Construction of Trail Suspended Bridges in Nepal: An Application of Traditional Technology

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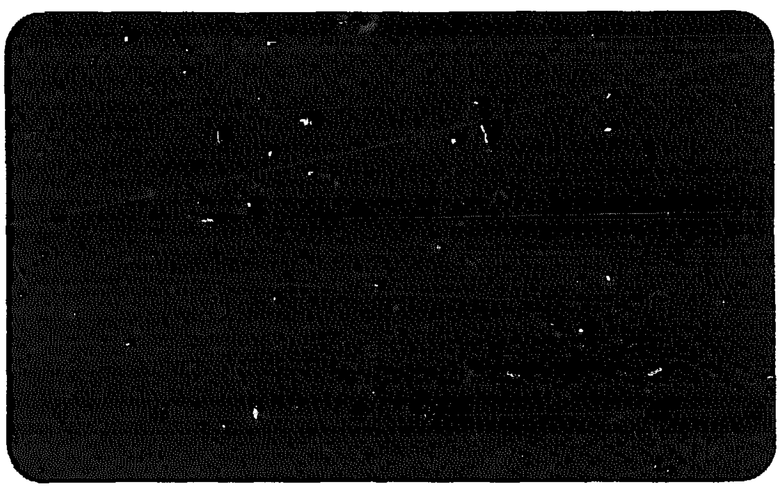

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CONSTRUCTION OF TRAIL SUSPENDED BRIDGES IN NEPAL: AN APPLICATION OF TRADITIONAL TECHNOLOGY

Prachanda Pradhan

Development Research and Communication
Group (Pvt. Ltd.)
Kathmandu, Nepal

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This paper is being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

INTRODUCTION

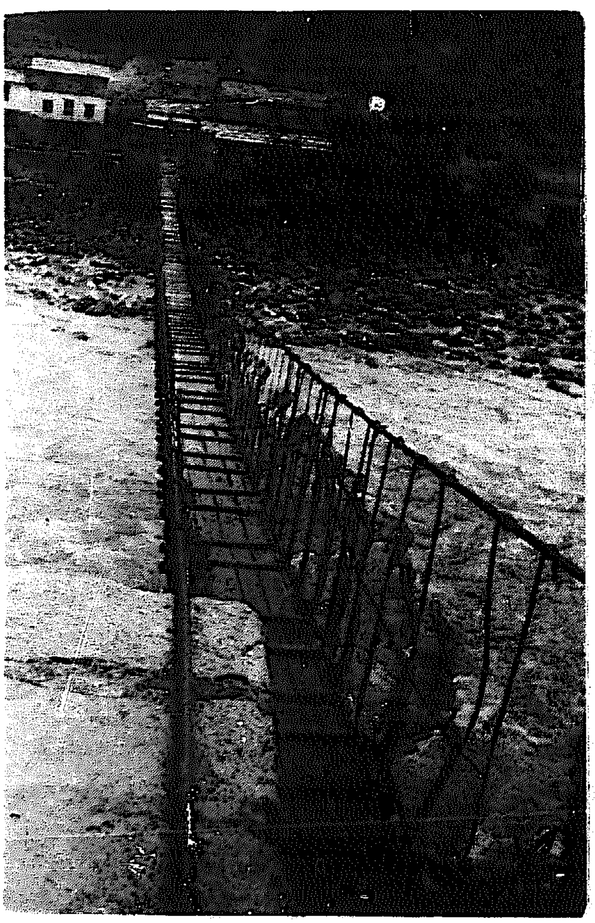
The hill terrain of most of the middle region of Nepal forced the people of the area to devise ways for negotiating the rivers which are interspersed across the valleys and along the mountains of Nepal. In earlier times, when Nepal was divided into a number of principalities and petty states, the rivers were viewed as natural boundaries providing protection from neighbouring principalities and from external socio-economic influences. When these principalities were unified into one nation under one political system, the economic activities of the people expanded and more social interaction was looked for. Consequently, it was necessary to find ways of negotiating the rivers in order to increase social and economic interaction beyond the isolated valleys and villages of the mountain regions.

Because of the turbulent, fast-flowing, high-current rivers cutting across the rugged hills and mountains, boats did not prove to be a very satisfactory mode of crossing the rivers in many places. So the people had to look for a technology that would provide a more durable, permanent, and secure system of crossing. They devised locally made rope suspended bridges, locally made rope cable cars, and improved cable cars, and also constructed cantilever-type bridges, suspended bridges, and suspension bridges. Cantilever bridges are seen in most of the northern mountainous regions of Nepal, where there are well-developed pine forests. In the middle hill regions, by and large, where rivers are invariably wide and where there is a shortage of the type of timber needed for cantilever bridges, the people developed a technology of constructing suspended bridges with cables or iron chains.

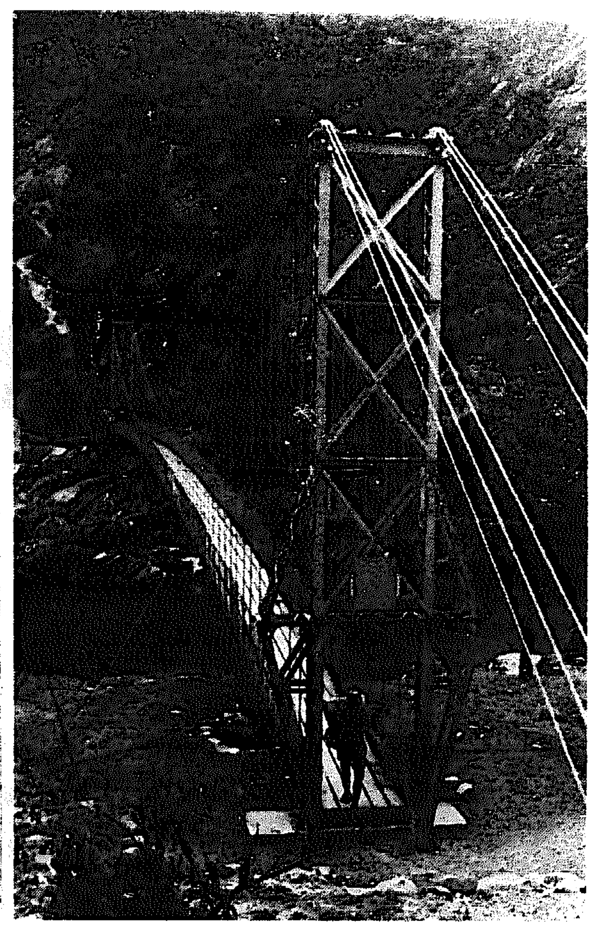
Rope suspended bridges, rope cable cars, and improved cable cars provided opportunities for very limited economic interactions. These modes with their limited scope of activities were developed by the local people themselves, but they had to be replaced each year. Also, their safety factor was low. The lower the level of economic transactions within an area, the worse would be the rural transport system in that area. The economically betteroff places in Nepal for the most part had cable or chain suspended bridges. These bridges were usually constructed by the local people, using the local skills and traditional technology, but often the Government would support these local projects by providing such materials as cables and iron fittings as well as financial help.

This paper will discuss in particular various aspects of the technology of constructing suspended bridges. Of the various means of crossing rivers we have mentioned, suspended bridges have gained wide acceptance and represent the most appropriate technology available in Nepal. Both suspension and suspended bridges are trail bridges; however, the technology used is different. In the case of suspended bridges the walkway is sustained by the lower cables, whereas in the case of suspension bridges the upper main cables sustain the walkway. In suspension bridges the main cables take the load. The walkway cable is tied by suspenders.

The use of a particular technology emerges out of the socio-economic, cultural, and political needs of a given society. Traditional suspended-bridge technology has been



Suspended Bridge



Suspension Bridge

extensively used for mass construction of bridges in the Banglung District of Nepal. The first section of this paper presents a case study of the Banglung Suspended Bridge Construction Project, undertaking to throw light on the dynamics involved in utilizing locally available skill and technology in suspended bridge construction. The following sections discuss the technical and economic aspects of the construction and the impact of the bridges on the life of the people.

I. A CASE STUDY ON THE DYNAMICS OF SUSPENDED-BRIDGE CONSTRUCTION USING TRADITIONAL TECHNOLOGY

This case highlights the use of traditional technology for construction of suspended trail bridges in Banglung District, which helped tremendously to improve the rural trail transport system within the district. By using traditional technology, the people of the district were able to construct in an unprecedented manner a large number of bridges at remarkably low cost because the project deliberately avoided using exotic and costly materials. With the exception of the basic cables themselves, materials that would have had to be imported from outside the district, such as cement, were avoided, and instead iron fittings and other materials that were made or available in the district were used. An important feature of the project was the large-scale participation of the local people in selecting the sites of the bridges, in transporting the construction materials, and finally in constructing the bridges themselves.

The planners in the initial phase of the Rural Transport Development Program, funded by USOM/Nepal in 1958, did not realize that the people in Banglung District used local traditional technology for bridge construction. The local people already had the technology for constructing different types of bridges, but the large-scale construction of suspended bridges with the maximum use of locally available materials has proved their knowledge of and their skill in suspended-bridge construction technology. There was a time when they made chains for bridges from locally mined iron; but eventually, when iron-mining became difficult, they had to abandon this method and depend on imported iron or cables.

The traditions of bridge construction were continually reinforced by social values and the concept of religious gains after death. It has been a tradition in this district that a well-to-do person who wanted to undertake a work of charity would donate money for a public facility such as a school building, a *chautara* (a stone structure built around a tree or two as a resting place for travellers and porters), or a bridge across a river. In such ventures, other people in the locality would contribute free labour to help the donor realize his act of charity. Contributions of voluntary labour have also been a part of the culturally recognized system of *parma* (a household labour-exchange system on a reciprocal basis). Parma takes place mostly during the planting and harvesting seasons and during the construction of individual houses in a village. So the sharing of labour is a part of culture in this region.

Because of the use of locally known technology, the level of people's participation in different activities of bridge construction was high. A committee was formed for the construction of a large number of bridges with the objective of making the district "suspension-bridge-free" in the course of time. As of now, the committee has been busy meeting the target of constructing 62 bridges at a cost of Rs 650,000. The committee has mobilized maximum participation of the local people. A sub-committee was formed to carry out the actual physical construction of the bridge at each site. The committee provided the sub-committee with the required quantity of cable and iron fittings and, if necessary, an amount of money depending on the span of the bridge. The materials required for the bridge had to be carried by the people from the nearest motor road to the bridge site. When asking for the materials for bridge construction, the sub-committee had to assure the committee that they would mobilize local people for the construction of the bridge. If such participation was not assured, the materials were not made available. In comparatively backward areas of the district with less articulate people, the committee took special initiative to help the people build the bridge.

In consultation with the local people, the sub-committee would make rules and regulations for contributions to the construction of the bridge. Generally, one person from each household in the village had to help with portering the materials. Those who could not participate in this effort were required to contribute food or money to the people who participated as their substitutes in the actual work. In some cases, only those villages which were going to get direct benefit from the bridges were involved in the bridge construction.

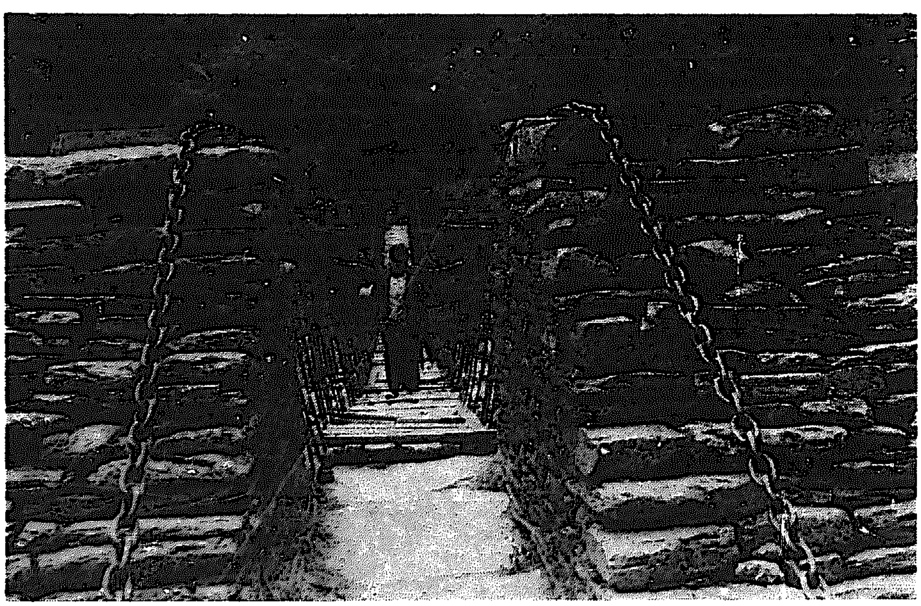
Timing is one of the important factors for getting such public works projects undertaken with people's participation. The villagers willingly co-operate and participate during the post-harvest period, when they do not have much work on their farms. Construction of bridges takes place two times a year — in March and April, when villagers bring materials to the site, and later in December and January, when they work on the actual construction of the bridge. According to the information collected in the field, once all the materials are at the site, it takes 25–40 days to get the bridge completed. The skills and technology of bridge construction have been handed down from generation to generation within the villages. For these people, a bridge is much more than just an easy means of river crossing; it is a symbol of the "capability" of the villagers.

II. TECHNICAL AND ECONOMIC ASPECTS OF THE BRIDGE CONSTRUCTION

Technical Aspects

The major tasks involved in the construction of suspended bridges are the hoisting of the cables or chains, construction of anchor blocks without the use of cement, anchorage, attaching the suspenders, and building the walkway. The major work connected with these different technological aspects of bridge construction is done by local technicians. The materials except the cable and iron-fittings are locally available, and the local technicians make use of them by applying the technology transferred from generation to generation within the community.

Cable or chain: The set of cables which rest over the anchor block and span the river appear to carry the greater portion of the load. There has been a shift in the use of materials for this main cable. Formerly chains made of iron mined locally were manufactured within this area and were used as "cables." Later, with the depletion of the forests



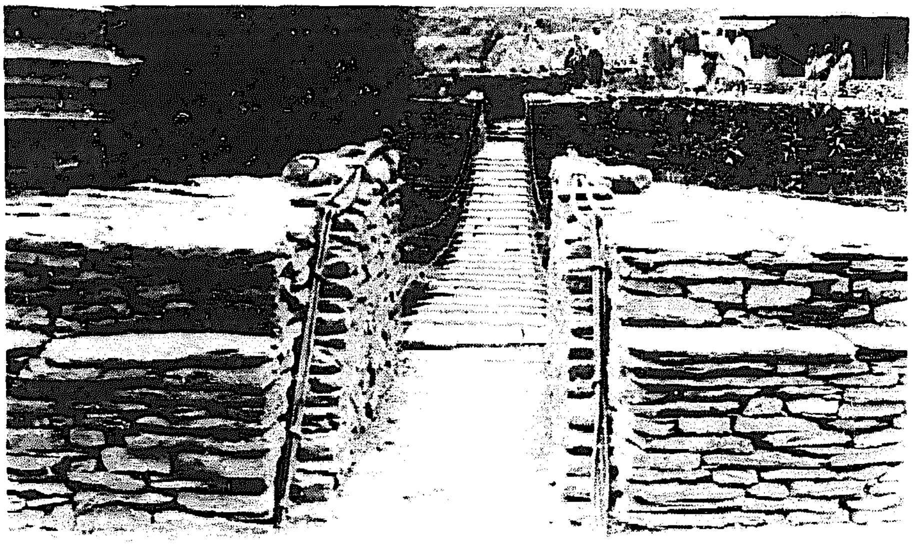
Chain Bridge

and the higher cost involved in exploiting the local iron mines, the people started importing raw iron from India and carried it up to the bridge sites, where they moulded it into chains. Later still, this system also proved uneconomical and pressure on forest resources forced the people to abandon this system of making chain out of iron imported from India. In search of alternatives, they started buying rejected ship anchor chain from Calcutta, India. Ultimately, the people started constructing suspended bridges using cables. The main cables usually consist of two 1¼-inch-diameter cables or sometimes two ¾-inch-diameter cables. The main cables and walkway cables are connected with flat steel suspenders or sometimes with round bar suspenders. The cables are hoisted manually except for those on long-span bridges, which require the use of a winch machine.

Cable Bridge

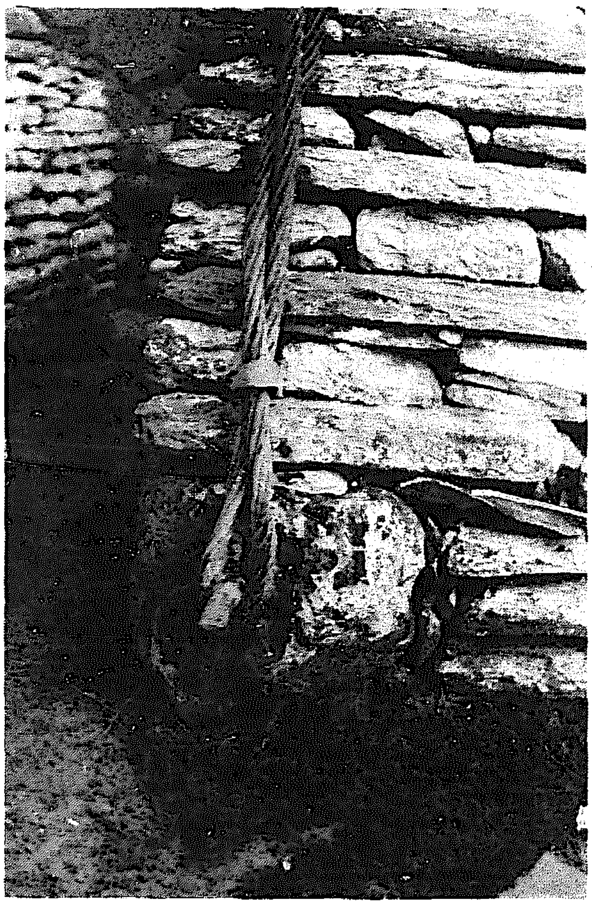
Anchorage: Two types of anchorage system are found. In the first type, the cables are stretched over the anchor block and the ends either are fastened to a fairly large stone of about 900 pounds (about 400 kilograms) by being passed through a hole bored into it and then wound up a couple of times or else are hooked to a metal shaft bored into a large stone. Then this stone is buried about 9 feet (2.75 metres) below the ground level and fixed to the main cable by means of locally made clamps. The same process is used for the walkway cables as well. This anchorage system appears to be fairly popular in the area.

The second type of anchorage system is the anchor-rod type. According to the local people, whenever they come across rock beds which cannot be excavated deeply enough

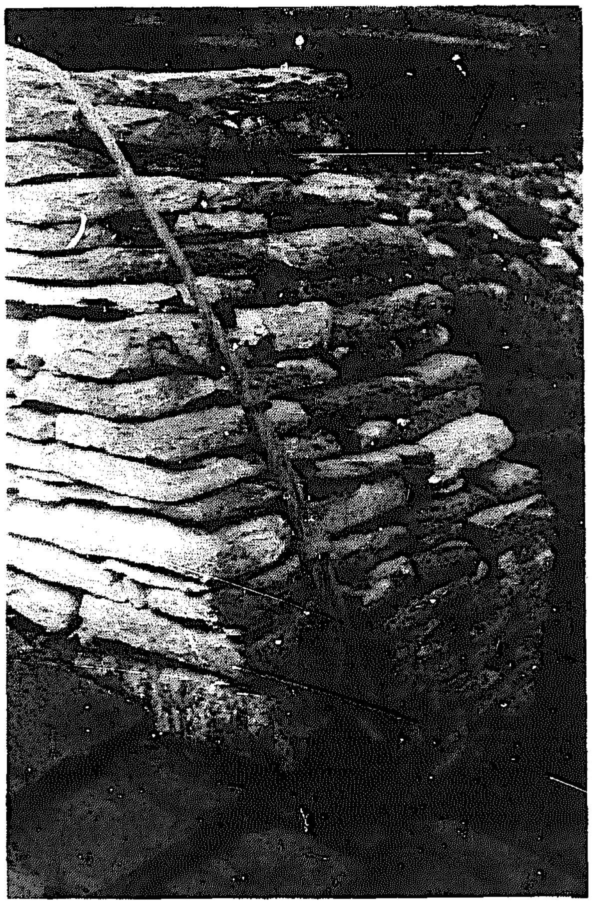


Underground Anchorage

to bury the anchorage stone and if the rock is found to be hard enough, they bore a hole into it for the anchor rod. A good hard stone such as gneiss or granite is selected and



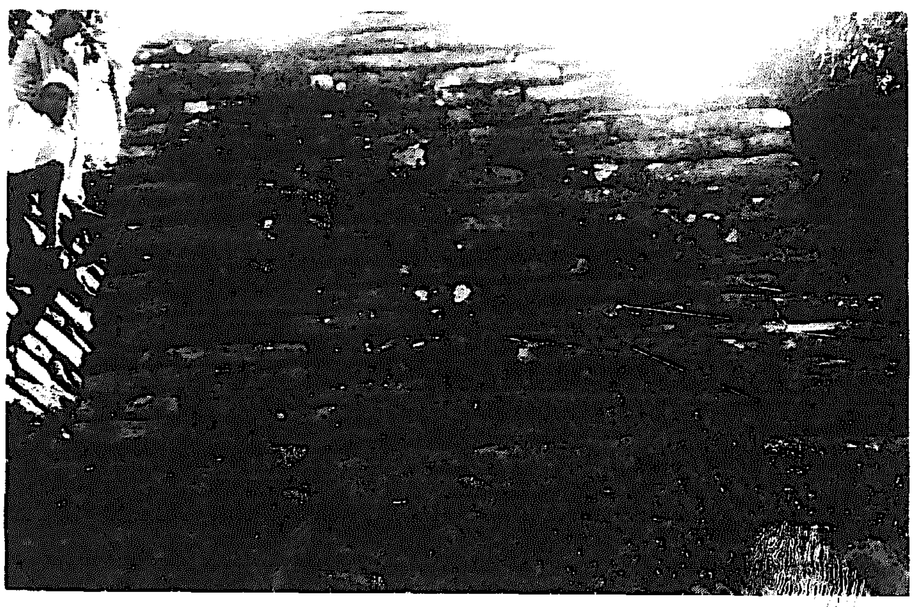
Hook Anchorage



Hook Anchorage

used as the anchoring rock. The hole is usually about 1½ feet (0.5 metre) deep and is bored in such a way as to form a bulb-like shape at the closed end. One end of a steel rod of ½- to 1½-inch diameter is heated until it is red hot and is hammered into the hole; this presumably causes the red-hot, malleable part of the rod to expand and fill the bulb hole and thus become permanently fixed. Then the outer end is bent into a hook.

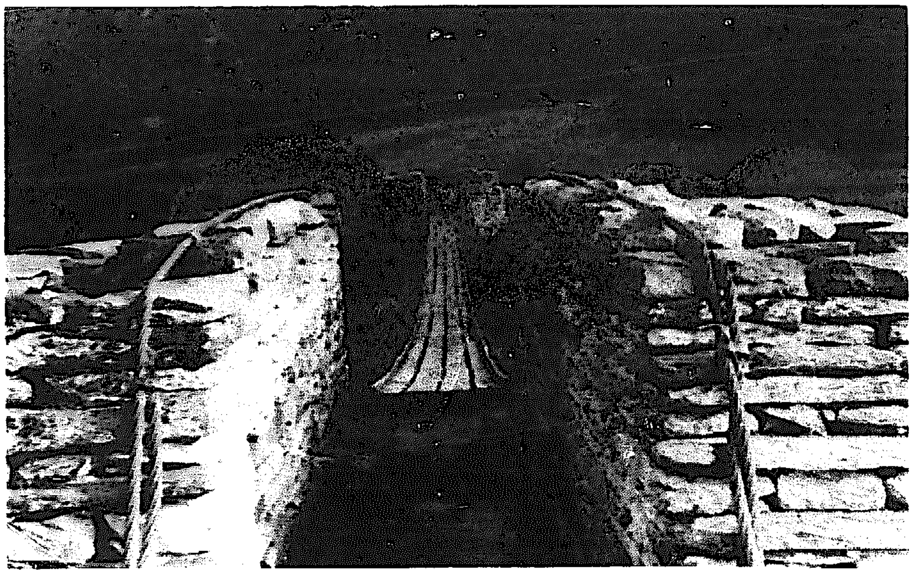
The anchor block: Hard stones like granite, gneiss, and quartzite are available in most of the area of the case study (Banglung District). Schist has also been used for anchor blocks. The stones are, in general, dressed and cut into flat rectangular blocks. No mortar is used, and the stones are held together by their own weight and the way they are laid which is invariably in an "English bond" arrangement.



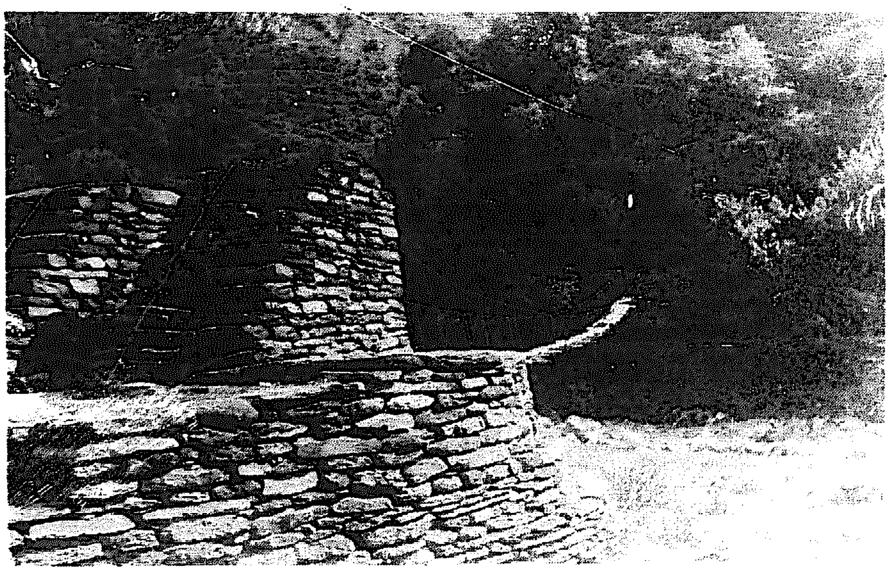
Anchor Block

The standard developed by the local people for the size of the anchor block is as follows: For a span of about 45 feet (13.7 metres) the length of the block, in the longitudinal direction of the bridge, should be about 12 feet (3.7 metres); and for a span of about 90 feet (27.5 metres) the length of the block should be around 18 feet (5.5 metres). The height of the block rarely exceeds 6 feet (1.8 metres) above the walkway entrance level.

Some anchor blocks are round and some are rectangular. According to the local people, round blocks are made only for aesthetic reasons. (But a round base would be preferable in the event of high water or flooding, because water would flow past the base of the block more readily.)



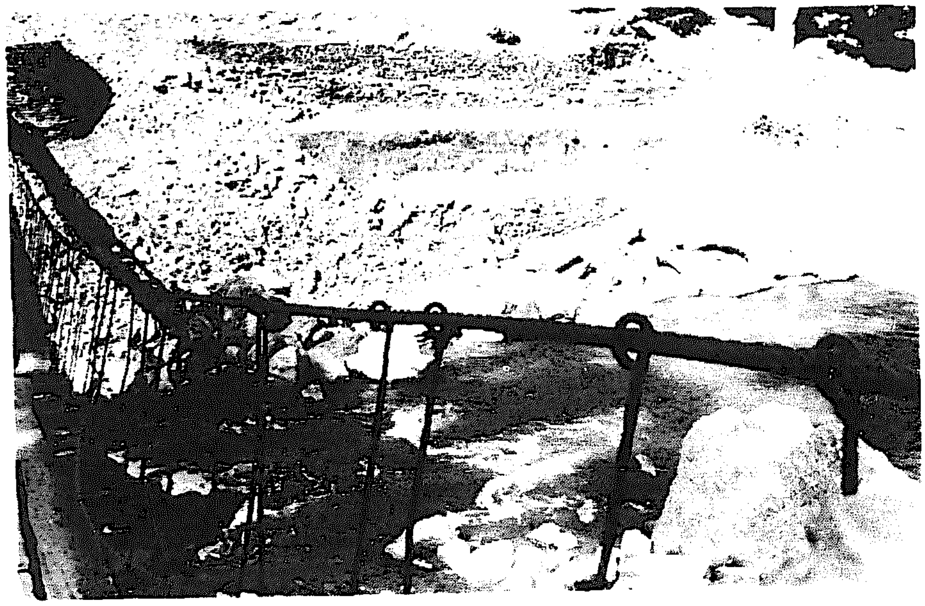
Anchor Block



Anchor Block

In all the bridges investigated in the study area, the anchor blocks are always above the highest water level that has been observed by the oldest man of the locality.

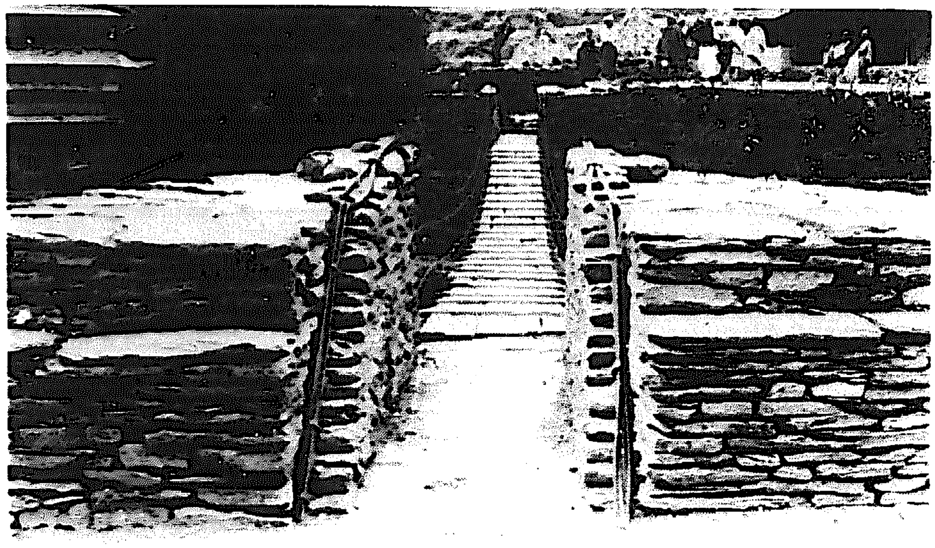
Suspenders: The steel suspenders either are locally made or are procured through manufacturers' workshops in Kathmandu. Sometimes ordinary mild steel rods are used. Different types of suspenders such as flat iron bars, rods, and even ropes are used, depending on their availability and suitability.



Suspenders

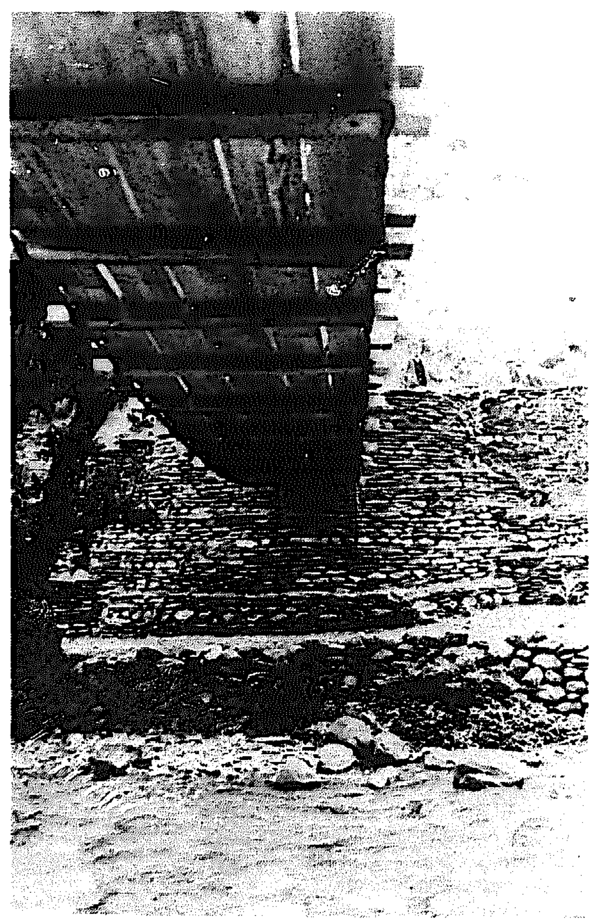
Suspenders

The walkway: The walkway is simple to construct, and those in the study area have been excellently made. The planks for the walkway are collected from the nearby forest. In some bridges, a pair of cross-beams are nailed or screwed to the top and bottom of the planks, presumably to hold the planks more firmly. It is also said that the cross-beam construction is better suited to animal traffic because the top cross-beams prevent the animals from slipping. The fixing of cross-beams to the walkway cables has been skillfully executed by the local craftsmen. The walkway with an average width of 2½ feet (0.75 metres) is wide enough for human as well as animal use.



Cross-Beam Walkway

Plain Walkway



Cross-Beam Walkway

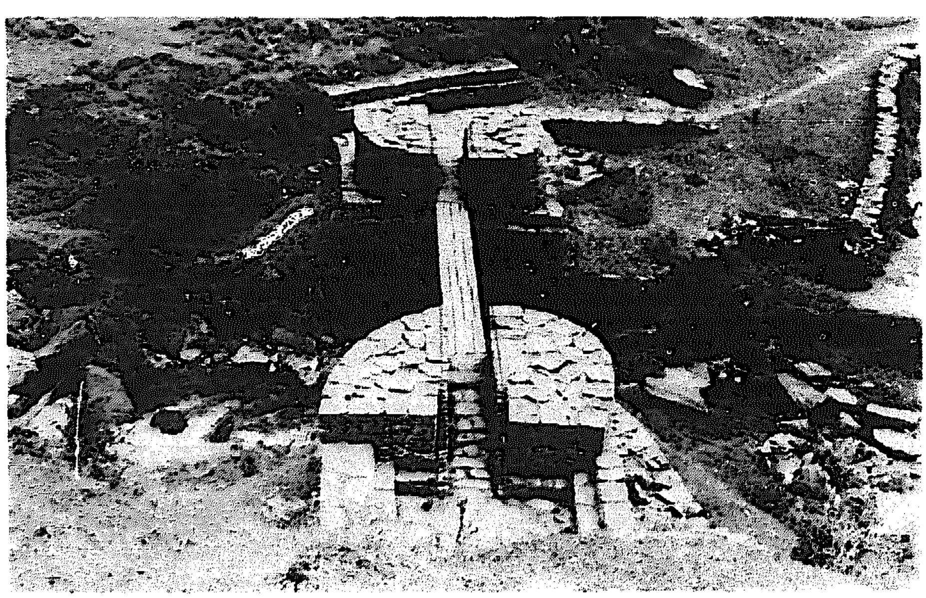
Cost Factors in Bridge Construction

Using technical know-how available locally, bypassing the usual administrative infrastructure, and making a deliberate effort not to use imported materials like cement reduces the cost of bridge construction tremendously. In the Government's undertakings, it is estimated that between 25 and 40 per cent of the total cost of a bridge goes for administrative overhead expenses such as office maintenance costs, salaries, and allowances for staff. In addition, the amount of money spent on materials like cement and its transportation is quite substantial.

A suspended bridge of 270-foot span over Kaligandaki at Armadi (Banglung District) cost only Rs 140,000, whereas a suspension bridge of similar span would cost about Rs 1,100,000. In the same district, the Government undertook to construct a suspended bridge over Kathe Khola near Banglung Bazaar at a cost of Rs 65,000, whereas a similar bridge was constructed by the local people at the cost of Rs 20,000. The Banglung people could not believe that the Kathe Khola suspended bridge cost Rs 65,000 because these people were directly involved in the construction of similar bridges in the district.

Safety and the Expected Life of the Bridges

Engineers are of the view that the safety factor for travellers crossing all major bridges is



Suspended Bridge

good. Structurally, the anchor blocks and anchorage have a large enough safety factor. The anchor block is sufficiently stable since it functions as a solid block, with less stress on it than on the towers of a suspension bridge. The cables used in the Banglung suspended bridges were bought second-hand from the Transport Corporation of Nepal; they had been replaced after being used in ropeways. Since the cables are used ones, they may have less load-carrying capacity than new ones, but the short-span bridges being constructed are safer than longer-span bridges as both types use the same type of cable.

The factor of safety required by international standards may not be achieved using second-hand cables, according to the engineers, but they feel that compliance with such standards should not be the only criterion. The safety factor appears to be adequate, particularly because the bridges are usually maintained by the local communities in a better way than are the rural bridges constructed by the Government. The expected life of such a bridge without any maintenance would be about ten years. To increase the life expectancy of some of the bridges, the local people do not use them during the dry season but do necessary repair and maintenance work during that time.

III. BRIDGE CONSTRUCTION THROUGH TRADITIONAL TECHNOLOGY: ITS IMPACT ON THE LIFE OF THE PEOPLE

Economic Impact

In and around the area where a bridge is constructed, landless labourers who are basically engaged in porterage will derive benefit from it. In the absence of a bridge, these landless labourers are deprived of work during the wet season because of the hazards involved in fording the rivers. However, in the presence of the bridge, job opportunities will be available to them round the year. Moreover, the bridges often shorten their travel time and detour time, and so they can increase the frequency of trips they make, which will bring them more money.

Bridges help stabilize the supply of commodities as well as the price and availability of commodities in the local markets within the influence area of the bridge. The influence area is determined to be a ten-kilometre radius around the bridge site. In the absence of a bridge, the supply of consumers goods becomes irregular and seasonal. Especially during monsoon, when the local people face greater hardships, there is a shortage of commodities, which encourages shopkeepers to raise the prices of the scarce commodities. Once a bridge is constructed, prices will be more stable, and the people can go to nearby markets where they can sell their surplus at a reasonable price so that they will be less affected by the adverse impact of the wet season.

Wider Interaction

Service centres have a tendency to concentrate where easy transport facilities are available. Therefore, with the construction of suspended bridges, service centres could be attracted to the locality. Meanwhile, the people in and around the bridge area can avail themselves of such facilities as post offices, credit offices, banks, agriculture extension offices, health posts, etc., available on the other side of the river.

In the absence of a ready means of access, government officials hardly visit such places. With the availability of bridge facilities, visits of government officials will be more frequent, and the local people will be in a position to exhort the officials to use their influence to bring more resources into the area.

The presence of a bridge increases the opportunity for children to go to lower secondary and secondary schools on the other side of the river. This helps the children to be regular in class and also to continue their education. If there are no bridges, the cost of education to the guardians will increase because they will have to finance their children's boarding and lodging on the other side of the river or somewhere else. However, with the availability of a bridge, the cost of education will be reduced and the children can continue their education regularly while living at home.

Displacement of Jobs

In some cases the construction of the bridges displaces the jobs of certain groups of people, such as boatmen. On big rivers, river crossings are made by boat. The boats are maintained and operated by professional boatmen, who are supported by either fees or rice provided annually by the local village. When bridges are constructed at such places, these people suddenly find themselves unemployed and migrate downstream or upstream to locations where bridge facilities are not available so that they can continue their job. In one case the displaced boatmen adopted a new occupation: they took up horticulture, specializing in growing tomatoes, and ended up making more money than they had earned earlier as boatmen.

Social Interaction

With the availability of bridge facilities, social and economic interaction increases. In the social system of Nepal a daughter, even after her marriage, has to maintain close contacts with her parents' home and has to perform a number of rites and rituals with her relatives back home. Such social obligations tie the people together into a compact community. If a daughter happens to marry on the other side of the river and it is difficult for her to come to her parents' home during the wet season, then the family finds itself deprived of the duties to be performed by the daughter. Consequently, parents would prefer to have their daughters marry within the village, and the choice of potential bridegrooms is therefore limited. However, if bridge facilities are available, those seeking to get married have a wider range of choices. Socially, the increased range of choice — which cannot be quantified in cost-benefit terms — definitely opens up wider social horizons and breaks parochial local feelings.

Environmental Impact

In the absence of a bridge and easy means of crossing a river, the natural resources of the other side of the river are naturally protected. When a bridge is built, people — because of ignorance of management on one hand and population pressure on the other — start the process of depleting the natural resources on the other side of the river by overgrazing and collecting grass and wood, and the depletion of natural resources is clearly visible within a few years. This does not mean, however, that the construction of bridges should be discouraged but only that, along with the construction of bridges, people should be made aware of the importance of natural resources and of how best they can be used.

Government Policy

The mass-scale construction of bridges in Banglung District using low-cost traditional technology definitely drew the attention of His Majesty's Government of Nepal and of numerous agencies such as UNDP, SATA, and USAID in Kathmandu. These agencies undertook the technical study of the bridges. The government now has two options: to invest in the construction of only a few expensive suspension bridges with the limited resources in hand, or to build large numbers of low-cost suspended bridges based on and requiring minimum resources. Swiss technicians with experience in suspension-bridge construction have helped prepare a proposal for an improved type of bridge that is still a low-cost suspended bridge. In order to successfully launch its Rural Transport Development Program, Nepal can afford only low-cost suspended bridges because thousands of them are to be constructed.

Bridges based on traditional technology have an important advantage which is one of the requirements of the development process: the indigenous know-how and skill to maintain them are available within the community. This helps keep them in good shape with constant maintenance.

Transfer of Technology

The local people feel that this type of bridge-construction technology does not require much effort to learn or to adopt. Within the study area some communities did not know how to construct suspended bridges; such a community would request a nearby community to help them. After observing the process of constructing a couple of bridges, the people of the community learnt the skill and thereafter were able to construct bridges on their own. This bridge-construction technique does not involve much sophistication, and therefore the transfer of the technology from one area to another should not be a problem. Transfer of technology is normally assimilated faster at the same wavelength of communication and perception; therefore within Nepal, especially in the middle hill region, this technology can play a very important role in elevating the rural transport system and tremendously improving the trail system.

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