

Eco-friendly Azadirachta Indica Ash and Miscanthus Fiber Brick for Carbon Neutrality Environment

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Abstract

Naturally grown fiber are not utilized properly they are neglected as wastes. These resources are thrown away due to insufficient research being conducted to discover viable uses for naturally existing fibres. These byproducts have a wide variety of applications in the manufacturing sector, notably in the construction sector. The prospective applications of miscanthus fibre, which may be found growing wild in uncultivated places, are investigated in this research. The production of bricks involves using miscanthus fibre, Azadirachta Indica ash (AIA), and a natural admixture (NAD). This is due to the fact that consideration is given to all three of these aspects throughout the manufacturing process. Egg albumen and egg yolk are used in the fly ash brick in the following ranges of concentrations as a binding agent: 0.5%, 0.10%, 0.15%, 0.20%, and 0.25%; and 5%, 10%, 15%, 20%, and 25% by weight of miscanthus fibre. Both ranges are expressed as a percentage of the total weight of the brick. Azadirachta Indica ash (AIA) of Miscanthus fibre and natural admixture (NAD) bricks are put through a series of tests over the course of 7, 14, and 28 days to determine their durability (compressive strength). These tests also evaluate the bricks' absorption, the presence of soluble salts, the size and form of the brick, as well as its soundness and level of hardness. At the conclusion of each time period, this evaluation is carried out. The discoveries have the potential to assist in the development of a building material that is friendlier to the environment.

Key words: Compressive strength, Absorption test, soundness, Hardness test, Naturally fiber.

INTRODUCTION

Brick play vital role in the field of construction industry. It procures more space in the building for partition wall and the usage of brick is high in the construction world. The Eco-friendly building material should be used and should not affect the environment but in the production of the cement brick the usage of the cement is more. It increases greenhouse gas causing global warming, because large amount of CO₂ is produced for the production of the cement and for the clay brick manufacturing more energy burned by fossil fuel [1].

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To reduce the detrimental greenhouse gases natural fiber, admixture, industrial and agro-waste are used as a replacement of cement, because this agricultural wastes are produced more and throw out every year. Instead of that by using these agricultural waste and industrial waste in the cement production is an eco-friendly, durable and economic. It is also new technology to recycle the waste materials and used as the construction materials like fly ash, rice husk ash, corn cob ash,

silica fume, etc [2] concerning to decrease the quantity of cement in brick fly ash is used in the production of fly ash brick.

In this research Azadirachta Indica ash (AIA) is used as the cementitious binding material in the brick manufacture. It is dried and burnt and ashes are collected after that it is sieved and used for the partial replacement of cement, and it is a sustainable building material. Natural fiber and natural admixture is also used in the production of AIA brick [3]. The aim of using this fiber is to reduce the brittle and increasing the ductility of the material and also increases the sturdiness capacity of the brick. The NAD is added to increase the strength and reduces the water adsorption and porosity by adding with different percentages. In this study brick of Azadirachta Indica ash, quarry dust, cement, Natural admixture and Miscanthus fiber is added with various proportions and to determine the Compressive Strength, [4] Water Absorption, Presence of soluble salt test, Soundness test, Shape and Size test and Hardness test were taken for this AIA brick to determine the strength and the water absorption of the brick with the various mix proportion. And also by using this Waste material in brick carried out by the researches and also concluded that the addition of these materials in brick satisfies the need of common building materials [5].

The objective of this research is to improve the quality of the brick and reduce the water absorption and porosity of the brick and to provide an alternative disposal method of Azadirachta Indica ash waste. The proportion of Azadirachta Indica ash, quarry, cement, NAD (0.5%, 0.10%, 0.15%, 0.20%, 0.25%), and same mix proportion by adding Miscanthus fiber (5%, 10%, 15%, 20%, 25%), quarry dust is decreased by increasing Miscanthus fiber by 5% for each proportion.

Materials and Methods

Azadirachta Indica Ash

Azadirachta Indica is a sustainable building material for thermal insulation. Azadirachta Indica is rich in cellulose. It contains 27.71% of cellulose, 14.8% of hemicelluloses, and it also contain significant amount of lignin is 14.63% [6–8]. The ash is obtained from the burning of Azadirachta Indica waste. Azadirachta Indica is broken into small piece and it is burned in the furnace about 700 degree Celsius up to 5 hours. The Azadirachta Indica ash is passed through 75 microns and retained at 63 microns is taken for the manufacturing of brick with partial replacement of the cement as shown in Figure 1.



Figure 1. Azadirachta Indica ash.



Figure 2. Miscanthus fiber.

Miscanthus Fiber

It is natural fiber and also called as elephant grass fiber, and it is 3 to 4 feet height. Miscanthus is varying from 21.7% to 30.9%, the holocellulose from 58.0 to 75.7%, the cellulose from 38.2% to 51% and hemi cellulose from 17.1% to 25.2%. The purpose of using this fiber is to reduce the brittle of the material. This fiber has more fiber content and less water content after harvesting [9–10]. After harvesting the fiber is dried and cut into small pieces 3 to 5 cm and 4 to 8 mm diameter and used in the brick as shown in Figure 2.

Natural Admixture (NAD)

The natural admixture Egg is used in manufacturing of brick with the partial replacement of the water. It is used as the ingredients of mortar to stick building materials for the construction. It is generally used as the adhesive which is a compound that bonds two materials [11].

METHODOLOGY

Mix Proportioning

The main intention of this project is to reduce the cement usage by the industrial waste and the agricultural waste such as Azadirachta Indica ash (AIA) [12], Miscanthus fiber is used for the production of brick and natural admixture is also used as the partial replacement of water. Before producing the brick, the standard mix proportion of the brick to be prepared according to the standard specification for a good engineered quality brick. To keep up the quality of the brick, calculate the quantity of the materials needed for a required number of bricks. Totally, 99 bricks were produced using Azadirachta Indica ash (AIA), Cement, Quarry dust, Miscanthus fiber and NAD, for comparison 9 fly ash (FA) bricks is manufactured, totally twelve specimens are produced. To find the quantity of the bricks the test were taken. For each test three bricks were required, so for single proportion nine bricks are needed, and the remaining is used for substitution of broken bricks.

In order to reduce the quantities of cement in cement brick. Fly ash is used as an alternative, accordingly composition of the brick is produced by the normal fly ash brick that is fly ash 35%, quarry dust 50% and cement 15%. In this project instead of using fly ash Azadirachta Indica ash (AIA) is used for sustainable building material. The cement and Azadirachta Indica ash (AIA) is common for all the mix proportion. In this manufacturing of the Azadirachta Indica ash (AIA) brick cement 20%, Azadirachta Indica ash (AIA) 35% and quarry dust 45% is used. In addition to the NAD is added as the binding agent with the partial replacement of the water as 0.5%, 0.10%, 0.15%, 0.20%, 0.25% and the cement 20%, Azadirachta Indica ash (AIA) 35% and quarry dust 45% is same as the Azadirachta Indica ash brick. Miscanthus fiber is added to reduce the fragility of the material in the

brick with the ratio of 5%, and it is getting increased by 10% and 15%, 20%, 25% in the composition of 20% cement, 35% Azadirachta Indica ash (AIA) and 40% of quarry dust by the addition of the fiber content in the brick it reduces the usage of quarry dust in the brick by 5% for each proportion and by increasing the fiber 5% in each proportion of brick manufacturing [13]. The manufacturing process of the brick is the twelve different types of mixtures are prepared to the requirement. Mix ratio of the raw materials manually put into the pan mixer as given in Figure 3.

Where water is added to their required proportion for homogenous grinding, and it depends on the consistency of the mix proportion. The proportion of raw materials depends upon the raw materials quantity. After the raw materials mixing for 4–5 minutes, the mixtures are led through the belt conveyor slowly for each time to the automatic brick making machine. This machine is used for automatic moulding $230 \times 110 \times 70$ mm for the manufacturing of brick. Where the bricks are pressed through the hydraulic press machine it is taken and placed on the wooden pallets for two days. After that process the bricks are shifted to the area where it is water cured for 10–14 days and got dried for one or two days and next to this is sorting and testing process is done. The procedure is same for all the mix proportion and given in Figure 4.

EXPERIMENTAL INVESTIGATION

Effects of Compressive Strength Test

The primary test conducted in the brick is to test the strength and suitability of the product for construction purpose. This test was taken through the compressive testing machine. A brick is placed in the machine then the load appeals till the failure crack exist in the brick. Then the brick compression strength is recorded from load indicator of the machine. The test was taken for all the specimens for 7, 14, 28 days [14]. It is represented as ratio of load to the area of the brick in Figure 5.



Figure 3. Pan mixer.

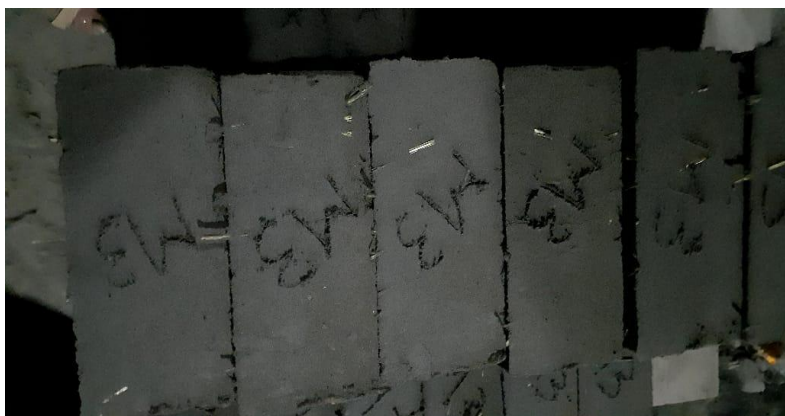


Figure 4. Manufactured brick.



Figure 5. Compressive test.

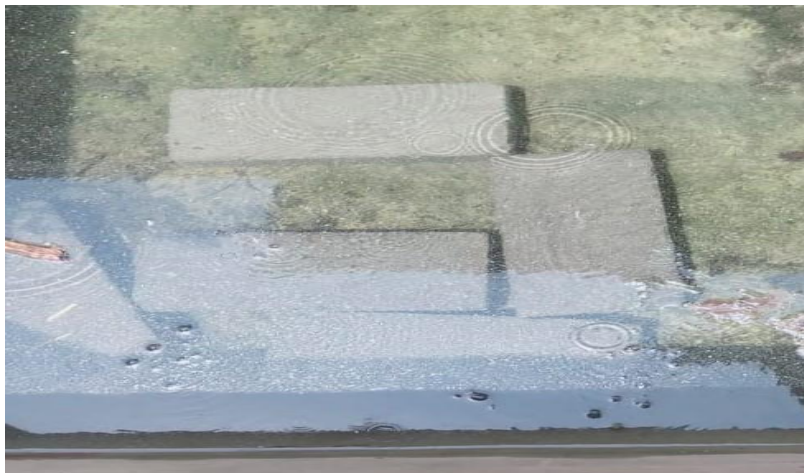


Figure 6. Water absorption test.

Water Absorption Test

This test is conducted to assess the water absorbing quality of the brick, by placing the brick in curing tank for twenty-four hours. The maximum limit of water absorption should not be exceeded 20 percent to the mass of dry brick. The dry bricks are getting weighted (W_1) [15] (Figure 6). They are then dipped in water for twenty-four hours, bricks are taken out and wiped with cloth and the brick weight is determined (W_2).

$$\text{Water absorption} = \left(\frac{W_2 - W_1}{W_1} \right) * 100$$

Presence of Soluble Salt Test

If the soluble salt present in the brick it may cause efflorescence on the surface of brick [16]. The brick is placed in a steel tray which is filling up to the height of 25 mm by water for twenty-four hours. It's taken out and allowed to dry in shade. If white deposit does not occurs in its surface it representing the absence of soluble salts. Observation is made with naked eyes are classified below.

- **Nil:** Imperceptible efflorescence
- **Slight:** Accumulation over the area below 10% of exposed surface
- **Moderate:** Accumulation over exposed surface 10% to 50%
- **Heavy:** Accumulation over exposed surface greater than 50%
- **Serious:** Accumulation is heavy and flake away the surface

The Soundness Test

The test carried to determine the clear resonates by striking the two bricks each other without breaking them.

Shape and Size Test

Test is taken to assess the physical structure of the brick whether the brick is broken or not and it has sharp edges and also it is seen that the structure homogeneous and free from holes, lumps etc. To check that random bricks are selected and they are stacked along the length, width and height. The standard brick size is $230 \times 110 \times 70$ mm.

Hardness Test

A good quality brick should resist scratches that produced by sharp things. So for this test a sharp tool or a finger nail is used to create an impression on the surface of the brick.

Acid Mass Loss Test

10% by volume of HCl was prepared (100 ml) in a beaker. The dry weight of the pellet was noted. The pellets were lowered into the beaker and kept inside the beaker for 24 hours. After 24 hours, the pellets were taken out and the mass noted.

$$\text{Acid mass loss \%} = \frac{M_i - M_f}{M_i} \times 100$$

M_i = Initial Mass

M_f = Mass after being dipped in acid

RESULTS AND DISCUSSION

Compressive Strength test

The strength of NAD brick get increases by increasing the percentage of NAD by 0.5% 0.10%, 0.15%, 0.20%, and it attains 9.41 N/mm^2 as displayed in Figure 7 (a) [17–18]. By increasing 5% of fiber in each proportion, the compressive strength is enhanced to 11.21 N/mm^2 as exhibited in Figure 7 (b). Adding more fiber that is 20% of M20, 25% of M25, the strength gets decreases and also the strength decreased by adding 0.25% of NAD. Compare to fly ash brick all the bricks have good in strength.

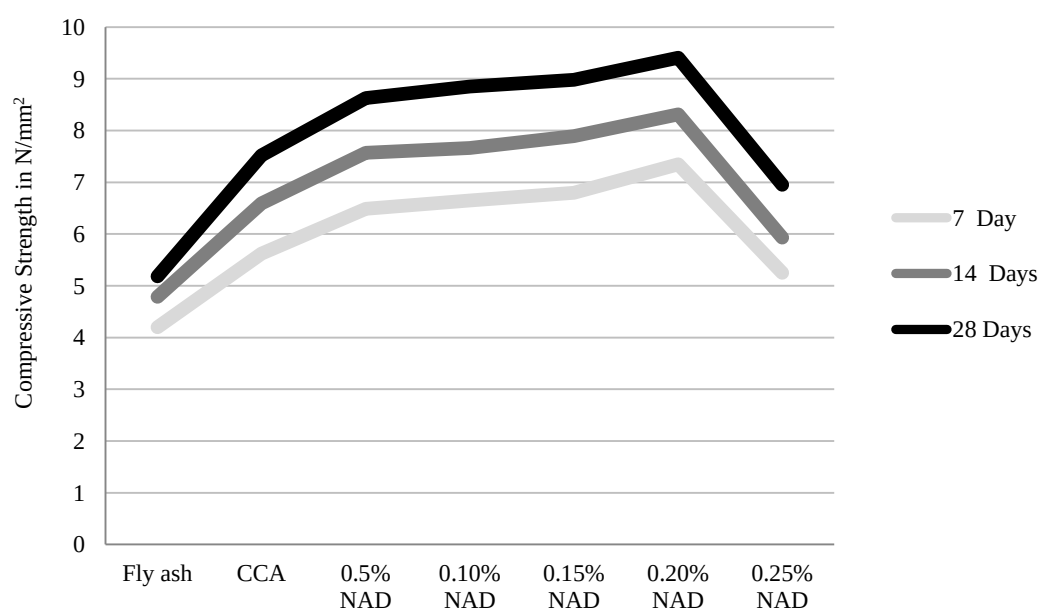


Figure 7. (a) Graph of Compressive test on brick of NAD.

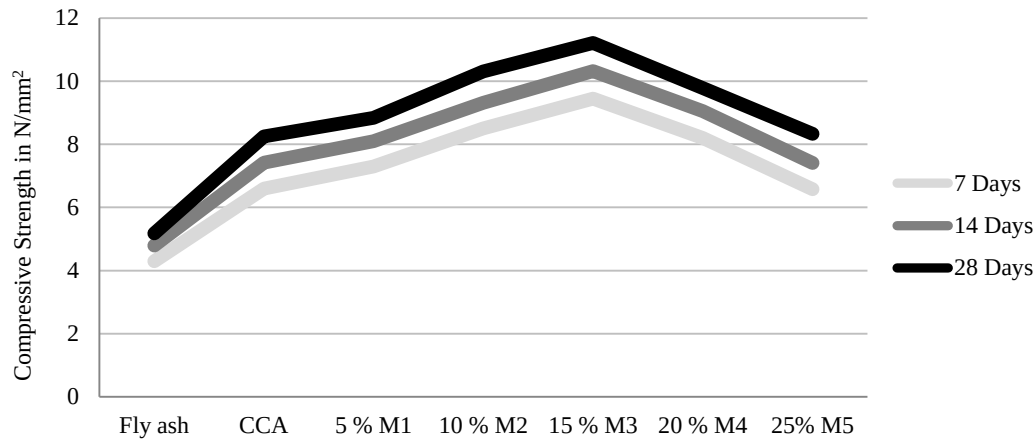


Figure 7. (b) Graph of Compressive test on brick of Miscanthus fiber.

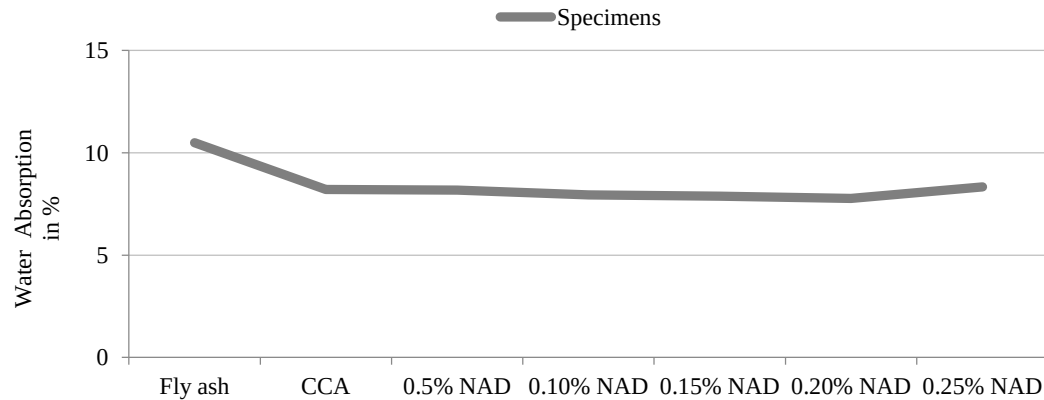


Figure 8. (a) Graph of water absorption test on brick of NAD.

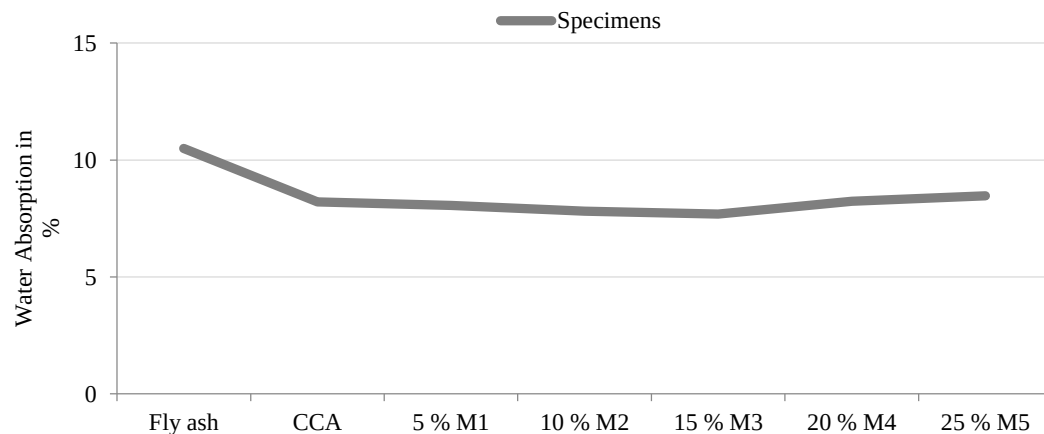


Figure 8. (b). Graph of water absorption test on brick of Miscanthus fiber.

Water Absorption test

The water absorption is less by adding NAD at 0.5%, 0.10%, 0.15%, 0.20% [17–21] And also it is decreased when fiber is increases by 5% in each proportion that is increase in NAD and Miscanthus fiber decreases the water absorption rate. By adding 0.25% of NAD enhance the water absorbing capacity and also by adding 20%, 25% of fiber increases the water absorption as seen in Figure, while comparing fly ash brick, the water absorption for Miscanthus fiber brick and Natural admixture (NAD) is very much low as compared to fly ash brick exhibited in Figure 8 (a-b).

Presence of Soluble Salt Test

It is free from soluble salts.

Soundness Test

Produce clear ringing a sound without breaking of bricks.

Shape and Size Test

Brick has perfect shape and size and no lumps and holes are found.

Hardness Test

No scratches were founded in the brick.

Acid Mass Loss Test

Acid Mass Loss <1.5% confirm to the IS 4860-1968 to be used as acid resistant brick.

CONCLUSION

Azadirachta Indica ash (AIA) is suitable for pozzolanic material because it contains $\text{SiO}_2 + \text{Al}_2\text{O}_3$ about 74.49%, so it is better to replace cement partially in the fly ash brick and, also it is good in the compressive strength and also less in the water absorption test. By adding the Azadirachta Indica ash, it reduces the weight of the brick compare to the fly ash brick. While adding fiber is less in weight compare to the adding of NAD as shown in Figure 9 (a-b).

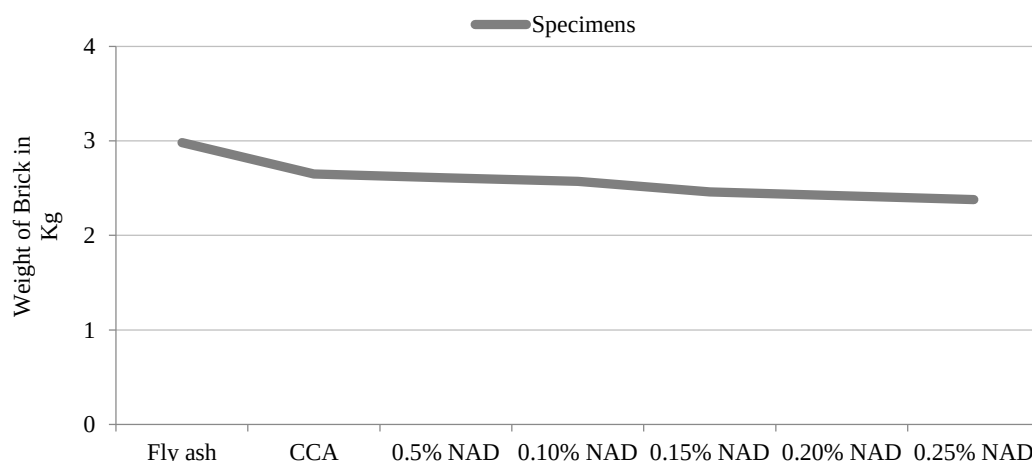


Figure 9. (a). Graph of Weight of the brick of NAD.

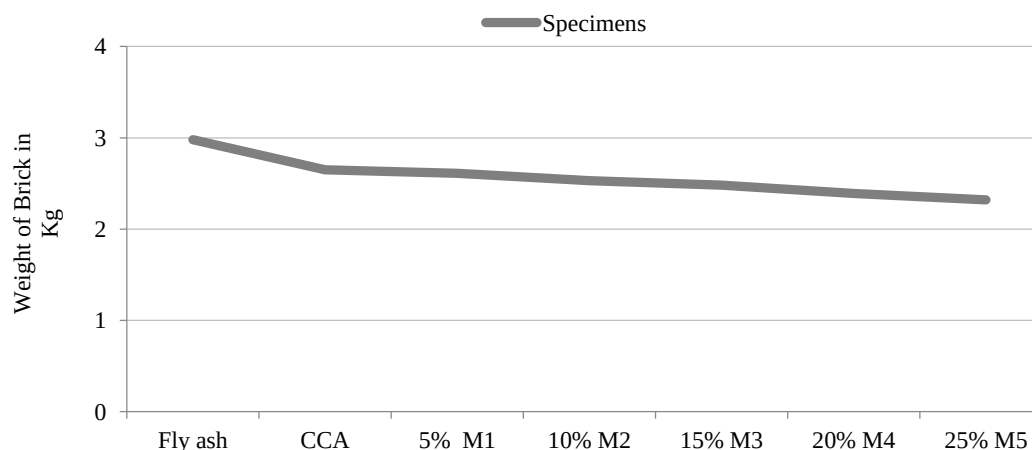


Figure 9. (b). Graph of Weight of the brick of Miscanthus fiber.

The NAD is added from 0.5%, 0.10%, 0.15%, 0.20% results in increases the strength of the brick and the water absorption is very low at this proportion. While increases the proportion to 0.25% it starts decreases the strength of the brick. So the extreme capacity achieves between 0.20% and 0.25% that is the maximum limit of adding NAD is 0.20%, and the mass of the brick gets decreased by adding of NAD. Miscanthus fiber is added by 5%, and it gets increased by 5% in each proportion, the strength gets increased by increases the fiber in the brick and water absorption is less in this proportion. In addition, of 20%, 25% of the fiber in the bricks increases the water absorbing capacity of the brick due to addition of more fiber absorbs more water, and it reduces the strength of the brick. But compare to the other brick the weight is less while adding Miscanthus fiber in the brick, hence the optimum quantity of the NAD is 0.20% and the fiber is 15% is used in the brick gives the best results.

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