Bamboo Floating Raft Bridge: Mutual Dependence of Man and Nature

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Abstract: In Ban Nongloo of Sangklaburi district of Thailand's western province of Kanchanaburi, rare mutual dependence between man and nature is still visible. There, some local villagers of the Mon descent are dwelling in a hut on a floating bamboo raft which is constructed by tying together tens of bamboo poles underneath to buoy the raft hut. In late July 2013, this local "buoying" wisdom was applied to the construction of a 450-meter floating bamboo raft bridge, in which hundreds of fastened bamboo poles are utilized as buoys. The bridge construction and completion is a representation of harmony and unity of local residents who individually brought bamboo poles or offered free labor. In addition to joining two communities of Ban Nongloo on both sides of the Songalia River, the ingenious structure serves as a floating recreation ground for local residents and a tourist magnet for visitors.

Keywords: Bamboo Bridge, Raft-Bridge, Cultural Bridge, Cultural Landscape

1. Introduction

1.1 Geography and climate

Ban Nongloo (Nongloo sub-district) of Kanchanaburi province lies along both banks of the Songalia River on the foothills of a densely forested mountain range bordering Thailand and Myanmar (Fig.1). Ubiquitous along the mountains are bamboo trees of multiple species, e.g. *Bambusa nutans*, *Bambusa bambos, Dendrocalamus membranaceus, Dendrocalamus aspe, Gigantochloa densa*. The sub-district's high elevation of 160m above mean sea level (MSL) contributes to high temperatures (32-40°C) in the summer (February-May) and in the winter (November-January) the weather is mild and dry (22°C). Ban Nongloo's rainy season begins in June and lasts until October, during which the sub-district receives heavy rainfall brought inland by the southwest monsoons from the Andaman Sea with an annual average rainfall of 1086 mm (D. MNRE 2008, pp.6-7).

1.2 Background of Bamboo Floating Raft Bridge Project

In early July 2013, the district of Sangklaburi where Ban Nongloo is situated was under unprecedented heavy rainfall for three consecutive days. The downpour caused runoff from mountains that carried logs and debris into the Songalia River. The logs and treacherous river currents knocked down multiple wooden support piers of three-decade-old pier bridge *Outtamanusorn*, which connects the two communities of Ban Nongloo on two sides of the river (Fig.2). The destruction in the middle section of the pier bridge forces local villagers to take a long detour for land transport or take a ferry to reach the other side.

To alleviate the hardship of residents of Ban Nongloo who relied on the *Outtamanusorn* pier-bridge for commute, *Phramaha Suchat Siripanyo*, a highly revered local Buddhist monk, initiated the floating bamboo raft bridge project. The project successfully mobilized the local residents to donate bamboo poles or offer free labor or both. The 450-meter bamboo floating raft bridge (Fig.3) was constructed for temporary use, and its completion is entirely based upon the local wisdom of bamboo raft hut construction (Svamivastu V 2002, p.108), in which the bundled-up bamboo poles are deployed as *Look Boub* or buoys (Figs. 4-5) to keep the raft bridge afloat.

2. The Design and Building Techniques

The Songalia River is relatively mild without high and low tides, making it resemble a natural reservoir. In the dry season when the river water is low, the riverbanks extend far into the river, whereas in the rainy season the river water travels deeper inland. The construction of the floating bamboo raft bridge was commenced in the rainy month of July when the level of river water is high, resulting in the bridge of 450m in length. In the dry season when the water level in the river is low, the length of the bridge can be shortened by removing sections of bridge. The completion of the bridge took merely six days, instead of a planned period of two weeks, because of the abundance of bamboos in the region and the simple construction technique without underwater support columns (Fig.6).

The floating bamboo raft bridge of Ban Nongloo is economically constructed from three simple components: buoys, horizontal walkways and elevated crossway. The transformation of these components into the floating raft bridge is successfully carried out without a need of a single metal nail but by tying them with ropes.

2.1 Buoys

The buoy of the floating raft bridge, or *Look Boub* in the Thai language, is fashioned by rope-tying multiple bamboo poles. The inner diameter and length are on average 6.5cm and 6.0m, respectively (Figs.7-8).

To fashion the buoy, some 50 bamboo poles are piled together and coiled loosely 4-5 rounds with rope at three locations: two toward both ends and on in the middle of the buoy (Fig.9). Either the *Pirod* (reef knot) or *Pramong* (fisherman's knot) knotting technique is utilized to join two ends of the ropes (Figs. 10). The *Kunchanow* method (tourniquet knot) using a one-foot-long bamboo stick is then employed to tighten the ropes (Nimlek 2007, p.86) and compress the bamboo poles (Fig.11). To stop the buoy from unraveling, another rope is coiled around the buoy and its ends are tied firmly to the bamboo stick using the *takrutbed* (clove hitch) technique (Fig.12). The buoys, which serve as the floating floor beams, are then laid across the Songalia River (Figs.13-14) and held from straying off with bamboo joists at a distance of approximately 1.50m between one another. Another one-foot-long bamboo stick is utilized to inhibit the unraveling of the rope joining the joists to the buoys (Figs.15-17). In addition, by removing the bamboo stick, repair of the buoys can be conveniently carried out.

The principle of Archimedes stipulates that the load capacity of a buoy can be determined based on the weights of the bridge, its support structure, and pedestrians/occupants (Vennard 1961, pp.6, 78). By simulation, the combined weight of one section of the bamboo floating raft bridge is estimated at 250kg. One section consists of one buoy, its support structure, and the walkway (1.5x2.0m). The maximum number of pedestrians and/or occupants on the walkway at one time is 8, which is equivalent to 560kg, assuming an average weight of 70kg (Figs.19-21).

$$W = F_b$$

where W is the load on one raft bridge buoy, F_b is the water buoyancy acting with the volume of parts of bamboo poles that are immersed in the water.

$$W = Mg \text{ Newton}$$

where M is the mass of one buoy, support structure, the walkway and eight occupants, and g is the gravity force ($g = 9.81 \text{ m/s}^2$).

By substituting, $W = (250 + 560)\ 9.81$ Newton $= 7946.1$ Newton

To determine the capacity of a raft bridge buoy made of 50 bamboo poles, each of which has an inner diameter and length on average of 0.065m and 6.00m,

$$F_b = pVg$$

where F_b is the buoyancy of the water acting with the air inside the caverns of the bamboo poles (i.e. 50 poles), P is the density of water (1,000 kg. /m^3), V is the air volume in the bamboo poles ($\pi r^2 \times L \times Q = \pi \times 0.0325^2 \times 6.00 \times 50 = 0.9955\ m^3$), g is the gravity (9.81 Newton).

$$F_b = 1{,}000\ kg/m^3 \times 0.9955\ m^3 \times 9.81 \text{ Newton} = 9765.85 \text{ Newton}$$

Then, subtract W from F_b. In other words, buoyancy force – (mass of one bamboo buoy, weights of walkway, support structure and eight occupants) = (9,765.85-7946.1) = 1819.75 Newton. It is found that F_b is greater than W ($F_b > W$) by 1819.75 Newton. This indicates that it is safe to deploy the buoys in place of piers for this floating bridge. Furthermore, at the length of 450 meters, a total of 131 buoys are required, which allows for 1048 persons (8 x 131) on the bridge at any one time.

2.2 Horizontal walkways

The walkway is 2m in width, placed symmetrically at the center of the buoy. It is fashioned from split bamboo poles woven together with flat nylon ropes. The optimal dimension of the split bamboo is 0.03x2.00x0.005m (W x L x T) individually because it provides optimal strength with minimal weight. In addition, the outer of the bamboo is scratch-resistant and water-proof.

It requires two strong volunteers working skillfully in sync to produce one section (i.e. 1.5x2.0m) of the walkway (Figs.22-23). The workers start by tying a *Pookrang* (Tarbuck knot) knot to one side of the support structure (Fig.24), on which the split bamboo poles are individually laid and weaved using the *Pomtakai* (overhand knot) technique (Fig.25). The process ends with typing another *Pookrang* (Tarbuck knot) knot to the opposite side of the support structure (Figs.26-27).

2.3 Elevated crossway

The elevated crossway is 3m long and erected in the middle of the bridge. It is an elevated section of the raft bridge through which boats and debris pass. The elevated crossway and the walkways are connected by flights of stairs (Fig.28). No floor beam is used in the elevated crossway to minimize the weight but the hanging joists (*Ra* in the local language) are used to strengthen the elevated floor (Nildej S 2004, p.26) and hold together the bamboo poles (Figs.29-30). Due to the absence of the floor beams, the diameter of the bamboo poles (7.5cm) for the elevated section is slightly larger than that of the buoys (7.0cm).

To prevent the elevated crossway from straying off, the handrails, in addition to the flights of stairs, are erected on to the crossway with both ends fastened to the walkways with ropes. The handrails are fashioned from young *Paipak* bamboo (*Gigantochloa densa*) of *Gramineae* family because of the small stem and malleability. In addition, the walkways that connect to the crossway (i.e. those under the stairs) are individually buoyed by three *Look Boub* to accommodate greater load induced by the stairs ascent and descent (Figs.31-34).

3. Project Success

Ban Nongloo's bamboo floating bridge is the longest bamboo floating bridge ever built in Thailand, whose completion not just bridges both banks of the Shangalia River but also brings out local residents' goodness. The entire raft bridge is constructed from the materials and labor contributed by the villagers who tirelessly worked and helped each other to see the project through, a phenomenon that gives rise to a proprietorial feeling of the bridge.

After its completion, the Ban Nongloo floating bridge has been transformed by local residents and visitors into a green "vegetation-less" recreational spot and playground (Figs.35-40). Despite being tree-less, the weather is comfortable throughout the day due to valley and mountain breezes all year round. Furthermore, the bridge is an outdoor living museum where visitors can witness and appreciate the ingenious application of generations-old local wisdom.

CONCLUSIONS

Ban Nongloo's bamboo floating raft bridge is a manifestation of ingenious application of centuries-old wisdom of bamboo raft huts building to the floating bridge. The spatial organization and construction of the bridge emphasizes functionality and structural simplicity (i.e. modular system). The simplicity of structure allows for ease of maintenance and literally injects "*life"* into the bridge as the structure can grow (lengthened) and age (shortened), depending upon the level of river water. Moreover, its presence is a non-eyesore. The bamboo floating buoy bridge reflects and suits the living and livelihoods of the residents of *Ban Nongloo*.

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Figure

Fig.1

Fig.2

Fig.3

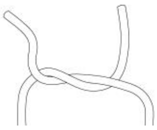
Fig.4

Fig.5

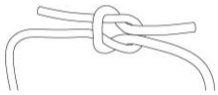
Fig.6

Fig.7

Fig.8

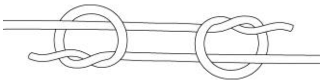


9a.



9b.

Fig.9



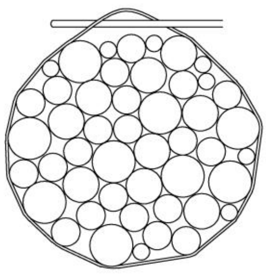
10a.

10b.

10c.

Fig.10

11a.



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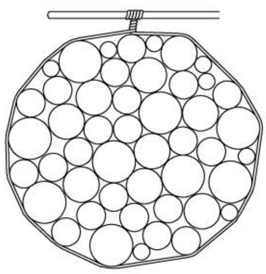
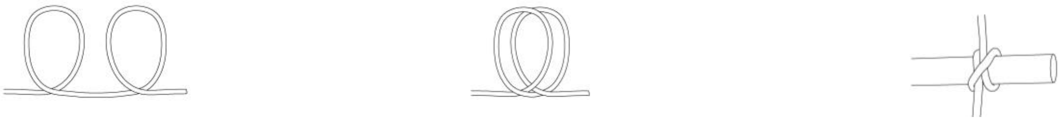


11c.

Fig.11



12a. 12b. 12c.

Fig.12

Figs.13, 14

Figs.15, 16

17a. 17b.

Fig.17

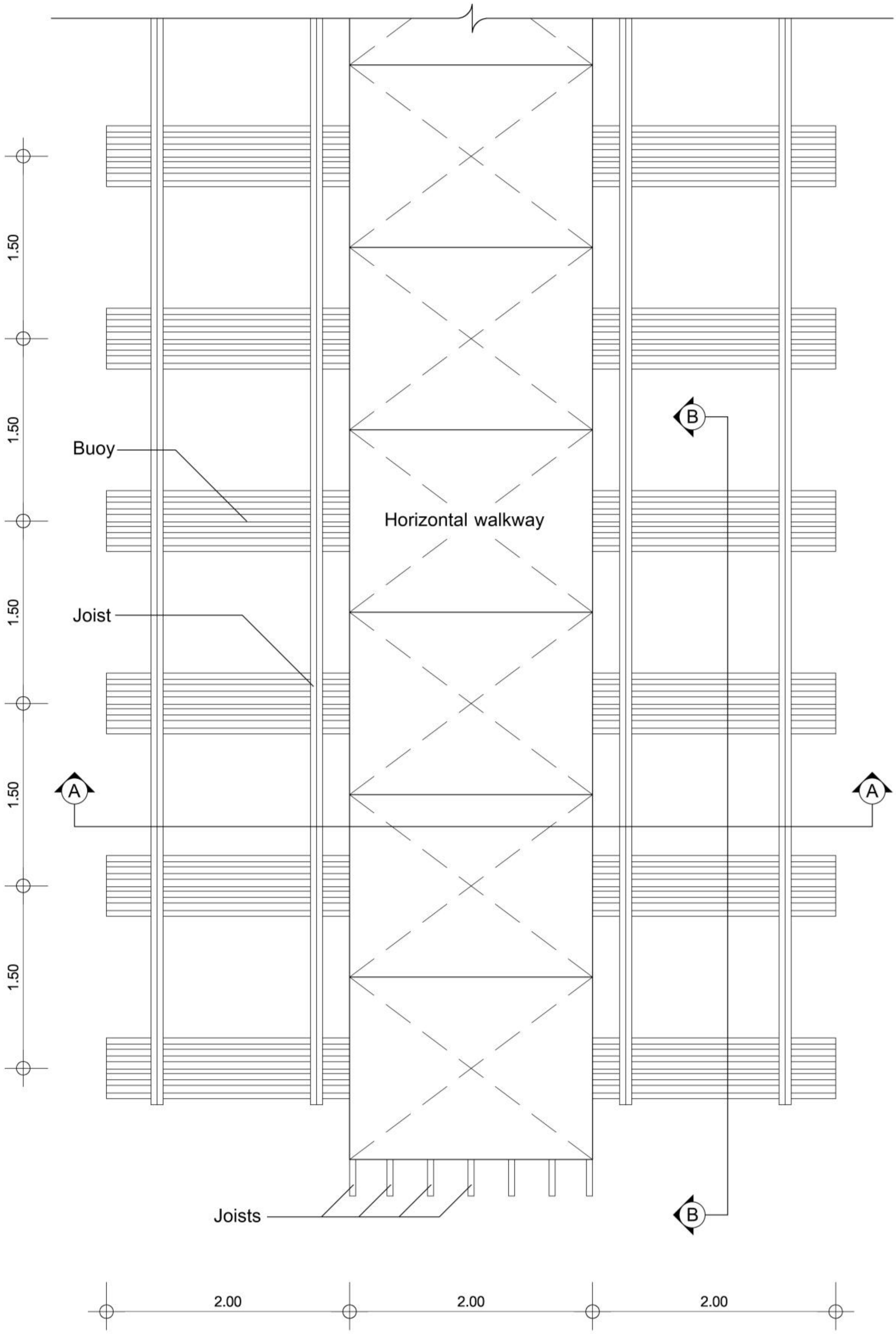
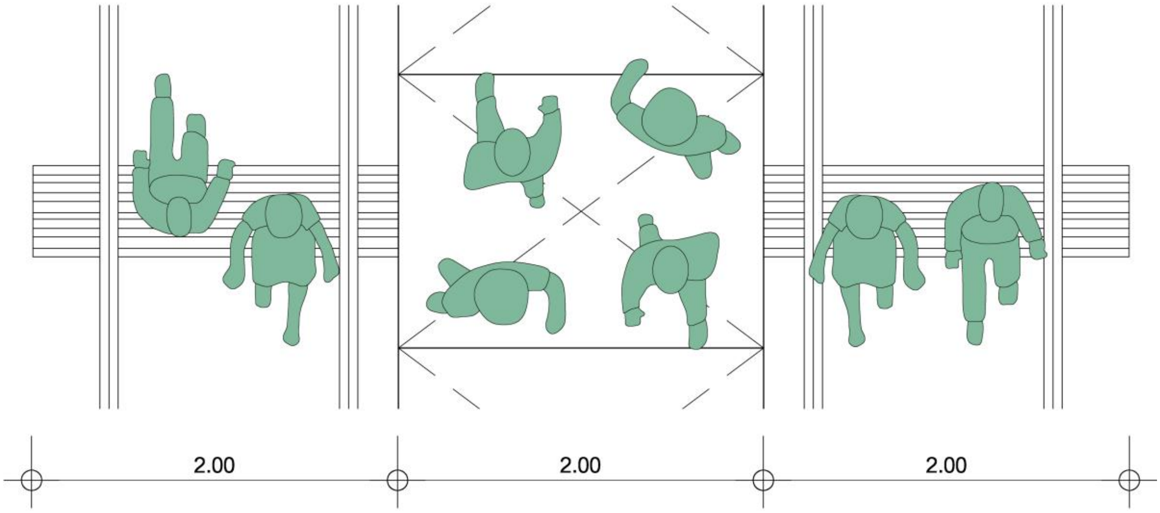

1.50
1.50
1.50
1.50
1.50
Buoy
Joist
Horizontal walkway
B
A
A
Joists
B
2.00
2.00
2.00

Fig.18



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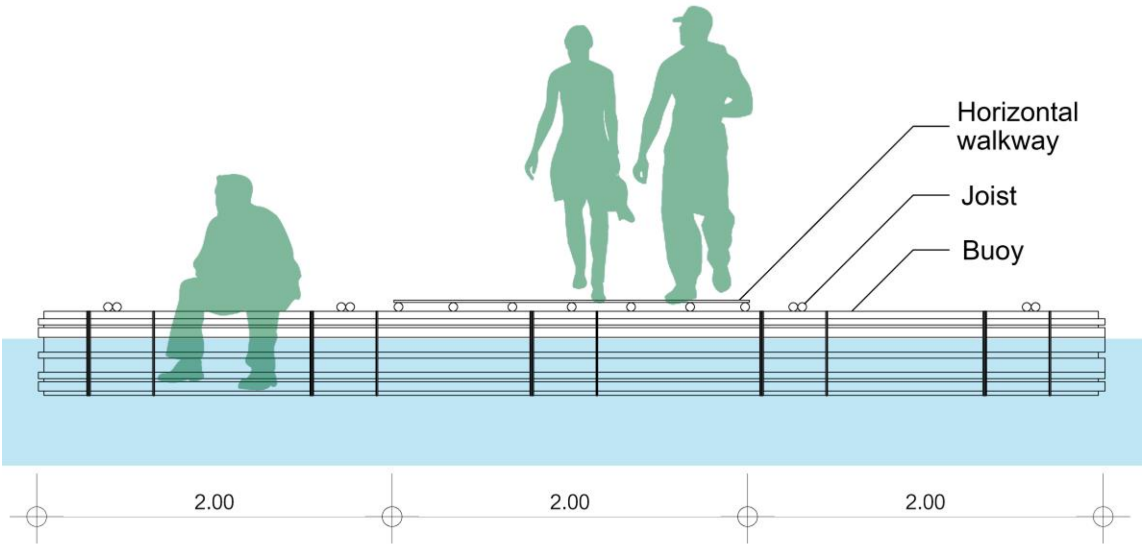


Fig.20

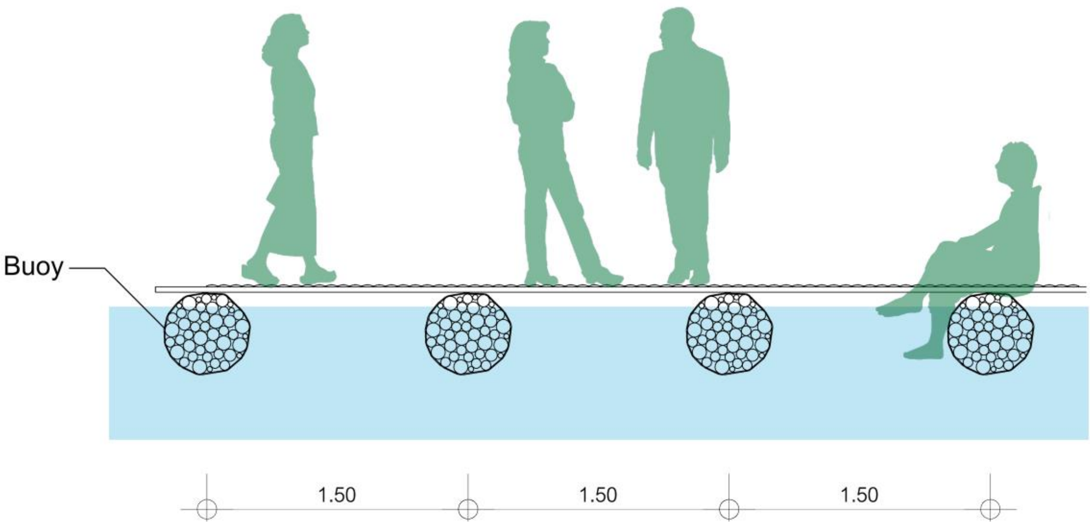
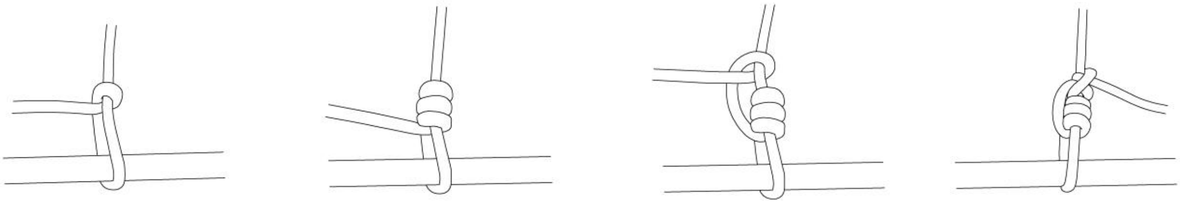


Fig.21

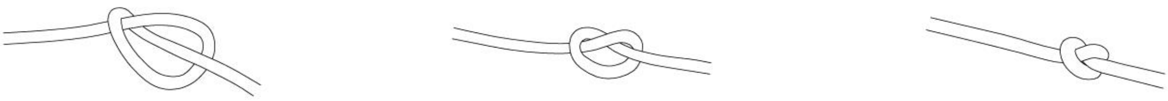
Fig.22

Fig.23



24a. 24b. 24c. 24d.

Fig.24



25a. 25b. 25c.

Fig.25

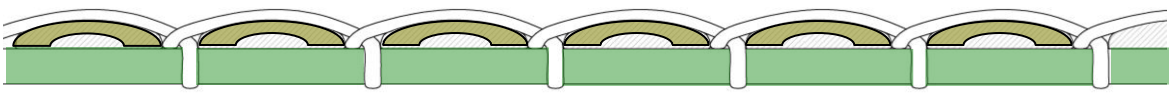


Fig.26

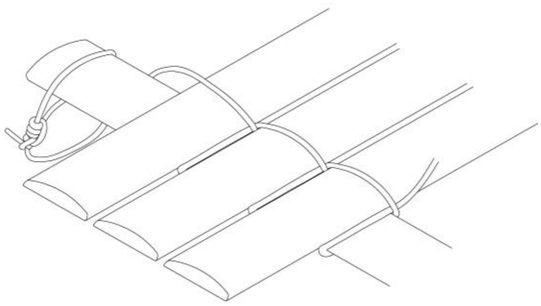


Fig.27

Fig.28

Fig.29

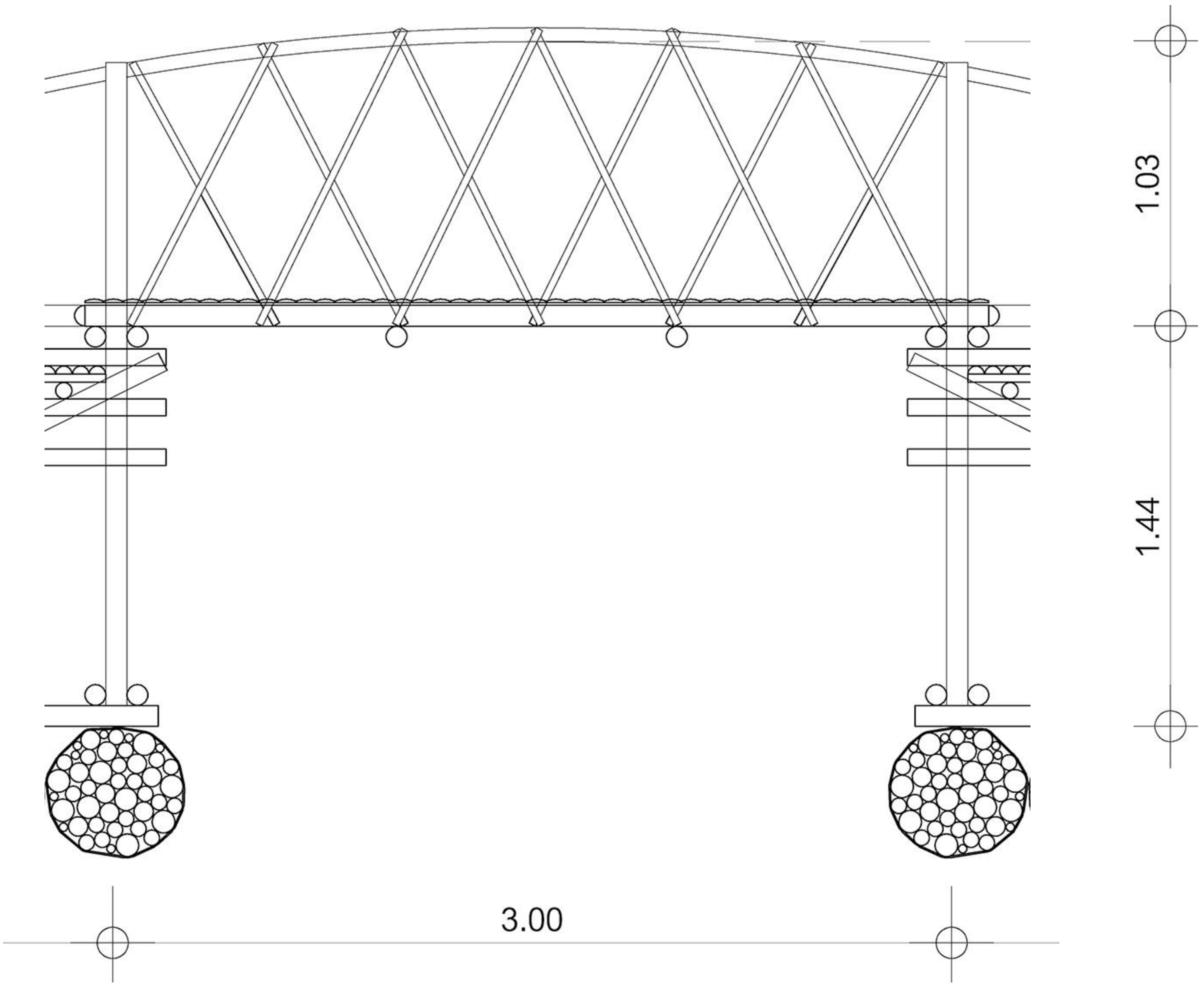


Fig.30

Fig.31

Fig.32

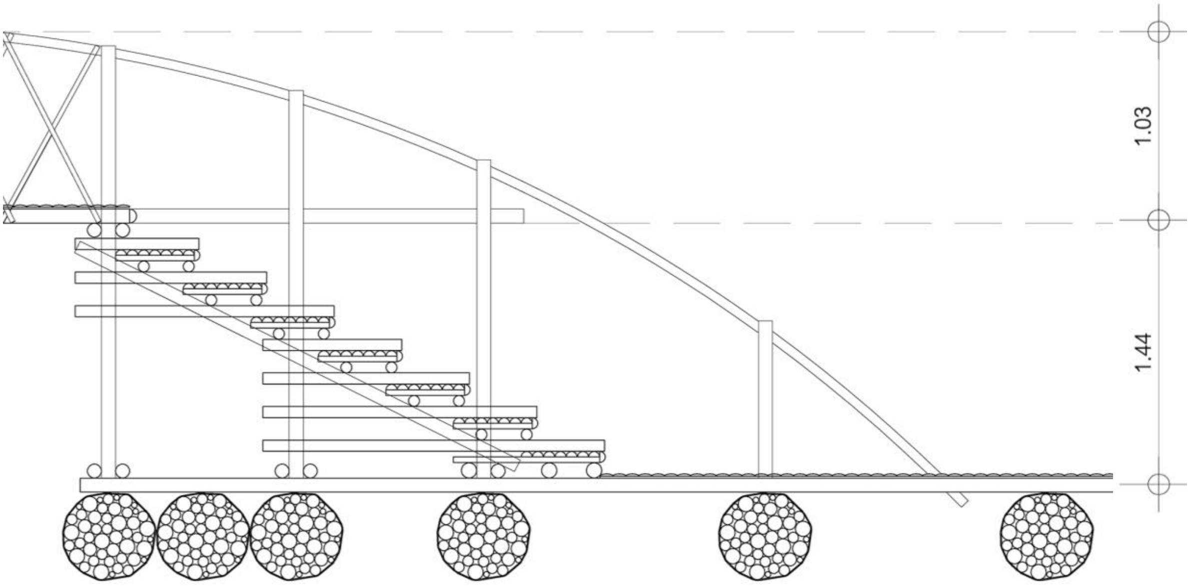


Fig.33

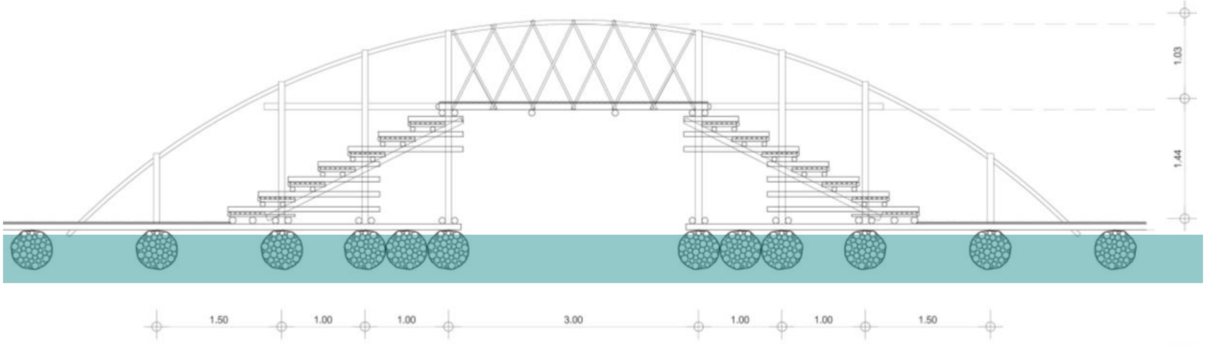


Fig.34

Fig.35

Fig.36

Fig.37

Fig.38

Fig.39

Fig.40