Traditional Bridges of Papua New Guinea

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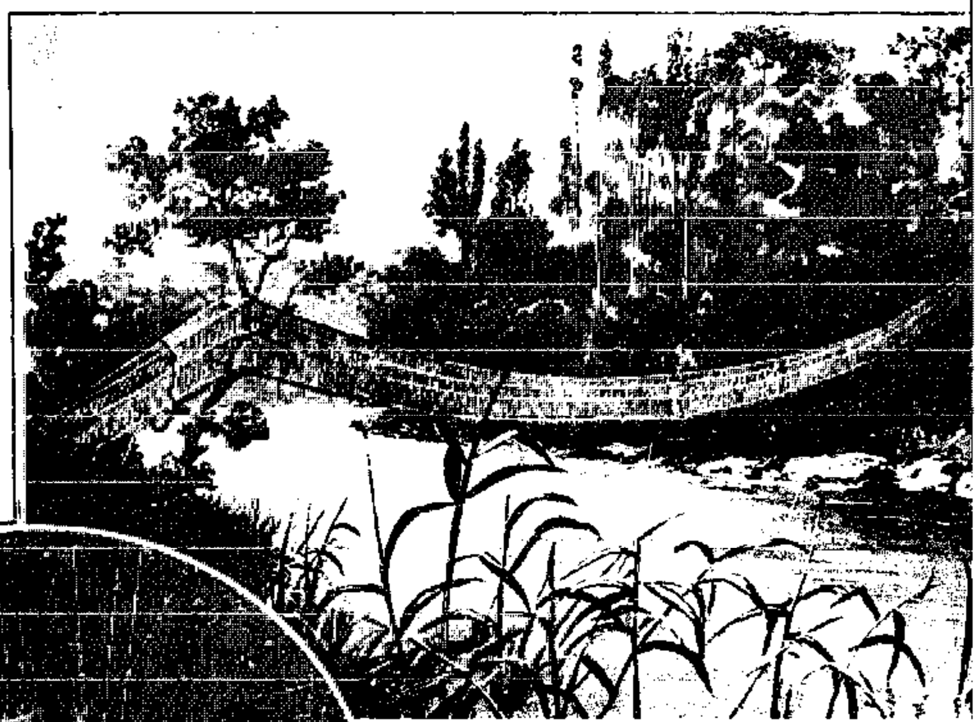

by: JEFF SIEGEL

TRADITIONAL BRIDGES of PAPUA NEW GUINEA

by: JEFF SIEGEL

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art work & design by : KOYASI STUDIO

TRADITIONAL TECHNOLOGY SERIES #1

THE APPROPRIATE TECHNOLOGY DEVELOPMENT INSTITUTE

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

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Preface

The people of Papua New Guinea have a long history of making and doing things which are compatible with their social and cultural framework. From this rich and diverse heritage have grown countless technologies, both simple and complex. Although evolved under differing conditions of climate, sub-culture and region, these technologies share basic common features; they utilize local materials, exert minimal impact on the environment and reflect the basic nature of community life. Together they form a tribute to the PNG people's cultural ingenuity and provide the basis for further technological development and assimilation.

Since the introduction of foreign technologies, traditional tools and techniques have diminished in importance often looked upon as too primitive to be of use in a modernizing society. Cash cropping for export and the lure of economic opportunity in the urban areas have resulted in a reduction of villagers who are available to carry on with community based technological innovation. Consequently, as the foreign influence has become more prevelant new indigenous technological development has slowed considerably. The older crafts people are less inclined to maintain practically based traditions. Present day students, especially those in technical fields, consider the old tools and techniques quaint but obsolete. Yet few are able to relate the new foreign technologies to basic village needs.

The impact of these technological changes is notable. Within ½ generation malnutrition rates have soared, currently reaching 60% in some provinces. This has been directly related to changing agricultural techniques and diets. The complex and impressive ceremonial buildings at one time served as the central point for community decision making. Now, for lack of able bodied labour and traditional expertise, they are deteriorating in many cases beyond salvation. These are but a few examples of the numerous changes affecting the PNG people creating a growing sense of alienation from traditional <u>and</u> new technology.

In order to create a greater awareness of the important continuing role that indigenous technology has in the society's development, the Appropriate Technology Development Institute in collaboration with several members of the University of Technology's staff and students has established this Traditional Technology Series. The Series is geared to record the technologies which are in danger of being lost, establish a forum for addressing the issue of traditional technology preservation and transfer, and encourage the development of techniques which combine the old ways with new technology to meet people's basic needs while maintaining cultural integrity. With these ideas in mind ATDI is pleased to present the first of this Series, Traditional Bridges of Papua New Guinea by Jeff Siegal.

Paul R. Warpeha
Director
The Appropriate Technology Development Institute

Contents

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Introduction

Long before contact with Western society the people of what is now Papua New Guinea had indigenous technologies relating to their own environment. Of these technologies, one of the most impressive is that of bridge building. The terrain of the inland areas of Papua New Guinea is extremely rugged with deep gorges and rushing rivers. The traditional "civil engineers" spanned these rivers with footbridges up to 90 metres long, showing a remarkable knowledge of structural principles and making the best possible use of the materials available.

Today many of these traditionally constructed bridges have become obsolete with new motor vehicle roads and air strips. Others have been replaced by "modern" bridges which use the same structural principles but imported materials. However, in quite a few areas of the country, bridges are still constructed as they have been for centuries. Some of these areas are very remote having little contact with the westernized areas of the country. Others are not remote at all, but use traditional methods because of the unavailability or prohibitive cost of imported materials.

This report is based on research done in the "Traditional Technology of Papua New Guinea" project, University of Technology research project number 175. The aim of the project is to rediscover and make a detailed permanent record of traditional or pre-contact technologies which still exist in Papua New Guinea. It is mainly concerned with examples of material culture such as bridges, traps, and tools. As many of these technologies are dying out or being replaced by imported ones, it would be beneficial to have records so that now and in the future Papua New Guineans, especially students of technology, will have information about their own technological heritage. Also, this information can be examined to see if traditional solutions to technological problems may still be appropriate.

The information in this report is from research carried out from 1979 to 1981. In this time 21 traditionally constructed bridges in 8 provinces were inspected and photographed. Detailed measurements were taken and where possible, people were interviewed to determine actual materials and construction methods. Also, published materials were examined for historical references to traditional bridge building.

The report begins with a general description of bridges: terms used, materials, styles, and construction methods. Then historical references to traditional bridges are given. Following this are detailed descriptions and photographs of individual bridges within three regions of the country: the Highlands, the western border area, and the Morobe Province. Finally, there is a discussion on change and appropriateness.

Bridge Materials, Types & Construction

1.1 Materials

Traditional bridges are constructed with materials usually found in the bush. The main materials are wood, bamboo, bark, vines, cane, and stones.

1.1.1 Wood (Tok Pisin : diwai)

Rigid wooden posts cut from a variety of trees are used for constructing approaches, abutments, anchorages, or pylons (see Appendix for definitions of bridge parts). They may be single thick posts planted in the ground or a series of narrower poles lashed together (see Figures 1, 2, 3, and 13). For cantilever bridges, more flexible wooden poles are used to make up the main span of either the walkway or handrails. Casuarina (Tok Pisin : yar) is often used (Fig. 4). For suspension bridges, cables making up the walkway often have transverse wooden slats. Others have planed wooden planks as the walkway (Fig. 5).

Live trees along the river bank are always used if available for anchorages or abutments (see Fig. 6). Often trees are planted so that they can be used in future bridge construction.

1.1.2 Bamboo (mambu)

Bamboo is used mostly for short pole bridges in which several pieces are lashed together to form a girder spanning the stream. It is not commonly used in larger bridges except for stabilization in pylon suspension bridges.

1.1.3 Bark of trees (skin diwai)

The thin, flexible but strong bark of young trees is often used as rope for lashing components together or for suspenders.

1.1.4 Vines (rop diwai)

Many types of high climbing, woody vines (also called lianas), common to the tropical forests, are used for bridge construction. They are almost always used for lashing together various components (Fig. 7). In some instances they are also used for spanning cables or suspenders and even to make up the walkway of the bridge (Fig. 8).

1.1.5 Cane (kanda)

Cane or rattan, mostly of the genus Calamus, is the most prized material for bridges because of its tensile strength and it is nearly always used in some capacity if available. It is sometimes used for lashing (Fig. 9), but most often for spanning or suspended cables. In many suspension bridges, with the exception of the approaches and anchorages, cane is used for the entire structure (Fig. 10 and 11). It is usually used whole, but sometimes it is stripped for suspenders or lashing (Fig. 12) usually when it is in short supply.

1.1.6 Stones

Large stones are used for counterweight in bridges using the cantilever principle (Fig. 13). They are also sometimes hung from holdback cables in order to maintain tension and help stabilize the bridge (Fig. 14).

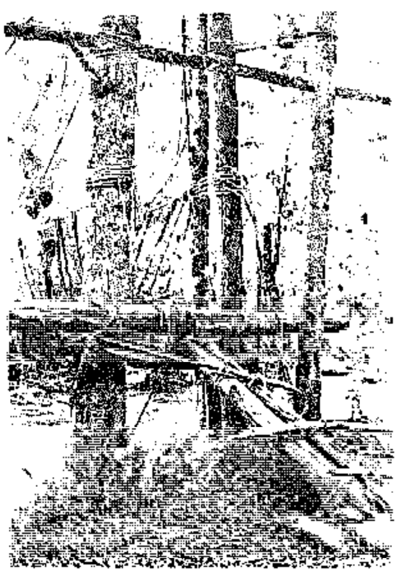

Fig. 1

Logs used for an approach to a cane suspension bridge and, along with trees, for the anchorage (near Upupuro village, Waria River, Northern Province.

Fig. 2

An abutment made of wooden poles lashed together with vines (Ambui Bridge, Lai River, near Wapenamanda, Enga).

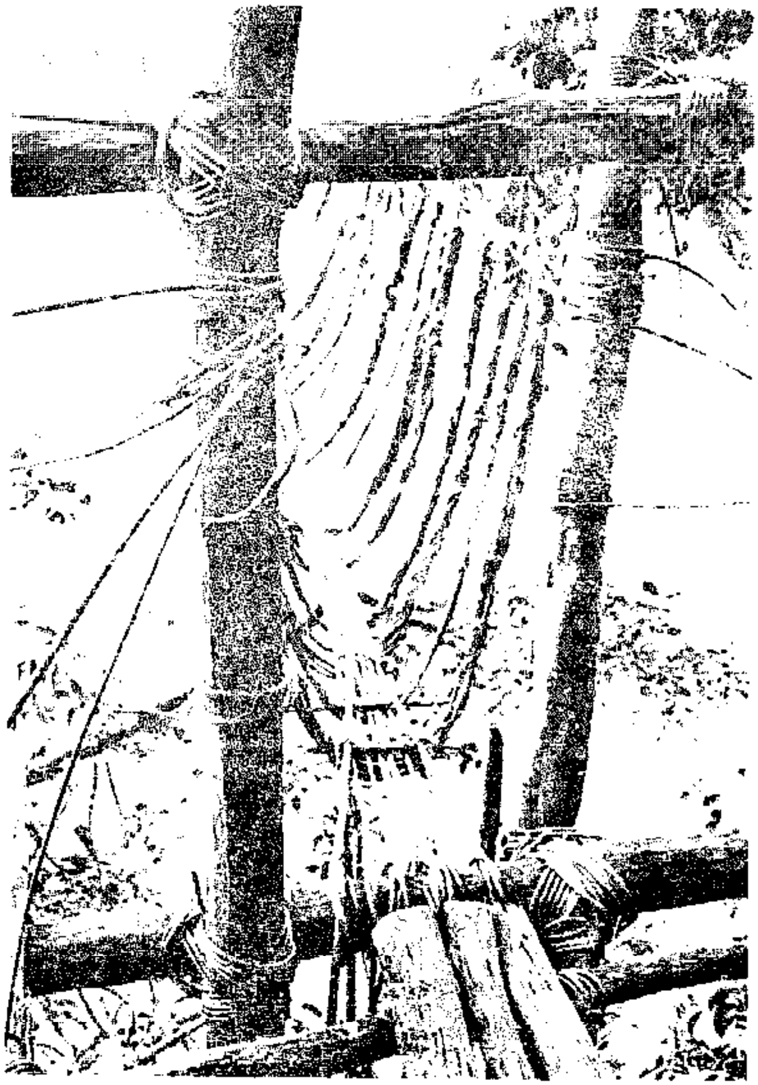

Fig. 5

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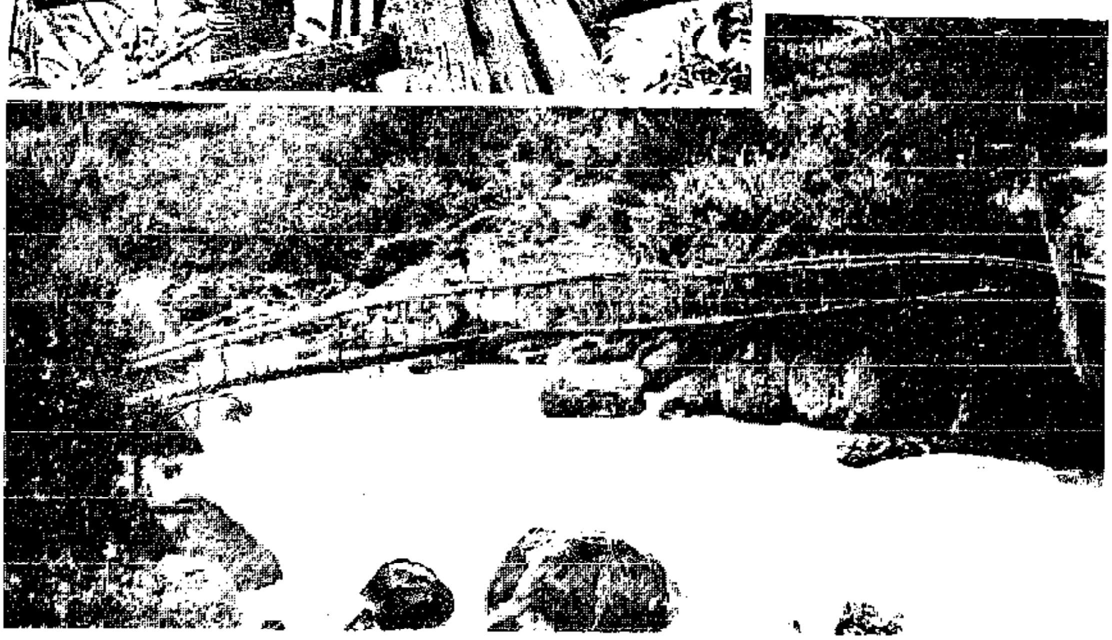


Fig. 4

Suspended cantilever bridge with casuarina handrails and walkway, vine suspenders, and cane suspended cables (Aua Bridge, Lagaip River, Enga).

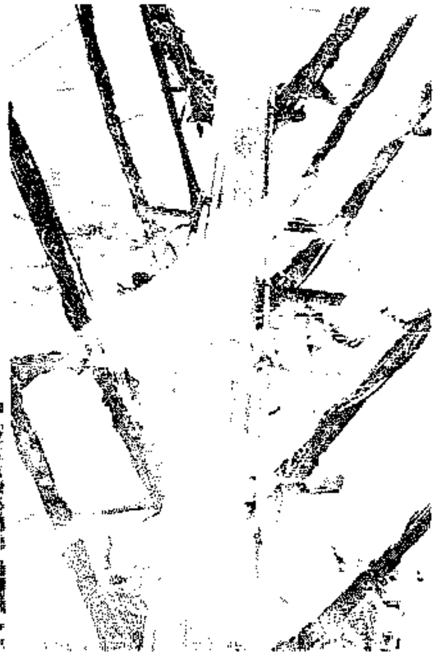
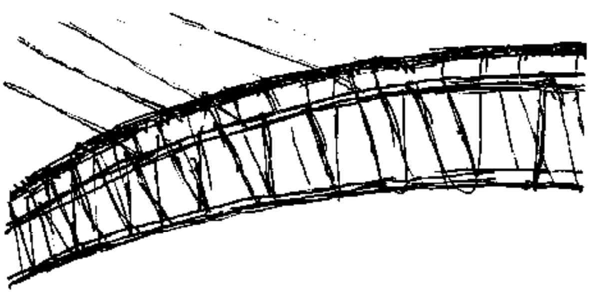


Fig. 5

Planned wooden walkway supported by transverse wooden slats and vine suspenders (near Upupuro Village, Waria River, Northern Province).

Fig. 6

Trees used as abutments (Meihinavi, Henganofi, Eastern Highlands) (photo by Aidan Kiagi and Nusela Gopave).



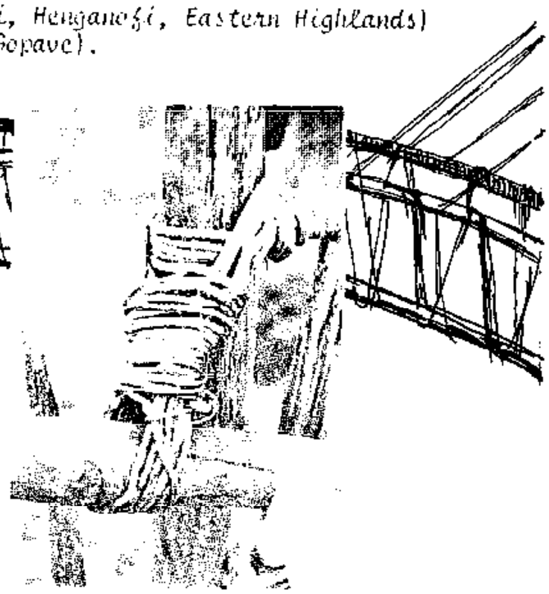


Fig. 7

Vines used for lashing together vertical and horizontal members (Kubib Bridge, Mendi River, Southern Highlands).

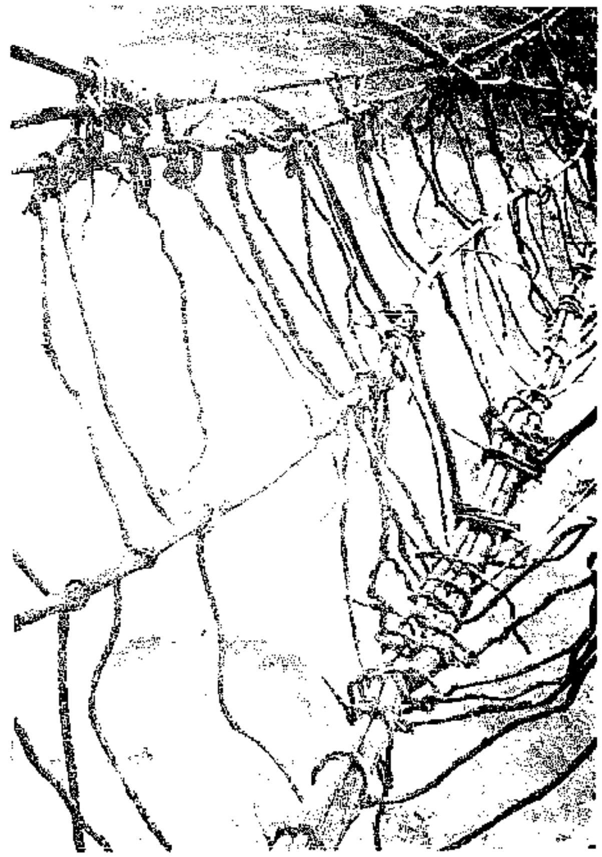


Fig. 8

Vines used for walkway, suspenders and spanning cables (Kobrenmin Bridge, Sepik River, West Sepik Province).

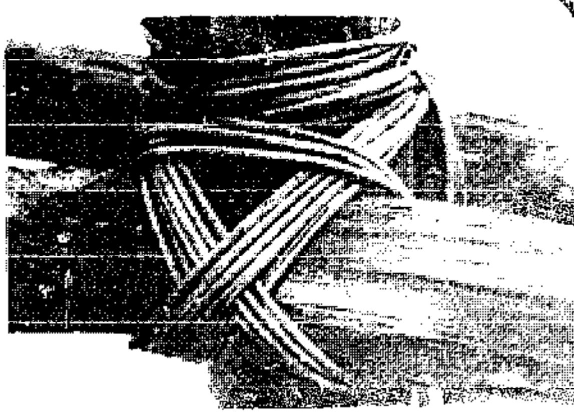


Fig. 9

Cane used for lashing together horizontal and vertical members ([illegible] Bridge, Waria River, Morobe Province).

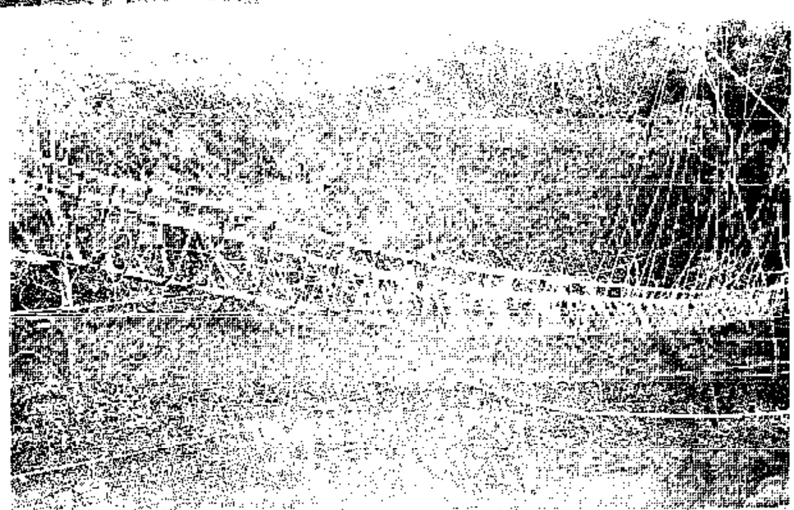


Fig. 10

Cane suspension bridge (Tewa Bridge, Waria River, Morobe Province). (Pictured: George Kumo).

Fig. 11

Cane used for walkway, suspenders, spanning cables, and suspended cables (Tewa Bridge, Waria River, Morobe Province).

Fig. 12

Suspension bridge using stripped cane for suspenders and some support calbes (Nepirik Bridge, Lai River, Enga/Western Highlands)

Fig.13

Pylon for suspension bridge with stones piled up as the counterweight for the cantilever walkway. Holdback cables can also be seen (Sukurum Bridge, Leron River, Morobe Province). Pictured: Maran Nateleo.

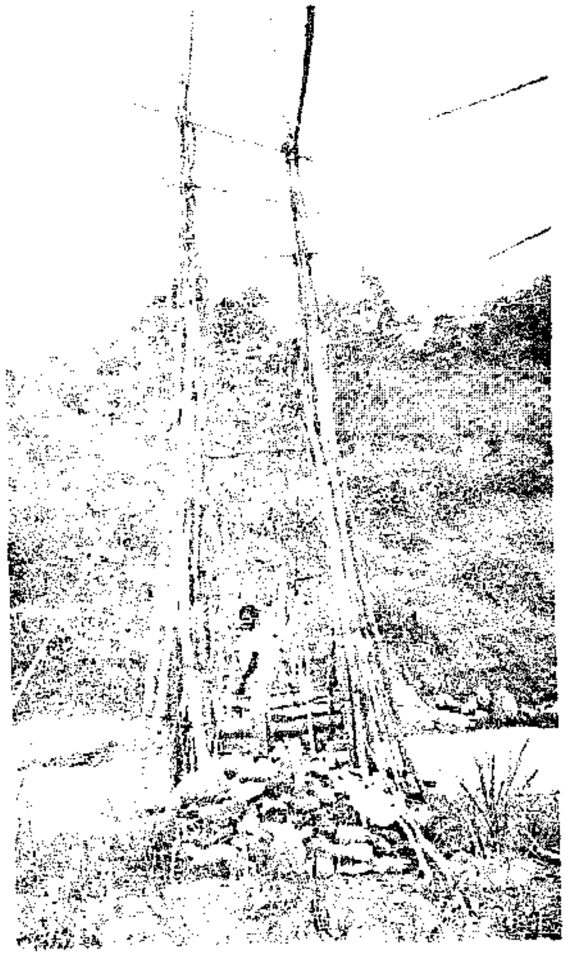
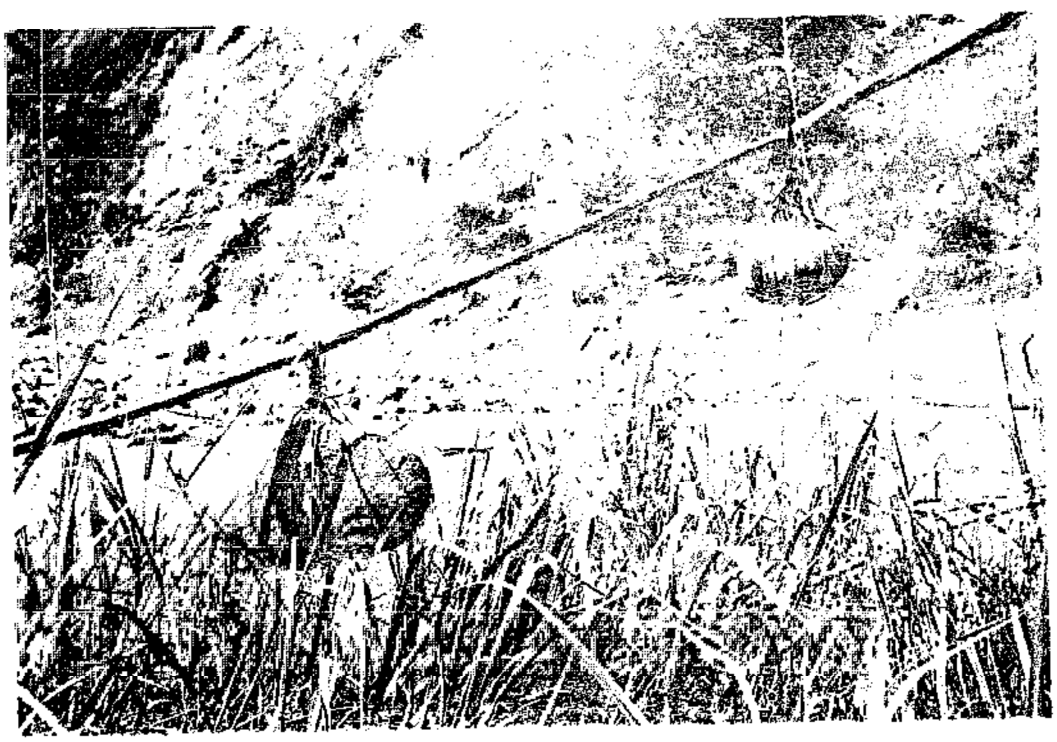


Fig. 14

Stones hung from a holdback cable to maintain tension to stabilize the bridge (Sukurum Bridge, Leron River, Morobe Province).



1.2 Types of Bridges

1.2.1 Girder (Fig. 15)

The simplest type of bridge is the girder type, a beam supported on both sides of a narrow river or stream. It may be just a thick log or two stretching across or a series of thinner poles lashed together. Some may have a handrail for balance.

1.2.2 Suspension (Fig. 16)

The most common bridge type for spanning rivers of up to 70 metres wide are the suspension bridges, usually made out of cane. Actually the technical name for this type of bridge is a suspended or catwalk cable bridge. It is generally a walkway suspended across the river from trees or constructed anchorages. The following bridges described in Section 3 are this type of suspension bridge: Kapolame, Nepirik, Olsobip, Iamdelmin, Athalmin, Tiaura, Tewa, and Bakeri.

1.2.3 Cantilever (Fig. 17)

If the bridge is not suspended over the river, it uses the cantilever principle in which a beam projects out over the water supported at the other end by an abutment, which acts as a fulcrum, and counterweighted by large stones or logs. Cantilever beams project from both banks and are extended by lashing on other wooden poles until they join over the middle usually forming an arch as in the Saimanda Bridge. (Section 3.1.7, Figure 93)

1.2.4 Combinations

Most often the cantilever and suspension principles are both used:

(1) cantilever bridge with suspended walkway (Fig. 18): A scaffold is built on each bank acting as the abutment for a cantilever projection over the river. A cane or vine walkway is suspended from the ends of these

projections. The Kobrenmin Bridge is a good example. (Section 3.2.2, Figures 108 and 109)

(2) suspended arch (Fig. 19): A cantilever arch bridge is given additional support by inclined support cables archored to nearby trees or constructed anchorages. Examples are the Kubib and Sau River Bridges. (Sections 3.1.3 and 3.1.5, Figures 59 and 76)

(3) suspension with cantilever walkway: There are two types:

(a) with constructed pylons (Fig. 20): This type looks most like Golden Gate variety. Pylons are constructed to support the spanning cable (usually because no trees are available). Holdback cables counterbalance the pulling of the spanning cables. The pylons also act as abutments for the cantilever walkway. Basically, the walkway is supported near the banks by the cantilever principle and at the middle by suspension. See the Sukurum and Gumbum Bridges. (Sections 3.3.1 and 3.3.2, Figures 132 and 143)

(b) with trees and constructed anchorages (Fig. 21): Anchorages are built to support spanning cables while abutments, either separate or part of the anchorage, support the cantilever part of the walkway. Inclined support cables from nearby trees are used. See the Pulumita and Kopeme Bridges. (Sections 3.1.1. and 3.1.4, Figures 42 and 69)

Fig. 15
Girder Bridge.
(photo by Geoff Smith)

1.3 Construction

1.3.1 Materials

The first and most important, and often the most time-consuming, step in constructing bridges is the gathering of the materials. It takes an average of one week to get the proper materials prepared. Long trips into the bush may be required, especially to get cane in areas where it is rare. Trees and saplings of the proper diameter must be found and cut to size. The right type of vines must also be found and cut at the correct time as some must be left a few days to lose their brittleness while others must be used quickly before they become brittle.

Thus, the bridge builders must have a thorough knowledge of the various construction materials. In many cases one or two older men are the experts and direct others in gathering materials and construction. But the importance of the materials is also reflected in language. For example, the Imbongu language, spoken in the Ialibu area of the Southern Highlands where many traditional bridges can be found, has commonly used names for at least 11 varieties of cane and vines. The English speaking layman would have difficulty distinguishing them and would certainly not have a word for each. Even botanists who were asked to identify samples of the vines could not do so without seeing the whole plant.

Specimens of these vines and cane (from the Kapolame Bridge, Section 3.1.2) were brought back to the University of Technology, identified by James B. Tende, and tested for tensile strength in the Civil Engineering Laboratory by John Kassman and Enok Poka. The results are given below. In the test, a machine is used to apply a pulling force on the specimen. The force is increased until the specimen breaks. The amount of force which causes the breakage is called the load of failure. It is measured in units called Newtons. (The results may not be completely reliable, however, because some of the specimens were old and strength decreases with age while others had defects.)

Tensile Test on Kapolame Bridge Materials			
name (Imbongu language)	Diameter	Description	Load of Failure
kelowa	18 mm	cane used for spanning & support cables	6000 N
kewaka	13 mm	thick, straight woody vine used for cables	3900 N
imi	18 mm	twisting light brown vine used for cables	5060 N
api	6 mm	vine used for suspenders	60.8 N
topona	5 mm	also used for reinforcement in baskets	188 N
kolgolo	7 mm	straight vine with rough bark, brown colour in baskets	245 N
glurembo	4 mm	outer white part of a vine (soft inner part removed), white colour in baskets	20.8 N
ametoka	9 mm	vine made up of several strands	184 N
ponapi	11 mm	bark covered straight vine	5600 N
upi	8 mm	curving, twisted vine with light brown bark	106 N
ponipi	7 mm	curving vine with U-shaped cross section	NA

The first seven listed are the preferred materials for bridge construction. The last four will be used only if the others are not available.

1.3.2 Construction methods

After materials are gathered and prepared, construction begins. It is usually a communal effort with from 5 to 50 men taking part. Construction time varies from one day to one week, depending on the size of the bridge and the number of men.

For a cantilever bridge, first the abutments are constructed by planting vertical posts in the ground and then lashing transverse posts to them. The cantilever beam poles are then planted diagonally in the ground resting on the transverse posts and counter-weighted by large stones, logs or earth. This is done on both sides of the river. The men work from both sides extending the projecting ends towards the centre of the river until they are joined. In some cases the walkway is constructed first and the handrails added later. In others handrails are the primary supporting members and a temporary walkway is used until the permanent one can be constructed.

For a suspension bridge, first the anchorages or pylons are constructed, if necessary. Then the first spanning cable must be taken across the river. This can be done by having a man swim across with it. Another method is to attach a thinner vine to a stick or stone and throw it across the river or to attach it to an [illegible] and shoot it across. The spanning cable is then tied [illegible] hin vine and pulled back across the river. Once the [illegible] link has been made, spanning cables are pulled bac[illegible] th[illegible], stretched and then tied in place.

The support cables for both types of bridge are [illegible] to branches in the trees by men climbing up and then [illegible] the other end down to be attached to bridge's spanning members.

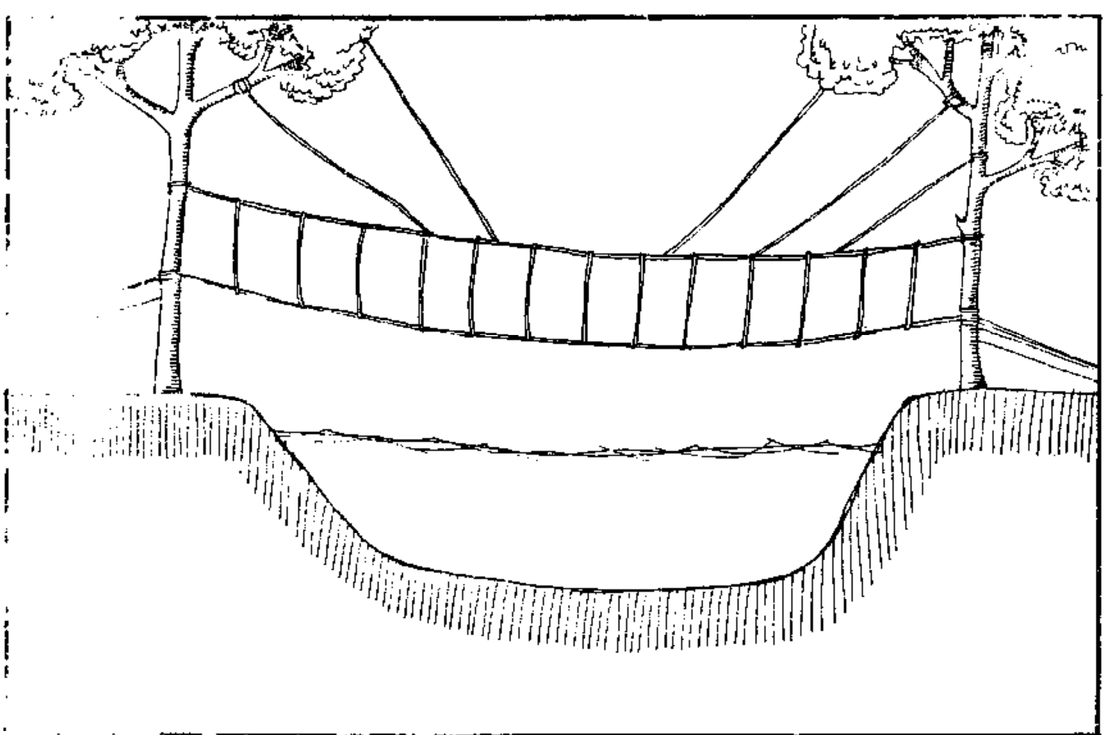


Fig. 16
Suspension (or suspended) bridge.

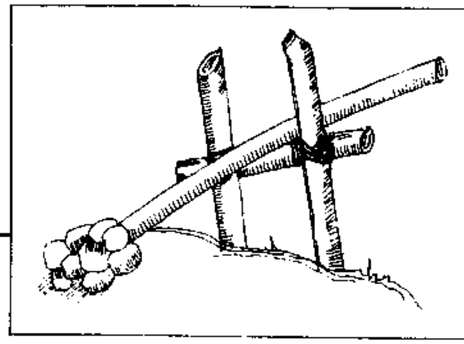
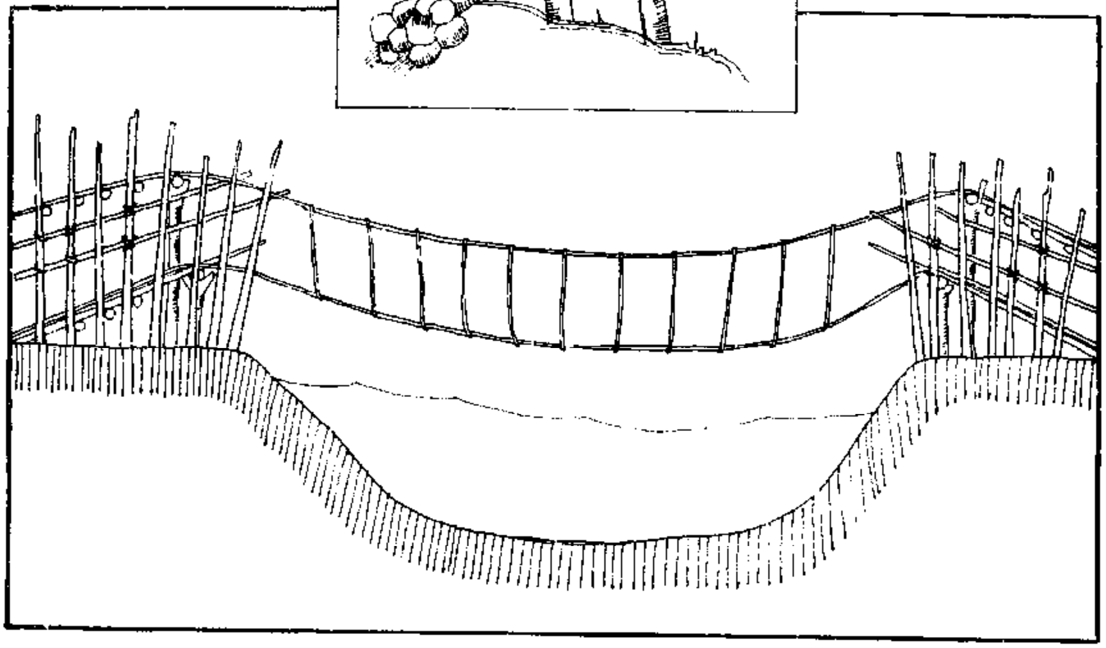


Fig. 17

The cantilever principle.

Fig. 18

Cantilever-suspended walkway combination.



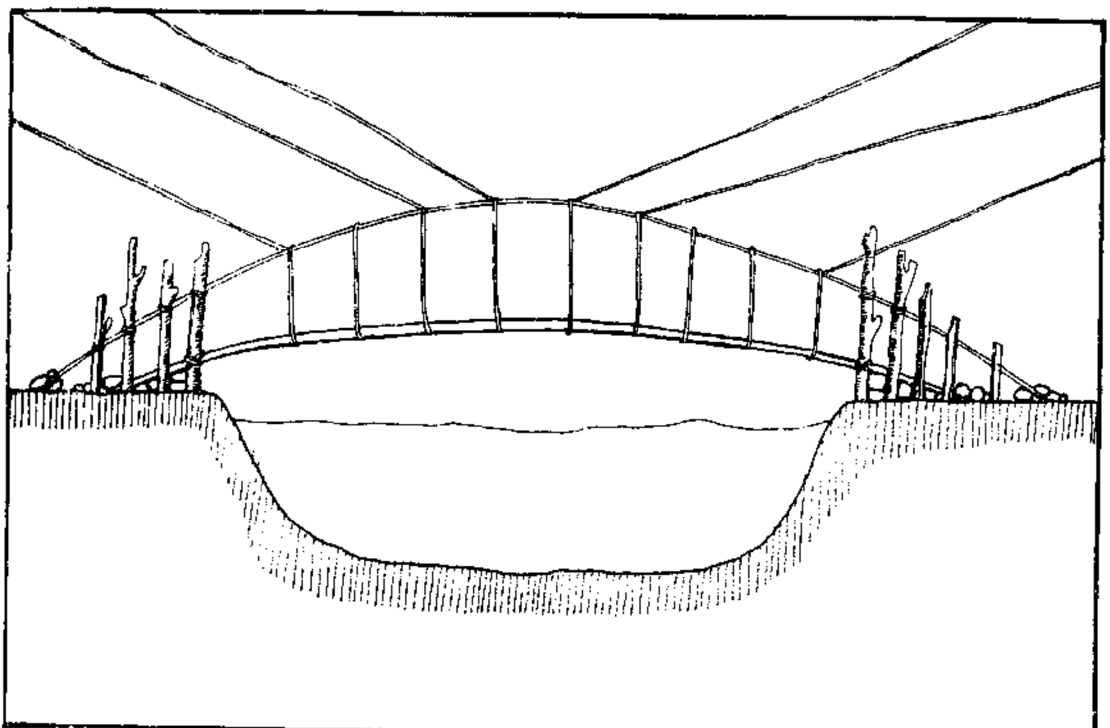


Fig. 19

Suspended cantilever arch.

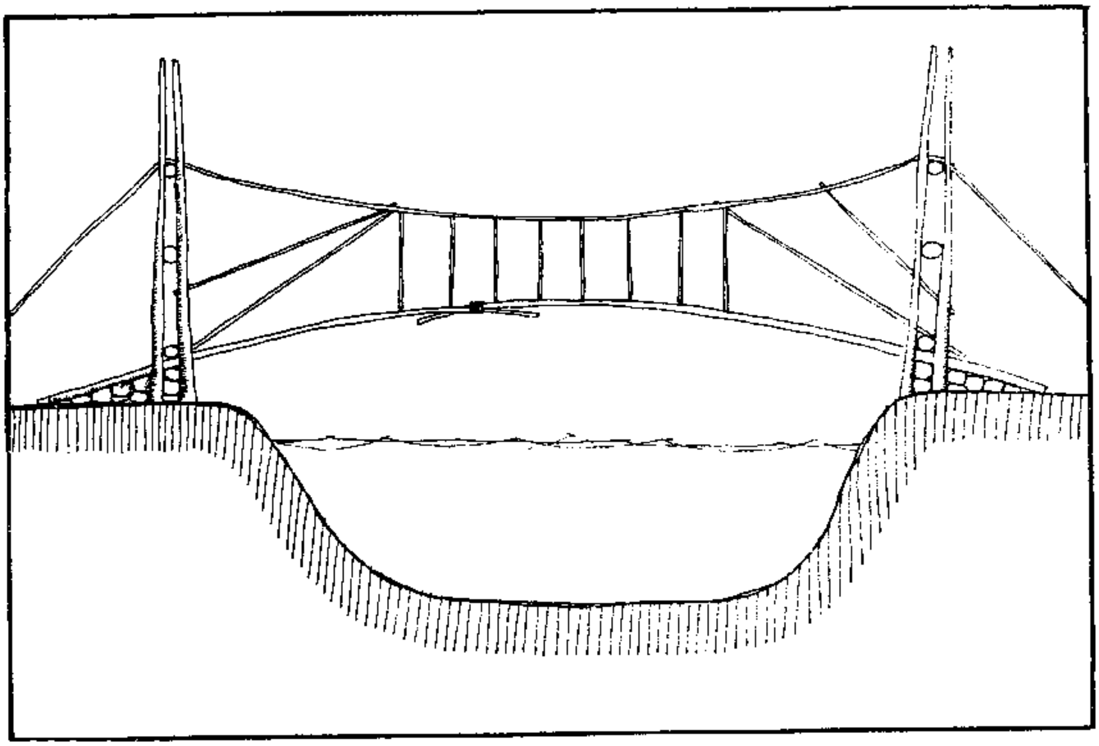


Fig. 20

Suspension-cantilever walkway combination, with piers.

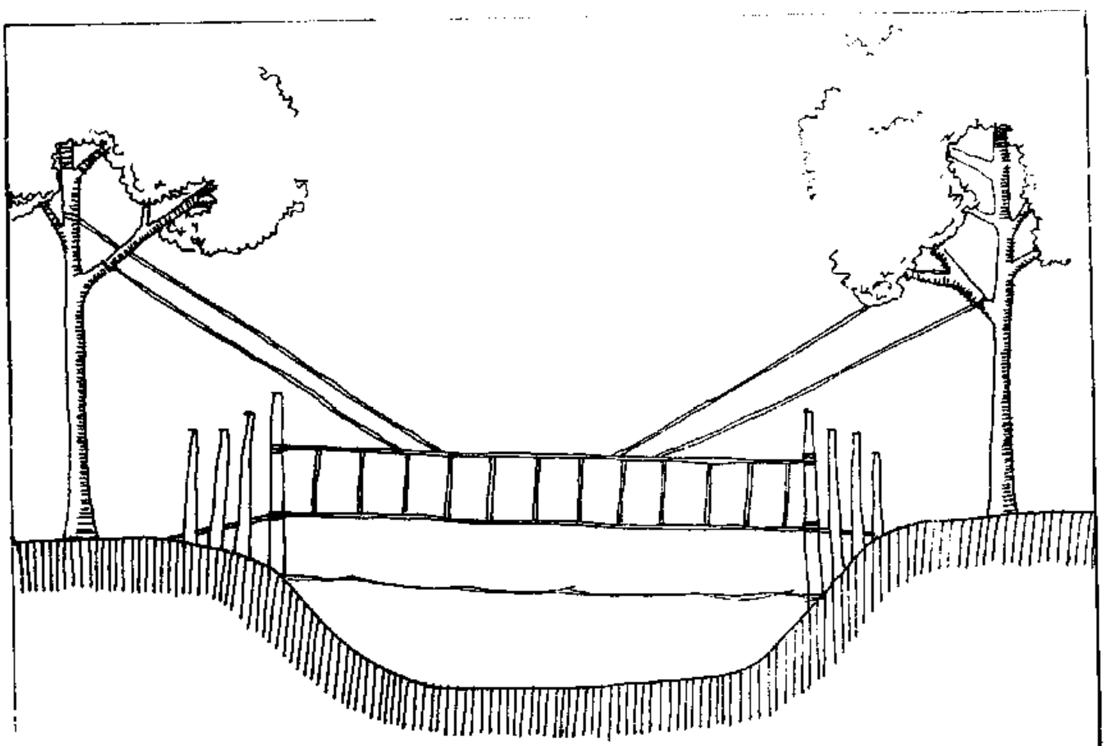


Fig. 21

Suspension-cantilever walkway combination, using trees and constructed anchorages and abutments.

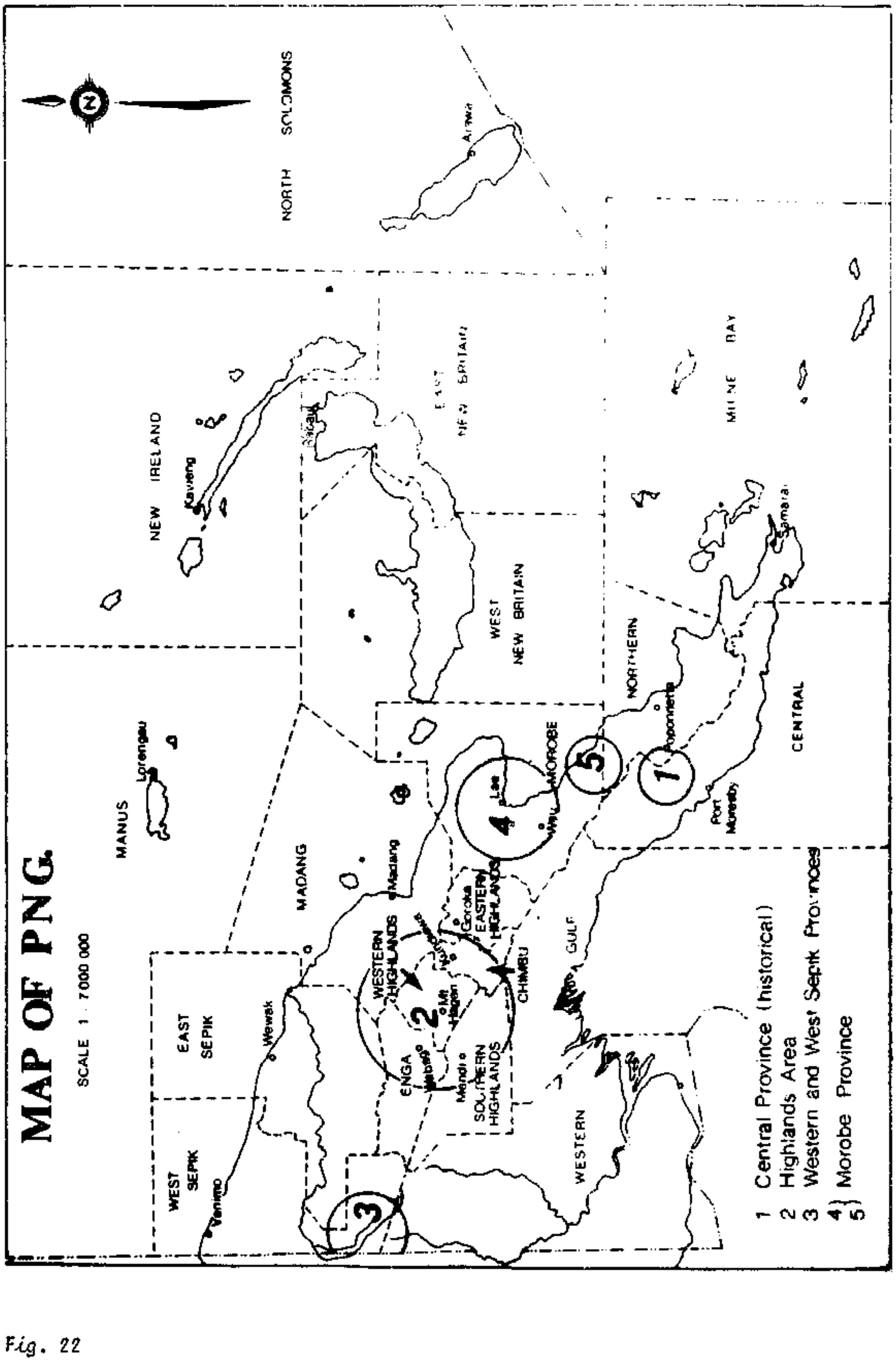


Fig. 22

Map showing areas where bridges discussed in this report are located.

Historical Background

The first published reports mentioning traditional bridges came from various administrators, explorers and missionaries around the turn of the century. Authors were mostly impressed and often surprised by the scale and workmanship of the bridges they saw. Their descriptions are often quite condescending in their astonishment that the people they considered so "primitive" had the technology to create such sophisticated structures. But the descriptions are revealing in what they tell us about the traditional technology before contact with outsiders.

2.1 Papua

The earliest references to bridges come from what was known as Papua or British New Guinea. In the Annual Report for 4 September, 1888 to 30 June, 1889, the administrator, Sir William Macgregor describes a bridge encountered on an expedition up the Vanapa River (now Central Province) in October, 1888:

> "Soon afterwards a European returned to report that the river was crossed by a fine suspension bridge, about a quarter of a mile above our camp. I went at once to see and examine this structure, which is well worth a detailed description, occurring in such a locality and built by such a primitive people as the inland natives are in this district. At the spot where the bridge stands the river is narrowed by a rocky point that encroaches on the left bank from a steep hill immediately adjoining; advantage has been taken of this in building. The bridge, which is thus only about 70 yards long, is chiefly supported by a large banyan tree, which grows on the rock on the left bank about 20 feet from the water's edge; it starts from this tree at an elevation of about 30 feet above the pool below, descends in mid-stream to about 12 or 15 feet from the water, and rises to about 20 feet on the right

bank, where it is suspended to a tree not sufficiently large or strong to receive the whole of this end of the bridge, and is therefore supplemented by a post put into the ground, and this again is strengthened by a cross-bar to the live tree, and fixed by stays extending backwards to trees behind. The material employed is rattan cane. Of these, fifteen are used to form supports, but as they have not all been long enough to cross the river, some of them have been joined by knotting. The floor of the bridge is formed of four of these canes, but as two appear to have been broken, the second pair have probably been laid down in effecting repairs. About 2 feet 6 inches from the floor there are two rattans on each side, and about 2 feet 3 inches above these again are three rattans on the lower, and four on the upper side. They are not plaited or twisted but are kept in position by split cane worked from the floor to the middle and top rattans, which serves the double purpose of connecting the several strands, and would probably prevent one from falling into the river should one stumble in crossing. A transverse section of the bridge would show it to be nearly V-shaped, but with the sides slightly rounded. The height of the V is about 5 feet, the width at the top about 3 feet 6 inches, and the distance of the middle strands from each other about 2 feet. The top strands are kept apart by a cross-stick, the ends of which are tied to the top of each strand. Suitable platform approaches have been built at the ends, and the whole structure is both strong and graceful. Five of our people crossed it at one time, and from all appearance it could have borne many more." (p. 38)

An illustration of the same bridge is found in a book by J.P. Thomson, British New Guinea, published in 1892 (reproduced here in Fig. 23).

Robert W. Williamson describes several bridges in two books about expeditions in mountainous areas of what are now the Central and Northern Provinces. In The Ways of the South Sea Savage published in 1914, the author includes a photograph (reproduced here in Fig. 24) with the caption: "A suspension bridge over the Angabunga River near Kuni village of Ido-Ido. Similar bridges are constructed by the Mafulu and, though very lightly made out of lawyer vine, they are quite strong and safe" (between pp 210 and 211). He describes the bridge as follows: "One day we took a walk down the river and inspected the suspension bridge across it. The river was here 150 ft or more across and the bridge, which was made of canes and rattan, was a remarkable piece of native work. It had rattan hand rails on each side and appeared to be perfectly easy and safe to cross" (p 183).

In an earlier book, The Mafalu: Mountain People of British New Guinea published in 1912, Williamson described the same bridge as follows:

> "I regret that I am unable to give a detailed description of Mafulu suspension bridges, but I think I am correct in saying that they are very similar to those of the Kuni people, one of whose bridges is described in the *Annual Report* for June, 1909, as being 150 feet long and 20 feet above water at the lowest part, and as being made of lawyer vine (I do not know whether this would be right for Mafulu), with flooring of pieces of stick supported on strips of bark, and as presenting a crazy appearance, which made the Governor's carriers afraid of crossing it, though it was in fact perfectly safe, and had very little movement, even in the middle." (pp 111-112)

The author goes on to describe the bamboo bridge constructed by the Mafulu:

> "This is a highly arched bridge of bamboo stems. The people take two long stems, and splice them together at their narrower ends, the total

length of the spliced pair being considerably greater than the width of the river to be bridged. They then place the spliced pair of bamboos across the river, with one end against a strong backing and support on one side of the river and the other end at the other side, where it will extend for some little distance beyond the river bank. This further end is then forcibly bent backward to the bank by a number of men working together, and is there fixed and backed. The bamboo stems then form a high arch over the river. They then fix another pair of stems in the same way, close to and parallel with the first one; and the double arch so formed is connected all the way across with short pieces of wood, tied firmly to the stems, so as to strengthen the bridge and form a footway, by which it can be crossed. They then generally add a hand rail on one side." (p 112)

A photograph of such a bridge (reproduced here in Fig. 25) appears in Papua or British New Guinea by J.H.P. Murray, published in 1912. Murray also describes a suspension bridge in the area:

"The track to the lower Aikora from the Government station at Ioma, on Tamata Creek a few miles above its junction with the Mambare, passes over two native bridges of simple but ingenious construction. A line of twisted vines, cut from the neighbouring scrub, forms what in an ordinary bridge would be the flooring, while about 4 feet above this and a little to the side is another line of vines which serves as a handrail. One line is attached to the other so as to prevent the two from swaying apart, and the whole is kept steady by guys, also of vine, attached to either bank. The bridge thus presents something of the appearance of a ladder placed from bank to bank and laid aslant. These bridges are rather terrifying in appearance, and the progress of one who crosses for the first time is apt to be somewhat deliberate, the irresistible temptation

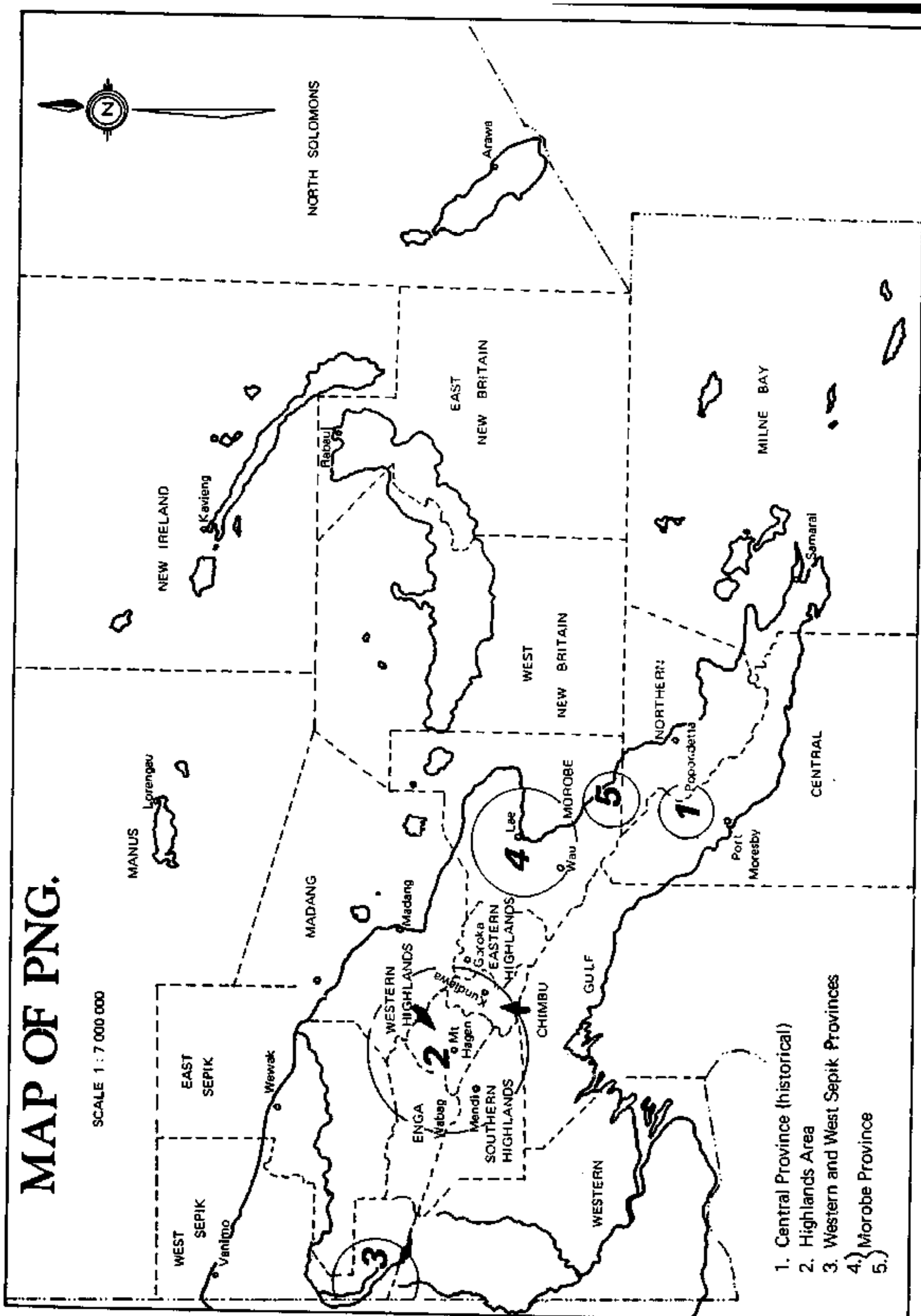


Fig. 22

Map showing areas where bridges discussed in this report are located.

being to clutch the top line with a grip which is only slowly relaxed. So long, however, as the bottom line is strong there is little danger, and some of the older hands merely rest their hand on the upper line and trip along with a nonchalance which, personally, I have never been able to attain." (p 32-3)

2.2 German New Guinea

While the British explorations were going on in Papua, similar explorations were taking place over the mountains in German New Guinea. One of the earliest was made by Leonhard Schultze in the Upper Sepik area for the purpose of establishing the border between German and Dutch New Guinea. In his report Forschungen im Innern der Insel Neuguinea published in 1914, he describes a 90 metre suspension suspension bridge over the Sepik as well as other bridges in what is now the Yapsei subdistrict. This bridge is shown in a photograph and drawings reproduced here in Figures 26, 27 and 28. Schultze describes the bridge as follows:

"The river, occasionally navigable by Papuan dug-out canoes up to around the 47th settlement though otherwise almost completely empty of human traffic, is up here the biggest obstacle to communication. We were amazed to see the masterly way in which the natives have surmounted this obstacle through their primitive construction. 400 metres downstream from the confluence of the Brücken River we saw the first bridge and near the wide bank about 1 km downstream and and 2½ km upstream from it, we saw two more stretched across the river in an equally elegant curve with a span of about 40 metres.

The bridges represent basically suspension types. Two strong suspension cables support the floor of the bridge from above, connected to it by suspenders. The bridge is supported on each bank by an anchorage.

The anchorage consists of supporting posts driven firmly into the ground in V- or X-shaped arrangements. Tied to them on either side are a suspension cable above and the floor of the bridge below. The supporting posts are connected by struts placed straight across and diagonally. These supporting posts continue without a break into the row of suspenders. Two well-rooted trees stand pillar-like at the sides. A crossbar presses the base of the floor of the bridge down to the ground and down to its abutment. A tree below the bank acts as a support butressing the floor by leaning diagonally forward from below.

The anchorage acts as a support in two senses: firstly in that it transfers the weight of the live load as long as it is near the anchorage, for the floor of the bridge directly to the lower parts of the supporting posts and from there to the ground. As soon as the load reaches the freefloating parts of the bridge beyond the anchorage, tensile forces become mobile which have an effect on the suspension cables, and through them are transferred to the upper ties of the anchorage.

The freefloating parts of the bridge consist of strong rattan which is stretched across in multiple parallel cables for the formation of the floor of the bridge" (p 69).

In Ivan Champion's expedition to the same area 20 years later, remains of the bridge described by Schultze were found. And in December, 1980, we inspected a similar bridge at what may be the same site (see the Atbalmin Bridge in Section 3.2, Figure 126).

In what is now the Morobe Province, R. Neuhaus described bridges over the Bulesom (now called Mongi) River and over the Waria River in his book Deutsch - Neu Guinea published in 1911:

"I saw my first real suspension bridge on the inland journey to the Hup area when we came to the mighty, roaring Bulesom. A large boulder in the middle of the river provided support for the lianas which were stretched from bank to bank and decked with roung logs 3 to 5 inches in diameter. There was even a really serviceable handrail provided. (photograph reproduced here in Fig. 29) The bridge depicted (reproduced here in Fig. 30) made of bamboo canes, which was also on the Bulesom River, had been washed away in a heavy downpour shortly before our arrival. However, the blacks had rebuilt the bridge in the shortest possible time. On the other side of the large midstream boulder is another identical bridge.

These two bridges are child's play in comparison with the big rattan suspension bridges which span the 60 to 80 metres wide bed of the raging Waria River in a single span (photo reproduced here in Fig. 31). Figure 32 depicts the left bank anchorage of this bridge. Rattan ropes as thick as your arm are wound around thick well-rooted trees and ropes extend from the middle of the bridge to the tops of trees (not visible against the white sky in the photograph). Ropes had even been stretched horizontally to limit the sideways sway of the bridge. In Figure 32 you can see the skilful ramp-approach of the bridge. The actual floor of the bridge consists of a fourfold rattan rope, on which you have to balance, and a handrail of two to three rattan ropes to the right and left" (p 245).

Similar bridges can still be found today across the Waria. See description of the Tiaura, Tewa and Bakeri bridges in Section 3.3.

Some old unpublished photographs of bridges in the Morobe Province have been provided by Rev. Karl Holzknecht. They were taken in the 1920's after Australia had taken over from the Germans (see Figures 33, 34, and 35).

A much later photograph of a suspension bridge comes from the German anthropologist H. Fischer in Watut, pub-lished in 1963 (Fig. 36).

2.3 Border and Highlands Areas

A description of suspension bridges in what is now the western part of Papua New Guinea near the Irian Jaya border is given by Ivan F. Champion in his book Across New Guinea from the Fly to the Sepik, published in 1932 (see Figures 37 and 38):

> "A single length of lawyer cane, an inch in diameter, formed the footway of the bridge. It was securely tied at each end to strong trees; a scaffolding of thick saplings lashed together formed supports for the two handrails, one on each side about 4 feet above the footway. They were braced by cross-pieces of wood. Running down from the handrails to the footway were small ropes of rattan forming an enclosed network. This is the general outline of a New Guinean suspension bridge" (pp 220-1).

The Highlands was the last area of the country to be opened up by explorers. One of the references to bridges is found in The Land that Time Forgot by Michael J. Leahy and Maurice Crain (see Fig. 39):

> "We crossed the Gauil by the best native bridge I have ever seen, a combination of the cantilever and suspension types of construction. The two end sections were anchored securely to the banks and the centre section was suspended by vines to pylons on either side. It was as effective a use as could have been made of the materials at hand" (pp 221-2).

Similar bridges can still be found today in the Southern and Western Highlands (see the Kopeme Bridge, Part 3.1.4, Figure 69).

Another author, Alfred A. Vogel, gives his impressions of bridge construction over the Jimi River, in the Western Highlands (see Fig. 40):

"The suspension bridge was very interesting and also very similar to the suspension bridge of many other savage peoples. Apart from the actual "carriage-way," which was composed of branches about eighteen inches long placed close together, the whole construction consisted entirely of lianas and sticks of bamboo, ingeniously plaited together, and had the abutments several yards higher up, each in a giant tree which was reached by a plaited rope ladder. The lianas which supported the whole construction were fastened high up in the tops of the trees. When the Pygmies, who cannot swim, wish to build such a bridge, their first task is to get a man with a liana over to the other side. This is how they do it.

A liana of sufficient length is fastened to a branch that juts out over the water from a tall tree at a place where there is a similarly tall tree on the other side. The lower branches are then cut off so that the liana, to the end of which a man is fastened, can swing freely and straight out over the water. The living pendulum is then set in motion and swung until the man is rising so high as to be able to get hold of a branch in the opposite tree with either his hands or a hooked stick. That achieved, the initial link is made and the actual bridge-building can begin. The finished bridge will creak and sway most horribly, but being so elastic it will support even people with heavy burdens following closely one behind the other. All the same, you scarcely feel heroic when you first embark upon such a bridge." (p.89)

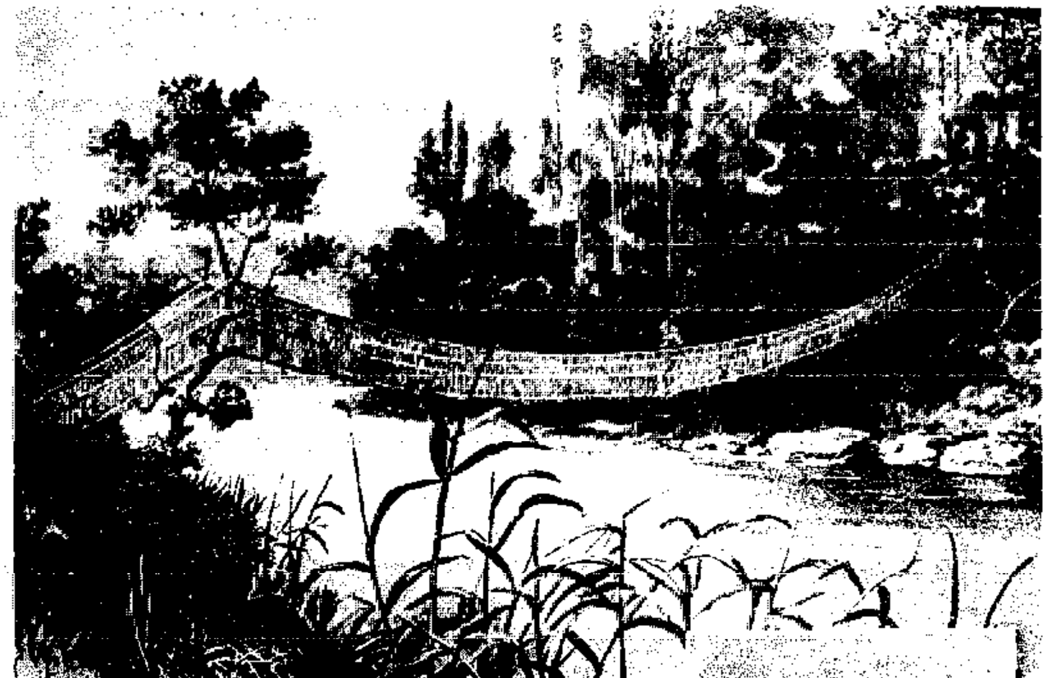


Fig. 23

Bridge over the Vanapa River (Thomson 1892).

Fig. 24

Bridge over the Angabunga (St. Joseph) River near Kuni village of Ido Ido (Williamson 1914)

Fig. 25

Bridge, Mafulu District (Murray 1912)

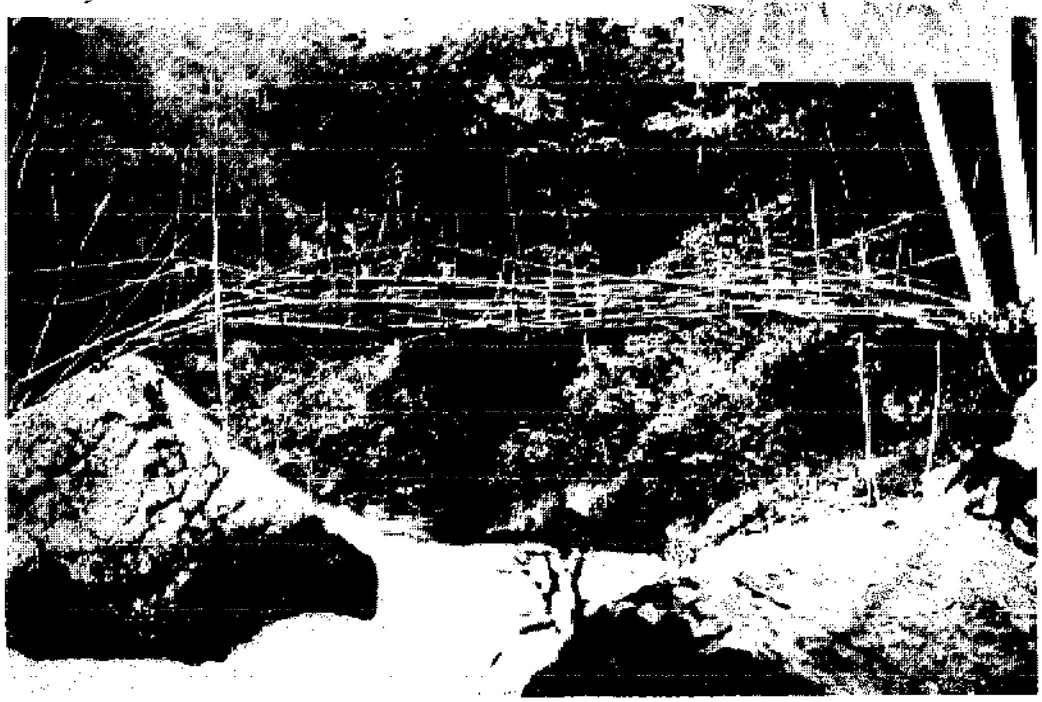
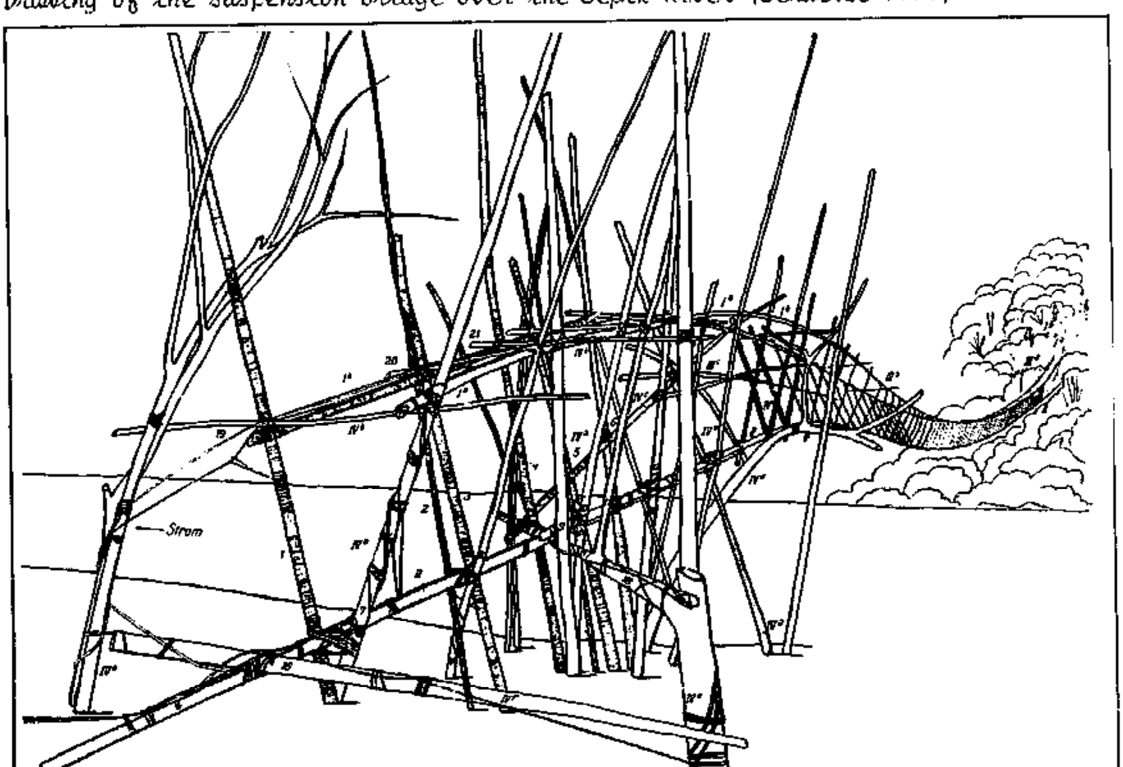


Fig. 26
Suspension bridge over the Sepik River (Schultze 1914).

Fig. 27
Drawing of the suspension bridge over the Sepik River (Schultze 1914)



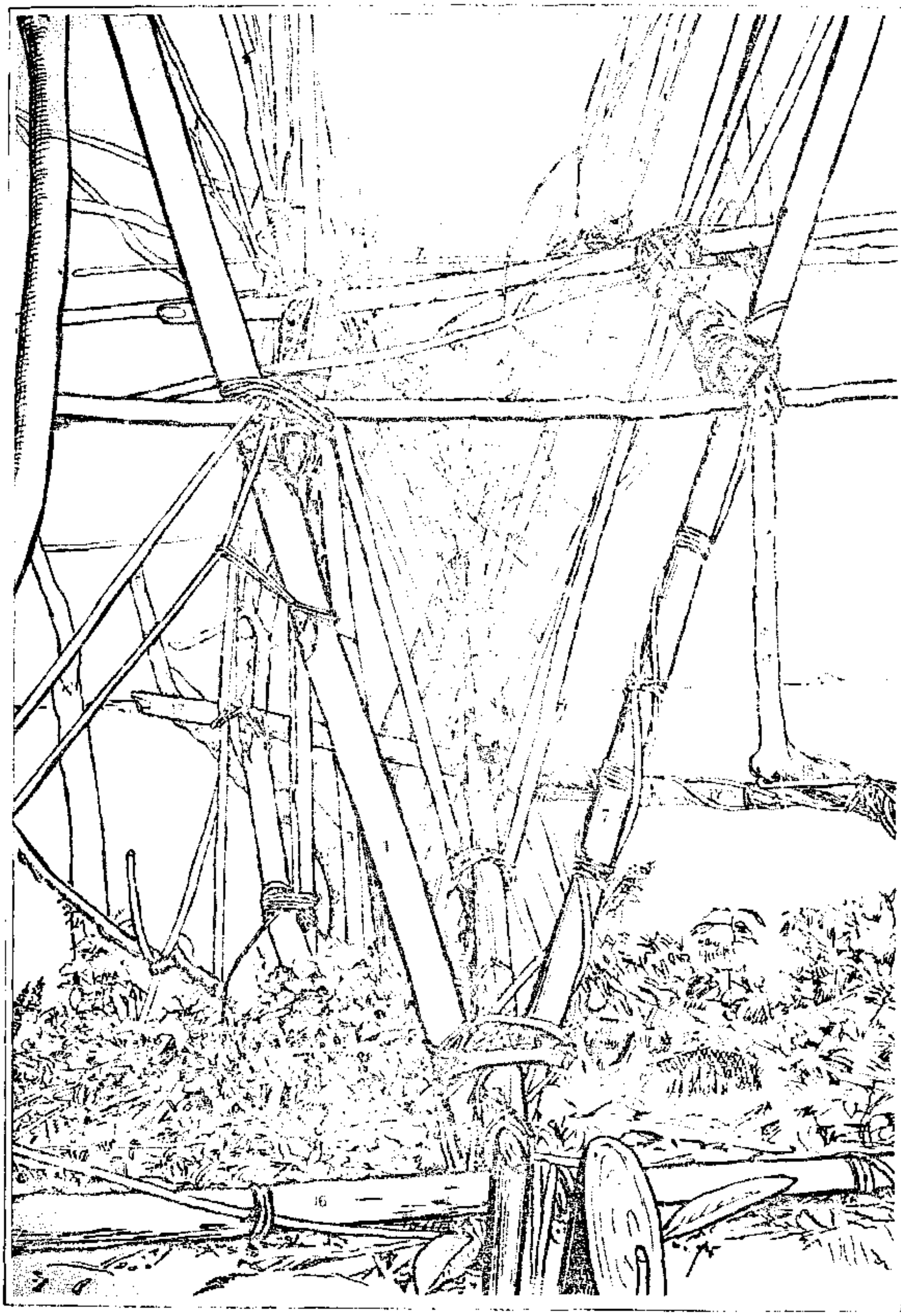


Fig. 28

Drawing of the end view of the anchorage of the bridge over the Sepik River (Schultze 1914).

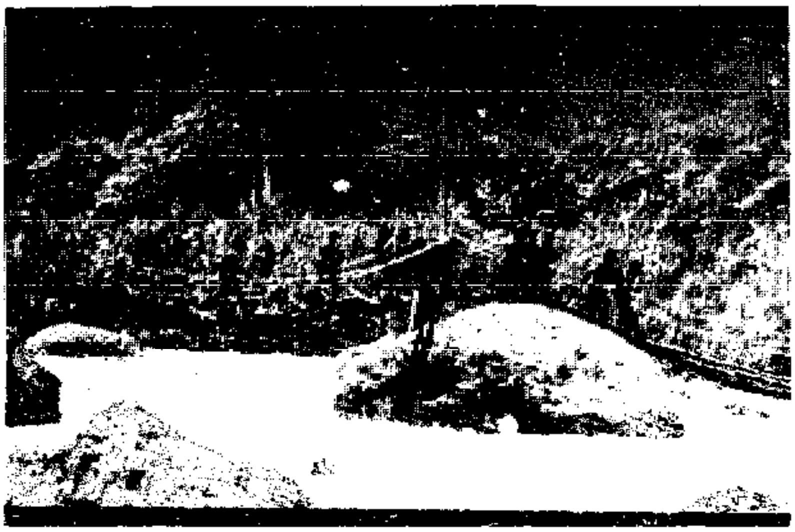


Fig. 29

Bridge over the Bulesom (Mongi) River (Neuhauss 1911)

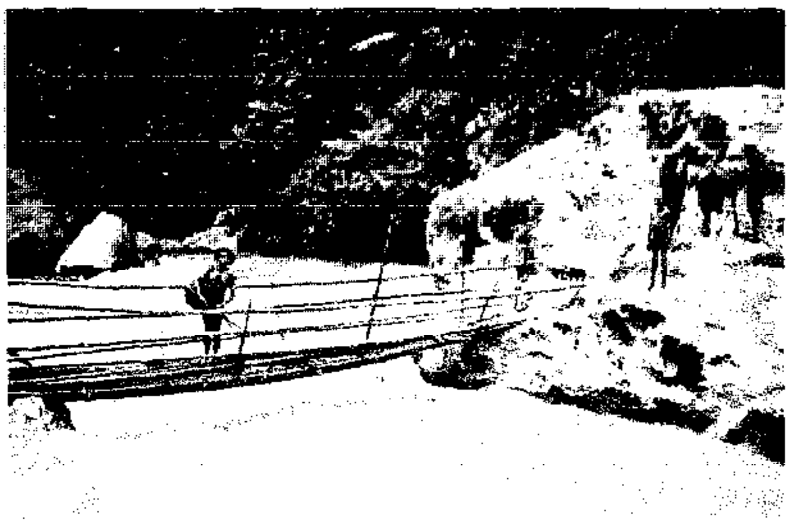


Fig. 30

Bamboo bridge over the Bulesom (Mongi) River (Neuhauss 1911).

Fig. 31

Bridge over the Waria River (Neuhauss 1911).

Fig. 32

Anchorage and approach of the bridge over the Waria River (Neuhauss 1911).

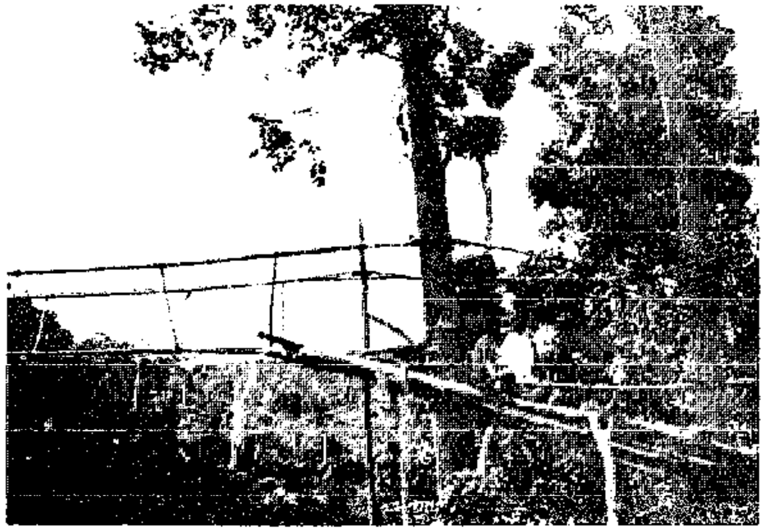


Fig. 33

Bridge-like path over the swamp near Lae (probably at Labu).

Fig. 34

Suspension bridge over the Adler (Busu) River

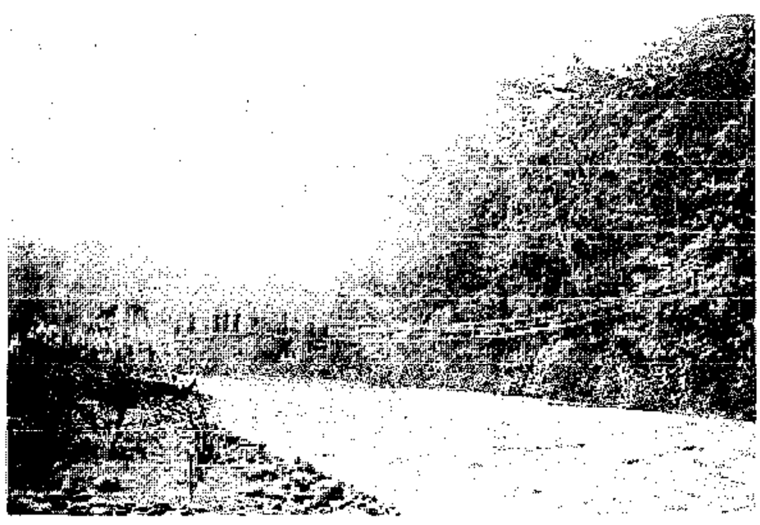


Fig. 35

Suspension bridge over the Adler (Busu) River, near Musom (pictured: Rev Gottfried Schmutterer).

Fig. 36

Suspension bridge over the Watut River (Fischer 1963).

Fig. 37

Suspension bridge, Western New Guinea (Champion 1932).

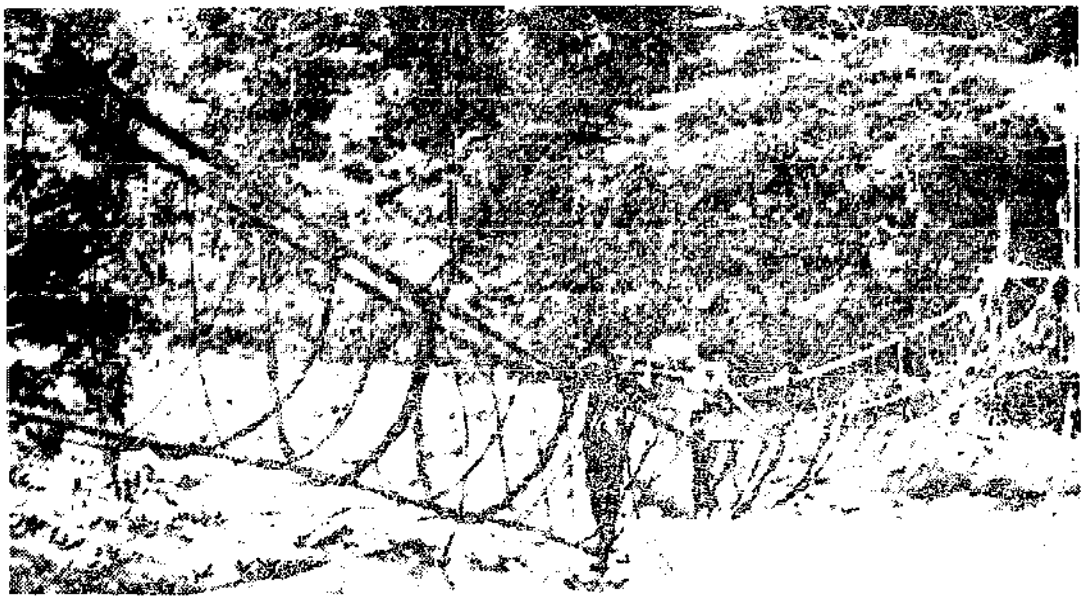


Fig. 38

Suspen[illegible],
Western [illegible]
(Cham[illegible])

Bridge over the Jimi River (Vogel 1955).

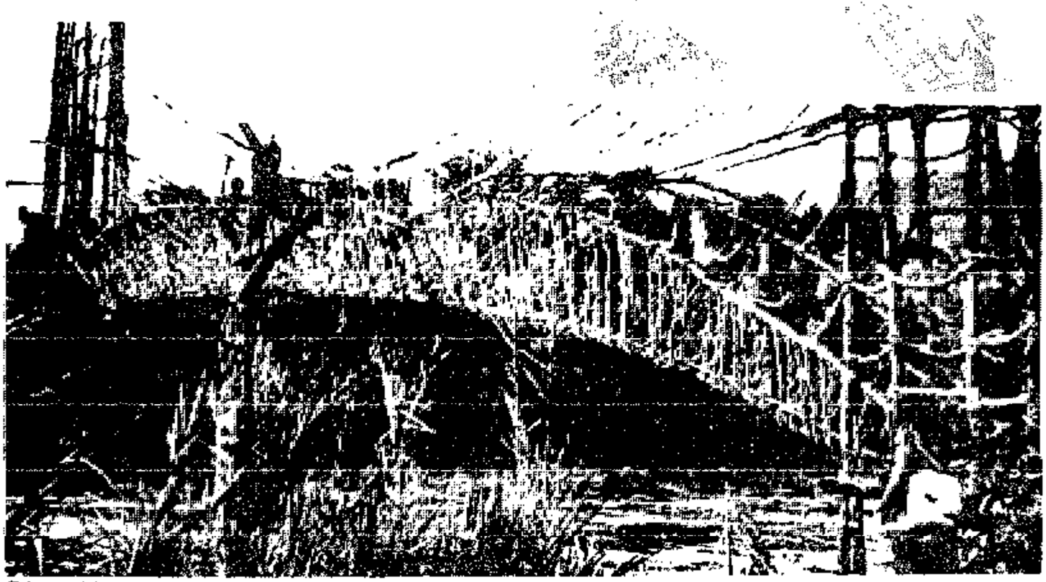


Fig. 40
Bridge over [illegible] River
(Leahy and [illegible]).

Descriptions of Individual Bridges

In this section 17 of the bridges inspected as part of the traditional technology research project are described by giving data in outline form and photographs. The bridges are divided into three main geographical areas: Highlands, Western and West Sepik Provinces (near the Irian Jaya border), and Morobe Province.

3.1 Highlands

Although the Highlands is one of the last major areas of the country to be contacted by the outside world, it is an area where traditionally constructed bridges are rapidly disappearing. This is mainly because of the Highlands Highway and a multitude of feeder roads which have been constructed throughout the area. Even where motor vehicle roads have not been built there is relatively easy access to imported materials such as wire cable. (See Section 4.) However, many fine examples of traditional bridges are still in existence, some in remote areas but others quite close to highways.

3.1.1

Name:	Pulumita Bridge (Figures 42 - 52)
River:	Iaro
Location:	Ialibu District, Southern Highlands Province; ½ hour walk from Muli.
Type:	cantilever - suspension combination with constructed anchorages
Materials:	wood (for anchorages, abutments, and walkway), vines and bark (for lashing components together), cane (for cables), and stones (for counterweights). Names of types of wood used in Kewa language: pai, mo, gili (a really strong wood) and muni (special timber for deck).

Dimensions:

total length:	27.5 m
clear span:	21.7 m
midspan height above water:	3.7 m
width of walkway:	.70 m
distance between handrails:	.80 m
handrail to walkway:	1.0 m

Construction details:

constructed by: people of Kada and Pulumita village

number of men: two men doing most of the walkway construction, others helping with cables.

construction time: 3-4 weeks to gather materials
1 day to construct

method:

1) Anchorages and abutments are constructed on both sides.
2) Walkway construction is started on abutments.
3) Spanning cables are tied on one side of the river and a man swims across the river carrying the other ends to be tied on the other side.
4) Two men, one on each side, work on extending the walkway and at the same time supporting it with suspenders from the spanning cable.
5) Last, the suspended cables from the trees are attached.

lifespan: one year (broken parts replaced)

Date of inspection: 6 April, 1980

Additional Information: A wire cable was installed in December 1979

3.1.2

Name: Kapolame Bridge (Figures 53 - 58)

River: Kaugel

Location: Ialibu District, Southern Highlands Province;

2 km down Tea Plantation Road which turns off the Highlands Highway south of the Kaugel River highway bridge, then 40 minutes walk

Type: suspension (with constructed anchorages)

Materials: wood (for anchorages and walkway), cane and vines (for cables and suspenders). See Section 1.4.1 for description of types of cane and vines in the Imbongu language.
Names of wood: miloko (for walkway and cross beams) and karili and kaungo

Dimensions:

total length:	36.4 m
clean span:	32.0 m
midspan height above water:	2.4 m
width of walkway:	.20 m
distance between handrails:	.56 m
handrail to walkway:	1.04 m
height of south anchorage:	3.32 m
diameter of posts:	.12 m

Constructed by: people of Kapolame and Kumunge village

Lifespan: 6 months

Date of Inspection: 8 April, 1980

Additional Information: now reinforced with wire

3.1.3

Name: Kubib Bridge (Figures 59-68)

River: Mendi

Location: Mendi District, Southern Highlands Province; just below Mendi-Bela road, 12 km from Mendi town, on the track from Was to Segip.

Type: suspended cantilever arch; two spanning arches make up the handrails, given additional support by cables suspended from trees and an anchorage, walkway suspended from handrails

Materials: wood (in Mendi language, wol for the handrails, nap which is casuarina for the walkway); vines (topen and omap) for suspended cables; bark of tree (won) for tying components together and suspenders; also large stones for counterweights

Dimensions:

total length:	20.9 m
clear span:	19.1 m
midspan height above water:	4.65 m
width of walkway:	.20 m
distance between handrails:	.80 m
handrail to walkway:	1.0 m
diameter of handrails:	.15 m

Construction details:

constructed by: people of the Surup clan of Was village with some help from people of Segip village

date: October, 1979

time: 4 days to get materials, 2 days construction

lifespan: 2-3 years

methods:
1) Abutments are constructed.
2) Cables are suspended from trees.
3) Handrails are put in place.
4) Large flat stones are used a counter-weights for the handrails.
5) The suspended cables are attached to the handrails.
6) Suspenders are attached to the handrails for the walkway. A temporary walkway is made to allow this construction to take place.
7) The permanent walkway, a piece of planed casuarina timber, is put into place.
8) Additional suspension cables are tied on and vertical posts are planted on both sides of the abutments to keep the handrails from moving apart.

Date of Inspection: 7 April, 1980

3.1.4

Name:	Kopeme Bridge (Figures 69 - 75)
River:	Kaugel
Location:	Tambul District, Kerepia subdistrict, Western Highlands Province, ½ hour drive south of Tambul on the Tambul-Ialibu road, ½ hour walk from the road
Type:	cantilever - suspension combination
Materials:	timber, vines, one strand of green cane (brought up from Morobe Province by truck)

Dimensions:

total length:	21.5 m
clear span:	19.0 m
midspan height about water:	4.6 m
width of walkway:	.14 m
distance between handrails:	1.0 m
handrail to walkway	1.4 m

Construction details:

constructed by:	people of Kopeme village
number of men:	20 to 50
time:	one month to slowly gather materials, 2 days to build
lifespan:	Some parts last only a month and must be replaced (e.g. some vines) Others last for more than a generation (e.g. the large vertical posts of the abutment).

Date of inspection:	9 April, 1980
Additional Information:	This bridge site is a good example of one which has been used for generations. No one in the village could remember a time when there was not a bridge there.

3.1.5

Name: Sau River Bridge (Figures 76 - 82)

River: Sau

Location: just below Kompiam station, Enga Province, on the path to Pakaliyam School

Type: suspended cantilever arch

Materials: wood (type used is called lokaiya in Enga language), and cane (kiowa) purchased from Maitumanda

Dimensions:

total length:	24.7	m
clear span:	22.6	m
midspan height above water:	7.8	m
distance between handrails:	.9	m

Construction details:

constructed by: people of Yawang and Malipin villages

date: August, 1980

number of men: 50

time: one day to prepare materials, 2 days to build

lifespan: 3 months

methods: The cantilever arch structure is built first. After it has been completed the suspended cables are added for additional support.

Date of inspection: 1 October, 1980

3.1.6

Name: Nepirik Bridge (Figures 83 - 91)

River: Lai

Location: Kompiam District, Enga Province, 2 hour drive on terrible road to Mamanda, 55

	minute walk down to bridge on track from Baiyer River to Kompiam (the Lai River is the border between Western Highlands and Enga)
Type:	suspension
Materials:	wood (landam) and cane (kiowa)

Dimensions:

total length:	42.5 m
clear span:	41.8 m
midspan height above water:	9.3 m
maximum height above water:	10.1 m
distance between handrails:	1.2 m

Construction details:

constructed by:	Lagakin line of Mamanda village
number of men:	7 (names: Ariap, Hia, Koi, Tokowa, Pama, Allan, and Win)
date:	September, 1980
time:	2 weeks to collect materials, e.g. the cane from Legemas near the Sau River); 1 week to build (camping out at the site)
lifespan:	3 months
other information:	To get the cane across the river for the spanning cables, a thin vine is tied to a stick and thrown across to a man on the opposite side. This vine is then attached to the cane which is pulled across.

Date of inspection:	2 October, 1980

3.1.7

Name:	Saimanda Bridge (Figures 92 - 100)
River:	Lagaip
Location:	Lagaip District, Enga Province; 10 km from Laiagam station on the Pogera road, just off the road
Type:	cantilever arch

Materials: wood (mostly casuarina), vines, and stones

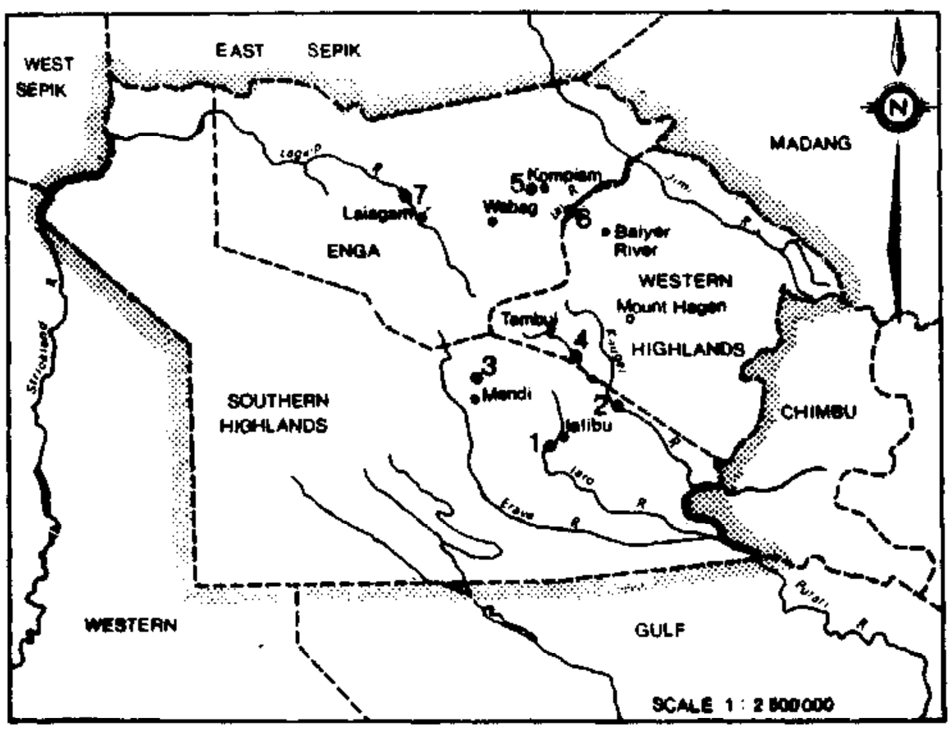
Dimensions:

total length:	25.0 m
clear span:	22.3 m
midspan height above water:	3.0 m
width of walkway:	.6 m
distance between handrails:	1.1 m
diameter of handrails:	.15 - .18 m

Construction details:

constructed by:	people of Saimanda village
number of men:	10, five on each side
time:	3 days
lifespan:	4-6 years unless washed away by floods

Date of inspection: 7 April, 1979



SOUTHERN HIGHLANDS, WESTERN HIGHLANDS AND ENGA PROVINCES

1	Pulumita Bridge	5	Sau River Bridge
2	Kapolame Bridge	6	Nepirik Bridge
3	Kubib Bridge	7	Saimanda Bridge
4	Kopeme Bridge		

Fig. 41

Map of the Highlands provinces showing bridge sites.

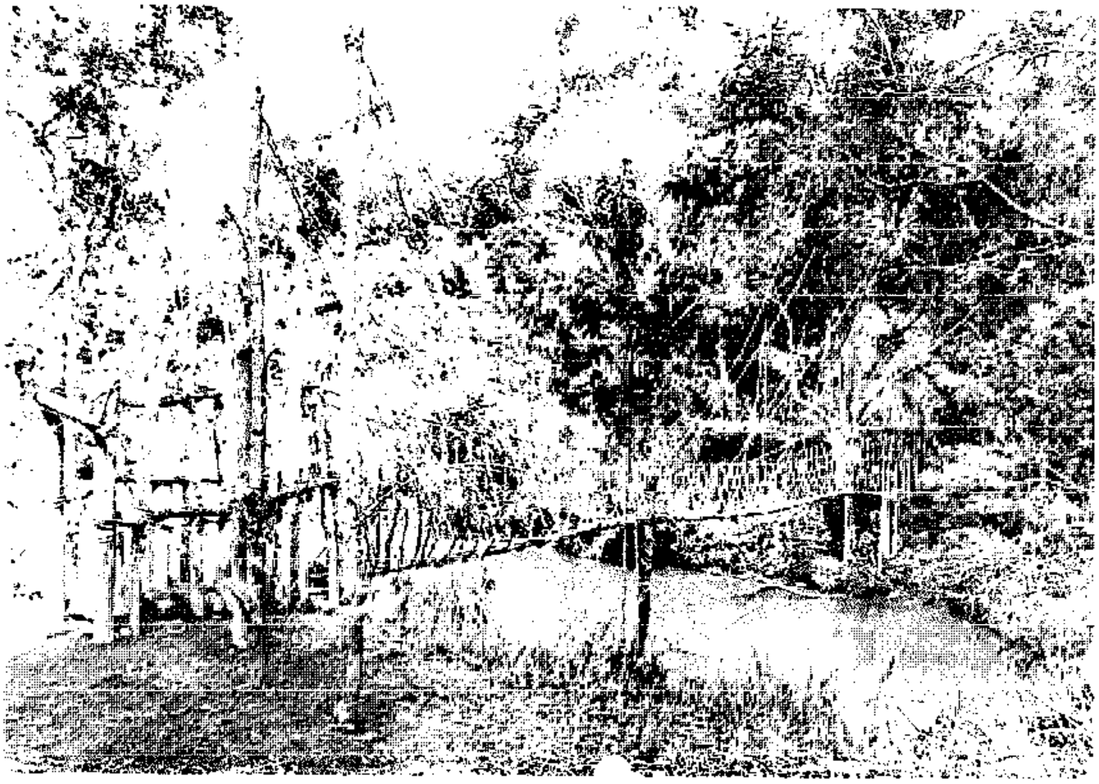


Fig. 42

Pulumita Bridge (from the south bank of The Iaro River).

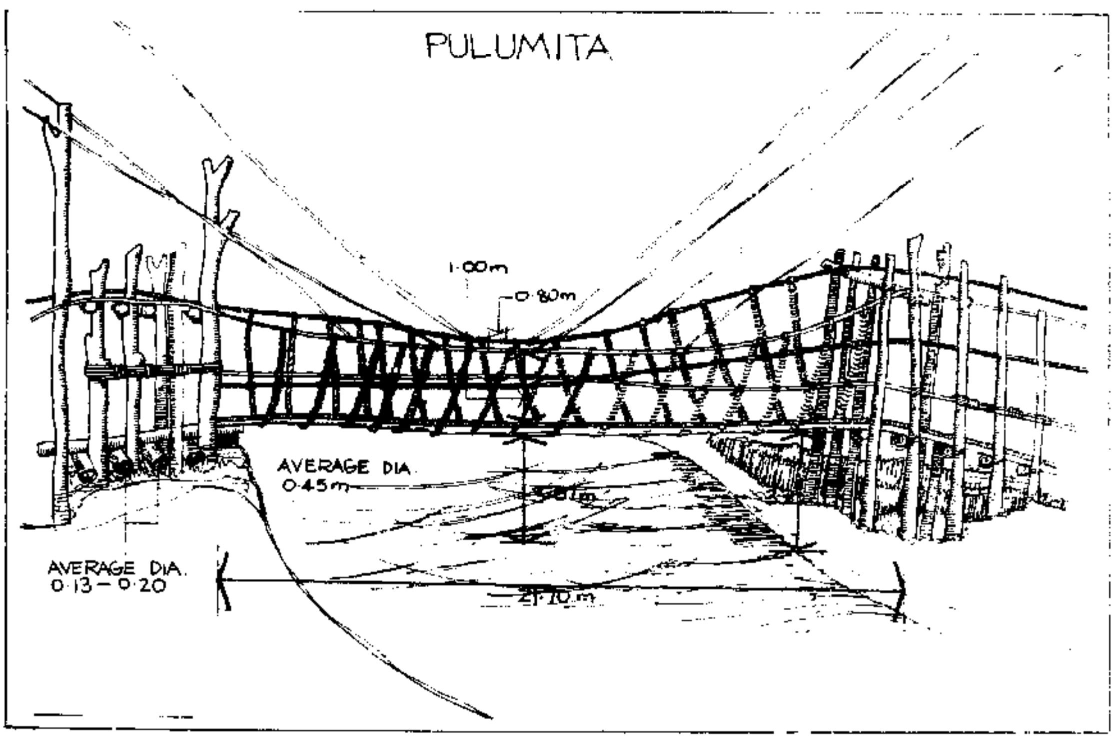


Fig. 43

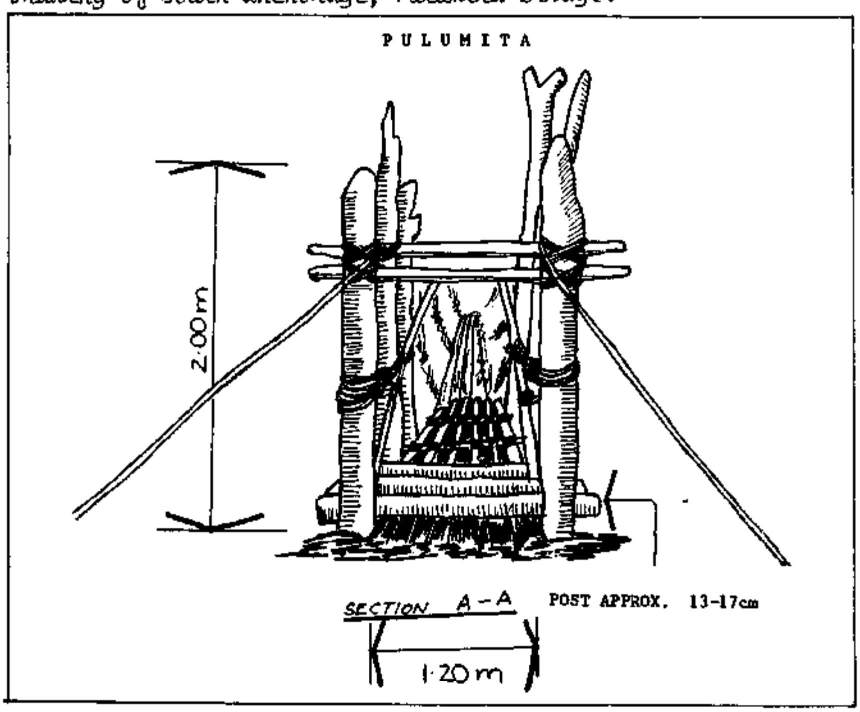
Drawing of Pulumita Bridge

Fig. 44

South anchorage and abutment, Pulumita Bridge.

Fig. 45

Drawing of south anchorage, Pulumita Bridge.



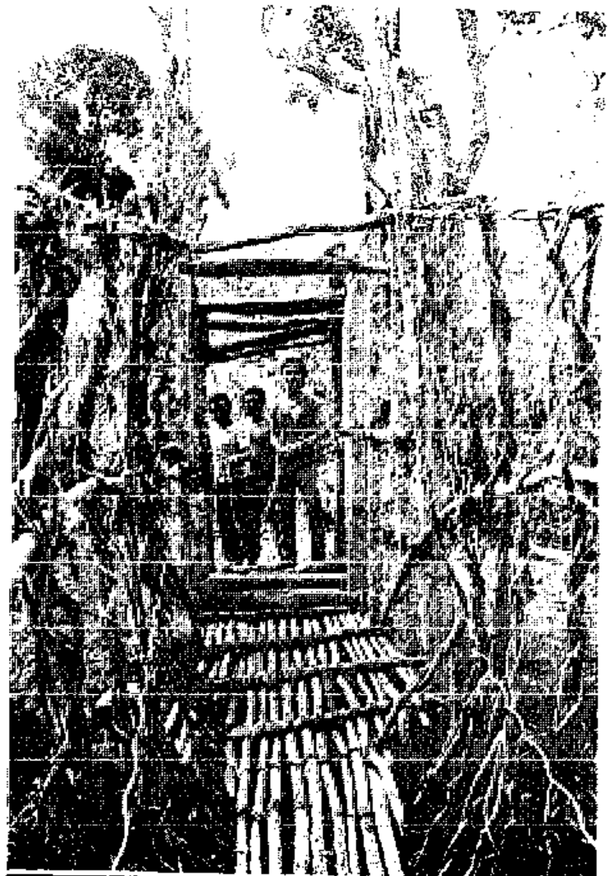


Fig. 46

South abutment viewed from the north. Note logs used as counterweights. (Pictured: James Tende, Guli Peke, Siang Lee).

Fig. 47

Abutment platform (detail), Pulumita Bridge.

Fig. 48

Another view of Pulumita Bridge.

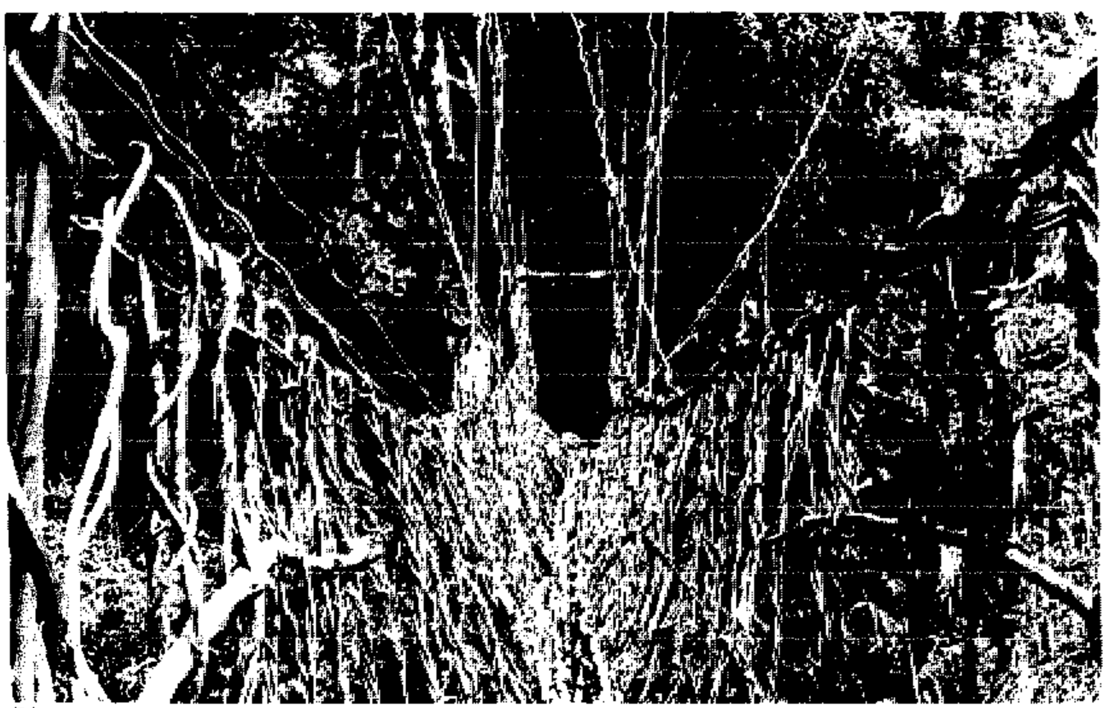


Fig. 49

Pole walkway (facing north) with vine spanning cables and suspenders, Pulumita Bridge. A recently added steel cable can be seen in the upper left hand corner.

Fig. 50

North abutment, Pulumita Bridge.

Fig. 51

Abutment detail showing vine lashing, Pulumita Bridge.

Fig. 52

The engineers of the Pulumita Bridge.

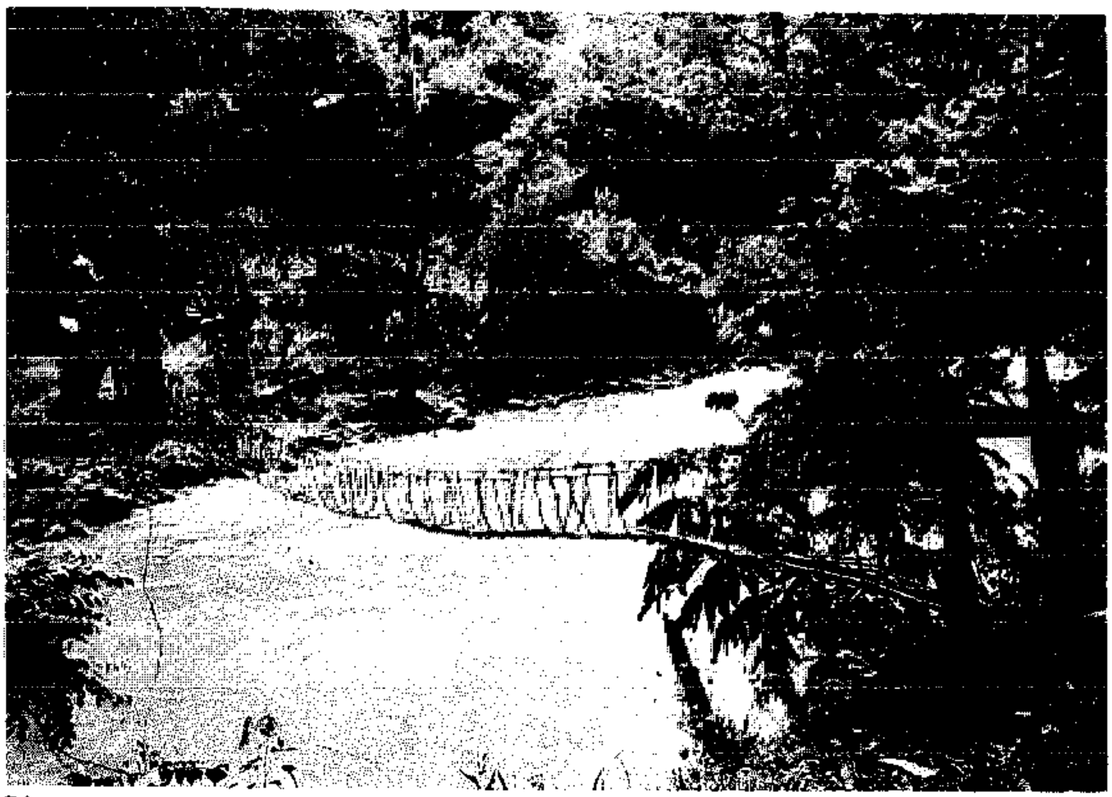


Fig. 53

Kapolame Bridge (from the south bank of the Kaugel River).

Fig. 54

Kapolame Bridge (from the south bank. Note the suspended cables.)

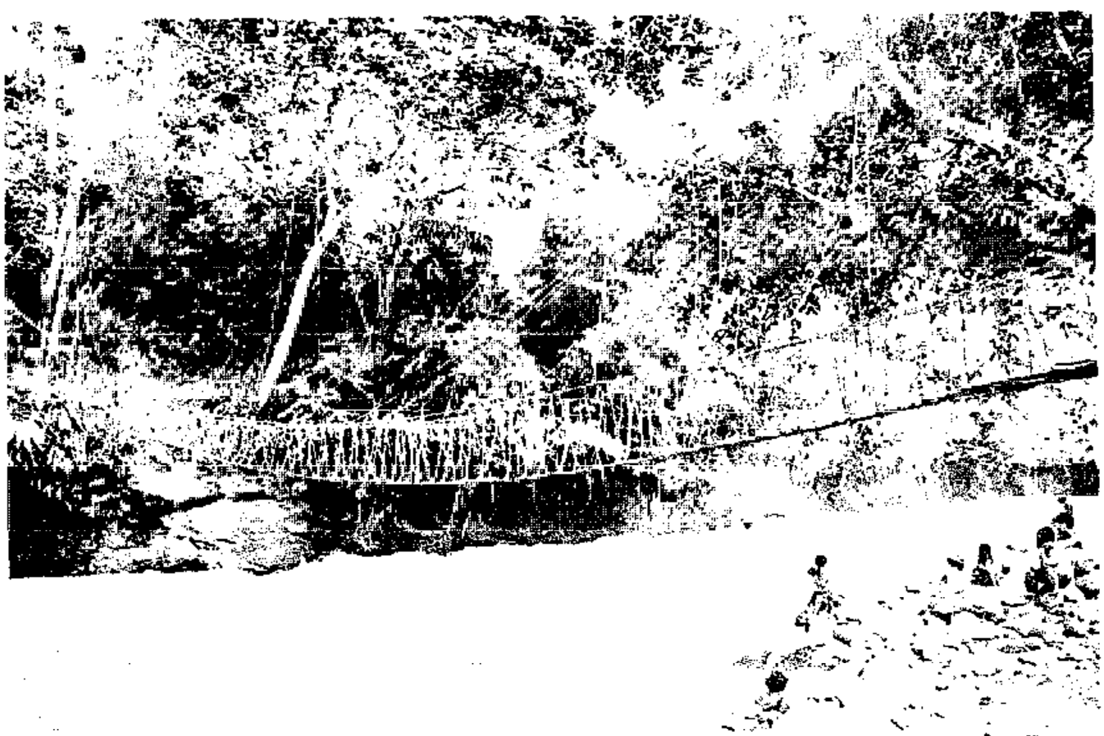


Fig. 55

Kapolame Bridge from the north bank.

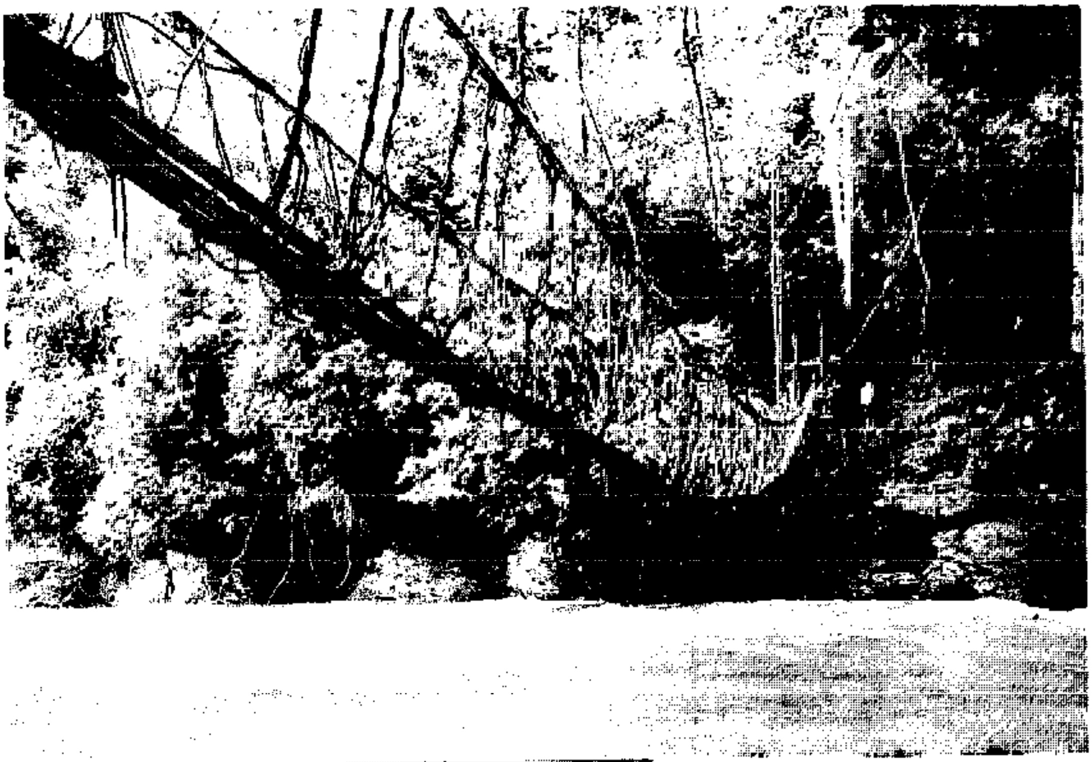


Fig. 56

Kapolame Bridge from the north bank.

Fig. 57

Kapolame Bridge from the north bank.

Fig. 58

North anchorage, Kapolame Bridge.

Fig. 59

Kubib Bridge over Mendi River, seen from the east bank looking south.

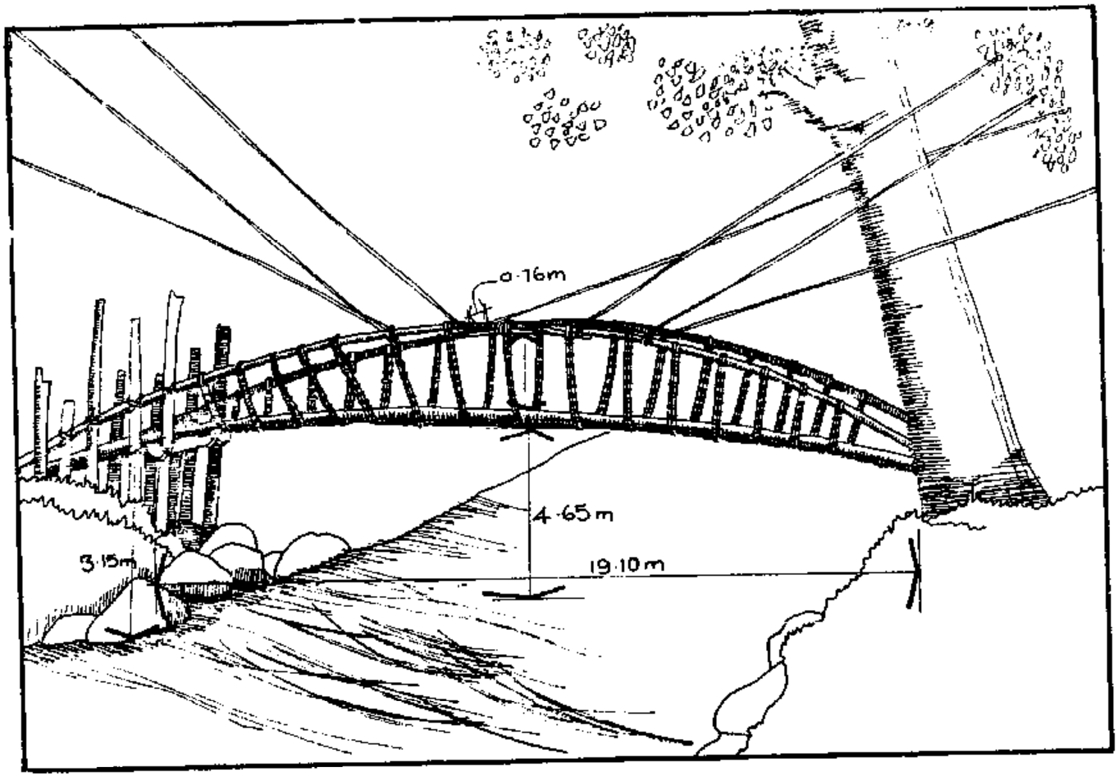


Fig. 60

Drawing of Kubib Bridge (view from west bank looking south).

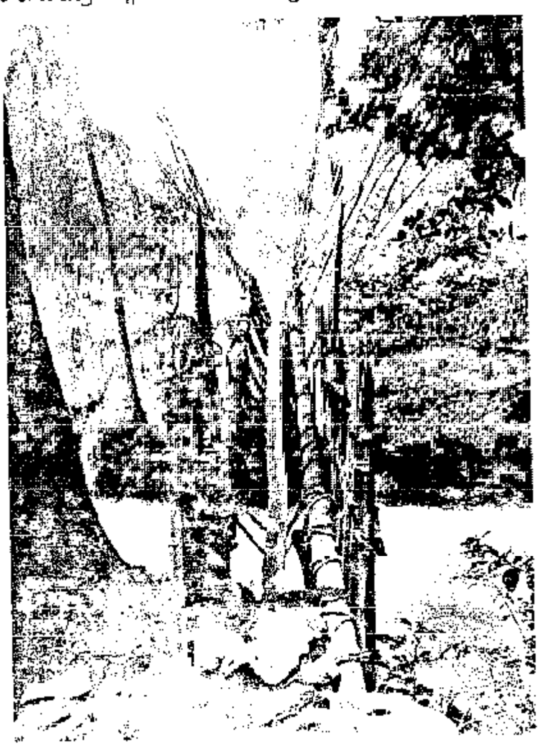


Fig. 61

West abutment, Kubib Bridge. Note stones used for counterweights and planed wooden walkway.

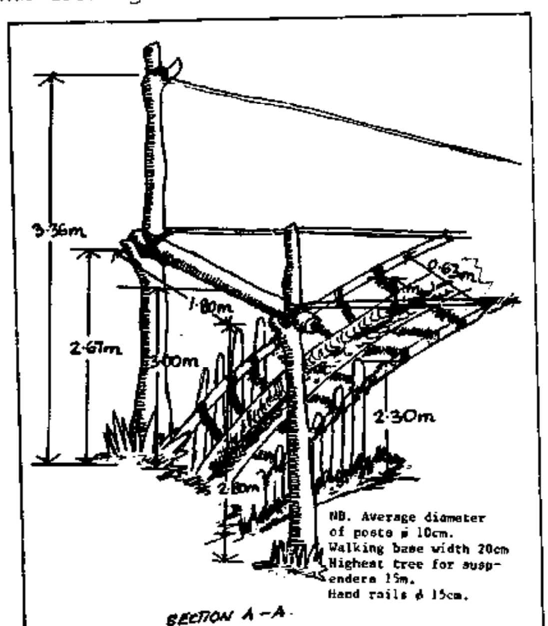


Fig. 62

Drawing of east abutment, Kubib Bridge.

Fig. 63

Abutment scaffolding, Kubib Bridge.

Fig. 64

Detail of abutment, showing vine lashing, Kubib Bridge.

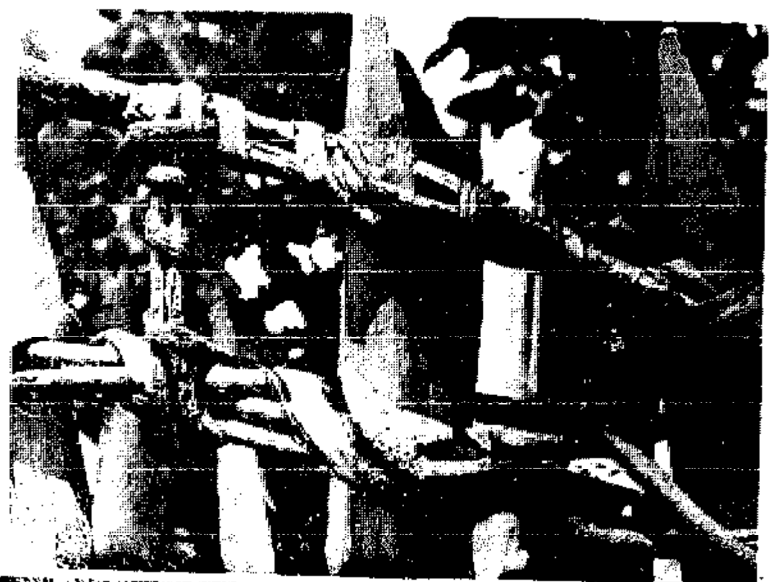


Fig. 65.

Kubib Bridge, from the east bank.

Fig.. 66

Detail showing extra support given to handrail by lashing it to the suspended cable, Kubib Bridge.

Fig. 67

View of Kubib Bridge from the west bank. Note the suspended cables and the continuous suspenders, going under the walkway.

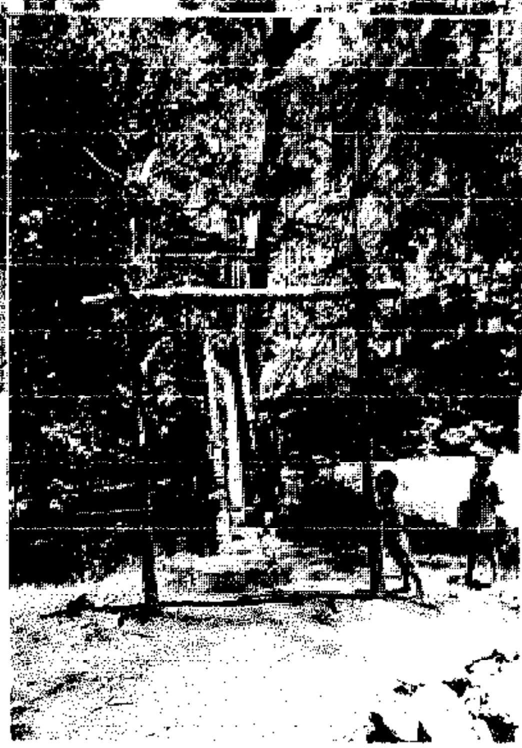


Fig. 68

Constructed anchorage on the east bank, Kubib Bridge.

Fig. 69

Kopeme Bridge (from the north bank of the Kaugel River).

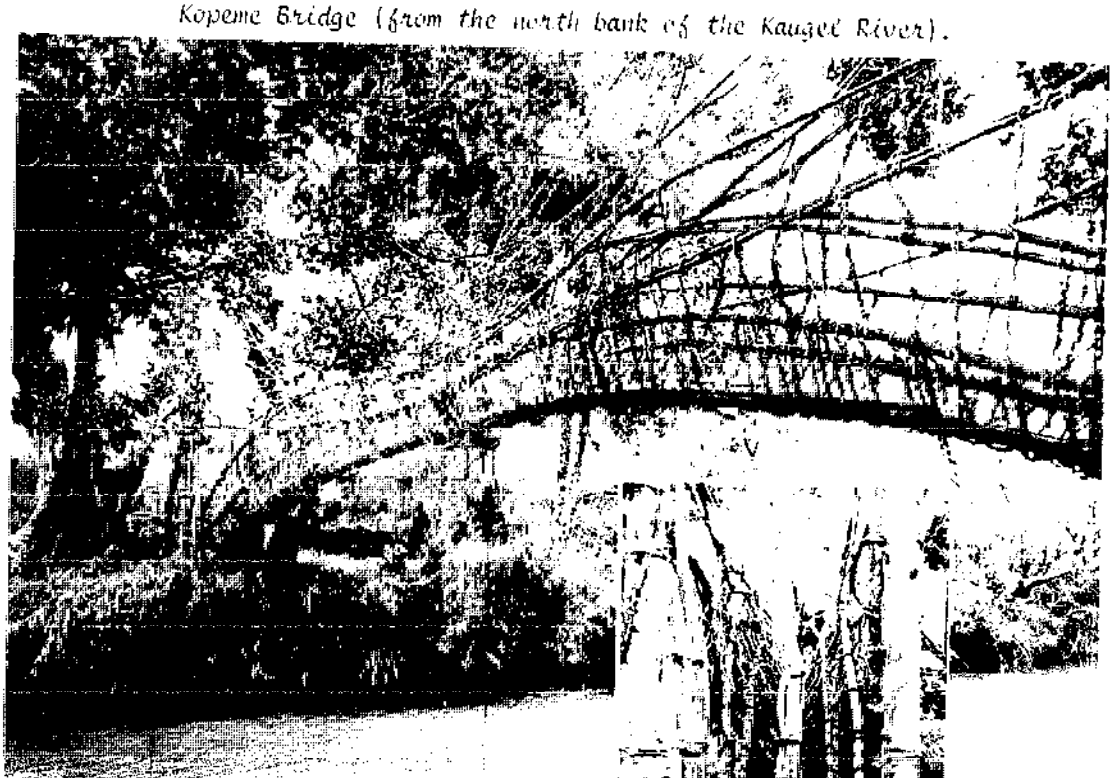


Fig. 70

Kopeme Bridge from the south.

Fig. 71

South abutment and anchorage. Note the cantilever walkway and handrails.

Fig. 72

View from the south bank, Kopeme Bridge.

Fig. 73

Kopeme man and the south abutment

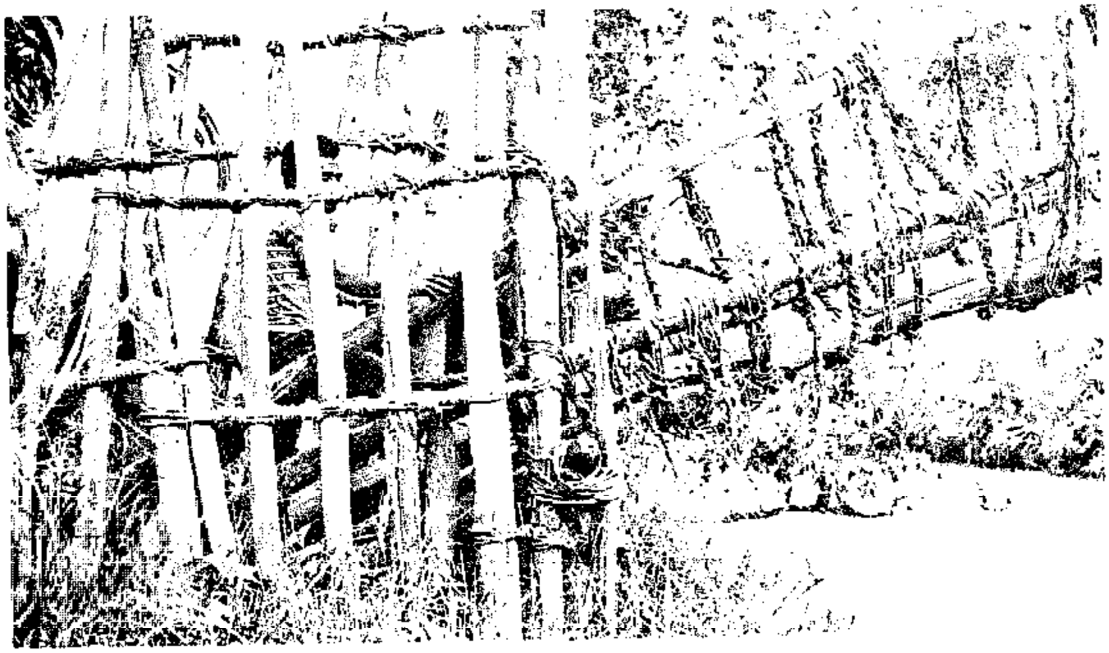


Fig. 74

The south abutment, looking west, Kopeme Bridge.

Fig. 75

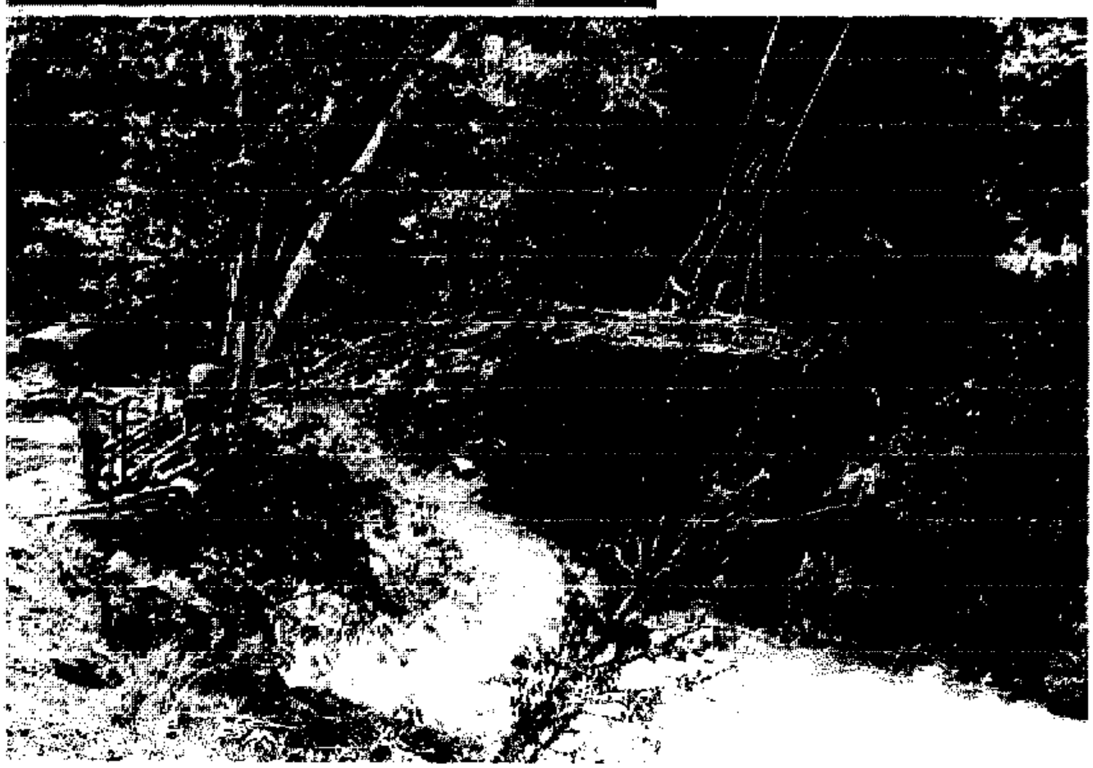
Detail showing vine lashing of vertical members of the abutment, Kopeme Bridge.

Fig. 76

Sau River Bridge.

Fig. 77

Sau River Bridge. Note cane suspended cables supporting the middle of the bridge.



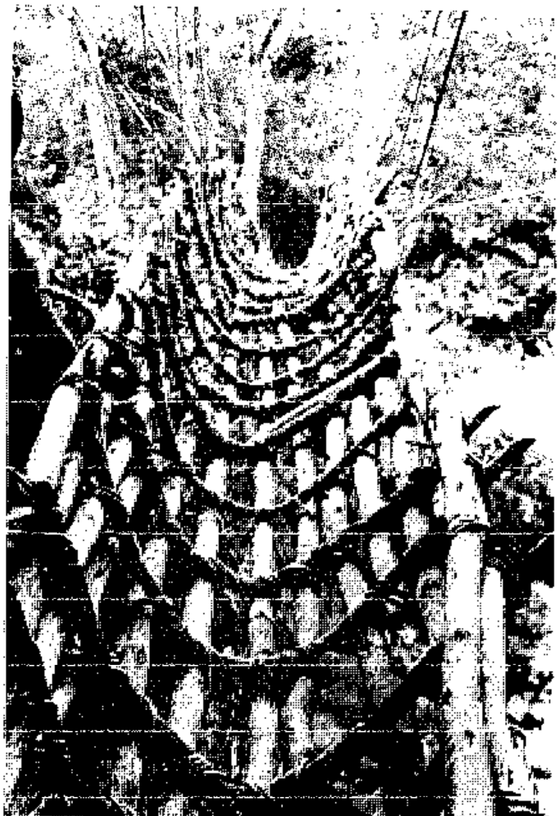


Fig. 78

Sau River Bridge, walkway showing the U-shaped transverse supports made flexible green saplings.

Fig. 79

Lashing using stripped cane, Sau River Bridge.

Fig. 80

Detail of lashing using stripped cane, Sau River Bridge.

Fig. 81

Sau River Bridge
from below.

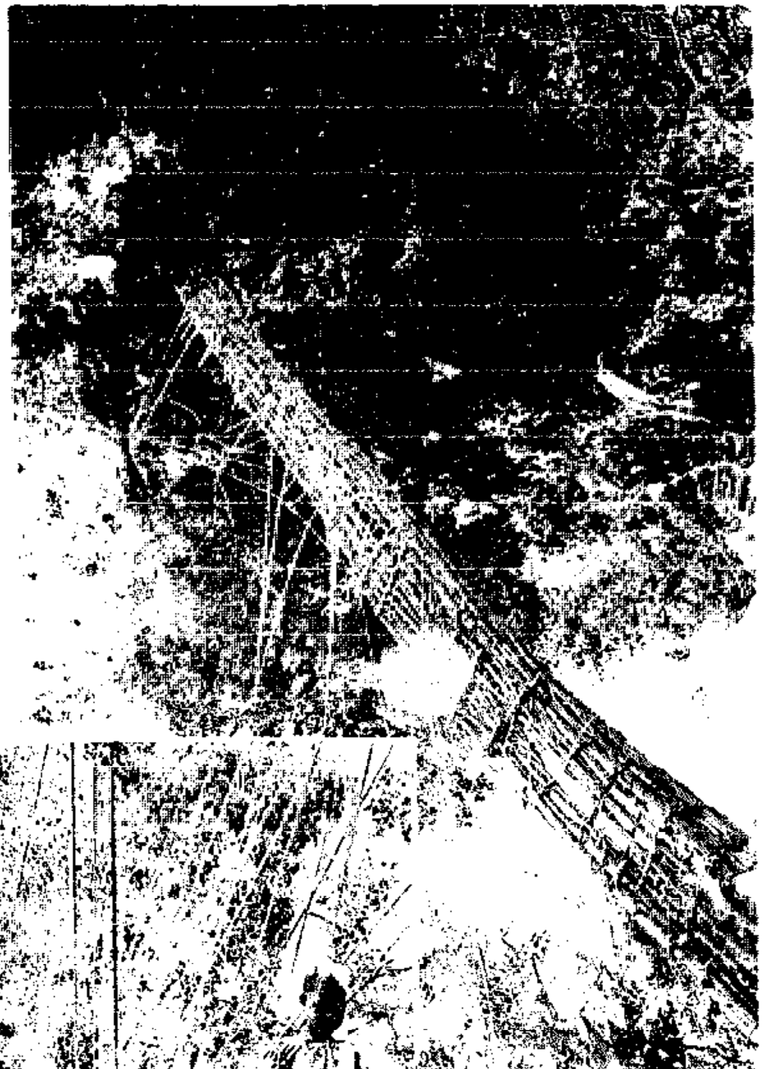


Fig. 82

Sau River Bridge,
another view.

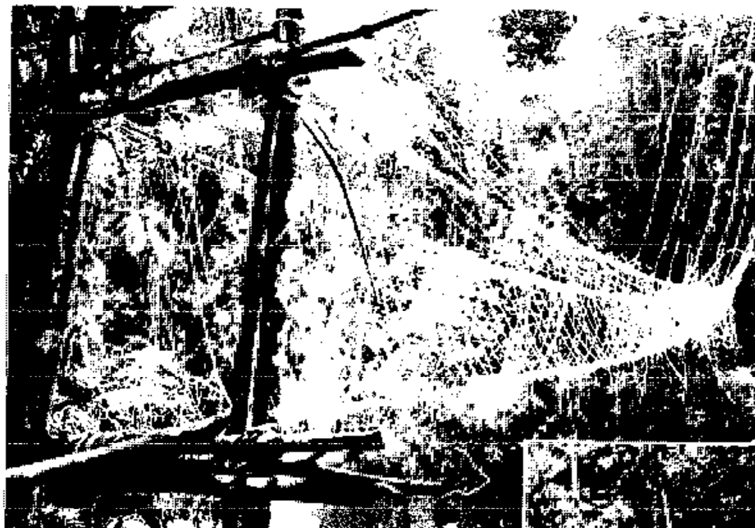


Fig. 83

Nepirik Bridge, from the west bank of the Lai River.

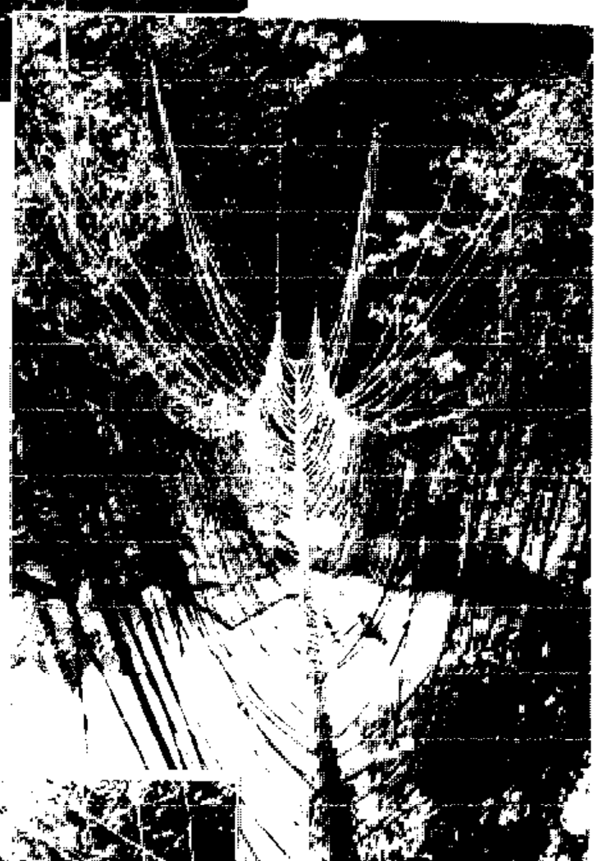


Fig. 84

Nepirik Bridge. Note walkway of 3-4 strands of whole cane and suspenders of stripped cane.

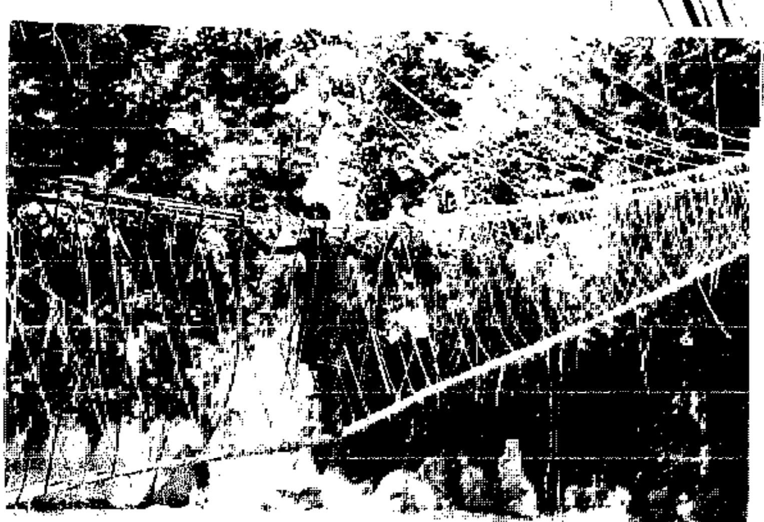


Fig. 85

Nepirik Bridge, showing how the walkway sags with the weight of the user.

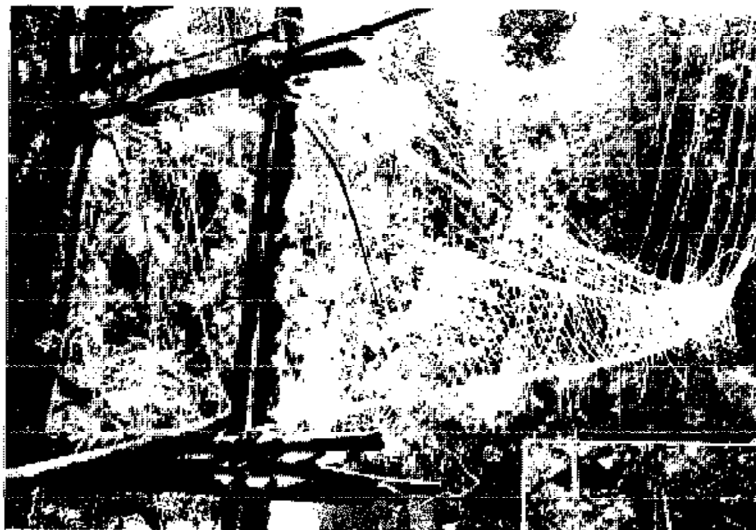


Fig. 83

Nepirik Bridge, from the west bank of the Lai River.

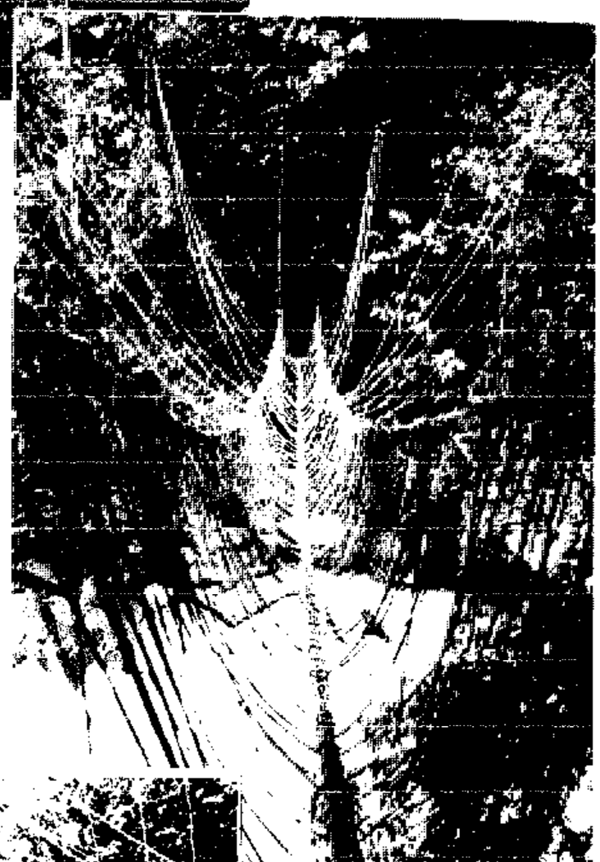


Fig. 84

Nepirik Bridge. Note walkway of 3-4 strands of whole cane and suspenders of stripped cane.

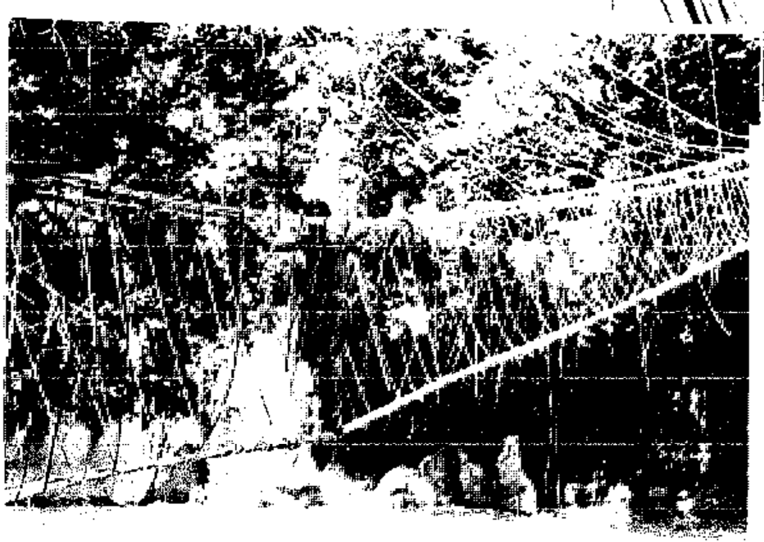


Fig. 85

Nepirik Bridge, showing how the walkway sags with the weight of the user.

Fig. 86

Nepirik Bridge, east anchorage, using trees for additional support.

Fig. 87

Lashing on anchorage, Nepirik Bridge.

Fig. 88

East anchorage and approach, Nepirik Bridge.

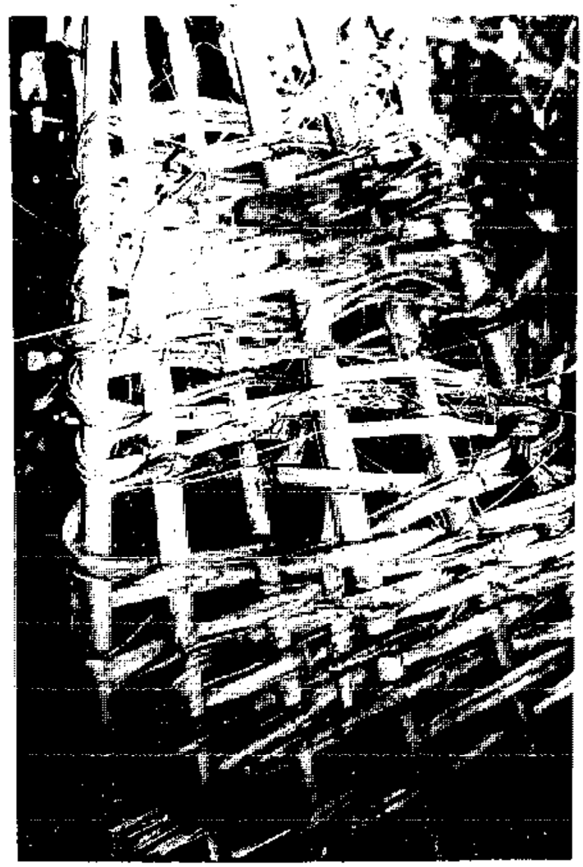


Fig. 89

Beginning of walkway, west side, Nepirik Bridge.

Fig. 92

Saimanda Bridge, over the Lagaip River.

Fig. 93

Saimanda Bridge. Young Flexible casuarina trees joined to form the arch.

Fig. 94

Saimanda Bridge, walkway and handrails supported by the abutment, lashed together with vines. Note vine guy to the right for additional stabilization.

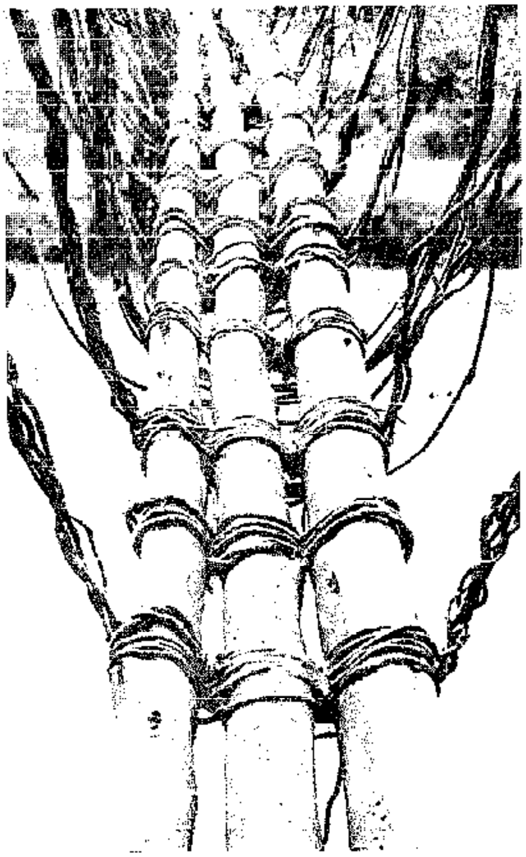


Fig. 95

Close-up of the walkway, showing vine lashing and suspenders, Saimanda Bridge.

Fig. 96

South abutment, Saimanda Bridge.

Fig. 97

South abutment seen from the opposite bank, Saimanda Bridge. Again note guy.

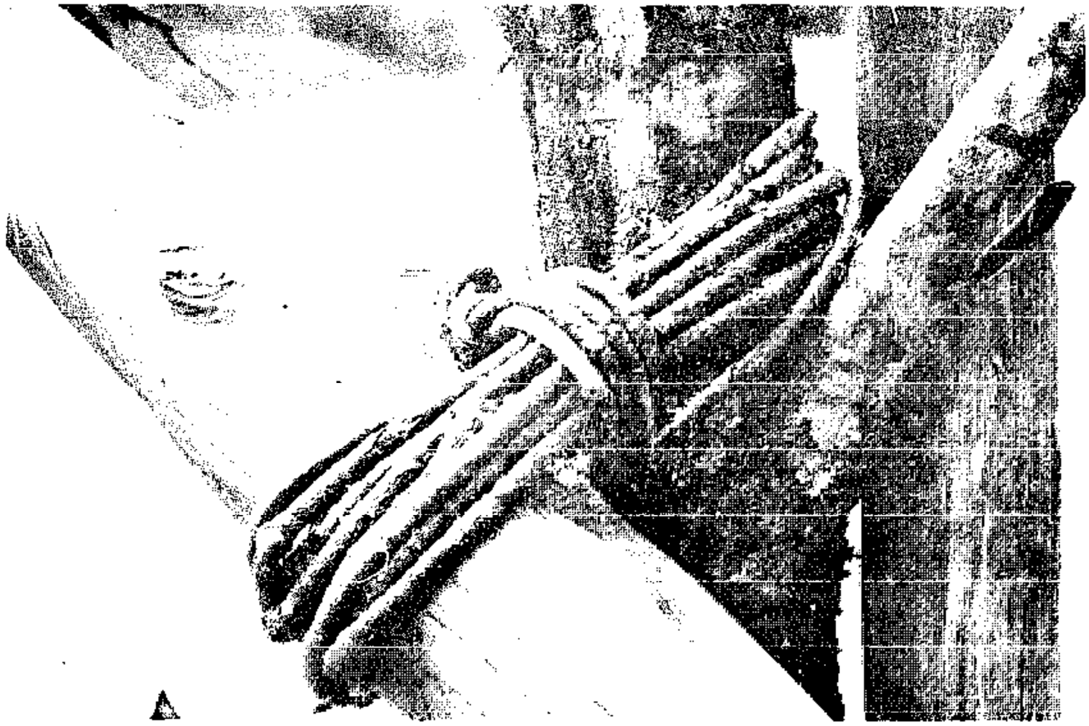


Fig. 98

Detail, handrail lashed to the abutment with vines, Saimanda Bridge.

Fig. 99

Luke Niap and Mark Kaeyo on the Saimanda Bridge.

Fig. 100
The author on the Saimanda Bridge.

3.2 Western and West Sepik Provinces (see the map in Figure 101)

The remote, rugged and sparsely populated mountainous areas of the Western and West Sepik Provinces are the areas of the country least affected by outside influences. Government stations such as Olsobip were established only in the 1950's. The bridge over the Sepik, photographed from an airplane (Figure 102) about halfway between Telefomin and the Irian Jaya border, would be about four or five days walk to the nearest government station or airstrip.

3.2.1

Name:	Olsobip Bridge (Figures 103 - 107)
River:	Fly
Location:	20 minute walk below Olsobip station, Western Province
Type:	suspension
Materials:	wood and cane, names given here in

Faiwol language:

tanong	--	large cane for cables
der	--	smaller cane for lashing
kirap	--	wood used from cross beams in anchorage
wap	--	vertical wooden posts of anchorages and approaches
trum	--	slats of the approach
abal	--	inclined logs of the approach ramp
kave'et	--	wood used for handrails of approaches

Dimensions:

total length:	48.2 m
clear span:	38.3 m
midspan height above water:	3.9 m
distance between handrails:	.8 m
handrail to walkway:	1.0 m
average diameter of cane:	.03 m

Construction details:

constructed by:	people of Loubip and Kongabip villages
number of men:	30 - 40, divided into groups, some to get cane, some to prepare the wood, etc.
construction time:	3 days to get materials, 2-3 days to build
date:	September, 1979
lifespan:	5-6 months before some cane has to be replaced
other information:	Informants stressed the importance of cooking food, especially taro, in an earth oven (Tok Pisin: mumu) during construction.

Date of inspection: 12 December, 1980

Additional information: The people of this area of country are unique in having specific words for various components of the bridges, thus testifying to the importance of bridges in their culture. Here are the components in the Faiwol language:

fargeŋal -- suspended cables
mu -- suspenders
teŋam -- handrails (spanning cables)
yanam -- walkway
gubap -- crossbeams of anchorages
din -- handrails of approach

3.2.2

Name:	Kobrenmin Bridge (Figures 108 - 117)
River:	Sepik
Location:	Telefomin District, West Sepik Province; 1½ hour walk from Telefomin station
Type:	cantilever with suspended walkway
Materials:	wood and vines; names given below in Telefol language:

at -- wood in general
kalman, *yegim*, *tapet*, *imo* -- types of wood used for abutment construction
sok -- vines in general
tawayam -- thin vine
balkul -- thick and rough vine
ilin -- flat, dark brown vine
ifa -- thick vines used for cables

Dimensions:

total length:	39.3 m
clear span:	23.6 m
length of suspended walkway:	20.8 m
midspan height above water:	2.7 m
maximum height of walkway:	4.7 m
width of walkway:	.6 m
distance between handrails:	1.0 m
handrail to walkway:	1.1 m
average width of abutments:	1.4 m
maximum load:	2 men

Construction details:

constructed by:	people of Kobrenmin village
date of construction:	September, 1980
time:	1 week to gather materials, one day to build
number of men:	50, some on each side (men either swim across or use other bridges up and down stream)
lifespan:	6 months
cooking:	<u>mumu</u> prepared during construction with taro, <u>marita</u>, or pig

Date of inspection: 7 December, 1980

Additional Information: Names of bridge components in Telefol language:

<u>saksuk</u> -- suspended cables
<u>sigirem</u> -- handrails (spanning cables)
<u>mu</u> -- suspenders
<u>yanam</u> -- walkway
<u>dabomam</u> -- approach/abutment

3.2.3

Name: Urapmin Bridge (Figures 118 - 121)

River: Sepik

Location: Telefomin District, West Sepik Province; 3 hours walk from Telefomin station, between Atemkiakmin and Urapmin villages

Type: cantilever with rough truss construction

Materials: wooden poles and vines

Dimensions:

total length:	14.6	m
clear span:	7.4	m
midspan height above water:	7.4	m
average width of walkway:	.6	m
distance between handrails:	1.1	m
handrail to walkway:	1.5	m
average height of abutment:	3.1	m

Date of inspection: 8 December, 1980

3.2.4

Name:	Iamdelmin Bridge (Figures 122 - 124)
River:	Al
Location:	Atbalmin area of West Sepik Province, 10 hours hard walk from Tumolbil airstrip, 12 hours walk from Yapsei station
Type:	suspension
Materials:	wood and cane

Dimensions:

total length:	21.2 m
clear span:	14.4 m
midspan height above water:	3.5 m
width of walkway:	.15 m
distance between handrails:	.75 m
handrail to walkway:	1.5 m

Construction:

constructed by:	people of Iamdelmin villages (there are two, one on either side of the bridge)
date of construction:	December, 1979
time:	one day after getting materials
number of men:	8, 6 to do the actual construction, 2 to prepare the <u>mumu</u> of <u>marita</u> (long red fruit of the pandanus)
lifespan:	one year (this bridge was beginning to deteriorate)

Date of inspection:	11 December, 1980
Additional information:	The bridge included two sticks placed transversely between the handrails to keep them apart. Those crossing the bridge have to duck under these cross-sticks.

3.2.5

Name:	Atbalmin Bridge (Figures 125 - 130)
River:	Sepik
Location:	Yapsei Subdistrict, West Sepik Province; 2½ hours walk from Yapsei station
Type:	suspension
Materials:	wood, cane

Dimensions:

total length:	75.4 m
length of suspended section:	66.5 m
midspan height above water:	3.9 m
width of walkway:	.10 m
distance between handrails:	.70 - .95 m
handrail to walkway:	1.2 - 1.7 m
height of north approach:	10.4 m

Date of construction: December, 1979

Date of inspection: 13 December, 1980

Additional information:

1) Compare this bridge to the one described by Schultze (Section2, Figure 26)
2) The Atbalmin people traditionally built bridges in this area to cross the river to attack their enemies, the Mianmin, who live on the other side. After the attack, they would retreat, cutting down the bridge behind them.
3) Remains of an uncompleted "modern" bridge can be seen at the same spot. Steel spanning cables and anchorages still exist above the present bridge (See Fig. 125). Hanging from the cables are fragments of a rotted wooden walkway. Information about the

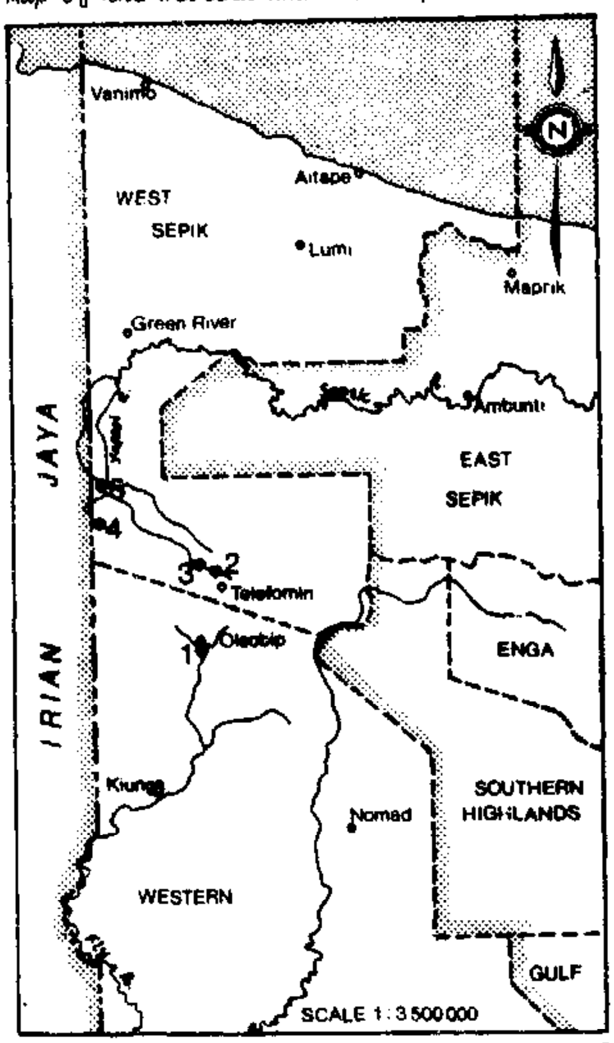
origin of this imported bridge was not available.

4) The present traditionally constructed bridge was in very bad repair. The cane was old and brittle and many of the suspenders were broken (See fig. 127).

5) In April, 1980 a carrier on a census patrol lost his footing while crossing the bridge. Because the suspenders were too weak to hold him, he fell through and down into the water. The rope of the large tent he was carrying got tangled around his neck and he drowned.

Fig. 101

Map of the Western and West Sepik Provinces showing bridge sites.



WESTERN AND WEST SEPIK PROVINCES

1 Olsobip Bridge
2 Kobrenmin Bridge
3 Urapmin Bridge
4 Iamdelmin Bridge
5 Atbalmin Bridge

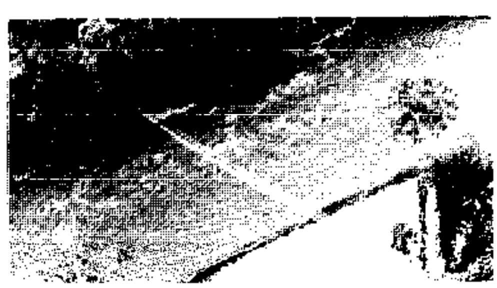


Fig. 102

Remote suspension bridge over the Sepik River, 4-5 days walk from the nearest airstrip.

Fig. 103

Olsobip station and airstrip and the Fly River.

Fig. 104

Olsobip Bridge over the Fly River.

Fig. 105
Olsobip Bridge.

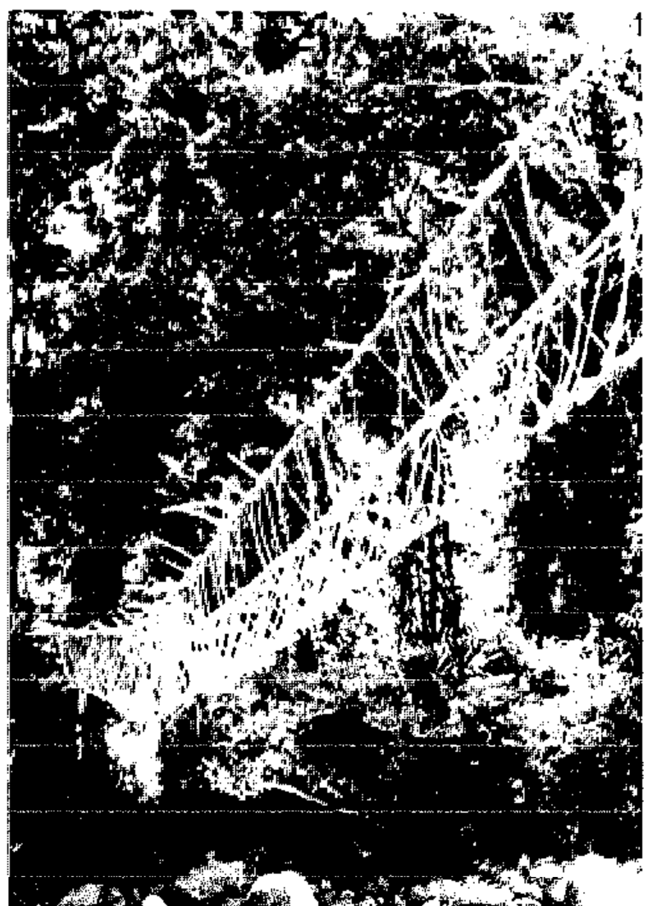


Fig. 106
Olsobip Bridge, cane walk-way, suspenders, and hand-rails.

Fig. 107

Some of the bridge builders: Baureng, Su[illegible]fit, Michael Rameng (OIC), Warip, and Philip.

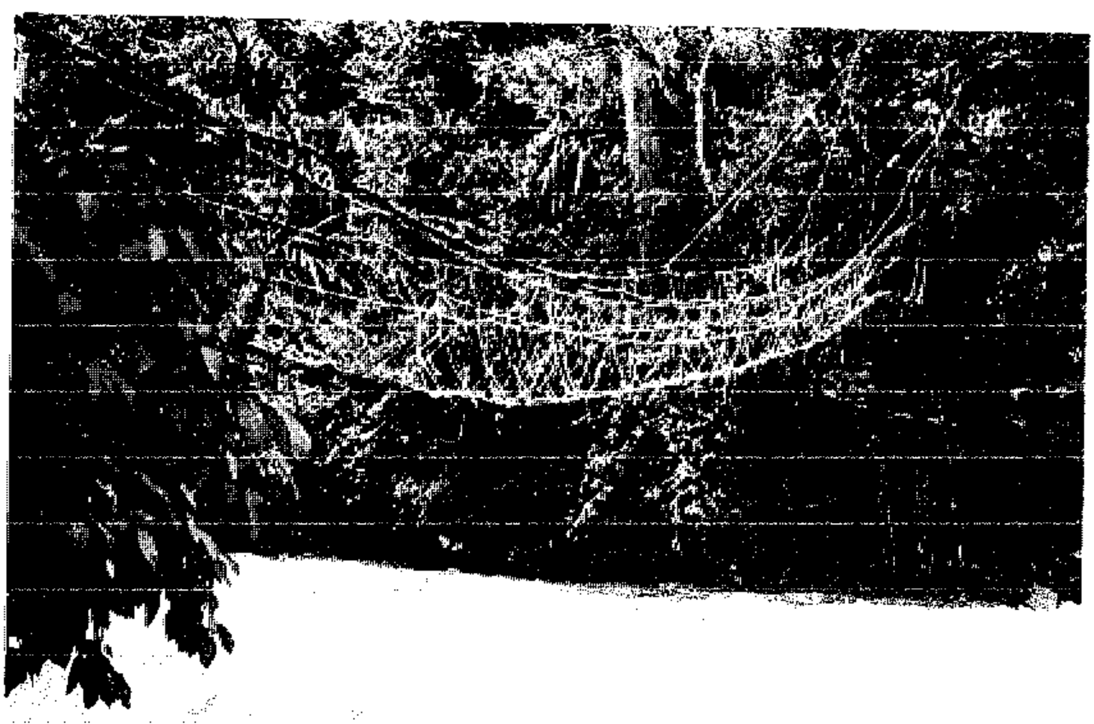


Fig. 108

Kobremin Bridge looking north across the Sepik River.

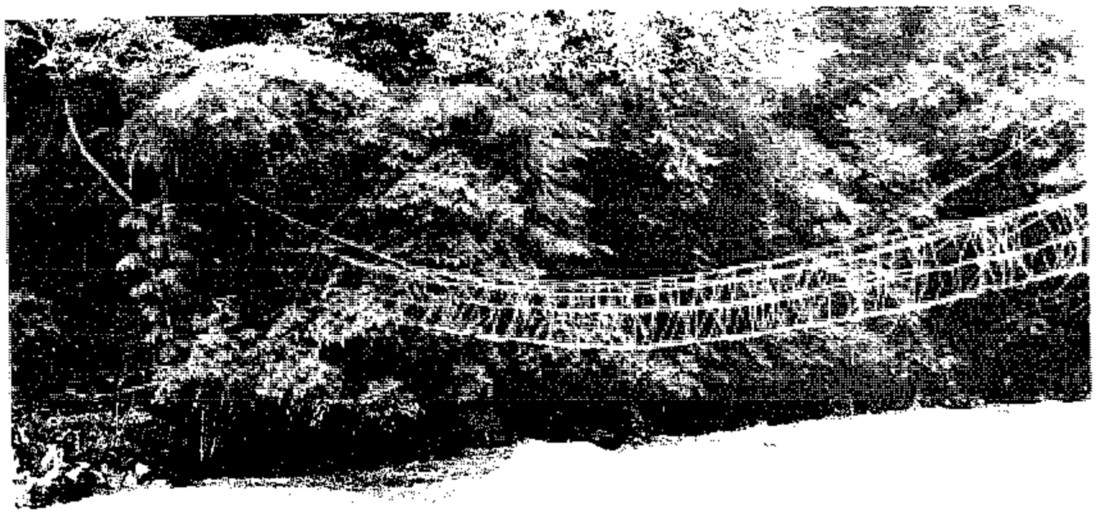


Fig. 109

Kobrenmin Bridge, looking south.

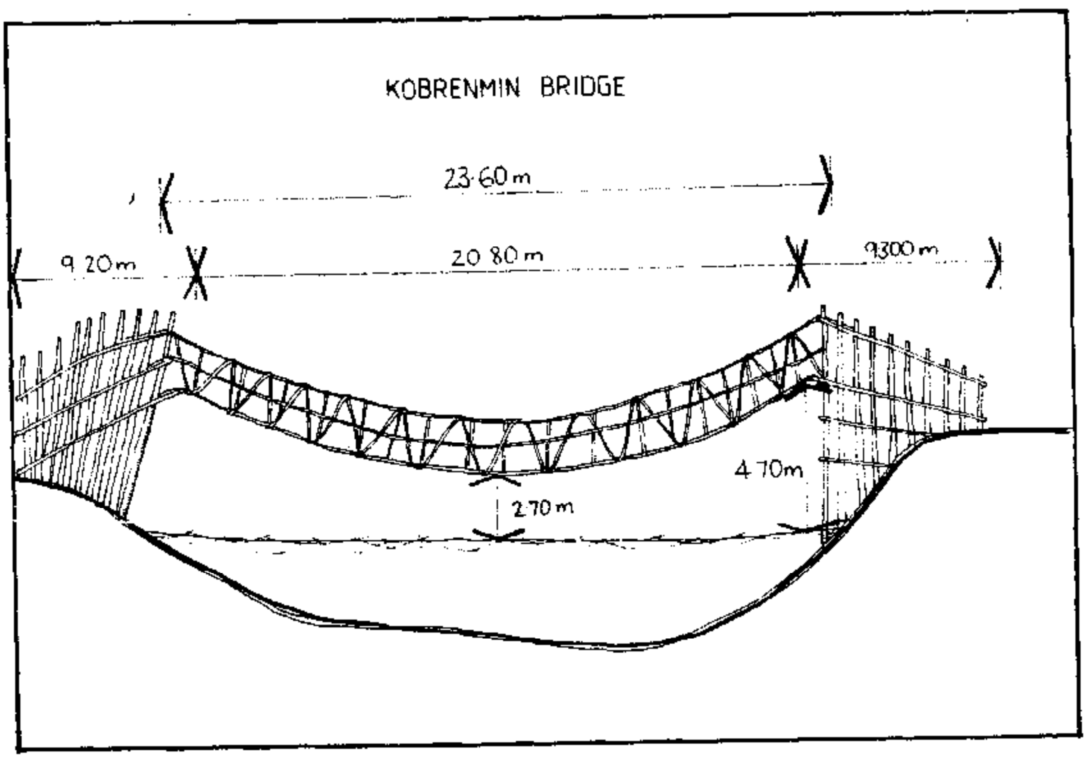


Fig. 110

Drawing of Kobrenmin Bridge.

Fig. 111

South abutment scaffolding, Kobremin Bridge.

Fig. 112

Detail, showing vine lashing, Kobremmin Bridge.

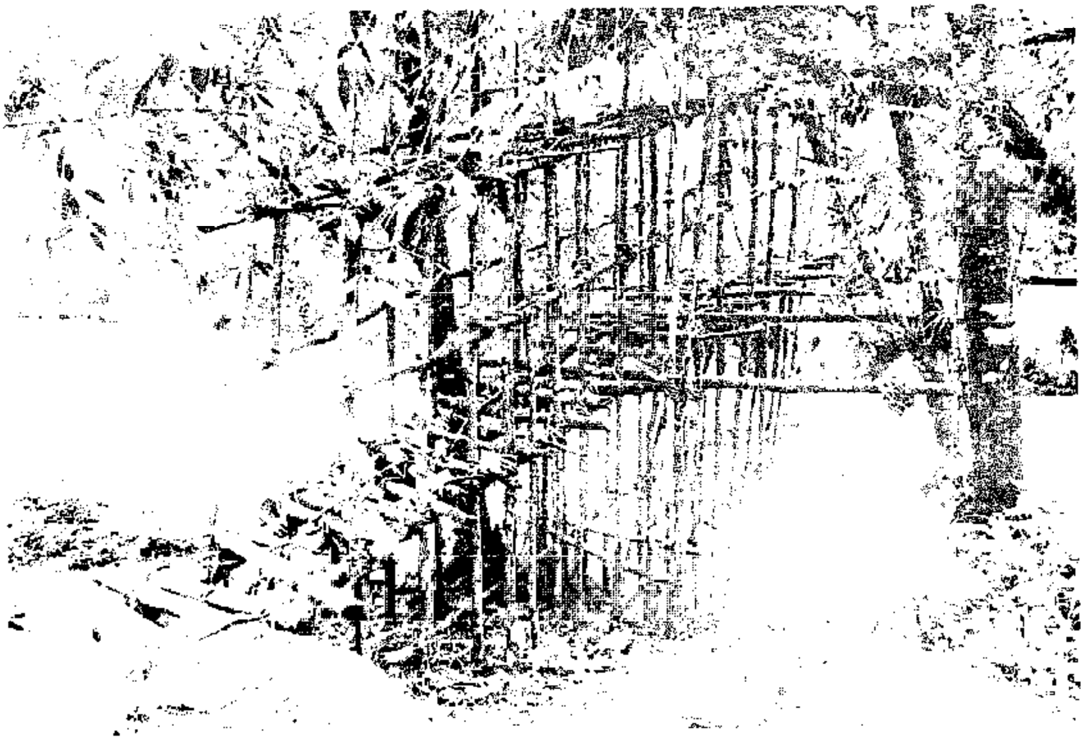


Fig. 113
North abutment scaffolding, Kobrenmin Bridge.

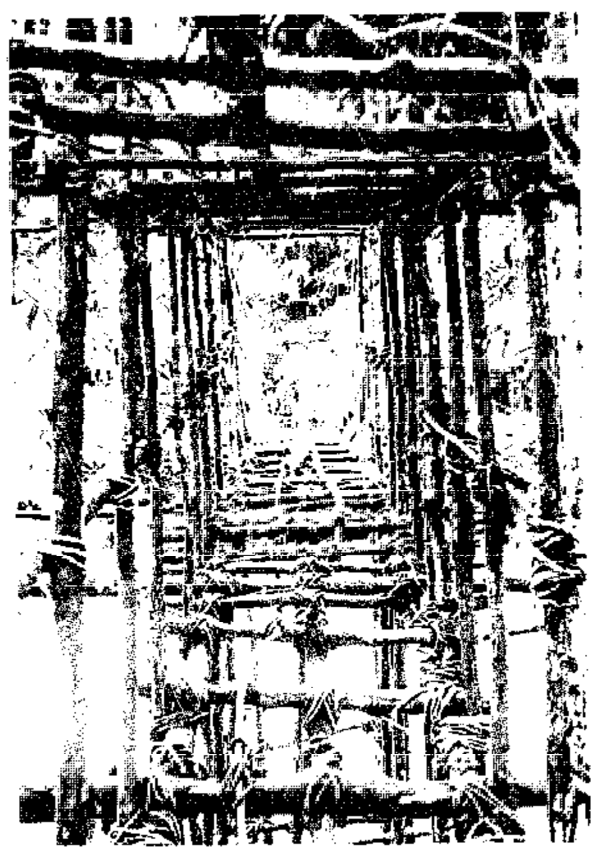


Fig. 114
North Abutment and approach,
Kombrenmin Bridge.

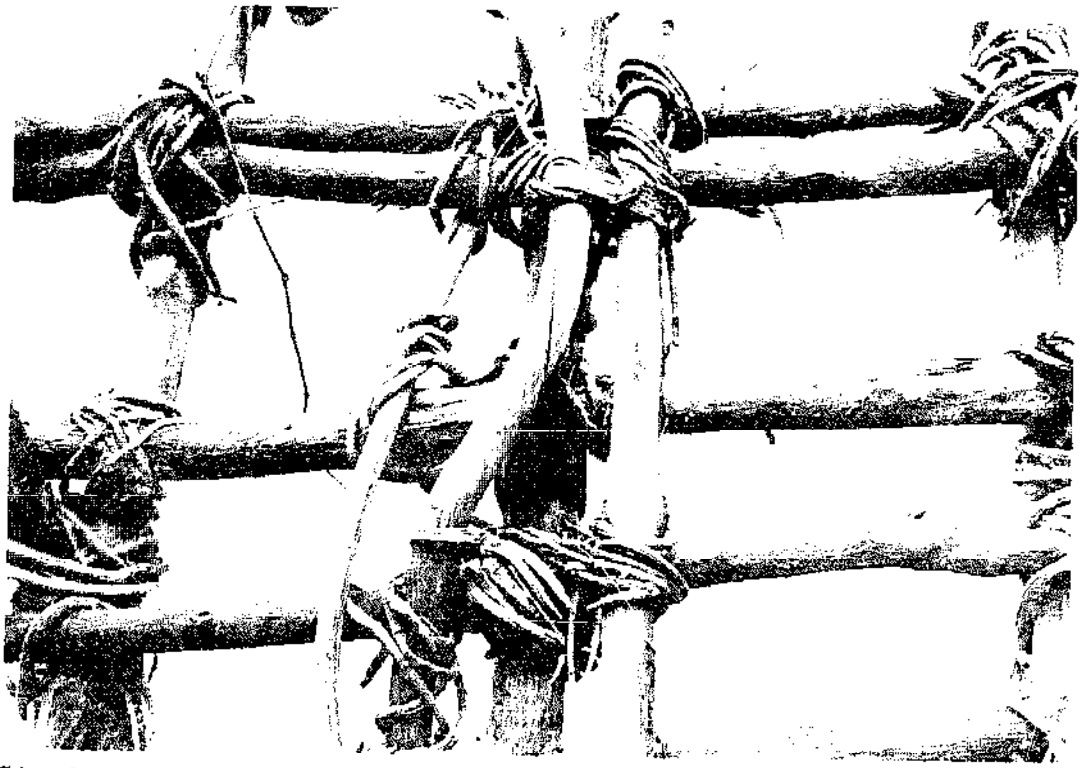


Fig. 115

Detail of scaffolding construction, Kobremin Bridge.

Fig. 116

Walkway suspended from cantilever section, Kobremmin Bridge.

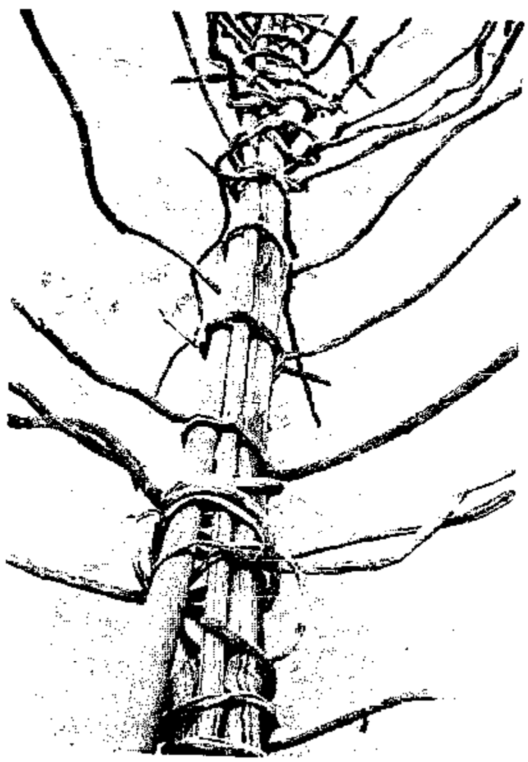


Fig. 117

Detail, walkway and suspenders made of vines, Kobremmin Bridge.

Fig. 118

Urapmin Bridge, over a narrow part of
the Upper Sepik River.

Fig. 119

Urapmin Bridge.

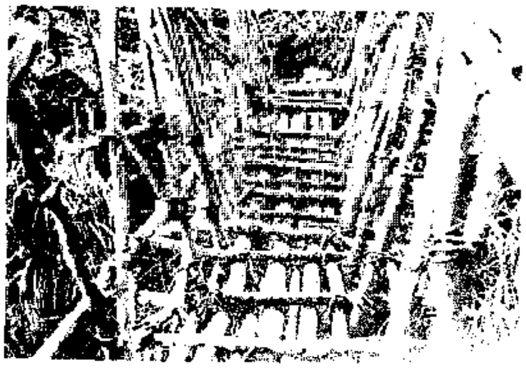


Fig. 120

Urapmin Bridge, walkway consisting of poles lashed together with a rough truss construction at the sides.

Fig. 121

Urapmin Bridge, abutment using trees for vertical members.

Fig. 122

Iamdelmin Bridge, over the Ak River.

Fig. 123

Anchorage and approach, Iamdelmin Bridge.

Fig. 124

Walkway and stripped cane suspenders, Iamdelmin Bridge.

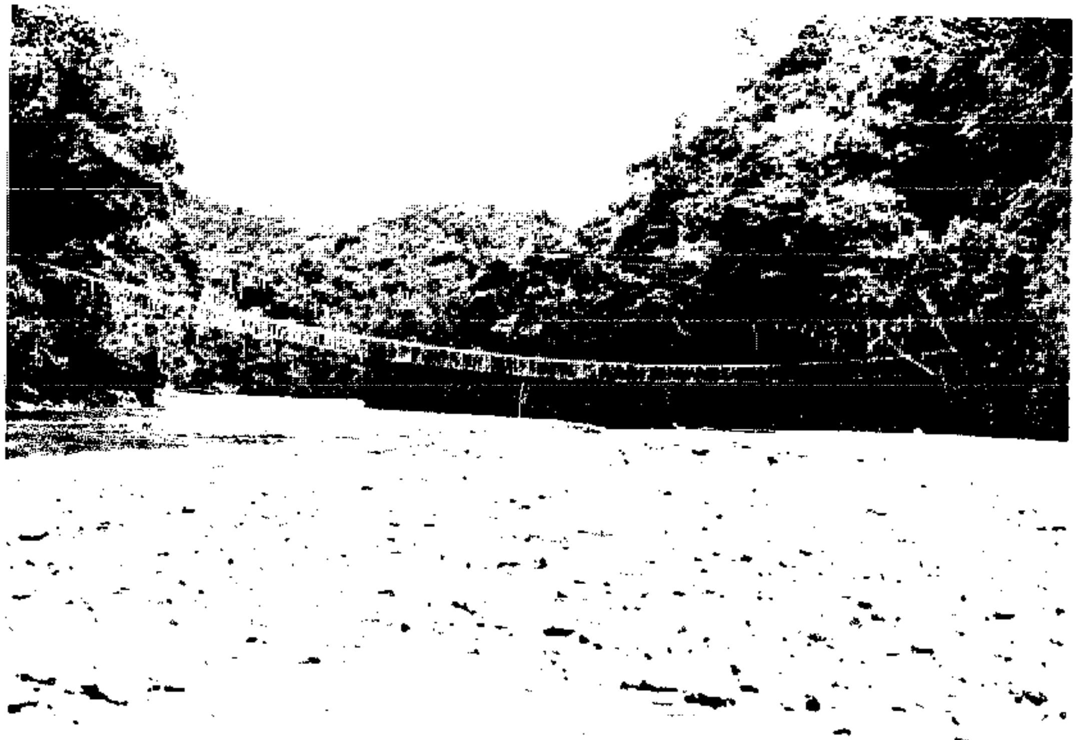


Fig. 125

Atbalmin Bridge over the Sepik River. Note steel cable and remnants of wooden platform (on the left) from a previously constructed imported bridge.

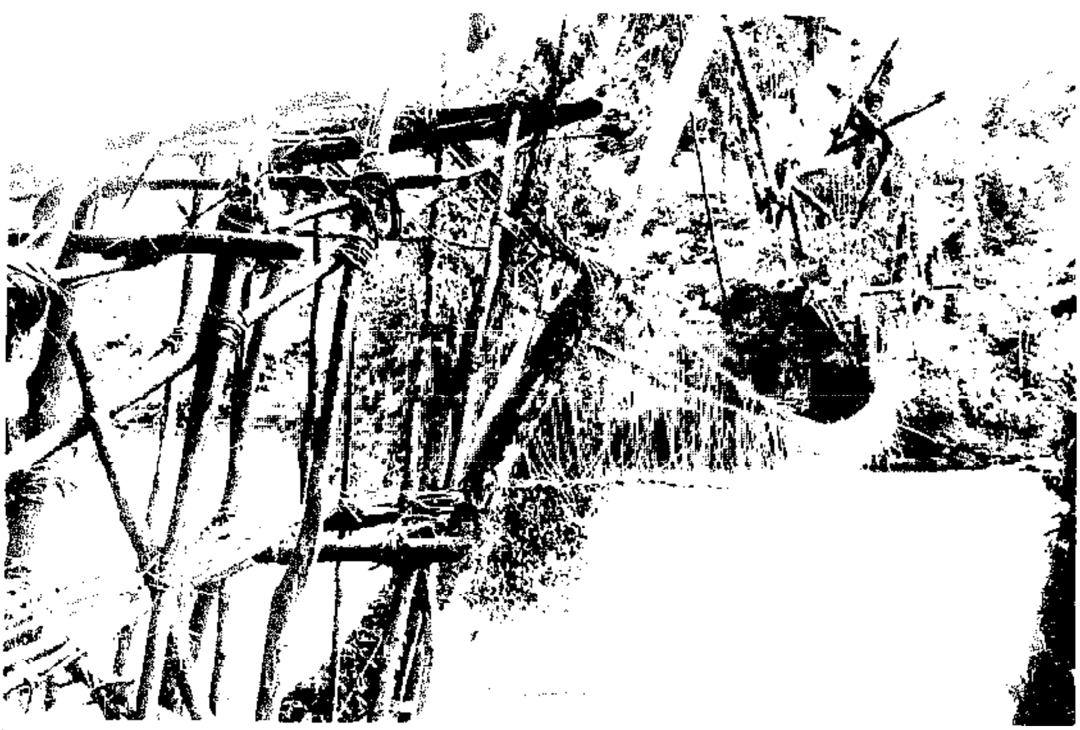


Fig. 126
South anchorage, Atbalmin Bridge. Compare with Schultze's photograph, Fig. 26.

Fig. 127

Atbalmin Bridge showing the cross bar and the poor state of repair of the bridge with many broken suspenders.

Fig. 128

Atbalmin Bridge from below.

Fig. 129

Atbalmin Bridge being crossed.

Fig. 130
Atbalmin Bridge. North anchorage.

Fig. 131
Atbalmin Bridge showing north anchorage.

3.3 Morobe Province (see map in Figure 131)

Morobe Province is one of the most diverse regions of Papua New Guinea with over one hundred language groups and terrain ranging from sandy beaches to misty mountains, kunai grass to alpine grass. There are also diverse styles of traditional bridge construction.

Besides the styles seen in other provinces, there is the classical suspension bridge with constructed pylons using the same basic design and structural principles as Western suspension bridges.

Also, there are the amazing cane bridges of the Waria River. Cane is plentiful in this area and it is used anything by sparingly to construct sturdy suspended bridges in which the cane cables are pulled so tight that there is almost no sag or sway. These bridges are perhaps the best constructed and best maintained of the those inspected for this research project.

3.3.1

Name:	Gumbum Bridge (Figures 132 - 142)
River:	Busu
Location:	Boana District, Morobe Province, 5 hours walk from Boana station
Type:	suspension with constructed pylons and cantilever walkway
Materials:	wood, bamboo, vines, cane and stones

Dimensions:

total length:	25.4	m
clear span:	19.8	m
midspan height above water:	2.2	m
height of pylons:	~ 7	m

width of pylons: 1.2 m
handrail to walkway (midspan): 1.2 m

Construction details:

constructed by:	people of Gumbum village
date of construction:	mid 1978
number of men:	15 - 20
construction time:	1 day (after collecting materials)
lifespan:	2 years
method:	(see Figures 139 - 143)

Date of inspection: 17 March, 1979

Additional information: This bridge was washed away in a flood in around April, 1981.

3.3.2

Name:	Sukurum Bridge (Figures 143 - 152)
River:	Leron
Location:	1½ hours walk from Leron Community School which is about 20 km up from the Highlands Highway, Morobe Province
Type:	suspension with constructed pylons and cantilever walkway
Materials:	wood, bamboo, vines, cane and stones

Dimensions (estimated):

total length:	42 m
clear span:	38 m
midspan height above water:	5 m
height of pylons:	10 m and 12 m

Constructed by:	people of Sukurum village (mainly so so their children can get to the school)
Lifespan:	3 years
Dates of inspection:	24 June, 1979 and 21 March, 1981
Additional information:	The bridge was in the process of being

rebuilt when visited again in March, 1981. Everything was completed except joining the two cantilever sections of the walkway with a slightly sagging centre section.

3.3.3

Name: Tiaura Bridge (Figures 153 - 156)

River: Waria

Location: Garaina District, Morobe Province, 3 hours walk from Garaina station

Type: suspension

Materials: wood and cane (itigiri in Guhusamani language)

Dimensions:

- length: 33.8 m
- midspan height: 5.5 m

Construction:

- constructed by: people of Tiaura village
- date of construction: April, 1979
- time: one day after gathering materials
- number of men: 36
- lifespan: 2 years

Date of inspection: 21 September, 1980

3.3.4

Name: Tewa Bridge (Figures 157 - 166)

River: Waria

Location: Biawaria area, Garaina District, Morobe Province; 3½ hours walk from Kira airstrip

Type:	suspension	
Materials:	wood and cane	
Dimensions:		
total length:	58.7	m
clear span:	53.0	m
midspan height above water:	6.0	m
distance between handrails	.9	m
handrail to deck:	1.6	m

Construction:

constructed by: people of Tewa village (especially Nonokam, Sisiri, Heupe, Tuavi, Souro, Iyania, Senilo, Jewase, Sogao, and Same -- see Fig. 166)

total number of men: 50

lifespan: cane must be replaced every six months;

maintenance: the bridge is constantly maintained rather than allowed to fall into ill-repair and replaced

Date of inspection: 4 November, 1980

3.3.5

Name: Bakeri Bridge (Figures 167 - 171)

River: Waria

Location: Biawaria area, Garaina District, Morobe Province; 9 hours walk from Garaina station or 6 hours walk from Kira airstrip

Type: suspension

Materials: wood and cane

Dimensions:

total length:	70.6	m
clear span:	54.4	m
midspan height above water:	7.9	m

length of north approach:	10.9 m
height of north approach:	5.6 m
length of south approach:	5.3 m
height of south approach:	5.9 m
distance between handrails:	1.2 m
maximum load:	12 men

Construction:

constructed by:	people of Bakeri village
number of men:	50
maintenance:	constantly maintained instead of entirely replaced;
last new cane:	October, 1980
date first built:	been on the same spot since World War II
method:	1. A thin vine is thrown across the river attached to a stick. This stick is fished out of the river with another long stick. The cane is then tied to it and pulled back. Cane is then pulled back and forth with a "pulley" system. 2. Platforms are constructed in the trees for men to sit on when pulling the cane tight. Several men will pull on each strand to get it tight.

Date of inspection: 5 November, 1980

Other information: According to tradition, if the vine thrown across the river breaks, there will be a death in the family of the man who threw it.

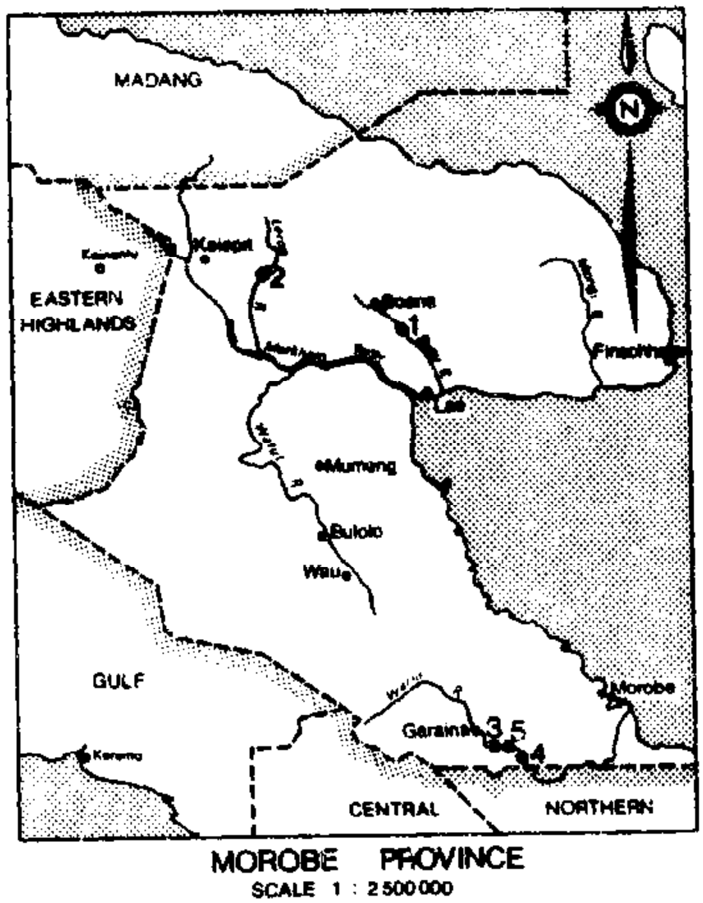


Fig. 132

Map of Morobe Province showing bridge sites.

1 Gumbum Bridge
2 Sukurum Bridge
3 Tiaura Bridge
4 Tewa Bridge
5 Baberi Bridge

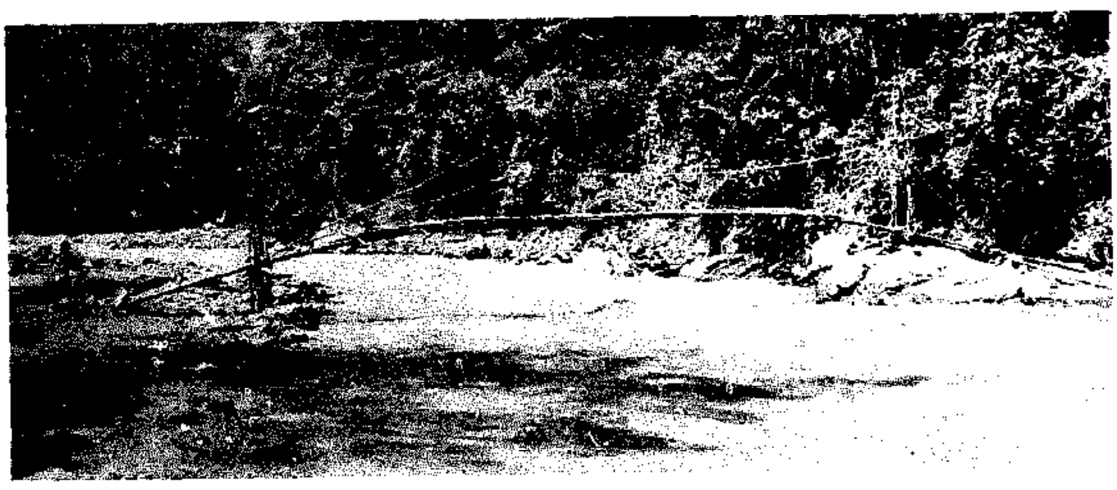


Fig. 133

Gumbum Bridge over the Busu River.

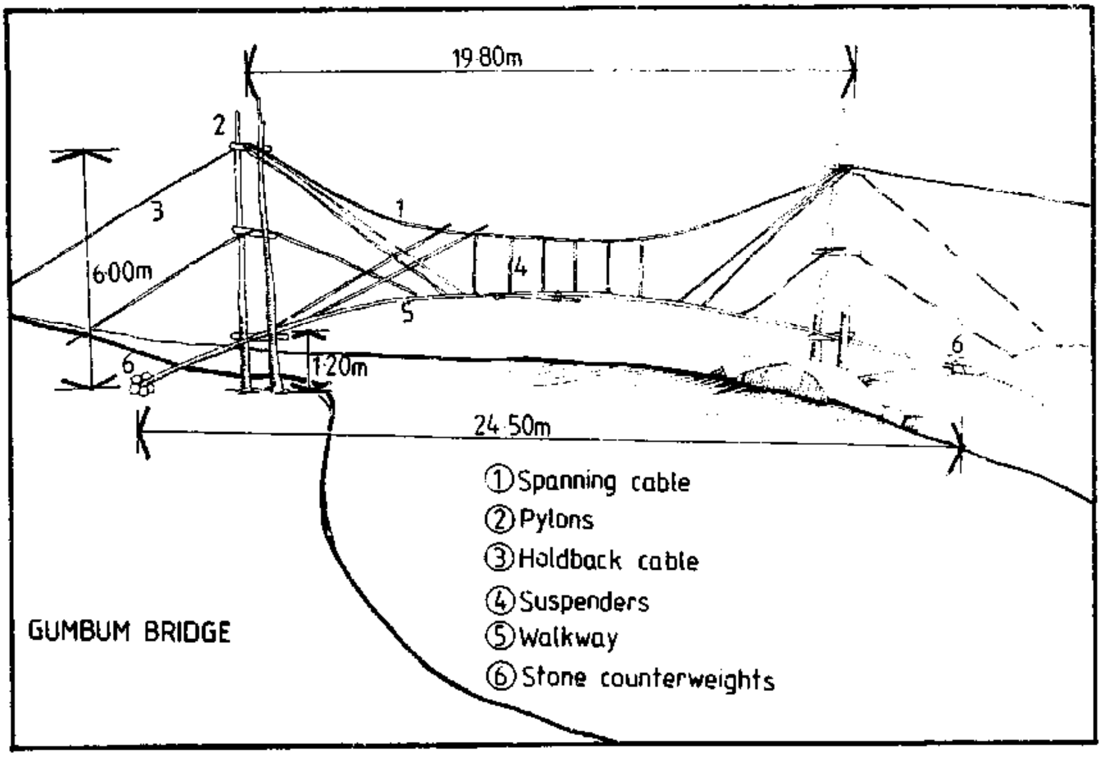


Fig. 134
Drawing of Gumbum Bridge.

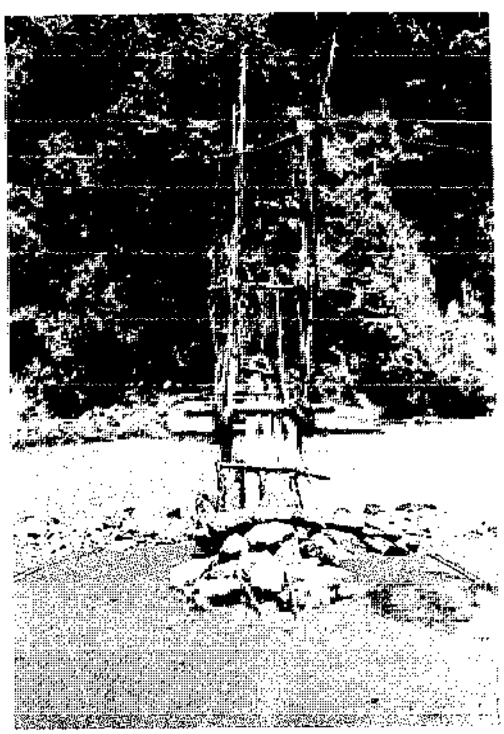


Fig. 135
View of west pylon, Gumbum Bridge. Note the stone counterweights.

Fig. 136
West pylon, Gumbum Bridge. Note the holdback cables at the top and the abutment and cantilever design at the bottom.

Fig. 137

West side of Gumbum Bridge. (Photo by Geoff Smith).

Fig. 138-142

Gumbum villagers, led by Andrew demonstrate with a model how they construct bridges:

Fig. 138

First the pylon is constructed.

Fig. 139

Then the cantilever poles are placed over the lower crossbeams of the pylon and counterweighted with stones.

Fig. 140

Inclined suspension cables from the pylon are added to give additional support to the cantilever walkway.

Fig. 141

Holdback cables are anchored to trees to counteract forces on the pylons from the walkway. A stone is hung from the holdback cable to keep it in tension and thus stabilize the bridge.

Fig. 142

See, it works!

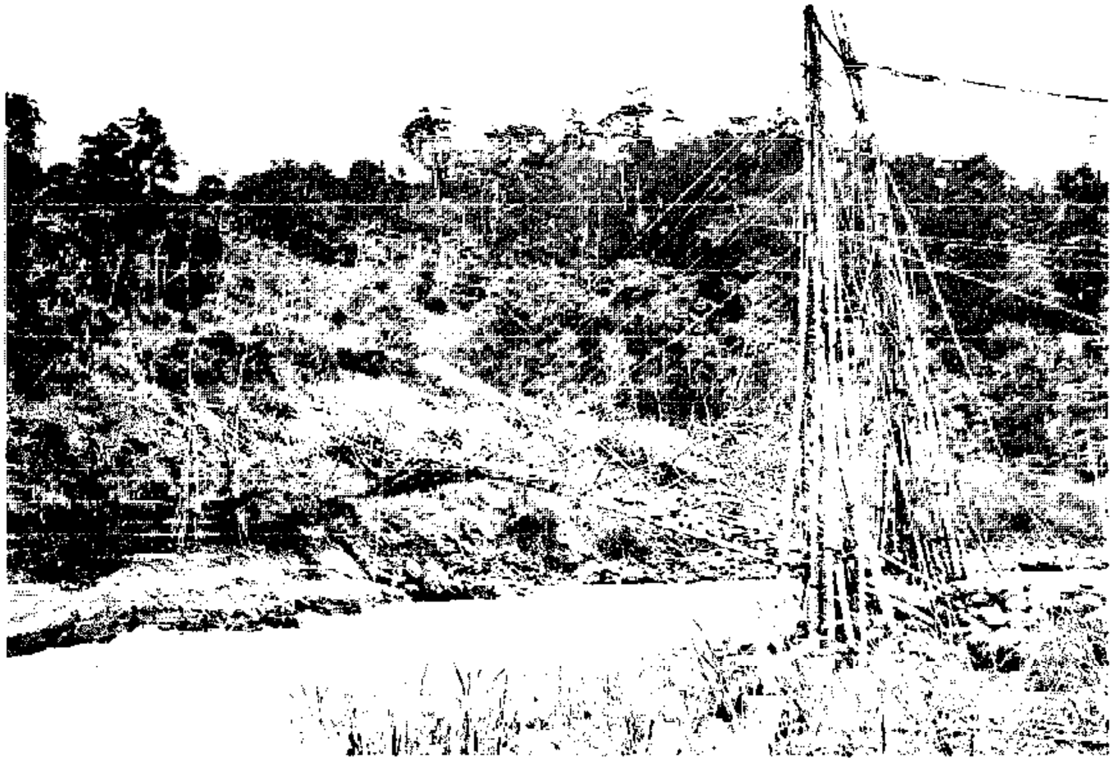


Fig. 143

Sukurun Bridge over the Leren River.

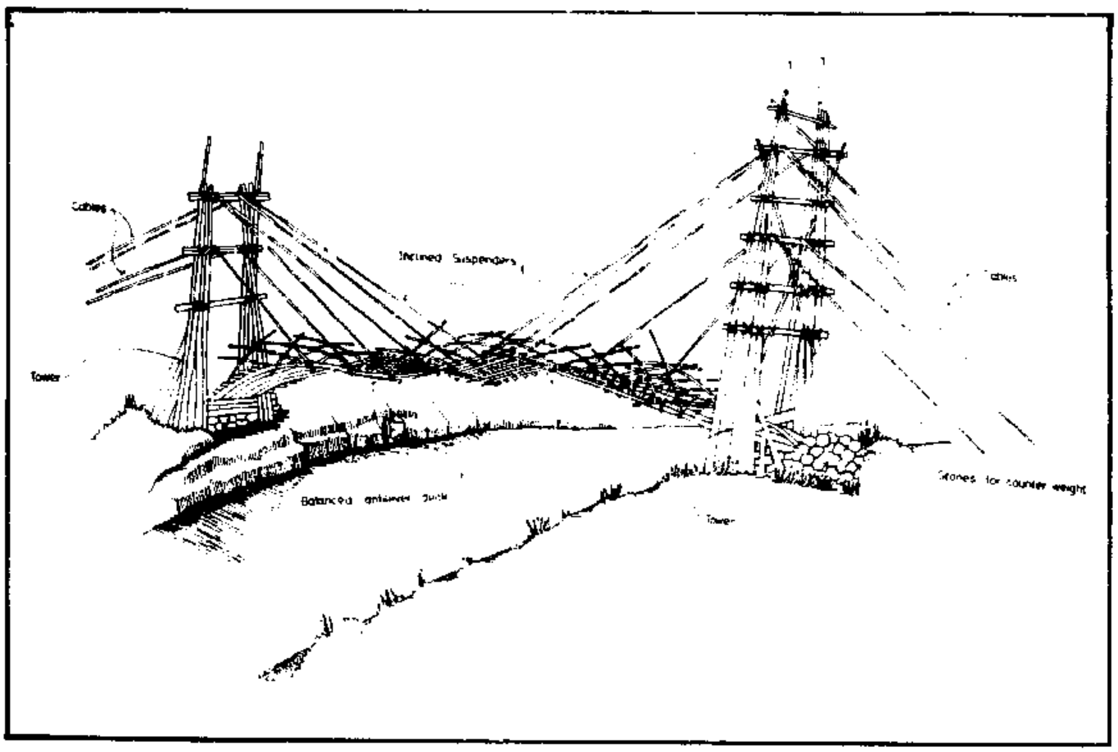


Fig. 144

Drawing of the Sukurun Bridge. (See also drawing).

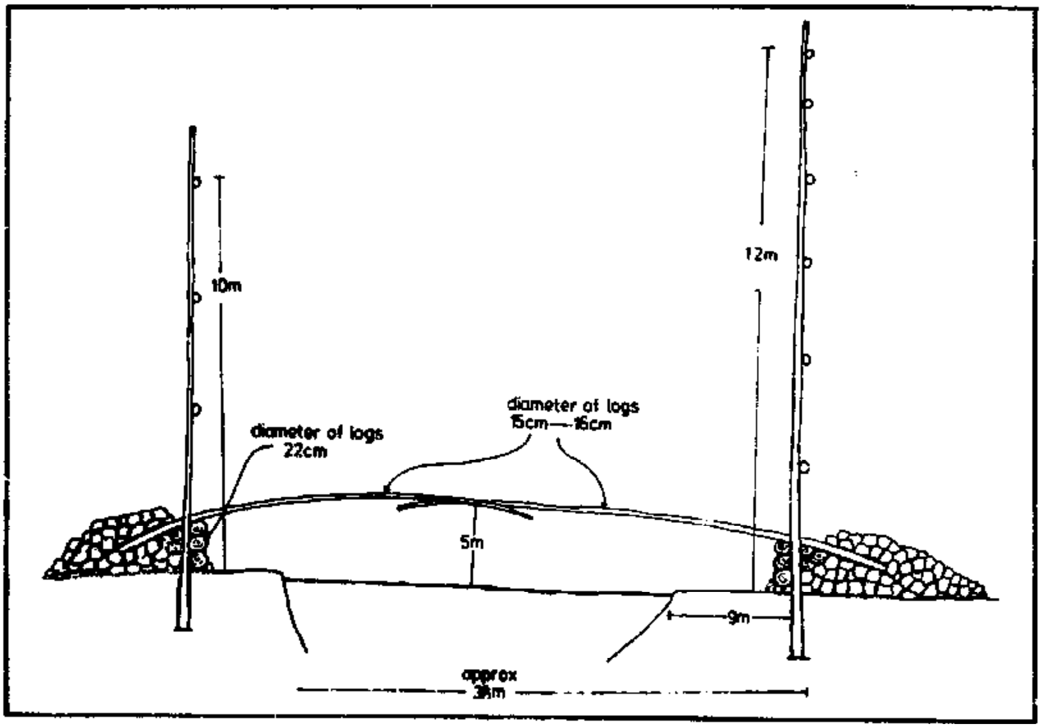


Fig. 145

Profile of the Sukurum Bridge.

Fig. 146

West Pylon, Sukurum Bridge.

Fig. 147

East pylon, Sukurum Bridge. Note the joint in the inclined support cable on the left.

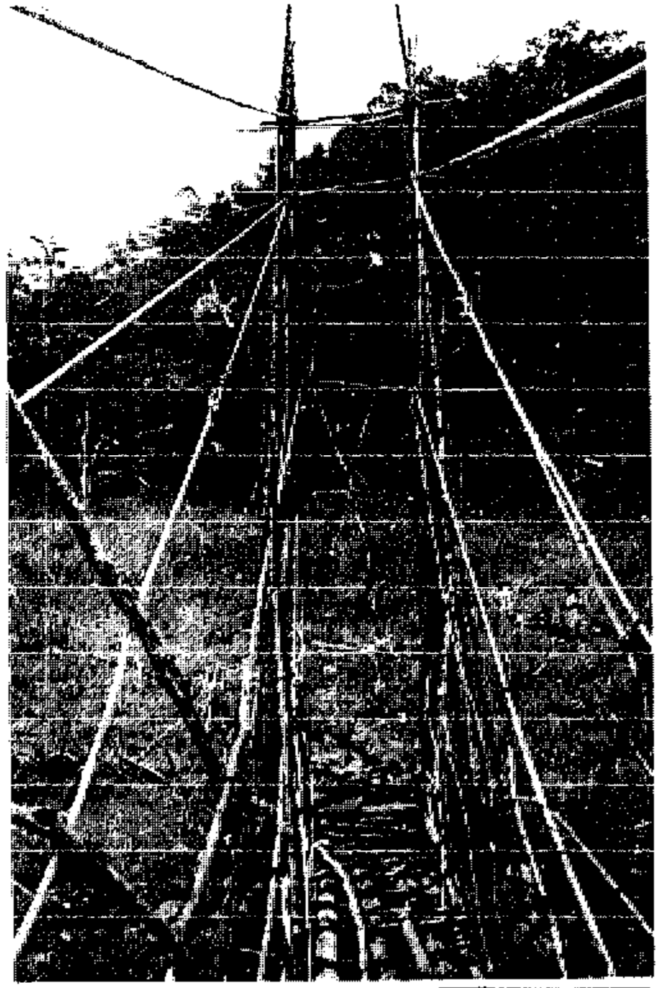


Fig. 148

View from under the walkway showing the lower part of the pylon functioning as an abutment, Sukurum Bridge.

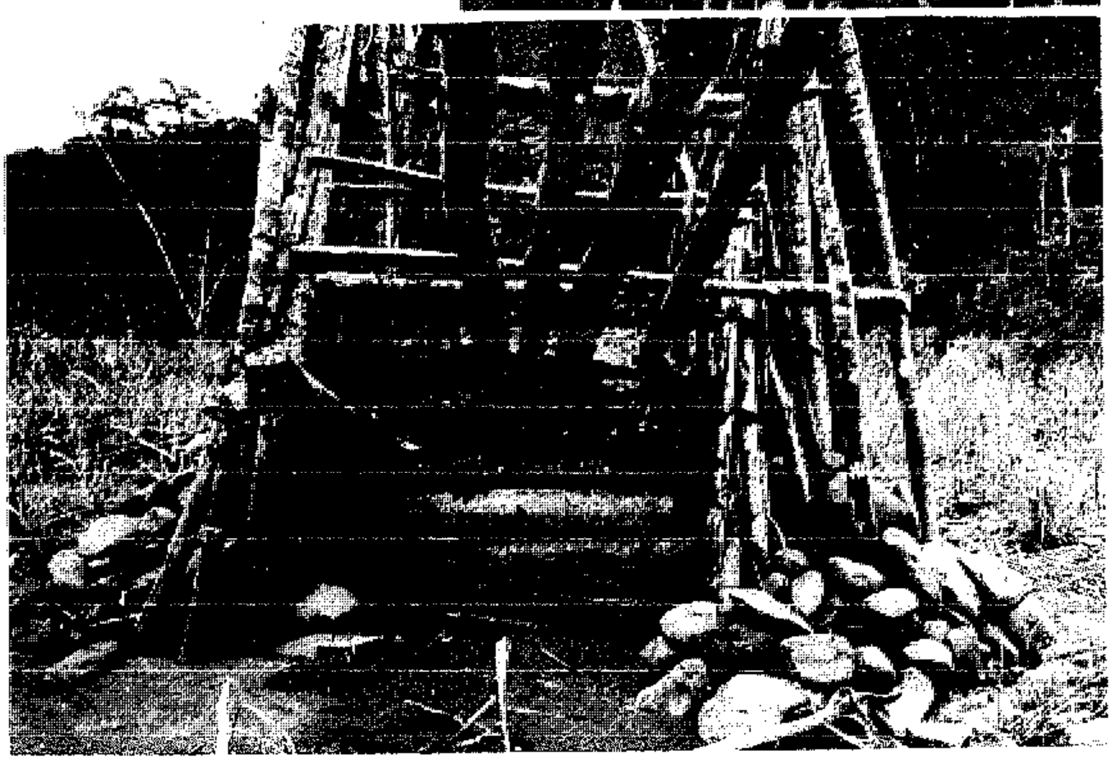


Fig. 149

Another view of the east pylon, Sukurum Bridge.

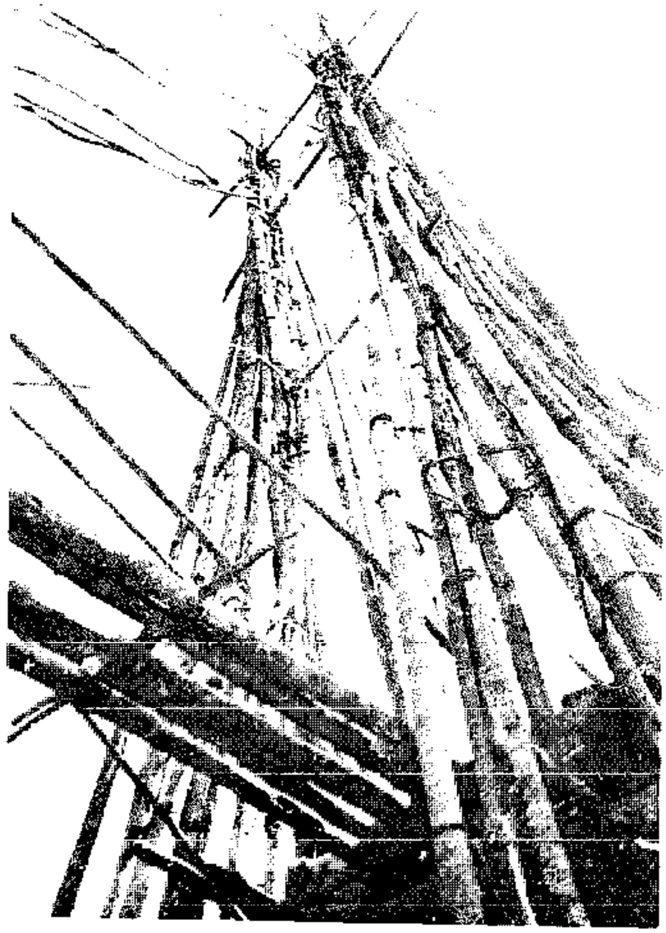


Fig. 150

Sukurum Bridge being constructed in March, 1981. Note the incomplete middle section.

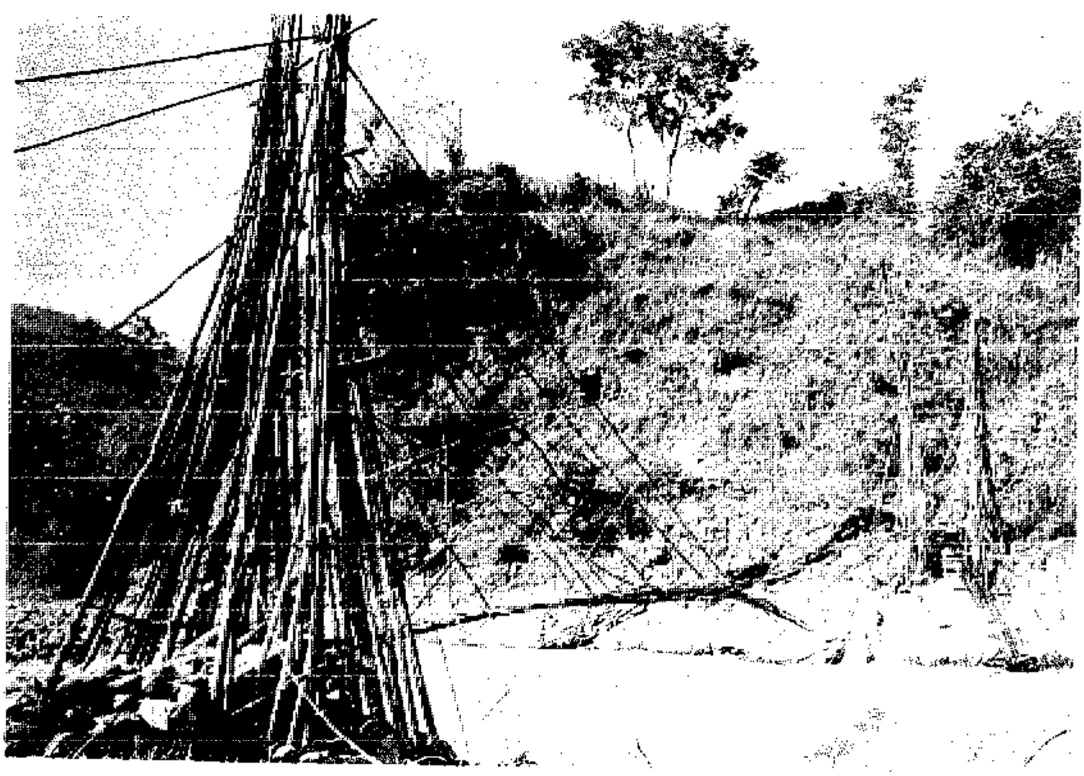
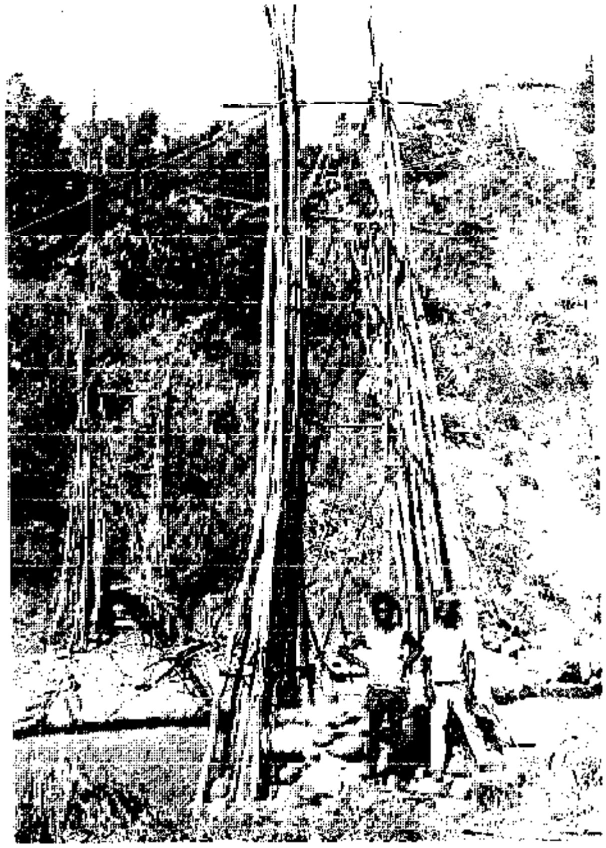


Fig. 151

Sukurum Bridge revisited in March, 1981.



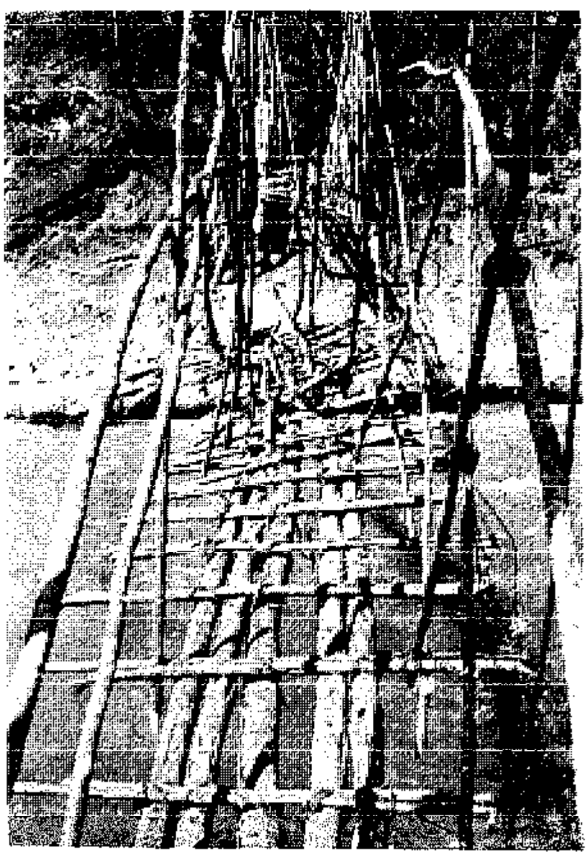


Fig. 152

Walkway under construction with incomplete middle section. Sukurum Bridge.

Fig. 153

Tiaura Bridge over the Waria River.

Fig. 154

Anchorage, Tiaura Bridge.

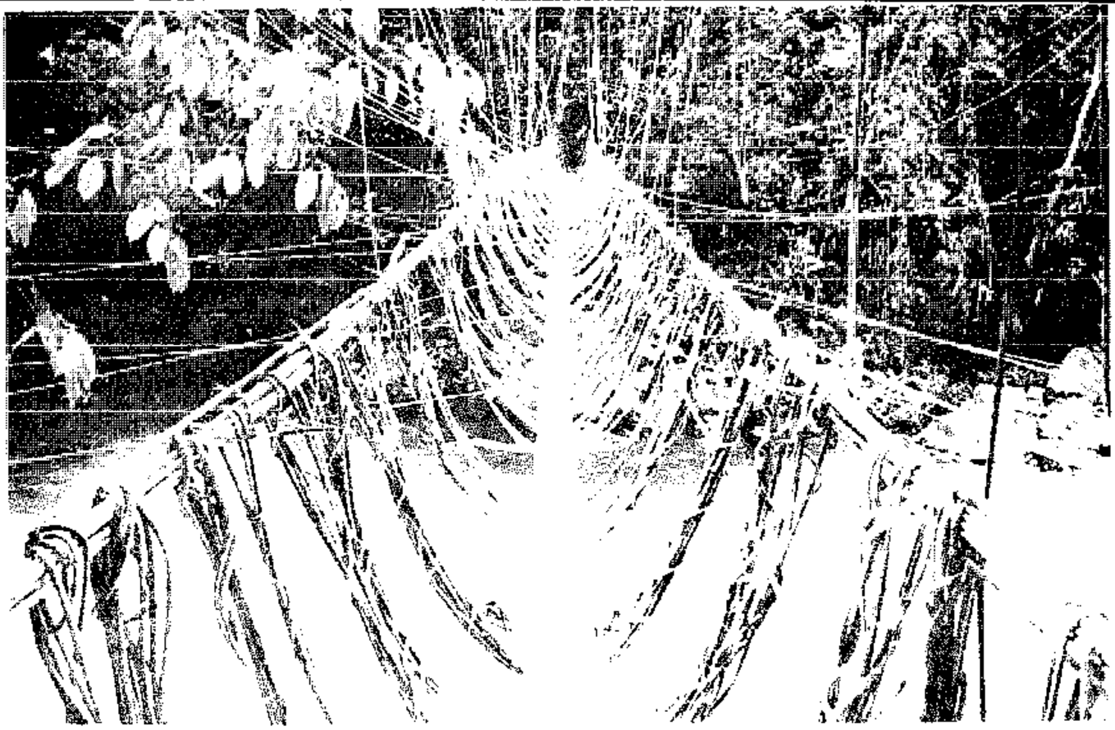


Fig. 155

Sturdy construction of multiple strands of cane for the walkway, suspenders, and spanning cables (forming the hand-rails). Note also the many suspended cables, Tiaura Bridge.

Fig. 156

Cane lashing, Tiaura Bridge.

Fig. 157

Tewa Bridge from the south bank of the Waria River.

Fig. 158

Tewa Bridge from the south bank of the Waria River.

Fig. 159

Tewa Bridge from the north bank of the Waria River.

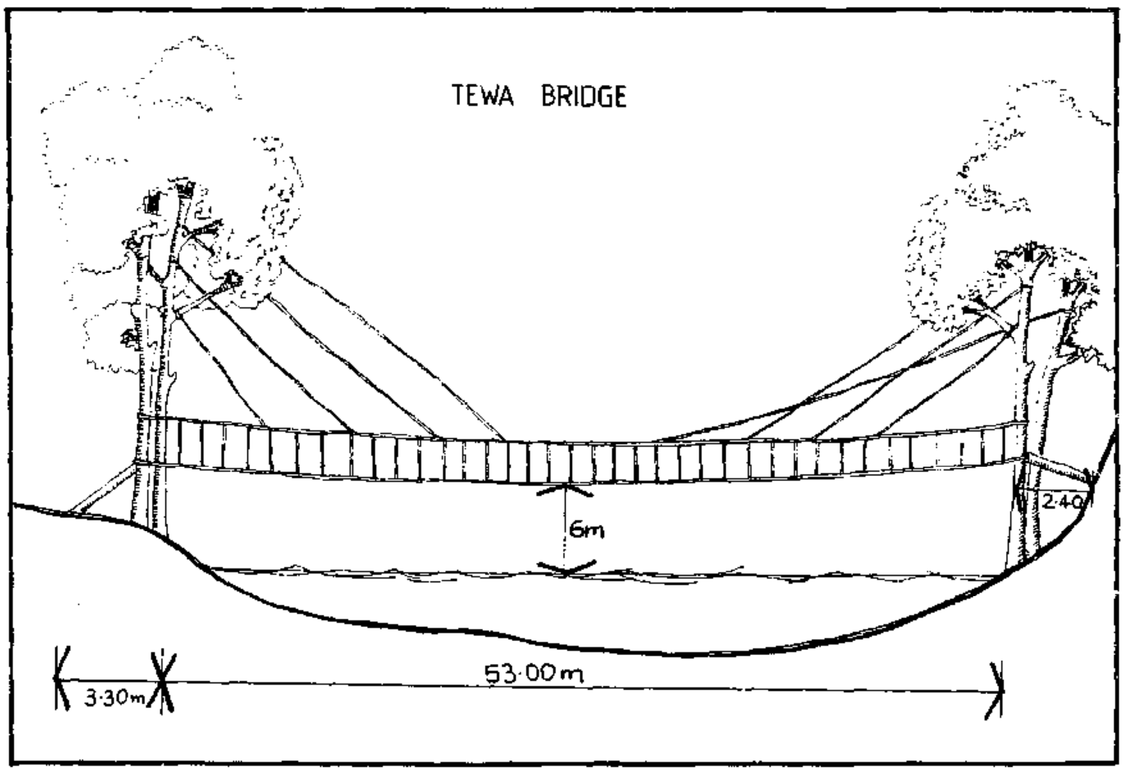


Fig. 160

Drawing of Tewa Bridge.

Fig. 161

South anchorage, Tewa Bridge.

Fig. 162

Lateral support, south anchorage, Tewa Bridge.

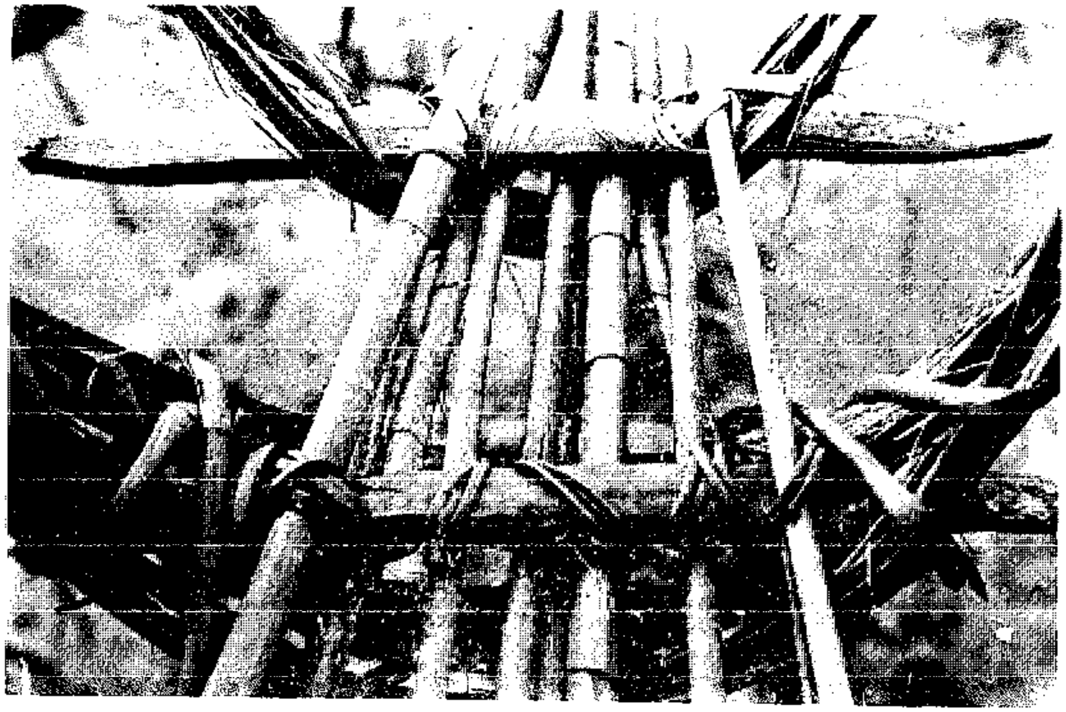


Fig. 163

Detail of walkway showing transverse slats, Tewa Bridge.

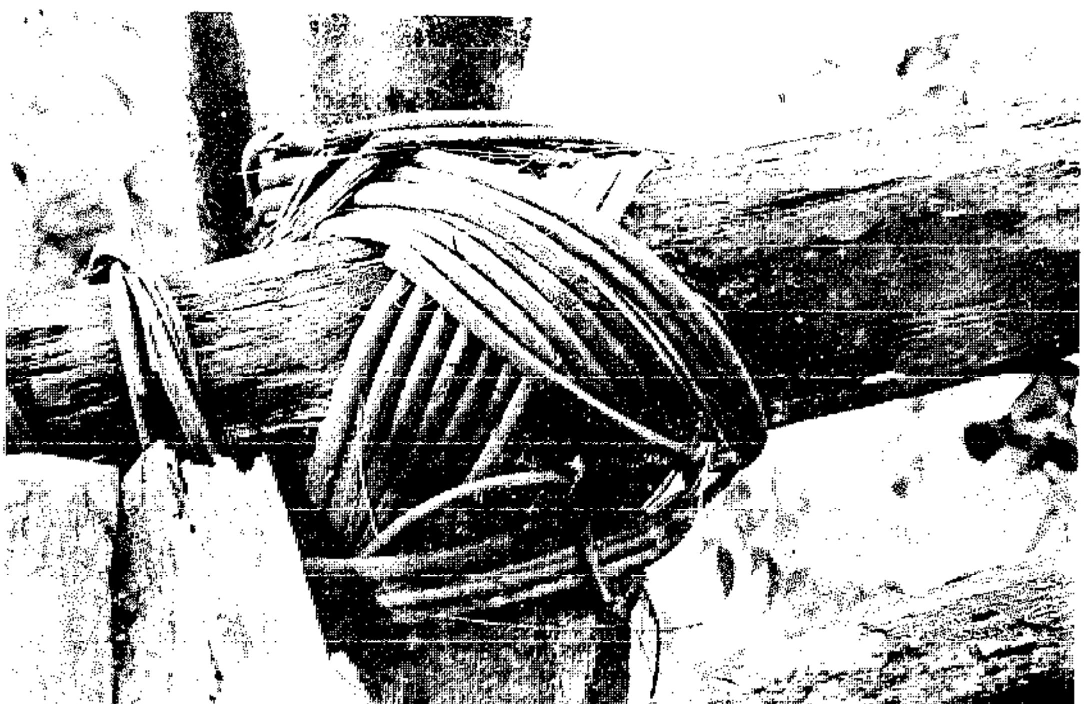


Fig. 164

Detail, cane lashing, Tewa Bridge.

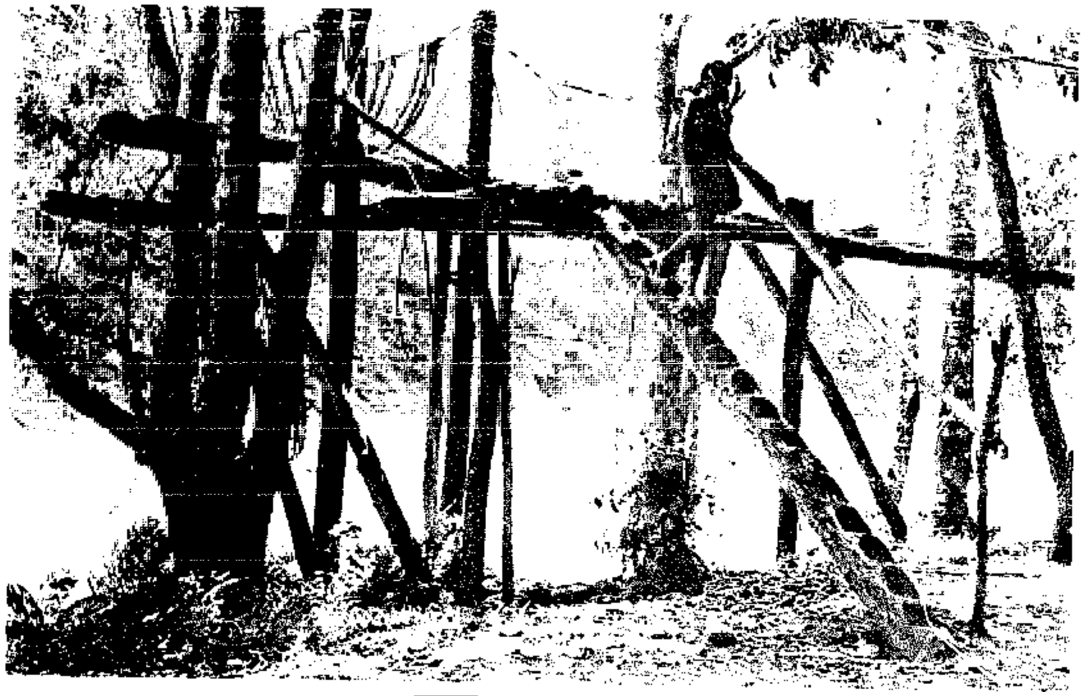


Fig. 165

North approach, Tewa Bridge.

Fig. 166

Bridge builders, Tewa village.

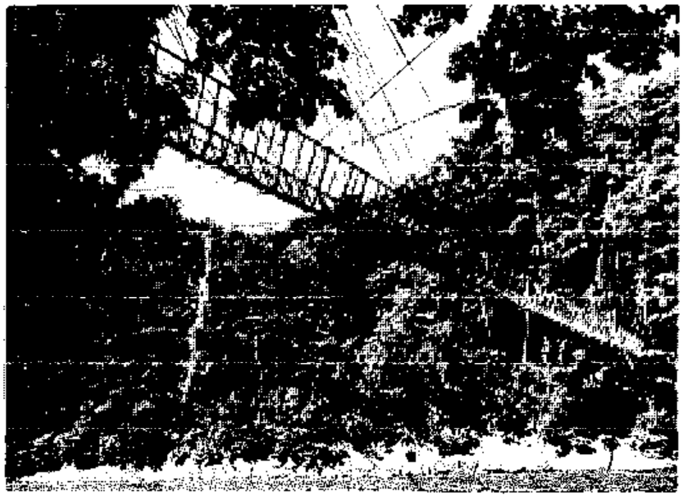


Fig. 167

Bakeri Bridge, looking south over the Waria River.

Fig. 168

North anchorage abd approach, Bakeri Bridge.

Fig. 169

North anchorage, mostly using trees, Bakeri Bridge.

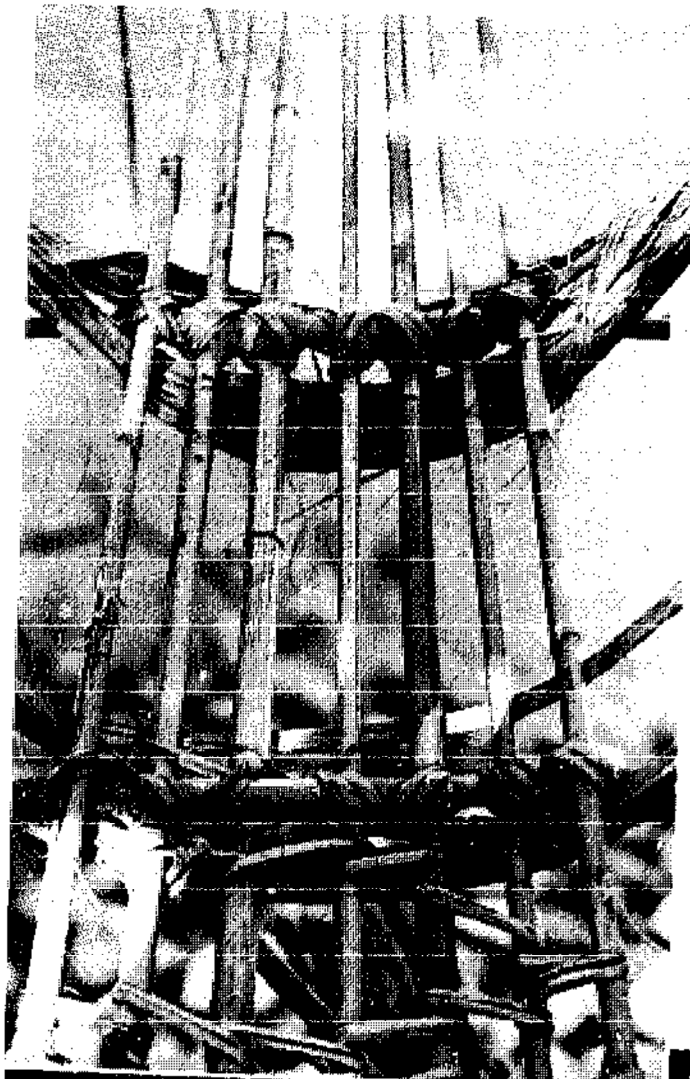


Fig. 170
Detail of walkway,
Bakeri Bridge.

Fig. 171
Bakeri bridge.

CHANGES

Traditional bridge construction has been changing in three ways: 1) complete replacement by imported materials and design; 2) obtaining traditional materials in new ways; and 3) replacing some traditional materials with imported materials in basically traditional constructions. Each of these changes is described here.

4.1 Complete replacement

Where motor vehicle roads have replaced walking tracks, traditionally constructed bridges have of course been replaced. But also on many walking tracks, traditional bridges have been replaced by footbridges using imported materials and design. An example is in Figure 172 and 173 showing a bridge constructed with wood and vines being superceded by a larger bridge using steel cables and concrete anchorages. This is just below Tambul station in the Western Highlands Province (April, 1980).

Such "imported" bridges, called 'wire bridges' in PNG, are more costly and require different knowledge to construct than traditional bridges, but they are supposed to be more durable. However, when Papua New Guinea's might rivers flood, they can take wire as well as traditional bridges. An example is the Fly River below Olsobip. In 1978 the government built a costly wire bridge to replace the traditional bridge. The bridge described in Section 3.2.1 was built in October 1979 after the wire bridge built by the government was washed away. There were no funds or materials for a new wire bridge, so a traditional one was built once again.

Wire bridges are also supposed to be easier to maintain, but the remnants of the bridge over the Sepik (Section 3.2.5) illustrate that the wire bridge may not have been appropriate because it could not be maintained properly.

4.2 New ways of obtaining traditional materials

With money and new forms of transportation, people have new ways of getting hold of traditional materials they may want to use for bridge construction. Two examples have been given earlier. Rather than go far into the bush to find cane, the builders of the Sau River Bridge (Section 3.1.5) purchased it from another village. And the builders of the Kopeme Bridge (Section 3.1.4) brought their cane up from the Markham Valley by truck.

4.3 New materials in traditional constructions

If imported materials such as wire, steel cables, or nylon rope are available, they are often used to repair or reinforce traditional bridges. The Kupolame Bridge (Section 3.1.2) uses wire for holdback cables as seen in the top right of Figure 174). The Pulumita Bridge (Section 3.1.1) also uses some wire as spanning cables. The Ambum Bridge below Wabag High School in the Enga Province (Figure 175) uses a few bits of wire for suspenders and lashing. The Sako Bridge, a 45 metre suspension bridge over the Waria (Figure 176 and 177) uses wire along with cane for spanning and support cables. Finally, the Ambui Bridge over the Lai River near Pompabus Mission (Figures 178 and 179) has replaced vines with red nylon rope for suspended cables.

For the purist, these foreign intrusions into traditional technology are an eyesore, but for the people using the technology, they are an improvement. Perhaps this compromise is the future of traditional technology in Papua New Guinea.

Fig. 172

Traditional bridge near Tambul, Western Highlands, being replaced by an imported one (in the background).

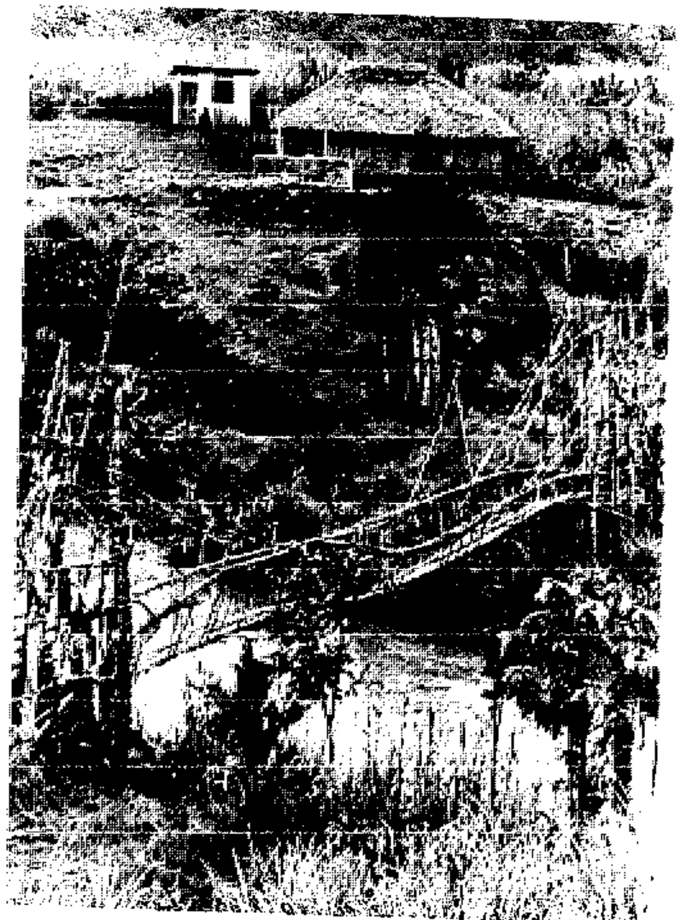


Fig. 173

Concrete abutment and steel spanning cables for a new "wire bridge" to supercede the traditional one below (near Tambul, Western Highlands).

Fig. 174

Wire used for holdback cables (upper right) for the anchorage of Kapolame Bridge, Southern Highlands.

Fig. 175

Wire used for some suspenders and lashing. Ambum Bridge, near Wabag, Enga Province.

Fig. 176

Wire is used for additional spanning cables, Sako Bridge, Waria River, Morobe Province.

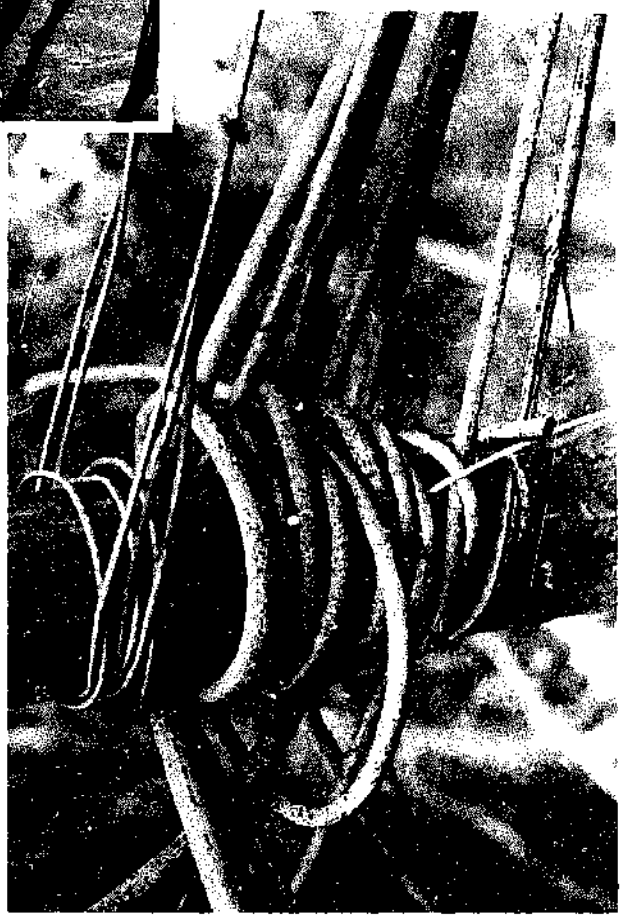


Fig. 177

Wire used for spanning cables fastened to the anchorage alongside the traditional cane, Sako Bridge, Morobe Province.

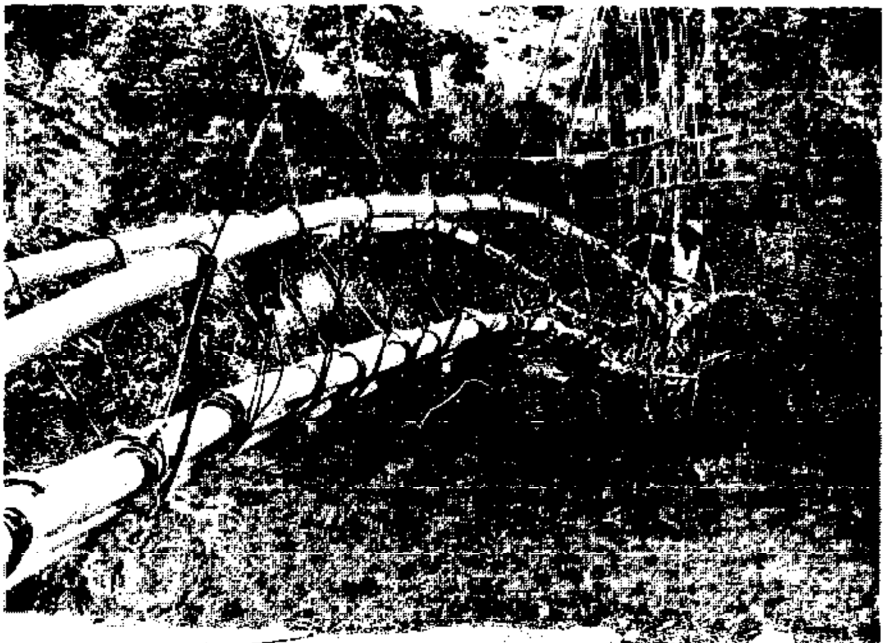


Fig. 178

Nylon rope used as suspended cables especially, midspan, Ambui bridge, over the Lai River near Pompabus Mission, Wapenamanda, Enga Province.

Fig. 179

Nylon rope used for suspended cables, Ambui Bridge, Lai River, Enga Province.

Appendix Bridge Components

Here is a list of the terms used to describe the traditional bridges of Papua New Guinea in this report: (see Figures 134 and 160)

walkway -- (also called gangway or deck) the part of the bridge spanning the river on which people walk.

handrails -- the two spanning members above the walkway which bridge users can hold for balance as they cross or which sometimes support the walkway.

abutment -- (or pier) structure on the bank which supports or carries the weight of the part of the bridge which extends over the water.

cantilever -- beam of a bridge which projects over the water supported at one end by an abutment (which acts as a fulcrum) and counterbalanced behind the abutment by weights such as logs or stones.

anchorage -- structure to which spanning cables for a suspension bridge are fastened.

spanning cable -- thick rope of steel or some natural material which goes from one side of the river to the other in a suspension bridge.

pylon (or tower) -- tall structure of a suspension bridge of which the upper part supports the spanning cables and the lower part acts as an abutment for the walkway.

holdback cable -- a cable which pulls on the pylon from the direction opposite to that of the spanning cable.

suspenders -- vertical, thinner cables connecting the walkway to the spanning cables or handrails.

inclined suspenders (or suspended cables) -- cables to give extra support or stabilization suspended at an angle from a pylon or tree.

approach -- part leading up to the bridge enabling people to reach the walkway.

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48. Another view of Pulumita Bridge.

49. Pole walkway (facing north) with vine spanning cables and suspenders, Pulumita Bridge. A recently added steel cable can be seen in the upper left hand corner.

50. North abutment, Pulumita Bridge.

51. Abutment detail showing vine lashing, Pulumita Bridge.

52. The engineers of the Pulumita Bridge.

53. Kapolame Bridge (from the south bank of the Kaugel River).

54. Kapolame Bridge (from the south bank. Note the suspended cables.)

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56. Kapolame Bridge from the north bank.

57. Kapolame Bridge from the north bank.

58. North anchorage, Kapolame Bridge.

59. Kubib Bridge over Mendi River, seen from the east bank looking south.

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Bridge.

118. Urapmin Bridge, over a narrow part of the Upper Sepik River.

119. Urapmin Bridge.

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136. West pylon, Gumbum Bridge. Note the holdback cables at the top and the abutment and cantilever design at the bottom.

137. West side of Gumbum Bridge. (Photo by Geoff Smith)

138-142. Gumbum villagers, lead by Andrew, demonstrate with a model how they construct bridges:

138. First the pylon is constructed.

139. Then the cantilever poles are placed over the lower cross-beams of the pylon and counterweighted with stones.

140. Inclined suspension cables from the pylon are added to give additional support to the cantilever walkway.

141. Holdback cables are anchored to trees to counteract forces on the pylons from the walkway. A stone is hung from the holdback cable to keep it in tension and thus stabilize the bridge.

142. See, it works!

143. Sukurum Bridge over the Leron River.

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168. North anchorage abd approach, Bakeri Bridge.

169. North anchorage, mostly using trees, Bakeri Bridge.

170. Detail of walkway, Bakeri Bridge.

171. Bakeri bridge.

172. Traditional bridge near Tambul, Western Highlands, being replaced by an imported one (in the background).

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174. Wire used for holdback cables (upper right) for the anchorage of Kapolame Bridge, Southern Highlands.

175. Wire used for suspenders and lashing. Ambum Bridge, near Wabag, Enga Province.

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177. Wire used for spanning cables fastened to the anchorage alongside the traditional cane, Sako Bridge, Morobe Province.

178. Nylon rope used as suspended cables especially, midspan, Ambui Bridge, over the Lai River near Pompabus Mission, Wapenamanda, Enga Province.

179. Nylon rope used for suspended cables, Ambui Bridge, Lai River, Enga Province.