

Comparative Analysis on Bamboo Reinforced Manhole Cover as a Sustainable Approach

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Abstract : Eco-friendly and natural materials are generally given more importance for supporting sustainable development. The non-renewable materials such as steel is being replaced with bamboo which has a potential of getting similar results as steel reinforcement in concrete according to many studies. The process of selection, seasoning, treatment on bamboo is carried out before, for improving its properties and performance as reinforcement in concrete. This research paper investigates the use of bamboo as reinforcement in the production of reinforced concrete manhole cover as alternative replacement to steel reinforcement. A main issue with manhole covers is stealing of cast iron manhole cover which may result in causing accidents due to hole left on road. The purpose of this study is to compare bamboo reinforced concrete manhole with steel reinforced manhole cover on the basis of preliminary analysis. Testing, grade, shape and size is considered as per IS 12592:2002. This research paper makes an approach to develop a new material which would contribute to sustainable development and also a green alternative material to steel reinforcement.

IndexTerms - Bamboo Reinforcement, Carbon Footprint, Green Alternative, Load Test, Manhole Cover.

I. INTRODUCTION

Due to vast development in whole world there is emission of harmful gases in environment from various industries which imbalances the ecosystem and a cause of adverse condition such as uneven rainfall, draughts, global warming, earthquakes, tsunamis etc. This research has an approach to reduce carbon footprint in construction industries from steel and cement manufacturing process. For manufacturing of 1 ton of steel there is emission of approximately 2 ton of carbon dioxide and for 1 ton of cement there is approximately 1 ton of carbon dioxide in environment (Suresh et al., 2008). Due to increment of carbon footprint in environment the earth's temperature is raising year by year. If this situation is continued, then it will cause an unfavorable environment for human as well as other living organisms existing on earth and sustainability of life will be an issue. So there is a need to have an alternative and environmental friendly material in construction which won't harm the environment and which can contribute towards sustainable development.

Bamboo is one such material which has a vast potential of replacing steel reinforcement in concrete. As has good tensile as well as compressive strength which can be used as a green alternative to steel reinforcement. Using bamboo as reinforcement in concrete the strength and behavior of structure will be similar to steel reinforced concrete structure (Ajinkya et al., 2013). But before using bamboo as reinforcement it should be properly selected, seasoned, treated for achieving best results, making compatible with concrete and to overcome some drawback (Anurag et al., 2013). The reinforcement ratio of bamboo in concrete is more than that of steel as it has less tensile strength than steel. Bamboo as reinforcement can be used for light weight RCC structures.

1.1 Bamboo

Bamboo belongs to the sub-family of the *Bambusoideae* of the grass family *Poaceae*. It is a composite material of long and parallel fiber cellulose fibers embedded in a ligneous matrix (Khosrow 2005). It is a fast growing woody grass which can grow fully in 3-5 years with less water requirement and can sustain mostly in any type of soil and weather conditions if suitable species of bamboo is taken for cultivation according to the regional atmosphere. There are more than 1000 of bamboo species available in whole world. Bamboo is used in construction majorly of scaffolding and roofing purpose. Now-a-days bamboo flooring and other decorative uses of bamboos are done in building system for achieving green rating for a particular project. Bamboo is one such material which can be an alternative material to wood as much attractive furniture can be made with use of bamboo. Bamboo can be used for treatment of rabies, Arthritis, urinal infection, mouth and gum sores, inflammations and irritability etc. Also research claim that there can be generation of bio-fuel with use of bamboo. Table 1 shows advantages and disadvantages of bamboo.

Table 1. Advantages and disadvantages of bamboo.

Advantages of bamboo	Disadvantages of bamboo
<ul style="list-style-type: none"> • Low-cost • Light weight compared to steel. • Bamboo can prevent pollution by absorbing large amounts of nitrogen from waste water. • Reducing the amount of carbon dioxide in the air • Bio degradable • Available every where 	<ul style="list-style-type: none"> • Tensile strength less than steel • High water absorption due to which it swell • Prone to termite attack and rotting • Non uniform structure • Low bond strength than steel with concrete

1.2 Manhole Cover

Manhole cover is a removable lid on the opening of manhole. The purpose of this is to avoid accidental falling of anyone or anything into manhole. The manhole cover allows the authorized person for repair and maintenance work.

1.3 Types of Manhole cover

- Fiber reinforced plastic (FRP)
- Glass reinforced plastic (GRP)
- Reinforced cement concrete (RCC)
- Cast iron
- Steel fiber reinforced concrete (SFRC)
- Ductile iron.

1.4 Shape of manhole Cover

- Circular
- Rectangular
- Square.

1.5 Grade of manhole Cover

Grades of manhole cover are shown in Table 2.

Table 2. Grades of manhole cover. (IS 12592:2002).

Grade	Grade Designation (Load capacity)	Uses/ purpose
Light Duty	LD-2.5 (25KN)	residential and institutional Complexes / areas with pedestrian, inspection chambers
Medium Duty	MD-10 (100KN)	Service lanes/roads, on pavements used under medium duty vehicular traffic, car parking areas
Heavy Duty	HD-20 (200KN)	institutional/commercial areas/ carriageways/city trunk roads /bus terminals with heavy duty vehicular traffic of wheel load between 50 to 100KN and parking areas and manhole chambers for road pavement

Extra Heavy Duty	EHD-35 (350KN)	carriageways in commercial/industrial/port areas/ warehouses/ godowns where frequent loading and unloading of trucks/trailers, slow to fast moving vehicular traffic for wheel loads up to 115 KN
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II. METHODOLOGY

In this research paper preliminary analysis on bamboo reinforced manhole cover is carried out. Bamboo reinforced manhole can also solve the issue of stealing of cast iron manhole cover which may result in causing accidents and health issue due to open hole left on road. And can also contribute towards sustainable development. Bamboo reinforcement ratio is considered as 3% of area of cross section. Grade considered is light duty 2.5 with dimension 510x510x50mm. Comparison of bamboo reinforced manhole cover with steel reinforced manhole cover for cost and carbon footprint is done and water absorption test is done on bamboo.

According to the literature survey bamboo cannot be used directly as reinforcement in concrete thus bamboo has to be properly selected, seasoned and treated before using. Also the flowchart showing the methodology of preparation process of manhole cover is shown in figure 1.

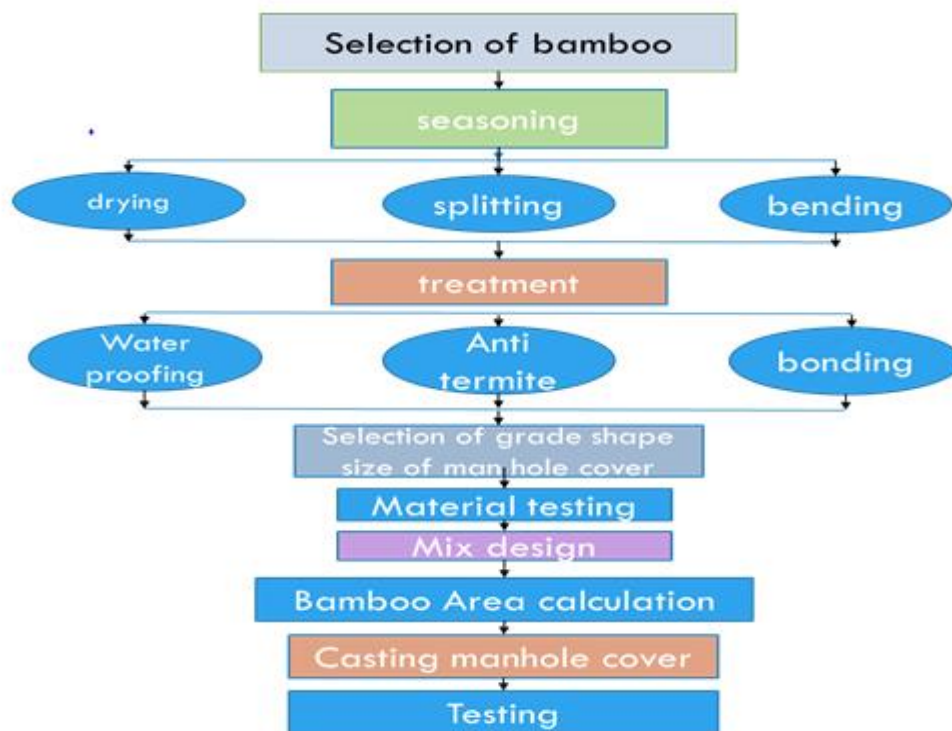


Figure 1. Flowchart of Methodology

2.1. Selection

For reinforcement the bamboo selected should show brown color that means the bamboo is minimum of 3 years old. Longest and largest diameter of bamboo should be preferred (Anurag et al., 2013).



Figure 2. Selection of largest diameter bamboo

2.2. Seasoning

Seasoning is a process that will make bamboo compatible for using as reinforcement in concrete.

- **Drying:** selected bamboo should be well dried for 3-4 weeks because due to moisture the tensile strength of bamboo reduces (Anurag et al., 2013).
- **Splitting:** bamboo cannot be used completely instead it should be split into strips of width size ranging from 18 to 25 mm.
- **Bending:** bamboo can bend with application of heat or pressure on it. (if required)



Figure 3. Splitting of bamboo in strips

2.3. Treatment

- **Waterproofing (Low water absorption):** bamboo should be coated with coal tar for low water absorption as bamboo has the capacity to absorb upto 50% of water of its weight.
- **Anti-termite:** coating or soaking in lethal solution to resist termite attack.
- **Good bonding in concrete:** sprinkling of sand on the coated bamboo with coal tar and dried for 24-48 hours (Shakeel et al., 2014).



Figure 4. Treatment on strips of bamboo with coal tar (Shakeel et al., 2014).

2.4. Selection of Grade, Shape and Size of Manhole Cover

The grade, shape and size of manhole cover is selected as per IS code 12592:2002. In this study the grade considered is Light duty 2.5 which has a resisting capacity 25 KN load on it without any development of cracks on it, which is used for residential and institutional Complexes / areas with pedestrian but occasional light motor vehicle traffic, inspection chambers. Shape casted is square shape and size is 510mm x 510mm x 50mm in dimension.

2.5. Material Testing

Raw material testing to ensure the quality of raw material used is as per the recommendation standard to achieve best results.

2.6. Mix Design

Grade of concrete considered is M30. For bamboo reinforced the water cement ratio must be as low as possible because bamboo can absorb water from concrete and the tensile strength of bamboo will reduce (Akash et al., 2014). Table 3 shows M30 mix design.

Table 3. Mix design of M30 grade concrete

	Materials	kg/m ³
1	Cement	380
2	Water	160
3	Fine Aggregate	711
4	Coarse Aggregate	1283
	20 mm coarse Aggregate	924
	10 mm coarse Aggregate	359
5	Admixture	1.90
6	Water Cement Ratio	0.42

2.7. Bamboo Area Calculation (ratio of bamboo reinforcement)

For bamboo as reinforcement in concrete the ratio varies from 2.5- 4% of area of cross section. In this study the bamboo as reinforcement is taken as 3% of area of cross section of manhole cover.

2.8. Casting of manhole Cover

For casting process, the mesh of bamboo strips tied with binding wire of the required size is placed inside the mould (formwork) and placing of concrete with required amount of tamping or vibration is recommended.

2.9. Testing on manhole cover

Load Test on manhole cover is done in UTM machine in this test application of target load i.e. 25 KN is applied use of 300mm diameter circular block (plate) placed on manhole cover at its geometrical center and load application will be made as per IS code 12592:2002 recommendation. Figure 5 shows the setup of UTM for testing manhole cover.



Figure 5. Test setup for testing of manhole cover in UTM

III. RESULTS AND DISCUSSION

34.1 Water Absorption Test on Bamboo

3 sample of bamboo strips are taken which were dried natural in sunlight were weighed and immersed in water for 24 hours. The average water absorption by bamboo is 44% by its weight. Table 4 shows the water absorption test results.

Table 4. Water absorption by bamboo sample

	Dried weight grams	Immersed weight	Water absorption %
Sample 1	95	136	43
Sample 2	102	149	46
Sample 3	107	155	44
		average	44

3.2 Cost Analysis

From the cost analysis of manhole cover it is observed that the concrete required is same in bamboo as well as in steel reinforced manhole cover but the variation in cost is due to the reinforcement. The steel reinforcement cost is 3 times the cost of bamboo reinforcement that also includes its treatment cost. The overall cost of bamboo reinforced manhole cover is approximately 40% less than steel reinforced concrete manhole. Table 5 shows the cost analysis of manhole cover.

Table 5. Cost analysis of manhole cover.

510x510x50mm Manhole cover	Quantity	Price (Rs.) Steel manhole cover	Price (Rs.) Bamboo manhole cover
Concrete M30 Rs.5000/cum	0.013 cum	Rs.65	Rs.65
Reinforcement	2.37Kg steel for Rs.50000/ton, Less than 1/3 bamboo will be used Rs.100 per Bamboo	Rs.118	Rs.30
Treatment	Coal tar	nil	Rs.10
Total cost of manhole cover		Rs.183	Rs.105

3.3 Carbon Footprint Analysis

For manufacturing of 1 ton cement there is 1 ton carbon emitted and for 1 ton steel manufacturing there is 2 ton carbon emitted in environment (Suresh et al., 2008). Bamboo reinforced manhole cover has controlled 4.74 kg that is 49% less carbon footprint than steel reinforced manhole cover. Table 6 shows carbon footprint analysis.

Table 6. Carbon footprint analysis

	Bamboo manhole cover (kg.)	Steel manhole cover (kg.)
Carbon from cement	4.94	4.94
Carbon from steel reinforcement	-	4.74
Total	4.97	9.68

IV. FUTURE SCOPE

Research can be conducted on bamboo reinforced boundary wall, bamboo reinforced benches, low cost housing project using bamboo reinforcement etc. for Sustainable development.

V. CONCLUSIONS

- Bamboo has very high water absorption capacity so proper water repellent coating has to be done on bamboo before using it as reinforcement.
- Bamboo reinforcement can reduce the cost of structure by approximately 40 % or more as compared to steel reinforcement.
- Bamboo reinforcement should be given more attention as it can be successful alternative to steel reinforcement.
- Using bamboo reinforcement there can be reduce carbon footprint from environment and can also lower the effect of global harming.
- Bamboo reinforcement technology can surely contribute towards sustainable development.

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