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LOW-COST MODULAR PREFABRICATED WOODEN BRIDGES

SM/BHU/84/010

BHUTAN

Technical report: Timber for the UNIDO Bridge *

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

Based on the work of C.R. Francis, consultant in timber construction

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United Nations Industrial Development Organization
Vienna

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Table of Contents

TIMBER SUPPLY

The volume of timber required for a 3m length of 4-panel bridges is 154 cubic feet. Then for bridges to be constructed at the rate described previously of one 15m bridge per 6 weeks, a monthly input of sawn timber of 513 cubic feet will be required: this will require a log volume of about 1000 cubic feet per month.

Orders on a continuing basis should be placed on the Forest Department for this log supply.

The log specification should read:

> "Logs should be freshly felled green chir pine logs cut square and free of sloven ends.
>
> Logs should be extracted and loaded immediately after felling. Logs which have been lying in the forest or on the road side so that they show discolouration or decay will not be accepted"

Log dimensions shall be:

> Length 4.0m (13ft 2in)
>
> Minimum centre girth 1.2m (4ft 0in)

Logs shall be sawn immediately to yield the following timber:

Sawn Size mm	Percent by Volume	Percent by piece count
260 x 55	25	16
210 x 55	18	14
160 x 55	10	10
105 x 55	37	57
160 x 160	10	3
	100	100

This timber should be stacked under cover to dry to 25% moisture content in the core, ready for treatment. This will take about 3 - 4 months, depending on the season.

TIMBER PROCESSING

The order of processing should be:

1. Dry to 25% MC in core.
2. Thickness to 50 mm.
3. Plane one edge straight where required.
4. Grade.
5. Saw gauge to width (250, 200, 150, 100mm).
6. Cross cut to length and angle.
7. Pressure treat.
8. Dry to 20% MC.

The reasons for this order of processing are:

1. Drying to this moisture content is required for treatment and will reveal any warping.

2. Thickness planing will yield a uniform thickness and gives a smooth surface to facilitate grading.

3. Planing will remove crook.

4. Grading at this stage will sort into acceptable structural quality for panel components and bracing and into non structural.

5. Saw gauging yields uniform width. The 100 x 50 may be either saw gauged or thicknessed to 100 mm width.

6. The panel and bracing components are cut to exact length for assembly and the superstructure components are also cross cut to give square ends prior to treatment.

7. All machining and sawing operations are now complete and no arsenically treated waste has been produced. This eliminates the health hazard caused by burning CCA treated wood for cooking or mere disposal of shavings. Also, all ends are exposed to treatment, which is heaviest at the ends of the timber.

8. Redrying before assembly is necessary to eliminate potential splitting at panel connections. The top chord members and the panel diagonal members should be treated first in a batch of timber since these will take longest to dry, and are the members most in need of drying since these are the ones which have potential for splitting. King post and bracing members need not be dry before assembly since they are fastened on their centre lines only and have no potential for splitting at connection.

The timber quantities required for one 3m length (one panel length) of 4 panel bridge are:

Size	Number	Length
250 x 50	18	4000
200 x 50	16	4000
150 x 50	12	4000
100 x 50	65	4000
150 x 150	4	4000

These pieces are to be graded and sorted as follows:

250 x 50 8 pieces for top chords structural quality, 10 pieces for running planks.

200 x 50 From each piece, cut one panel diagonal 2180 long from the best part of the stick. The remainder should be ripped back to 150 mm to yield 1 king post member 1330 long or one vertical brace 1140 long. **Note that, after cutting the diagonal, 1820 mm is left, so a fair degree of flexibility for component position in the stick is available.**

150 x 50 From two in each 10 pieces cut one horizontal diagonal brace 2230 long. Select one piece of structural quality for horizontal transverse brace. The rest goes for handrails.

100 x 50 All for decking. Non structural.

150 x 150 Kerbs and handrail posts - non structural.

The simplified cutting list has minimum waste and allows a large amount of flexibility in selecting the best quality pieces for use in panel construction with poorer quality pieces going into handrails and wearing boards.

Note that the 200 x 50 pieces have only one panel diagonal cut from them. The offcuts go into the king posts and the diagonal braces. These may be made from 200 x 50 or rippped down to 150 x 50 either is satisfactory.

The handrails and kerbs are made in 4m lengths, not 3m as shown on the drawings. Handrail posts should be spaced at 1330 mm centres. This is slightly closer than the 1500 mm centres shown on the drawings, but less joints occur in the handrails and the superstructures making them slightly stronger.

The joints in handrails and running planks should be staggered not concentrated at every 4m.

Note that any increase in timber thickness will require alteration to some bolt and steel component lengths, particularly panel plates 10 and 10A.

DRYING

Timber must be carefully stacked for drying. Ends should be kept square and the stack built on substantial bearers as has been demonstrated and taught.

Cross bearers 100 x 100 should be spaced at 750 centres. A 4m long stack will require six cross bearers. Each layer of planks is separated from the one below by 1200 x 25 x 25 fillet sticks. These must be accurately positioned vertically one above the other over the centres of the cross bearers. Stacks may be built up to about 2.4 m in this way. Note that three stacks 4 m long x 1.2 m wide x 2.4 m high will contain enough timber for one complete bridge.

The process of drying must be checked continually with the Protimeter moisture meter. The pins on the electrode should be hammered full depth into the wood so that the moisture content in the core of the piece is read. If the enamel on a pin becomes damaged, the pin should be discarded and a new one inserted. Use scale A for untreated and Scale C for treated wood.

FORCED AIR DRYING

Although not undertaken in this project for lack of funds and opportunity, it is recommended that forced air drying should be undertaken in the future.

Forced air drying /process speeds up the drying by drawing air through the stacks by means of fans. Two parallel stacks 1 m apart are built, and roofed over with CGI sheets weighted down on the stacks. At each end a plywood baffle containing three 600 mm diameter fans is fixed to draw air through the stacks. The arrangement is shown in Fig 1.

Forced air drying is relatively expensive in terms of electricity. The daily cost for six 0.5 Kw fans will be Nu. 28/80. The two stacks will contain about 540 cft of timber with a value of Nu. 24,570/-.

The annual interest charge on this at 10% interest rate is 2457/- or daily charge Nu 6/73.

Forced air drying can be expected to reduce the time of drying by about 33%. thus a saving of one month in three is expected. The cost of this in electricity will be Nu 28/80 x 2 x 30 = Nu. 1728/-. The interest cost saving will be Nu 6/73 x 30 = 201/90. Overall cost Nu 1526/10.

Contd

Forced Air Drying Contd

Forced air drying thus cannot be considered as a routine. However occasions will probably arise when no useful work can be performed due to lack of dry timber. The monthly wage bill for factory regular staff is about Nu 6300. Consequently forced air drying could be economic if it saved $\frac{1526}{6300}$ months per month say 1 week per month of lost time due to waiting for timber. This situation could very easily arise.

THICKNESS PLANING

Thickness planing and grading should be carried out simultaneously. The most important sizes to be graded are the 250 x 50 and 200 x 50. However, all the other timber should be sorted into "Accept" and "Reject" piles.

Grading should be done after the second pass through the thicknesser so that the grader can examine both faces. Details of grading requirements are given in the section "Grading".

Thickness planing produces large volumes of shavings. A labourer should be assigned with broom, shovel and wheelbarrow to continuously remove shavings from the tailing out area.

EDGE PLANING

Edge planing will produce one edge straight and square to the face. Not all the timber needs to be edge planed unless the sawmill sawing is of very poor quality. The pieces which do require edge planing are:

Top chords	250 x 50
Panel diagonals	200 x 50

Top chord pieces should be edge planed the full 4m length A small amount of skip is acceptable.

Panel diagonals need not be planed the full 4m length. Instead it is suggested that the length of the 4m stick which will be used for the diagonal should be marked using a length stick, and roughly cross cut after thickness planing. Use the electric hand saw to cross cut. Then the selected pieces are edge planed and the remainder are taken directly to the rip saw for ripping back to 150 mm.

SAW GAUGING

This is performed on the rip saw. Set the saw with a rule, take a short trial cut, check and adjust if necessary. Edge planing after saw gauging is not necessary.

Only panel components need to be saw gauged. Decking (100 x 50) may require a preliminary gauging before edge thicknessing. This will depend on the quality of sawing in the sawmill. If this sawing is poor, then the decking should be skimmed on one edge before thickness planing to width.

CROSS CUTTING

Cross cutting is the start of the fabrication process. The radial arm saw can get out of alignment quite easily and needs to be checked frequently for:

Straightness of fences

Flatness of tables

Squareness of cut, in both horizontal and vertical directions

Decking - 100 x 50

Square cut one end, cut to 3800 long. since the table is only 3300 long, an auxiliary length stop will need to be clamped to the right hand table.

Top chords - 250 x 50

These pieces MUST be cut accurately to length of 2968 to within 1mm. this length must be checked frequently by the foreman. The clamp stops tend to get bumped away from the saw, so the timber must be gently eased up to the stop.

The offcut from each top chord is cut into two 450 long packers. The best of the stick should go into the chord with one or both ends going into packers. The exact length of the packers is not critical, so these may be sawn to a mark on the fence.

Panel Diagonals - 200 x 50

Set the saw to 45° angle to the right.

Starting 100mm from the end, cut off one corner. (Fig 2, Cut No.1)

Without sliding the stick along, turn it upside down and mark 125 along the cut.

Cross Cutting Contd

Square off this to the rear edge and cut. (Fig 2, cut No. 2).

Clamp a scrap of timber square across the saw table 2187 mm from the saw to form a stop. Turn the stick over a second time, and slide along to the right until the point of the stick reaches the stop. Cut the piece to length. (Fig. 2 cut No. 3).

Note that the piece must be turned over TWICE. The length of the edge should be 2099 mm as shown in the drawings.

King Post - 150 x 50

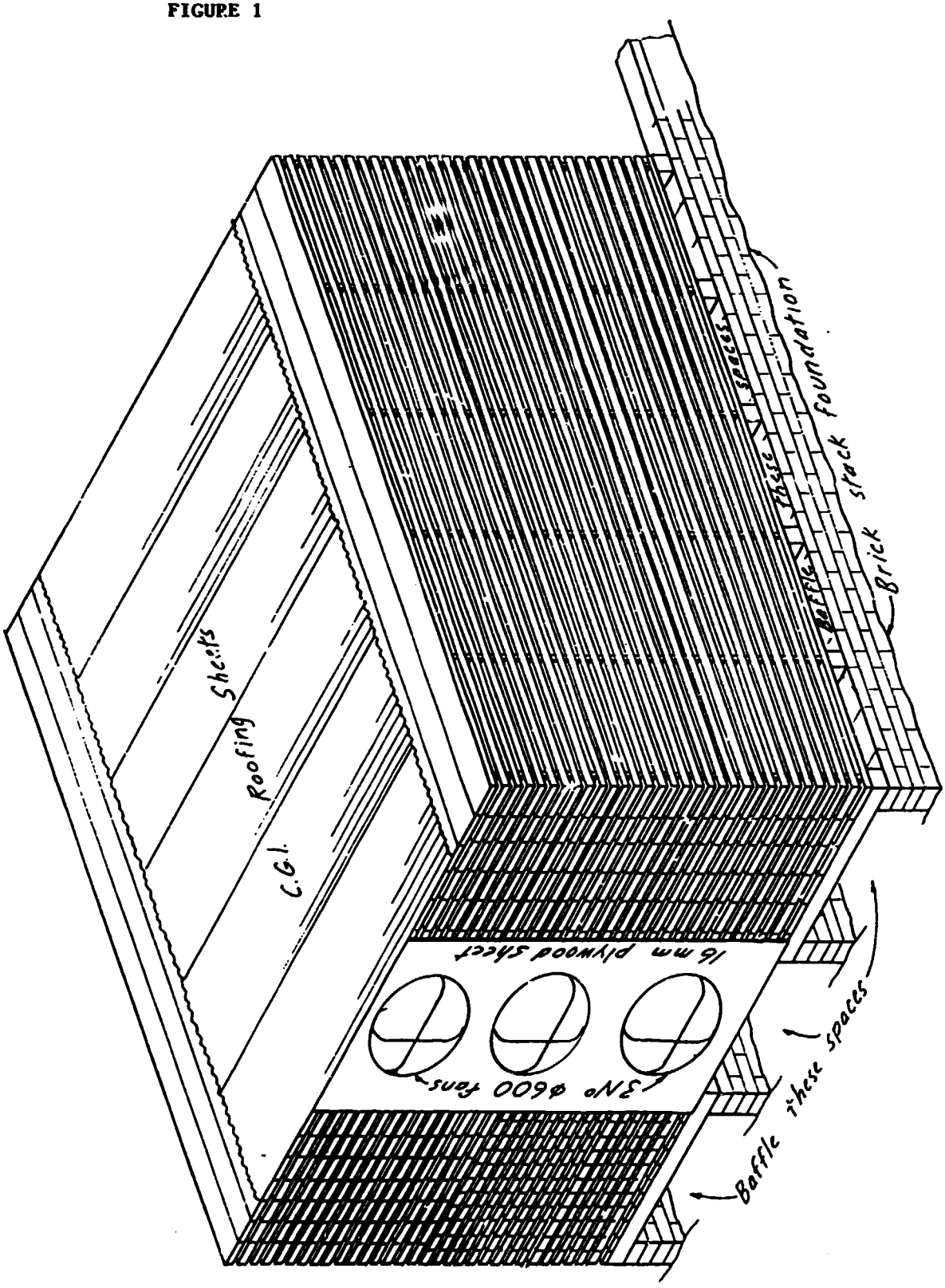
Set the saw to cut 45° to the right and cut the points of all the king posts in the batch. Set the saw to cut square and clamp a 100 x 50 stop to the fence to cut the king post 1315 mm long overall. This is 10 mm shorter than shown on page 16, Part 2 of the Manual, but it precludes the possibility of the king post being proud of the top chord of the panel.

GLOSSARY

Skip:	A depressed area on a board which does not get planed and still shows a rough sawn surface.
Snipe:	A tapered end on a board caused by bad sawmilling practice.
Sloven End:	The end of a log or board which displays the rough axe cuts and shattered grain caused when the tree is felled.
Saw Gauging:	Production of uniform width or thickness timber by careful ri[illegible] sawing against a fence.
Thicknessing:	Production of uniform thickness timber by passing it through a thickness planer.

C. R. FRANCIS,
Registered Civil Engineer

FIGURE 1



FORCED AIR DRYER

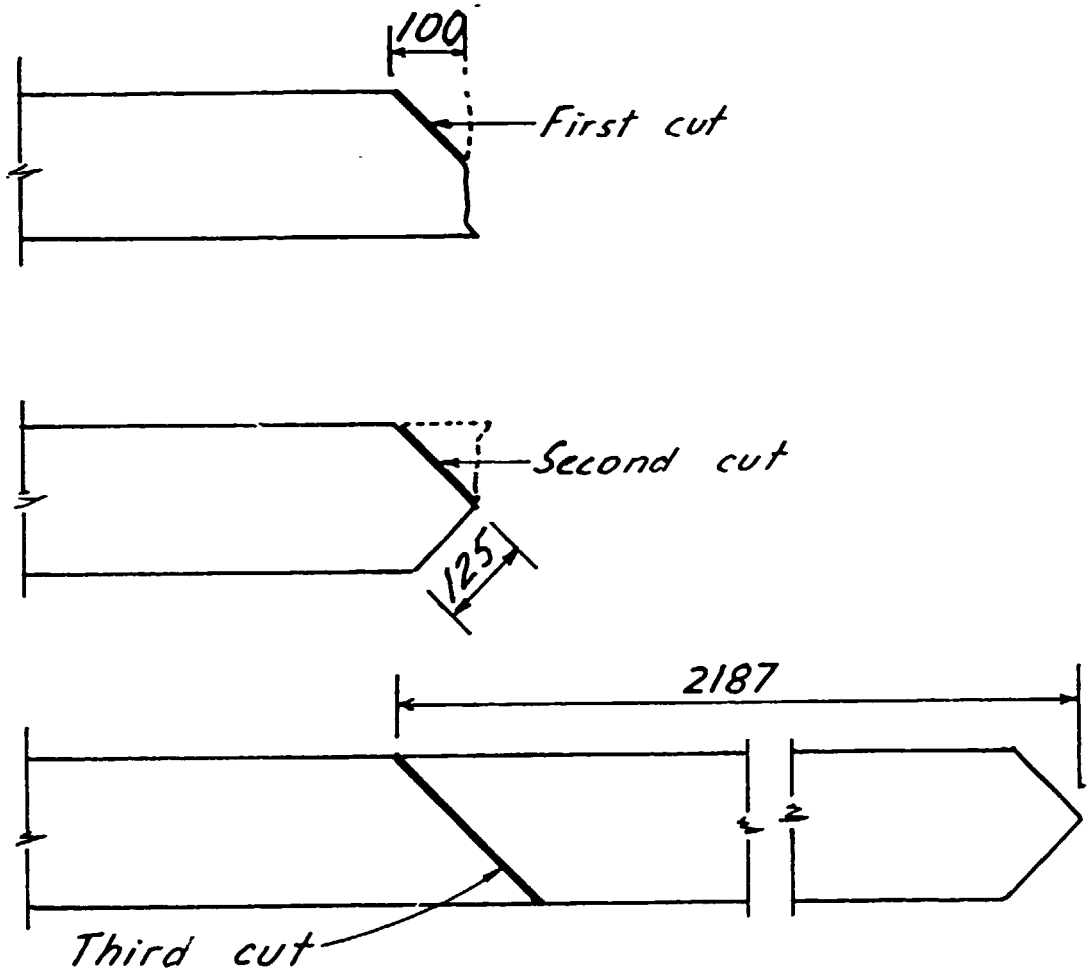


FIGURE 2