

Bamboo Cane as an Alternative Reinforcement in Reinforced Concrete Beam

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Abstract—Concrete is one of the most energy consumed materials in construction, which has higher compressive strength but poor in tensile strength. Steel is used to compromise the tensile strength of the concrete. Bamboo is a versatile and fast-growing natural material that has high compressive and tensile strength. The use of bamboo as an alternative to steel reinforcement will reduce the energy consumption in construction and reduce the cost. To investigate the feasibility of using bamboo as an alternative reinforcement, the bamboo fiber mix concrete, and bamboo reinforcement in a structural element such as beam were tested under compressive and flexural tests. The experimental study consisted of 12 cubes and 6 beams specimens. Results show that the load-carrying capacity of concrete beams reduced because of the usage of bamboo fiber in concrete. However, the ultimate load-carrying capacity in a hybrid beam was observed to almost equal to the steel-reinforced beam and showed a similar deflection. Based on this study results, it was concluded that the bamboo can be used as an alternative reinforcement in reinforced concrete beams, and it can reduce the cost of beams in the construction.

Keywords: *Bamboo fiber, Bamboo reinforcement, Hybrid beam, Steel reinforcement*

I. INTRODUCTION

In the current situation, a large part of development projects are being constructed utilizing conventional materials like concrete and steel and the demand for these materials has been increased exponentially in the last two decades. In construction, one of the most commonly used material is concrete as it has high compressive strength and durability but very low tensile strength. So that the concrete is required to be reinforced with additional tensile elements to increase the tensile capacity of the concrete. Nowadays steel is used to reinforce concrete in form of a rebar which helps to increase the tensile strength very much. Undoubtedly, steel is non-renewable material and its production cost is very high. The production process pollutes the environment as well. Most importantly, due to its high production cost in developing countries like Sri Lanka, steel reinforcement is not affordable. Therefore, there is a need to study alternative materials that can reduce the cost and the adverse effects on the environment.

Bamboo can be proved to be one of the appropriate materials that may reinforce with concrete to produce desirable results. Traditionally, bamboo has been used as a construction material throughout the world's tropical and

sub-tropical regions. It has been broadly used for many forms of construction, mostly for housing in rural areas. Bamboo is a versatile and renewable resource, and it has high strength and low weight [1]. Also by using simple tools, bamboo can be shaped easily. Due to the high socio-economic benefits from bamboo-based products around the world, it is widely recognized as one of the most important non-timber forest resources [2]. More than 1200 species of bamboo are growing in about 14.5 million hectares' area as estimated. Most of them grow in Africa, Latin America, and Asia. Besides, it is registered as the world's fastest-growing woody plant. Approximately 7.5 cm to 40 cm grows in a day, it is three times faster than most other species in the world [3].

The geometry of the typical bamboo culm comprises of hollow circular cross-section with nodes along with the culm height. The wall thickness intermodal diameter, distance, and fiber density vary from the bottom to the top end. The bamboo strip possesses high tensile strength due to the fibrous (along the grains) structure of the culm [2]; bamboo possesses high strength to weight ratio (about six times higher) compared to conventional reinforcing steel [4]. Bamboo culm, around three to four years of age, achieves its optimum strength, and it matures completely by the fifth year [5]. Bamboo can sustain tension as well as compression loading unlike any other natural material, which can only take tension in major, due to the dense fibrous structure. Nevertheless, bamboo is being an organic natural material and the durability of the bamboo in a concrete composite has impeded to its utilization [6]. The bonding between bamboo and concrete is majorly influenced by the friction on the surface of bamboo and concrete. To increase the durability and bond quality between bamboo and concrete, many researchers have investigated various bamboo treatment processes including soaking, drying, waterproof coating (different adhesives on the bamboo surface to make the exterior surface impervious), sandblasting, and thin wire warping to counteract the slipperiness of the bamboo surface [7]. With the above-mentioned characteristics of bamboo, many experimental research studies have been conducted to investigate the feasibility of using bamboo as an alternative reinforcement in beams to compare their properties with a conventional reinforced concrete beam. Although, the comparative aspect of Ease of Use, bamboo reinforced concrete beams (BRC) has not been explored so far. In this study, bamboo is utilized in different aspects and ratios in concrete beams to increase its ultimate load-carrying capacity