International Journal of Future Generation Communication and Networking
Vol. 13, No. 4, (2020), pp. 2825–2834

Experimental Study On Chemically Treated Sawdust As A Partial Replacement Of Sand In Pavement Blocks

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Abstract

Paver blocks are precast concrete products manufactured using cement, fine aggregate, pigmented water and admixture. Many researchers have pointed out the shortage of sand to make concrete after few years, as India herself consumes an estimated 450 million cubic meter of concrete annually. Hence there is an urgent need for the replacement of sand. Sawdust is considered as a waste product of the lumber industry hence with years of research it has been proved that treated sawdust can be used as an alternative to sand when added in the form of filler in concrete. To promote a practical use and acceptance of a new material in concrete pavement blocks by the potential end users, it is necessary to investigate the manufacturing process, properties and feasibility of sawdust in concrete. Sawdust being highly hydrophilic in nature cannot be used without processing in concrete as only limited water is added in concrete for hydration and early strength gain purposes. Hence in this study based on research, two different textile industry processes mercerization and acetylation was carried on pinewood sawdust as 5% and 10% volume fraction replacement of sand. The abrasion resistance of these blocks increased whereas the compressive strength almost remained same when compared to conventional concrete which is significant. This gives an initial hope of partial replacement of sand with the lumber industry waste sawdust in the future by certain changes in the volume fraction, type of sawdust and parameters of the mercerization and acetylation process.

Keywords: *Acetylation, Abrasion resistance, Compressive strength, Lumber industry, Mercerization, Paver block.*

Introduction

General:

Now-a-days scarcity of sand for manufacturing of cement as well as construction of any structure has been observed. Hence there is need to find a suitable replacement in the form of sawdust. Sawdust is nothing but a plant fiber waste. One such useful replacement of sand is sawdust obtained from the various operations of the milling industry such as grinding, drilling, sawing etc. Other than this, basically sawdust is the waste material from lumber industry. The utilization of waste material in the concrete is recognized as a one of the best option to dispose the solid waste from other industries. The physical and mechanical properties of sawdust in concrete mixes are not only depended on the amount of the sawdust used but also on the chemical properties of the sawdust[1]. Due to high water absorption property, sawdust shows the poor mechanical properties when it used in the significant amounts in the concrete mixes. However, with years of research, it has been proven to produce eco-friendly concrete and light weight construction[2]. It has been observed that the mixture of sawdust improves the workability and hydration of the concrete. Hence it can be inferred that sawdust can act as a good filler or binding material. The implementation of waste sawdust can not only decrease environmental damage, but also can economically save the concrete

ISSN: 2233-7857 IJFGCN

materials. It has many advantages over traditional concrete, which could create more environmental profits. Concrete paver blocks are precast concrete products used for the construction of sidewalks, roads or landscaping. Concrete paving blocks have been extensively used in many countries for quite some time as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. These blocks were rectangular in shape and had more or less the same size as the bricks. Interlocking pavers are most commonly made from cement mixed with other constituents and tend to stimulate the effects of pathways. These special interlocking features enable pavers to be easily installed without the use of mortar. It is available in many colors, shapes and designs ranging from 2 to 2.5 inches thick, similar to that of a regular block [3].

Materials and test

Sawdust:

Sawdust is obtained from woodworking operation especially from lumber industry. The sawdust used in this study was obtained from the timber sheds located in thane, Maharashtra. The sawdust used for this experimental study was from pine wood. Obtained sawdust was dried under sun and kept in waterproof bag. This sawdust was then sieved through 850 microns sieve. The concrete manufactured from this sawdust is a mixture of pinewood sawdust, gravel with certain percentage of water to enhance the workability and full hydration of cement thereby enabling great bonding of concrete. Concrete was observed to be harsh as a sawdust percent increase that means more water is required to make a mix more workable [4]. Use of sawdust can be economical as it is a waste product and easily available. Sawdust can preserve the resources particularly sand and thus make construction industry sustainable. Sawdust is a fine powdered which has less void ratio [5]. Water first gets absorbed on the layer of sawdust and then slowly penetrates into micro void present in it thereby rendering it vulnerable to cracks. So, we should use the admixtures with sawdust in concrete to prevent water logging in concrete.

Fig.1: sawdust

Sawdust concrete has several unique characteristics which makes it competitive among other building materials:

1. Sawdust concrete is a naturally available light weight material.[6].
2. It is an economical alternative to conventional building concrete method and material also saves labor and natural resources.
3. At the end of its initial service life, concrete can be crushed and reused as aggregate for new concrete continuing the cycle of environmental benefits

A. Moisture content test on sawdust:

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The calculated moisture content of sawdust is 8.8%.

B. Fineness modulus test on sawdust:
The calculated fineness modulus test of sawdust is 5.526.

Cement:
Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and the second most-consumed resource. Cements used in construction are usually inorganic; often lime or calcium silicate based, and can be characterized as either hydraulic or non-hydraulic, depending on the ability of the cement to set in the presence of water.

A. Fineness test on cement:
The obtained value of fineness test is 13%.

B. Initial and final setting time:
As per IS1489 part 1 the minimum initial setting time is 30 min and the maximum final setting time is 600 min. the obtained values of initial setting time is 91 min and final setting time is 211 min.

C. Soundness test on cement:
The calculated values of soundness test 2.8.

Water:
Tap water is used for the concrete mixes but for chemical treatment of sawdust distilled water was used.

Aggregate:
Aggregate is a broad category of coarse to medium grained particulate material used in the construction. Aggregates are included in the concrete in various forms like sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregate. Aggregates are a component of composite materials such as concrete and asphalt concrete[7]. Due to the high mechanical property of the aggregate, it serves as good reinforcement to add strength to the overall composite material. The hydraulic conductivity value is relatively high as compared to most soils.

A. Sieve analysis of aggregate:

The calculated value of sieve analysis is 3.868. Therefore a selected aggregate belongs to grading zone 1.

B. Impact test:
The average value of impact test on aggregate is 13.39.

C. Crushing test:
The average value of crushing test on aggregate is 15.54%.

D. Shape test:
The flakiness index of aggregate sample is 26.71%.
The elongation index of aggregate sample is 70.18%.

Super plasticizers:

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Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics (Rheology) of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio without negatively affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. The strength of concrete increases when the water to cement ratio decreases.

Experimental procedure:

Concrete mix design:

M30 grade with nominal concrete mix having proportion of 1:0.75:1.5 by weight is prepared. The calculated water cement ratio is 0.4 for the investigation the properties of concrete pavement block. Concrete cubes of size 150mm x 150mm x 150mm were casted with partial replacement of the sand with 0%, 5% and 10% of sawdust.

Chemical test on sawdust:

Here, two textile industry methods like mercerization and acetylation which used to chemically treat the natural fibers or fillers.

Mercerization:

Mercerization is an alkali treatment process. It is widely used in the textile industry. Concentrated caustic soda is used for the treatment [8]. Natural fiber consist of some cellulose and non-cellulose chemical constituent such as lignin, hemicelluloses, pectin, natural oil, wax etc. these cellulosic and lignin contain component could be removed by appropriate alkali treatment which will help to increase the tensile strength of fiber [9]. The treatment consists of immersing the fibers in a solution of sodium hydroxide for a period of time and then material is treated with distilled water and acid to neutralize the sodium hydroxide[10]. Various parameters of mercerization such as concentration, temperature and soaking duration also play a mitigating factor in deciding the effect of the technique in making the filler hydrophobic[11].

Table 1: Adopted parameter for mercerization treatment

Natural fiber	Concentration of NaOH	temperature	Duration (min)
Pine wood	5%	50°C	30

In this research, 5g of fibers were treated with 5% of NaOH solution and heated at 50°C for 30 min. The fibers were then filtered and washed with 2% of glacial acetic acid and neutralized. It is essential to neutralize the solution before washing with water. The fibers were then washed with distilled water twice. Later, these fibers were oven dried for 24 hours at 105°C and stored in clean plastic air tight bags.

Acetylation:

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Acetylation is also one of the chemical treatments which enhance the chemical properties of fiber. This treatment may help to remove partially lignin and hemicelluloses content from fiber. It improves the chemical bonding between fiber and matrix [12]. In acetylation the soaking time or retention period of natural fiber also influence the chemical properties of fiber.

Natural fiber	Concentration of acetic acid	Temperature	Duration (minutes)
Pine wood	5%	Room temperature	30

Table 2: Adopted parameter for acetylation treatment

In this research, 5g of fibers were treated with 1% NaOH solution for 120 rpm at room temperature for 15 min. The fibers were then filtered and washed with distilled water. Later these fibers were added into 5% of glacial acetic acid at 120 rmp for 15 min. Finally the fibers were filtered and oven dried at 105°C for 24 hours.

Result and discussion:

1) Compressive strength:

Volume fraction	Load (kN) 7 days	Compressive strength (Mpa)	Load (kN) 28 days	Compressive strength (Mpa)
0%	870	39	1450	64
5%	800	36	1400	62
10%	740	33	1370	61

Table 3: compressive strength test on mercerized sawdust concrete block

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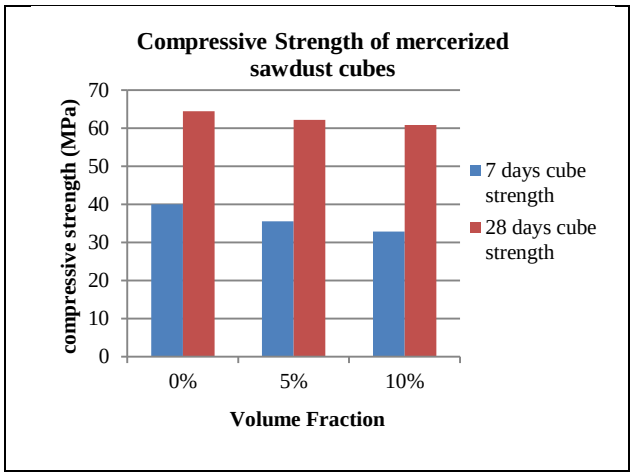

Fig.2: Compressive strength on mercerized sawdust concrete block

It has been observed that 5% replacement of mercerized sawdust showed 3.1% decrease in the strength when compared to no sand replacement concrete results. Also with 10% replacement of mercerized sawdust showed 4.6% decrease in the strength when compared to no sand replacement concrete results.

Volume fraction	Load (KN) 7 days	Compressive strength (Mpa)	Load (KN) 28 days	Compressive strength (Mpa)
0 %	900	40	1500	67
5 %	850	38	1440	64.1
10 %	810	36	1390	62

Table 4 : Compressive strength test on acetylated sawdust concerete blocks

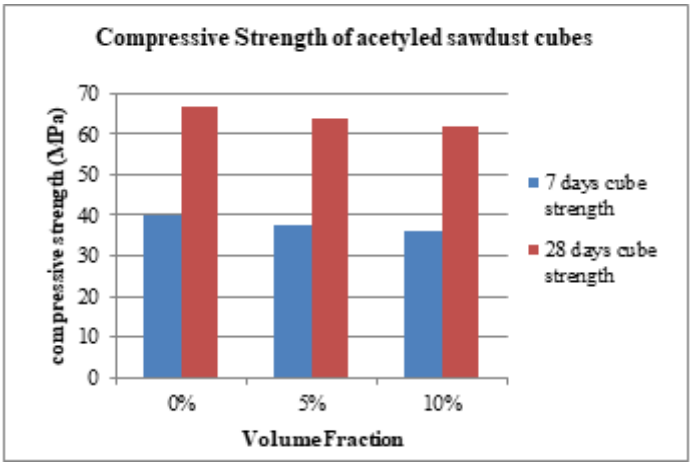

Fig.3 : Compressive strength on acetylated sawdust concrete block

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It has been observed that 5% replacement of acetylated sawdust showed 4.4% decrease in the strength when compared to no sand replacement concrete results. Also with 10% replacement of acetylated sawdust showed 7.4% decrease in the strength when compared to no sand replacement concrete results.

Water absorption:

Volume fraction	7 days (weight in kgs)	28 days (weight in kgs)
0%	0.625	0.623
5%	0.842	0.835
10%	0.702	0.934

Table5 : water absorption test on mercerized sawdust concrete block

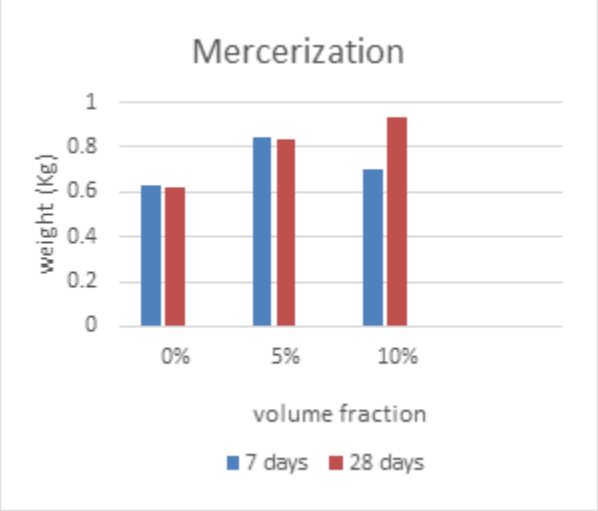

Fig.4: water absorption test on mercerized sawdust concrete block

It has been observed that 5% replacement of mercerized sawdust showed 34% increase in the water absorption when compared to no sand replacement concrete results. Also with 10% replacement of mercerized sawdust showed 12% increase in the strength when compared to no sand replacement concrete results i.e. water absorption of mercerized sawdust decreases with increasing sawdust by weight

Volume fraction	7 days (weight in kgs)	28 days (weight in kgs)
0%	0.625	0.623
5%	0.83	0.627
10%	0.69	0.92

Table 6 :Water absorption test on acetylated sawdust concrete block:

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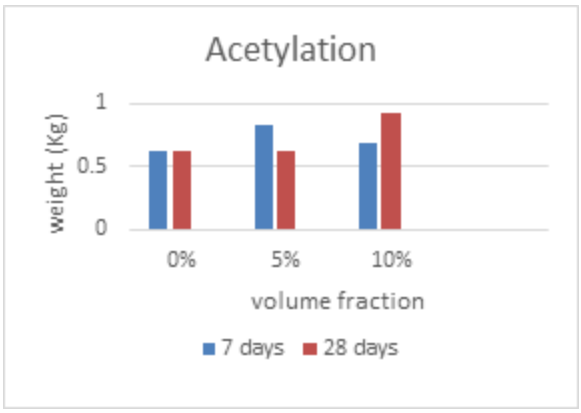

Fig 5 :: Water absorption test on acetylated sawdust concrete block:

It has been observed that 5% replacement of mercerized sawdust showed 32.8% increase in the water absorption when compared to no sand replacement concrete results. Also with 10% replacement of mercerized sawdust showed 10.4% increase in the water absorption when compared to no sand replacement concrete results

Abrasion resistance:

Volume fraction	7 days (mm)	28 days (mm)
0%	0.2	0.1
5%	1.35	1.12
10%	1.48	1.78

Table 7 : Abrasion resistance test on mercerized sawdust concrete blocks

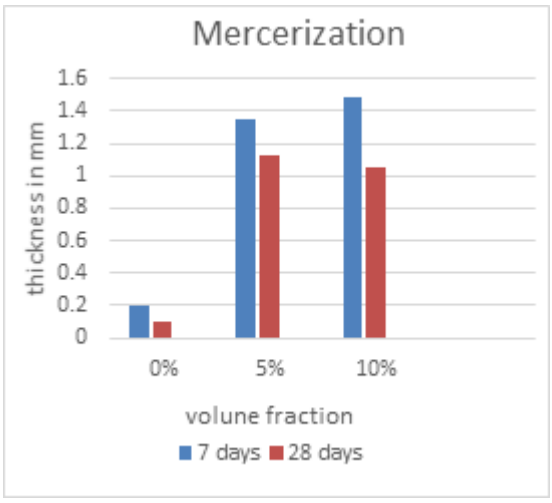

Fig.6: Abrasion resistance test on mercerized sawdust concrete blocks

It has been shown that with increase in sawdust content by weight the abrasion resistance increase.

Volum	7 days	28 days

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e fraction	(mm)	(mm)
0%	0.2	1.05
5%	1.27	0.975
10%	1.45	1.18

Table 8 : Abrasion resistance test on acetylated sawdust concrete blocks

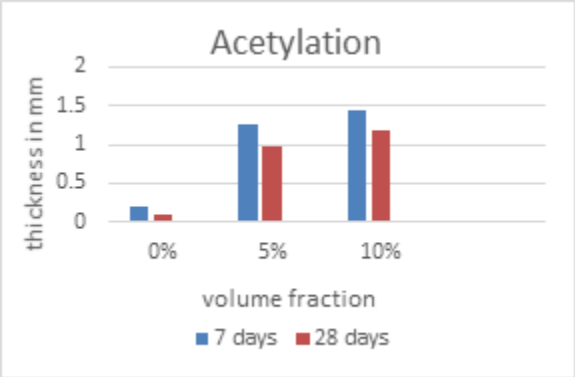

Fig.7: Abrasion resistance test on acetylated sawdust concrete blocks

It has been shown that with increase in sawdust content by weight the abrasion resistance increases.

Conclusion:

From the above experimental investigation we can conclude that:

1. Acetylation process has worked significantly better on plant fiber than mercerization process i.e. acetylated sawdust concrete blocks gives higher value of compressive strength than mercerized sawdust concrete blocks. Also acetylated sawdust concrete blocks absorbed 1.8% less water as compared to mercerized sawdust concrete blocks.
2. It has observed that 5% replacement of sand with sawdust gives satisfactory results.
3. By changing the treatment parameter such as normality (concentration), temperature and soaking duration the properties of plant fiber also changes. It can also give better result by changing it.
4. These blocks are only applicable for light weight traffic.

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ISSN: 2233-7857 IJFGCN