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DESIGN OF BAMBOO REINFORCED CONCRETE WATER TANK RESTING OVER FIRM GROUND

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Abstract: Traditionally steel is used as reinforcement in concrete structure. But because of cost and availability, replacement of steel with some other suitable materials as reinforcement is now a major concern. It is a fact that the construction industry is the main consumer of energy and materials in most countries. Though bamboo has been used as a construction material, especially in developing country, until today its use as reinforcement in concrete structure is very limited due to various uncertainties. Since bamboo is a natural, cheap and also readily available material, it can be a substitute of steel in reinforcing of concrete structure.

Authors have tested & evaluated physical and mechanical properties like compressive strength, tensile strength, Flexural test, Bonding strength, water absorption, density etc. of the selected bamboo species in material testing laboratory. Purpose of the experiments on bamboo strips is for validation and justification of these results confirm the application of bamboo as reinforcement element.

Keywords: Bamboo; water tank; bamboo reinforced water tank design; Bamboo reinforced concrete wall design; Bamboo reinforced concrete base slab design; ground rested water tank design.

I. Introduction

Bamboo is versatile resource characterized by high strength to weight ratio and ease in working with simple tools. Bamboo is the fastest growing, renewable natural resource known to us. It is a small wonder, therefore, that this material was used for building extensively by our ancestors. It has a long and well established tradition as a building material throughout the tropical and sub-tropical regions. It is used in many forms of construction, particularly, for housing in rural areas. But, enough attention had not been paid towards research and development in bamboo as had been in the case with other materials of construction including timber.

Due to ecological materials and having many advantageous characteristics of bamboo, in the last few years, studies have been made on bamboo as structural material and reinforcement in concrete. Bamboo has great economic potential, especially in the developing countries, because it can be replenished within a very short time. A critical assessment of the present status and future prospects of bamboo housing would be helpful in exploiting that potential.

A. History of Bamboo

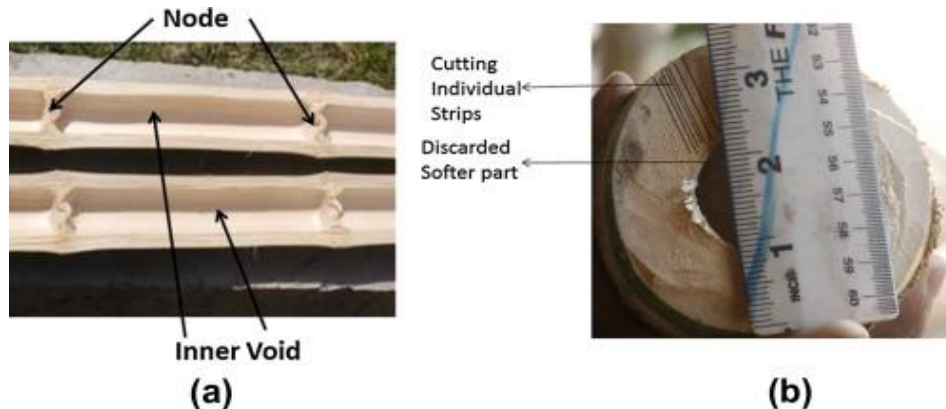
An archaeological discovery in Ecuador has traced back the use of bamboo for housing to the pre-ceramic for years ago. Although no such hard evidence is available in Asia, it is known that bamboo has been employed since several centuries for several purposes, including housing, in South, East and Southeast Asia. It is the single most important organic building material in these regions. It is used in over 70% of rural houses and extensively employed as informal shelter for the urban poor. At present, there is an acute shortage of housing because of the scarcity of conventional materials coupled with rapid population growth. Many villagers were already adopted weavers of bamboo, thus quickly mastered the frame construction technique. There use of this technology to built catchment tank for rainwater collection. A study of the feasibility of using bamboo as reinforcing material in precast concrete element was conducted at U.S. Army Engineer Waterways Experiment Stations in 1964.

The importance of bamboo as a construction material, particularly for housing, has received renewed attention in recent years, but conceptual application of bamboo as a reinforcement is as old as in 1979. This new born hybrid technology first developed in village areas of Colombia.

The density of the fibres in the cross-section of a bamboo shell varies along its thickness. On the outer skin of a bamboo shell the fibres are concentrated and more resistant to degradation. This presents a functionally gradient material, grew according to the state of stress distribution in its natural environment.

In view of the hollowness and the fibres in longitudinal direction, bamboo has a very efficient natural structural design and less material mass is needed than materials with a massive section, such as timber.

Figure 1 shows the parts of a bamboo which are usual to most of the species.



II. **Figure 1: Parts of Bamboo**

Bamboo to the mankind have for ages been the source/fountain head of a myriad use. The house he lives in, the bridge he uses, the pipe through which he distributes water, are all made of bamboo. For these applications he made use of some remarkable properties of bamboo such as its excellent strength. Bamboo is as strong as timber.

Bamboo possesses excellent strength properties, especially tensile strength. Most of the properties depend on the species, and the climatic conditions under which they grow. Strength varies along the culm height. Compressive strength increases with height, while bending strength has the inverse trend. An increase in strength is reported to occur at 3-4 years, and thereafter it decreases. Thus, the maturity period of bamboo may be considered as 3-4 years with respect to density and strength.

In our test on bamboo strips, results for Elasticity of Bamboo strips are evaluated 5098 N/mm² which is comparative same as steel. Same as load carrying capacity of bamboo strips with concrete is justifying with steel reinforcement. Replacement of steel reinforced can be possible by using Bamboo as bonding element in concrete. Bamboo is naturally available material as compared to steel but properties as well workability of Bamboo is compatible.

Reference [3] Brink F. E. et al. had prepared a report to assist field personnel in the design and construction of bamboo reinforced concrete. The information in this report has been compiled from reports of test programs by various researchers and represents current opinion. Comments on the selection and preparation of bamboo for reinforcing are given. Construction principles for bamboo reinforced concrete are discussed. Design procedures and charts for bamboo reinforced concrete are given and conversion methods from steel reinforced concrete design are shown.

III. **Design of bamboo reinforced concrete water tank:**

A. **Bamboo reinforced concrete base**

$$f_{c(\text{concret})} = 1300 \text{ psi and } f_{c(\text{bamboo})} = 4000 \text{ psi}$$

At intersection of the allowable stress curves (From Figure 2) for concrete and bamboo,

$$\text{Coefficient of resistance } R = \frac{M}{bD^2} = 145 \text{ (From Figure 2)}$$

$$\text{Moment on wall } M = 1.356 \text{ KN.m}$$

$$\text{Moment at base } M = 5.45 \text{ KN.m (Producing tension at base)}$$

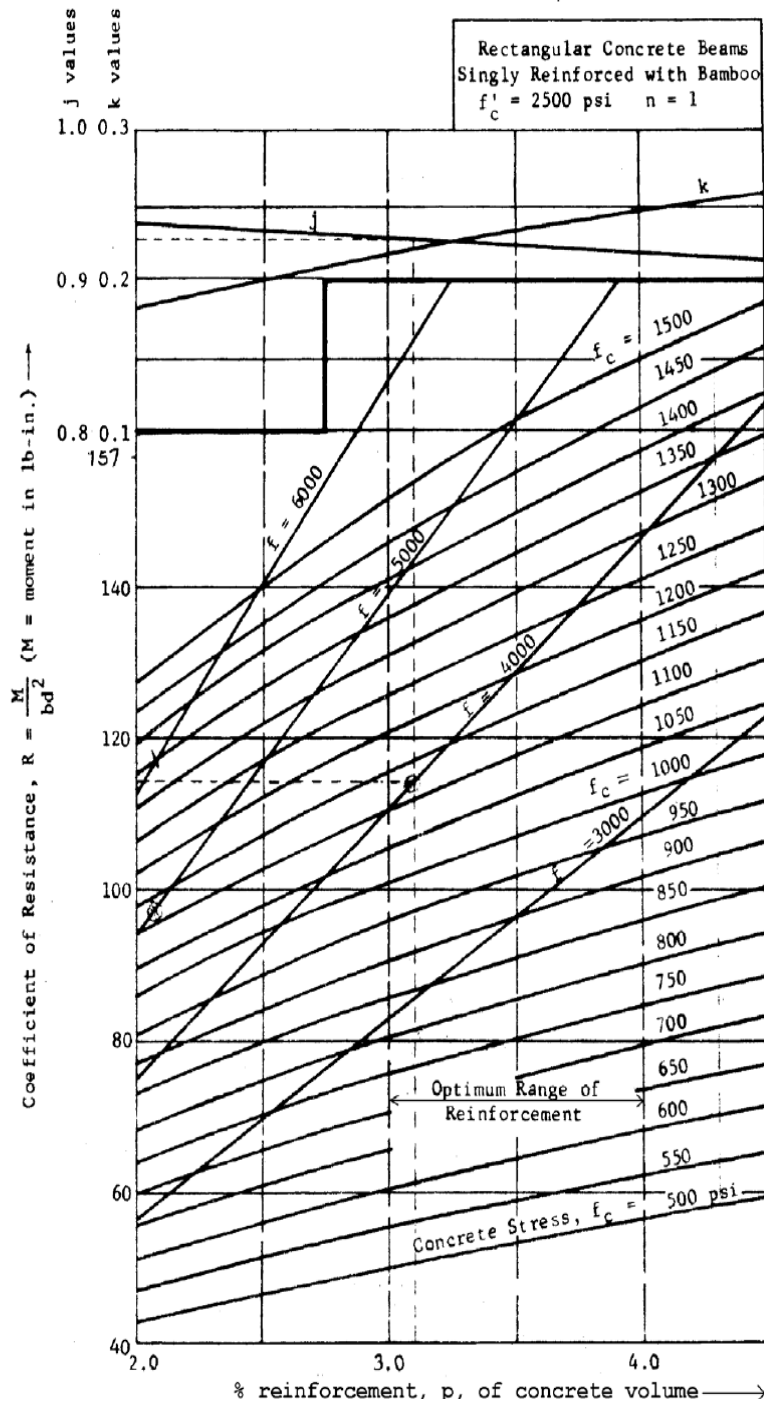


Fig.2 Resistance coefficient for bamboo reinforced concrete panel and their flexural members.

B. Bamboo reinforced concrete wall design

Moment at centre of wall = 1.356 KN.m

$M = 17958.42 \text{ lb.in}$

$$R = \frac{M}{bd^2}$$

$d^2 = 3.146 \text{ in}^2$, $d = 1.774 \text{ in}$ (45.06mm), Provide 70mm thickness.

$P = 4\%$ (Figure 2)

Bamboo required = $p \times b \times d = 0.04 \times 39.37 \times 1.774 = 2.79 \text{ in}^2$ (1802.38mm²)

Provide 13 bamboo strips on liquid face for 1m length @ 75mm spacing.

C. Bamboo reinforced concrete base slab design

Moment = 5.45 KN.m

M = 72178.025 lb.in

$$R = \frac{M}{bd^2}$$

$d^2 = 12.64 \text{ in}^2$, $d = 3.556 \text{ in}$ (90.32mm), Provide 150mm thickness.

P = 4% (Figure 2)

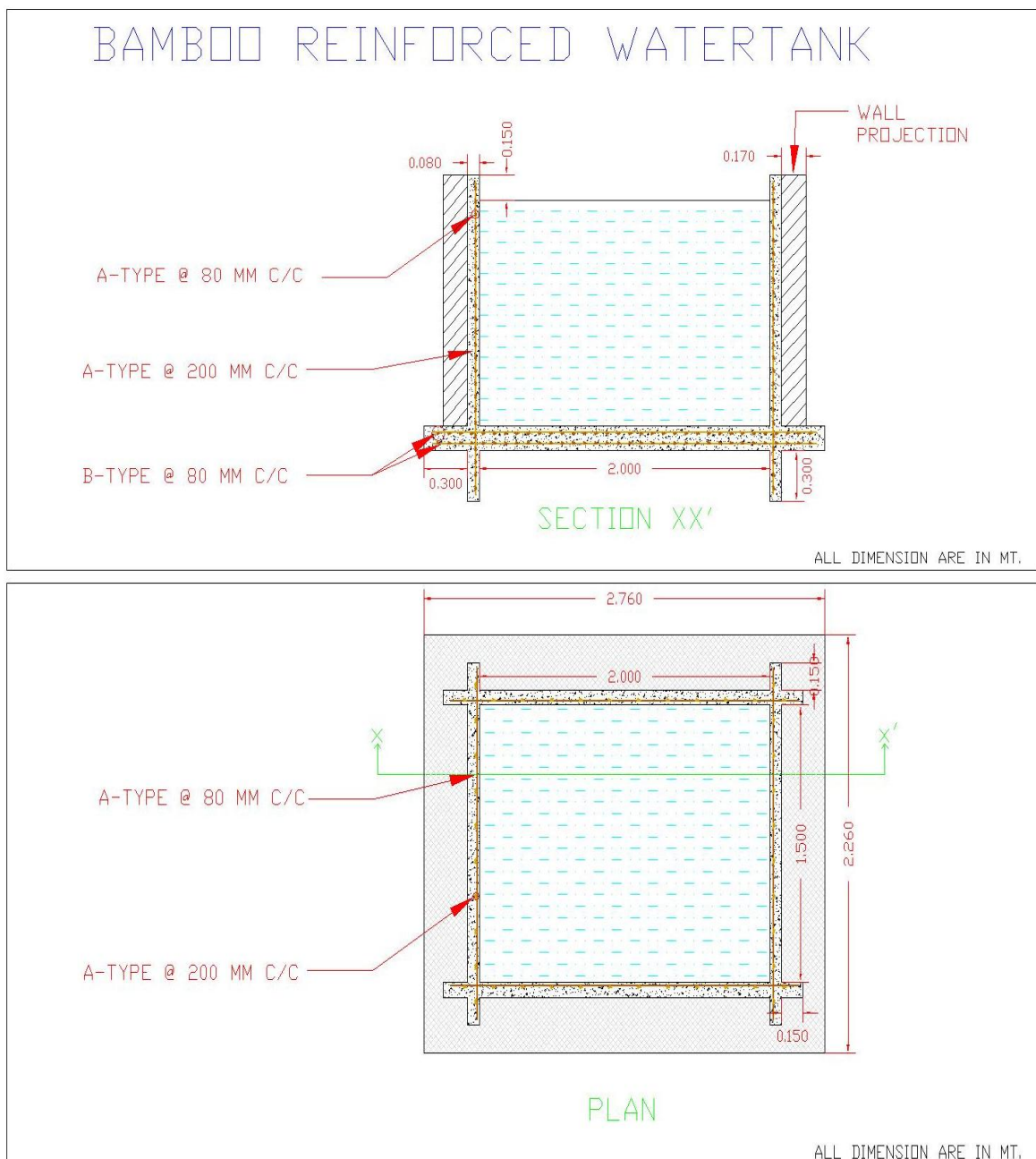
Bamboo required = $p \times b \times d = 0.04 \times 39.37 \times 3.556 = 5.60 \text{ in}^2$ (3612.89mm²)

Provide 13 bamboo strips @ 80mm spacing per meter (Both way).

Length of embedment = $25 \times 6 = 150 \text{ mm}$.

0.3 m wall projection is provided below base slab in ground and around four side of wall.

Hear in fig. A type = 145 mm² c/s area and B type = 290mm² c/s area of bamboo strip.



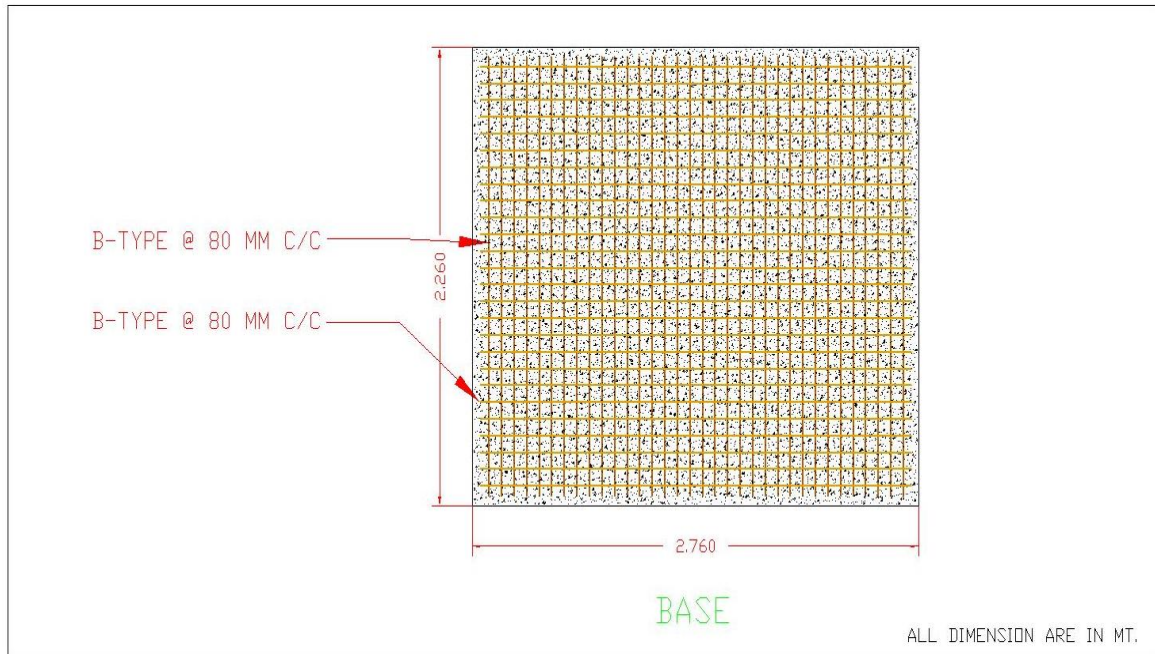


Fig 3 Design of bamboo reinforced concrete water tank

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