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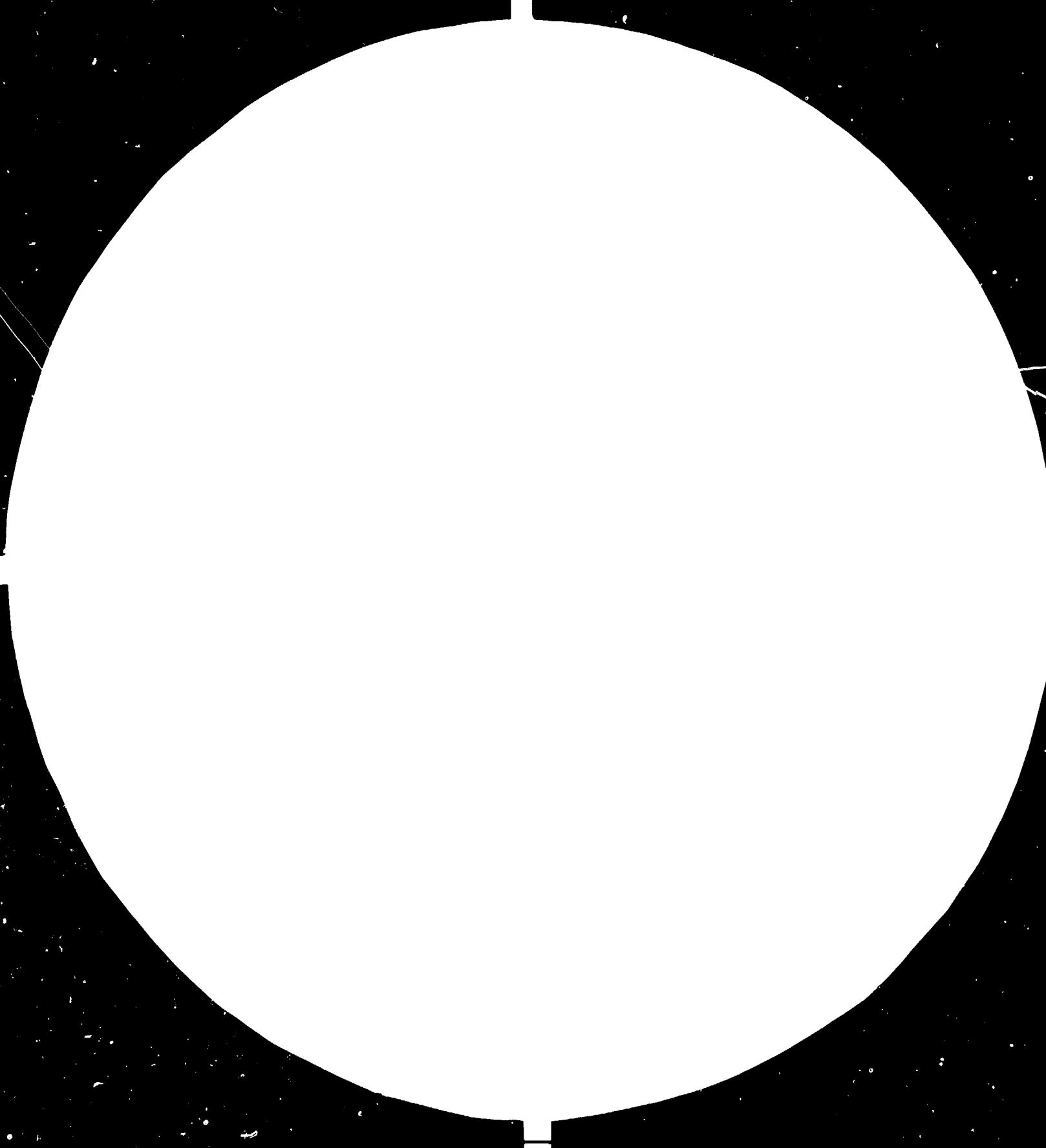
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## MICROSCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS  
STANDARD REFERENCE MATERIAL 1010a  
ANSI and ISO TEST CHART No. 25



# Wooden Bridges

UNIDO'S PREFABRICATED MODULAR SYSTEM



# **WOODEN BRIDGES**

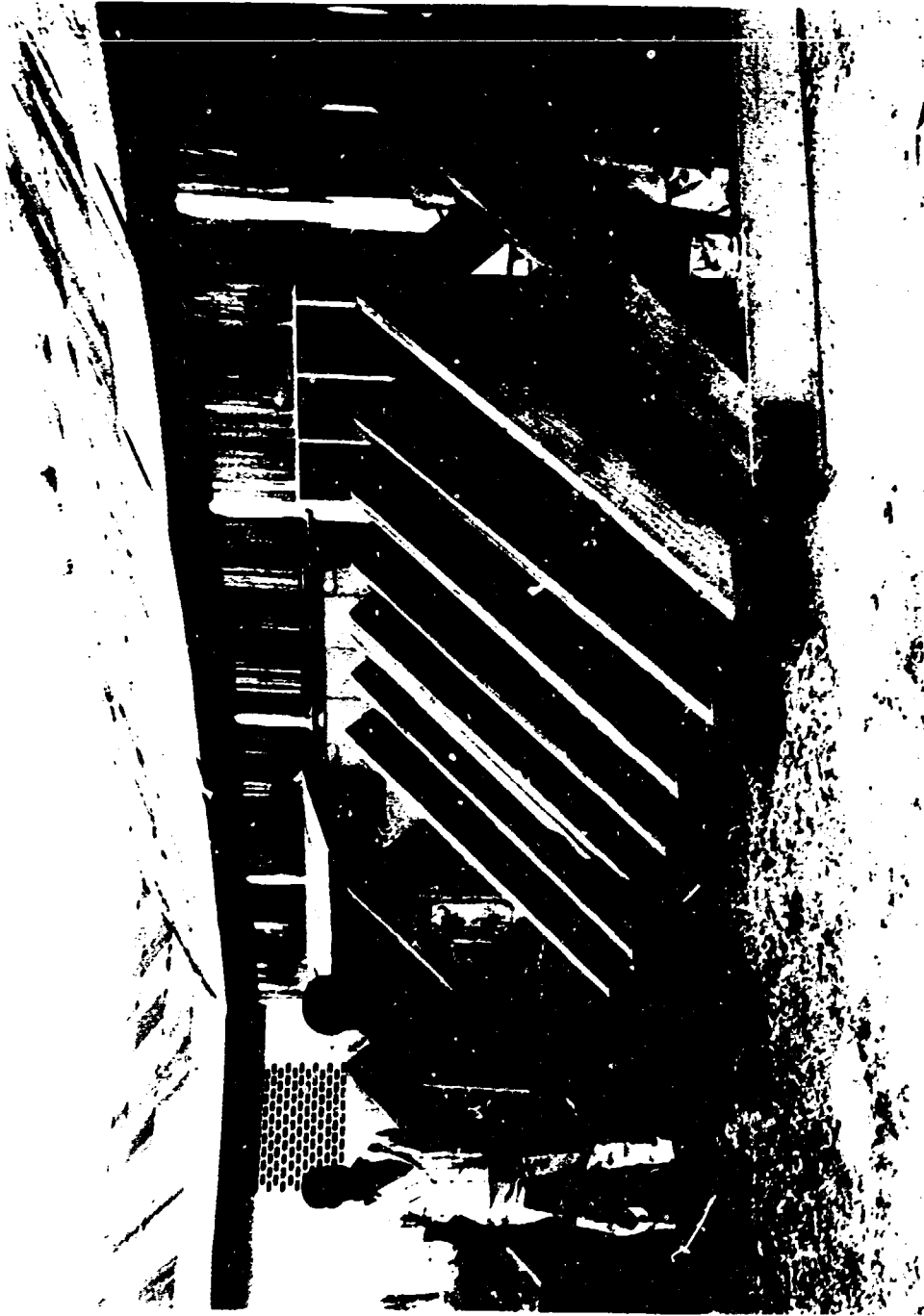
## ***UNIDO'S PREFABRICATED MODULAR SYSTEM***

- 
- **A fully engineered timber structure suitable for secondary and access roads**
  - **Designed for up to 30-metre clear spans and 40-tonne loads**
  - **Standardized modular components and speed of erection mean relatively low cost**
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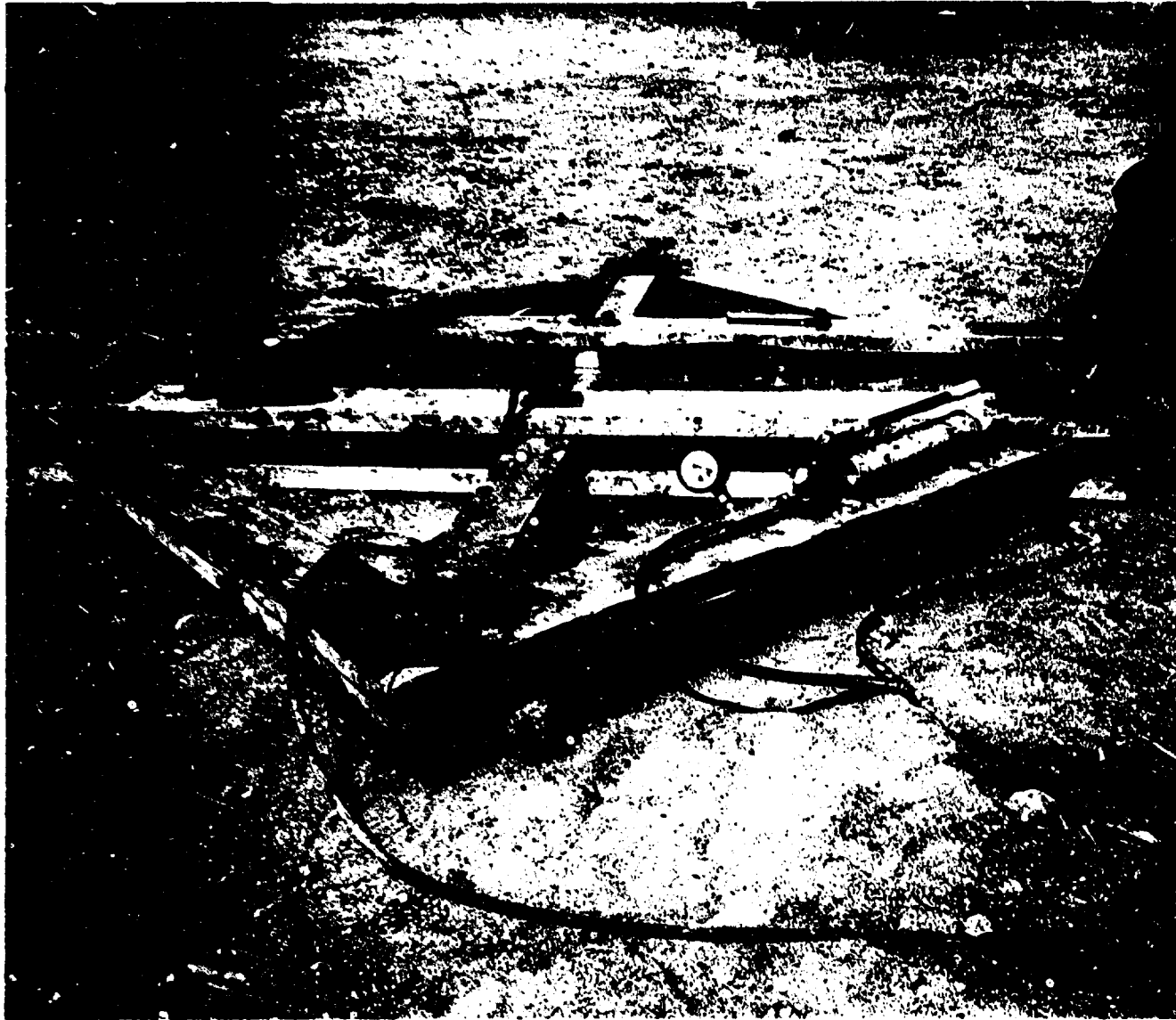
## **THE UNIDO PREFABRICATED MODULAR WOODEN BRIDGE**

The United Nations Industrial Development Organization (UNIDO) has developed, through a project in Kenya financed by the United Nations Development Programme (UNDP), a unique bridge system suitable for developing countries with or without forest resources. The bridges can span up to 30 metres (longer bridges with multiple spans are possible) and carry up to 40 tonnes live load and are therefore most suitable for secondary and access roads. The bridges are fully engineered; the cost is estimated to be less than one-half that of reinforced-concrete bridges.

The basic element is a triangular, 3-metre long timber panel with mild-steel plates pinned and spot-welded at the joints. It weighs 150-200 kg depending on the materials used.



Panels and steel  
tension chords completed at  
the workshop await transport  
to the bridge site at Avakaba,  
Central African Republic



Prior to leaving the workshop for the bridge site, all panels are loaded in pairs using a hydraulic jack to ensure that they meet design specifications.

*Test loading panels, Kenya*





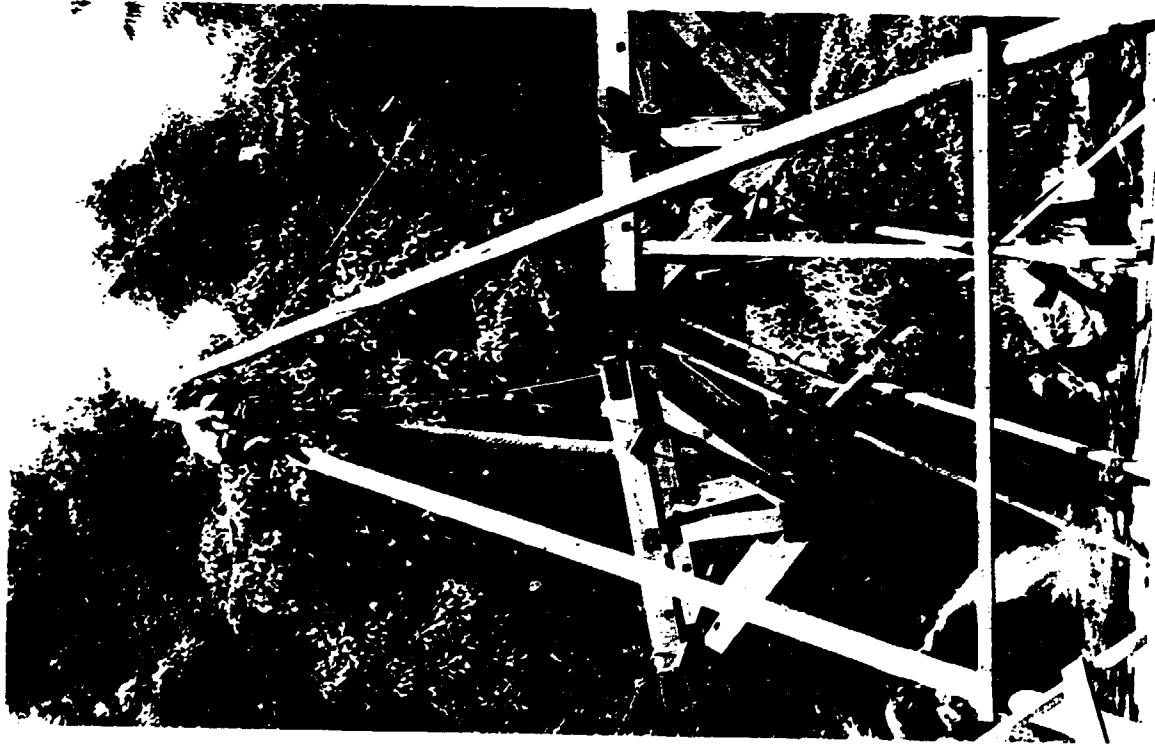
Pipes and conduits ready for transport.  
Central African Republic



Other advantages are that the standardized components (3-metre wide, fully engineered wooden triangular panels and 3.1-metre steel tension chords), do away with the need for expensive and, in some developing countries, scarce engineering design for each bridge. The components can be made in small workshops, transported without heavy lifting equipment and, once the abutments are built, erected in a few days using various tripod, cable and winch arrangements. The expected lifetime of the bridge is between 15 and 25 years.

Pairs of panels are assembled into cross-braced trusses and launched by various means across the river. With the wet-crossing method two tripods are used, while with the stream-bed method, the elements are lifted into position and held with a scaffolding until the span is completed.

The ends of the first and last panels are fixed to the abutments with a bearing plate.



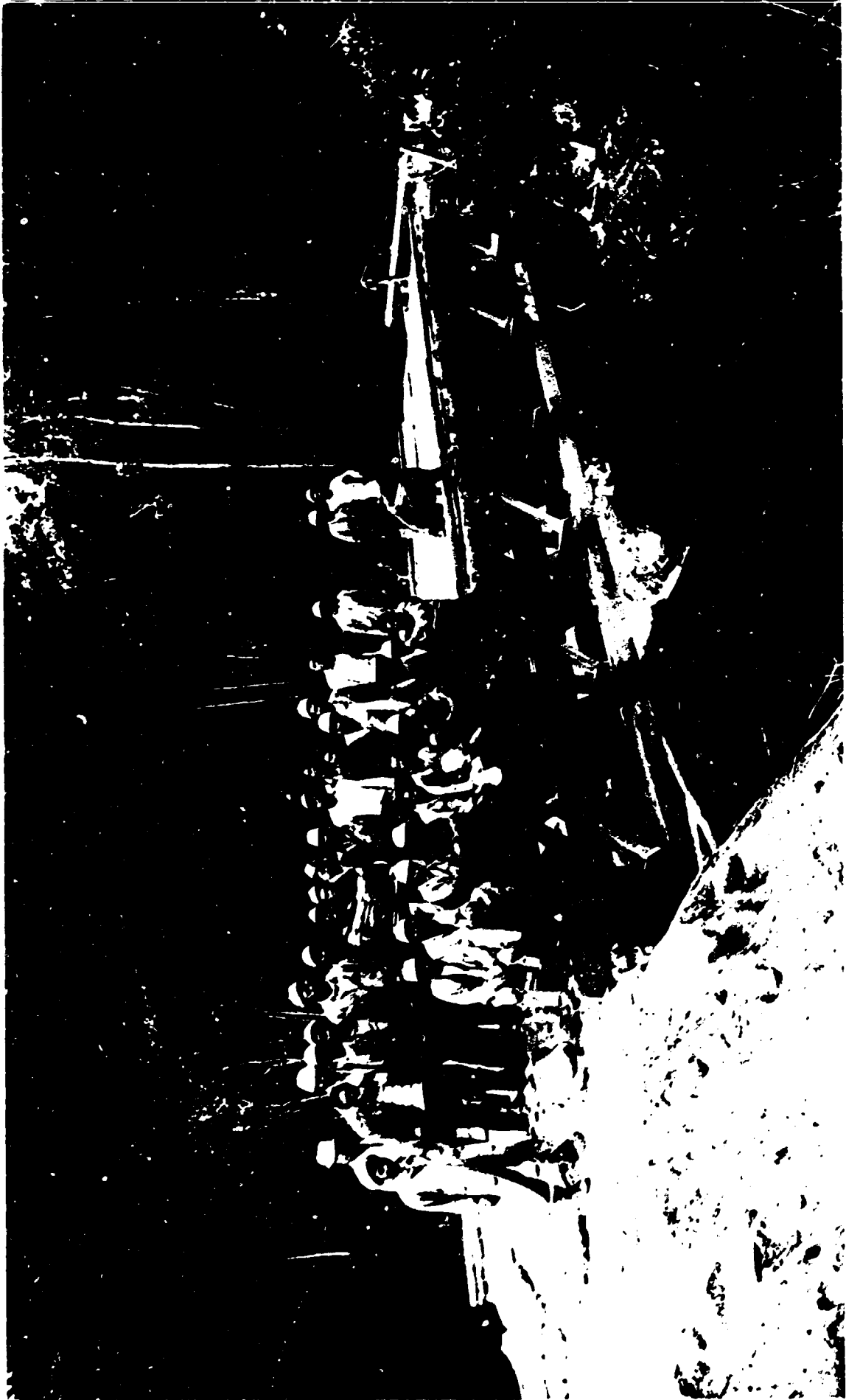


The panels are always launched in pairs, and each pair of panels is cross braced. After the truss has been fixed, diagonal bracing is added.

The bridge deck is then nailed onto the trusses, and the handrails are fitted.

*Cross and diagonal bracing  
on underside of bridge, Honduras*





Almost any species of timber may be used, provided the timber is selected for quality and its strength is sufficient. Preservative treatment is necessary if the species is not naturally resistant to biodegradation. Mild-steel plates, flats and rods are used, plus nails and bolts which should be galvanized for bridges in tropical areas. Normally, cement and reinforcing rods are used for abutments; however, development on use of timber for abutments, approaches (cribwork) and tension chords, which are normally of mild steel, is under way.

Strict quality control, test loading of each panel and attention to detail are necessary for safety and to avoid problems in erection. The training of workshop and site crews is straightforward. Various options exist for the manufacture of components: they can be subcontracted to specialized workshops or made entirely in a bridge workshop that has woodworking and metalworking facilities.

The costs will vary from country to country and depend on the source of supply (imported or domestic) and the size of the order. The following specifications and costs for a 15-m, four-truss bridge are based on UNIDO experience and are intended only as an example.

*An 18-m bridge  
that was erected  
in four days  
on prepared abutments.  
Madagascar*

## **Timber**

\$2,000<sup>1</sup>

15 m<sup>3</sup> (about 1 m<sup>3</sup> for each metre of span)

Cut to sizes:        50 × 150 mm  
                          50 × 200 mm  
                          50 × 250 mm

Maximum length: 3,100 mm

Strength groups (Australian system): S3-S6  
(density 600-900 kg/m<sup>3</sup>)

A pressure-preservative treatment, using such commercially available salts as copper-chrome-arsenic or creosote, is best. The advice of a specialist should be sought to ensure proper protection since many treatments exist.

## **Steel**

\$2,300

Mild steel, minimum ultimate tensile strength 435 N/mm<sup>2</sup>

Plates:	6 to 15 mm	} \$1,000
Flats:	6 × 50 mm to 12 × 75 mm	
Rods:	12 and 50 mm diameter	

<sup>1</sup>References to dollars (\$) are to United States dollars.



Galvanized nuts and bolts:	12 × 150 mm to 12 × 300 mm	}	\$1,200
Nails:	100 and 150 mm × 5 mm diameter		
Welding rods:	To standards BS439 (E4333 R21 or E4322 C19) or AWS (E6012 or E6010) for 6 mm fillet welds in the connecting plate components. Welding must be done by experienced welders.	}	\$100

**Concrete** \$1,000

Ordinary structural quality, 360 kg/m <sup>3</sup>	}	\$800
Maximum aggregate size: 20 mm		
Water/cement ratio: 0.40-0.45		
Reinforcing rods: 12 and 16 mm diameter		\$200

Total materials cost \$5,300

**Workshop**

\$15,000-\$20,000  
European port

Planer/thicknesser  
Radial-arm saw  
Assembly/jig tables  
Power drills  
Hand tools

Power hacksaw or  
flame-cutting equipment

Power drills

Oxy-acetylene welding equipment

} if steel  
parts are  
made

**Bridge site**

\$4,000  
European port

100 m wire rope (for 6 tonnes safe working load)

Hand-operated winches

Pulley blocks

Sheaves and slings (plus ropes)

Temporary bracing timber

One or two 6-m high derricks or shear legs

Shovels

Other

## ***Labour***

Some 6-10 workers and 1 foreman would be necessary for the workshop. At the bridge site, 5-6 trained workers, 10-30 local workers<sup>2</sup> and 1 foreman would be needed.

## ***Design***

Design is limited to a simple procedure of checking the strength group of timber and looking up the required number of trusses to use for the span and loading specification. Obviously, the weaker groups must not be used for maximum loads and spans, but they are particularly suitable for pedestrian crossovers, bridges for light vehicles and animal cart traffic or bridges of shorter spans. The pre-fabricated modular system is most

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<sup>2</sup>Involving the local population improves prospects for continued inspection and routine maintenance and thus the prospects for longer service life.

suiting for clear spans in the 12- to 24-metre range, single lane, with light to moderate traffic. Low terrain is not usually appropriate since the depth of the UNIDO bridges is about 1.7 m.

### **Costs**

Costs have not yet been firmly established since prototype manufacture can give only an indication of likely cost under production conditions. Also, conditions around the world differ widely, especially with regard to steel and imported hardware prices. Labour productivity and the bridge site requirements also vary greatly, but in general, abutments are lighter than those for reinforced concrete bridges. Design costs, except for abutments, are practically eliminated, material transport costs are less and, where suitable timber species are readily available, imported inputs are minimized.

The above cost estimates were taken from UNIDO experience so far. Prototype bridges have been built in the Central African Republic, Honduras, Kenya and Madagascar under UNIDO auspices, while in Costa Rica a commercial firm has erected several of these bridges although somewhat modified. A full-scale programme to use the system, including the formation of a special Bridge Section within the Ministry of Public Works, started in 1982 in Honduras.

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