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LOW-COST MODULAR PREFABRICATED WOODEN BRIDGES

DP/BHU/84/010

BHUTAN

Technical report: Preparatory mission for the introduction of the UNIDO modular bridge system and project document *

Prepared for the Government of Bhutan
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Harald Erichsen, Forest Industries Consultant (specialized in UNIDO bridges)

United Nations Industrial Development Organization
Vienna

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BASIC DATA

Exchange rate February 1985: $US 1.00 = Nu 12.20 (UN rate)

Ngultrum in par with Indian rupee (Rs)

Monsoon season: May - October, heaviest rainfalls July - September

Season to construct abutments: November - March

Gasoline Nu 6.30 per litre

Diesel Nu 3.30 per litre

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Lhuntai

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Tashigan

Dasho Dzongkhag

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Thimphu

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Introduction

The demand for bridges on the rugged territory of Bhutan is high, and will increase with the growing network of roads, secondary or feeder roads, and forestry or agricultural roads.

There are various successful bridge designs in use, especially for spans of more than 30 metres. Pedestrian bridges are usually of the suspension bridge type, whereas motorable bridges are either of reinforced or pre-stressed concrete or of the well known "Bailey" type.

UNIDO has designed a low-cost modular prefabricated timber bridge for short spans of up to 30 metres, designed for employment on secondary or feeder roads, with a maximum load capacity of 36 tons. This design has proven its viability in various countries on the way of development, where the use of local materials (timber) has helped to economize foreign currency.

The Government of Bhutan has requested the implementation of a demonstrative project, with the purpose to introduce, and vulgarize this bridge system in order to complement the existing designs in the short span range.

The Public Works Department (PWD) as the official Government counterpart institution has conducted a preliminary survey, which stated a present demand of 120 bridges of this kind in Bhutan.

As a result of the request from the Government, Mr. Harald Erichsen, a UNIDO consultant, specialized in the UNIDO bridge design, and the implementation of pilot projects, undertook a three-week preparatory mission to Bhutan (9 - 27 February 1985).

The findings of his mission were positive, and it is proposed to implement a one-year demonstration project in Gaylephug, starting in 1985, with the aim to construct 10 UNIDO bridges on the national territory, and to prepare the workshop for series production of these bridges.

Due to the positive aspects of the proposed project, an Advanced Authorization was signed for the employment of IPF funds, in order to secure a fast implementation.

This preparatory report contains therefore not only the mission findings and the project document, but also the practical aspects, and preconditions necessary for a fast implementation of the project in Bhutan.

1. The timber

Bhutan's rich timber resources, about 70 per cent of the country are covered with forest (even though only a considerably lower percentage is accessible for timber exploitation) comprising many timber species which are suitable for the construction of UNIDO bridges.

There are a great variety of hardwood species, especially in the lower parts of the country, with coniferous forests in the higher parts. The timber selected for UNIDO bridges should as far as possible comply with the following ideal conditions:

- Good mechanical properties for medium heavy constructions.
- Good natural durability to resist fungus and/or insect attack without chemical treatment, or:
  Good impregnation qualities (in an autoclave with salty preservatives). This treatment would then render the timber resistant.
- Little shrinkage, and good dimensional stability during the drying process.
- Medium density of 500 - 800 kg/m^3 at 15 per cent moisture content.
- Good workability, especially in respect to nailing (it should not split).
- Sufficient availability (abundance).
- Straight grain, and availability in sufficient dimensions to obtain clear boards of 3.5 m length and a minimum width of 25 cm without sapwood.

As already pointed out, the occurrence of the different species is highly dependent on the altitude.

The specific properties of Bhutanese timbers are not yet well known, and until various samples of the same timber species taken from various locations are tested in a timber laboratory, one can only judge their suitability for the construction of UNIDO bridges from comparable areas (e.g., Peshawar/Pakistan).

It is therefore suggested to start the project with hardwood species, and to switch at a later stage, and after respective tests to coniferous species, which are normally faster growing, and are therefore by far more "renewable" than slow growing hardwood species. This would also be in line with the Government's careful and wise forest policy.

1.1 Timber species

Some of the deciduous species, suitable for the construction of UNIDO bridges in Bhutan are:

OAK (Quercus spp. - especially Q. griffithii)
KATUS (Castanopsis spc.)
SIRIS (Albizzia lebbek)
PHAMFAL or KAWLA (Machilus edulis)

Whereas Quercus and Castanopsis from the Gedu area are often encountered with big "grub holes" caused by insect attack, these species can be found in other areas (Wangdi Phodrang, Tongsa) in rather good qualities. Machilus is not much known yet, but it is abundant, and readily available in the Gedu area, and occurs in large diameters. Since up to now it does not have any specific used other than for firewood, and because it appears to have good strength characteristics, it should be examined and tried in the construction of UNIDO bridges.

From the various coniferous species, which occur in Bhutan, the best suitable would be:

LARCH (Larix griffithii)

which on the other hand was not seen in abundance during the preparatory mission.

In this context it may be noted that this valuable and durable species should have more priority in the existing reforestation programme (50 per cent commercial species / 30 per cent fuelwood / 20 per cent hardwood species).

The other timber which occurs abundantly, and in excellent dimensions in altitudes between 600 and 1,200 m is:

CHIR PINE (Pinus roxburghii)

Its mechanical properties are superior to those of BLUE PINE (Pinus wallichiana), the other important, and abundant pine species of Bhutan (in altitudes of about 2,500 m), which will be too light and soft for the construction of UNIDO bridges.

CHIR PINE has an average weight of 600 kg/m^3 when air dry. The timber is easy to season, and moderately easy to saw and work.

Strength data for air dry timber (Pakistan Forest Institute, Peshawar):

Modulus of rupture	774 kg/cm^2
Modulus of elasticity	128,451 kg/cm^2
Maximum crushing stree parallel to grain	536 kg/cm^2

This timber should be tried and tested for its suitability during the UNIDO modular bridge project. It may in the future become the principal "renewable" construction material for UNIDO bridges in Bhutan. Large stands were encountered during the preparatory mission on the Lhuntsi-road close to Mongar, and in the Limetang area west of Mongar. Other good stands are reportedly encountered on the road from Tongsa down to Gaylephug in the area north of Shemgang.

Whereas FIR (Abies spp.) and SPRUCE (Picsa spp.) species are abundant in altitudes of about 2,500 m (Paro, Thimphu, Bhumtang, etc.), and occur in good dimensions, they are not durable under exposed conditions, and they are difficult to treat in pressure tanks.

PINES (Pinus spp.) on the other hand are usually easy to treat with preservatives, and can then have a great variety of exterior uses such as constructions, fence posts, electricity poles, sleepers, etc.

1.2 Timber specification for the project

This specification comprises the timber for the construction of 10 single lane, motorable UNIDO bridges with an average span of 15 m (4-truss construction), and to add 10 - 15 per cent for security.

The specification given on page 6 already includes this additional quantity.

All timber should be truly sawn, and it should be over-dimensioned (normally without surcharge) by about 10 mm in thickness and about 15 mm in width to allow for volume shrinkage during the drying process.

1.3 Timber prices

Bhutanese timbers are grouped in rate classes. The royalties per tree are levied according to the species and the girth measurement. There are six classes ("Special", "A", "B", "C", "D" and "E"-class). CHIR PINE, for example, ranks in "A"-class, LARCH in "B"-class, PHANFAL or KAWLA and KATUS in "C"-class, OAK in "D"-class, which means that will be valued considerably lower than CHIR PINE (about 1 : 4). On the other hand, transport charges - Nu 1.35 / km / ton, and sawing charges, will be higher for OAK, thus more or less levelling the price of sawn OAK timber with that of CHIR PINE timber for example.

Various sawn timber prices were given to the consultant, depending on the location of the sawmill in relation to the logging sites. With the exception of SAL (Shorea robusta), a "Special"-class timber, which in Gedu was quoted at NU 140/cft (Nu 4,900/m^3), the other timber species did not much differ in price, and ranged from Nu 32/cft (Nu 1,120/m3) at the Domkhar sawmill near Bhumtang to Nu 48/cft (Nu 1,680/m^3) at the Evergreen sawmill in Phuntsholing.

After various discussions with the staff of the carpentry shop in Bhumtang, the staff of the Gedu complex, and the Department of Forests in Thimphu, it was considered viable to assume an average price of Nu 50/cft (Nu 1,750/m^3) for timber suitable for the construction of UNIDO bridges, and in the required specification, put at the bridge workshop site.

The founded calculatory timber costs for 10 bridges will therefore be: 170 m^3 at Nu 1,750/m^3 = Nu 300,000 (or Nu 2,000/rm of bridge).

1.4 Timber drying

All timber received should be stacked orderly in flat stacks at the workshop site for air drying during 3 - 5 months. For practical purposes and later accessability each stack should only contain timber of the same dimension. It is advantageous to construct a timber shed with open walls for air flow of about 300 m^2 (e.g. 10 x 30 m) for correct air drying.

Dimension (mm)	Length (mm)	Description of element (see plans)	No. of pieces	Volume (m^3)
50 x 250	3.5	1 T and running boards	850	36
50 x 200	2.5	2 T	800	20
50 x 200	3.5	Horizontal brace	60	2
50 x 150	1.5 (or multiples)	3 T and vertical brace	630	7
50 x 125	3.5	Hand rail and diagonal brace	230	5
50 x 100	3.0	4 T	200	3
50 x 100	4.0	Normal deck	3,500	70
50 x 100	5.0	Special deck	120	3
25 x 150	3.5	Hand rail and vertical brace spacers	150	2
100 x 100	3.0	Hand rail posts and spacers inside module	200	6
150 x 150	2.5	Bottom chord spacers	160	9
150 x 150	3.5	Kerbs	90	7
		Total		170 m^3

The correct stacking of the timber is important (see Figures 1 and 2 on pages 8 and 9), and will have to be supervised by a trained person. The drying process should be monitored at regular intervals with a portable moisture meter. A moisture content of 15 - 18 per cent will have to be achieved, before the timber can be used for the construction of bridge modules.

1.5 Side note (timber)

Almost all bridges, Bailey bridges, suspension bridges, pedestrian bridges (including the elaborate S.A.T.A. design), which the consultant saw during his field trip - concrete bridges excepted - were fitted with timber decks, made of untreated BLUE PINE, sometimes brushed with a coat of diesel, and often covered with asphalt.

It may be easy to use this readily available soft timber, but it is definitely not the appropriate material for bridge decks, as it will deteriorate within a short period of time, in the case of an asphalt cover unconspicously from underneath, which can even be more dangerous. It is suggested to make better use of the available hardwoods, which for these purposes, and to specify their imperative employment for bridge decks, or at lease for the running boards.

2. Steel procurement - specification and prices

Steel is imported from India, and does not have to be paid in convertible currency. This must be considered a great advantage for Bhutan. The February 1985 prices (see page 10) were obtained in Phuntsoling, the most important border city with India, for the supply of the steel quantities and specification required for the construction of 10 UNIDO bridges (standard 4-truss construction) or 150 running bridge metres.

Figure 1. Well stacked sawnwood - end view.

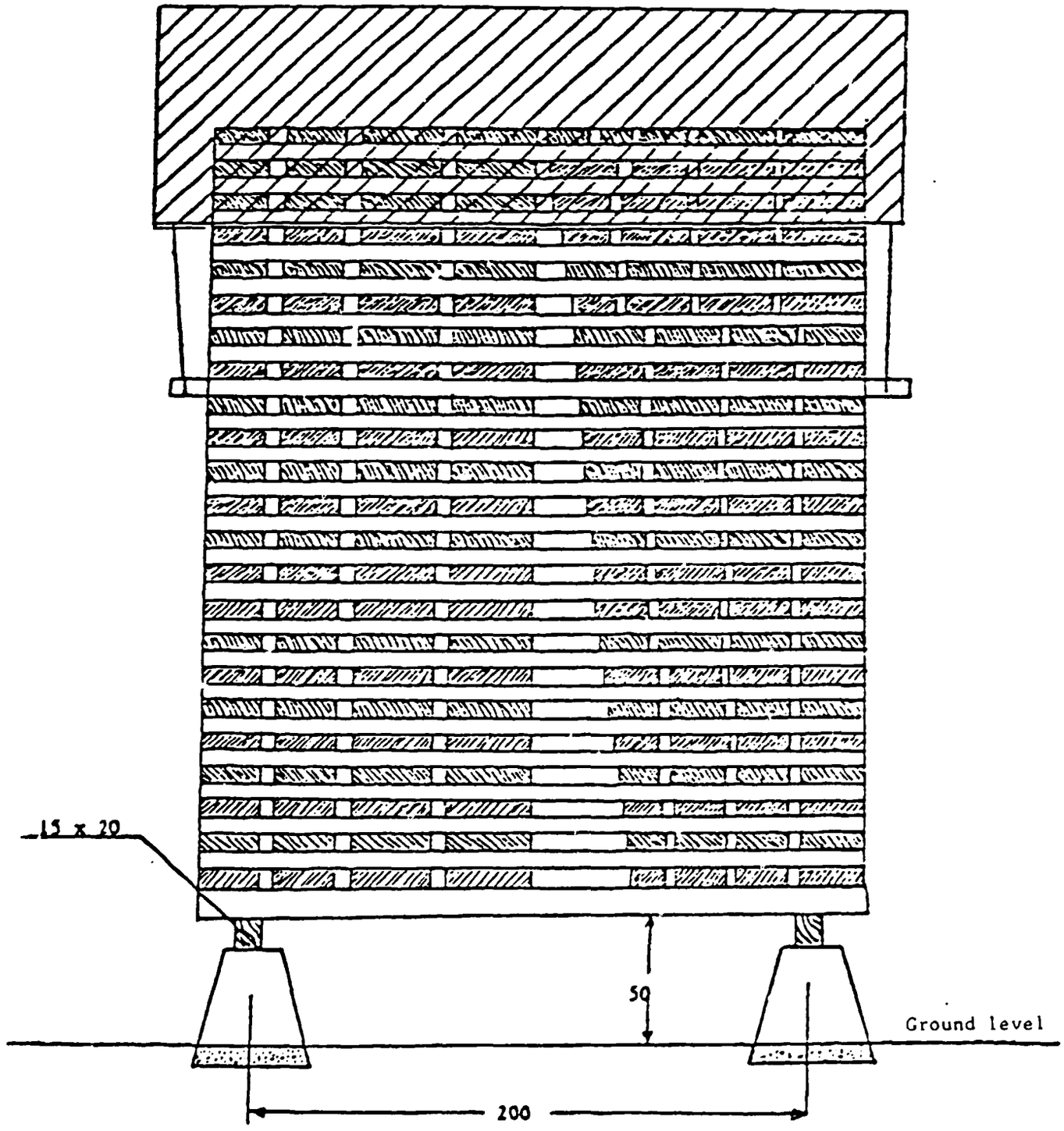
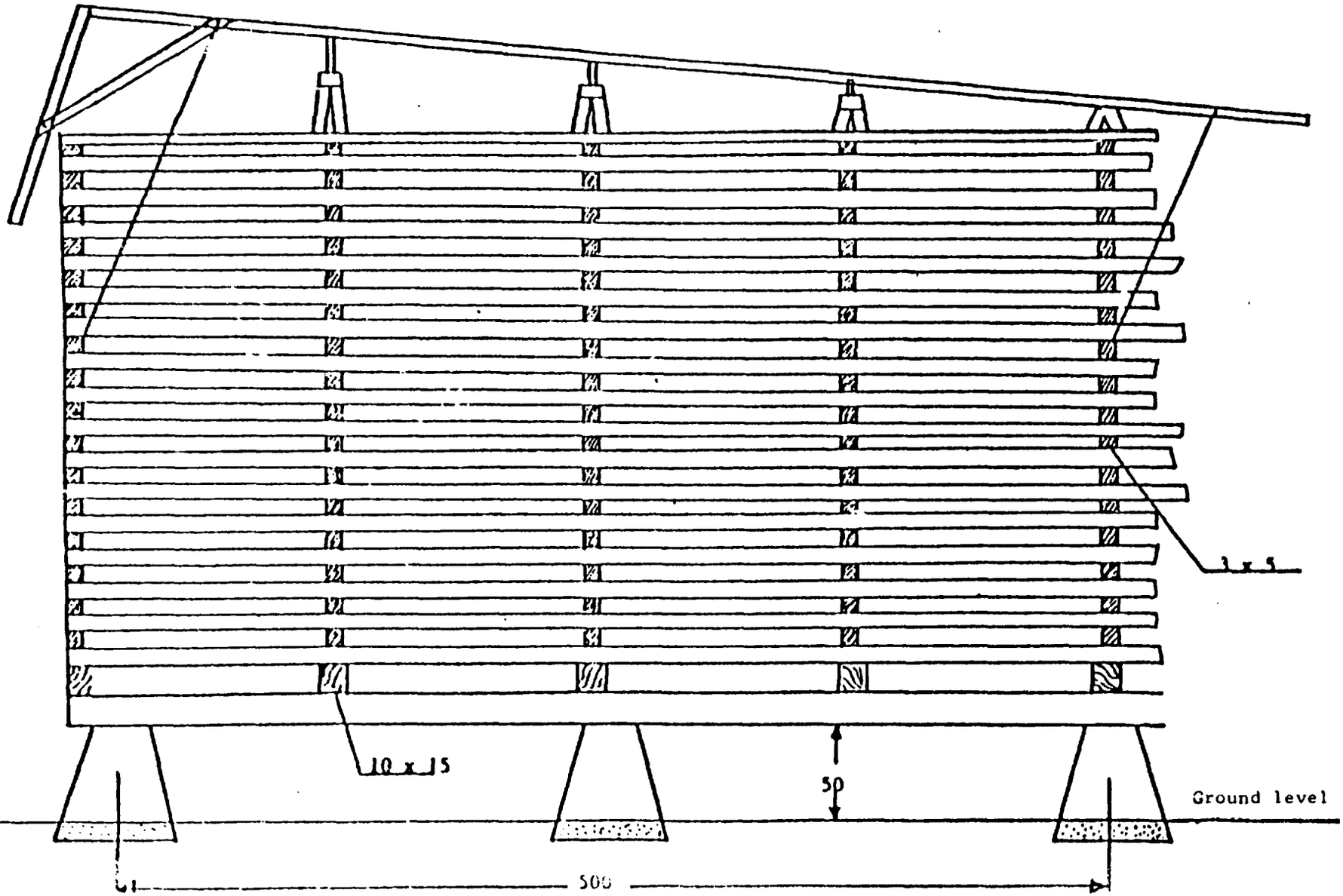


Figure 2. Well stacked sawnwood - side view.



2. Steel procurement - specification and prices (cont'd.)

Specification	Quantity (tons)	Price/kg (Rs)	Price/ quantity (Rs)
8' x 4' MS sheets			
9 mm	5	8.50	42,500
12 mm	3	8.50	25,500
MS strips 6 mm (dimension 3,150 x 150 mm)	10	9.00	90,000
Plain structural steel (diameter 12 mm)	2	6.50	13,000
Round steel bars			
38 mm diameter	0.15	10.00	1,500
50 mm diameter	0.40	10.00	4,000
Nails (100 mm or 4")	2.25	9.00	20,250
Nuts and bolts (see separate specification)	ca. 3.5	9.50	33,250
		Total	Rs 230,000

Specification for bolts (minimum commercial grade), including 1 nut and 2 washers each:

Dimension	Quantity (pcs)
1/2" x 6"	400
x 8"	400
x 10"	300
1" x 2"	400
x 4"	400
x 6"	200
x 7"	100
x 10"	400
x 12"	200

Note:
On 26 February 1985 the consultant received a notice that general steel prices had gone up 15 %. This would bring the total up to about Rs 265,000.

2.1 The steel workshop

A capable steel workshop has been identified in Phuntsoling. It is the BGTS workshop, which is presently supported by a UNIDO project (DP/BHU/81/03), and is sufficiently equipped, and well organized to produce the steel parts for the UNIDO bridge project.

The workshop management confirmed their willingness to supply the required number of steel parts (on a commercial basis), and to also fabricate a chromium steel template for each of the UNIDO bridge steel plates, which would greatly help the precision fabrication of the places in series, and would also be of excellent use, should the parts fabrication later be transferred to another workshop (e.g. Namcha workshop) or on to the bridge workshop itself.

The following parts specification for 10 UNIDO bridges (200 modules) refers to the set of TRADA plans in Annex 3. A full size set, at least numbers S.E. 245 - 0, 2, 3, 4 of the steel parts should be made available to the BGTS workshop, so that they can start production. In the plans only the specification for "heavy construction" should be considered.

Marking in the plans	Plan No.	Quantity (pieces)
Panel plate Mark 9	0	200
" " Mark 9A	0	200
" " Mark 5	0	800
" " Mark 10	0	200
" " Mark 11	0	200
" " Mark 13	0	200
" " Mark 8	4	400
Bridge bearing plate (male)	1	40
Bridge bearing plate (female)	1	40
Panel chord Mark 6	1	320

The costs involved in the production of the steel components can at this time only be estimated from theexperience in similar projects. They will not only contain labour and machine hours, but also additional materials such as welding rods, gas, utilities, replacement of cutting tools, etc.

Total costs of steel components for 10 bridges:

Materials	Nu 265,000
Parts production (estimate)	117,000
Total	Nu 362,000

3. Manpower

Bhutan has, quite unlike other countries on the way of development, a shortage of manpower, and has to fall back on imported labout (e.g. for road construction).

The relatively simple production - and launching process of the UNIDO bridges - requires only a limited amount of manpower.

The bridge workshop will require - apart from an actively engaged counterpart technician/engineer - only 8 persons:

- 2 trained carpenters
- 4 helpers for the carpenters
- 1 skilled welder
- 1 helper for the welder

The launching of prepared sites will also require a group of 6 - 8 persons, under the supervision of the counterpart engineer:

- 1 trained carpenter
- 5 - 7 helpers

Labour costs in Bhutan range from NU 12/day for unskilled labour to NU 20/day for skilled labour (carpenter, welder).

In this report labour costs, including social benefits, etc., are conservatively calculated at NU 50 per manday (M/D).

Experience from other projects shows that 10 UNIDO bridges can be prefabricated, assembled and launched with a labour requirement of 980 M/D. The estimated labour costs are therefore:
980 M/D at Nu 50 = Nu 49,000.

4. Cost calculation for 10 UNIDO bridges and cost comparison

Timber		Nu 300,000
Steel parts		382,000
Labour		49,000
	Total	Nu 731,000
Miscellaneous (about 10 %)		69,000
	Total	Nu 800,000

This figure corresponds to costs of NU 5,330 ($US 437) per running metre for a single lane motorable bridge with a load capacity of up to 30 tons, which compares favourably with the prices of other bridge designs in steel or concrete.

	Approximately	
- Bailey bridge	Nu 25,000	($US 2,050)/rm
- Concrete bridge (single lane) (only superstructure)	Nu 11,000	($US 900)/rm
- Suspension bridge for pedestrians	Nu 2,500	($US 200)/rm
- S.A.T.A. bridge for pedestrians (including abutments)	Nu 2,500	($US 400)/rm

The UNIDO modular bridge design can be easily adapted to Bhutan's requirements of pedestrian bridges by simply cutting the specification in half, and adding one more handrail.

The costs for such a design would then be approximately NU 3,000 ($US 245)/rm. It would have the advantage that it could be converted into a motorable bridge of full value by adding another pair of trusses, if this should be desired.

Pedestrian bridges are most often constructed on strategically important sites, which means that possibly already in the not too distant future they may have to be replaced with motorable bridges. This is, for example, the case on three sites near Bhumtang (Dorjibe, Dur, Doktiba), where recently built 12 - 18 m pedestrian bridges should now be motorable.

5. The bridge workshop

5.1 Location

At the end of his mission, the consultant undertook a one-week field trip to Bhumtang and East-Bhutan, in order to get a clearer picture of the stands of CHIR PINE (one of the most potential timber species for the project), bridge sites, the state of sawmilling in the area, and to identify a possible location for the future bridge workshop.

Bhumtang appeared to be an excellent choice, due to its geographically central location, the already existing and functioning infrastructure (including buildings) of the Integrated Rural Development Project, which is currently supported by HELVETAS, the availability of trained local personnel, the existing forestry training centre, the forestry - and feeder road construction unit, and the general development potential and perspectives of the area (possible future air link with Paro/Thimphu).

During the last day round-up meeting with PWD it became clear though, that the Government would prefer the production of UNIDO bridges to start in Gaylephug, the second most important border city with India, for various reasons:

- Decentralization (Phuntsholing/West-Bhutan is the centre of industrial operations, so far).
- Gaylephug being an upcoming location, also for exports (the traffic flow is changing southward).
- Considerable road building activities in the area.
- Existing sawmills and closeness to forest resources.
- Good power supply from India.
- Availability of PWD land for the construction of a workshop, and good general infrastructure.

- Good road link with Phuntsholing (steel workshop) through the North-eastern Indian State of Assam; however, foreigners need a special innerline permit, which has to be applied for well in advance, and is then only good for 2 - 3 days.

Whereas the consultant regrets no having been able to visit personally this area, in order to obtain a first hand view of the situation - which would have been possible had he been informed earlier about this preference - he thinks that the location would be a good choice for an easier start of the project. Also the desirable multiplying effect will, apparently, be higher in Gaylephug than in Bhumtang.

In this respect it may be noted that after a successful start of the project, a second production unit within the Integrated Rural Development Project in Bhumtang could be previewed, which would then mainly be based on coniferous timber (LARCH, CHIR PINE), and would serve the needs for bridges of this type in East-Bhutan.

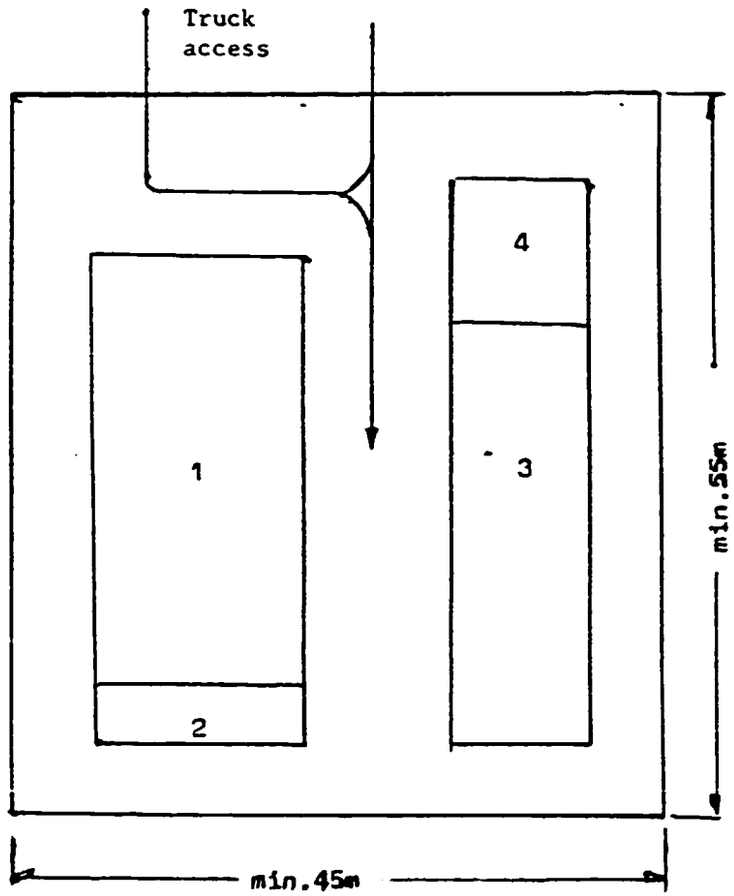
5.2 Layout

The workshop in Gaylephug should be erected on about 2,500 m^2 of land, and should have a covered floor surface of about 400 m^2 (e.g. 15 x 30 m). An additional and adjacent storage and office space is also desirable. The floor should be of concrete.

Furthermore, a covered timber shed of about 300 m^2 (e.g. 10 x 30 m) should be erected, as well as a shed to house the previewed pressure treatment plant and the preservatives.

The facility is to have easy truck access, and should have power supply, as well as piped water supply. The drawing on page 16 gives an example for a possible layout. In Annex 3 there are plans for a prefabricated timber construction - demonstration by itself - which is in use for a similar project in Ecuador/South America, and has proven its viability.

1. Bridge workshop (About 15 x 30 m)
2. Office and storage (About 15 x 5 m)
3. Timber shed (About 10 x 30 m)
4. Preservation building (About 10 x 10 m)



6. The abutments

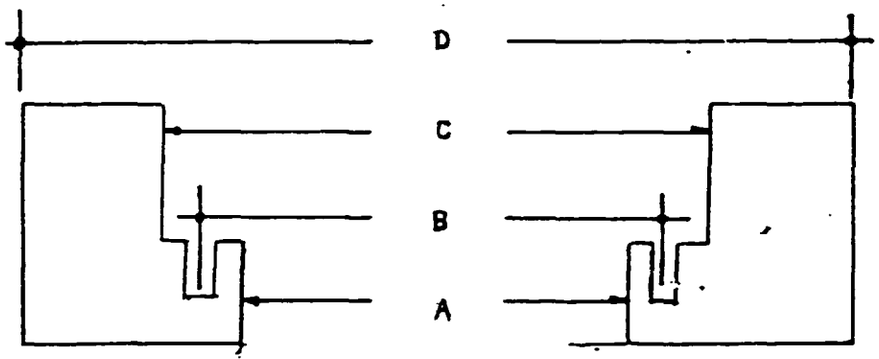
The abutments for UNIDO bridges will be constructed in the traditional way with rocks and concrete, in much the same manner as for short-span Bailey bridges.

During his field trip the consultant had the opportunity to witness the very satisfying work being done on abutments.

The UNIDO bridge design requires additional piercaps of reinforced concrete, the layout of which can be taken from Plan No. 5 (Annex 3).

It is important that the piercaps will be perfectly aligned and levelled one with the other. Also, they will have to be raised to a minimum of 2.80 m above the maximum water level (1.80 m for the bridge construction design plus minimum 1 m for security).

The following critical distances between the various measuring points should be achieved with the highest possible accuracy:



Nominal span (m)	6	9	12	15	18	21	24	27	30
A	5.75	8.78	11.77	14.78	17.79	20.80	23.81	26.82	29.83
B	6.29	9.30	12.31	15.32	18.33	21.34	24.35	27.36	30.37
C	6.55	9.56	12.57	15.58	18.59	21.60	24.61	27.62	30.83
D	7.15	10.16	13.17	16.18	19.19	22.20	25.21	28.22	31.23

The accesses, at least on one side, will also have to be filled in, and prepared, before the launching by means of two launching derricks, and a launching platform (all constructed at the site from material which will later be used in the termination of the bridge) can take place. The abutment costs will vary, depending on the site conditions. One m^3 of

rock and concrete poured will cost about Nu 600, whereas 1 m^3 of reinforces concrete poured will cost about Nu 1,500. The standardized piercaps contain about 3.5 m^3 of reinforced concrete per pair, and taking an average of 70 m^3 for both abutments, the costs will be:

Abutments	70 m^3	at Nu 600	Nu 42,000	
Piercaps	3.5 m^3	at Nu 1,500	Nu 5,250	
		Total	Nu 47,150	($US 3,8775)

7. List of equipment to be purchased by UNIDO and estimated costs

Item	Approx. $US
- 1 radial armsaw (WADKIN UNIVERSAL 350 BRA) with 2 8' roller tables, including measure bars, removable stops, and 5 carbide-tipped crosscut blades	4,500
- 1 circular saw (about 5.5 KW) with 5 carbide-tipped ripping blades, interchangeable with a.m. crosscut blades	3,000
- 1 surface planer (e.g. BÄUERLE), about 4 KW, 410 - 510 mm, with 3 sets of knives	4,500
- 1 thickness planer (e.g. BÄUERLE), about 7.5 KW 630/250 mm, with 3 sets of knives (high-speed steel)	5,500
- 1 knife sharpening machine (VOLLMER)	2,000
- TIRFOR equipment (as for project UC/ECU/83/206)	3,500
- Handtools (to be purchased by the expert in Europe)	3,000
- 1 portable generator for work on-site (capable to operate 2 600 W power drills or handsaw - 220 V)	1,000
- 1 electric welding set (complete outfit)	1,500
- 1 mobile pressure treatment plant for CCA-salts (ASCU HICKSON, Calcutta), dimensions about 3' diameter x 13'	25,000
- 1 portable moisture metre (GANN)	250
- 1 4-WD vehicle (TOYOTA HJ 47), RHD, 6 cylinder diesel, LWB Landcruiser with power sterring, trailer hitch, cassette player, and supply of fuel and oil filters	15,000
Total	$US 68,750

With the exception of the project vehicle (TOYOTA), and the pressure treatment plant (ASCU HICKSON, Calcutta, India), all other equipment, as per specification, should be purchased in Europe, if possible with the active participation of the expert - time requirement about 14 days.

All electrical machinery should be wired for 3 phases: 380/440 V, 50 cycles. Electrical handtools for 220 V, 50 cycles.

The various items should then be collected in a warehouse and, once complete, be shipped to Gaylephug via Calcutta in a 20' container. Upon arrival the material (if possible the container) should be stored in trust of the PWD, until the expert arrives in Bhutan to arrange the installation in the assigned workshop.

8. Remarks

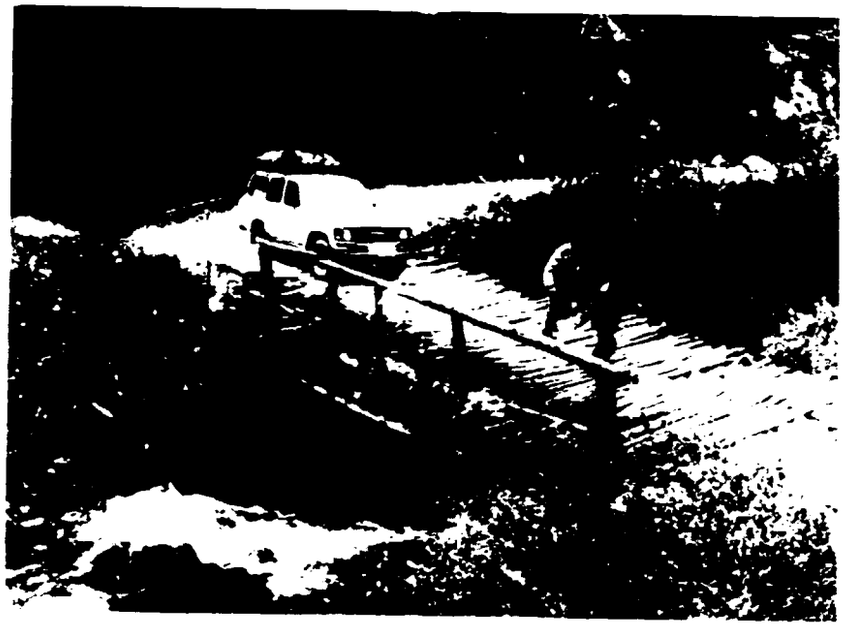
During the interim phase, especially for the different activities in respect to the timber procurement, it would be very advantageous for the project if a timber expert could be contracted by UNIDO to assist the PWD counterpart engineer in the organization and supervision of the selection (quality grading), transport and correct stacking of the timber at the workshop site in Gaylephug.

Also, during the implementation phase, after the return of the UNIDO bridge expert, the assistance to the project of a second expert would be very useful, since the various activities of the project will need constant supervision by a trained person, and the principal expert's time will be limited.

Such a person could be Mr. Hugh Thom, an FAO logging expert, who is already residing in Bhutan, and whose contract will end in June 1985. He had already expressed his interest to assist the UNIDO bridge project through short-term or longer-term participation.

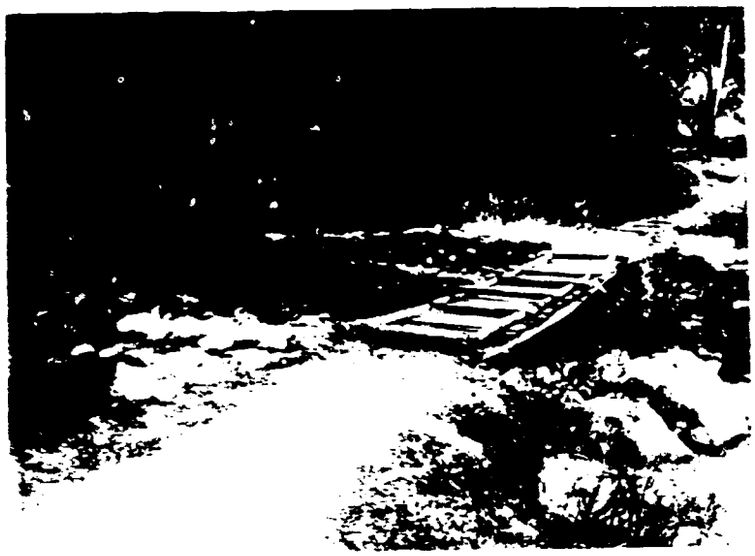
ANNEX 1

Photographs

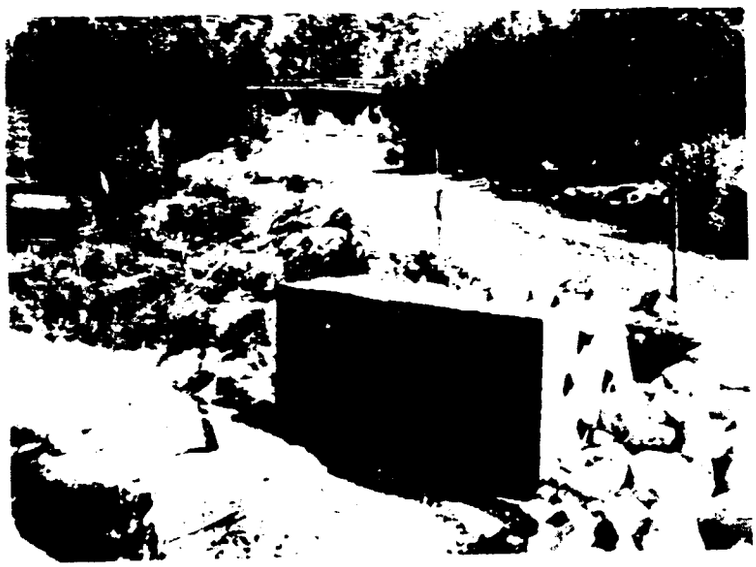


12 m bridge site on Lhuntsi road

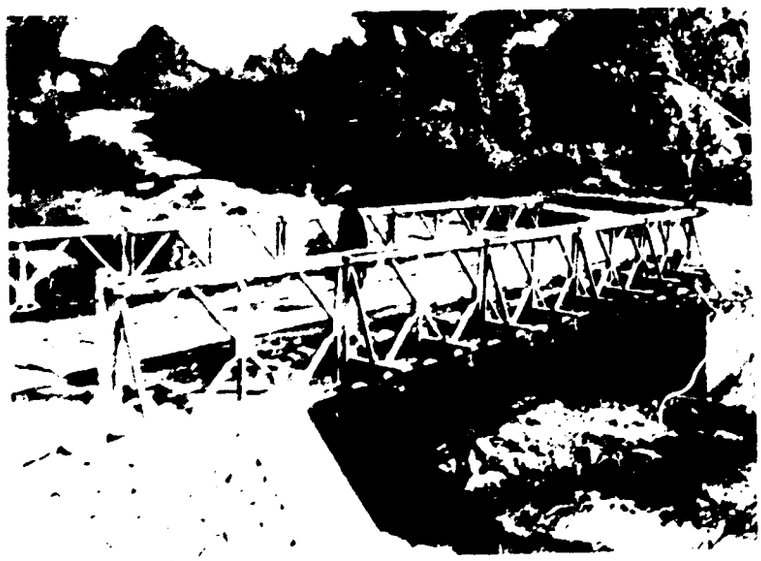
15 m bridge site on agricultural road
near Punakha



15 m pedestrian bridge near Thimphu

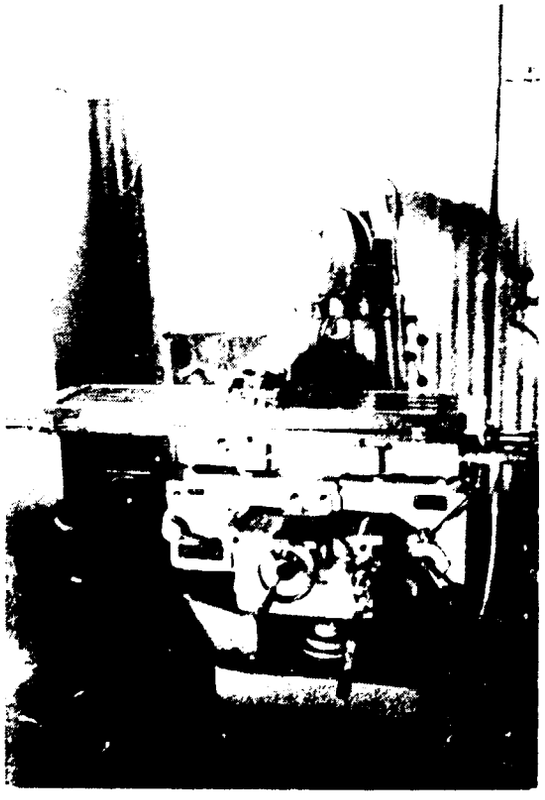


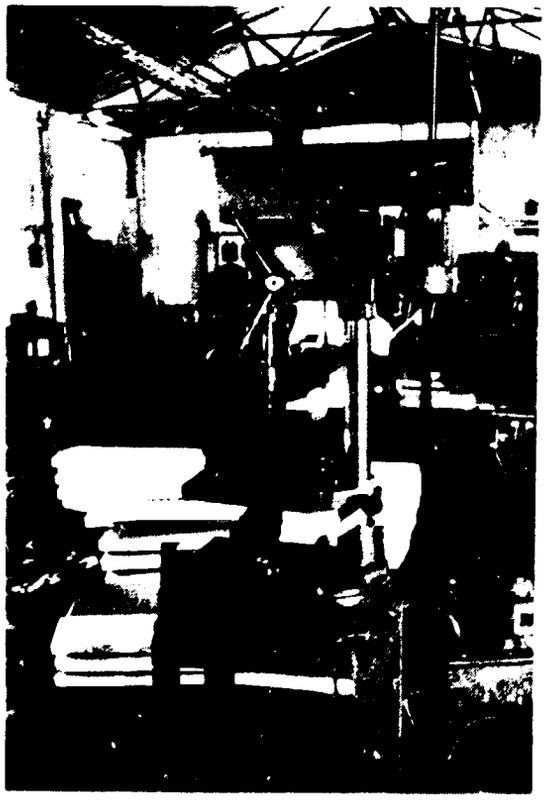
Abutment work for 15 m Bailey bridge on Gaza road



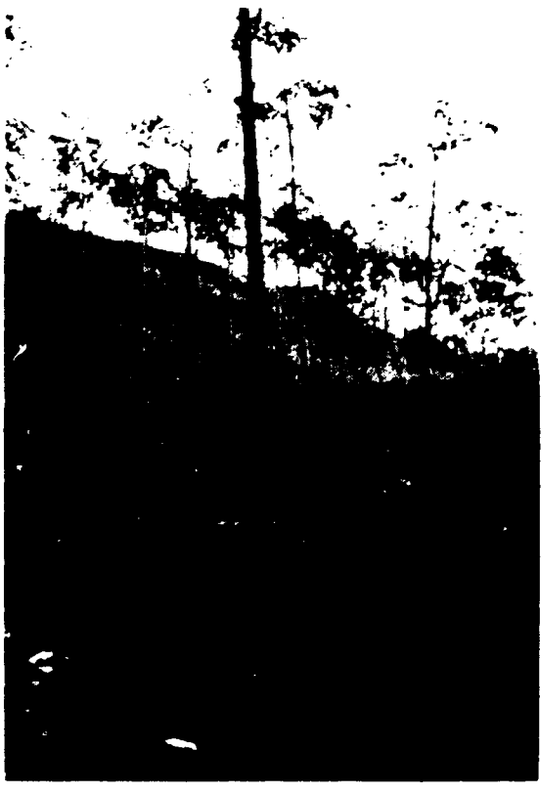
12 m Bailey [illegible] deck Gaza road

BGTS workshop in Phuntsholing





Chir Pine Stands (Mongar/Lhuntsi road)



ANNEX 2

Project document

Basic data

Project of the Royal Government of Bhutan

Project title:	BHU/84/010: Low-cost modular prefabricated wooden bridges
Primary function:	Direct assistance
Secondary function:	Development of new construction technologies
Sector:	Construction, transformation industries
Subsector:	Timber and derivated products
Government body for the implementation:	Public Works Department (PWD)
Executing agency:	UNIDO / UNDP
Duration:	One year
Scheduled start:	As soon as possible
Government contribution:	In kind
Agency contribution:	$US 205,000

Signed:

for the Government — Date

for the executing national agency — Date

for the executing international agency — Date

1. The project

1.1 Development objectives

The long-term development objectives are:

1.1.1 Assist the Government in the improvement of the national roadwork system with emphasis on the rural development, and the improvement of secondary and feeder roads.
This can be achieved through a modular bridge system, using local materials (timber), and simple technology, as well as simple equipment at costs below those for conventional constructions.

1.1.2 Promote the use of timber as construction material, substituting imported materials.

1.1.3 Provide the Government with the possibility to contribute continually, and in a valuable manner to road building and road improvement projects.

1.2 Immediate objectives

The immediate objectives of the project are:

1.2.1 Installation of a workshop, capable of producing prefabricated modules for modular timber bridges.

1.2.2 Advice on timber drying, timber preservation and timber technologies.

1.2.3 Construction and launching of about 10 demonstration bridges on selected sites.

1.2.4 Preparation of a manual containing the information necessary for the construction of these bridges in Bhutan.

1.2.5 Investigation - together with the PWD counterpart engineer - of sites on the national territory.

1.3 Special considerations

1.3.1. The project applies to an LDC country, namely Bhutan.

1.3.2 The project aims at establishing closer links between industrial promotion and organizations for promoting small and medium-sized industries, here in particular within the woodworking sector.

1.3.3 The project is in accordance with the Lima Declaration and Plan of action concerning the development of industrial co-operation.

2. Background and justification

Bhutan possesses a considerable wealth in forest resources, containing a variety of hardwood species and extensive coniferous forests. A functioning infrastructure is the precondition to fully be able to take advantage of these natural riches, in accordance with the Government's careful and wise forest policy, which applies a high priority to reforestation programmes and to well guided use of timber.

Bridges constitute an important factor within the costs for road construction and maintenance. Bridges in bad shape and often impassable add to the high costs of transport, and contribute to the isolation of rural communities.

The capacity, on the other hand, to construct low-cost bridges, which do not require costly design work, through self-help is without doubt a valauble contribution to the objectives of the national plan for the improvement and extension of the road network.

The use of local materials (timber), and the simple process of construction and installation of these bridges with only basic equipment will provide a positive impulse to the small industries in Bhutan.

The visual aspect of well constructed modern timber bridges will fit perfectly into Bhutan's beautiful landscape, which also will be in accordance with the Government's ecology-minded policies. Bhutan has a long history of outstanding timber structures for bridges, and in the housing sector.

Under the guidance of a PWD engineer, a group of workers, trained by the project, and specialized in the construction of the modules, and the launching of bridges, will be able to continue on their own after being trained by the project for about one year.

A manual will provide the information necessary for the construction and installation of modular bridges with free spans ranging from 6 - 30 m, produced in a local workshop with local staff in only a few days. The useful life of the bridges is estimated to be more than 20 years, due to the qualities of the available hardwoods or coniferous timbers after pressure treatment with salts in the project's preservation plant.

3. Results of the project

3.1 A manual prepared for the conditions in Bhutan.

3.2 A workshop with machinery and equipment, capable to produce modules for prefabricated timber bridges in series.

3.3 A group of persons (about 8) trained to select the timber for the construction, and to assemble the modules.

3.4 A group of persons (about 8) trained to launch these bridges at prepared sites.

3.5 About 10 demonstration bridges with free spans of 15 m on average.

3.6 An investigation into the requirements for short span bridges in Bhutan.

4. Activities

All located in Gaylephug, Thimphu, Phuntsholing and selected sites/areas:

4.1 Preparation phase, 3 weeks, accomplished and subject of this report.

4.2 Interim phase, to start as soon as possible, and if possible under the guidance of a UNDP timber expert, residing in Bhutan (see also Remarks, page 19). Duration: about 6 months.

4.2.1 Government activities:

- Construct a workshop building, a timber shed, and a building for the preservation plant on the appropriate land in Gaylephug.
- Contract the timber according to the specification given in this report, and have it stacked for air-drying in the timber shed. It is not necessary that all of the timber has arrived before the UNIDO expert returns, but the quantity should be sufficient to start work.
- Designate a PWD engineer as project manager (Mr.Kunzan Wangdi). The workshop personnel (No. 3, page 12) could be assigned to the project at a later stage (e.g., upon the return of the expert).

- Supply the BGTS workshop in Phuntsoling with a full-size set of steel parts plans (Nos. 0, 1, 2 and 4), purchase the steel material as per specification, and have it transported to the BGTS workshop (with the exception of bolts and nails, which should be stored at the project site in Gaylephug).
- Contract the BGTS workshop to manufacture the steel parts as per specification, and according to the plans, including a set of chromium steel templates. It is not necessary that all steel parts are finished before the return of the UNIDO expert, but there should be a sufficient quantity to start work.
- Contact with UNIDO through UNDP for the co-ordination of the expert's return mission.

4.2.2 UNIDO activities:

- Purchase and shipment of the equipment as per specification.
- Contract a resident timber expert to assist the project and the PWD project manager during the absence of the expert (see Remarks, page 19).
- Co-ordination of the expert's return mission.

4.3 Implementation phase, about 12 months, to start with the expert's return to Bhutan:

- Reception of project vehicle and imported equipment.
- Control steel parts' production and timber quality, and arrange/organize further activities in this respect.
- Install workshop and make it functional.
- Construct jigs necessary for series production of bridge modules.
- Preparation and conservation of timber elements.
- Construction of 200 modules.
- Construction of abutments at selected sites (Government input).
- Launching of about 10 bridges at these sites.
- Investigation of short span bridges required in Bhutan.
- Preparation of a construction manual.
- Test coniferous timbers (e.g. CHIR PINE) for suitability.
- Induce and co-ordinate further production units (e.g. in Bhumtang).

5. Contributions to the project (input)

5.1 Government contributions

The Royal Government of Bhutan will contribute to the realization of the project in the following manner:

- Assign appropriate land (about 2,500 m^2) to the project - Gaylephug.
- Construct workshop building (about 400 m^2), timber shed (about 300 m^2), and building for treatment plant on this property.
- Secure other infrastructure such as power supply and water supply.
- Assist the expert in finding suitable housing in the project area.
- Designate a full-time counterpart, a PWD engineer (Mr. Kunzang Wangdi) to the project as project manager.
- Construct abutments on selected sites.
- Secure all necessary truck transport.
- Contract about 170 m^3 of timber as per specification.
- Purchase steel material and contract manufacture of steel parts at the BGTS workshop in Phuntsholing.
- Provide workshop personnel and launching personnel to the project.

5.2 Contributions of the Implementing Agency

- Two experts with a total of 24 man-months:
  (01) timber engineer, familiar with the UNIDO bridge system as principal project adviser (12 months).
  (02) construction superviser - or master carpenter specialized in heavy construction, to assist the PWD project manager during the interim phase, and possibly to assist the project after the return of the principal expert as workshop adviser (12 months).
- Purchase and shipment of project equipment as per specification. Purchase and shipment of project vehicle to be at the disposition of the UNIDO expert(s) during his(their) stay in Bhutan.

- Coverage of operating expenses by means of a working fund, to be at the disposition of theprincipal expert.
- Fund for spare parts and repairs (20 per cent of equipment costs).

6. Work plan

A tentative work plan is given under No. 4 (Activities, page 28) of this project document.

A more specific work plan will be prepared by the principal expert at the end of the first monthof the implementation phase.

7. Framework for the efficient participation of local personnel

All activities to comply with the immediate objectives of the project will be carried out by the national and the international personnel in the form of teamwork.

PWD extends their facilities to the project, provides the counterpart personnel, and acts as the intermediate between the Government and the executing agency.

8. Institutional frame

All activities of the project will be co-ordinated through the PWD. Other public or Government institutions will assist the project, should this become necessary.

9. Obligations and preconditions

None, except for the Government contributions mentioned under 5.1.

10. Future assistance of the executing agency

A future assistance will depend on the necessities, constituted 2 months before the end of the project.

There may be the possibility to prolong the project, if necessary, for the complete transfer of the technology, to extend the expert(s) contracts accordingly, and provided that the project has a positive outcome, there may also be the possibility to sponsor a second production unit, and/or to diversify the activities to cover other prefabricated timber products (e.g. trusses).

11. Evaluation and reports

The project will be evaluated continuously to determine future actions.

An intermediate report will be prepared by the principal expert after the third month of the implementation phase, and the final report will contain the manual and recommendations for a national/regional strategy concerning the production of UNIDO bridges.

12. Budget UNIDO/UNDP (estimate)

	MM	$US	$US
Timber engineer (principal expert)	12	84,000	
Second expert	12	72,000	
Expert travel		3,000	
Total personnel component	24	159,000	159,000
Equipment for workshop and launching		53,750	
4 WD vehicles		15,000	
Fund for spares and repairs (20 %)		13,750	
Total equipment component		82,500	82,500
Miscellaneous, including working fund and operating expenses (at expert's disposition)		5,500	5,500
TOTAL			247,000

ANNEX 3

Bridge plans

Pre-fabricated modular wooden bridges

Part 5 - typical design - 15 m span - 4 truss bridge*

*A complete Bridge Manual will be made available to the project as soon as produced (possibly June 1985).

PRE-FABRICATED MODULAR WOODEN BRIDGES

PART 5 Typical design - 15m 4 truss bridge

COMPONENT IDENTIFICATION...FIGURE 1

Item number	Description		Figure number
1	Truss modular unit assembly (Drg. no. SE-245-19)	- Light chord	5
	(Drg. no. SE-245-21,	- Heavy chord	15
1a	Timber members for truss modular unit assembly (Drg. no. SE-245-3)	- Light and Heavy chord	6
1b	Nailing pattern for above (Drg. no. SE-245-17)		7
2	Panel plates Mark 1 and 1a (Drg. no. SE-245-30)	- Light chord	8
	Panel plates Mark 9 and 9a (Drg. no. SE-245-34)	- Heavy chord	16
3	Panel plate Mark 5 (Drg .no. SE-245-30)	- Common	8
3a	Panel plates Mark 3 and 3a (Drg. no. SE-245-31)	- Light chord	9
	Panel plates Mark 10 and 10a (Drg. no. SE-245-34)	- Heavy chord	16
4	Panel plate mark 13 (Drg. no. SE-245-31)	- Common	9
5	Steel tension chord, Mark 2 and 2a (Drg. no. SE-245-33)	- Light chord	10
	Steel tension chord, Mark 6 and 6a (Drg. no. SE-245-36)	- Heavy chord	17
5a	Timber tension chord (Drg. no. SE-245-41/1)(40/1)	- Light chord	13/14
	Timber tension chord	- Heavy chord	19/20

COMPONENT IDENTIFICATION...Figure 1 continued

Item number	Description	Figure number
6	Bridge bearing plates Mark 14 and 14a (Drg. no. SE-245-32) - Light chord	11
	Bridge bearing plates Mark 15 and 15a (Drg. no. SE-245-35) - Heavy chord	18
6a	Holding down details - (Drg. no. SE-245-37)	2
	and - (Drg. no. SE-245-20)	3
7	Vertical brace arrangement - (Drg. no. SE-245-38)	24
	Timber members - (Drg. no. SE-245-3)	6
	and - (Drg. no. SE-245-4)	12
	Panel plate Mark 8 - (Drg. no. SE-245-4)	12
8	Details on longitudinal view of assembled bridge (Drg. no. SE-245-8)	21
9	Deck details - (Drg. no. SE-245-8)	22
	and - (Drg. no. SE-245-9)	23
	and - (Drg. no. SE-245-38)	24
10	Horizontal timber brace - (Drg. no. SE-245-8)	21/22
11	Timber tie - (Drg. no. SE-245-8)	21
12	Cross tie - (Drg. no. SE-245-8)	21/22
	and - (Drg. no. SE-245-38)	24
13	Handrail barrier details - (Drg. no.SE-245-8)	21
	and - (Drg. no.SE-245-38)	24
	and - (Drg. no. SE-245-9)	25

COMPONENT IDENTIFICATION...Figure 1 continued

Item number	Description	Figure number
14	Steel linkage arrangement - (Drg. no. SE-245- 12)	26
15	Masonry / concrete abutment details, Sheet 1, - (Drg. no. SE-245-37)	2
15a	Masonry / concrete abutment details, Sheet 2, Holding down arrangements / pier reinforcement - (Drg. no. SE-245-37)	2 cont.
16	Timber abutments and details - (Drg. no. SE-245-44)	4

NOT ITEMIZED:-

	Testing rig for modular bridge panel - (Drg. no. SE-245-42)	27
	Arrangement for testing deflection of modular bridge panel - (Drg. no. SE-245-43)	28
	Single jig and assembly table for modular panel manufacture	29
	Typical workshop arrangement for bridge panel manufacture - (Drg. no. SE-245-18)	30

GENERAL NOTES RELATING TO ALL DRAWINGS

1). The following notes are relevant to all of the drawings in this manual and their recommendations should at all times be observed.

All steel in the fabrications detailed to be weldable structural mild steel, flat plate or round bar to specifications on the drawings. The steel should be bright mild steel and prefrably to conform to BS 449 'Specification For The Use Of Structural Steel In Building' and BS 4360 'Weldable Structural Steels'. The steel, flat or bar, to have a minimum ultimate tensile strength of 435 N/mm^2-494 N/mm^2, and a minimum yield stress of 236 N/mm^2.

All welding in the fabrications to be fillet welds as detailed and should be manual shielded arc welding by experienced welders, see A.W.S. 'Code For Welding In Building Construction' for further information. Welding should be in accordance with BS 5135 'Metal-Arc Welding of Carbon and Manganese Steels'. Filet welds must be to the size specified, and without discontinuities and undercutting of metal.

All steel fabrications in flat plates to be bench marked from the centre line and baseline as detailed in the drawings. All holes to be accurately set-out by scribing and centre-punching. Holes for positiong the steel pins, as in Figure no's. 8, 9, 11, 13, 14, 16, 18, 19, and 20, to be accurately set-out by scribing on the steel plate upper faces, centre-punching for the diameter of the centreline position and pilot drilling using a 4mm diameter pilot drill. Accuracy in the setting-out and marking of all steel fabrications is essential for ease and correctness of truss element assembly.

Holes in steel fabrications, for fitting bolts and steel pins exceeding 12mm finished diameter should be opened-out in stages from the pilot drilling diameter to the finished diameter, as detailed on the drawings, using drilling increments of 12mm diameter as appropriate, to achieve the finished diameter required.

The steel pins detailed in the drawings should be machined to the finished specified diameter. Holes in the steel fabrications to be opened out as necessary during final fitting of the steel pins.

All bracing cleats, secondary plates and steel pins specified as being square to the main plates, should be checked with a steel square whilst tack welding, prior to final assembly.

All burrs and swarf to be removed from steel fabrications after final cutting and drilling.

All steel flat plate and round bar in fabrications to be clean and free from dirt, grease, surface corrosion or scale prior to welding.

2). The notes which follow, referring to critical dimensions, must be closely adhered to.

Critical dimensions are those which must be set-out as first priority dimensions, since the accuracy of the modular truss units and of subsequent bridge trussed construction will depend upon these critical dimensions being acheived.

Critical dimensions should be checked whenever a new jig is made or an exsisting one modified, and during quality control checks of manuafctured panels.

3). The following notes refer to individual fabrications and their appropriate Figure/Drawing no's:-

Panel plates Mark 1, 1a, 9, 9a and 5 to be drilled with 12mm diameter holes, as detailed on Fig. no's. 8 and 16 (Drawing no's. SE-245-30 and 34) to receive the mild steel panel plate dowel pins. These holes may require opening-out to 13.5mm (17/32 inches) diameter to provide a hand sliding fit of the dowel pins into the panel plates.

Panel plates Mark 1, 1a, 9 and 9a, (Fig. no's. and drawing no's. as above) to be fabricated in reverse sided pairs to ensure alignment of all bolt receiving holes and main bearing pins. These plate pairs should be marked for identification and preferably wire bound together.

The 6mm thick mild steel reinforcing End Plate to Tension chord Members Mark 2 (Fig. no. 10, Drawing no. SE-245-33) to be welded to the 10mm thick mild steel Chord Plates and the centreline distance marked-out, before drilling the 40mm diameter bearing holes.

The 40mm diameter bearing holes to Tension Chord Members Mark 2a (Fig. no. 10, Drawing no. SE-245-33) may be drilled in the 12mm mild steel Extension Plates before welding, but, if this is done, a timber bed-jig with distance pins attached must be used for setting-out before final welding.

The 6mm thick reinforcing End Plates to Tension Chord Members Mark 6, (Fig. no. 17, Drawing no. SE-245-36) are to be welded to the 10mm thick mild steel Chord Plates and the centreline distance marked out before drilling the 52mm diameter bearing holes.

The 52mm diameter bearing holes to tension Chord Mark 6a, (Fig. no. 17, Drawing no. SE-245-36) may be drilled in the 15mm mild steel Extension Plates before welding, but, if this is done, a timber bed-jig with distance pins must used for setting-out before final welding.

Panel Mark 8, (Fig.no. 12, Drawing no. SE-245-4) to be set-out in position on the timber Brace Member, and located using nail fixings. The timber Brace Member is then drilled out using Panel Plate Mark 8 as the drilling template. Bolts should be fitted through the timber Brace Member and the steel Panel Plate with the bolt integral heads seating onto the face of Panel Plate Mark 8, (bolt shanks away from the panel plates).

NB. The mild steel dowels used in the Panel plates to be 12mm diameter to correspond with the Panel Plates acceptance holes. The drill depth stop for timber members receiving mild steel dowels, should be pre-set to 50mm and 100mm respectively and the drilling of timbers receiving mild steel dowels to be carried out with the panel plates located in their positions. Mild steel dowels are to be a sliding fit into the receiving holes of the Panel Plates.

4). The following notes refer to the timber members that are detailed in the drawings in this manual.

All timber sections to be preservatively treated by one of the methods given in the Part 4, Timber Technology.

Sawn timber in section should be cut to a width and thickness tolerance on each section dimension of +2mm -3mm maximum in respect of the sawn section dimensions as detailed on Fig.no. 6, (Drawing no. SE-245-3). Critical length dimensions to be cut as accurately as posssible, and all timber members detailed on the drawings to be cut to length, including shaped ends where shown, unless oterwise stated. Holes for bolt fixings to be drilled as specifically noted.

5). The following notes refer to the nailing and fixing of timber members and steel fabrications used in the assembly of modular truss units.

All nailing positions to be pre-drilled to a diameter of 4.00mm prior to receiving 4.88mm diameter (20d) nails, but after the assembly of each truss unit half. The exception to this are the location nails for the Panel Plates Mark 5, 1 and 1a, which may be drilled and nailed at assembly of each truss unit half. Reference should be made to Drawing no. SE-245- 17 for the nailing patterns to attach spacing packs between the Upper Chords.

Bolts, should be Hexagon-Round-Hexagon, Metric Course Threaded; Black Mild Steel Bolts and Nuts. Shank and overall lengths to be as detailed in the drawings. Mild steel washers to be provided as detailed. Bolts to be of an engineering quality, at least complying with the requirements of BS 4190 or similar specifications.

6). The following notes refer to the decking, bracing, handrail construction and completion of a typical modular wooden bridge.

Camber to the bridge trussed-girder structure is automatically provided during assembly and for a 15.0 metre bridge span the camber of the deck level is likely to be in the order of a 60mm to 70mm rise at mid-span.

The timber spacer lengths between adjacent pairs of Tension Chords Mark 2 and 6, (Fig, no's. 10 and 17, Drawing no's. SE-245-33 and 36), are not detailed in the cutting schedule, (Fig. no. 6, Drawing no. SE-245- 3). These lengths should be pre-marked and pre-drilled (using the Tension Chords as templates) with 4.0mm diameter drillings to receive the 4.88mm diameter by 65mm long (6 S.W.G.) fixing nails, as detailed on Fig. no. 26 (Drawing no. SE-245-12). The timber spacer lengths should be preservatively treated.

The 150mm by 50mm section, splay-cut timber tie pieces on the trussed-girder assembly top-chords, are nominal members fixed to each side of the assemblies by nailing, as detailed on Fig no. 21 (Drawing no. SE-245-8). They are primarily required to retain top chord compression joints during erection and launching stages. These members may be left in place in the finished bridge construction. It should be noted that they are not detailed on the cutting schedule Drawing no. SE-245-3 (Figure no. 6) and should be preservatively treated.

The 200mm by 50mmm section trussed-girder assembly Cross Tie timbers Fig. no's. 21/22 (Drawing no's. SE-245-8 and 38), are to be fixed in postion after launching and final positioning of the trussed-girders.

The 100mm by 50mm section by 5000mm long special deck boards are to be laid in pairs as detailed, their positions along the bridge deck being suitably selected as decking proceeds. It is recommended that special deck board pairs be drilled for bolt positions prior to final fixing of the boards. NOTE: Special deck board ends may be left square-cut at brace connections if desired, the alternative is to site-cut the end to suit the line of bracing as shown on Fig. no. 24 (Drawing no. SE-245-38).

The 150mm by 25mm section handrail-barrier capping, as supplied in random length timbers, is to be site-cut to suit construction requirements and fixed in position by nailing, as detailed in Fig. no. 25, (Drawing no. SE-245-9). Capping sections are to be square cut at the ends and butt-jointed, the capping joint positions being staggered from the side rail butt-joints by at least 1200mm.

The 125mm by 50mm section handrail-barrier side rails are to be site-cut to suit the bridge dimensions and fixed in position by nailing as detailed in Fig. no. 25, (Drawing no. SE-245-9). Side rail sections are to be square cut at the ends and butt-jointed over the barrier centreline positions as shown.

The 100mm by 100mm section handrail-barrier support posts may be workshop-cut to the required length, the ends rebated and drilled for bolt positions, as detailed in Fig. no. 25 (Drawing no. SE-245-9).

The 100mm by 50mmm handrail-barrier diagonal brace timbers are to be site-cut (including the shape cut ends), and drilled for bolt positions to suit support post and deck board arrangements.

The 150mm by 150mmm section kerbing timbers, supplied in random lengths, are to be site-cut and jointed as detailed in Fig. no. 25 (Drawing no. SE-245-9), to suit the construction. It is recommended, once kerbs have been cut and laid out to suit their final positions, that they should be marked and drilled for bolt positions before nail fixing into their final position commences.

The 250mm by 50mm section running boards, supplied in random lengths, are to be site-cut and nail fixed as detailed in Fig. no. 24 (Drawing no. SE-245-38). Running boards may be square cut and butt-jointed longitudinally. Butt-joints must be staggered from adjacent board joints by at least 1200mm, and should be avoided over trussed-girder connection positions.

All nails in handrail-barrier timber components are to be counter-punched and set below the surface of the timbers.

Nail fixings are to be as detailed in the drawings and are specified according to the Imperial Standard Wire Gauge (S.W.G.) with corresponding diameters also given. Alternative nails may be used, but they should correspond as closely as possible to the diameters specified. Nail lengths and type to be as detailed in the drawings.

All bolts, mild steel washers for steel and wood, to be as specified in the drawings.

It is recommended that the 3,66mm diameter 100mm long (9 S.W.G.) nails specified for deck board fixings should be 'Lost Head' type or similar.

The 75mm diameter by 2.5mm thick mild steel, flat machined bearing washers, (drilled to receive 50mm diameter pins), are intended to be used to space Panel Chords Mark 2 and 6 linkages off Panel Plates 9 and 9a faces, thus avoiding fouling of the dowel pin fixings to the Panel Plates.

Split pins are to be used on trussed-girder assembly to retain top-chord Panel plates Mark 10 and 11, and Panel Plates Mark 9 and 9a bearing pin assemblies, with steel chord Mark 2 and 6 linkages.

7). The following notes are concerned with the bridge pier abutments:

Opposing pier abutments should be formed square on to one another, and not skewed or offset. Opposing pier caps, particulary at bearing level, should be flat and with a maximum vertical difference between them of no more than 20mm.

Concrete in pier caps should be of structural quality and conform to the following requirements regarding constituents:

(i) Structural Quality Hydrating Cement.

(ii) Minimum cement content by weight of 360 kg. per cubic metre of concrete produced.

(iii) Maximum aggregate size of 20mm, well graded for structural concrete use.

(iv) Suggested water/ cement ratio at production of 0.4 to 0.45.

The strength of the concrete should be as follows:

(i) 20 N/mm^2 Cube strength at 7 days after casting.

(ii) 30 N/mm^2 Cube strength, (Characteristic Strength) at 28 days after casting.

Four test cubes should be taken during the casting of the concrete from each bridge pier cap mix, (eight in total), with 2 by 2 being tested after 7 days and 2 by 2 tested after 28 days.

Grout used at the bearing positions to consist of Structural Quality Hydrating Cement and fine graded aggregate. The strength of the grout should be as follows:

(i) 17 N/mm^2 Cube strength at 7 days after casting.

Two test cubes to be taken at the grouting stage from each bridge pier cap mix (four in total) and to be tested after 7 days.

The reinforcement to the pier caps is to be of mild steel round bar with a minimum ultimate tensile strength of 435 N/mm^2 - 494 N/mm^2 ; and a minimum yield stress of 236 N/mm^2 . Chamfers on the pier cap upstands to be 15mm by 15mm.

Four 16mm diameter mild steeel bars , each 1000mm long, are to be used to each abutment pier cap to provide a continuity tie between the pier caps cast in-situ and general abutment masonry. The bars are to be embedded into the general abutment masonry to a depth of 600mm. NOTE: The bars are not shown on Fig .no 2, Drawing no. SE-245-37, (Holding Down Details). For the construction sequence at the bearings, see Fig. no. 3, Drawing no. SE-245-20.

TRUSS MODULAR UNIT ASSEMBLY...Figure 5 (Light chord)

Notes:- PLAN VIEW ON Y-Y

With panel plate Mark 3a welded in final position, drill through members 2T with a 40mm drill to a depth of 42mm from bearing face of panel plate Mark 3a to accomodate spigot pin.

MEMBER 1T

All four corners of 1T to be eased by 6mm chamfers to accomodate welds.

MEMBER 2T

A total of 21 4.88mm diameter (6 S.W.G.) x 100mm nails at 150mm centres in each row. Nails are driven in from side uppermost on drawing.

MEMBER 3T

A total of 13 4.88mm diameter (6 S.W.G.) x 100mm nails at 150mm centres in each row. Nails are driven in from side uppermost on drawing.

PANEL PLATE MARK 5

A total of 16 12mm diameter M.S. dowels x 100mm long and 2 off 12mm diameter M.S. dowels x 50mm long to each plate.

PANEL PLATES MARK 3 and 3a

Panel plates Mark 3 and 3a are welded to panel plate mark 5 with 6mm fillet welds on 2 by 3 sides (see detail).

PANEL PLATES MARK 1 and 1a

A total of 24 12mm diameter M.S. dowels 50mm long to each panel plate.

TIMBER TENSION CHORD...Figure 13 (Light chord)

The following items are required for Figure 13, (Drawing no. SE-245-40/1).

Nails

Diameter	4.88mm
Pennyweight	20d
Length	100mm

DOWEL PINS

Dowel pins, 12mm diameter by 50mm long are driven in from both sides of the assembly. The heads are then welded to 6mm MS plates in accordance with the standard bridge panel plate method.

SPLIT PINS

Diameter	8mm
Length	55mm

TRUSS MODULAR UNIT ASSEMBLY...Figure 15 (Heavy chord)

Notes:- PLAN VIEW ON Y-Y

With panel plate Mark 10a welded in final position, drill through members 2T with a 40mm drill to a depth of 42mm from bearing face of panel plate Mark 10a to accomodate spigot pin.

MEMBER 1T

All four corners of 1T to be eased by 6mm chamfers to accomodate welds.

MEMBER 2T

A total of 21 4.88mm diameter (6 S.W.G.) x 100mm nails at 150mm centres in each row. Nails are driven in from side uppermost on drawing.

MEMBER 3T

A total of 13 4.88mm diameter (6 S.W.G.) x 100mm long nails at 150mm centres in each row. Nails are driven in from side uppermost on drawing.

PANEL PLATE MARK 5

A total of 16 12mm diameter (6 S.W.G.) x 100mm long and 2 off 12mm diameter M.S. dowels x 50mm long to each panel plate.

PANEL PLATES MARK 10 and 10a

Panel plates Mark 10 and 10a are welded to panel plate Mark 5 with 6mm fillet weld on 2 by 3 sides (see detail).

PANEL PLATES MARK 9 and 9a

A total of 24 12mm diameter M.S. dowels x 50mm long to each panel plate.

TIMBER TENSION CHORD...Figure 19 (Heavy chord)

The following items are required for Figure 19.

NAILS

Diameter	4.88mm
Pennyweight	20d
Length	100mm

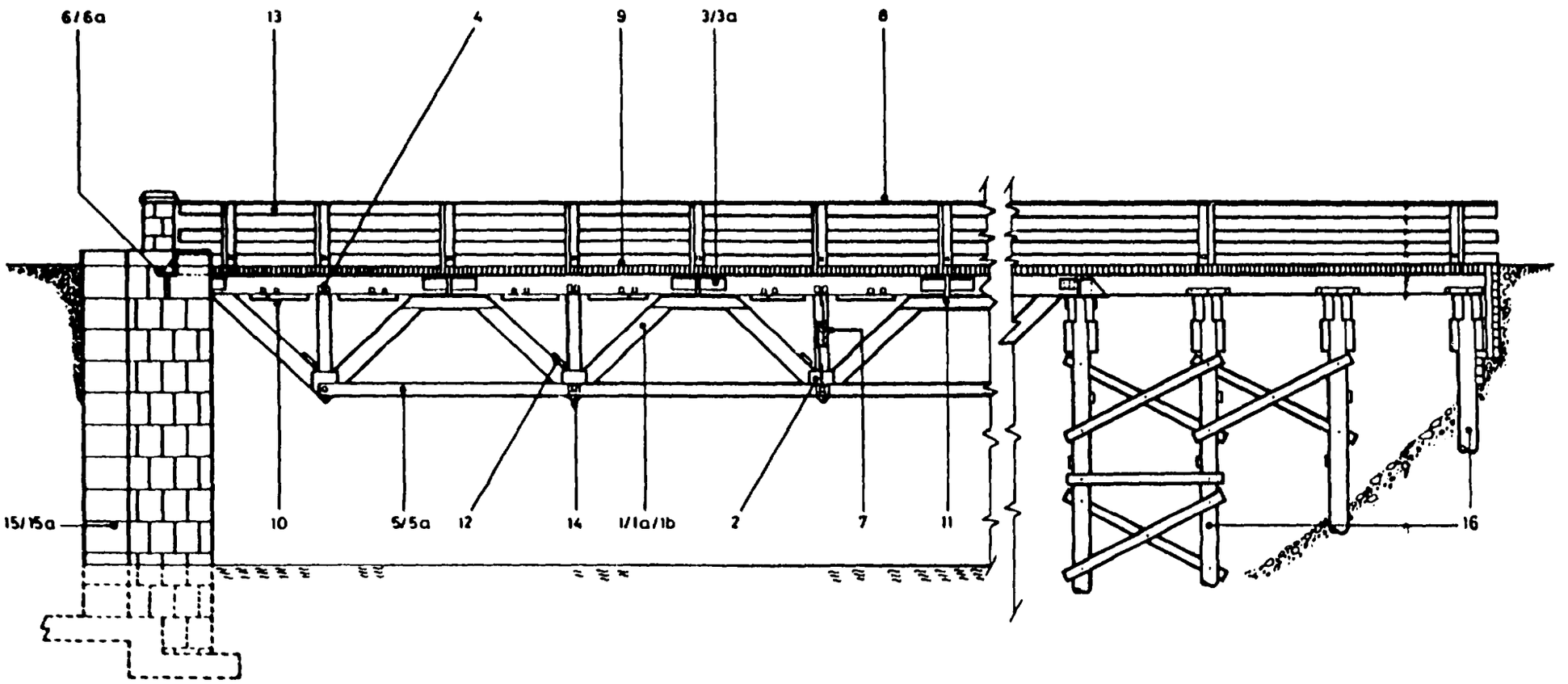
DOWEL PINS

Dowel pins , 12mm diameter by 50mm long are driven in from both sides of the assembly. The heads are then welded to the 6mm MS plates in accordance with the standard bridge panel plate method.

SPLIT PINS.

Diameter	8mm
Length	55mm

PRE-FABRICATED MODULAR WOODEN BRIDGES - GENERAL LAYOUT FOR COMPONENT IDENTIFICATION



Figure

MASONRY/ CONCRETE ABUTMENT DETAILS (SHEET 1)

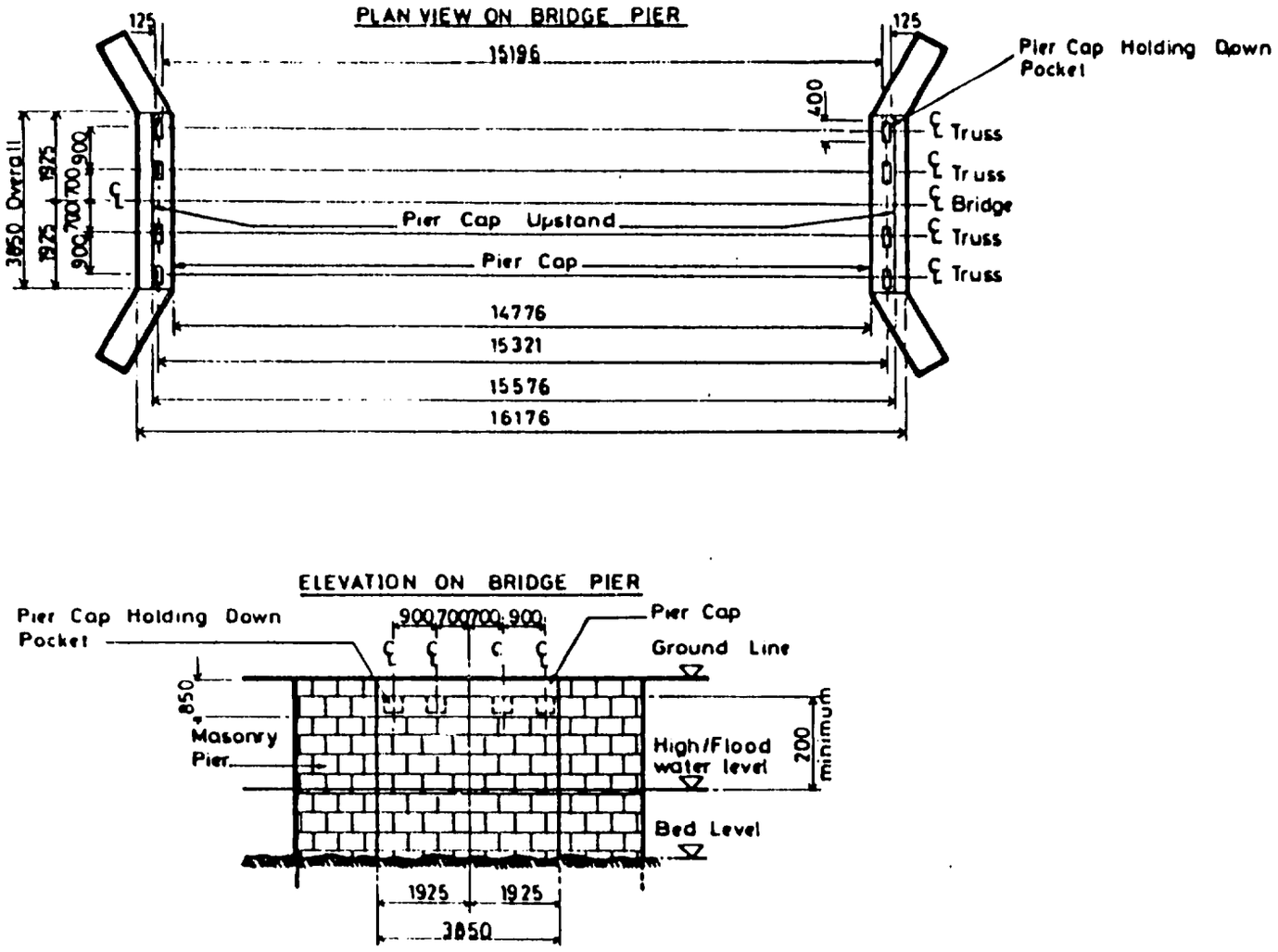
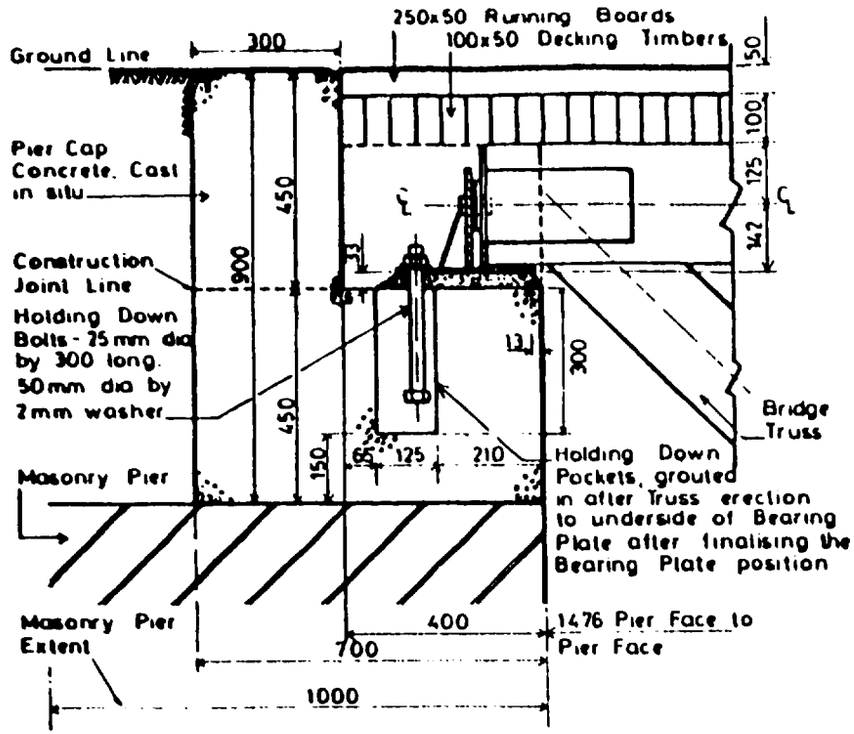


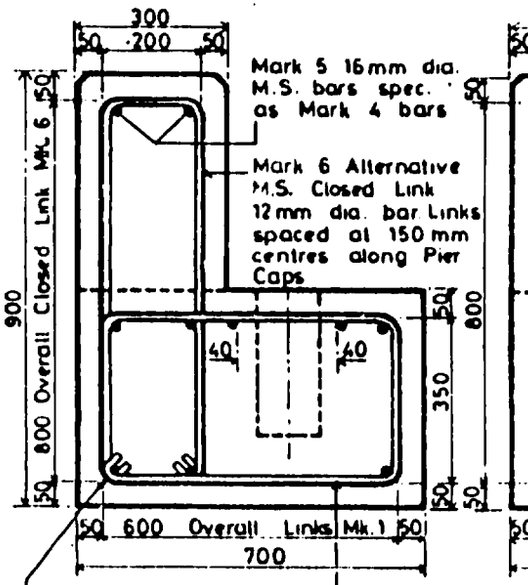
Figure 2

MASONRY/CONCRETE ABUTMENT DETAILS (SHEET 2)

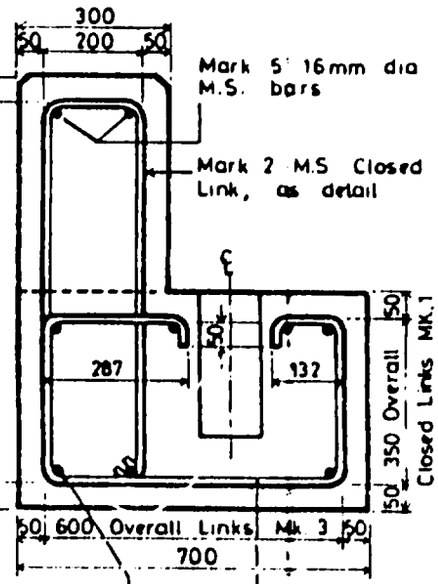
SECTION THROUGH PIER CAP SHOWING HOLDING DOWN ARRANGEMENTS FOR BRIDGE TRUSS BEARINGS



DETAIL 'A' - SECTION ON CONCRETE PIER CAP SHOWING REINFORCEMENT BETWEEN HOLDING DOWN POCKETS



DETAIL 'B' - SECTION ON CONCRETE PIER CAP SHOWING REINFORCEMENT AT HOLDING DOWN POCKET LOCATIONS



Mark 4 16mm dia. bars by 3750 long. Ends hooked to form full radius 'U' end return - 65mm from hook bend to bar

Mark 1 M.S Closed Links, 12 mm dia bar spaced at 150 mm centres along Pier Caps excluding Pockets

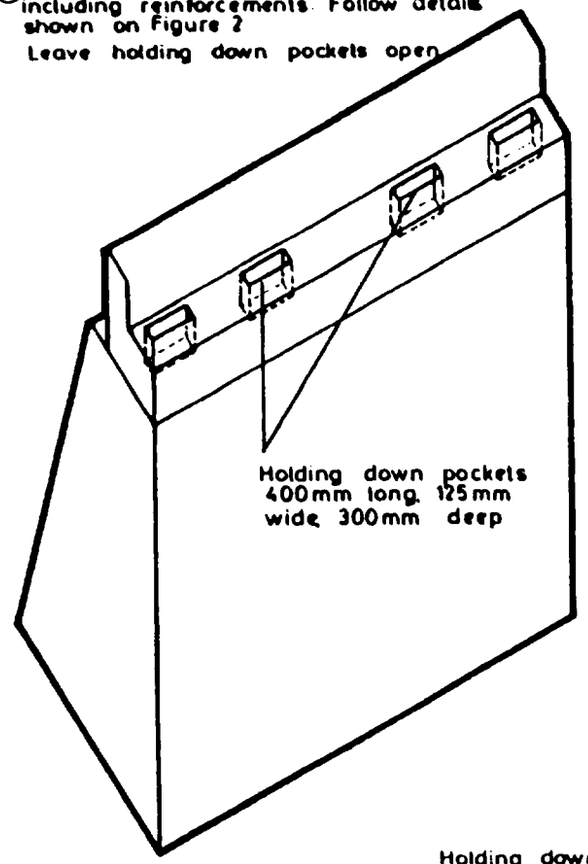
Mark 4 bars

Mark 3 M.S Open Link 12 mm dia bar Links at 100 mm centres along Holding Down Pockets

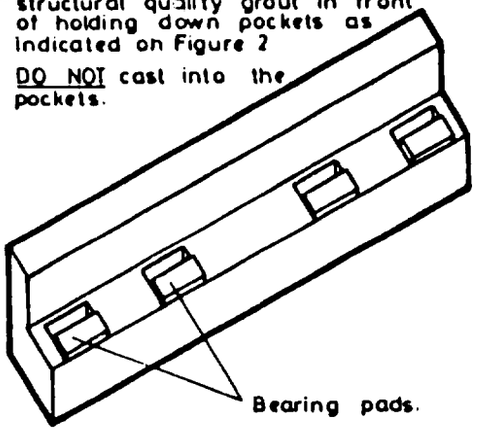
All cover to reinforcement to be 50 mm

Figure 2
continued

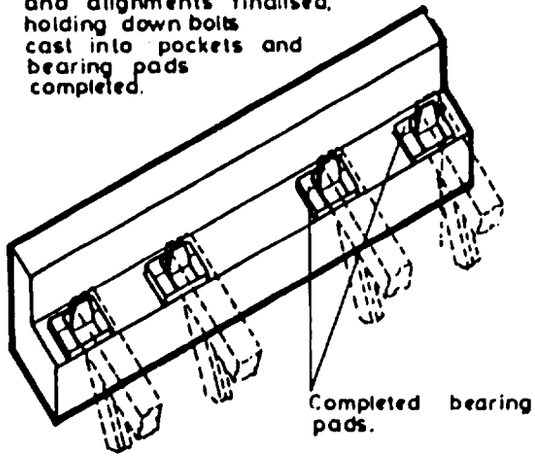
Ⓐ Construct abutments and pier cap, including reinforcements. Follow details shown on Figure 2
Leave holding down pockets open

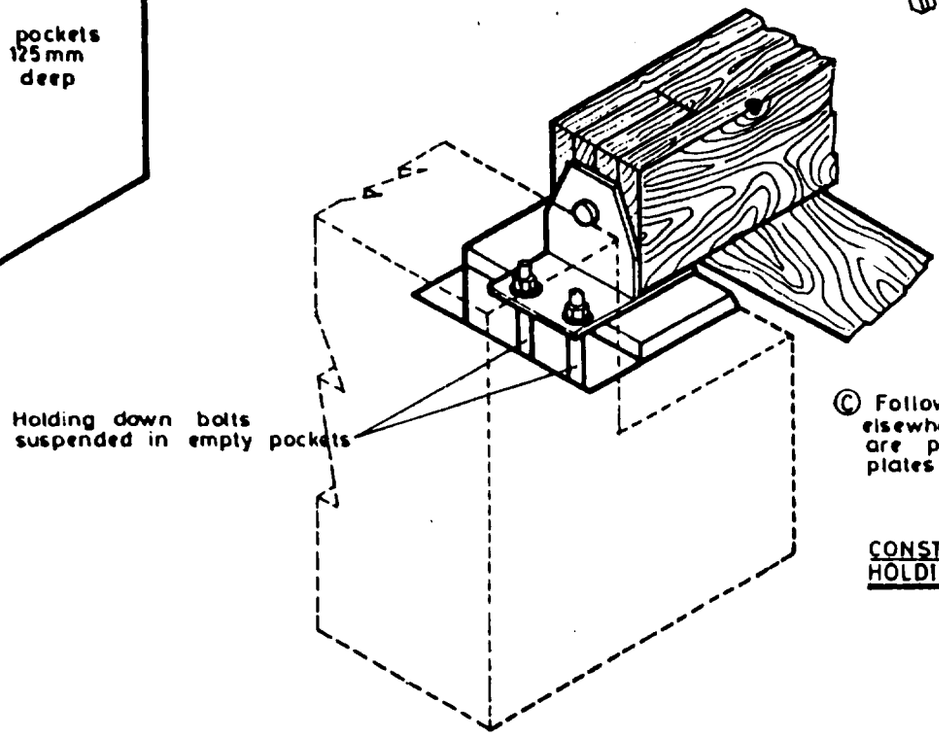


Ⓑ Form bearing pads by casting structural quality grout in front of holding down pockets as indicated on Figure 2
DO NOT cast into the pockets.



Ⓓ After completing launch of all trusses and alignments finalised, holding down bolts cast into pockets and bearing pads completed.

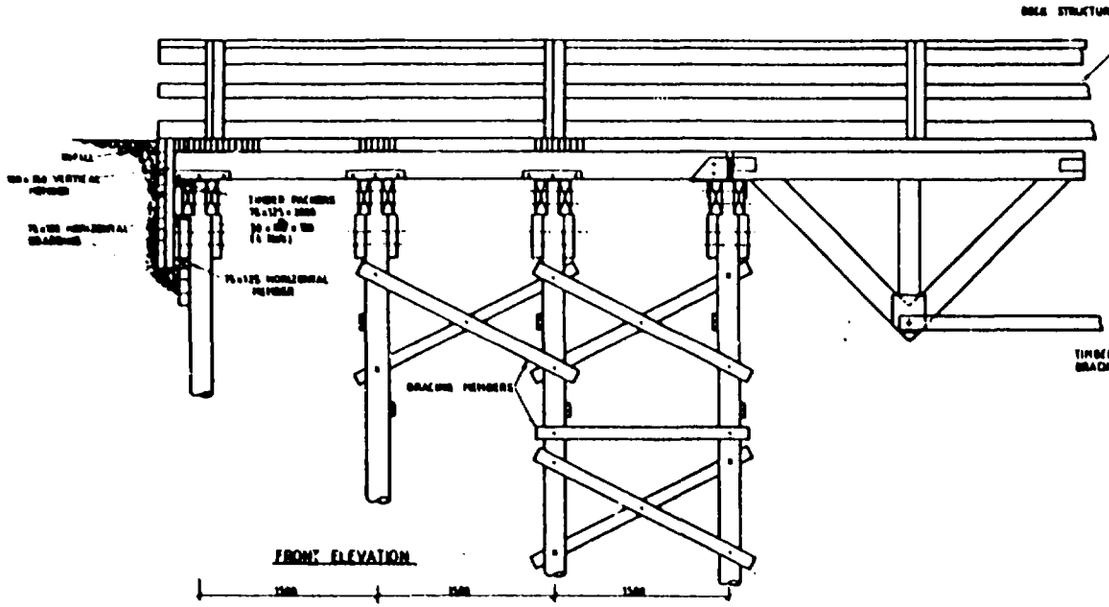




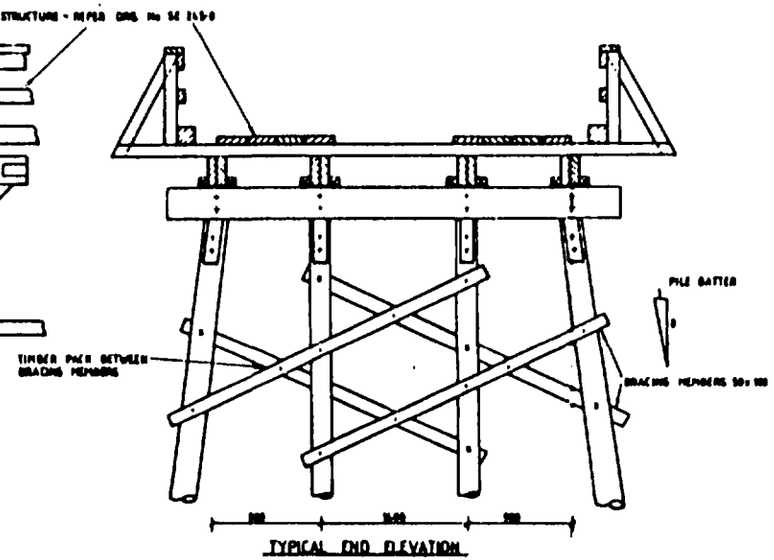
Ⓒ Following launching procedures detailed elsewhere, holding down bolts and washers are placed in accurately located bearing plates and lowered into position

CONSTRUCTION SEQUENCE FOR HOLDING DOWN DETAILS AT BEARINGS

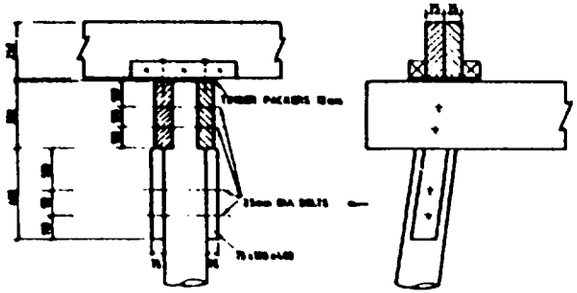
Figure 3

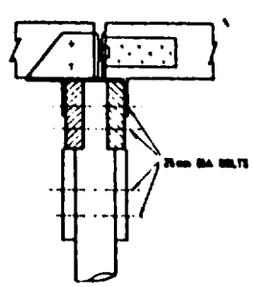


FRONT ELEVATION

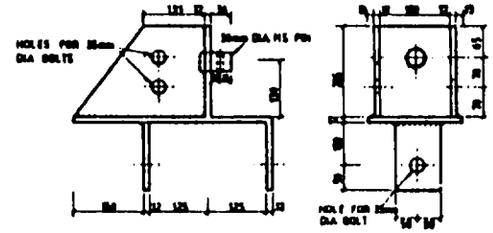


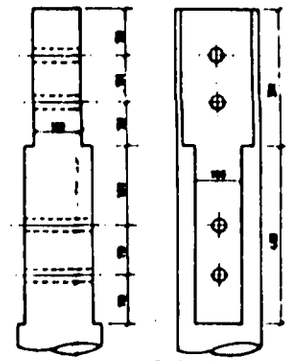
TYPICAL END ELEVATION



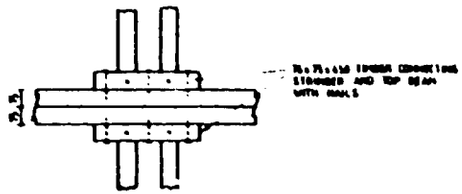


ELEVATION



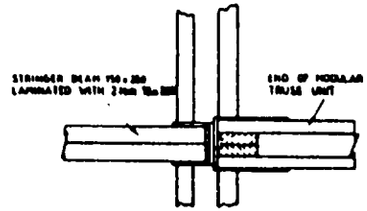


CUTTING ARRANGEMENT OF TOP END OF PILE



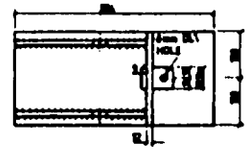
PLAN

DETAILS - CONNECTIONS - PILES TO BEAMS



PLAN

DETAIL OF END TRUSS AND STRINGER BEAM AND BEARING CONNECTION



DETAIL OF MODIFIED END BEARING PLATE

TIMBER ABUTMENT DETAILS

Figure 4

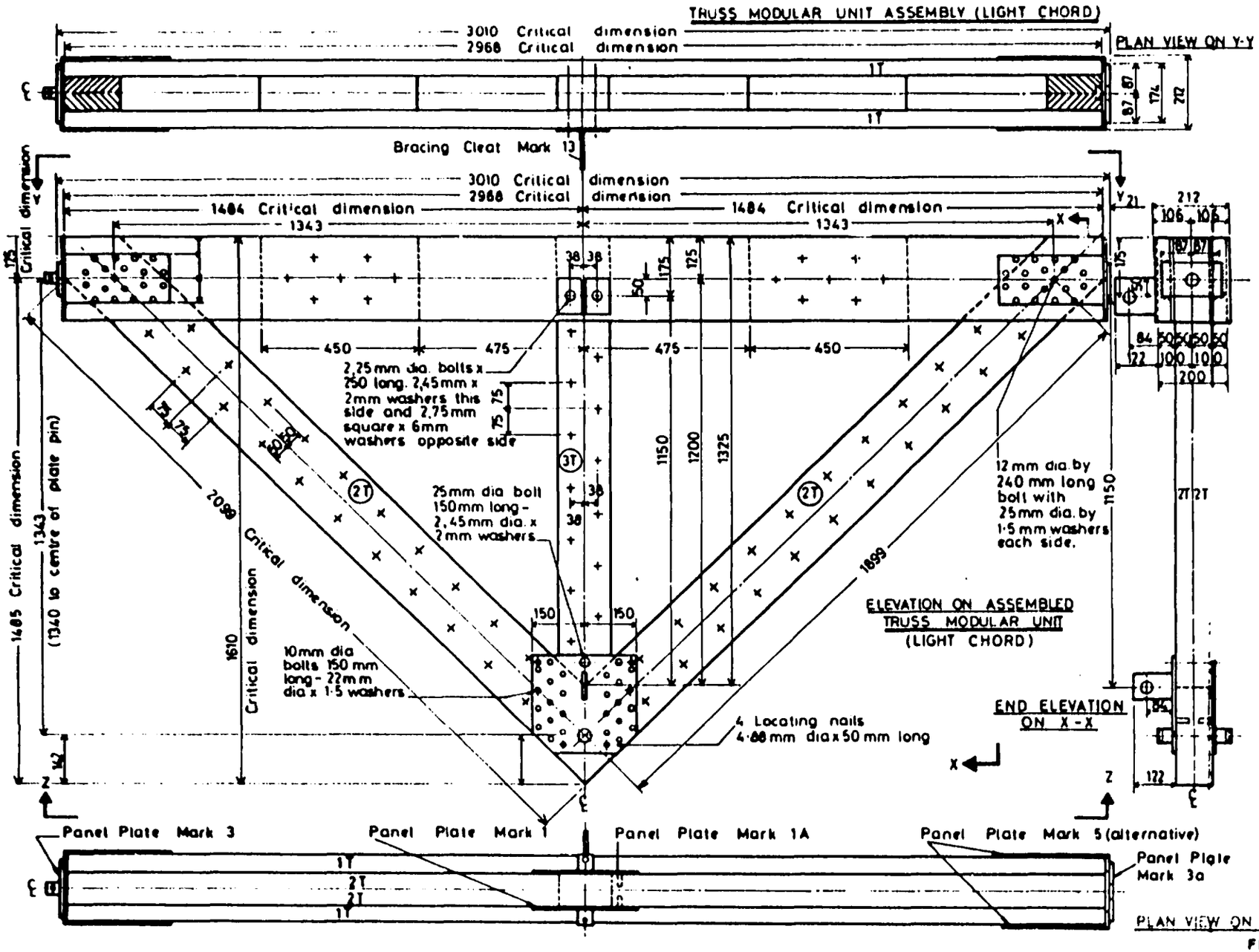

TRUSS MODULAR UNIT ASSEMBLY (LIGHT CHORD)
3010 Critical dimension
2968 Critical dimension
PLAN VIEW ON Y-Y
Bracing Cleat Mark 13
1484 Critical dimension
1343
450
475
2,25mm dia. bolts x 250 long. 2,45mm x 2mm washers this side and 2,75mm square x 6mm washers opposite side
25mm dia bolt 150mm long - 2,45mm dia. x 2mm washers
12 mm dia. by 240 mm long bolt with 25mm dia. by 1·5 mm washers each side.
ELEVATION ON ASSEMBLED TRUSS MODULAR UNIT (LIGHT CHORD)
END ELEVATION ON X-X
10mm dia bolts 150 mm long - 22mm dia x 1·5 washers
4 Locating nails 4·88mm dia x 50 mm long
1685 Critical dimension
(1340 to centre of plate pin)
Critical dimension
Panel Plate Mark 3
Panel Plate Mark 1
Panel Plate Mark 1A
Panel Plate Mark 5 (alternative)
Panel Plate Mark 3a
PLAN VIEW ON Z-Z

Figure 6

TIMBER MEMBERS FOR TRUSS MODULAR UNIT ASSEMBLY(LIGHT AND HEAVY CHORD)

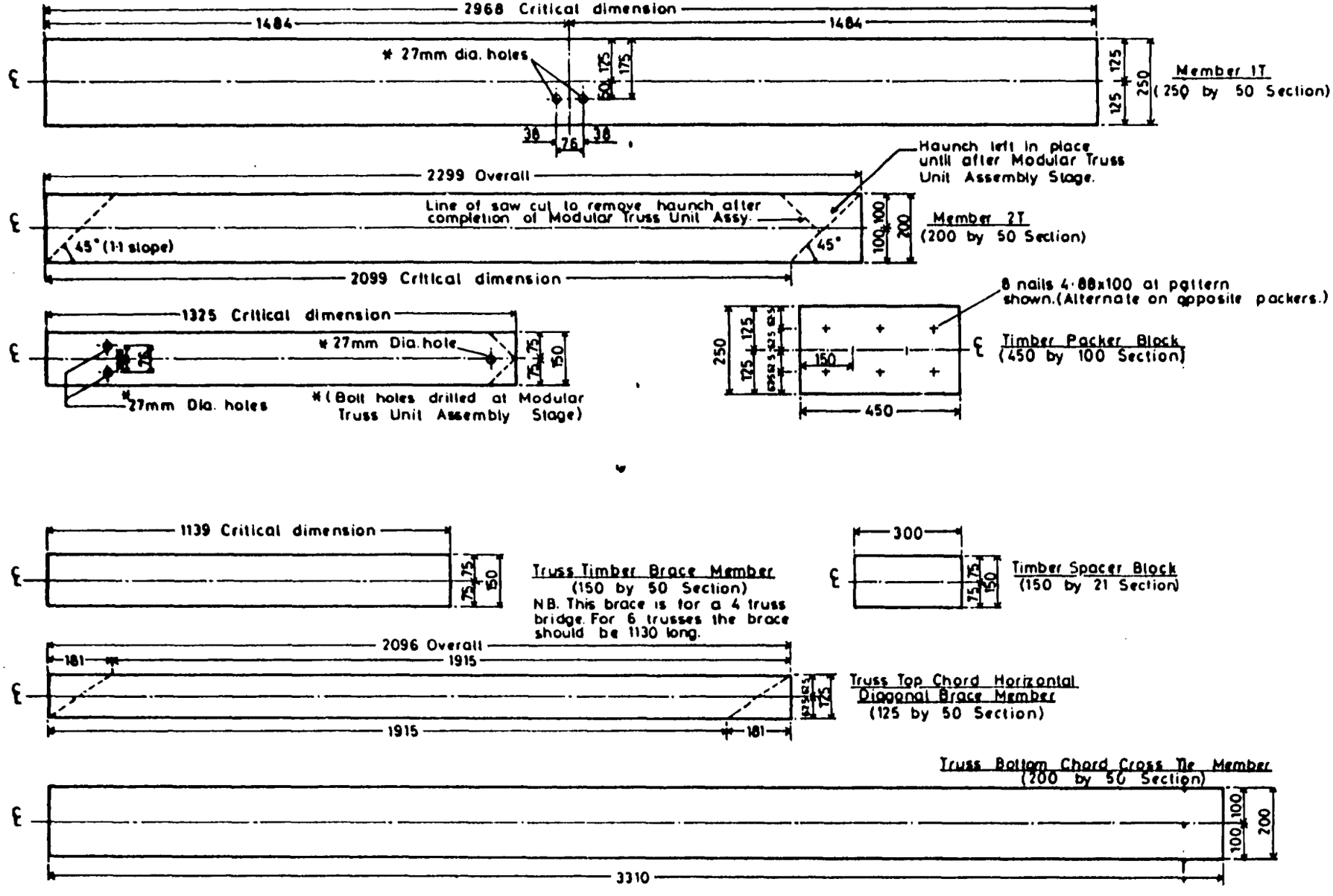
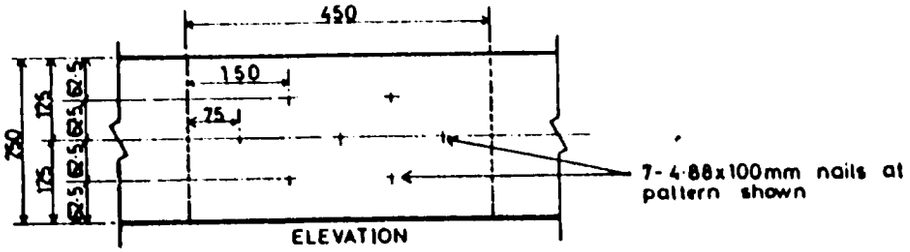
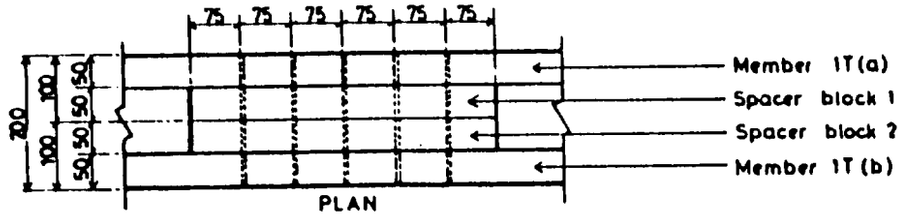


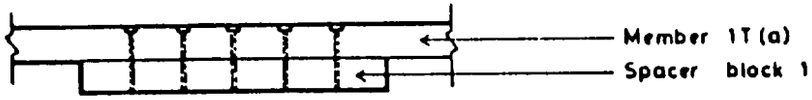
Figure 6

NAILING PATTERN FOR MEMBERS 1T

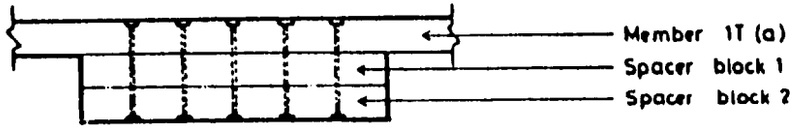




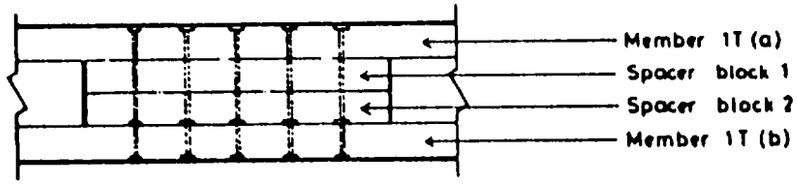
STAGE 1 - Locate spacer block 1 to member 1T(a) using member 1T nailing pattern



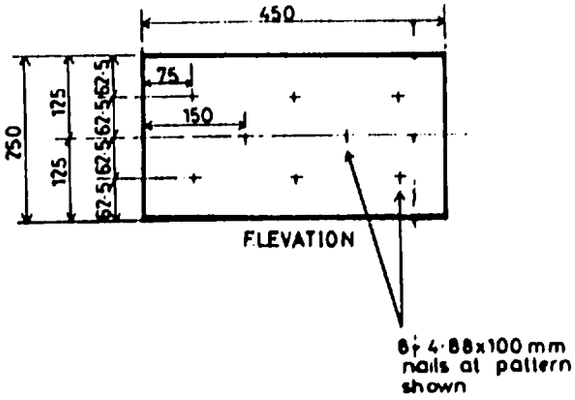
STAGE 2 - Nail spacer block 2 to spacer block 1 using spacer block nailing pattern



STAGE 3 - Nail member 1T(b) to spacer block 2 using nailing pattern for member 1T



NAILING PATTERN FOR SPACER BLOCKS



NAILING PATTERNS FOR TIMBER MEMBERS

Figure 7

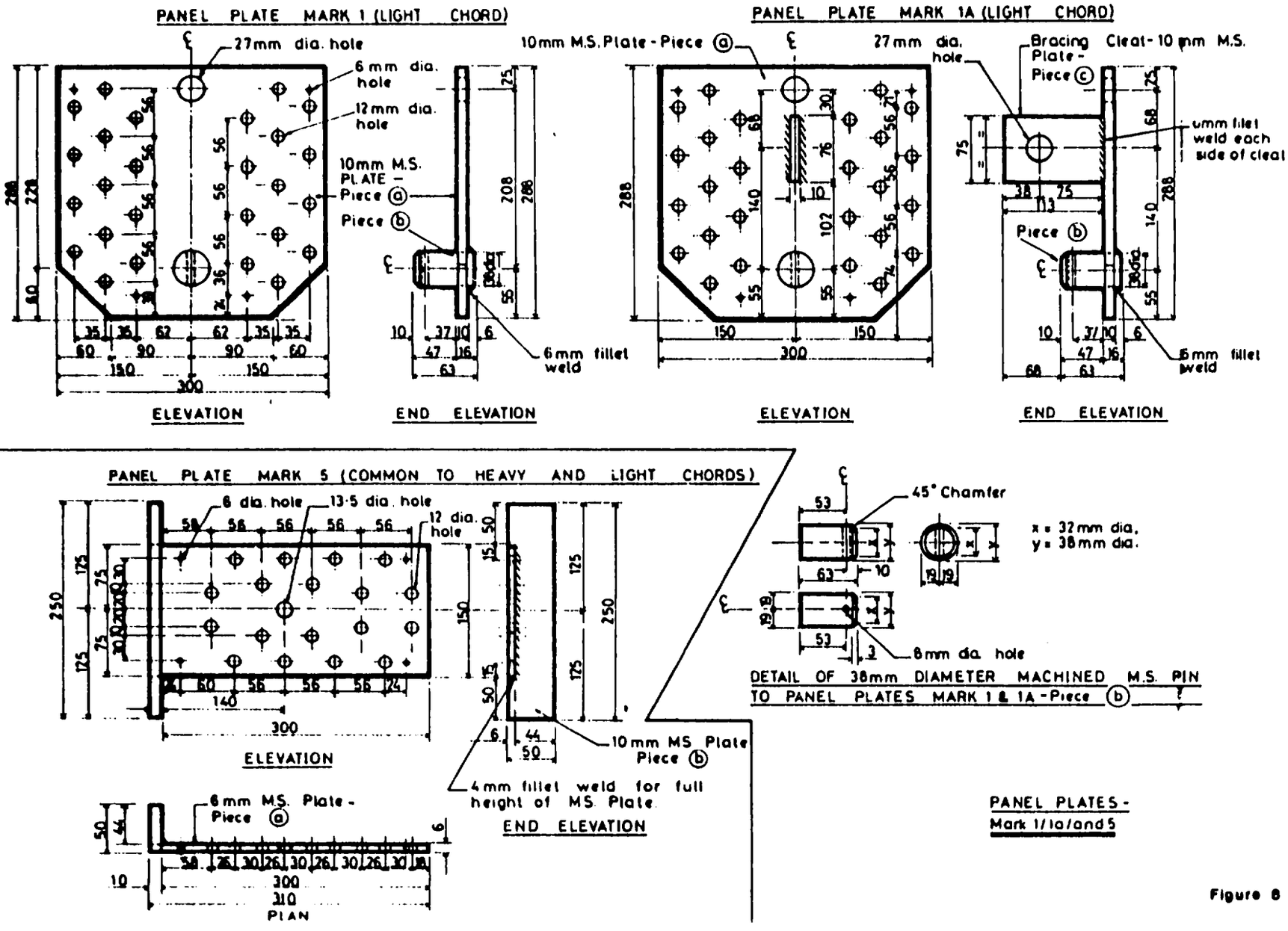
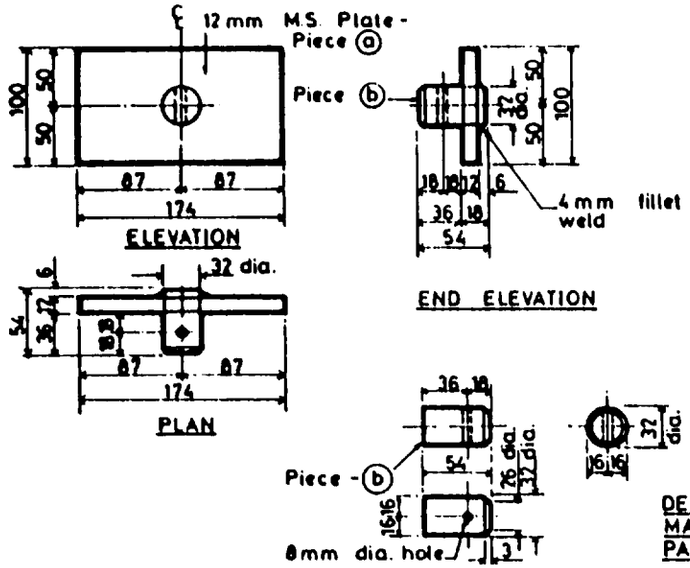
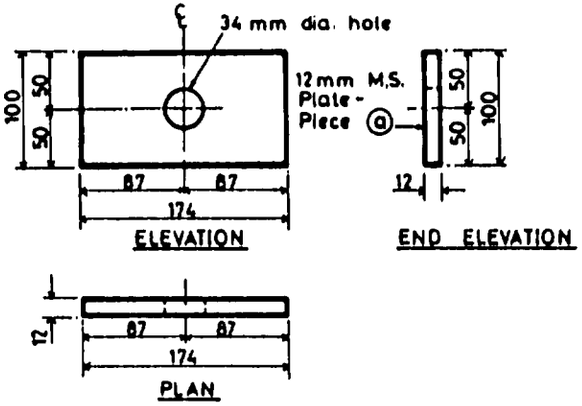

PANEL PLATE MARK 1 (LIGHT CHORD)
27mm dia. hole
6 mm dia. hole
12 mm dia. hole
10mm M.S. PLATE - Piece (a)
Piece (b)
6 mm fillet weld
ELEVATION
END ELEVATION
PANEL PLATE MARK 1A (LIGHT CHORD)
10mm M.S. Plate - Piece (a)
27 mm dia. hole
Bracing Cleat - 10 mm M.S. Plate - Piece (c)
mm fillet weld each side of cleat
Piece (b)
6 mm fillet weld
ELEVATION
END ELEVATION
PANEL PLATE MARK 5 (COMMON TO HEAVY AND LIGHT CHORDS)
8 dia. hole
13·5 dia. hole
12 dia. hole
ELEVATION
6mm M.S. Plate - Piece (a)
PLAN
10 mm MS Plate Piece (b)
4 mm fillet weld for full height of MS. Plate
END ELEVATION
45° Chamfer
x = 32 mm dia.
y = 38 mm dia.
8 mm dia. hole
DETAIL OF 38mm DIAMETER MACHINED M.S. PIN TO PANEL PLATES MARK 1 & 1A - Piece (b)
PANEL PLATES - Mark 1/1a/and 5

Figure 8

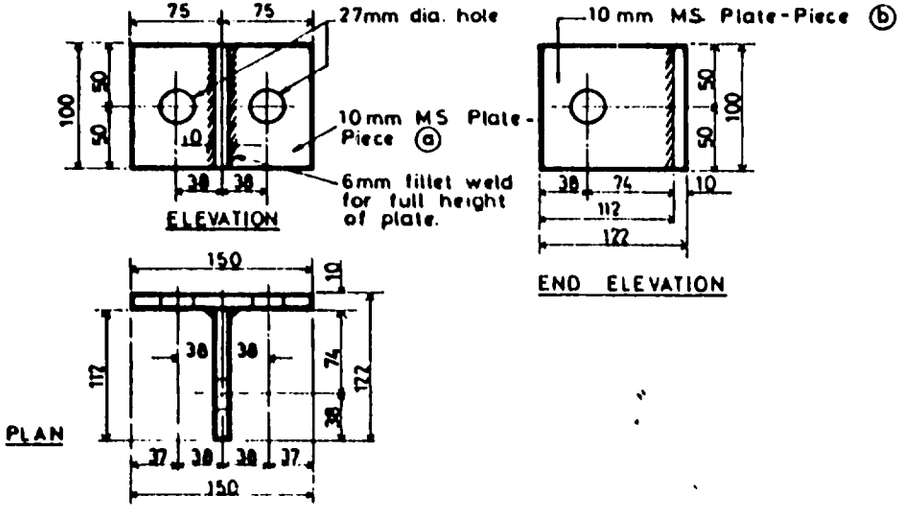
PANEL PLATE MARK 3 (LIGHT CHORD)



PANEL PLATE MARK 3A (LIGHT CHORD)



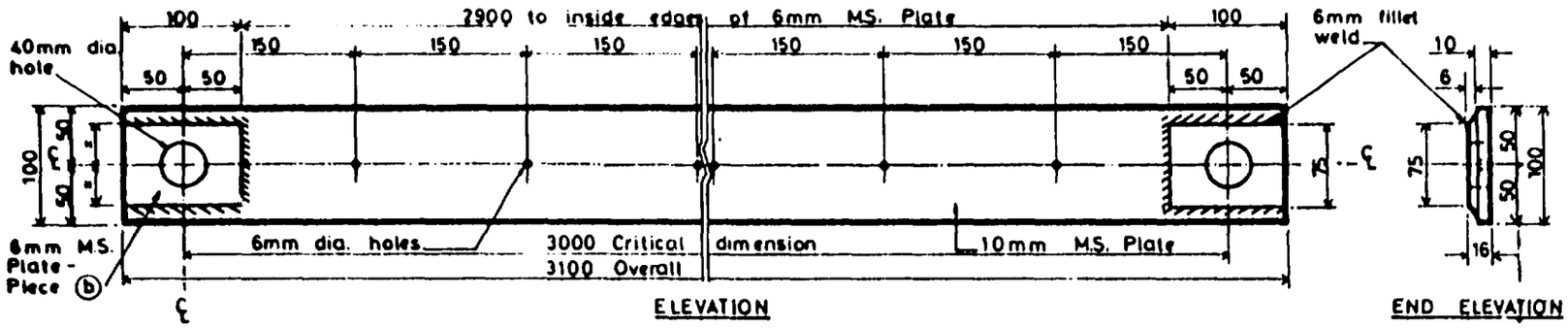
PANEL PLATE MARK 13 (COMMON TO HEAVY AND LIGHT CHORDS)

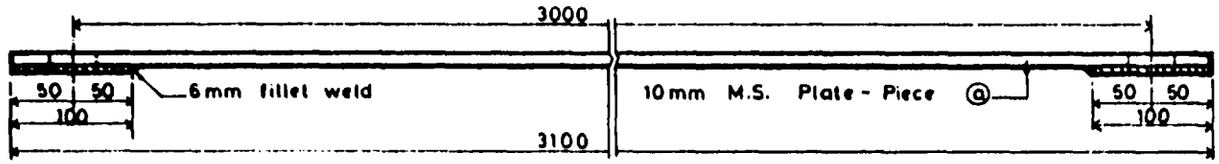


PANEL PLATES - Mark 3/3a/and 13

Figure 9

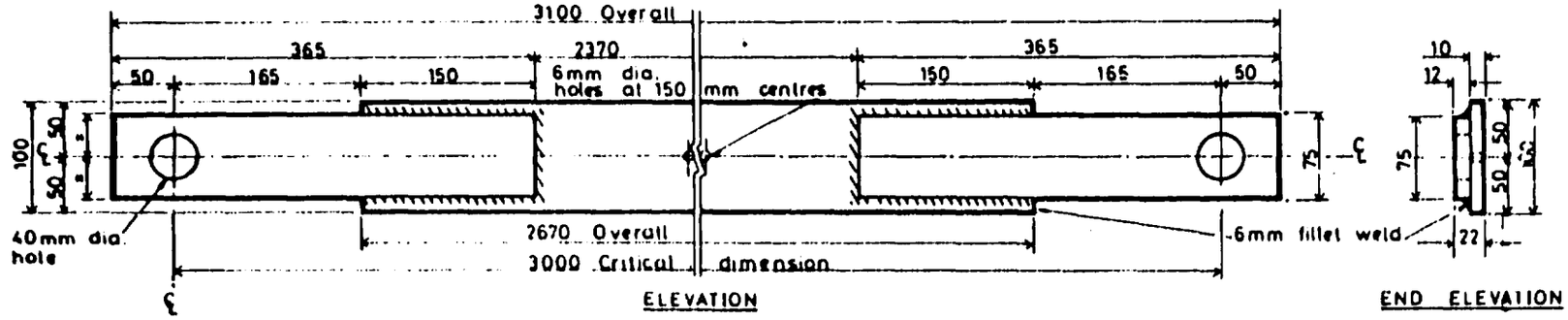
TENSION CHORD MARK 2 (MODIFIED) - LIGHT CHORD CONSTRUCTION

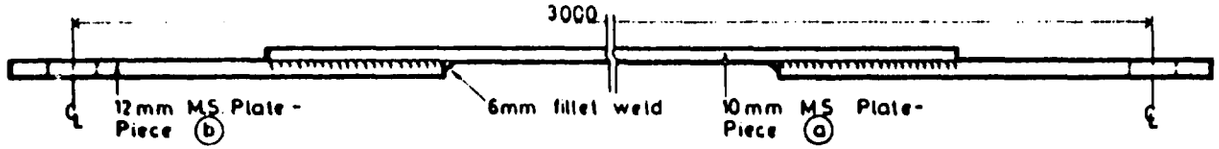




PLAN

TENSION CHORD MARK 2A (MODIFIED) - LIGHT CHORD CONSTRUCTION

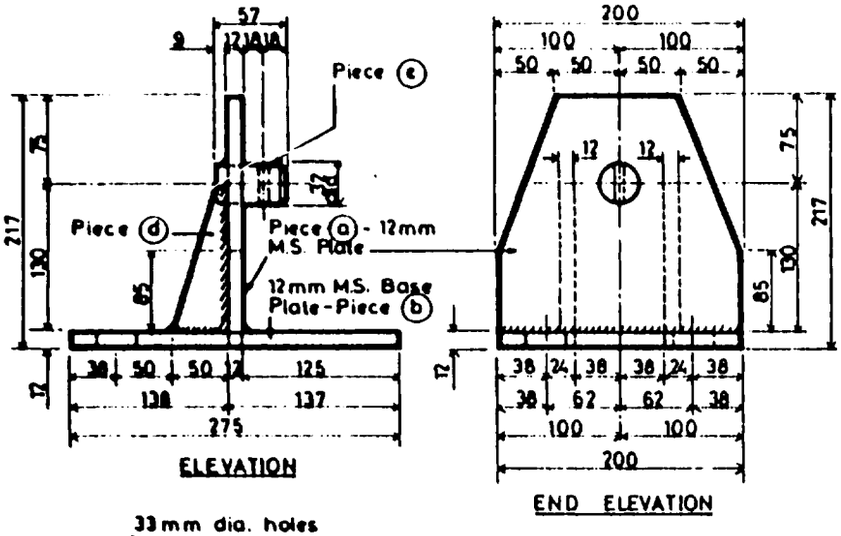


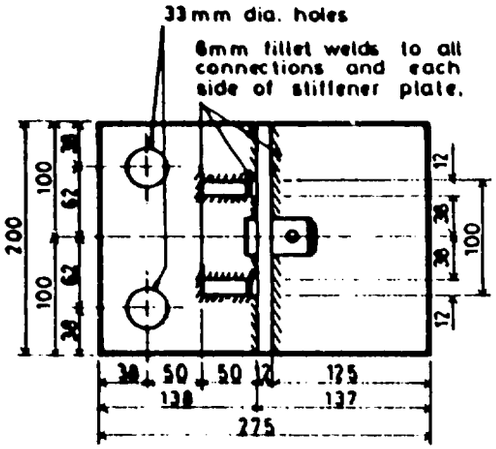


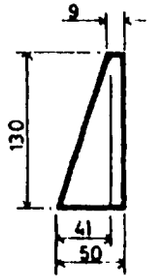
PLAN

Figure 10

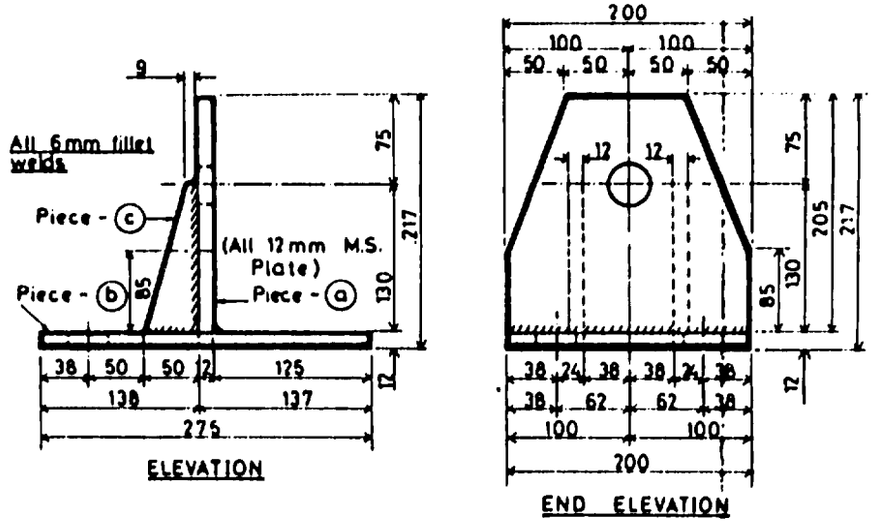
BRIDGE BEARING PLATE - MALE, MARK 14 (LIGHT CHORD)

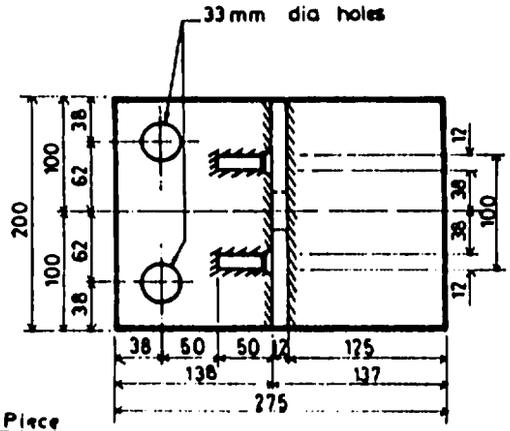






BRIDGE BEARING PLATE - FEMALE, MARK 14A (LIGHT CHORD)





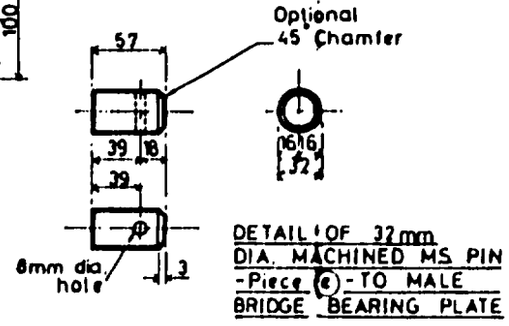


Figure 11

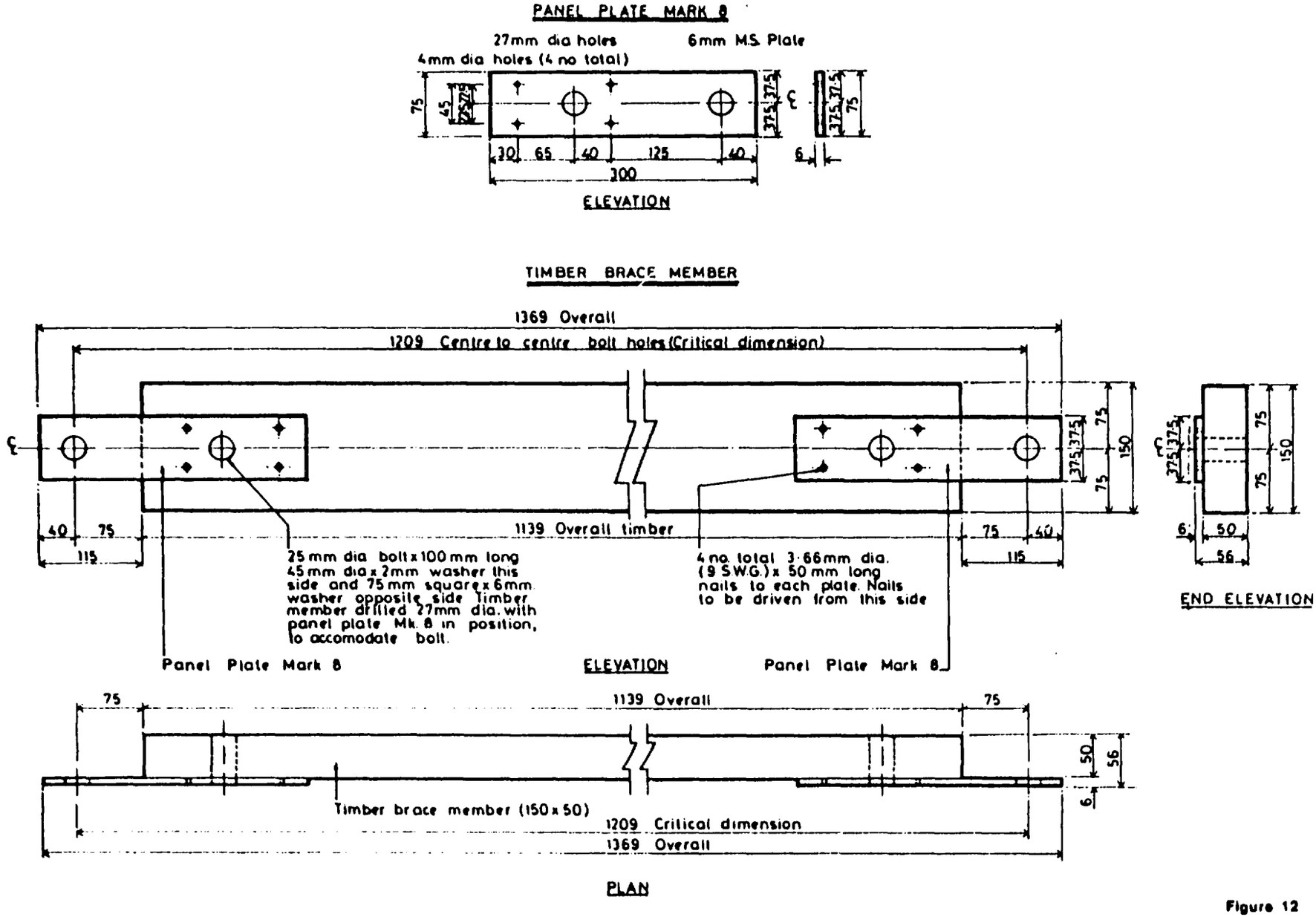

PANEL PLATE MARK 8
27mm dia holes
6mm M.S. Plate
4mm dia holes (4 no total)
75
45
25
37.5
37.5
37.5
37.5
75
30
65
40
125
40
300
6
ELEVATION
TIMBER BRACE MEMBER
1369 Overall
1209 Centre to centre bolt holes (Critical dimension)
75
150
75
40
75
115
1139 Overall timber
75
40
115
25 mm dia bolt x 100 mm long 45 mm dia x 2mm washer this side and 75 mm square x 6mm washer opposite side Timber member drilled 27mm dia. with panel plate Mk. 8 in position, to accomodate bolt.
4 no. total 3·66mm dia. (9 S.W.G.) x 50 mm long nails to each plate. Nails to be driven from this side
Panel Plate Mark 8
ELEVATION
Panel Plate Mark 8
75
150
75
6
50
56
END ELEVATION
75
1139 Overall
75
50
56
6
Timber brace member (150 x 50)
1209 Critical dimension
1369 Overall
PLAN

Figure 12

TIMBER TENSION CHORD (LIGHT CHORD CONSTRUCTION)

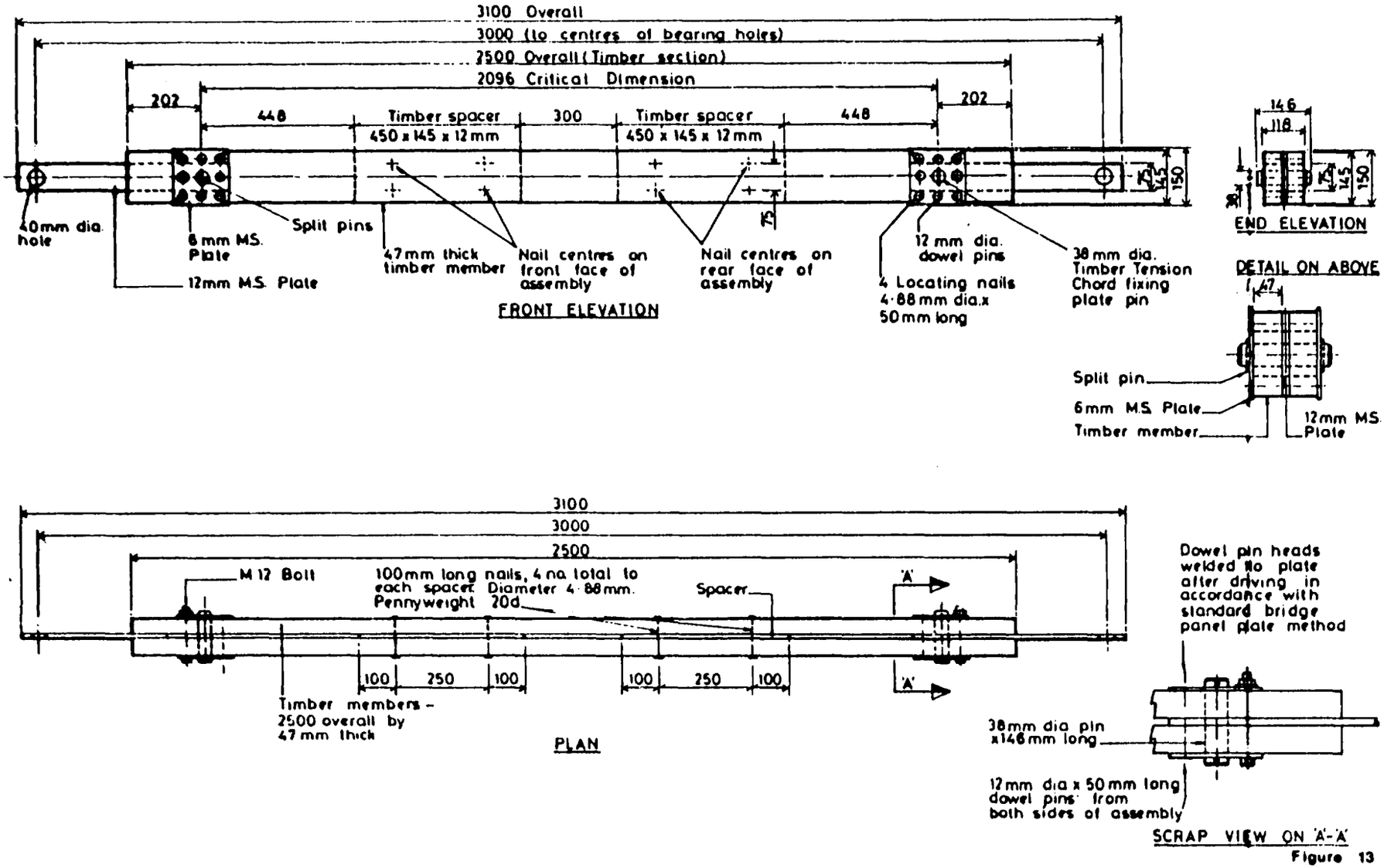
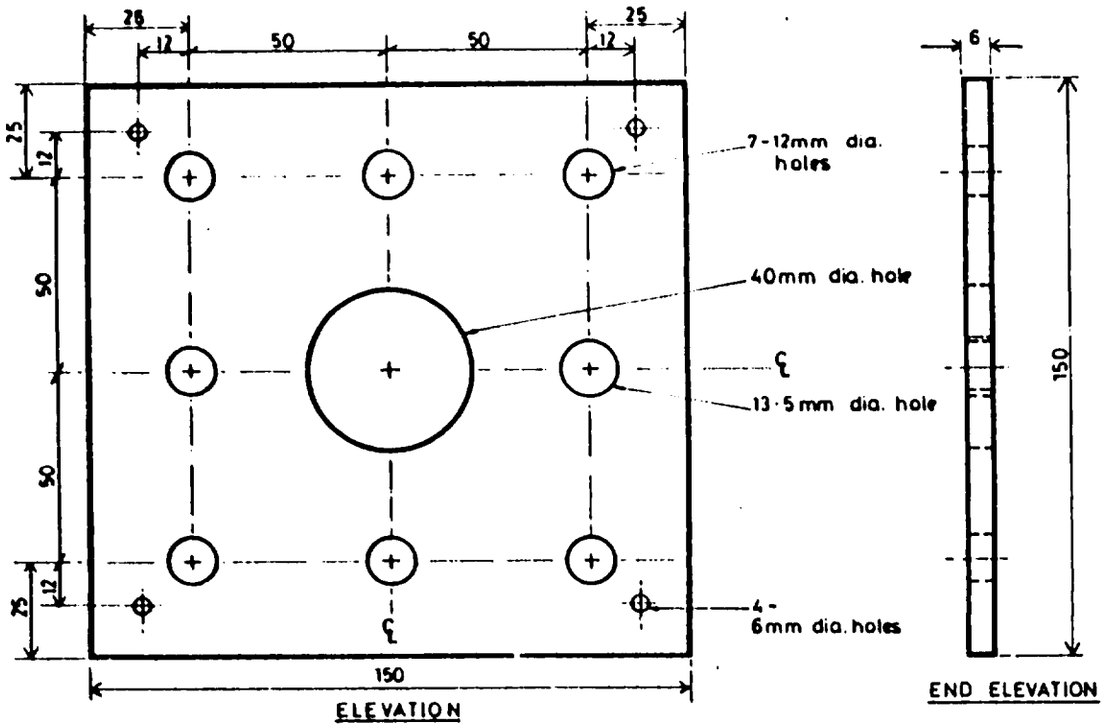


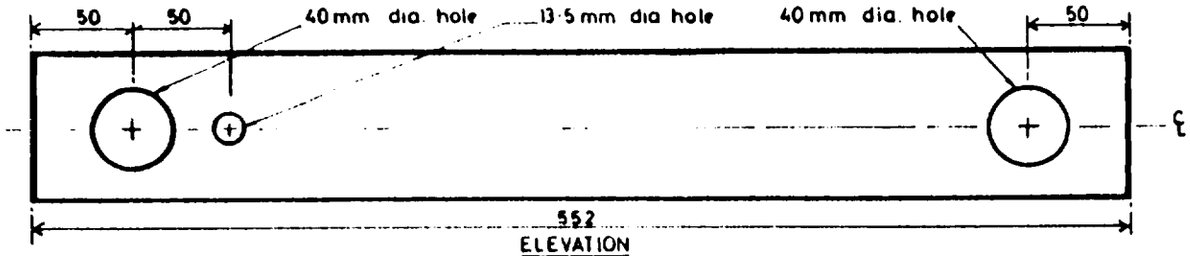
Figure 13

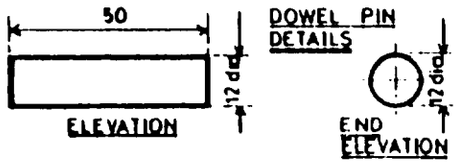


TIMBER TENSION CHORD SIDE PLATE

N.B. These drawings are for bridges of light chord construction

TIMBER TENSION CHORD LOCATING PLATE





TIMBER TENSION CHORD SIDE PLATE PIN

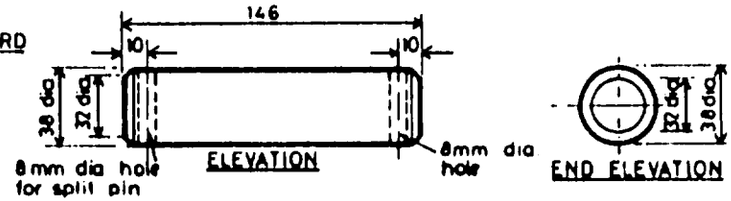


Figure 14

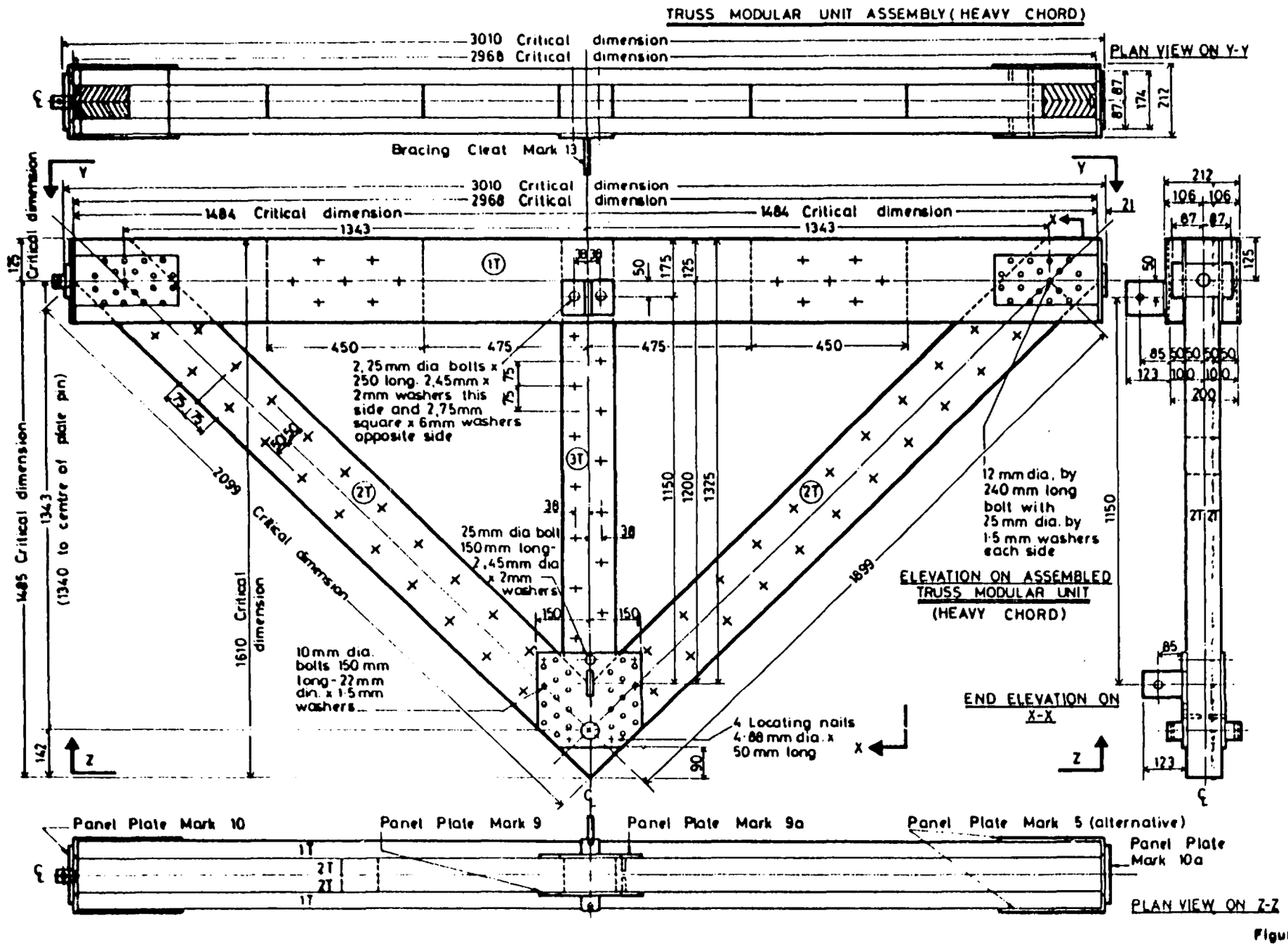
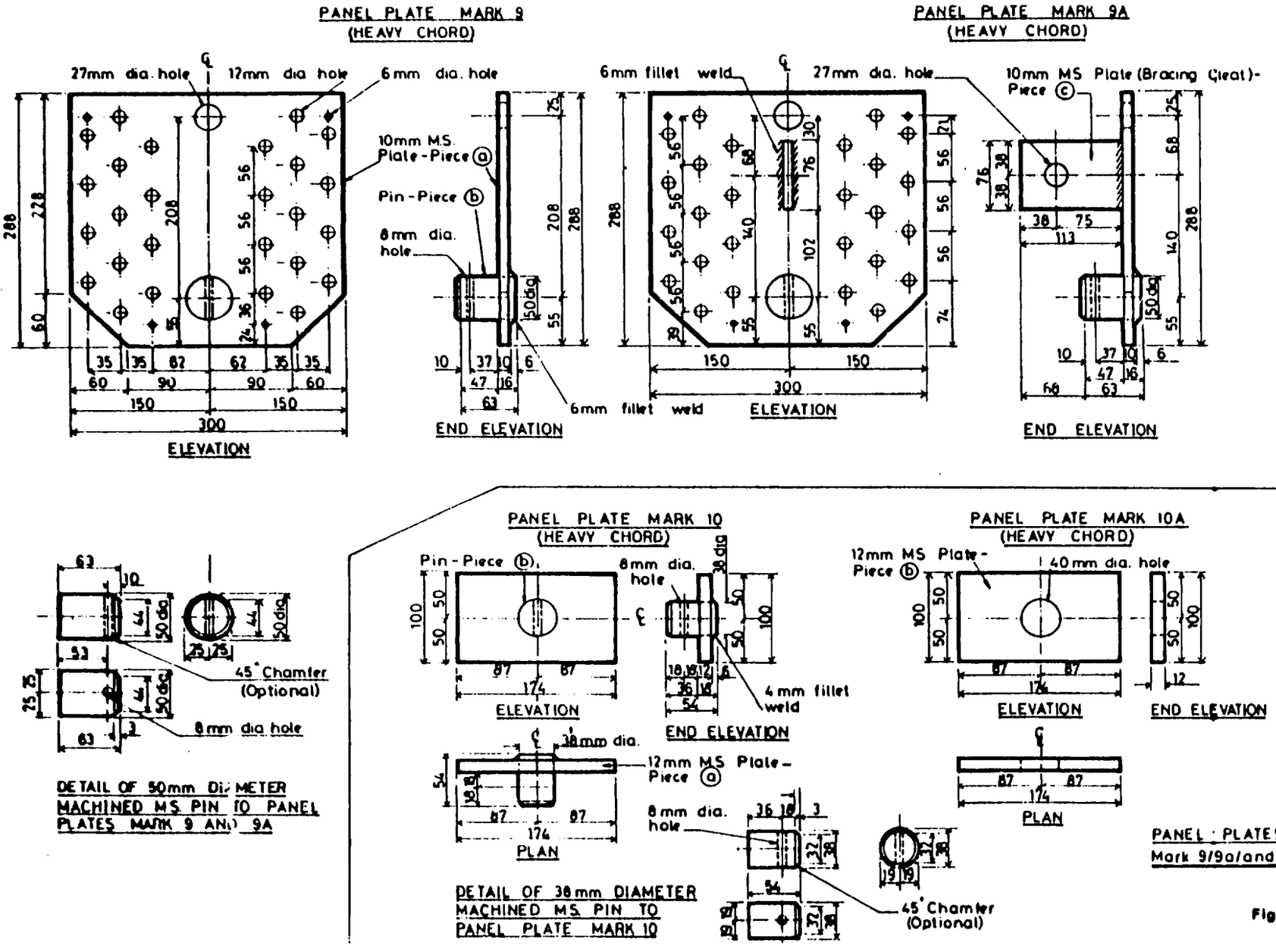

TRUSS MODULAR UNIT ASSEMBLY (HEAVY CHORD)
3010 Critical dimension
2968 Critical dimension
PLAN VIEW ON Y-Y
Bracing Cleat Mark 13
1484 Critical dimension
1343
450
475
2,25mm dia bolts x 250 long. 2,45mm x 2mm washers this side and 2,75mm square x 6mm washers opposite side
25mm dia bolt 150mm long-2,45mm dia x 2mm washers
12 mm dia. by 240 mm long bolt with 25 mm dia. by 1·5 mm washers each side
ELEVATION ON ASSEMBLED TRUSS MODULAR UNIT (HEAVY CHORD)
END ELEVATION ON X-X
10mm dia. bolts 150 mm long - 22 mm dia. x 1·5 mm washers
4 Locating nails 4·88 mm dia. x 50 mm long
1485 Critical dimension
(1340 to centre of plate pin)
1610 Critical dimension
Critical dimension
2099
1699
Panel Plate Mark 10
Panel Plate Mark 9
Panel Plate Mark 9a
Panel Plate Mark 5 (alternative)
Panel Plate Mark 10a
PLAN VIEW ON Z-Z

Figure 18



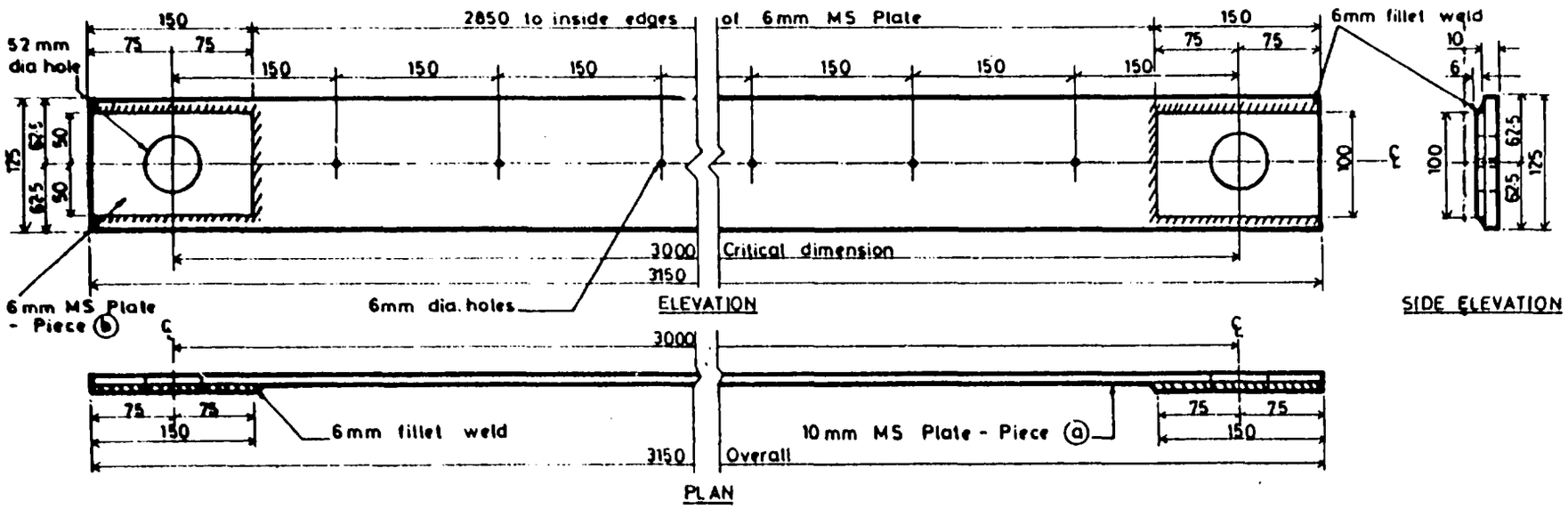
DETAIL OF 50mm DIAMETER MACHINED MS PIN TO PANEL PLATES MARK 9 AND 9A

DETAIL OF 38mm DIAMETER MACHINED MS PIN TO PANEL PLATE MARK 10

PANEL PLATES - Mark 9/9a/and 10

Figure 16

TENSION CHORD MARK 6 (MODIFIED) - HEAVY CHORD CONSTRUCTION



TENSION CHORD MARK 6A (MODIFIED) - HEAVY CHORD CONSTRUCTION

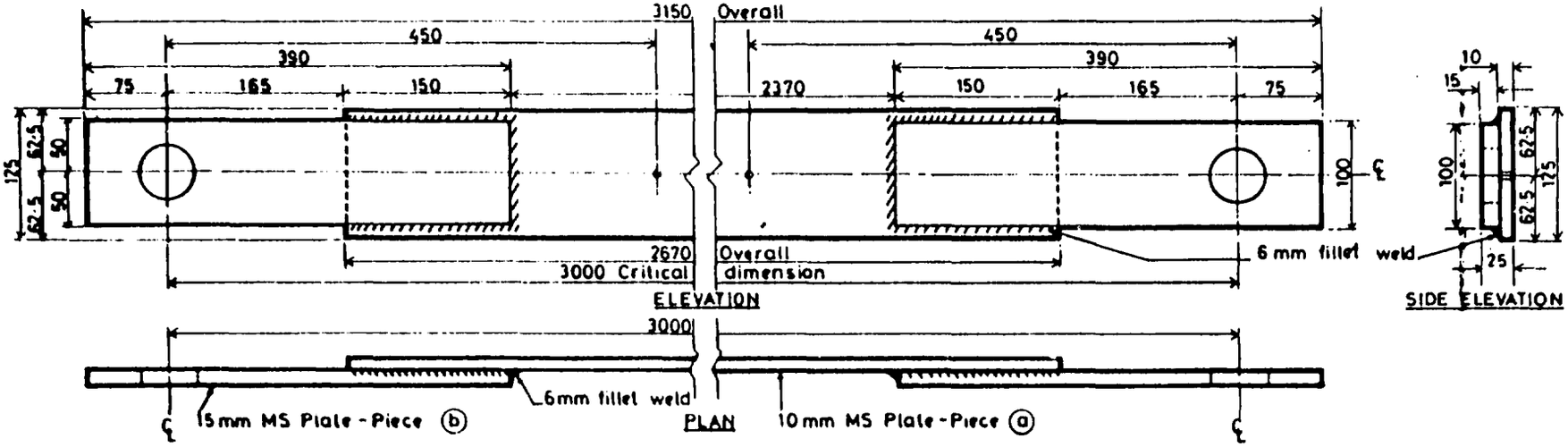
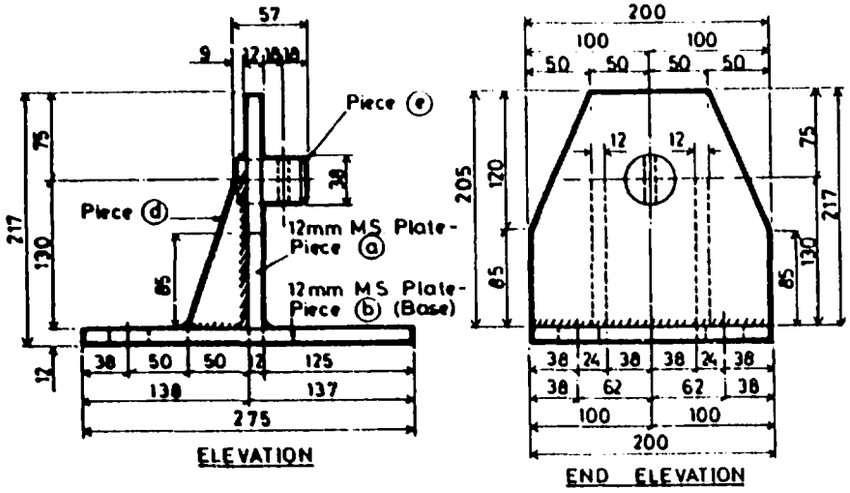
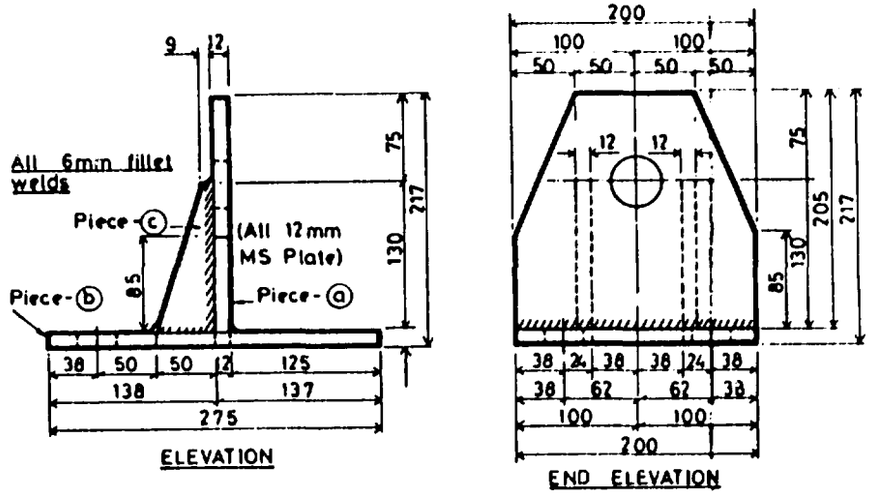


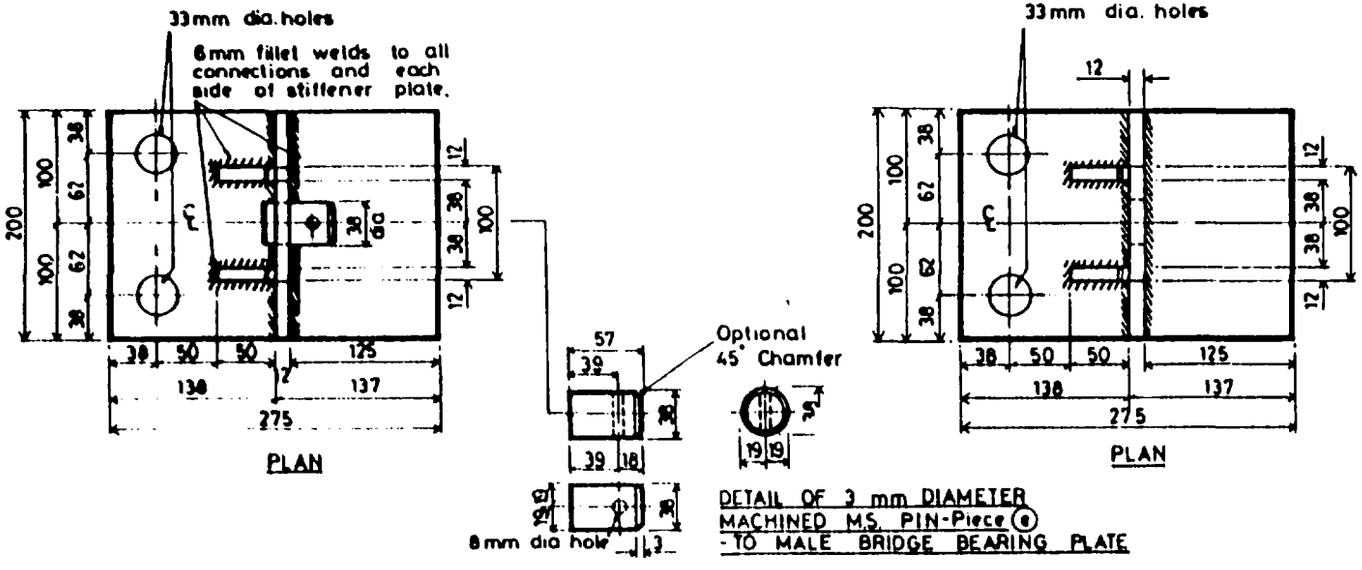
Figure 17

BRIDGE BEARING PLATE - MALE, MARK 15 (HEAVY CHORD)

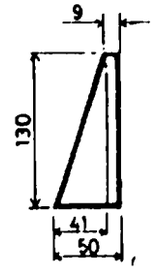


BRIDGE BEARING PLATE - FEMALE, MARK 15A (HEAVY CHORD)





BRIDGE BEARING PLATES AND DETAILS



MS. PLATE STIFFENER - Piece (c) & (d) - PATTERN ELEVATION (All 12mm MS. Plate)

Figure 18

TIMBER TENSION CHORD (HEAVY CHORD CONSTRUCTION)

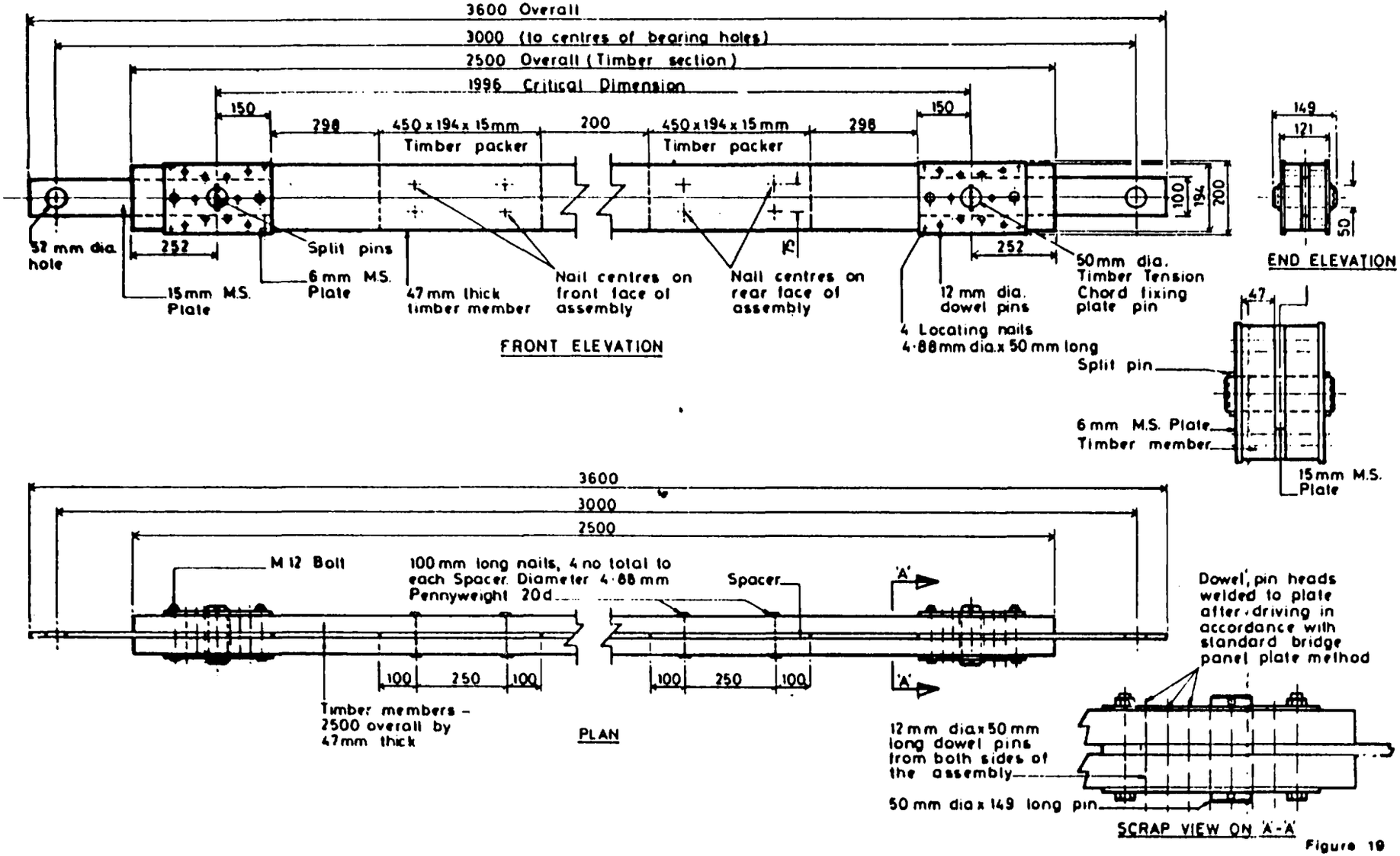
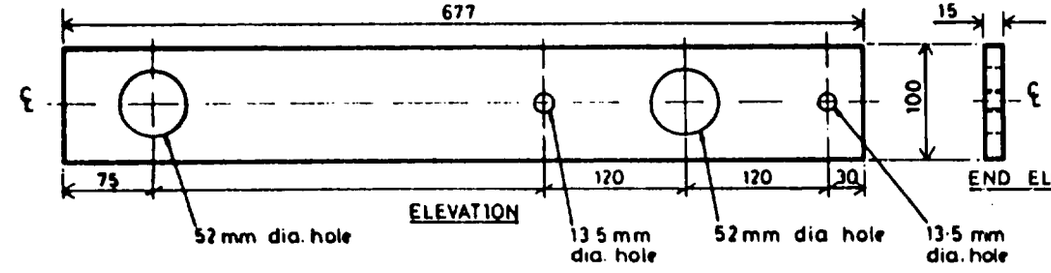
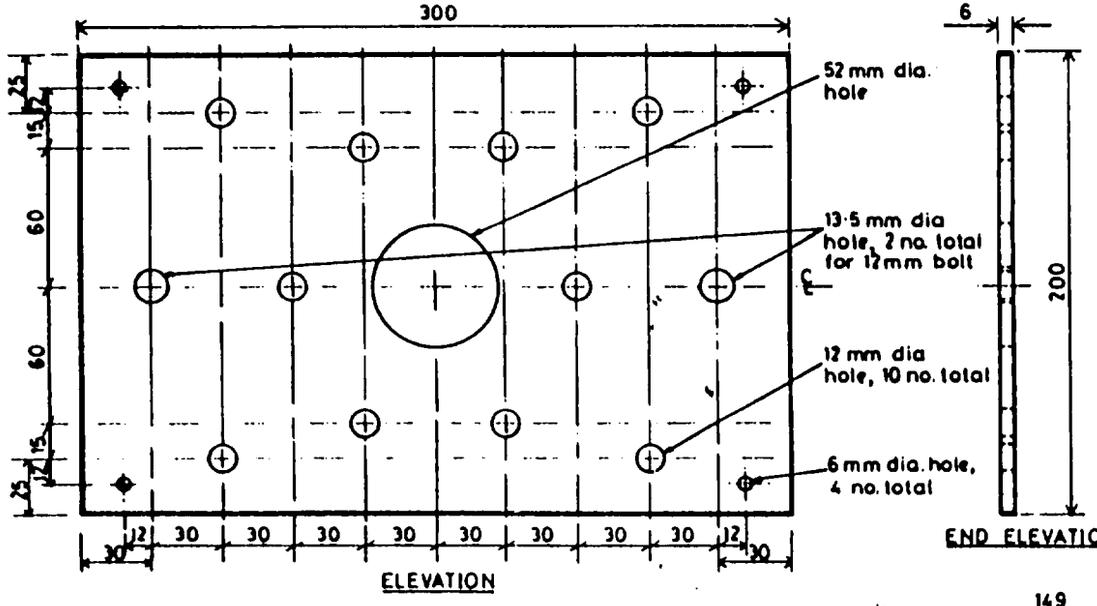


Figure 19

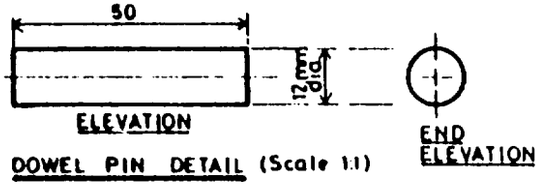


TIMBER TENSION CHORD LOCATING PLATE (Scale 1:4)

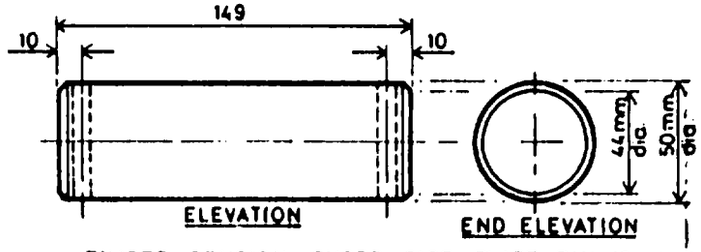


TIMBER TENSION CHORD SIDE PLATE (Scale 1:2)

N.B. These drawings are for bridges of heavy chord construction



DOWEL PIN DETAIL (Scale 1:1)



TIMBER TENSION CHORD SIDE PLATE PIN (Scale 1:2)

Figure 20

PART SECTIONAL LONGITUDINAL VIEW ON ASSEMBLED BRIDGE

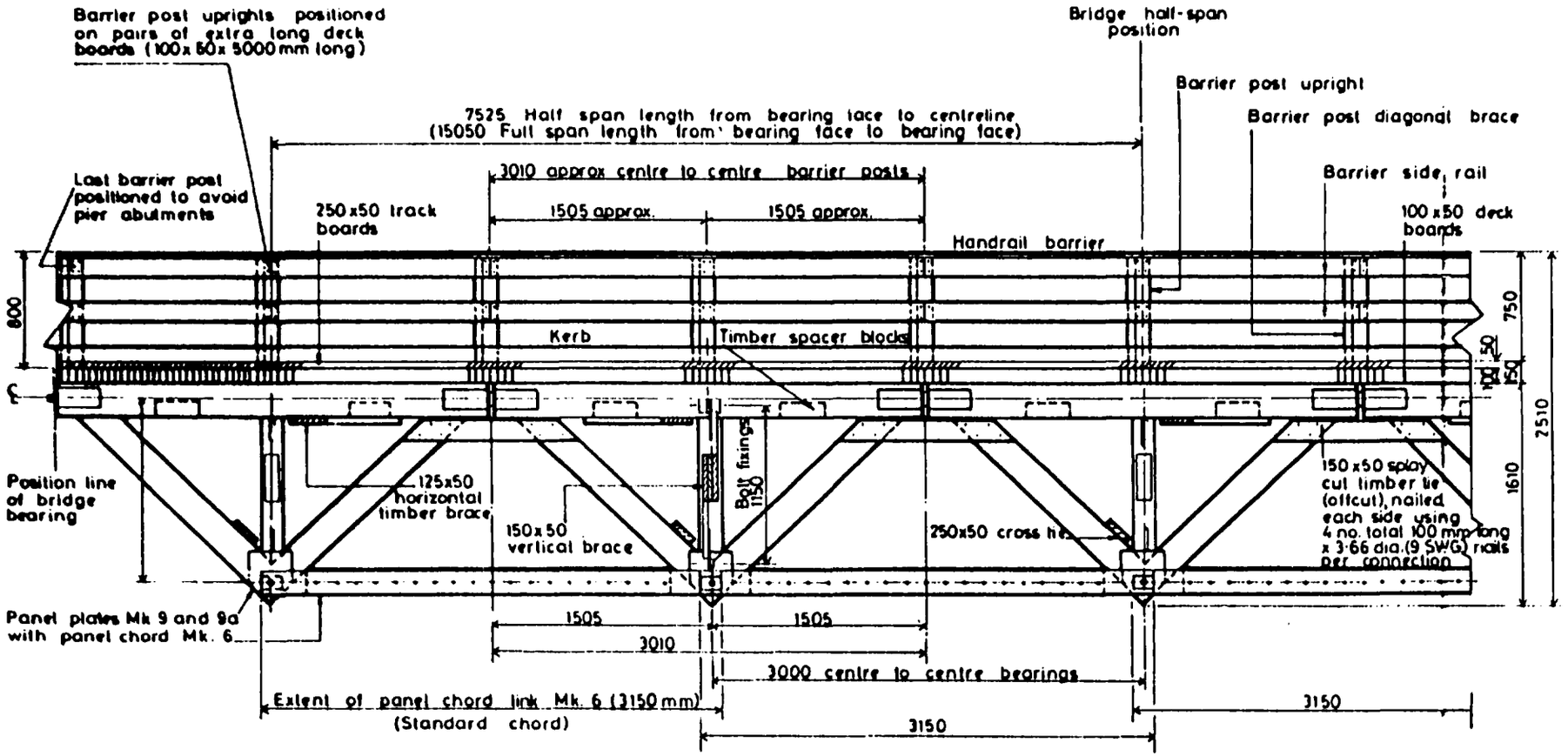


Figure 21

PART SECTIONAL PLAN VIEW ON ASSEMBLED BRIDGE

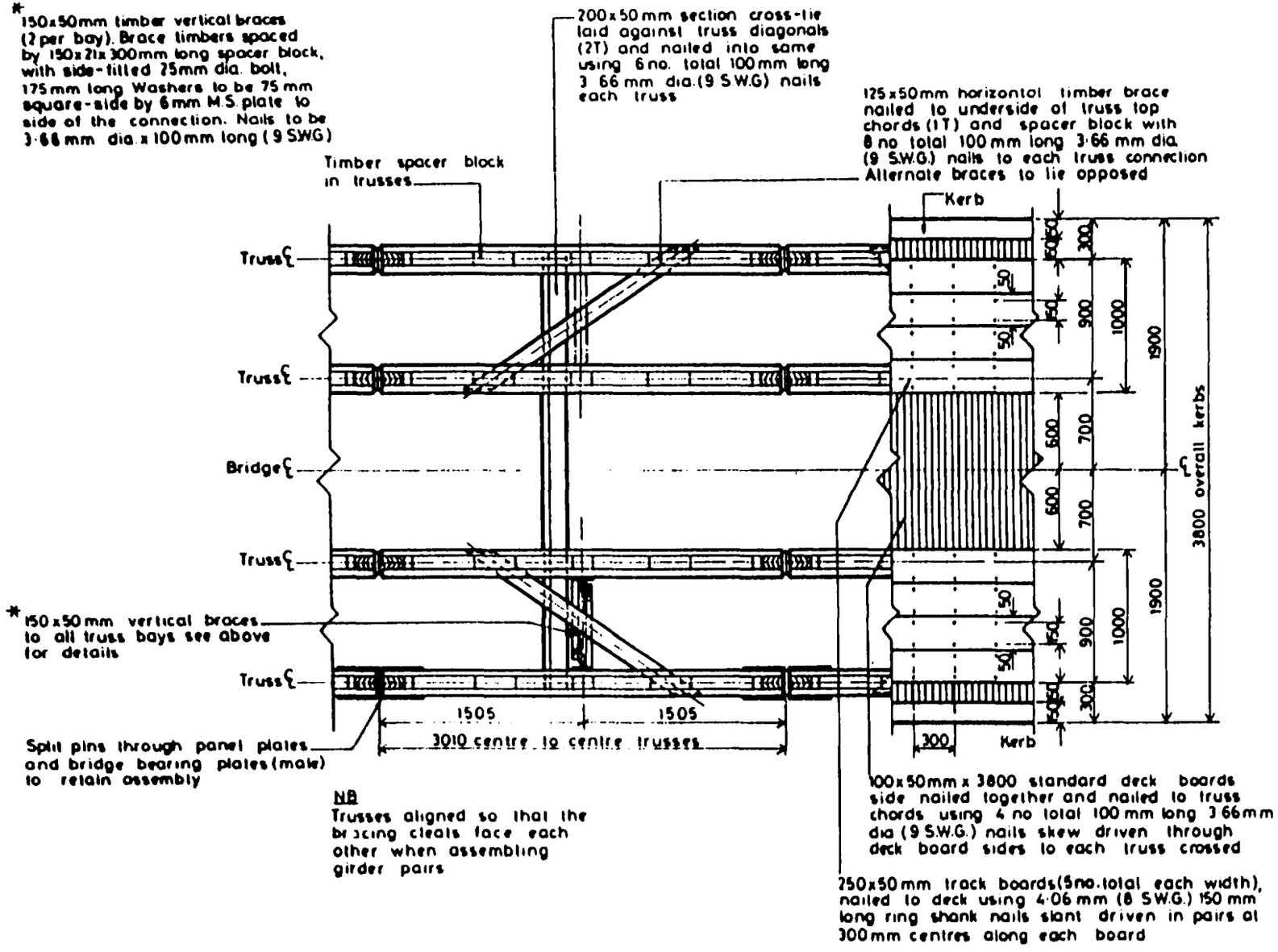
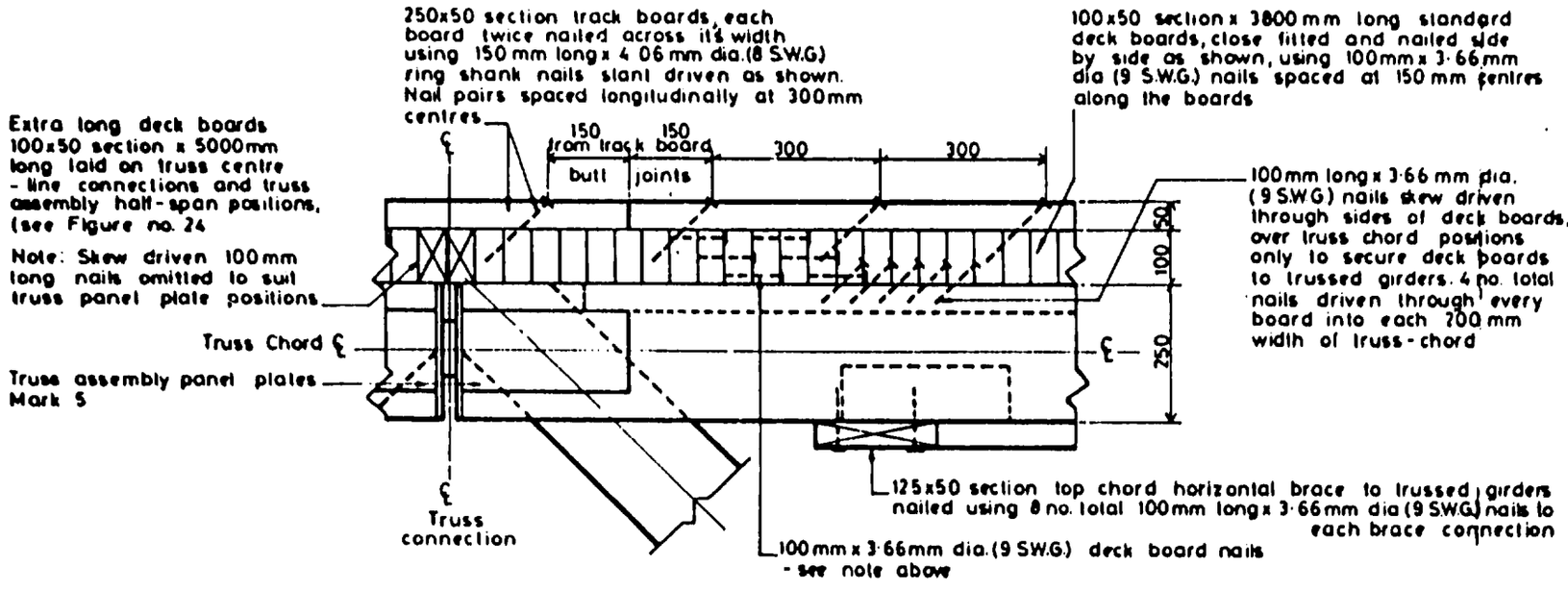
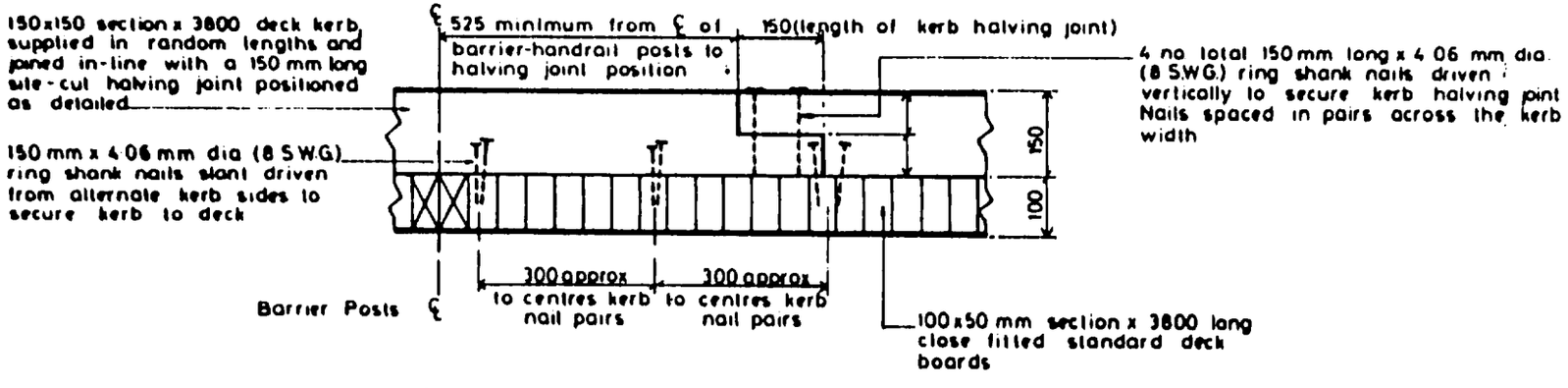


Figure 22

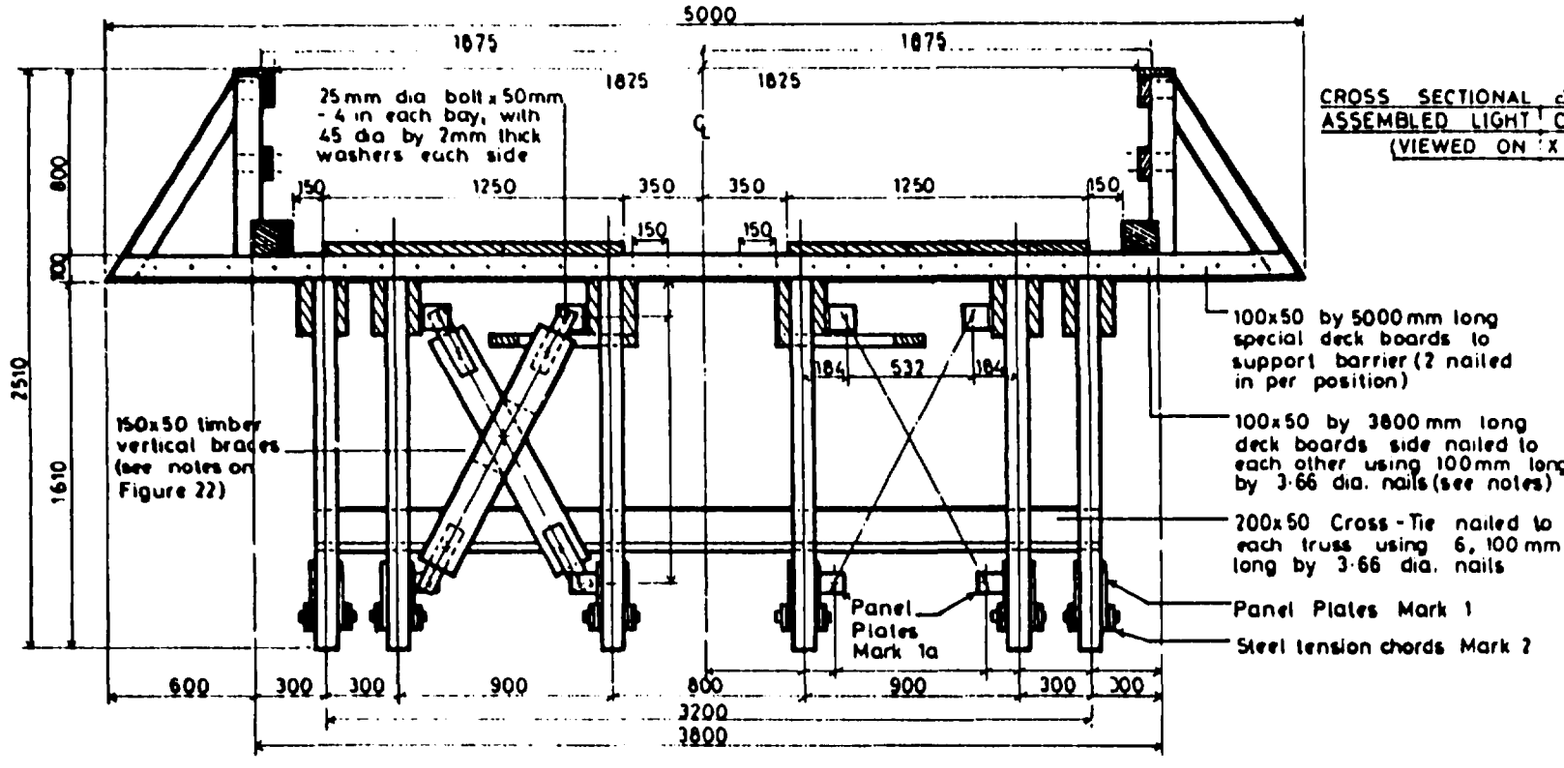


TYPICAL ELEVATION SHOWING BRIDGE DECK FIXING DETAIL

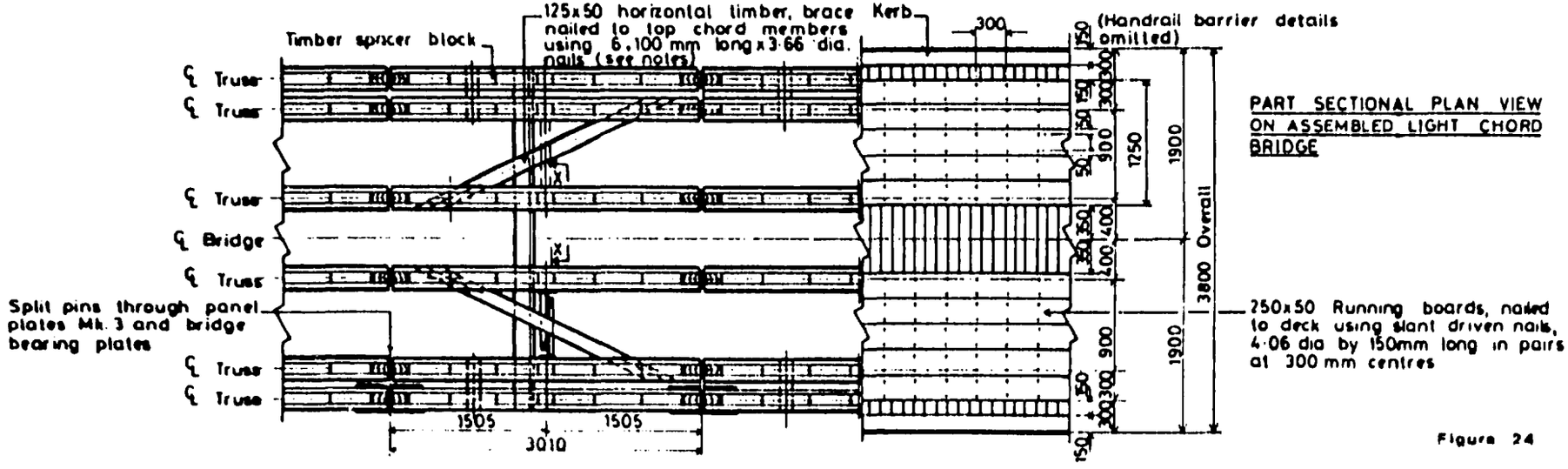


TYPICAL ELEVATION SHOWING BRIDGE DECK KERBING DETAIL

Figure 23



CROSS SECTIONAL ELEVATION ON ASSEMBLED LIGHT CHORD BRIDGE (VIEWED ON X-X)



PART SECTIONAL PLAN VIEW ON ASSEMBLED LIGHT CHORD BRIDGE

Figure 24

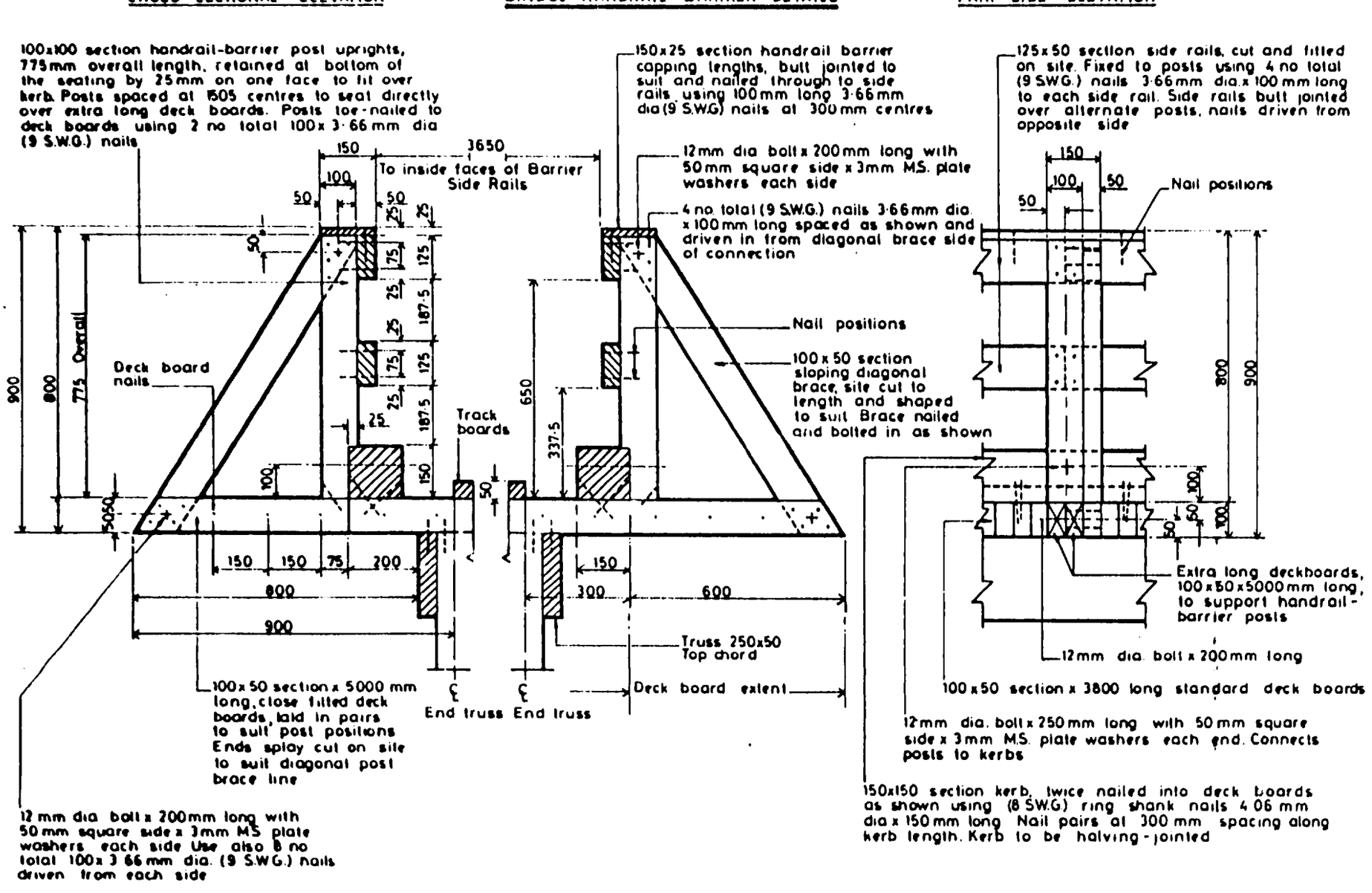
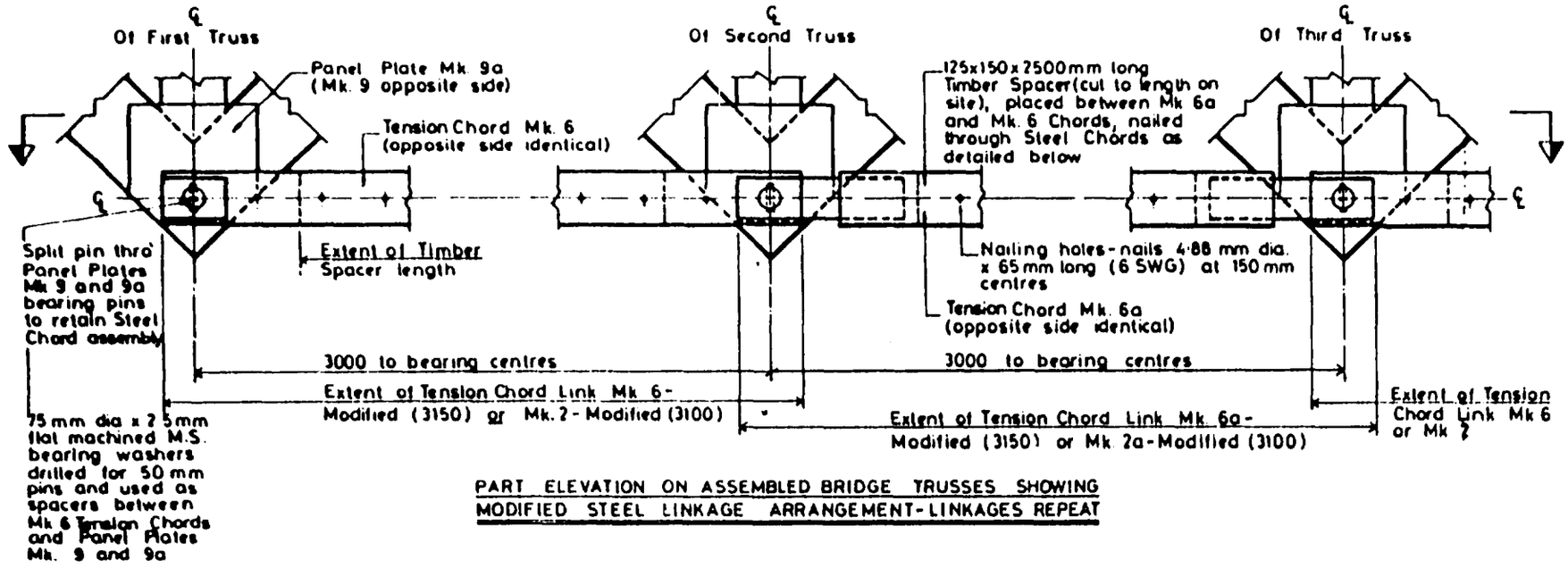
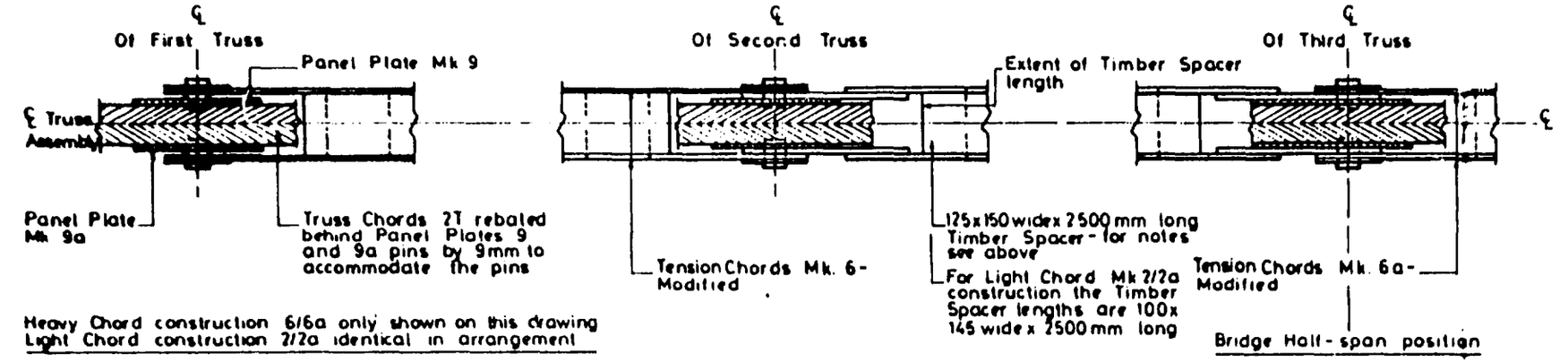

CROSS SECTIONAL ELEVATION
BRIDGE HANDRAIL - BARRIER DETAILS
PART SIDE ELEVATION
100x100 section handrail-barrier post uprights, 775mm overall length, retained at bottom of the seating by 25mm on one face to fit over kerb. Posts spaced at 1505 centres to seat directly over extra long deck boards. Posts toe-nailed to deck boards using 2 no total 100x3·66 mm dia (9 S.W.G.) nails
150x25 section handrail barrier capping lengths, butt jointed to suit and nailed through to side rails using 100mm long 3·66mm dia (9 S.W.G) nails at 300mm centres
125x50 section side rails, cut and fitted on site. Fixed to posts using 4 no total (9 S.W.G.) nails 3·66mm dia.x 100 mm long to each side rail. Side rails butt jointed over alternate posts, nails driven from opposite side
To inside faces of Barrier Side Rails
12mm dia bolt x 200mm long with 50mm square side x 3mm M.S. plate washers each side
4 no total (9 S.W.G.) nails 3·66mm dia. x 100mm long spaced as shown and driven in from diagonal brace side of connection
Nail positions
Deck board nails
Overall
Nail positions
100 x 50 section sloping diagonal brace, site cut to length and shaped to suit Brace nailed and bolted in as shown
Track boards
Extra long deckboards, 100x50x5000mm long, to support handrail-barrier posts
12mm dia. bolt x 200mm long
100x50 section x 5000 mm long, close filled deck boards, laid in pairs to suit post positions Ends splay cut on site to suit diagonal post brace line
Truss 250x50 Top chord
Deck board extent
End truss
End truss
100x50 section x 3800 long standard deck boards
12mm dia. bolt x 250mm long with 50mm square side x 3mm M.S. plate washers each end. Connects posts to kerbs
12 mm dia bolt x 200mm long with 50 mm square side x 3mm MS plate washers each side Use also 8 no total 100x3 66 mm dia. (9 S.W.G.) nails driven from each side
150x150 section kerb, twice nailed into deck boards as shown using (8 S.W.G.) ring shank nails 4 06 mm dia x 150 mm long Nail pairs at 300 mm spacing along kerb length. Kerb to be halving-jointed

Figure 28



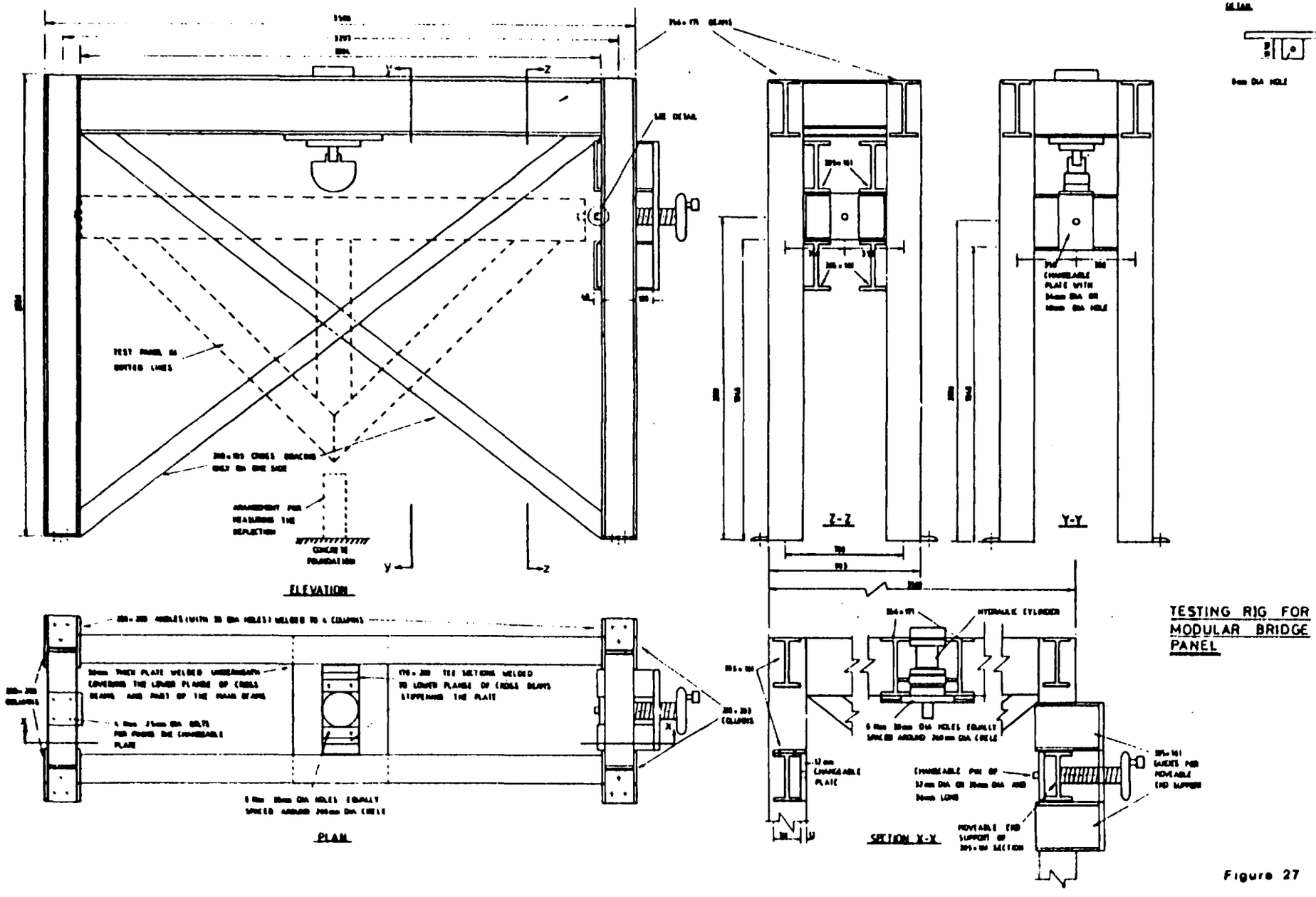
PART ELEVATION ON ASSEMBLED BRIDGE TRUSSES SHOWING MODIFIED STEEL LINKAGE ARRANGEMENT - LINKAGES REPEAT



Heavy Chord construction 6/6a only shown on this drawing
Light Chord construction 2/2a identical in arrangement

PART SECTIONAL PLAN VIEW ON 'W-W' SHOWING MODIFIED ARRANGEMENT OF STEEL LINKAGES TO EACH TRUSS ASSEMBLY

Figure 26



TESTING RIG FOR MODULAR BRIDGE PANEL

Figure 27

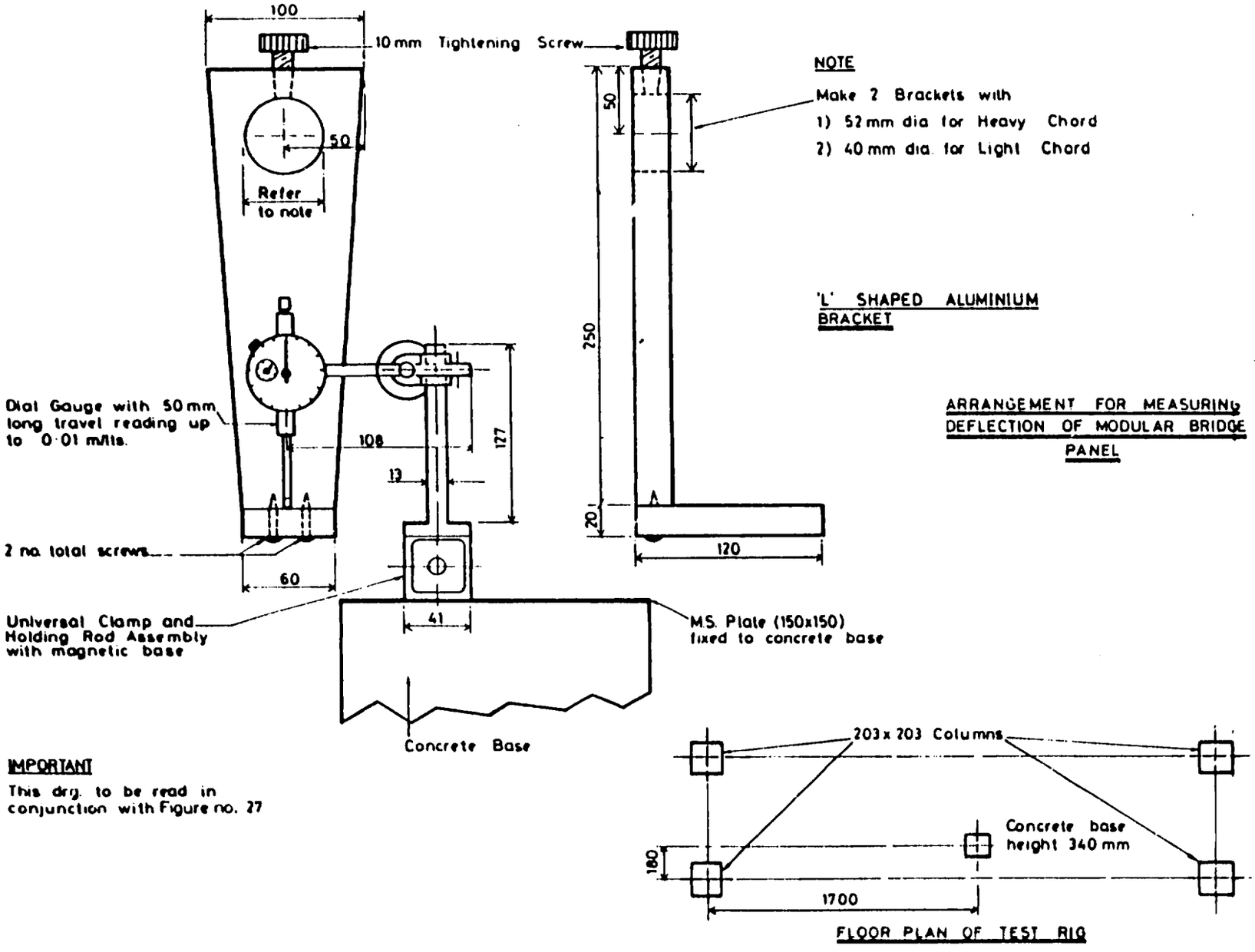
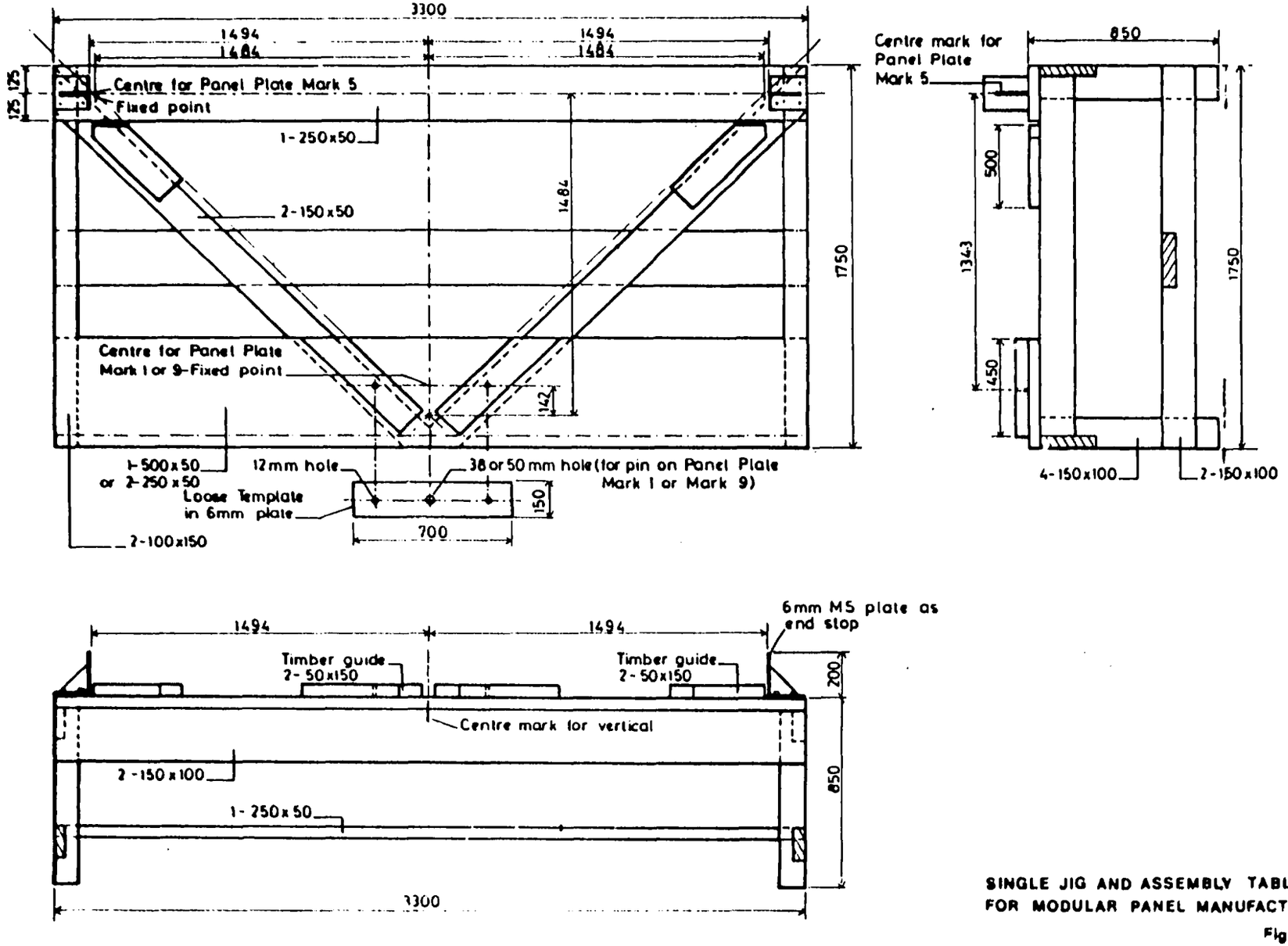
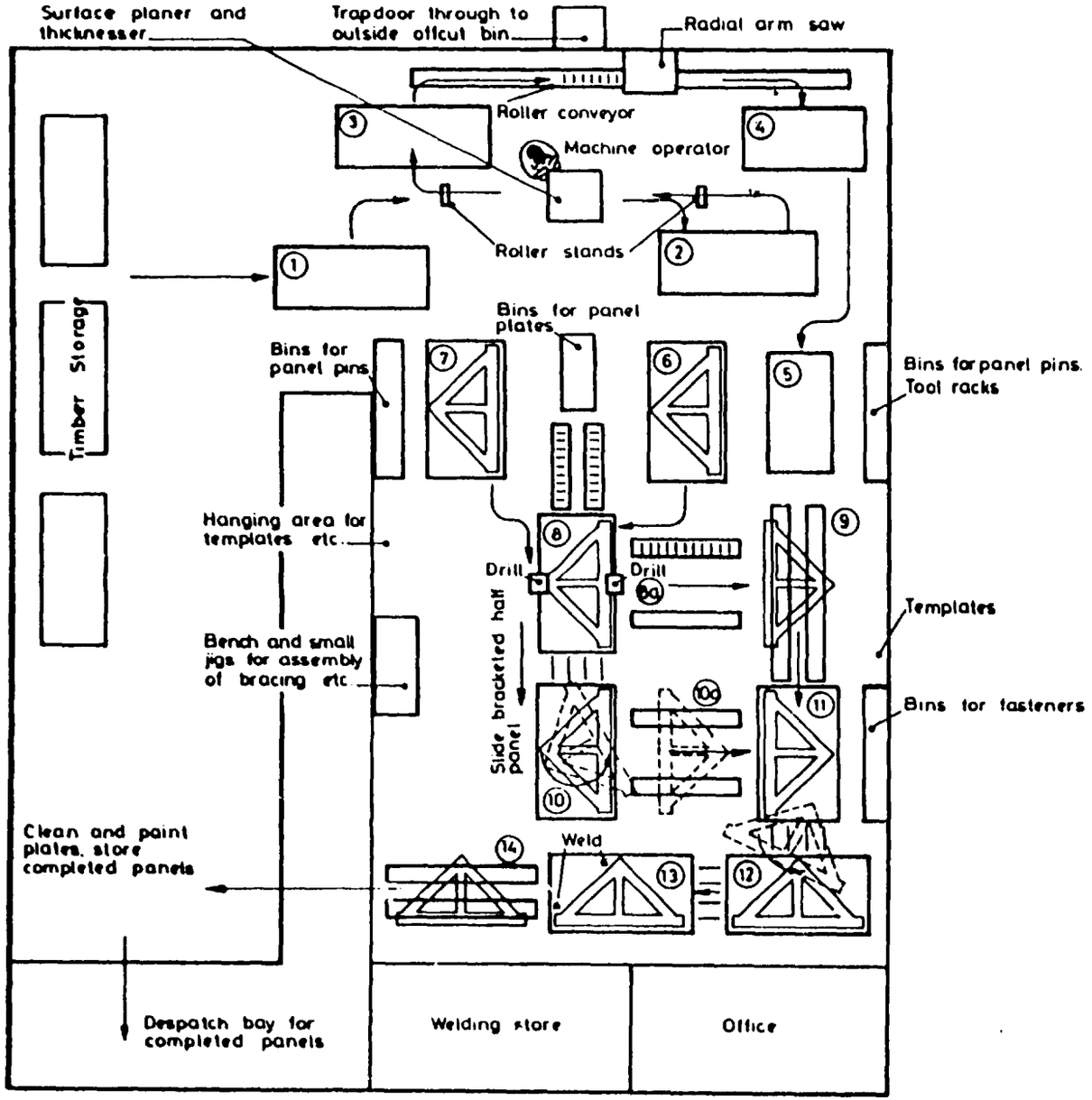

100
10 mm Tightening Screw
50
Refer to note
Dial Gauge with 50 mm long travel reading up to 0·01 m/ts.
108
127
13
2 no. total screws
60
41
Universal Clamp and Holding Rod Assembly with magnetic base
M.S. Plate (150x150) fixed to concrete base
Concrete Base
50
250
20
120
NOTE
Make 2 Brackets with
1) 52 mm dia for Heavy Chord
2) 40 mm dia. for Light Chord
'L' SHAPED ALUMINIUM BRACKET
ARRANGEMENT FOR MEASURING DEFLECTION OF MODULAR BRIDGE PANEL
IMPORTANT
This drg. to be read in conjunction with Figure no. 27
203 x 203 Columns
Concrete base height 340 mm
180
1700
FLOOR PLAN OF TEST RIG

Figure 28



SINGLE JIG AND ASSEMBLY TABLE FOR MODULAR PANEL MANUFACTURE

Figure 20



TYPICAL WORKSHOP ARRANGEMENT FOR ASSEMBLY OF MODULAR BRIDGE PANELS

Key to Stage numbers:

1	Set of unprocessed timber
2	One face surfaced (or edge for decking)
3	Surfaced and thicknessed
4	Finished, cross-cut members
5	Timber members awaiting assembly
6	Assembled plain half-panel
7	Assembled bracketed half-panel
8	Panel moves laterally for the corners to be drilled
8a	Turn plain panel over and slide to stage 9
9	Parking area for plain half-panel and slide up stage 11
10	Rotate bracketed half-panel by 180°
10a	Slide bracketed half-panel onto plain half
11	Bolt and nail together the half-panels
12	Rotate panel by 90°
13	Welding bay
14	Descale and park for removal to despatch bay

Figure 30

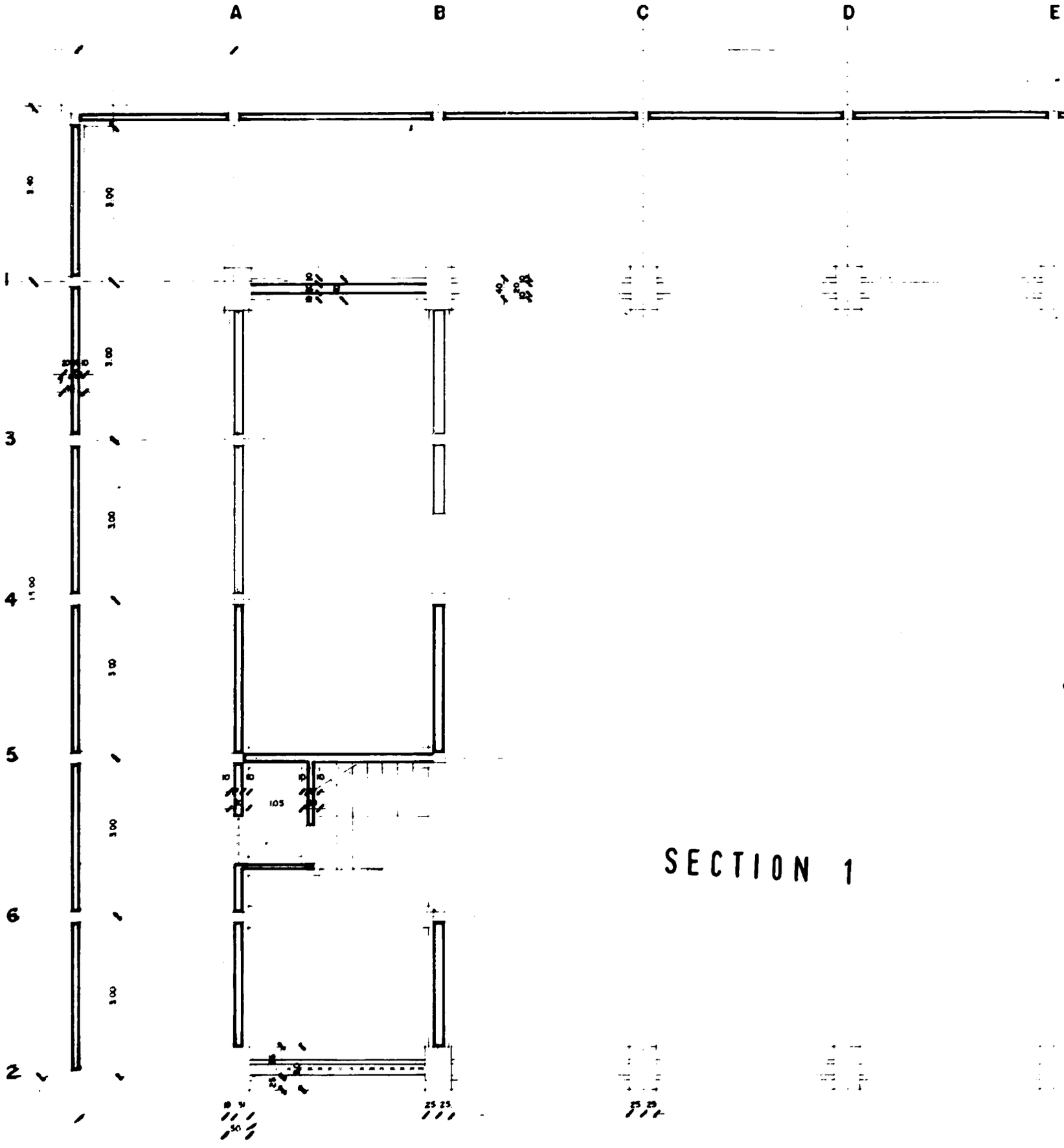
ANNEX 4

Workshop plans

(timber construction - 480 m2)

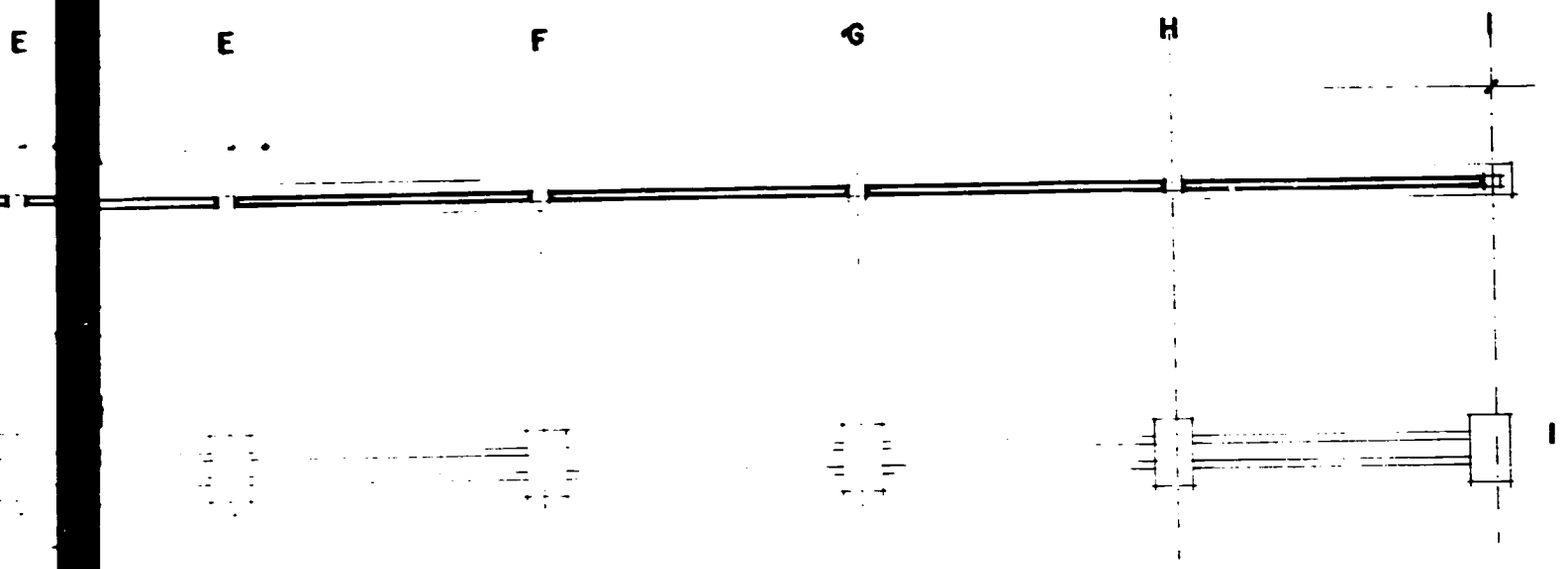
with integrated storage and office space

Seven (7) plans follow

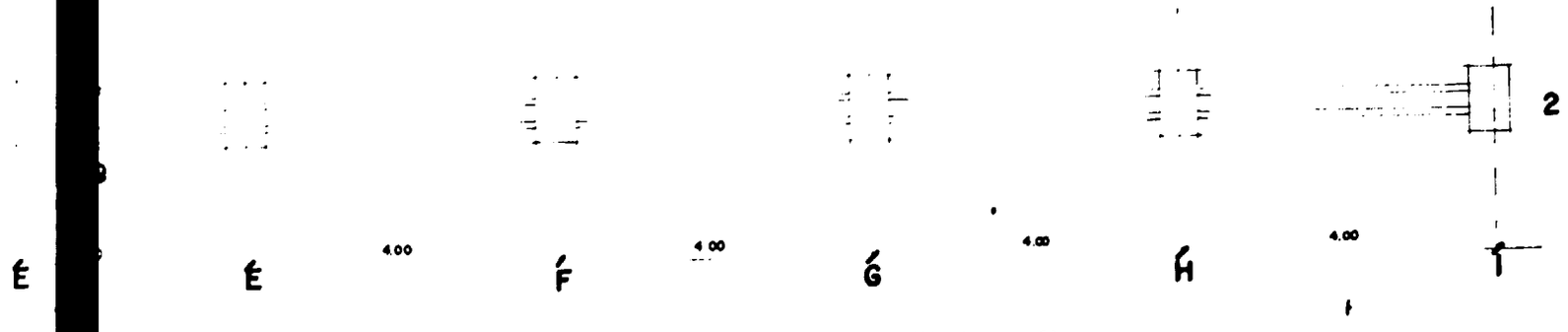


SECTION 1

GALPON DE CARPINTERIA _ CIMENTACION

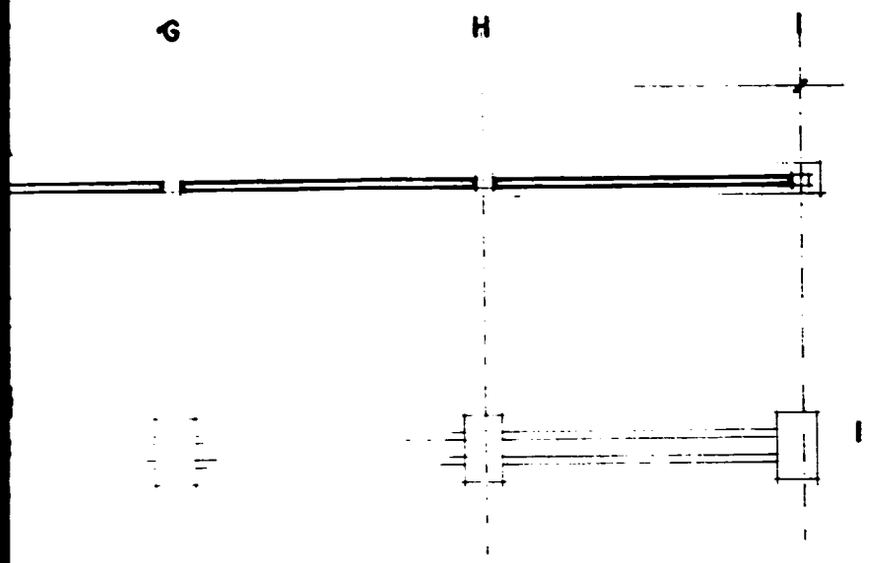


SECTION 2



ESCALA 1 50

MINISTERIO
PROGRA
PROYECTO
REVISO
APROBO
Octubre 1981



SECTION 3

MINISTERIO DE AGRICULTURA Y GANADERIA
PROGRAMA NACIONAL FORESTAL

PROYECTO Arq. Sergio L. Silva Mejía

REVISO Ing. Nelson Toledo Echeverría

APROBO Ing. Carlos Aguirre Castillo

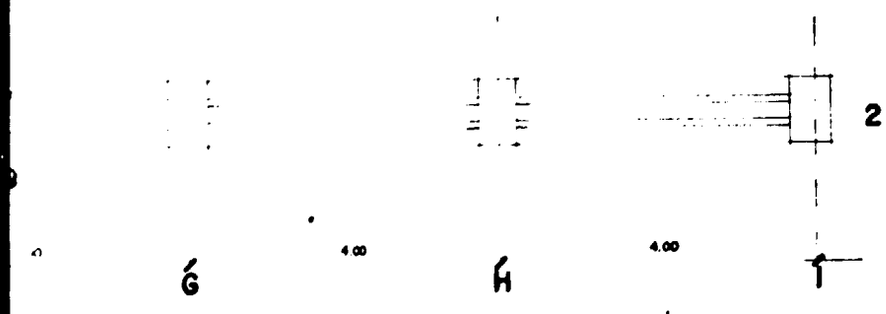
CONTIENE

CIMENTACION

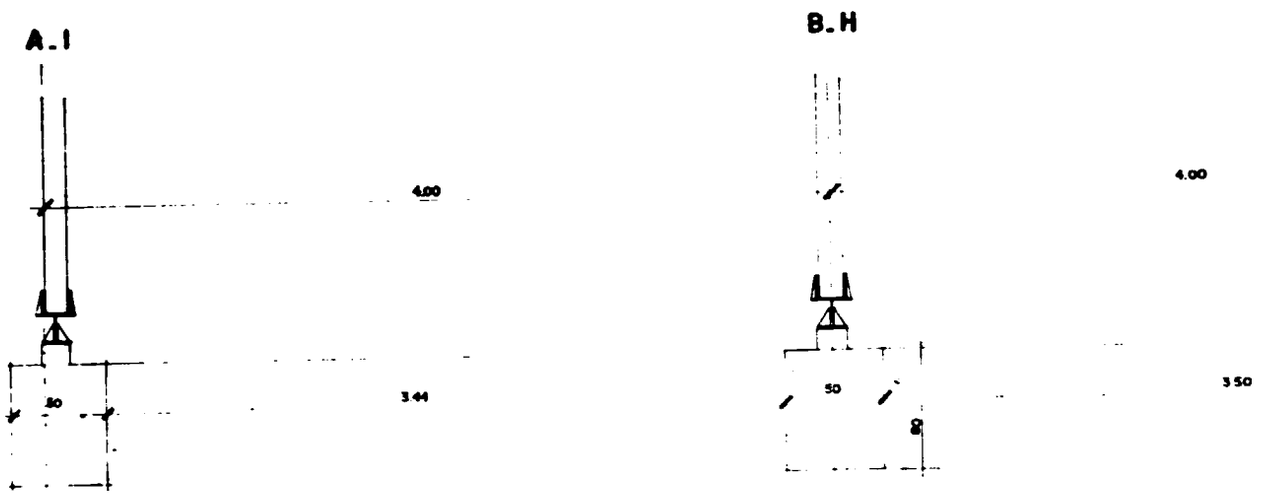
Octubre 1981

ESCALA 1:50

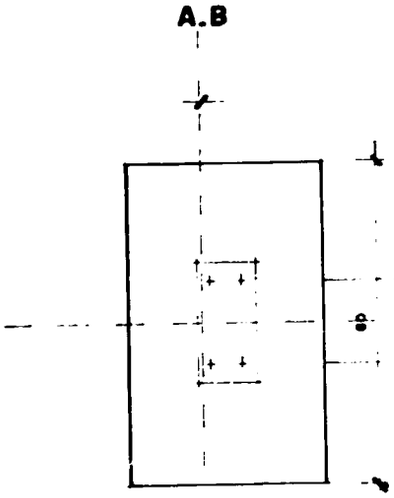
FOUNDATION



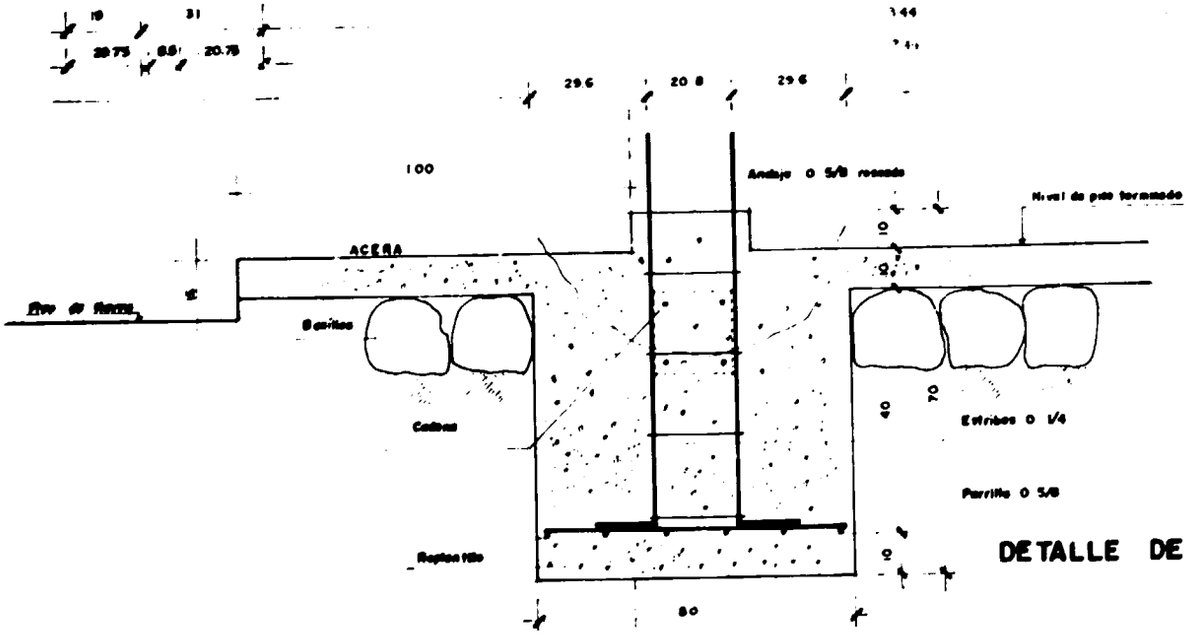
ESCALA 1 50



UBICACION DE PLINTOS LATERALMENTE



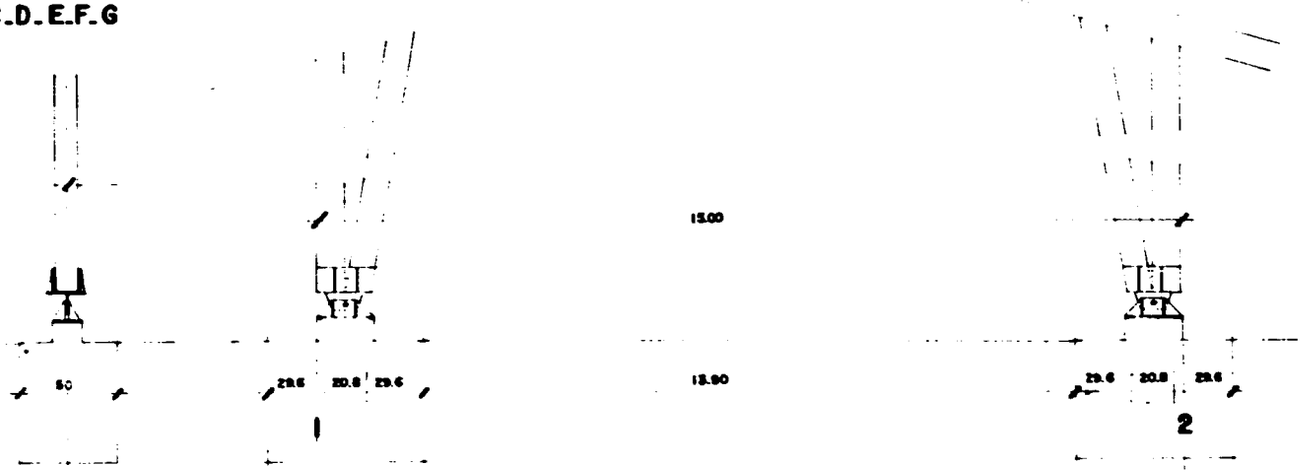
DETALLE DE UBICACION



DETALLE DE PLINTO

SECTION 1

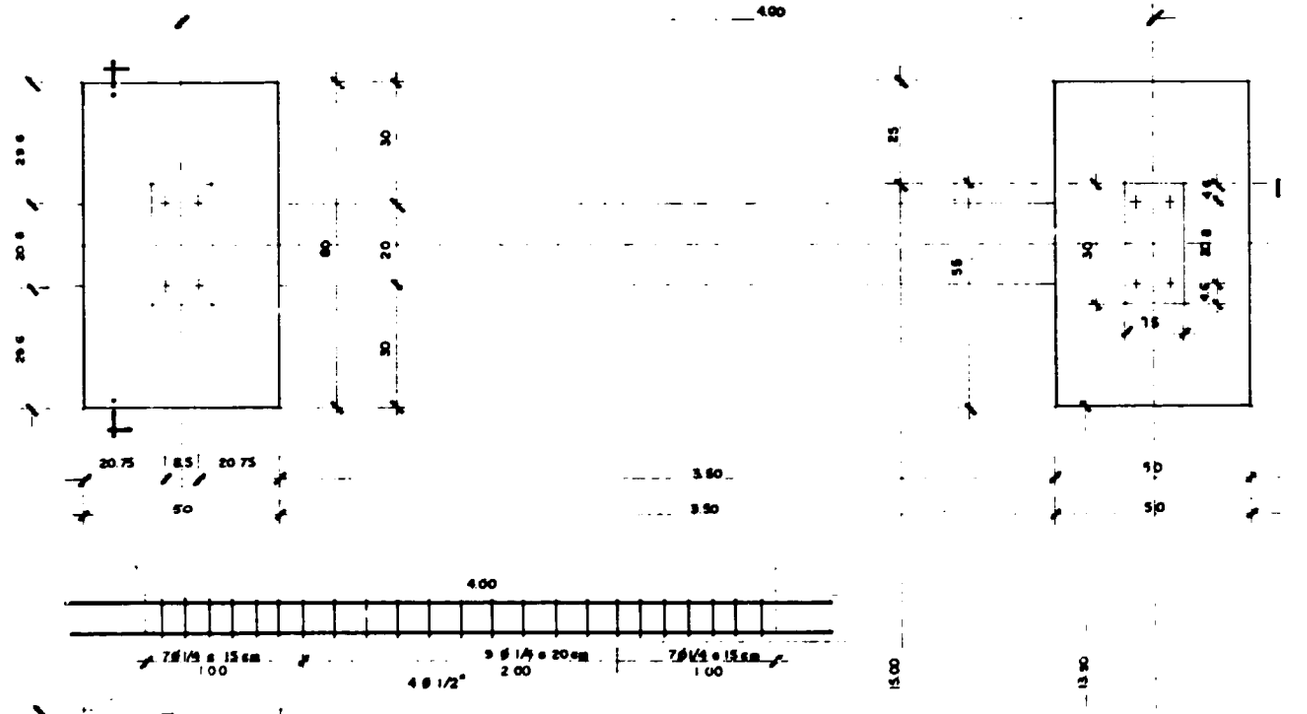
C.D.E.F.G



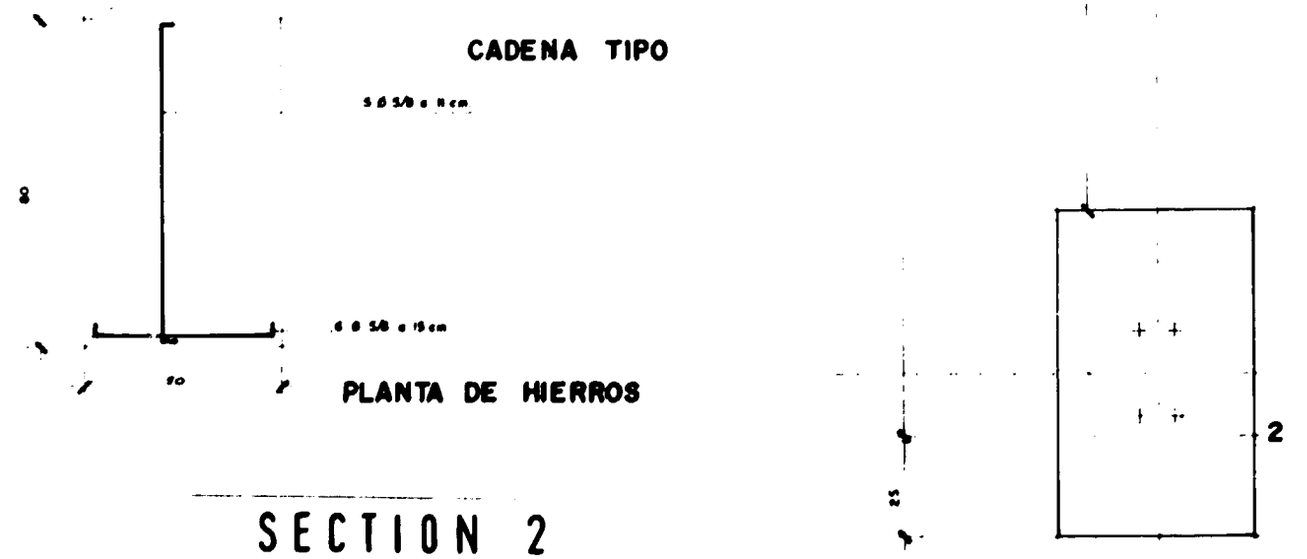
B.H

UBICACION FRONTAL DE PLINTOS

C.D.E.F.G



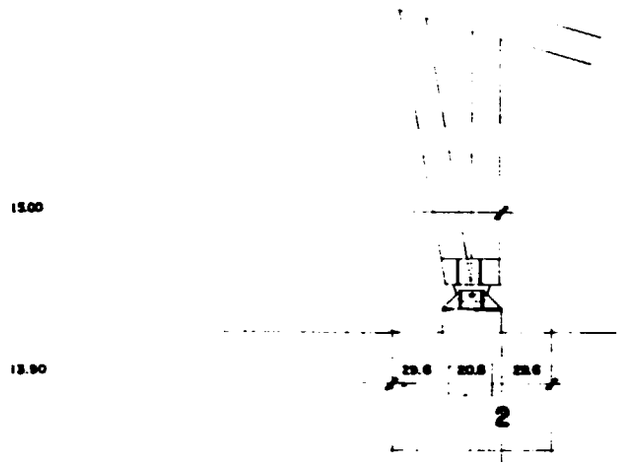
CADENA TIPO



PLANTA DE HIERROS

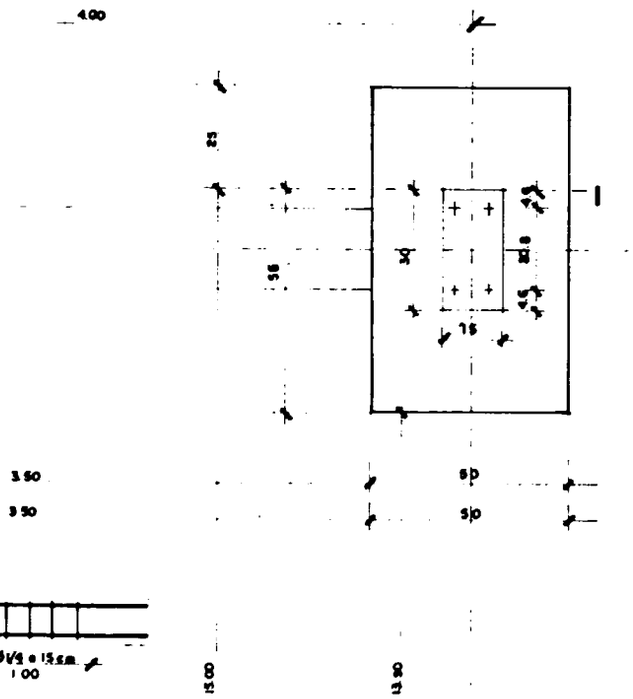
INTO

SECTION 2

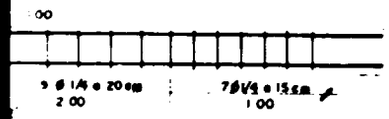


UBICACION FRONTAL DE PLINTOS

C.D.E.F.G

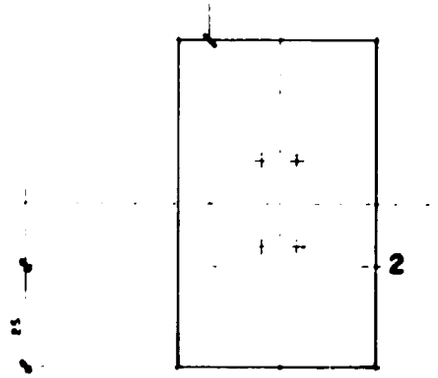


SECTION 3



CADENA TIPO

DE HIERROS



MINISTERIO DE AGRICULTURA Y GANADERIA
PROGRAMA NACIONAL FORESTAL

PROYECTO Arq. Sergio L. Silva Mejía

REVISO Ing. Nelson Toledo Echeverría

APROBO Ing. Carlos Aguirre Castillo

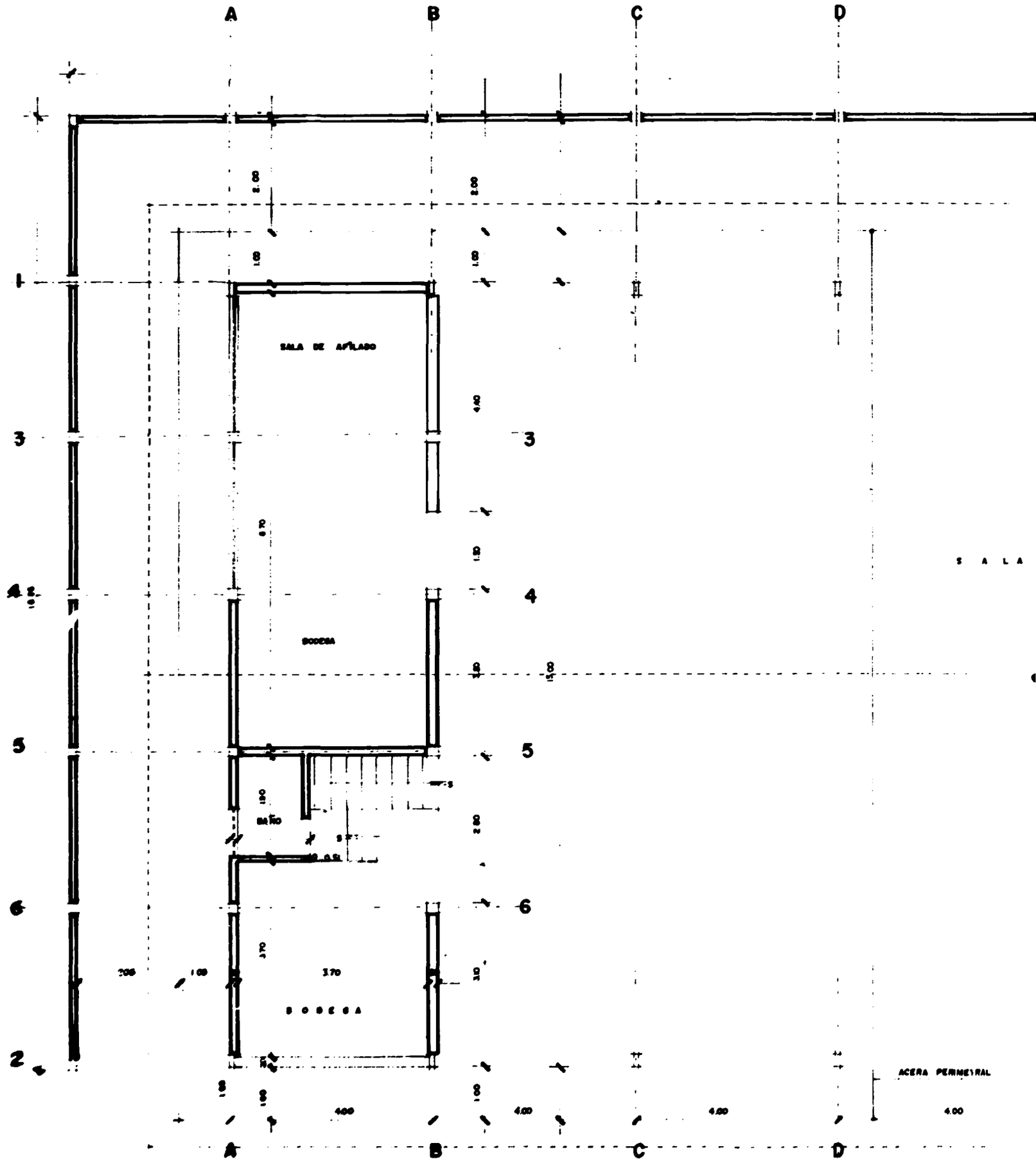
CONTIENE

Plintos _ Detalles

D-2

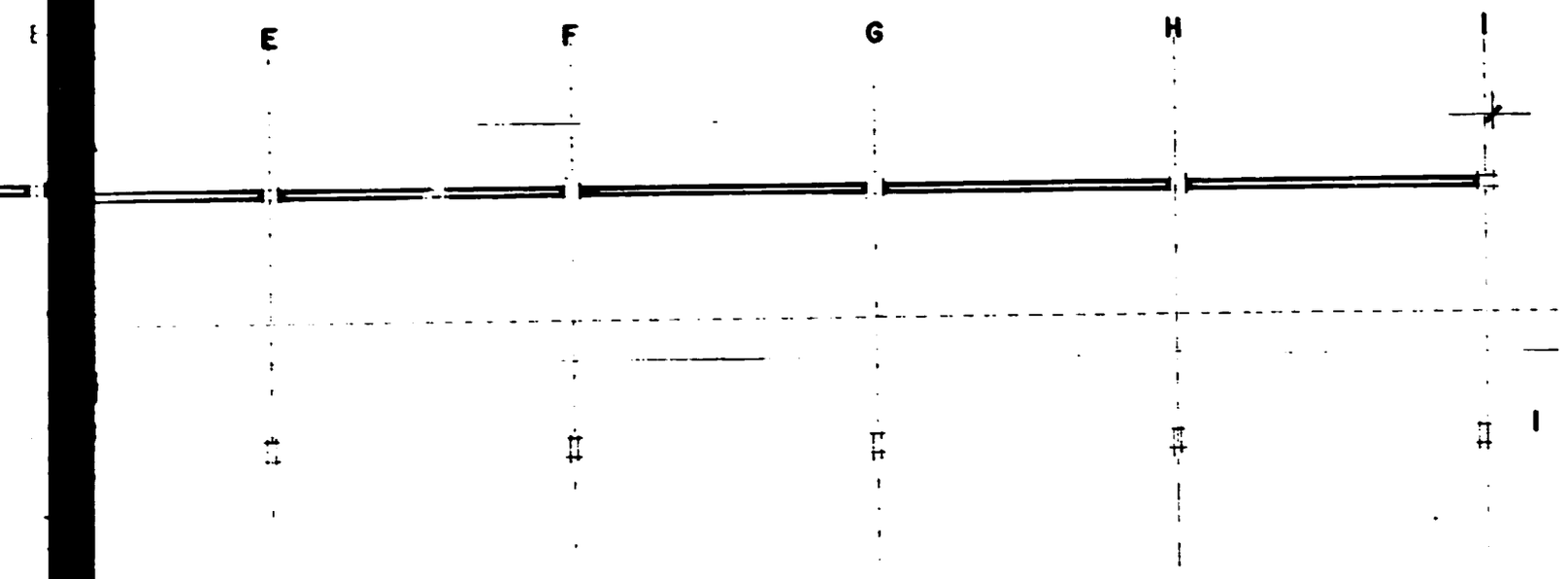
Noviembre 1990

ESCALA 1:20



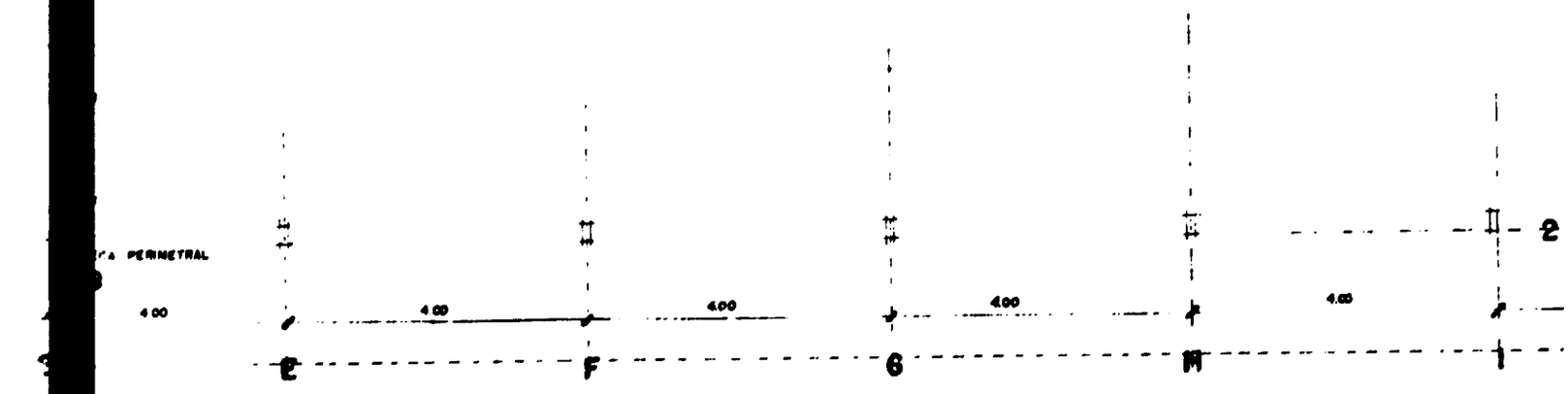
GALPON DE CARPINTERIA — PLANTA BAJA

SECTION 1

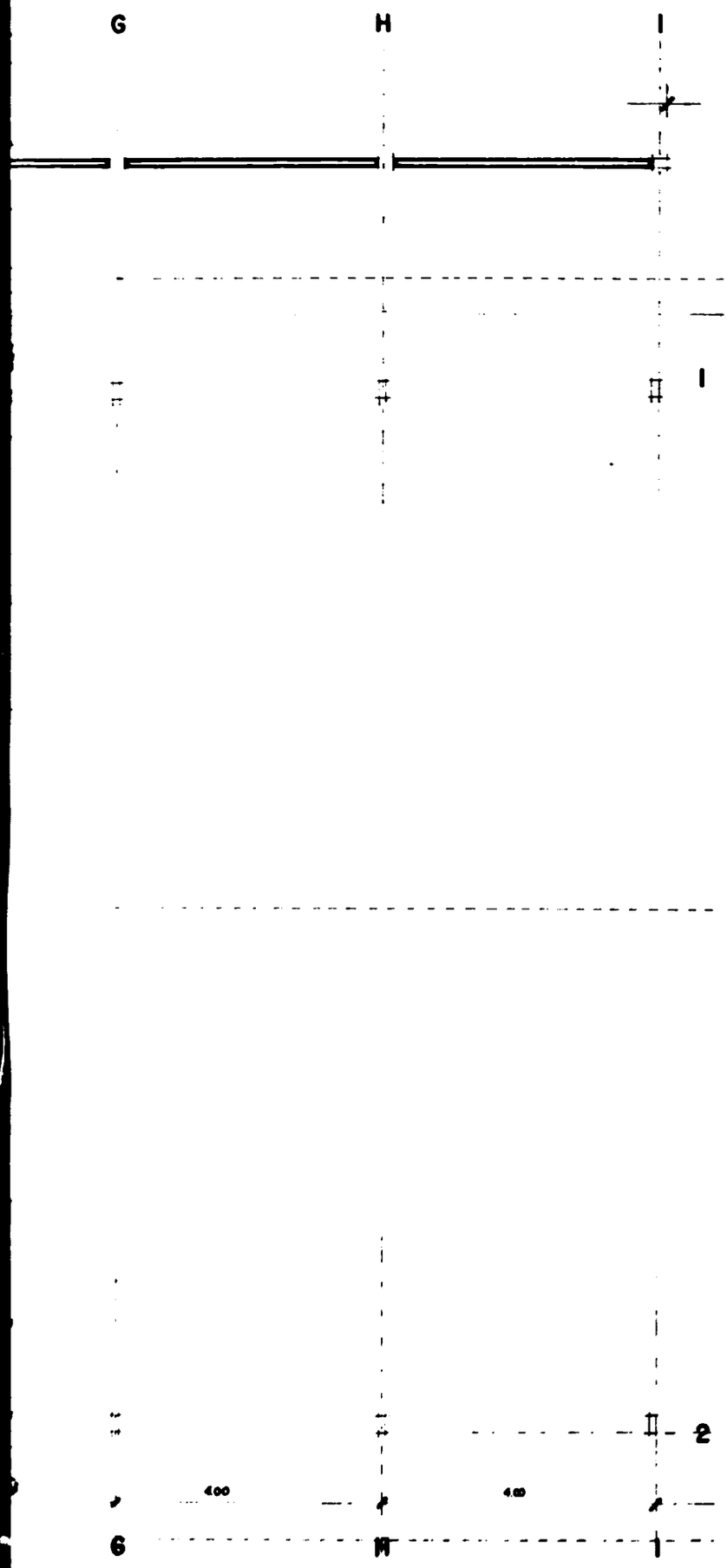


S A L A D E M A Q U I N A S

MINISTERI
PR
PROYECTO
REVISO
APROBO
Octubre 1.981



SECTION 2



MINISTERIO DE AGRICULTURA Y GANADERIA
PROGRAMA NACIONAL FORESTAL

PROYECTO Arq. Sergio L. Silva Mejía

REVISO Ing. Rolando Toledo Echeverría

APROBO Ing. Carlos Aguirre Castillo

CONTIENE

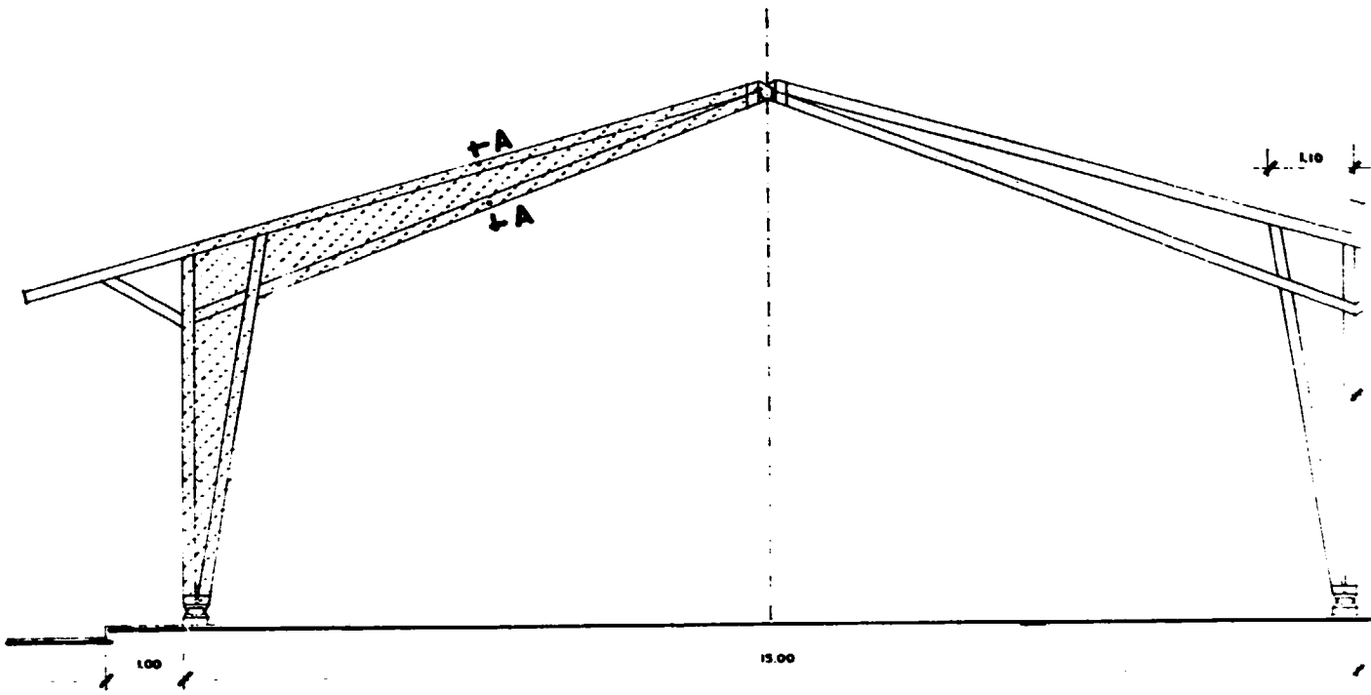
PLANTA BAJA

Octubre 1.991

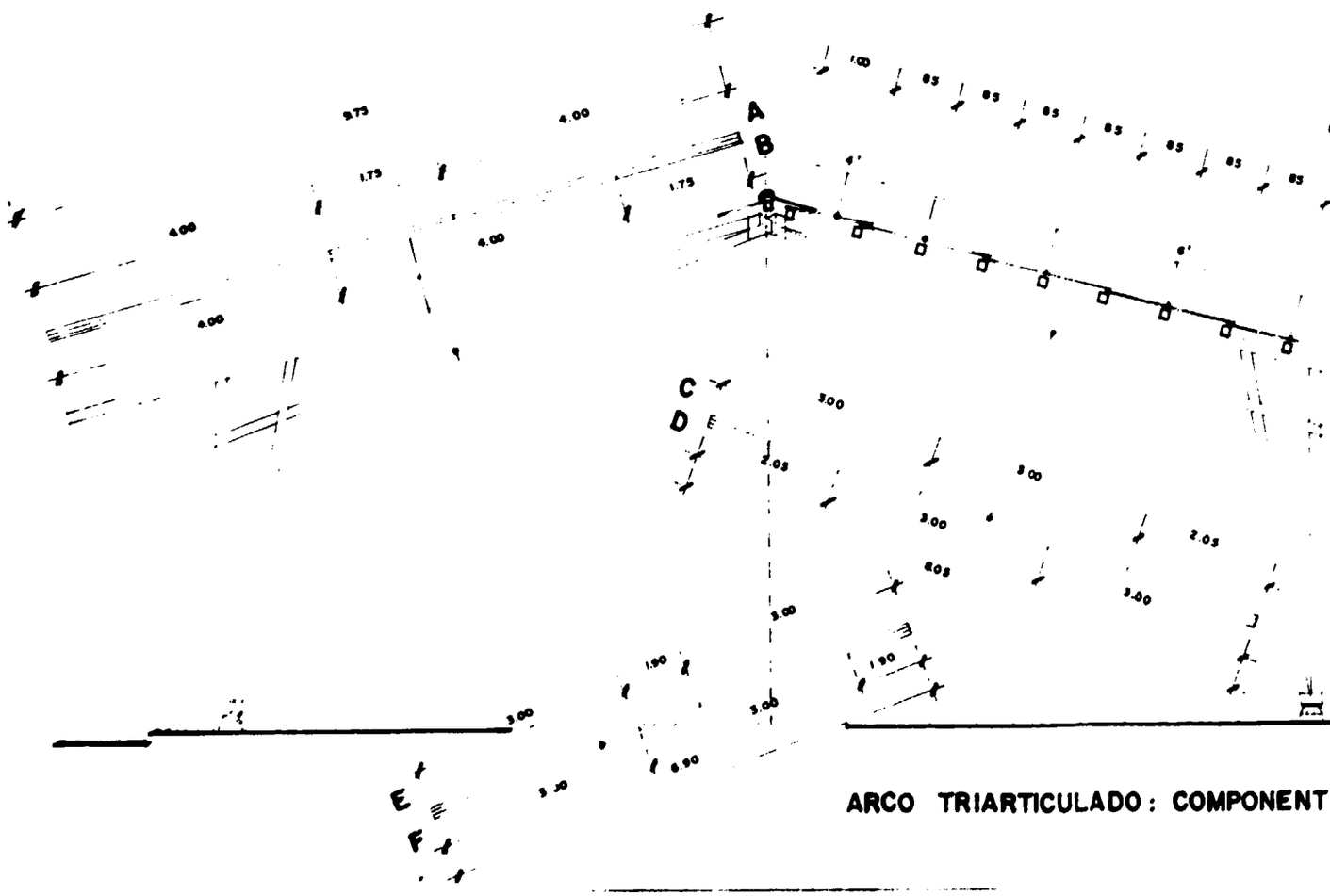
ESCALA 1:50

SECTION 3

GROUND FLOOR PLAN

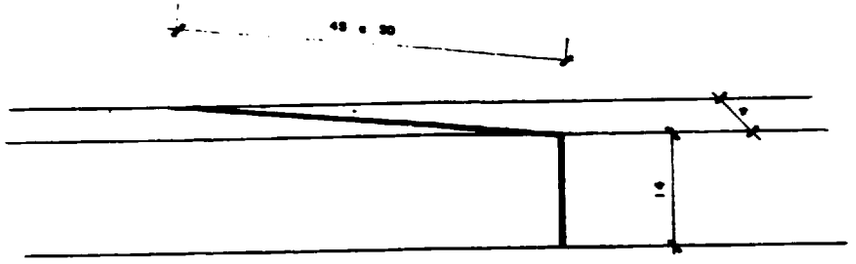


ARCO TRIARTICULADO

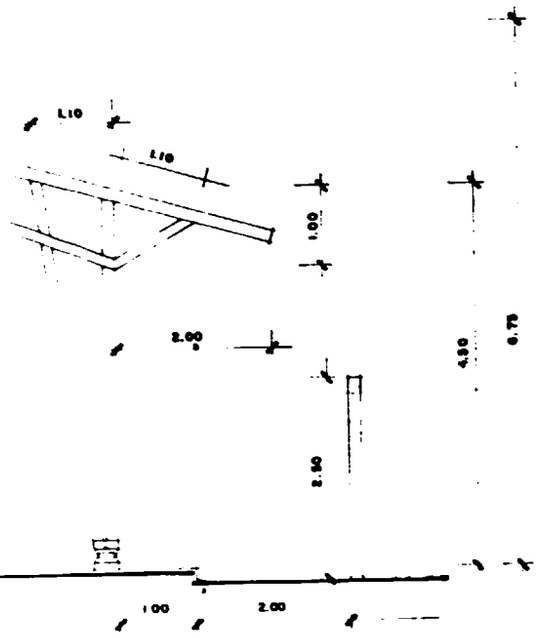


ARCO TRIARTICULADO : COMPONENT

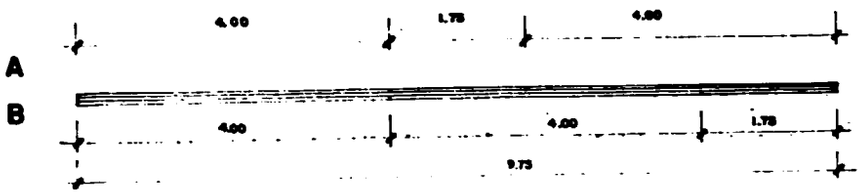
SECTION 1



DETALLE DE UNION DE CUERDAS ESCALA 1:5

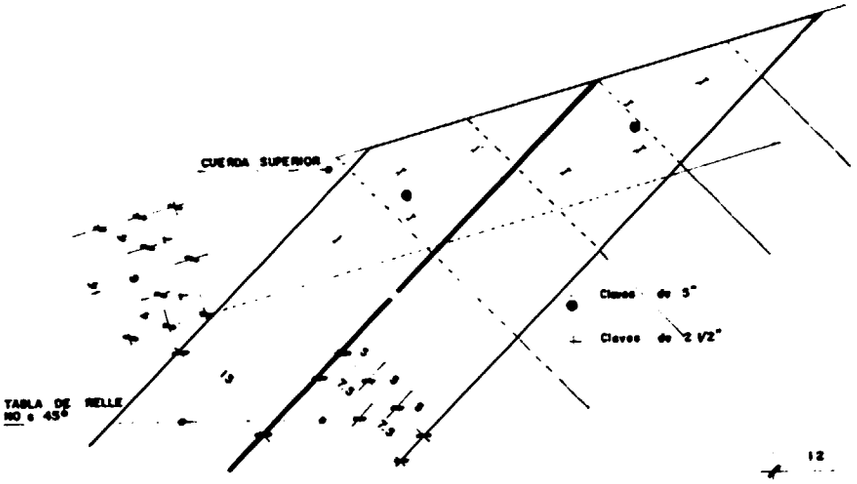


ESCALA 1:50

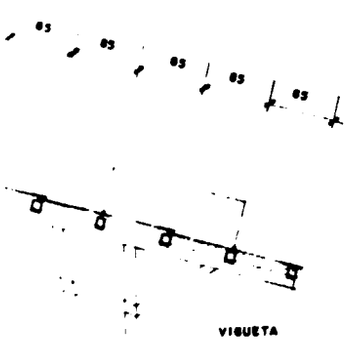


CUERDA SUPERIOR ESCALA 1:50

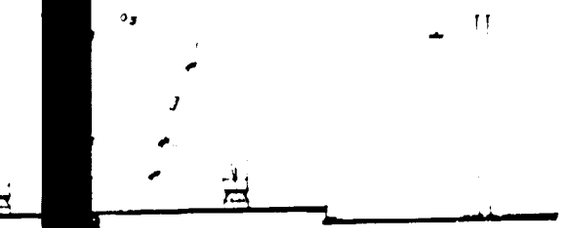
CORTE



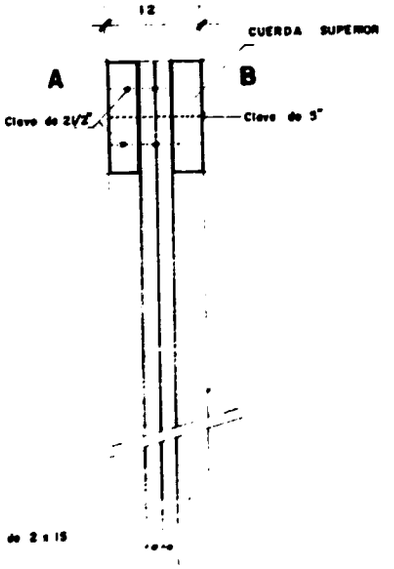
DETALLE DE FIJACION DE ELEMENTOS
ESCALA 1:5



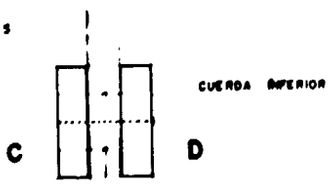
VIGUETA



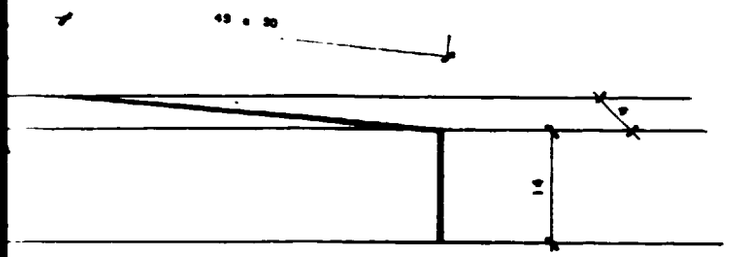
OMPONENTES ESCALA 1:50



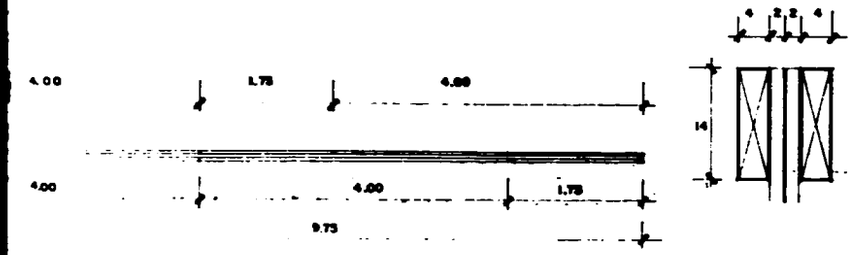
CORTE A-A ESC. 1:5



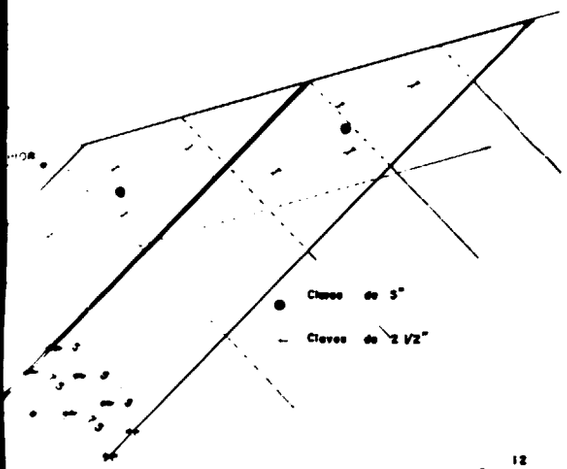
SECTION 2



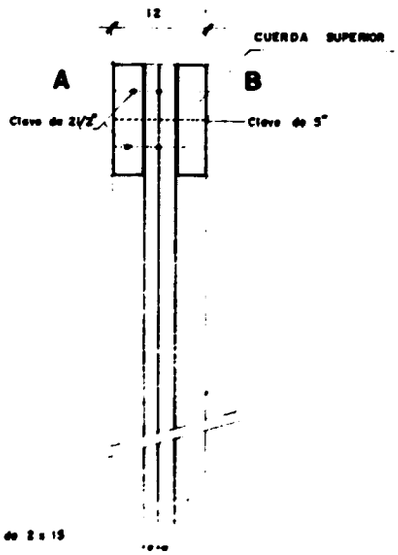
E DE UNION DE CUERDAS ESCALA 1: 5



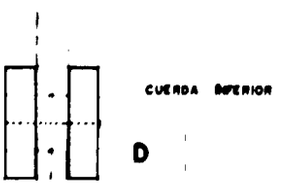
A SUPERIOR ESCALA 1: 30 CORTE B.B



ICACION DE ELEMENTOS 1 5



CORTE A_A ESC 1:5



ESPECIFICACIONES TECNICAS:-

CUBIERTA :- Planchas de asbesto cemento. Cumbrera móvil

MADERA :- Grupo C o mejor.
Resistencia mínima a la flexión 100 kg/cm2
compresión 80 kg/cm2
cortante 8 kg/cm2
Modulo de elasticidad. 10.000 kg./cm2
Contenido de humedad 6 20%
Preservación.- a presión con CCA o pentaclorofenol
Defectos: NO SE ACEPTAN : fallas de composición
grietas o rajaduras
nudos o perforaciones de + 5 mm Ø

CLAVOS.- Galvanizados o alambres de alambre

COLAS:- Resorcinol, Fenol o Melamina, Formaldehído o similar que sirva para exteriores, y son termoplasticos

SECTION 3

MINISTERIO DE AGRICULTURA Y GANADERIA
PROGRAMA NACIONAL FORESTAL

PROYECTO Arq. Sergio L. Silva Mejía

REVISO Ing. Nelson Toledo Echeverría

APROBO Ing. Carlos Aguirre Castillo

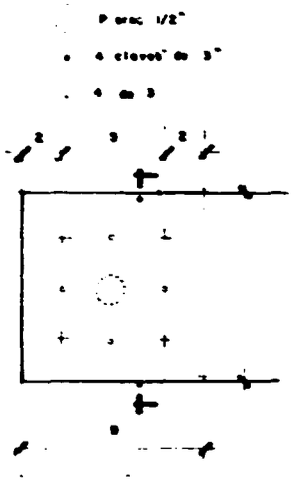
CONTIENE

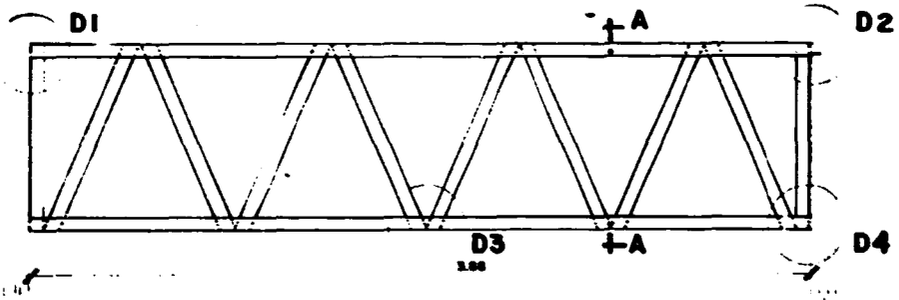
Arco Triarticulado. Detalles

DE

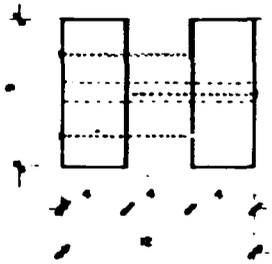
Noviembre 1981

ESCALA 1:20

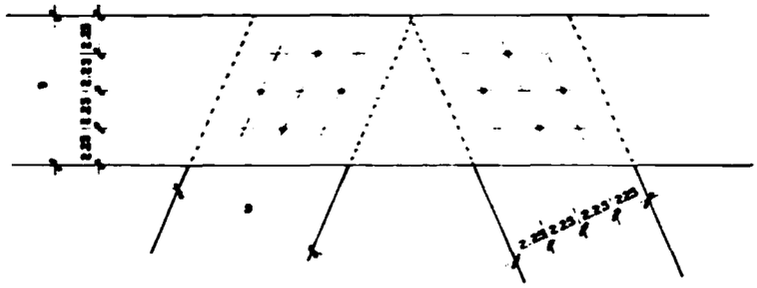




ARRIOSTRE FRONTAL ESC. 1:20

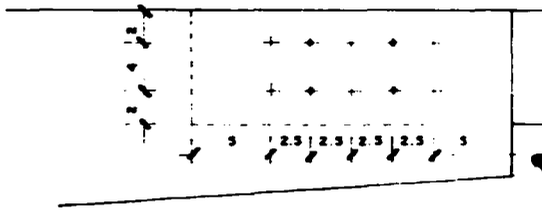


EMPALME D1 ESC 1:2.5



EMPALME D3 ESC. 1:2.5

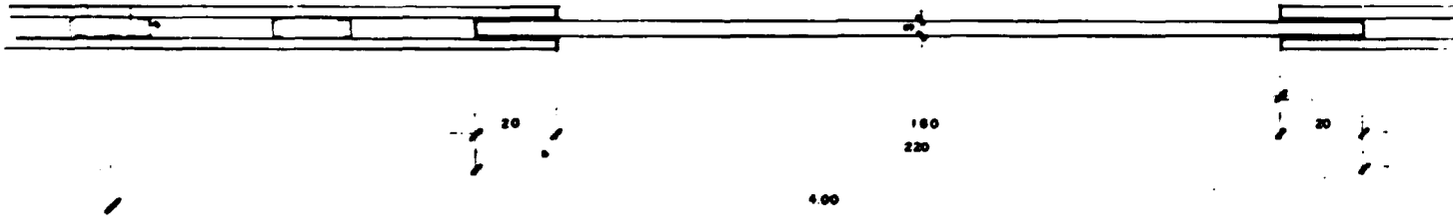
CORTE A-A ESC 1:5



D5

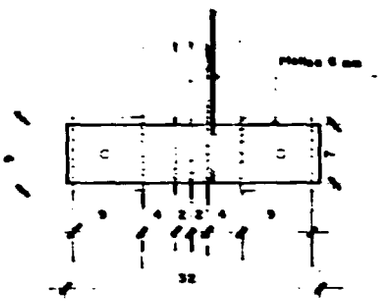
Sección de 5 x 7 cm

VIGUETA ALTERNATIVA 1 ESC. 1:100

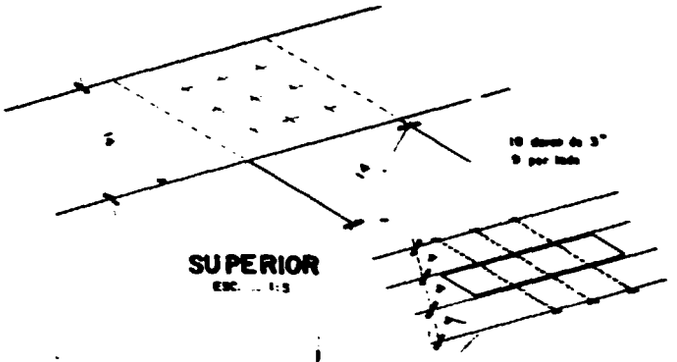


VIGUETA ALTERNATIVA 2 ESC. 1:100

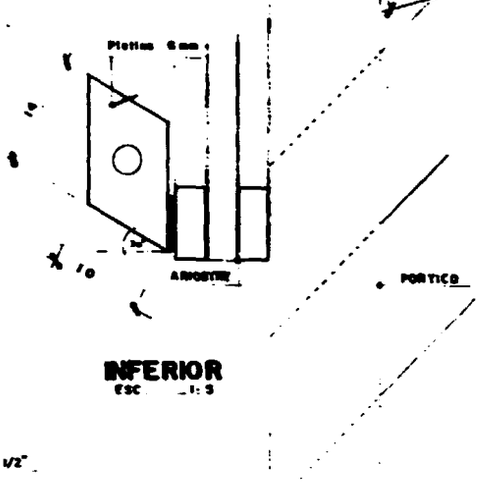
SECTION 1



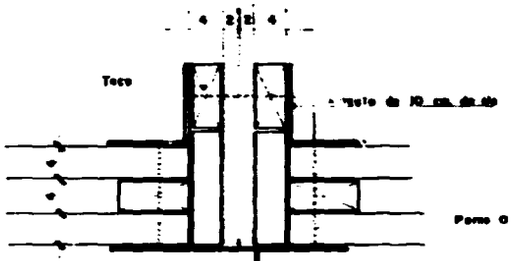
EMPALME D4 FRONTAL
ESC. 1:5



SUPERIOR
ESC. 1:5



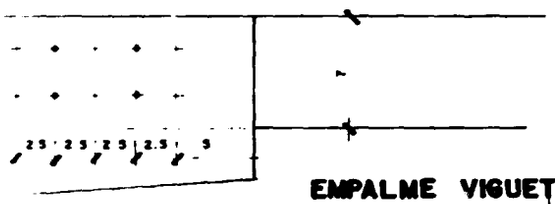
INFERIOR
ESC. 1:5



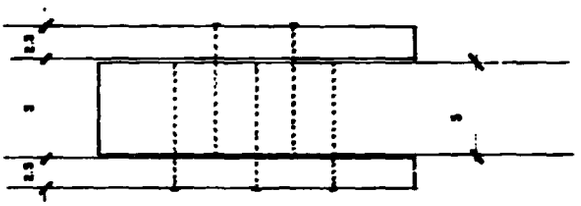
EMPALME D4 ESC. 1:5

EMPALME PIE DE AMIGO

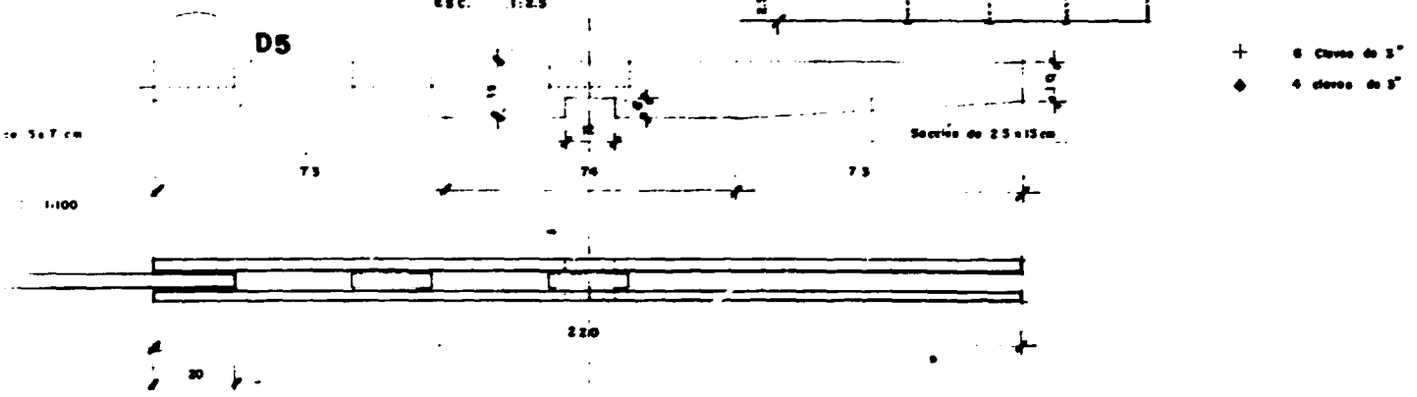
CORTE A_A ESC 1:5

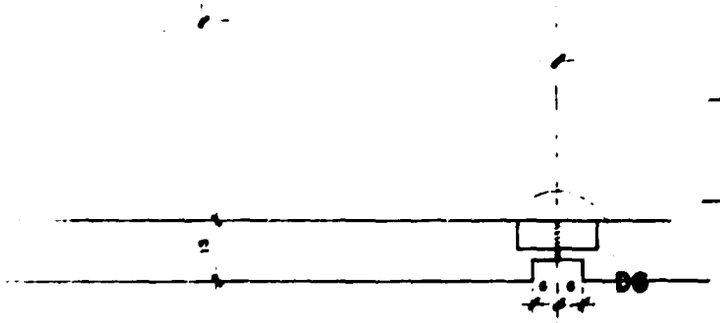


EMPALME VIGUETA D5
ESC. 1:2.5

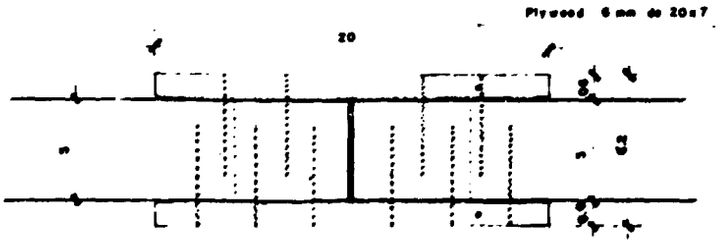


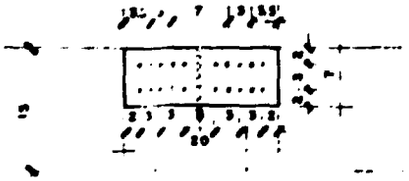
D5





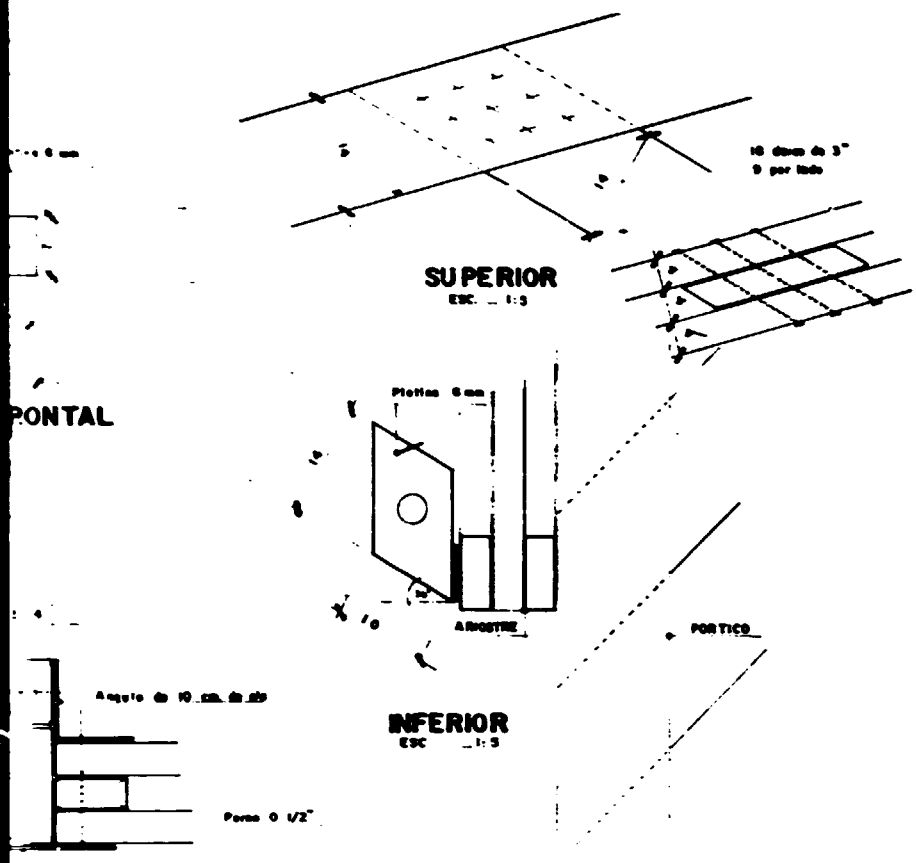
D6





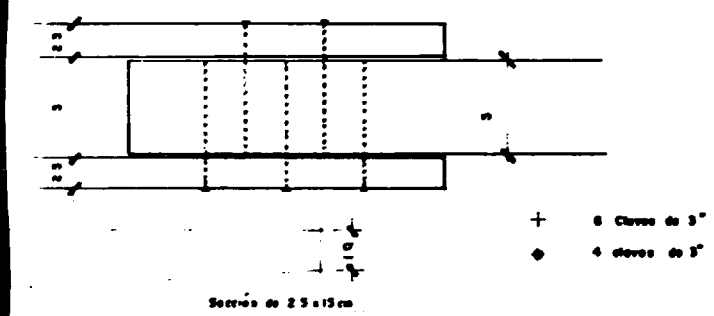
EMPALME D6

SECTION 2



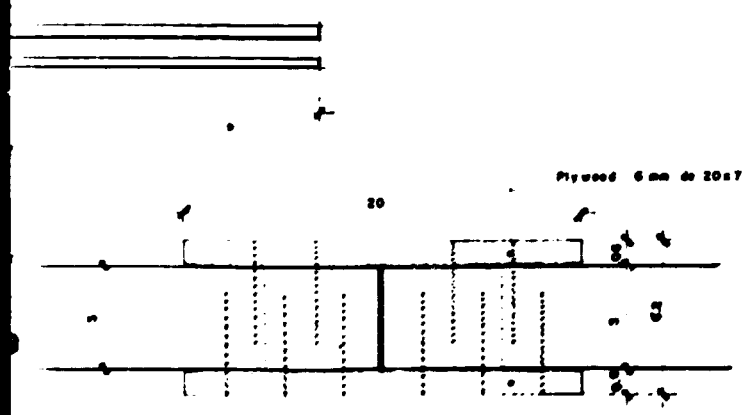
EMPALME PIE DE AMIGO

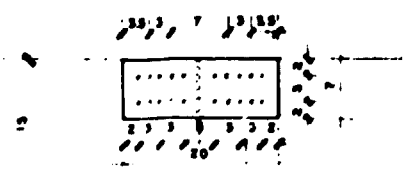
D4 ESC 1:5



Sección de 2.5 x 15 cm

F3



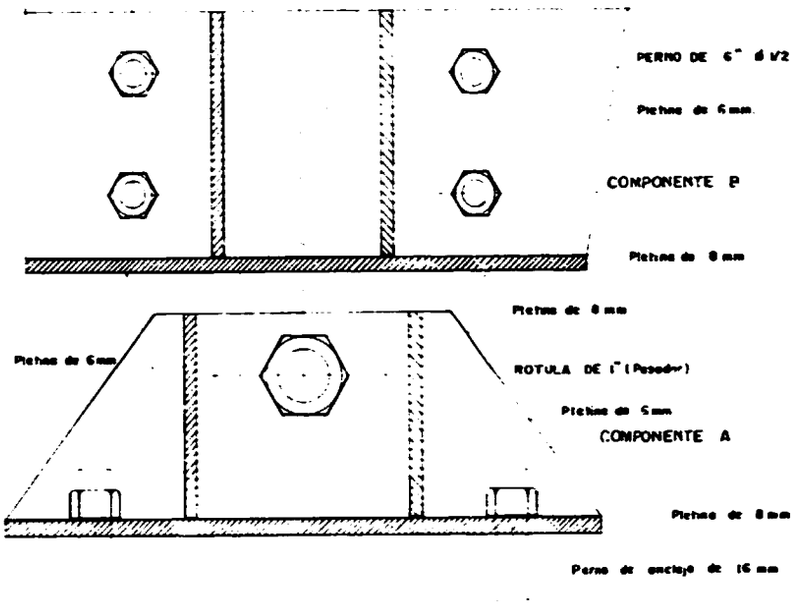


EMPALME D6

6 clavos de 2"
12 de 2"

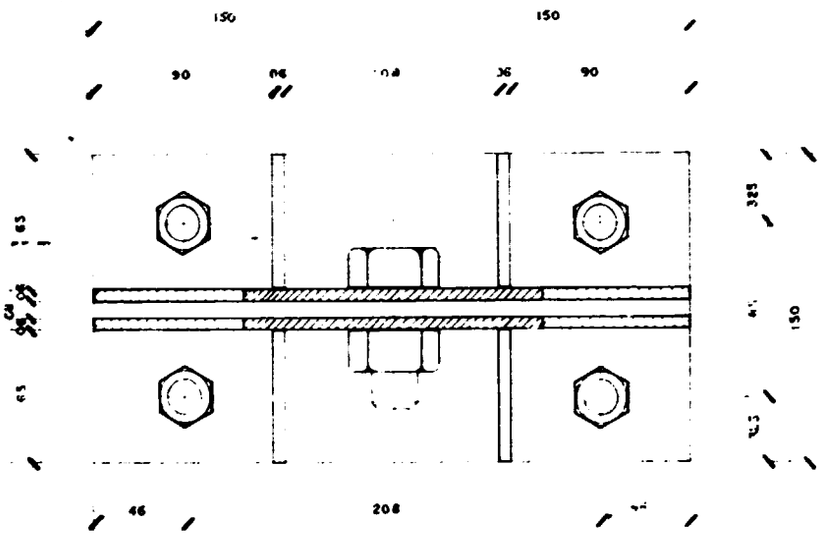
SECTION 3

MINISTERIO DE AGRICULTURA Y GANADERIA PROGRAMA NACIONAL FORESTAL	
PROYECTO	Arq. Sergio L. Silva Mejía
REVISO	Ing. Nelson Toledo Echeverría
APROBO	Ing. Carlos Aguirre Castillo
CONTIENE	Fachada lateral - Viguetas - Detalles LATERAL BRACES
06	
Noviembre 1988	ESCALA 1:20



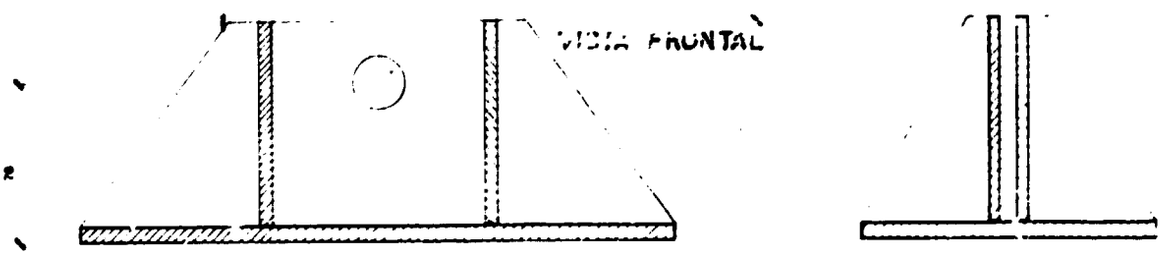
CONJUNTO DE LA ARTICULACION INFERIOR

ESCALA 1 20



COMPONENTE A DE LA ARTICULACION INFERIOR

VISTA DE PLANTA



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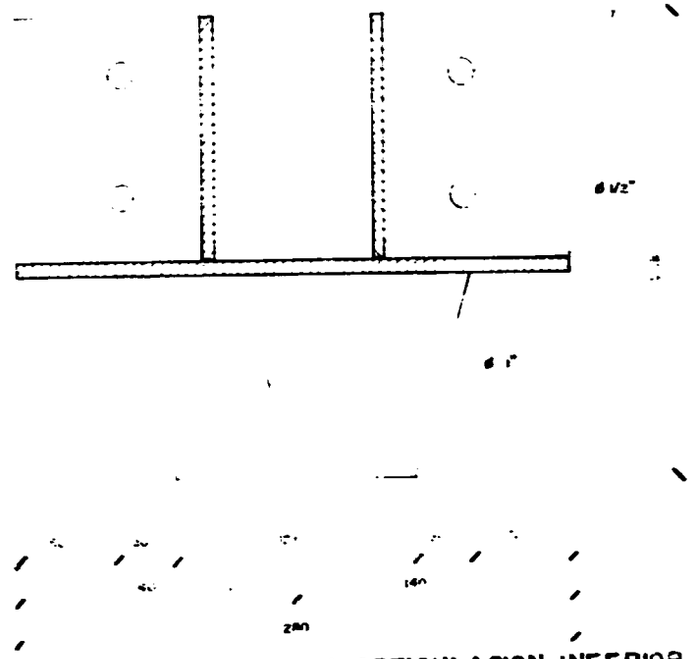
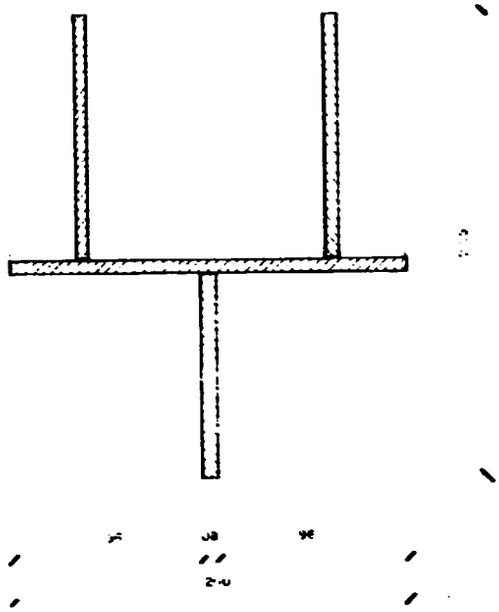
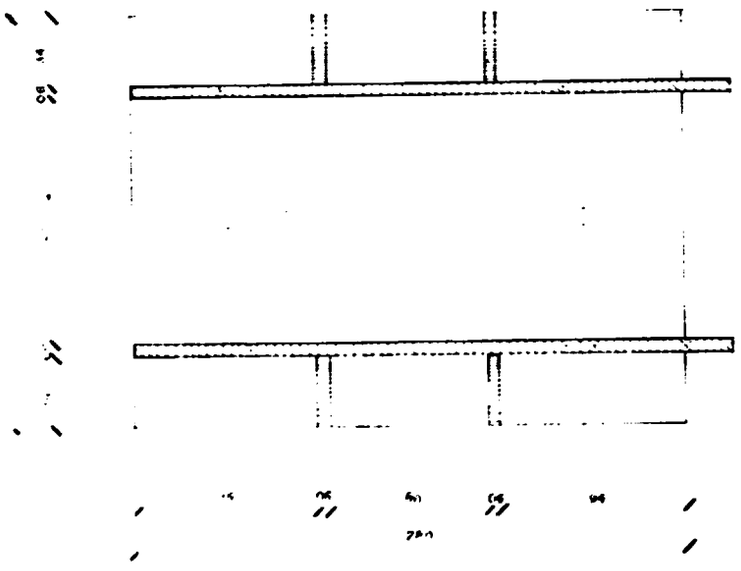


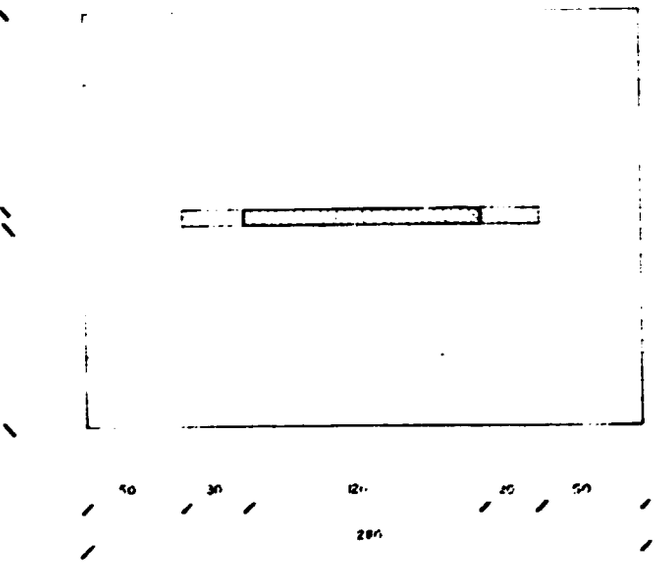
COMPONENTE B DE LA ARTICULACION INFERIOR
VISTA FRONTAL
ESCALA 1:20



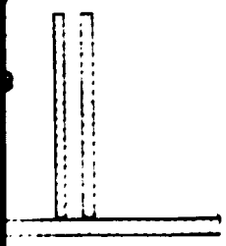
COMPONENTE B _VISTA LATERAL

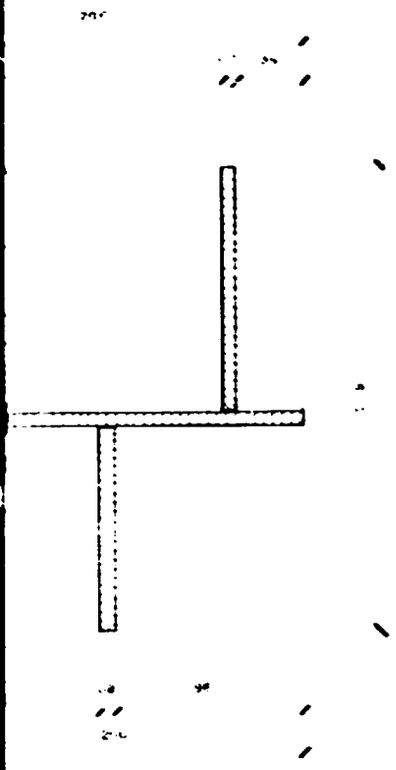


COMPONENTE B _ VISTA DE PLANTA

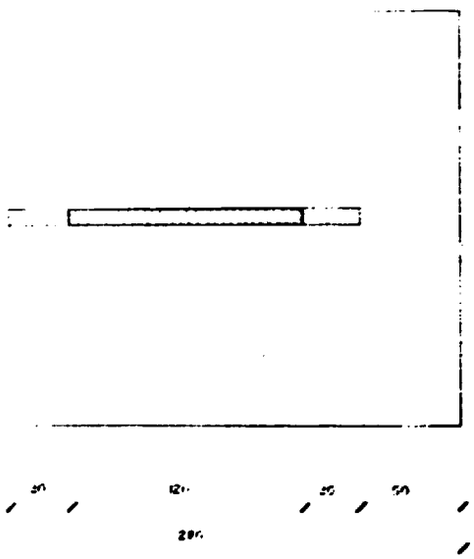


COMPONENTE B _ VISTA DE ABAJO ARRIBA





NENTE B _VISTA LATERAL

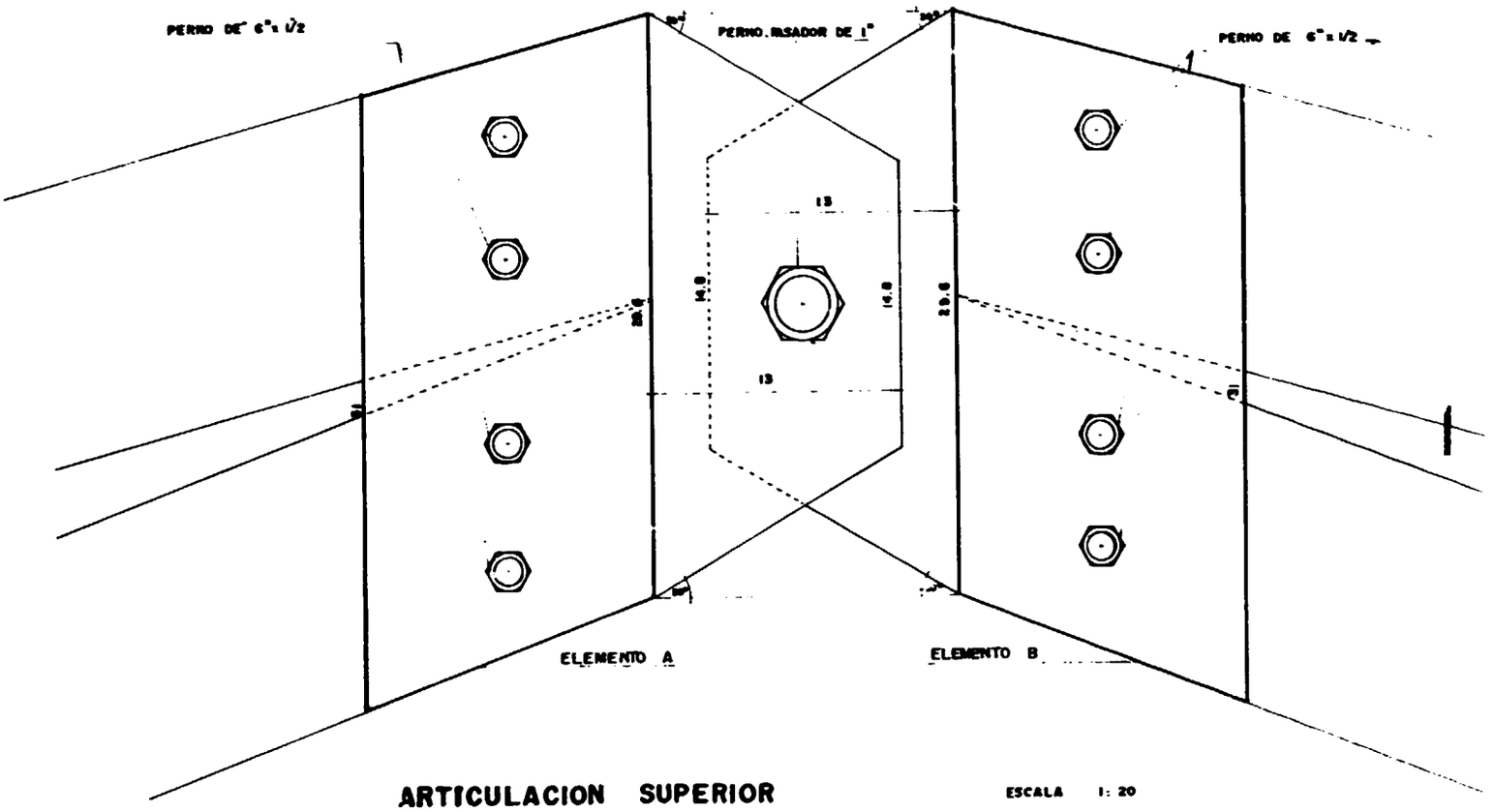


ONENTE C _VISTA DE ABAJO ARRIBA

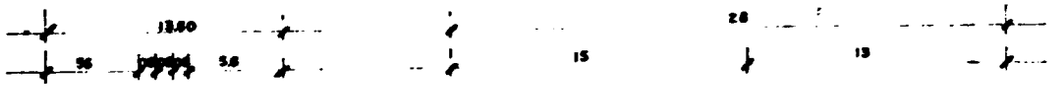
MINISTERIO DE AGRICULTURA Y GANADERIA PROGRAMA NACIONAL FORESTAL		
PROYECTO	Arq. Sergio L. Silva Mejía	
REVISO	Ing. Nelson Toledo Echeverría	
APROBO	Ing. Carlos Aguirre Castillo	
	CONTIENE ARTICULACION INFERIOR	DE
Octubre 1.98		ESCALA 1:20

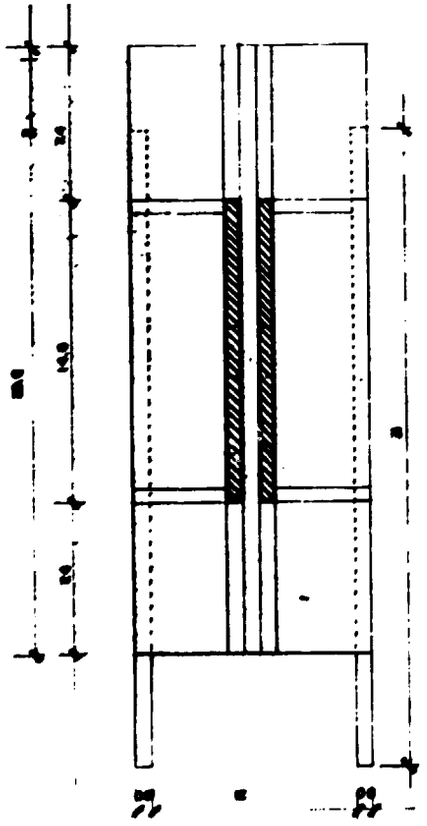
LOWER JOINTS

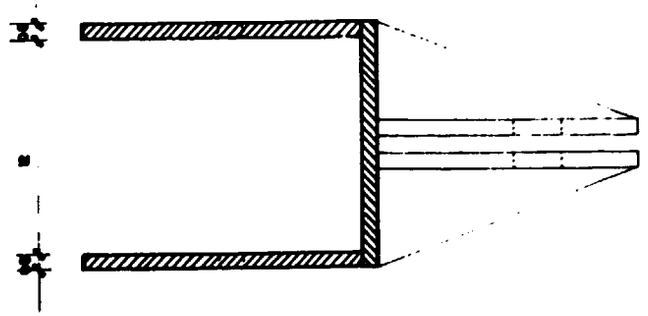
SECTION 3



ARTICULACION SUPERIOR ESCALA 1: 20



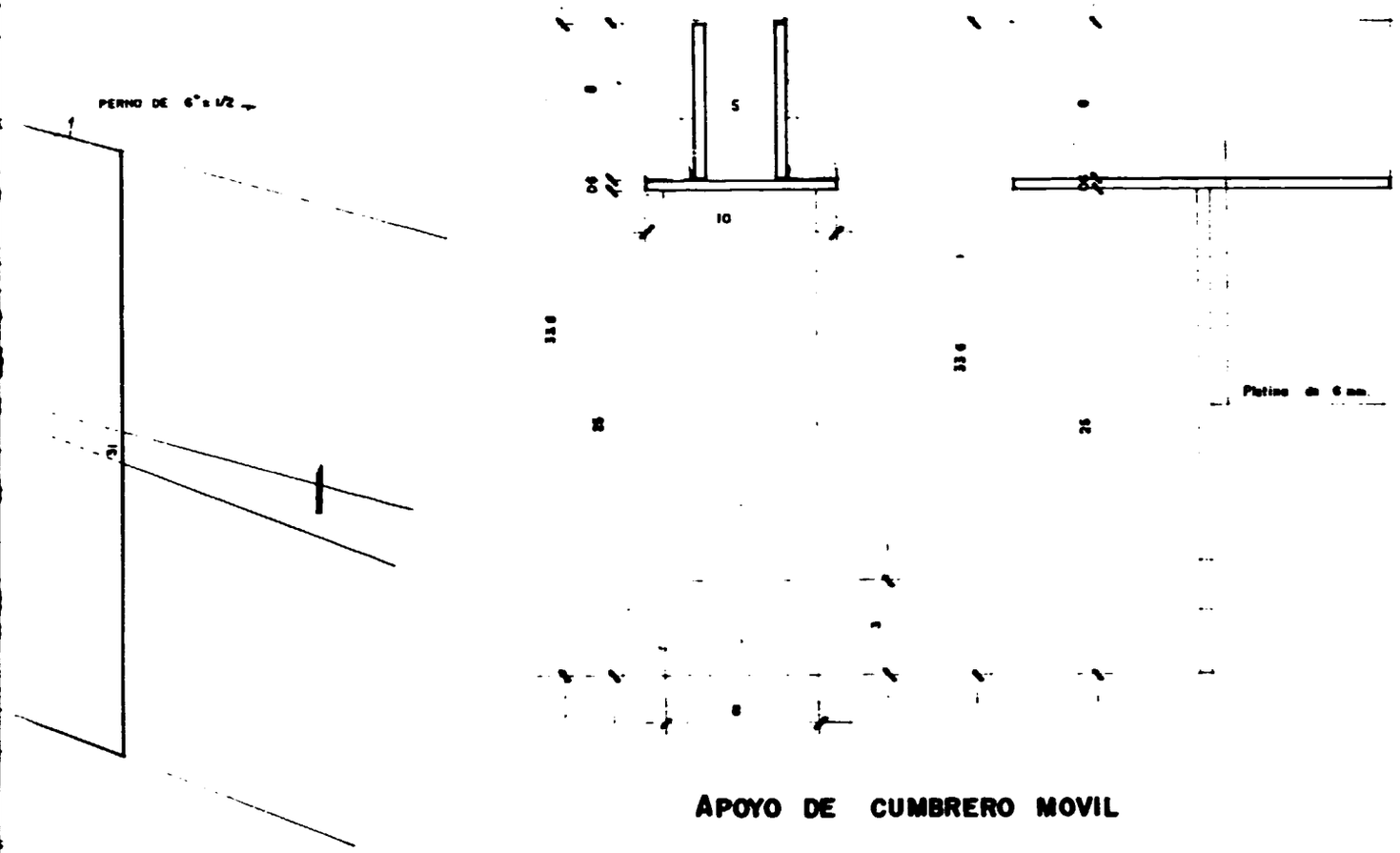




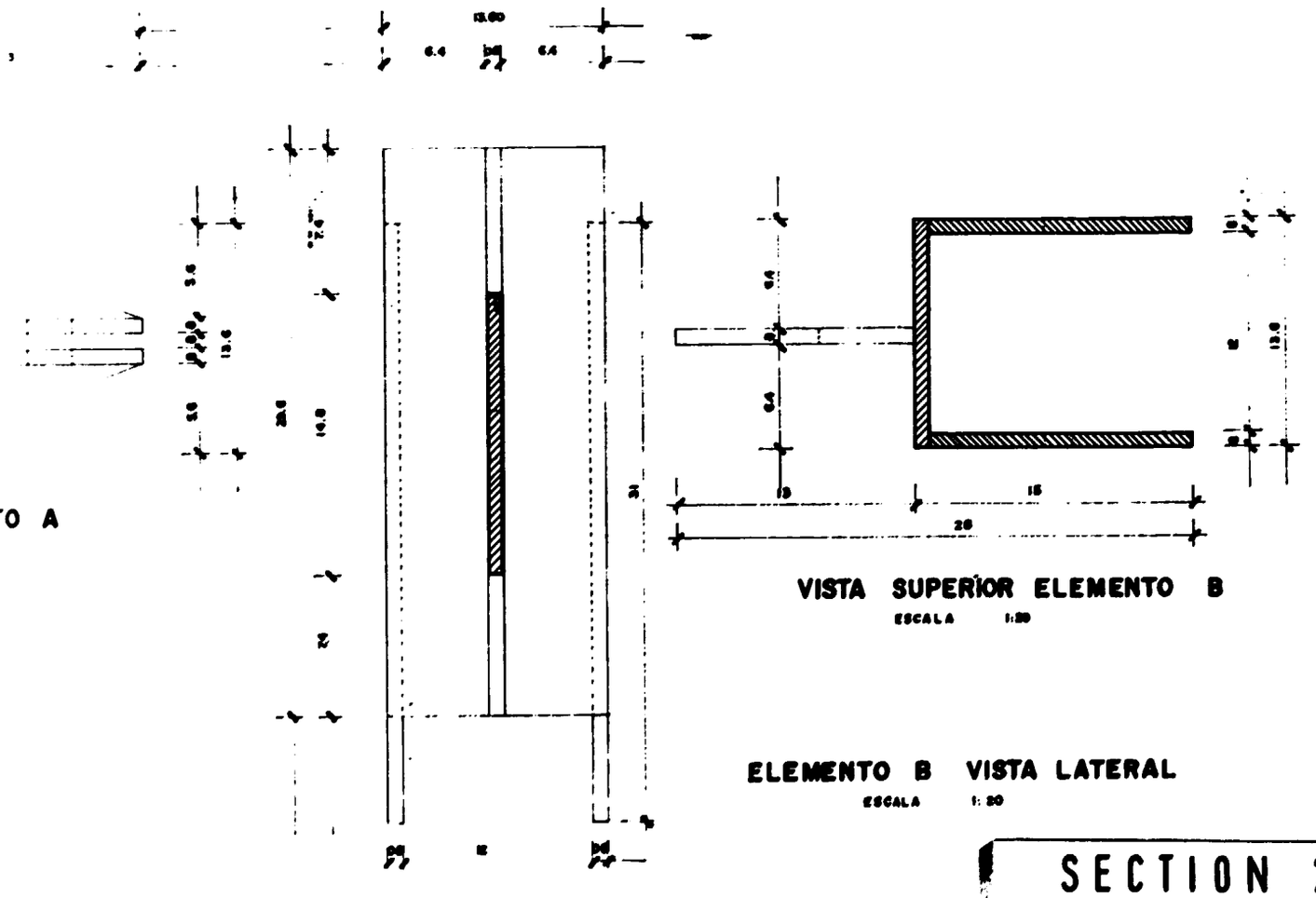
VISTA SUPERIOR ELEMENTO A
ESCALA 1: 20

ELEMENTO A VISTA LATERAL
ESCALA 1: 20

SECTION 1



APOYO DE CUMBRERO MOVIL



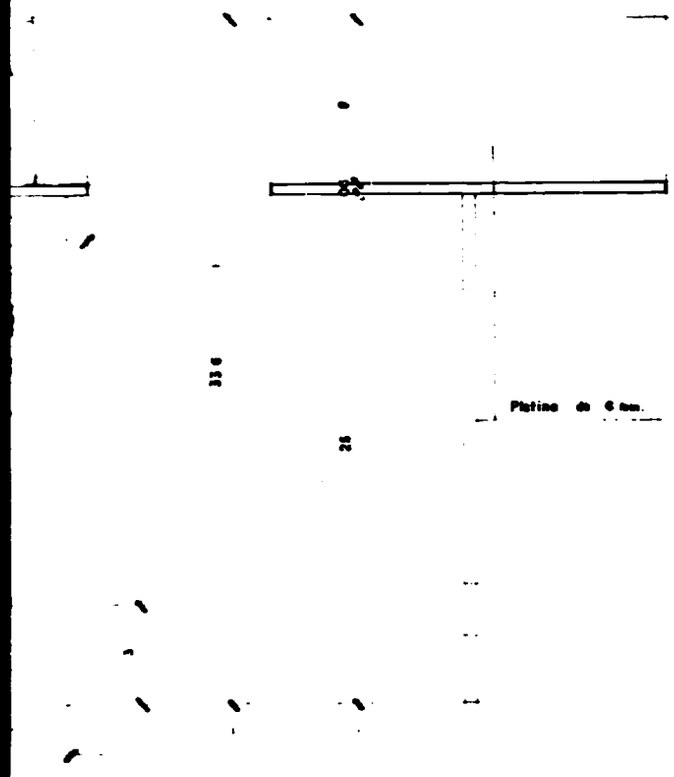
VISTA SUPERIOR ELEMENTO B

ESCALA 1:20

ELEMENTO B VISTA LATERAL

ESCALA 1: 20

SECTION 2



DE CUMBRERO MOVIL

MINISTERIO DE AGRICULTURA Y GANADERIA
PROGRAMA NACIONAL FORESTAL

PROYECTO Arq. Sergio L. Silva Mejía

REVISO Ing. Nelson Toledo Echeverría

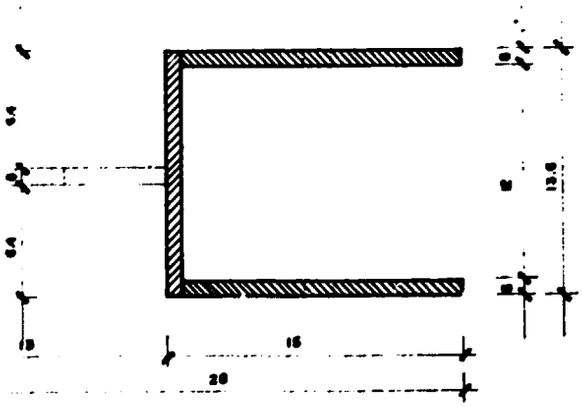
APROBO Ing. Carlos Aguirre Castillo

CONTIENE

ARTICULACION SUPERIOR

Octubre 1.981

ESCALA 1:20



VISTA SUPERIOR ELEMENTO B

ESCALA 1:20

ELEMENTO B VISTA LATERAL

ESCALA 1: 20

SECTION 3

UPPER JOINTS

ANNEX 5

Wood processing units in Bhutan