Suitability Investigation of Bamboo Fibers with Superplasticizer Admixture in Concrete: An Experimental Studying

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Abstract

Bamboo fiber is the type of natural fiber obtained from true wood bamboo with high strength to weight ratio useful for building structures. On the other hand, the super plasticizer is used where well-dispersed particle suspension is required to improve the flow characteristics interruption in the concrete application there by reduction of the water to cement ratio without negatively affecting the concrete performance of mix preparation. The primary intention was to make eco-friendly concrete using bamboo fibers and superplasticizer admixture (SP's). In this research, bamboo fibers mix with a superplasticizer in concrete. Mix design was used C-25 grade. The source of data, technical compatibility exploration of concrete workability, strengths, water absorption were done in Arba Minch University, institutes of technology, department of civil engineering laboratory. Results obtained from technical data by varying the percentage of bamboo fibers from 0.5% to 1.5% concrete performance tests were performed. The test results have shown that a decrease in workability, compressive strength, and an increased water absorption. However, the addition of superplasticizers admixture leads to improving the flexural strength and reducing the cracking size of concrete. The study suggested that required evaluating the durability of concrete increases with bamboo fibers at different percentages of superplasticizer admixtures.

Keywords: *Bamboo Fibers, Cement, Modern Concrete and Superplasticizer Admixture*

1. INTRODUCTION

Concrete is the most important construction material working in public works and is used for a majority of structures nearby the world[1]. Then originated the majority of concrete structures are cement, fine and coarse aggregates, water, and admixtures. Modern concrete technology is the material adopted by the construction industry for it the ability to be readymade into different shapes and for affordability, but at the same time, it is not an environmentally friendly material because it utilizes large quantities of natural resources and it is also a source of environmental adverse impact because of its CO2 emission though cement manufacturing, Whereas the cement industry releasing CO2 during cement production process almost 5% to atmospheric [2]. Hence, the use of bamboo fibers with superplasticizer admixtures in concrete mix preparation can be suitable for environmental protection, economical cement quantity. Bamboo fibers come from agriculture plantation of bamboo wood after cutting and drying, detaching by manual and mechanical manufacturing processes for end-use.

Todays in the world various researchers have investigated the quality concerns for the abating environment, efforts are made to create more ecological concrete with many essential materials additional [3]. Studies on the engineering application of vegetable fibers including, soil, and wastes from industry, mining, and agriculture are underway in many academia in European, American, and Asian nation-states. Thus, the use of concrete worldwide is twin as much as aluminum, plastic, and wood put together, and are only exceeded in the existing world by the usage of naturally occurring water [4]. Correspondingly, since 960 AD bamboo is as well customarily associated with the cultures of Asia, the South Pacific, and American nations in the aesthetic of purpose. But in China and India countries it is used to construct up simple suspension bridges, either by making cables of split bamboo together [5]. Researchers' have closed that bamboo products at this time have a very vast demand in the world. Even if there is no rare documented data instead of the Ethiopian context. Hence, 67%, of African bamboo species and greater than 7% of the world total are found in Ethiopia next to Madagascar[6].

In Ethiopia, also the widespread major problem is the rapidly increasing price of concrete materials, especially cement. The projected demand for cement up to 2025 is linearly increasing by almost 10% per annum as per the Ministry of Finance and Economic Development report [7]. This report also reveals that great disparity exists in market price shoot-up for cement because of shortage. Simultaneously, the use of superplasticizer admixture to improve the properties of concrete made with natural and supplementary cementation materials such as marble powder, fly ash, silica fume is

documented in the literature. Several researchers are trying to investigate the possible properties of these materials for broader uses. On other hand, adding straw fibers and other waste materials mud in wall construction to construct a composite with a better performance. However, the application and use of bamboo fiber for concrete mix preparation are limited in the Ethiopian context. Even though the overview of natural fibers in concrete can be found in literature, there is nothing new exploration for assessing the use of bamboo fibers in concrete, likes water absorption and chloride ingress of concrete properties in general. These problems bring this investigation and to assessing remedy for the rapid increase in the price of cement. Thus, there was an evident obligation of needs investigation on the use of bamboo fibers made with superplasticizer relating to concrete performance to answer the following questions: what ways do the properties of normal concrete differ from the concrete made with bamboo fibers and superplasticizer admixture? What is the effect of bamboo fibers and superplasticizer admixtures incorporation in fresh and hardened properties of concrete? What are the economic and environmental benefits way of adding bamboo fibers and superplasticizer admixtures in concrete?

2. LITERATURE REVIEW

Workability, Compressive, Tensile, and Flexural Strength: Observation shows that the addition of carpet fibers, resulting in a reduction in workability. This is to be expected, because of the low density of carpet fibers as compared to normal concrete. However, concrete with carpet fibers significantly increases in tensile and flexural strength of concrete properties [8]. Natural fibers (NF) are unlikely to achieve considerable improvements in compressive strength by steel fiber inclusion. Increased up to 7% at 1% can be obtained as compared to normal concrete. However, superplasticizer admixture with bamboo fibers provides post-cracking ductility to the concrete [9]. In another observation, 1.5% addition of sisal fibers made with superplasticizer admixture will give better concrete performance compared to the normal concrete and it has an increasing rate for 3~6% incorporation [10]. Construction industries are facing problems of cracking and tensile strength problems, for that to add something in concrete to improve concrete tensile [11]. Cement content can be reduced by using a 125-aspect ratio of coconut fibers. This reduces the total production of cement content thereby resulting in less emission of CO2. Thus, the natural fibers are abundant effective in local areas in reducing cement price as well as environmental pollution [12]. A Critical review on the properties of natural fibers such as bamboo and sisal fibers reinforced polymer composite has enhanced the performance of concrete [13]. The results of using bamboo in the compression, tensile and

flexural strengths study suggest that the maximum improvement was 50% at 28days when the fibers content was 1% and aspect ratio (L/d=40) with length was 4.9mm[14]. The case of using bamboo rebars as partial replacement in concrete production causes no remarkable negative effect in the concrete properties and it has also increased load carrying capacity almost by 8% for singly reinforcing beam. Thereby increasing in compressive strength, but also decreasing in unit weight and a lack of remarkable negative effect on water absorption was reported [15]. Study shows that a comparative of bamboo reinforcing concrete beams using different stirrup materials for rural construction, indicated the use of steel stirrup as the most economical. But the most expensive means of shear reinforcement provision in bamboo reinforced beams in by rattan cane stirrups regardless of the grade of concrete. It is therefore, the author suggested that steel stirrups be used to improve the performance of bamboo reinforced concrete beams [16].

Toughness and Ductility: The primary purpose of fiber inclusion in concrete is not to increase strength but to provide toughness and ductility. There are various ways of defining and quantifying the toughness of fibers. Flexural toughness can be defined as the area under the complete load-deflection curve. Fibers with better bond characteristics like fibers with a high aspect ratio, or deformed fibers give higher toughness values when compared with other types of steel fibers [17]. The study has observed that the addition of bamboo fibers to concrete leads to improving the concrete strength toughness torsion and tensile stress. However, the researcher has not suggested on durability (like chloride ingress and water absorption) of concrete improved with bamboo fibers[18].

Water absorption: Limited studies have been carried out to determine the water absorption of concrete made from bamboo fibers. In general, the water absorption of concrete prepared from bamboo fiber is expected to be higher than that of normal concrete. This is due to the significantly high-water absorption of concrete made from bamboo fibers. The researchers have an investigation on different natural fibers in concrete and showed that the water absorption is increased with the increase in natural fibers content. Researchers did not discuss the rationale for water absorption concrete, they have endorsed further investigation[19].

Bamboo fibers manufacturing process

Bamboo is along an interesting history courting back more than 5,000 years and commonly used for multi-purposes since time and a viable source of livelihood for many persons and families in rural areas worldwide. The ancient Chinese also used this versatile grass for many projects, including arrow making, construction, weaving books, and paper [20]. Sometimes bamboo fibers are collated into bundles using water-soluble glue

dissolving during the mixing process, to ease handling and mixing.

- **Application of bamboo fibers made with superplasticizer admixture**

The uses of Bamboo fibers are so diverse, and making a categorization is difficult. But applications include the flight of stairs, pavements, airport pavements, slabs, tunnel linings, shotcrete, refractory elements, and various types of concrete repair. The application areas of bamboo fibers are expanding through the accumulation of research conducted on this topic, but unfortunately, bamboo fiber made with superplasticizer addition to concrete in most cases increase the properties of concrete. The higher structure will be highly vulnerable to earthquake loads, but the addition of bamboo fibers and superplasticizer in concrete mix preparation makes the structure the most economic appraisal [21].

Using bamboo fibers made with superplasticizer admixture in concrete is an effective measure concerning reducing the cost of concrete and keeping the environment clean along with decreasing the use of natural raw materials. In this regard also bamboo was used as reinforcing materials without any treatment and stirrups for low-cost building [22]. More research is required to evaluate the economical and eco-friendly of natural fibers like bamboo in concrete making [23]. Generally, as there are no in-depth studies found in literature, the exploration of this research will provide critical insists on the use of bamboo fibers with a super plasticizer for producing concrete products in the Ethiopian context.

3. MATERIALS AND METHODS

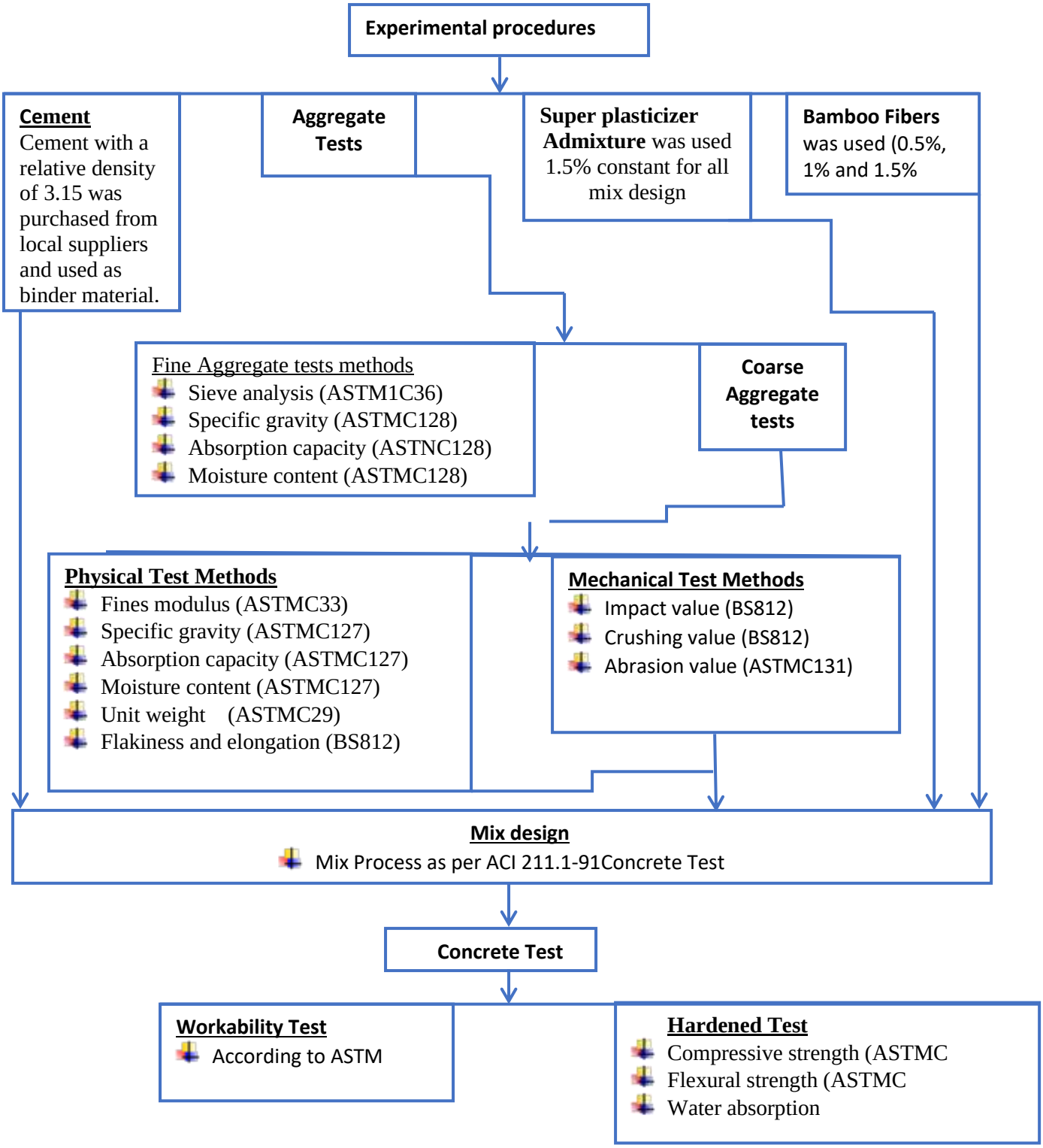

Chart 3.1-Experimental procedure for research Methodology

4. RESULTS

The results required from this research study were obtained to examining of the mechanical properties of concrete prepared from bamboo fibers and superplasticizer more over conventional concrete to formulate a new mix design for C-25 concrete application areas in the Ethiopian construction industry.

4.1 Mix Design of Concrete

The mix design process as per ACI 211.1-91 is followed for design C-25 concrete grade as well as target slump was 25~100mm (ACI committee, 2002). A total of 4 mix ratio was used. For all normal mix cement was substituted by 1.5% superplasticizer except to normal concrete. Bamboo fibers content is included in three different weights of fraction i.e., 0.5%, 1.0%, and 1.5% concerning fiber length 15mm, 25mm, 35mm, and aspect of (L/d) 50.

Table 3.1. Mix proportions for aspect ratio of (L/d)50.

Mix series	Cement quantity kg/m3	W/C	Fine aggregate kg/m3	Coarse aggregate kg/m3	bamboo Fiber (%)	Admixtures (%)
M0	456	0.45	746	956	0	1.5
M1	410	0.5	746	956	0.5	1.5
M2	372	0.55	746	956	1.0	1.5
M3	342	0.6	746	956	1.5	1.5

4.2 Workability

All Mix serials design to a given slump value 25-100mm.

Table 3.2 . Slump value from mix proportions for aspect ratio 50

Mix series	Fiber content (%)	Water /cement ratio	superplasticizer content(%)	Slump (mm)
M0	0	0.45	1.5	90
M1	0.5	0.45	1.5	85
M2	1.0	0.45	1.5	78
M3	1.5	0.45	1.5	67

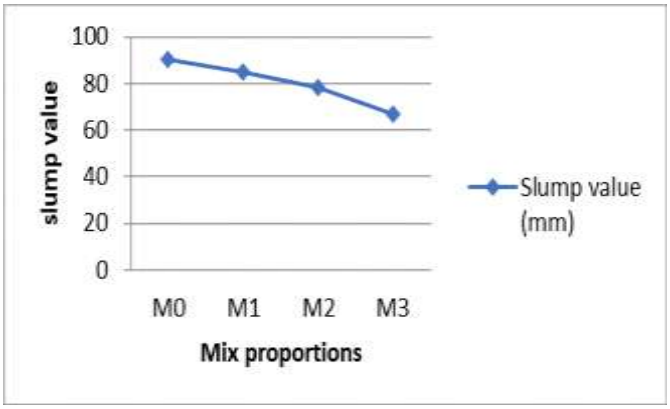

Figure 3.1 – Results from test Slump 25~100mm

As described in Table 3.2 and figure 3.1, the slump value decrease from 0.5%~1.5% as compared to normal concrete in weight fraction of bamboo fibers and 1.5% weight of superplasticizer content. Despite the lowest slump value obtained, but almost all mix serials were attended workability of concrete. As a result of this test, it can be concluded that according to ACI code is a reliable measurement of workability.

4.3 **Hardened properties**

4.3.1 **Compressive strength**

The value of compressive strength obtained at 1.5% of both fibers and superplasticizer shows declining with increasing fiber content.

Table3.3 Variation of compressive strength with the different fiber and curing time at constant superplasticizer Admixture

Mix series	Fiber content (%)	Water /cement ratio	superplasticizer content(%)	Compressive @ 28day (Mpa)
M0	0	0.45	1.5	28.05
M1	0.5	0.45	1.5	27.97
M2	1.0	0.45	1.5	28.02
M3	1.5	0.45	1.5	27.72

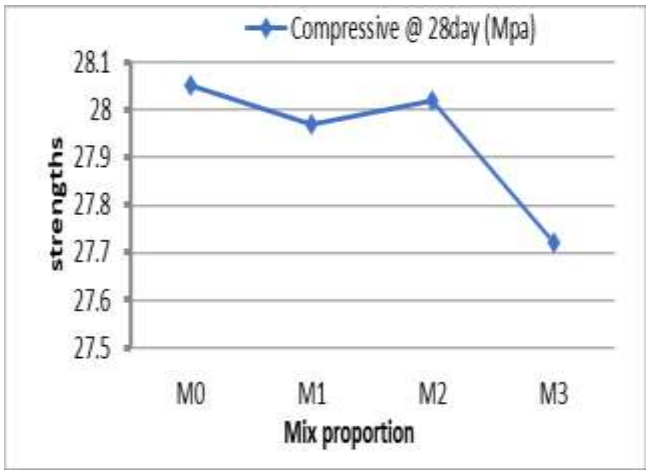

Figure 3.2 -Results from Compressive strength

As result obtained in Table 3.3, the compressive strength for normal concrete Mixed in series M0, M1, M2, M3, and M4 were found 28.05 Mpa, 27.9 Mpa,28.2 Mpa, and 27.72Mpa respectively. In this mix series addition of bamboo fiber and superplasticizer, the values of mean compressive strength vary from 28.05~27.72Mpa with minimum Relative compressive strength loss of 0.33%. it can be concluded that increase fiber content becomes a decline in compressive strength.

4.3.2 **Flexural strength**

Table 3.4 Variation of Flexural strength with the different fiber and curing time at constant superplasticizer Admixture

Mix Series	Fiber content (%)	Water /cement ratio	Superplasticizer content(%)	Flexural @28 day (Mpa)
M0	0	0.45	1.5	6.45
M1	0.5	0.45	1.5	6.67
M2	1.0	0.45	1.5	7.27
M3	1.5	0.45	1.5	7.87

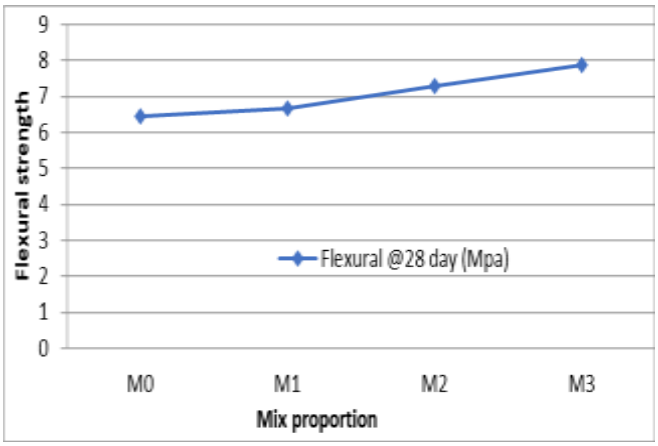

Figure 3.3 -Results from Flexural strength

As results in Table 3.5, clearly showed that percentages (0.5~1.5%) of fibers increase at 1.5% superplasticizer content, then the Flexural strength slightly increased by 1.42%. The results observed that the value of Flexural strength of both fibers and superplasticizer shows increased with increasing fiber content.

4.3.3 Water absorption

Table 3.6 Variation of water absorption with the different fiber and curing time at constant superplasticizer admixture

Mix Series	Fiber content (%)	Water /cement ratio	Superplasticizer content(%)	Water obsorption (%)
M0	0	0.45	1.5	63.15
M1	0.5	0.45	1.5	78.56
M2	1.0	0.45	1.5	83.27
M3	1.5	0.45	1.5	92.32

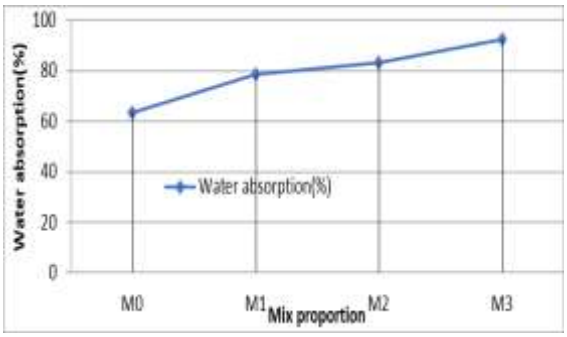

Figure 3.3 -Results from Water Absorption Test

From Table 3.6, it can be noted that water absorption of the normal mix is 63.15%, However, bamboo fibers inclusion has resulted in water observation with a maximum of 78.56%, 83.27%, and 92.32% respectively. It noted that increasing percentage content becomes raising water absorption, due to fibers stored water.

5. CONCLUSIONS AND RECOMMENDATIONS

The addition of bamboo fibers strongly affected the workability of fresh concrete. The test results clearly show that increased fiber at constant content of superplasticizer admixture leads to decrease workability of concrete. A relative compressive loss and raised again. If what is wanted a compressive strength is increased, change the cement types. Fiber inclusion of all percentage weights and superplasticizers admixtures leads to an increase in the flexural strength values almost by 1.5%. However, the relationships between percentage fiber weights and superplasticizers admixtures lead to increase water absorption. For further studying, it suggested that need to assess the durability with different percentages of superplasticizers admixtures.

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