payment in one sum. Customer cannot build a small amount at a time as his finances permit.

Geographical Spread

Prefab housing is most widely used in areas where building skill is lacking, either in general, or in particular materials, or where a large amount of housing is required quickly as following a natural disaster - Skoplje, Darwin.

In Europe, skill is lacking in timber construction, therefore wooden housing is mostly factory built. In N-Z. skill in bricklaying is lacking and brick companies sell prefab brick panels.

Where there is not a major shortage of buildings, classical techniquies are used except in particular circumstances, e.g. additions to schools carried out in school vacations, construction in remote areas where site labour costs are very high e.g. mountain resorts.

III Future Development at R.O. "Janj"

Most important is the determination of future markets.

1. Exports: Will the Arab countries continue to take large quantities of existing type of building? If so, then no necessity for major changes.

2. Internal: I have gathered that the present appearance of prefab housing is generating market resistance. Is this because of:

Roof style? Traditional is usually much steeper and has tiles, also hipped roof.

Lack of flexibility in layout.

Appearance of numerous joints

Separation of windows by panel sides

Limitation to single storey

If the findings from the market investigation indicate that the present system will satisfy needs for the forseeable future then the present system possibly with minor modifications should not be changed.

If the findings from the market investigation show resistance to the present system then steps must be taken to change it. In my opinion if the same general materials are to be used this can only be done by increasing the size of the elements and accepting the disadvantages of these described above. Manufacture of larger panels does not mean abandoning the present panels and the larger panels should be designed to integrate with the existing ones for some types of buildings.

Workers Accommodation on Building Sites

Requirements are standard and appearance unimportant. The existing system is therefore satisfactory.

Offices

Requirements are fairly standard for single storey and two storey offices for individual industries. To a large extent the existing system is satisfactory.

Restaurants

A wider architectural range of possibilities is required than the present system can offer and new solutions are required.

Schools and Kindergartens

Requirements are fairly standard and most of the building can be built from standard panels. In some of the service areas economy would result from the use of larger panels with pre-wiring or pre-plumbing.

Hospitals

Same as for schools, for most ward areas. Specialist rooms e.g. operating theatres, sterilising rooms etc. are probably best designed by specialised architects.

Family Houses

The present system is not flexible enough and does not allow economical construction of two storey houses. The roof appearance needs to be changed to look like traditional construction.

Solutions

I have previously recommended the installation of a toothed plate connector (TPC) truss plant and I understand that this is at present being negotiated. This should proceed with all possible speed. The potential of the system should be exploited and the mistake of merely substituting a TPC truss for the present nailed ones should be avoided. The use of TPC trusses allows easy fabrication of hip roofs and other shapes in a number of pitches and these possibilities should be adopted wherever appropriate.

If the licensee offers a coputer aided design service, advantage should be taken of this and if possible the software offered should be used on JIPAD's computer.

Floors

A system of prefabricated floor panels should be designed on the basis of the sketches supplied. The floor joist strenght and stiffness must be designed to comply with local building code, but in addition the stiffness should be such that the feel of the floor underfoot is not too different from a concrete floor, to which most of the population is accustomed.

At the present state of design technology it is not possible to design accurately for "feel" and some prototype floors should be constructed and rated for "feel" by a cross section of the population.

ANNEX IV

"KRIVAJA" - GLULAM FACTORY DESIGN AND REPORT

1. Capacity

Estimated total production 3000 - 4000 m^3 per year. For calculation purposes take 3600 m^3 per year = 15 m^3 per day.

Straight laminates (beams, columns) 80 % of production
= 2880 m^3 per year.

Curved laminations (arches, portal frames) 20 % of production
= 120 m^3 per year.

2. Products

Straight Members

Maximum size = 40m x 1.8m x 40cm

This will determine size of jig and space required in factory, also maximum handling equipment size.

Average size 20m x 1.0m x 16cm.

This will cover about 60 % of straight laminate production.

Curved Members

Allow to make half frames for buildings 40m span x 8M eaves height. These will determine lateral clearances required.

Virtually all glulam products are produced to order and there are no standard lines of production which can be stockpiled in advance of order. Consequently short term and medium term production planning of a high order is required to keep the factory operating smoothly at its design capacity. Ordering of timber of the various sizes required must also be carefully planned.

3. Process of Manufacture

Production of glulam consists broadly of the following processes.

1. Sorting and upgrading of timber into the required qualities.
2. End jointing into long lengths.
3. Planing to remove excess glue, and remove irregularities of end joints.
4. Spreading glue on laminations.
5. Assembly of laminations with correct placement of various grades and clamping.
6. Curing of glue.
7. Planing of full sized glulam members to give a suitable surface finish.
8. Repair of any blemishes, trimming to length, staining, wrapping, packing and dispatch.

These processes are described in detail.

1. The primary requirement of glulam stock is that it shall be up to required size. Undersized stock leads to delamination if it is too thin and excessive patching of finished members if it is too narrow.

   Undersized stock is most easily found by preliminary planing ("blanking") of all incoming timber. Undersize pieces are then obvious through planer skip. Blanking is essential if mechanical grading is to be used and it greatly facilitates visual grading.

   It is proposed that mechanical stress grading (MSG) should be used rather than visual grading alone. MSG is more accurate than visual grading process, it results in an improvement in grade recovery and a reduction in the number of defects to be removed.

   MSG must be supplemented by visual grading and three opportunities exist for this at the defecting saws, the sorting after defecting and the infeed to the fingerjointer.

   It must be understood that operation of MSG must be preceeded by a comprehensive testing programme to establish stiffness - strength characteristics of the timber to be graded, therefore purchase of the MSG should be the first item to allow sufficient time for the testing programme.

   x
   x (of 2 in Notes)

2. Fingerjointing is the best way to make end joints in glulam stock, since the process is strong, automatic and wastes a minimum of timber. The process requires regular quality control.

   Stacking of the FJ output should be by hand. Mechanical stacking would be very expensive in such long lengths, also manual stacking provides visual inspection of the FJ which is critical in this process. Stacks should be built on low trolleys fitted with castors and layers of freshly FJ boards should be separated with steel fillets 8 mm diameter, bent so they will not roll.

3. Fingerjointed stock should be replaned at least on the faces. Curvature of the unjointed stock frequently results in a step at a fingerjoint and this step shows up as an irregularity in the finished glulam. Also fresh glue does not bond well to previously cured glue and the glue smeared surfaces round finger joints are potential sources of delamination. Providing the fingerjointer is functioning correctly, planing on the edges should not be required.

4. Glue spreading requires to be carefully controlled to ensure sufficient spread without excessive waste. A single sided ribbon spreader is recommended for several reasons.

   i Ribbion spread glue has the longest open assembly time in hot weather since it has minimum contact with the wood and minimum exposure to the atmosphere;

   ii It is proposed that the glue spreader should be placed in line with the thicknesser. The timber will then be under the mechanical control of the thicknesser feed rolls, both vertically and horizontally. This would be a major disadvantage with a roller spreader, but with a ribbon spreader does not matter.

   iii Very accurate and simple control of the glue spread rate is possible by varying the angle of the spreader head and the speed of the glue pump.

5. Assembly of laminations is a hand job and should be carried out by a small skilled team. The operations of planing, glue spreading, assembly and clamping should all be done by this team. They require mechanical assistance in the form of conveyors for handling long length laminations, air tools for tightening clamping nuts and trolleys which contain the various clamping accessories.

6. Curing of glue is quick in summer time when the problem is to ensure a sufficiently long open and closed assembly times. In winter additional heat will be required. This is most easily supplied by steam pipes under the jigs with tarpaulins over the jigs to contain the hot air. This is impractical for curved laminations and portable electric fan heaters should be used to supply heat in this instance.

7. Planing of cured glulam members is required to:

Remove squeezed-out glue;
Eliminate irregularities in level of individual laminations;
Provide an acceptable architectural appearance.

This process is most efficiently accomplished by passing the members through a large surfacer (planer). This surfacer should be mounted on a turntable to allow curved laminates to be planed. It may be single sided or double sided. There are arguments in favour of both types.

Double sided surfacer: Both sides are planed at a single pass and turning the laminate over is avoided. A minimum of handling is required.

Single sided surfacer: The machine is considerably cheaper and simpler than a double sided surfacer, both important considerations in a machine of this size. These machines usually have a top head, therefore the planed surface is readily inspected without having to bend down underneath the laminate as is the case with a double sided surfacer.

If only a single cut is required with a double sided surfacer the laminate ends up on the far side of the machine. This is an advantage if a very long factory is planned, however, in our case with limited length the laminate will have to be carried back past the surfacer. With a single sided machine, for a single cut, the sequence would be:

Plane first cut
Rotate surfacer on turntable
Invert laminate
Plane second cut

The laminate is then back in its starting position. Of course, this argument does not apply if two cuts are required. A final decision can only be made on receipt of prices from the manufacturers for the two types of machine.

8. Finishing is generally a hand operation. The amount of handwork can be minimised by use of power tools as much as possible, including electric routers, planers and circular saws. Preparation of inserts can be done on the table rip saw required for preparation of quality control samples. Use of routers allows the machining of a large and uniform arris on all edges. This precaution greatly reduces minor but unsightly damage incurred in handling.

The sequence of operations is as shown on the following schedule:

1. Store incoming packets
2. Separate and remove piling sticks (tilt hoist) (sticks)
3. Plane
4. Increase feed speed to separate ends
5. Stand on edge
6. Pass through MSG
7. Transport to defecting area
8. Store (buffer)
9. Defect (waste out)
10. Sort accept to grade
11. Make packets
12. Store
13. FJ
14. Cure store
15. Surface plane (2 sides) some to storage
16. Apply glue in line with planer
17. Lay up
18. Clamp
19. Cure
20. Unclamp
21. Transfer to planer
22. Plane 1 side
23. Turn over
24. Rotate planer
25. Plane other side
26. Finish, trim ends (hand tools)

Selection of Machines

1. Blanking Planer

Volume 80 % of 26.3 m^3 in 38 x 220 mm = 2525 m
20 % of 26.3 m^3 in 25 x 170 mm = 1236 m
3761 m

(For derivation of input figure of 26.3 m^3 see page 13)

Allow 60 % efficiency of 360 minute effective day = 216 minutes

Speed required = $\frac{3761}{216}$ = 17.4 m/minute

A machine capable of taking 30 cm x 5 cm maximum size timber at 20 m/minute is required. A long bed machine for straightening should be used. Five heads should be used. First bottom, top two sides, second bottom. Numerous manufacturers offer suitable machines and equiries are being sent to suitable manufacturers, viz.

Wadkin	England
Robertson	England
Jansereds	Sweden

2. Machine Stress Grader

The only machine with world wide acceptance is the Plessey "Computermatic". This has ample size and capacity, being capable of taking timber 30 cm x 7.5 at 150 m/minute.

3. Defecting Line

The average length of timber at present going into the fingerjointer is 130 cm. The number of pieces per day is therefore $\frac{2929}{1.3}$ = 2253.

The number of cuts is therefore 2253 x 2 = 4506. The number of cuts per minute at 60 % efficiency is $\frac{4506}{216} = 21$

From experience, one sawyer can make about 6 cuts per minute with a knee or foot controlled pneumatically operated rising cross cut saw provided he has a minimum of timber handling to do. Therefore the number of saws required $= \frac{21}{6} = 4$.

(Note: 2929 = Knot free timber from defecting line in lineal meters).

The timber has to be distributed from a single flow line to these four saws. The best way without intermediate handling is the type of defecting line made by Industrial Machinery of Houston, Texas. In this line boards on a 3 strand chain conveyor pass under arms which can be dropped by the sawyers into the flow to divert a few boards up to a position where they can be handled on to each sawyers roller bench. Here they are passed over the cross cut saw manually. Rejects fall into a waste conveyor and accepts are dropped on to a sloping table whence they are manually sorted and stacked.

Apart from the saws, the structure is quite simple and could be made locally by a competent engineering workshop.

4. Fingerjointer

Capacity required = $\frac{21}{2}$ = 10.5 joints per minute. The latest model Cook Bolinder machine has the necessary capability and has an excellent reputation.

An enquiry requesting a proposal for the supply of a machine has been sent to the manufacturer.

A 20 m long outfeed table has been shown on this machine. Laminations longer than this are almost impossible to handle and this length allows butt joints or FJ assembled in the lay up to be located in areas of low stress in members up to 40 m long. It is suggested that this machine should have a fixed stop at the far end of the outfeed table and a saw which can be moved along to cut off the required lengths. This is the reverse of the usual arrangement, but it has the advantage of providing a fixed timber line further up the factory adjacent to the in-feed of the thicknesser.

5. Thicknesser

After timber has been FJ and the glue is cured it should be resurfaced on both faces to eliminate any irregularities at FJ and also to remove excess glue. A top and bottom head short bed machine would be satisfactory. It would be an advantage if this machine were mounted on rails so it could be moved across the factory, depending on the position of the stack to be planed. This machine should preferably be equipped with tungsten carbide tipped knives because of the shallow cuts it will be making and also because the glue on the surface of the timber.

The feed speed of this machine will largely control the speed of layup of glued laminations.

Assume it is required to layup a 1 m deep beam 20 m long in 30 minutes.

No. of laminations = $\frac{100}{3.3}$ = 30 = 1 per minute

Say 1/3 of time is required to pick up lamination and get it clear

of gluing area. Time for lam.to pass planer = 40 sec.
Therefore speed = 20 m x $\frac{60}{40}$ per minute = 30 m per minute.

6. Glue Spreader

It is not known whether suitable machines are available from manufacturers. However, they are quite simple and several glulam manufacturers have built their own. A detailed sketch of a spreader has been included in the drawings. The pump capacity is based on the following calculations:

Rate of glue spread = 0.3 litre/m^2
Area of widest timber per minute = 0.3 m^2 x 30 m
= 9 m^2
Volume of glue per minute = 2.7 l.

A pump with rather more capacity than this should be chosen then the actual flow adjusted by varying the final drive ratio. If the ribbon head is about 40 cm long, then fine adjustment of the spread rate is made by varying the angle of the head relative to the direction of the timber.

A long and a short head should be provided with appropriate speed drives to the pump, to minimise the amount of glue recirculated since pumping glue tends to shorten its pot life.

Also two glue spreaders should be provided since they are prone to clogging through the glue curing in the machine. Easily cleaned pumps are eesential. The "Mono" rubber bodied type is suitable, as are several rubber impellor positive displacement types used in the food and beverage industries.

7. Mobile Conveyors

The freshly glued laminations are diffioult to handle and in some cases will have to be transported quite long distances. Five or six slat bed conveyors will assist the transport and also perform the necessary function of continuing to move the lamination through teh ribbon spreader after the lamination has paseed through the thicknesser. For this reason the speed of these conveyors should be the same as the feed speed of the thicknesser.

A sketch of a suitable conveyor is included in the drawings. Various conveyor manufacturers could fabricate these or they could be made locally.

8. Surfacer

A single sided surfaoer with a throat 180 cm x 40 cm is required. Feed speed need not be very fast, but since members weighing nearly 20 tons will be passed through the machine, rugged and powerful feedworks are required. Manufaoturers are being contaoted for quotations. This machine must be mounted on a turntable to give at least 180° rotation.

9. Gantry Crane

An electric crane of at least 5 tons capacity x 17 m span should be provided over the area of the faotory from the surfaoer to the far end of the laminating area. Numerous manufacturers supply suitable oranes.

10. Laminating Jigs, Large and Small

Two jigs should be provided for flexibility and to avoid the difficulties of making the smaller sizes of glulam on oversized jigs. Individual jig elements for curved work are also required. These should be manufactured to the sketches attached to the drawings which include the T bolts and nuts.

11. Glue Mixer

The most suitable type is a bakers dough mixer with a bowl capacity of 20 litres. Two speed drive to the paddle is required and it should be fitted with a 5 minute timer. Numberous manufacturers of bakers machinery manufacture suitable mixers.

12. Rip Saw

A 25 cm table ripsaw without tilting arbour is required for quality control and cutting repair patches. Numerous manufacturers make suitable machines.

13. Knife Grinder

This machine should be primarily for sharpening FJ cutters, but should have the capacity to handle tungsten carbide tipped knives for the double sided thicknesser and TCT saws from the defecting line.

14. Cutter Grinder

Ditto.

15. Handling Equipment

This equipment can be made locally. The equipment required is:

Triangular trolleys:	1 m x 30 cm high on heavy duty castors. 12 required.
Adjustable Height Rollers:	10 cm dia x 1.5 m wide 4 required
Turn over ring clamps:	See sketch. 2 required

16. Power Tools

Electric tools required are:

Electrical circular hand saws	2 x 25 cm Ø 1 x 48 cm Ø; 1 x 75 cm Ø
Hand routers	2
Electric hand planers	1 x 10 cm wide 1 x 20 cm wide
Electric drill	1 x 2 cm Ø

Suitable brands include, Stanley, Black and Decker (England), Maffel (Italy), Makshukiti (Japan). All these are reliable, reputable brands.

Pneumatic tools

Two pneumatic impact wrenches are required, either Ingersoll Rand or Atlas Copco (Sweden).

Weighing Scales for glue mixing

Either platform or hanging scales are suitable. They should read 25 kg x 100 gm

17. Tilt Hoist

This can be purchased from the manufacturer of the blanking planer as a package which includes the hoist, fast feed table and planer.

Testing Machine and Compressometer

A laboratory precision testing machine is not required. A suitable machine could be manufactured around a 2 ton hydraulic jack, and the load read either from the hydraulic oil pressure, or preferably from an electronic load cell. A compressometer is required for checking the torque-tension relationship of the clamping bolts. This can be either hydraulic or electronic. If both testing machine load cell and compressometer are electronic then one amplifier can serve for both applications.

Machinery

The required machinery is summarized on the attached list.

Labour

The labour rquired is as follows:

Planer	1
MSG	1
Defecting	4
Stacking from defecting	2
Fingerjointer	4
Thicknesser	1
Laminating	3
Finishing	2
Glue mixing	1
Knife grinding	1
Fitter	1
Foreman	2
TOTAL	23

The location of each worker is shown on the main layout drawing except for the fitter and foremen who will be moving about. In fact the fitter will probably be attached to the central workshop and his inclusion in the labour list is merely an indication of the amount of maintenance effort that should be applied to a factory of this degree of mechanization.

The organization of the labour falls into two major divisions

= 1 Wood preparation - up to the stacking of planed, graded shorts ready for fingerjointing

2 End jointing and laminating - completion of production

Each of these requires a foreman for the supervision of processes. Each section subdivides further into production teams

Wood preparation = Planing and MSG
Defecting and stacking

End jointing and laminating = FJ team
Surfacing gluing and laminating team
Finishing and wrapping team.

It is not intended that these should be rigid divisions and depending on what type of work is being undertaken, some variation of personnel will occur. Thus during effort of assembling a very large laminate the FJ team would join the laminating team, the glue mixer likewise

will be free much of the time to assist in either surfacing or laminating etc. and the finishing team will frequently require assistance to move large members through the surfacer.

Because of the wide range of work which passes through a glulam factory it is not possible to be absolutely specific as to production jobs in the laminating section, but the wood preparation section is fairly routine.

Responsibilities here are:

Blanking Planer Operator

Controls infeed conveyor, tilt hoist, feeds planer, ensures there are no conveyor jams down to outfeed spiral rolls.

MSG Operator

Ensures even spaced flow to MSG, supervises operation of machine, including freedom from jams, maintains dye containers, ensures nozzles spray correctly. Maintains conveyors to defecting line infeed functioning correctly. Supervises fullness of waste bin.

Defecting Sawyers

Square trim ends, if excessive planer skip return boards to defecting line, remove defects indicated by MSG, cut to grades indicated by dye sprays.

Stackers

Sort defected timber into grades and rejects, stack on pallets.

Fork Lift Truck Driver

Moves pallets from stackers to storage. Moves pallets from storage to FJ. Also moves completed members for laminating and finishing teams.

Finger Jointer

Feeds FJ machine, checking grades fed in. Maintains glue level, arranges cutter sharpening as required.

Finger Jointer Stackers

Stack freshly FJ boards, examine FJ's for quality, remove unsatisfactory joints for remanufacture. Tally output to correspond to orders. Move stacks from FJ to curing area.

Thickness Operator

Thicknesses cured FJ laminates as rsquired for laminating. Operatss surfacer for finishing work.

Glue Mixer

Prepares glue for FJ and laminators, cleans glue pots from FJ, operates glue spreader and cleans it. Responsible for cleanliness of glue room and gluing equipment. Will assist laminating team as required during lay up.

Laminating Team

Lay up members, tighten clamp bolts, move oompleted members from jigs to handling equipment.

Finishing

Arris corners, trim ends, surface wide faces of finished members, assistsd as necessary by laminating team. Hand plane edges of finishsd members, wrap and pack. Prepare QC samples for testing.

Knife Room

Maintain planer knives, FJ cutters and TCT saws. Set up planers and joint knives.

Administration

Personnel required are:

Manager

Responsible for overall operation and supervision of factory.

Materials Clerk

Prepares orders for timber, glue, spare parts, wrapping materials etc. Arranges dispatch of finished work.

Technician

Plans production techniques for complex work, i.e. disposition of different grades, end joints, set out of curved work. Undertakes quality control, tests rate of glue spread, tests fingerjoint strength and lamination bond quality.

Personnel Clerk - Accountant

Keeps personnel records, arranges pay, costs incoming materials, labour content, prepares cost data for quotation purposes and for invoicing, supervises preparation of invoices if done elsewhere.

Note: Detailed designs ars supplied by ths structural engineer and include data on grade, placement, glue type etc.

Interior Transportation

Mechanized transport has been used to the maximum extent possible consistent with provision of visual inspection and maintenance of flexibility in the production end with its widely differing requirements from job to job.

Mechanical transport eliminates labour but it also removes opportunities for inspection. Therefore in this factory it is proposed to use a maximum of mechanical transport up to the stage where inclusion of defective material beoomes detrimental to the final product.

A complete mechanical handling system has been designed up to ths end of the defecting line. From there on the wood is handled pieoe by piece into or out of bulk storage to give maximum opportunity for the elimination of defective materials.

Provision for buffer storage has been made at three plaoes in this mechanical handling system to allow for brief interruptions of any of the processes involved. Also the layout is such that in the case of the breakdown of any one machine the remainder of the line can continue to work with hand feeding of parts of it. For example, if the planer is broken down, boards planed elsewhere could be loaded manually on to the table leading to the MSG over the spiral roll case drive. If the MSG is broken down, boards can be lifted off

its infeed table and placed on to the conveyor feeding the defecting line. Details of these points should be designed to allow such operations to proceed safely and easily.

The list of conveyors with their construction, speed and power requirement is attached.

Waste Conveyors

Waste will be produced in solid pieces from the defecting line and the finishing end. It will be produced as shavings or sawdust from the various planers and saws.

A solid waste system of two belt conveyors feeding to an outside bin has been shown. It is recommended that special arrangements need not be made for the finishing end since the volume is small and the pieces relatively large. Solid waste produced here can be barrowed to the defecting line waste conveyor and sawdust and shavings either swept up or vacuumed into the pneumatic shavings system.

The three planing machines and the defecting saws will produce a large volume of fine waste, too much to be economically handled manually. A pneumatic waste system mounted in the roof will be required. This cannot be designed until the planing machines are chosen as the hood characteristics will effect the air flow.

For preliminary purposes only, an allowance of 30 KW fan power, and a 60 cm main duct should be made. Detailed design of the exhaust system should be done by a specialist. Machines which will require connection and number of connections are:

Machine	No. of Connections
Blanking Planer	5
Defecting saws	4
Ripsaw	1
Thicknesser	2
Fingerjointer	1
Surfacer	1
Finishing area floor sweep	2

The flow of timber and type of waste produced, based on production of 15 m^3 per day are as shown in the following diagram.

Operation	Volume of material m^3	Volume of waste - m^3	% of waste of incoming material
Sawn timber in			
↓	26.3		
Blank		5.6	21.3
↓	20.7		
Defect		4.1	20
↓	16.6		
Fingerjoint		0.1	0.8
↓	16.5		
Surface		1.0	5.7
↓	15.5		
Laminate		0	0
↓	15.5		
Finish		0.5	3.2
↓	15		
Laminated products out			
Totals		11.3	42.9

Note: Volumes and percentages rounded to 0.1

Other Handling Equipment

A small forklift truck is required to:

Move packets of timber from dry storage to planer infeed chain;

Move packets of defected timber from defecting line to storage;

Move packets of timber from storage to finger jointer;

Help move finished laminates to finishing area and outside for dispatch;

Handle drums of glue.

A machine of about 3000 Kg capacity is required.

Trolleys have been listed as production equipment under item 15 of machinery.

Services

Until machines are finally decided and architectural plans completed the electricity, compressed air and other requirements can only be estimated. The preliminary estimates for electricity and compressed air are:

Item	Description	Est. KW	Compressed Air - litres/sec
1	Planer	77	2
2	MSG	3	2
3	Defecting Saws	15	5
4	Fingerjointer	30	12
5	Thicknesser	13	
6	Glue Spreader	1	
8	Surfacer	30	
9	Gantry crane	10	
11	Glue mixer	1	
12	Rip saw	3	
13	Knife grinder	2	
14	Cutter grinder	1	
16	Power tools - total	15	15
17	Tilt hoist	3	
-	Water heater	3	
-	Conveyors - total	16	15
	Total	223	51

Water

Industrial Use: Mainly wash up water for glue equipment.

Hot Water: 150 litre boiler
Cold Water: 500 litres per day
Drinking and sanitary water

Allow 40 litres per person per day

Total staff = 28
Volume of water = 28 x 40 = 1120
Total volume of water say 2000 litres per day

Steam

Apart from central heating, steam will only be required to heat laminations during curing. This will be required during approximately 16 hours out of 24 at the rate of 200 Kg per hour, or 3200 Kg per day.

Tools

Hand tools are required for:
Machine adjustment
Finishing and laminating
Emergency repairs and maintenance

Major machines are supplied with the necessary tools for adjustment and a large proportion of these are also useful for maintenance.

Hand tool requirements in addition to those supplied are:

Laminating:

2 x handsaws
4 x carpenters hammers
1 x 4 Kg hammer
2 x 30 cm long adjustable spanner

Finishing

1 x handsaw
2 x carpenters hammers
2 x chisels 12 mm
2 x chisels 25 mm
2 x handplanes
2 x rebate planes
2 x measuring rules or tapes = 1 m
1 x steel tape 20 m
1 x square 60 cm x 40 cm
2 x carpenters penoils
1 x oil stone
2 x nail sets
4 x paint brushes

Emergency Repairs

1 x adjustable spanner 60 cm long
1 x adjustable spanner 40 cm "
2 x adjustable spanner 30 cm "
Hacksaw and blades
Pipe wrench 40 cm "
1 x set cold chisels
3 x files
1 x pliers
1 x valve tongs
1 x set hexagon keys
1 x 15 cm vice opening to 20 cm

Maintenance

1 x dial gauge 0.01 mm with magnetic stand
1 x micrometer set - 15 cm
1 x precision protractor
2 x large grease guns

The knife room is the usual place for these tools to be stored. They should be on a shadow board over a substantial bench.

Laboratory

The laboratory must be equipped to perform the following tests:

Moisture content
Strength of finger joints
Cleavage of lamination samples
Weight of glue spread
Tension in clamping bolts

The equipment required for these tests is:

Electronic moisture meter, either resistance or power loss type;
Simple testing machine for breaking samples in bending.

This has already been discussed in the Section - Selection of Machines - as was the compressometer.

Laboratory balance 100 gm x 0.1 gm
Small electronic calculator
Vernier calipers, 20 cm x 0.1 mm
Hammer, 30 mm chisel
Bench, desk, chair

Storage

There are various materials delivered to the factory which require storage. Many of the bulkiest items are not "attractive" and can therefore be stored in the factory itself. These include:

Glue in drums
Hydraulic oil in drums
Hardener in paper sacks
Wrapping paper in rolls
Strapping in coils
Cutting oil in drums

The following items require secure storage

Grinding wheels
Tins of grease
Nails
Power tools
Hand tools

The knife room can be regarded as semi-secure, but it should contain several lockers, both for security and good housekeeping.

In addition a large tool and material locker should be provided in the finishing area.

Covered storage need not be provided for finished laminations. Provided they are suitably wrapped they can be stored in the factory yard for weeks if necessary until dispatch.

Covered storage may be required for incoming dry timber. The need for this depends on the arrangements made between the kiln drying dept and the glulam factory. If daily deliveries from the kilns are not made, then dry storage will be required. The most convenient way of providing this is to extend the factory roof and side walls one bay beyond the end wall at the planer end, but leave the end wall as shown on the drawings.

Wrapping and Packing

Finished glulam requires to be protected from the weather and from damage in transit. This requires protection of corners and wrapping with waterproof paper.

Dunnage for protecting corners can be converted from reject timber from the defecting line on the small rip saw.

Wrapping paper should be heavy kraft with a waterproof plastic film on one surface.

Steel strapping will be required to hold the dunnage to the finished glulam, also industrial grade adhesive tape to complete the wrapping process.

The estimated quantities of materials for wrapping per day are:

Timber, mostly 10 cm x 2 cm	0.8	m^3
Wrapping paper	80	m^2
Strapping	30	m
Nails	2	Kg
Adhesive tape	50	m

Sanitary Facilities

WC's	1 per 5 men	6
Urinals	1 per 4 men	7
Handbasins	1 per 3 men	10
Towels	1 per 2 handbasins	5

CONVEYORS

	Description	Material	Length	Speed m/min	Remarks	KW
1.	Packet infeed to tilt hoist	3 strand C111 chain	7	4	Manual control	7.5
2.	Outfeed from tilt hoist	3 strand H78 chain	3.5	10	Manual control	.75
3.	Fast feed to planer	Spiral rolls	6	30		.75
4.	Planer outfeed	30 cm belt	2	30		)
5.	Spiral roll transfer	6 spiral rolls	4	30		).75
6.	Transfer table to MSG	3 strand H78 chain	3	5	Waterfall at end	.38
7.	Infeed to MSG	10 cm belt	8	40		)
8.	Outfeed to MSG	10 cm belt	6	40		)
9.	Transfer table to return conveyor	3 strand H78 chain	2	5		).75))
10.	Return to defecting line	30 cm belt	22	25		)
11.	Spiral roll transfer	6 spiral rolls	4	25		).75))
12.	Defecting line	3 strand H78	12	3		.75
13.	Waste collecting conveyer from saws	30 cm belt	13	20		)
14.	Waste outfeed	30 cm belt	27	20		).75)
15.	Defecting saws roller benches	5 cm dia. x 40 cm rollers	4.5	-	4 required	
16.	Mobile slat conveyers	See sketch	5.6		5 required	2.5 total

MACHINERY LIST

Major Machines

Tilt Hoist:	3 Knee x 4 m long.
Planer:	30 cm x 10 cm 5 heads long bed e.g. Wadkin 12 FDF 300.
Machine Stress Grader:	Plessey "Computermatic".
Defecting Line:	Movable arms. 3 arms on shaft, skate wheels on top about 1 m long. Pneumatic 2 position lift - 4 sets.
Defecting Saws:	Rising cross cut saw, 30 cm blade with top knee or foot operated. Pneumatic stroke e.g. Wadkin 12 BCW 400. 4 required.
Fingerjointer:	Capability 10 joints per minute in 30 cm x 5 cm, e.g. Cook-Bolinder.
Thicknesser:	Top and bottom head, short bed 30 cm x 10 cm, e.g. Wadkin 16 BFR 2 (500). Mounted on rails.
Surfacer:	Single head short bed 180 cm x 40 cm, mounted on turntable.
Gantry Crane:	5 tons x 17 m.
Laminating Jig: (Large)	40 m x 2 m wide x 90 cm high.
Laminating Jig: (Small)	15 m x 1.0 m wide x 1 m high.
Glue Mixer:	Baker's type 15 - 20 litre, 2 speed.
Rip Saw:	25 cm, table type - for cutting QC test specimens.
Knife Grinder:	180 cm.

Cutter grinder for F.J. cutters and saw blades, e.g. Stehle

Triangular trolleys: 1 m x 30 cm high on heavy duty castors
12 required.

Adjustable height Rollers: 10 cm dia x 1.5 m wide - 4 required

Turn over ring-clamps - see sketch 2 required.

Glue spreaders: Ribbon spreader, see sketch. 2 required.

Minor Equipment and Power Tools

Electrical circular hand saws	2 x 25 cm ø 1 x 48 cm ø 1 x 75 cm ø
Hand routers 2	
Electric hand planers	1 x 10 cm wide 1 x 20 cm wide
Electric drill	1 x 2 cm ø

Pneumatic impact wrenches - 4 with extended sockets

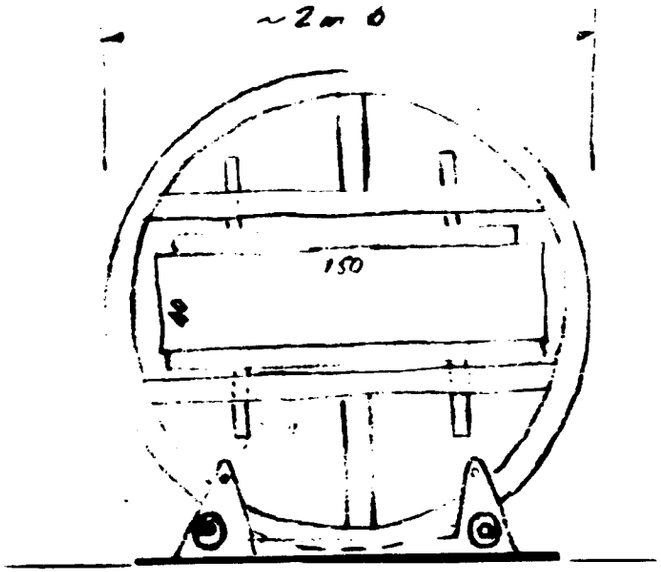
Weighing scales - 25 Kg

Compressometer - hydraulic or electric type for through bolt

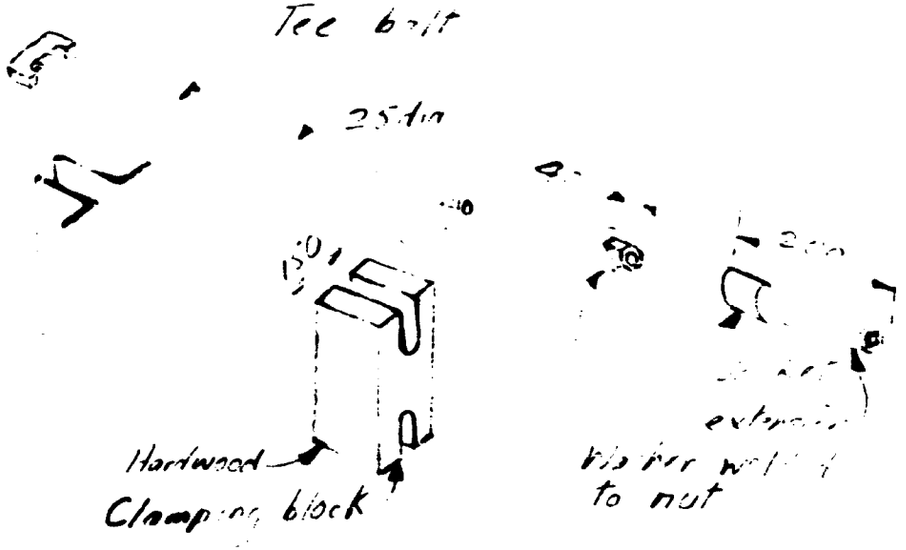
	Length	Quantity	Diameter
T Bolts	2 m	200 x	25 mm
	1.6 m	400 x	25 mm
	1.2 m	400 x	25 mm
	1 m	160 x	25 mm

Long nuts with washer attached 600

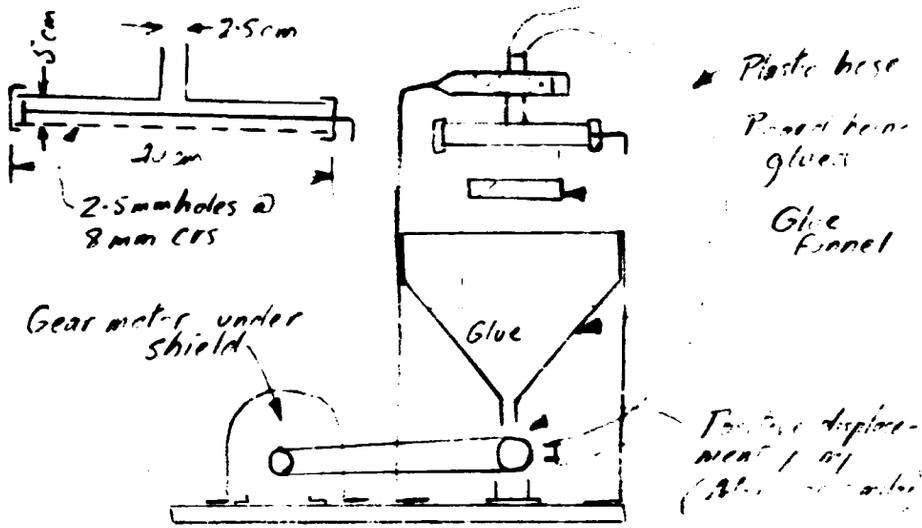
Packing blocks as required.



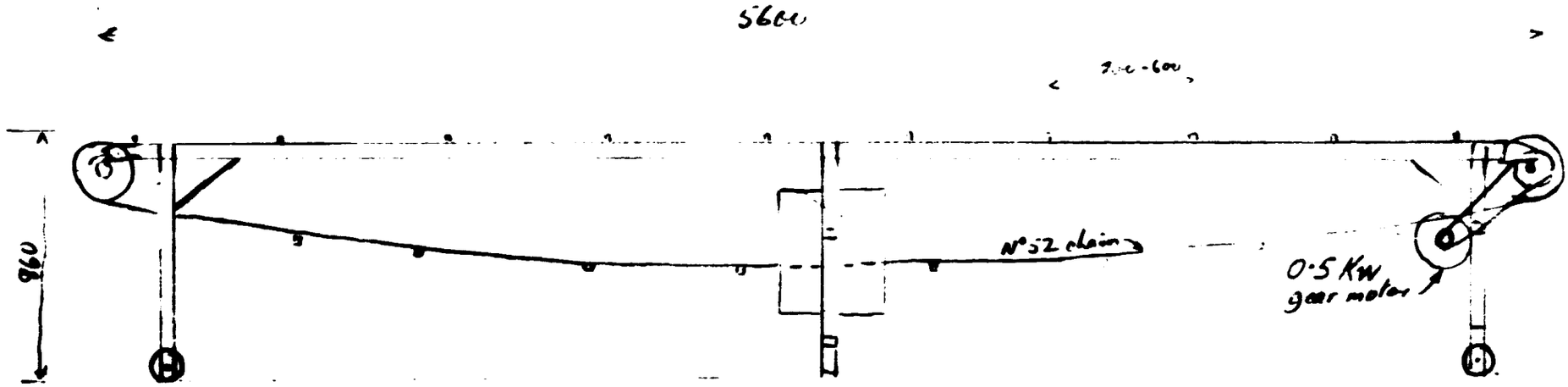
Turn over ring-clamp



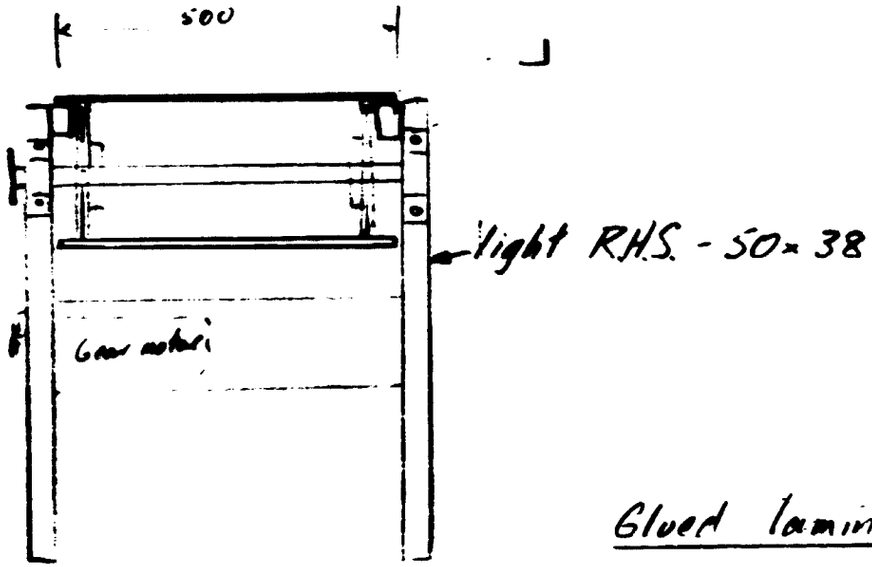
Clamping equipment



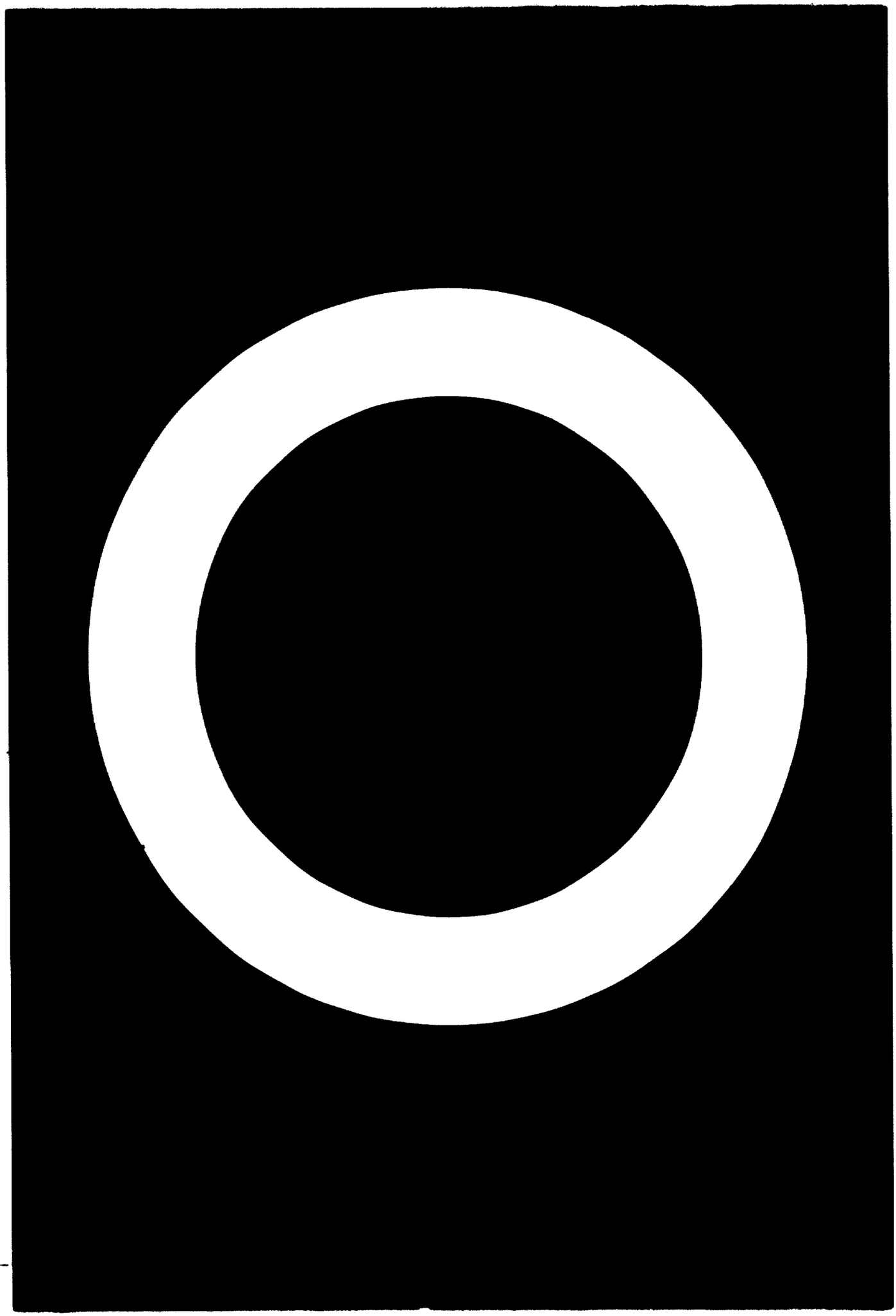
Ribbon Spreader

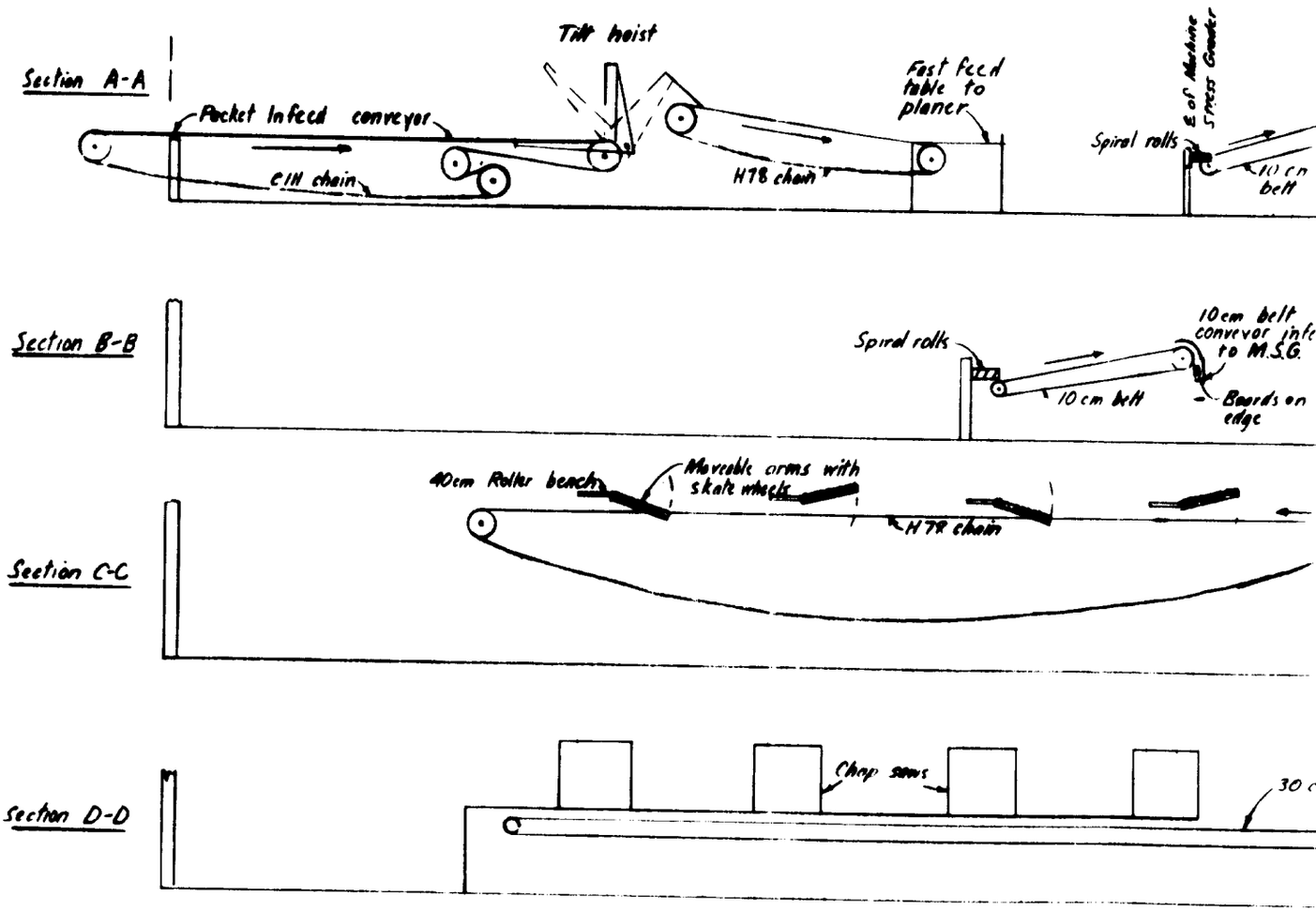


Elevation



Glued lamination conveyor





KRIVAJA - PROPOSED GLULAM

CROSS SECTIONS · SCALE 1:5C

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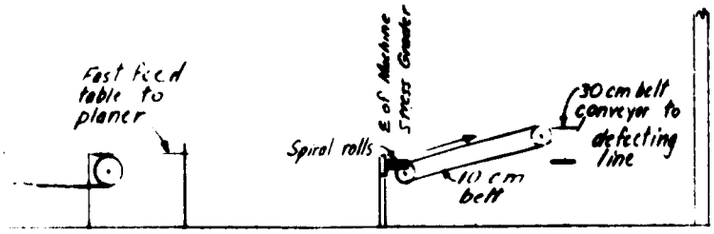
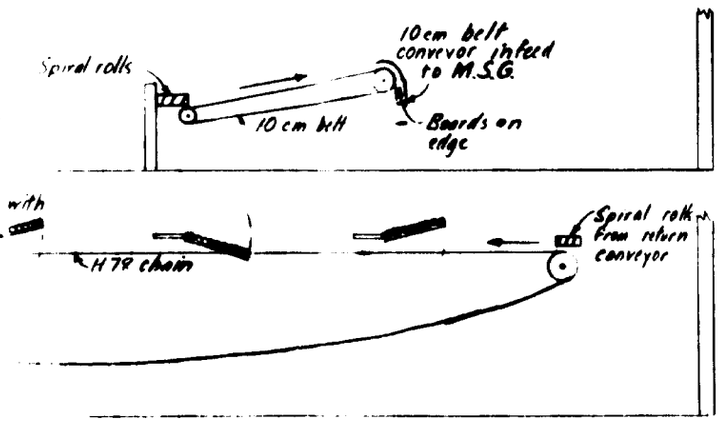
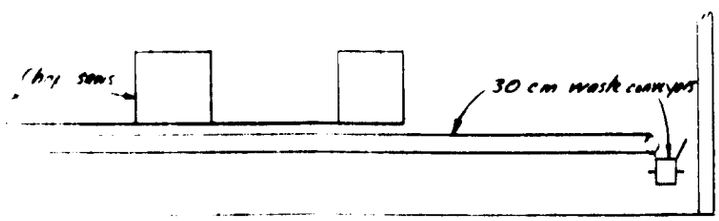
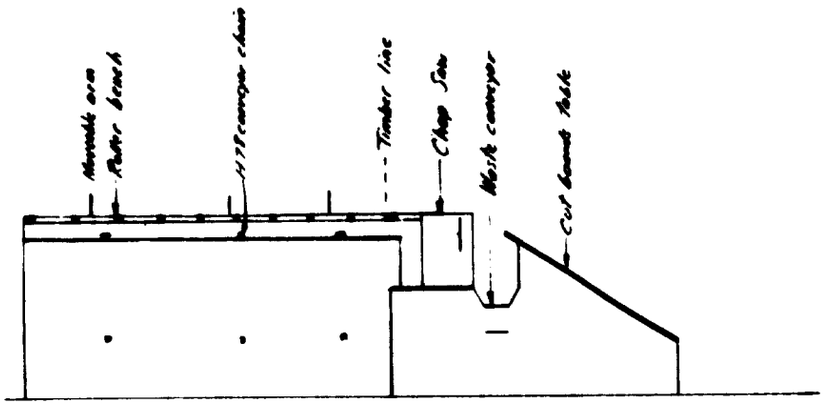








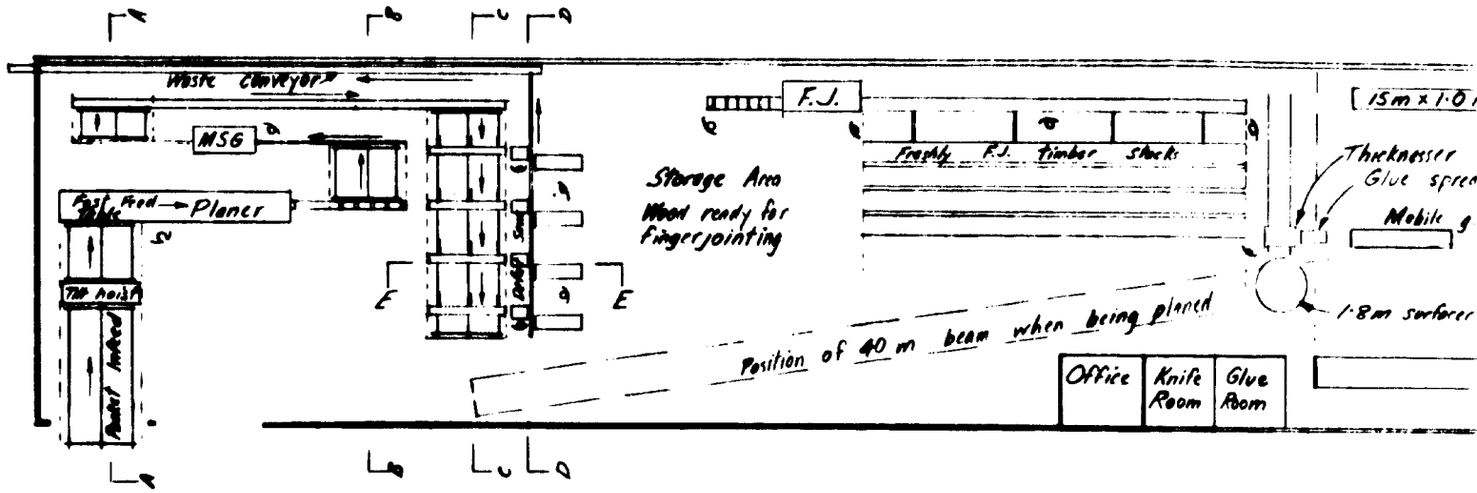
Section E-E

AJA - PROPOSED GLULAM FACTORY

SECTIONS - SCALE 1:50

24-10-77

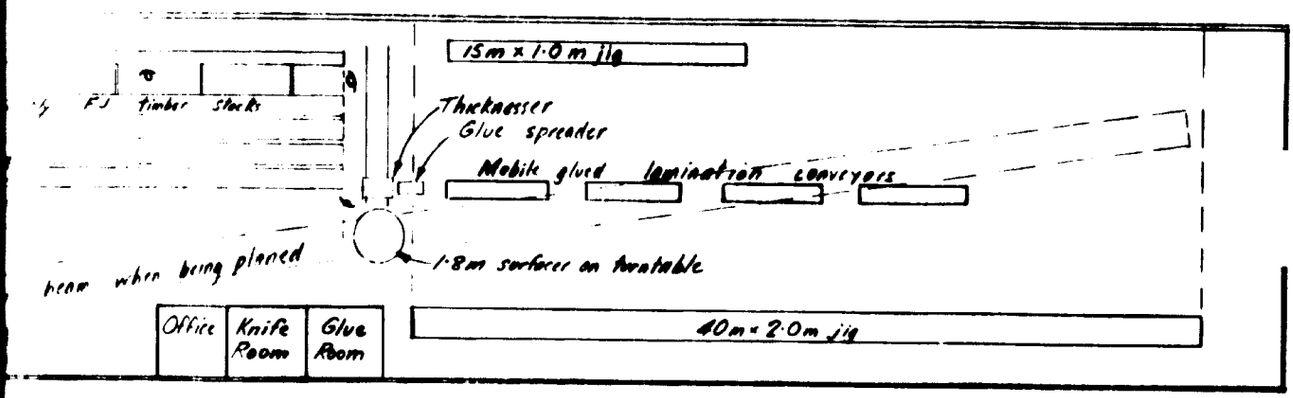
[redacted]



KRIVAJA - PROPOSED GLULAM FAC

PLAN Scale 1:200

24-



ROPOSED GLULAM FACTORY

: 1:200

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ANNEX V

INTERNATIONAL
TRUSS PLATE ASSOCIATION

SYSTEM OWNERS

Truswal Systems Ltd.,
2, Cheapside,
Reading,
Berks. RG 1 7AA — Reading (0734) 595518

Thomas Simson & Co. Ltd., (Structiomatic)
Simson House,
West Hill,
Oxted, Surrey RH8 9HU — Oxted (08833) 7551

Hydro-Air International Ltd.,
U-K. Branch, Colston House,
London Road, Loudwater,
High Wycombe,
Bucks. HP11 1HR — High Wycombe (0494) 34006

Beves Manufacturing Ltd.,
Harbour Way,
Shoreham-by-Sea,
Sussex, BN4 5HS — Shoreham-by-Sea (07917) 4411

C.P.C. Ltd., (Panaplate)
Fircroft Way,
Edenbridge, Kent. TN 8 6EL — Edenbridge (073271) 5371/3

Automated Building Components Ltd., (Gang Nail)
The Trading Estate,
Farnham, Surrey, GU9 9PQ — Farnham (02513) 22425

TCT Engineering (Trans-Canada),
Campeau Corporation,
Industrial Estate,
Sandwich, Kent. CT13 9LY — (03046) 3705

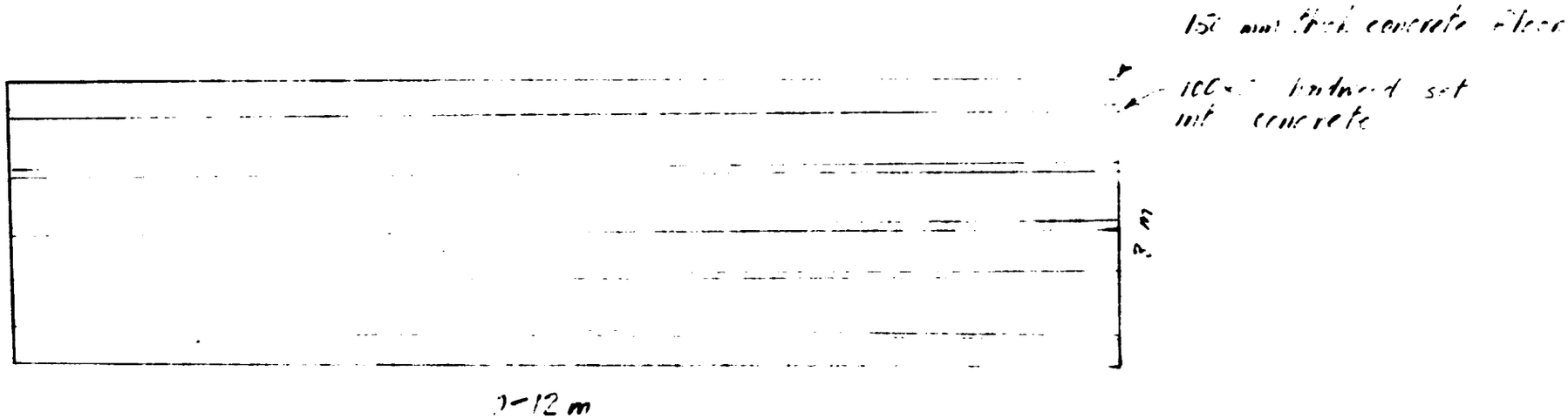
U.B.M. Structural Services Ltd. (Twinaplate)
Garras Wharf,
Truro,
Cornwall. TR1 1QX — Truro (0872) 4671

Automatic Pressings Ltd. (Bat-U-Nail)
Halesfield Industrial Estate,
Telford,
Shrops. TF7 4LD — Telford (0952) 586193

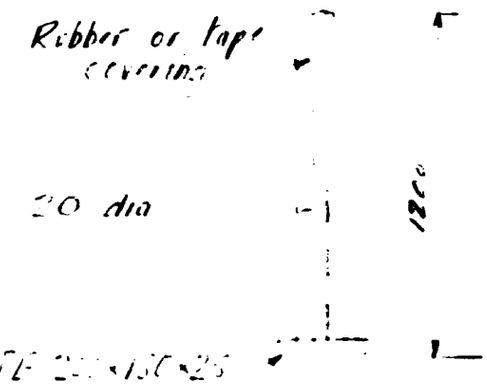
Bostitch Sofrembal,
112 Avenue Charles du Gaulle,
91420 Morangis,
B.P. 24 France.

A. B. Traforband,
Box 24,
S-570 40 Anaby,
SWEDEN

ANNEX VI



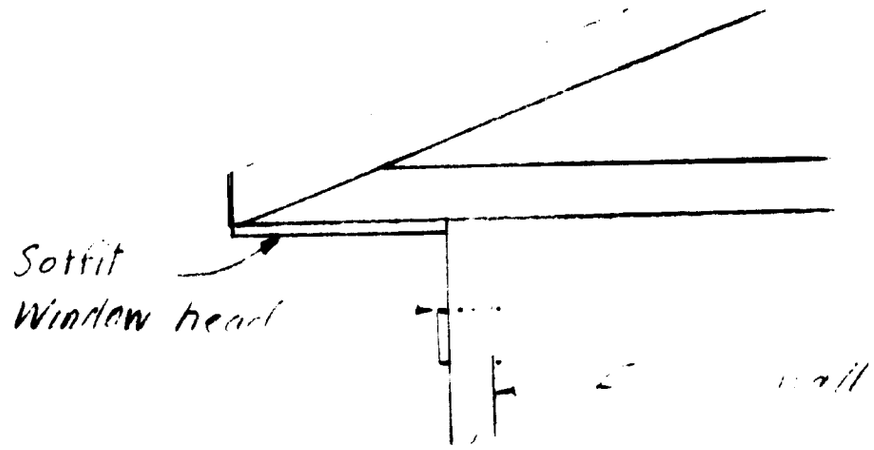
CONCRETE SQUARE PIT

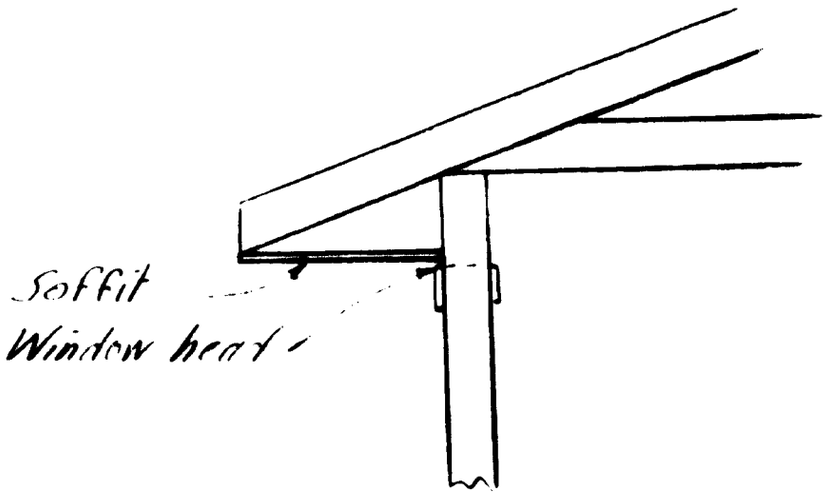


MANUAL TOOTHED PLATE SPLICE FOR PLANT RACK

Sketch - Not to scale

ANNEX VII
PROFILES FOR EAVES ROOF TRUSSES





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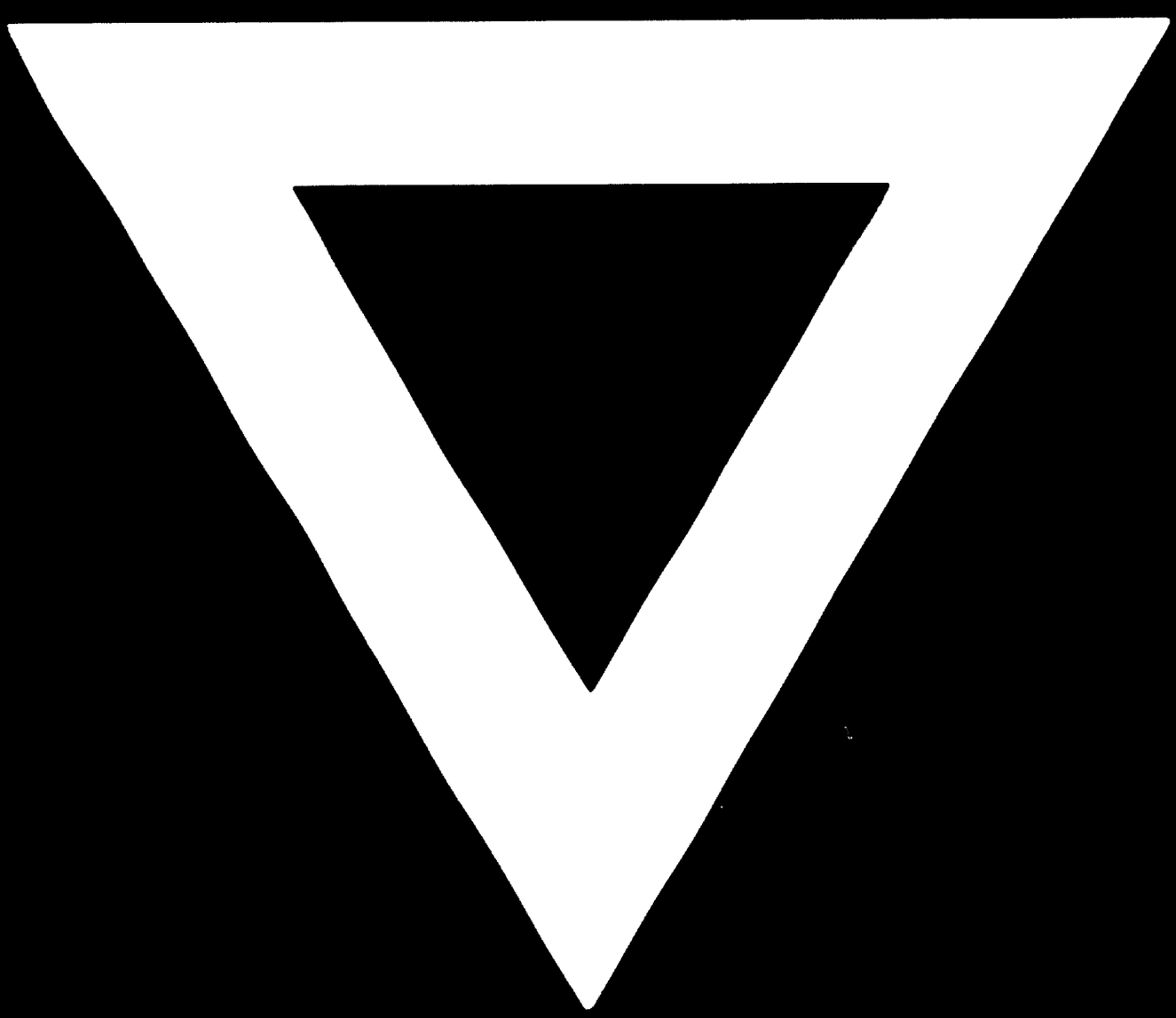

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