Effect Of Asbestos, Cellulose Wood And Rice Husk Fibres On The Compressive Strength Of Polymer Concrete

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***Abstract*—Polymer concrete (P.C.) composites possess a unique combination of properties that depend upon the formulation. The use of Styrofoam for the manufacture of polyester+ has been found useful as replacement for cement binder as it also possesses the adhesive properties that make it bind the aggregates together. This polyster+ is used together with aggregates for the manufacture of the polymer concrete used in this research work. Using fibers of various forms has reinforcement in this concrete has been found useful in enhancing many engineering properties of concrete. Several fibres such as asbestos, coconut fibres, and wood fibres have been tested on this polymer concrete with each improving the engineering properties of the polymer concrete in one way or the other. For this research work asbestos fibre, rice husks fibre and cellulose (sponge) wood were impregnated separately into the polymer matrix as fibres and it was observed that the percentage variation from 1% , 2% to 3% had effect on the compressive strength of the polymer concrete respectively when tested for after 28 days. For the rice husks there was a continuous increase in the compressive strength as the fibres were increased while a drop in the compressive strength at 3% was observed for the sponge wood which also shows the least strength when compared to the asbestos and rice husks fibre at 3%. When subjected to open air curing for this period. From the result it shows that the rice husk when used as a fibre in the matrix showed the highest strength.**

Keywords—Styrofoam, Asbestos fibres, Cellulose wood fibre, Rice husk, Polyster+, Fibre reinforced polymer (FRP).

INTRODUCTION

Concrete as a structural material is definitely weak in tension with a brittle character. Hence the idea of making use of fibers to improve the characteristics of these construction materials is very old. Concrete plays a very vital role in the construction industry but it has some drawbacks [6]. Thus in order to overcome this drawbacks the search for durable and sustainable construction materials has become inevitable. Early applications of impregnating structural components with fibre included the addition of straw to mud bricks, horse hair to reinforce plaster and asbestos to reinforce pottery. The introduction of fibres into the concrete ensures it becomes homogenous and isotropic in nature such that the problem of crack formation and propagation is arrested by the fibre impregnated randomly inside the concrete which consequently improves the strength and ductility property of the concrete [7]. Polymers when used in combination with fibres like steel, asbestos, rice husks are proving worthwhile when the properties of concrete such as strength, cohesiveness, excellent durability and resistance to acid alkalis are examined [5]. The idea of polymer concrete came from studies in the wood industry which resulted in the formation of "polymer wood". The technique for forming polymer Wood involves impregnating the wood with a particular simple plastic monomer and exciting the monomer to form a complex plastic polymer. Unlike the formation of polymer wood, there exist two possible methods for the formation of polymer concrete. These are to premix the plastic with the fresh concrete or to impregnate the hardened concrete [3].

Polymer concrete can then simply be said to be a composite material that is formed from the combination of mineral aggregates such as sand or gravel or both with monomer. Due to its profound high strength and also durability polymer concrete has been found very useful as an alternative to the cement [7]. Similarly polymer concrete can be defined as a composite material which results from the polymerization of a monomer and aggregate mixture [1]. The polymerized monomer acts as binder for the aggregates and the resulting composite is called “Concrete”. Concrete with advanced technologies such as reinforce cement concrete (R.C.C.) and fibre reinforced concrete (F.R.C.) provides extra strength and durability against sliding, cracking, buckling and overturning. For this research work a matrix mix of Styrofoam has been used in the manufacture of polyster+ which has then been used as a replacement for cement binder. When this is mixed together with our fine aggregates forms the concrete mix, inside which the fibres are impregnated. . The Styrofoam used is a waste material which is cheap and readily available hence the cost of manufacture for the binder is cheap The overall objective of this research work is to determine the compressive and tensile strength of asbestos fibres reinforced polymer concrete with the mixture of Styrofoam and petrol as binder.

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1.2 Fibre Reinforced Concrete (FRC)

Concrete is relatively a brittle material and it is a known fact that its tensile strength is typically just about one tenth of the compressive strength with this knowledge it becomes very necessary to reinforce normal concrete with steel reinforcing bars to enhance its tensile strength. Hence it has now become common increasingly to reinforce concrete with small and randomly distributed fibres for many purposes and applications, which has the main function of increasing the energy absorption capacity and toughness of the material, but also increases the tensile and flexural strength of concrete. There are a lot of fibres which come in several shapes and sizes such as steel, plastic, glass, asbestos [2]. However these fibres which are made use of in the manufacture of composite materials must possess a high strength they must be durable having a high stiffness and the process of manufacture must not be all that expensive (reinforced concrete with fiber polymer).

1.3 Fibre Manufacture

The synthetic fibres such as asbestos, glass and rice husks are manufactured industrially by the matrix mixture of resins together with the fibres. The manufacture of asbestos fibre, sponge wood and rice husks like any other synthetic fibre can also be done locally. The preparation of the wood fibre was done by measuring the diameter of the purchased fibre using the vernier caliper, before cutting them into smaller size of 7-9 cm. while that of the asbestos and rice husks fibre were manufactured by mixing the grounded asbestos, rice husks together with hardener which can then be molded into any desired shape and size. The fibres forms 3% by weight of the resin and are mixed together very quickly and placed into the desired mould of the desired size if this is done locally. In the absence of mould, the fibres can still be locally manufactured by simply pouring the liquid mixture of the fibre and the resin into a plastic bottle whose cork has been appropriately punctured to a lesser than the required diameter and the mixed are then carefully forced out of the plastic bottle through its cork by compressing the plastic bottle, and are carefully laid on a leveled surface, covered with a nylon to ensure that the hardened fibre can be removed easily with less stress. The fibres can be of various shapes.

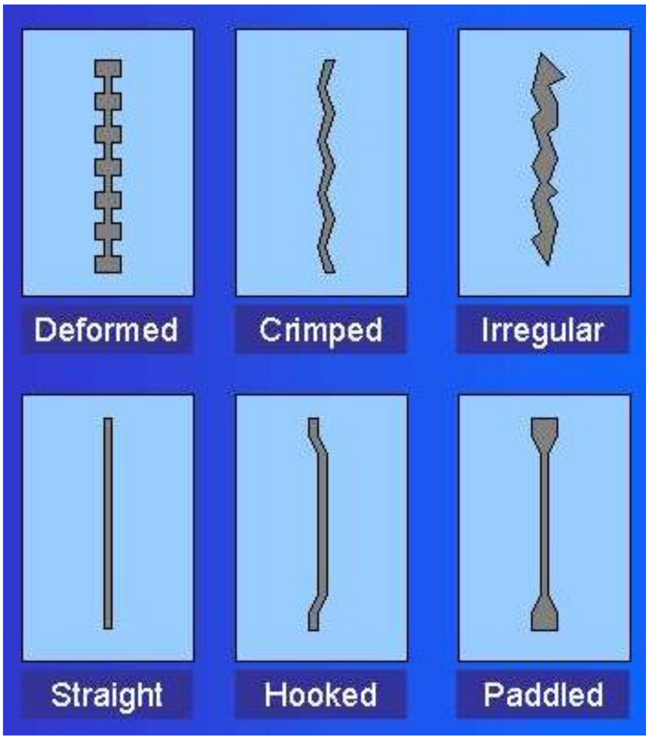

Fig 1 Various shapes of fibres (source Nemati, 2015)

Fig 1.1 cellulose wood fibre

Fig 1.2 rice husk fibre

Fig 1.3 Asbestos fibres

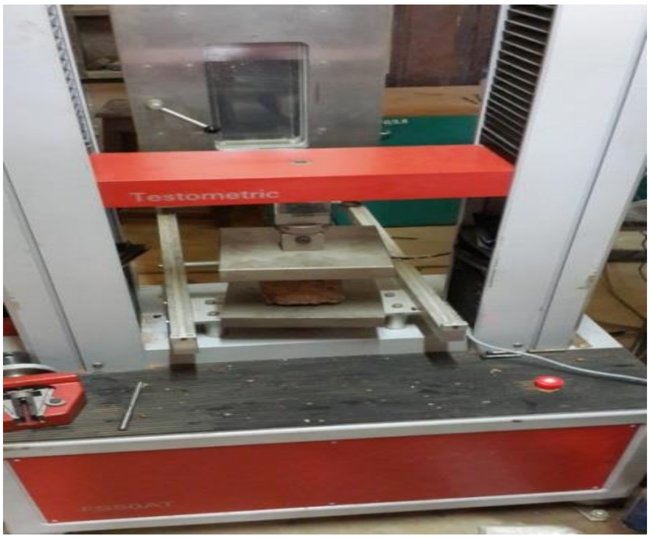

Fig 1.4 UTM machine

1.4. Polymer Resin

The polymer resin is known to consist of three distinguished class they include the Class I resins, which as the ability to resist mild corrodents and non oxidizing mineral acids. Class II resins, isophthalic type, which are even more resistant as compared to class I. Class III resins are based on bisphenol-A and have the best overall resistance to corrosive solutions[7]. However it has been observed also that when the polymer contents are increased the flexural strength and the flexural modulus of the concrete also increase however there is a reduction in the compressive strength of the concrete. Polymers have been used replaced cement binders to improve tensile, flexural and compressive strength of concrete [4]. In the cause of this research work the polymer resin used is the mixture of Styrofoam and gasoline which serves as the binder. In general the lowest polymer resin content which gives the highest compressive and tensile strength represents the optimum polymer content for the polymer concrete.

1.5. Aggregates.

Aggregates composed primarily of silica; quartz, granite, good limestone and other high-quality material have been used successfully in the production of PC. Aggregates used must be usually dry and free of dirt to get the best bond between aggregates and resin. For this particular research work fine aggregates composed of silica are used and coarse aggregate is not included at all in the matrix mix [7].

2 Methodologies

The experimental method is based on the additional of asbestos fibre into the polymer concrete mix in order to investigate its effects on the strength of the concrete. It involves the following steps.

2.1. Manufacture of the polymer resin.

The resin which acts as the binder consists of a mixture of Styrofoam with a solvent (which is the polystyrene used) from where the polyster+ is manufactured

Fig 2.0 Resin manufacture

2.2 Manufacture of asbestos fibre.

The asbestos fibres used were manufactured locally. First of all the powdered asbestos were obtained by grinding the asbestos plate and sieving them making use of powder passing through 75 micron sieve size. There after the powdered asbestos are made into fibre form by mixing the powder with resin containing hardener using a mixing ratio of 2:1 resin to the powdered asbestos by weight. This mixture are poured very quickly into a plastic bottle on whose cork a tiny hole has been drilled, the bottle is then covered with the cork and the mixture are then pressed out of the bottle through the tiny hole with the initial aim of producing fibres of uniform diameter. These were laid on surfaces such as nylon membrane or Styrofoam where they can be easily removed after solidifying. The fibres obtained are shown in fig 1.0 above.

2.3 Manufacture of rice husk fibre.

Finely milled rice husks waste was obtained from a local rice mill factory in Ilorin, Kwara state, Nigeria. Figure 1 is the waste of rice husks around a factory that might contain many impurities such as sand, dust, small rice particles, and other small particles. The research was started by cleaning and washing rice husks with fresh water and dried under the sun for 8 hours in order to get pure rice husk. After getting the pure rice husk, the rice husks were made into fibre form (Figure 1.2) by mixing the powdered rice husks with epoxy resin containing hardener using a mix ratio of 2:1 (epoxy resin to hardener) to the powdered rice husk by weight. This mixture was quickly laid on a nylon membrane surface where they can easily be removed after solidification of the hardener has taken it hardening effect on the mix. The mixture was cut into equal sizes and allowed to dry for 24 hours.
Preparation of cellulose wood fibre

2.4 Preparation of cellulose wood fiber

The wood sponge fiber is bought from market in Kwara State

• Average diameter of fiber measured from vernier caliper is 0.0224cm

• Fibers were cut to the length of 7cm and 9cm

2.5 Polymer Concrete Mix Design

The proportioning of ingredients of concrete is governed by the required performance of two states namely; the plastic state and the hardened state. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes important.

For Compressive Strength Test, 1% of fiber to be 5.4g, 2% of fiber by weight of binder was calculated to be 10.8g and 3% to be 16.2g. 1% fiber (5.4g) was added in matrix to the polymer concrete and the FRP is filled into the mould compacted in 3 layers. The same procedure was followed for 2% and 3% of fiber respectively.

2.6. Batching the constituents of the polymer concrete.

The batching of the constituents of the polymer concrete majorly fine aggregates and the binder are done by weighing. Here the mass of the binder and sand aggregates are 25% and 75% respectively with the fibre forming 3% by weight of the binder. The constituents after been weighed out are then mixed properly.

2.7 Mixing procedure.

The mixing procedure involves pouring the sand contents on a leveled ground overlaid with thick water proof nylon. The fine aggregate should be free from impurities. Once the fine aggregates is placed on the ground a hollow is created right at the centre of the heaped sand, inside which the binder is poured in carefully and the two constituents are mixed thoroughly with the shoveling done from the centre to the sides and then back to the centre until a uniform homogenous mix is obtained.

2.8. Placing in the Mould

Here cube moulds of size 100mm x 100mm x 100mm are used for the compressive strength test, while a cylindrical mould of standard size 100mm base diameter and 200mm height are used for the split test for tensile strength determination. The moulds should be oiled or greased properly. The homogenous mix are placed inside the mould in layers and carefully compacted to ensure that the polymer mix fills every corner of the mould. For the cylindrical mould with no base the cylindrical mould should be placed on a level ground initially overlaid with nylon so as to ensure the cured polymer concrete can easily be lifted. The mix should be left in the mould and should be shielded away from sunshine allowing the curing to be fully by air.

2.9. Curing

The curing process was done via open air curing and under no condition should the curing be done through sun drying. This is because the presence of sunshine melts the resin, expands and makes it more fluid, even after been mixed with the aggregates it doesn't stop the expansion process. This makes the matrix looks for any available space to leak out of the mould. Under water curing is still a method in view, in which the cast cubes are wrapped inside a thin water proof material such as nylon and then deep inside the water, but the application of this method on site is something not realistic. However adequate care must be taken in the process of de-moulding the cast cubes.

This is polymer concrete with resin that has similar characteristics like that of an evo- stik gum hence the process of removing the form work is quite different. In the cause of this research work it was discovered that the removal of the mould even after 48 hours led to the collapsing of the cubes on its own weight due to insufficient early strength, suggesting that the rate of the early strength gain is very slow. The collapsing of the cube on its own weight can be explained thus. It is a known fact that pressure increases vertically downward and ordinarily the pressure at the first 3mm layer from the top of the cubes is lesser than the next 3mm layer and the pressure increases like that. More so the top surface of the cube is side the mould is exposed to more air than the other surfaces while still inside the mould. This means that the top surface cures faster and gains more strength quickly than the other surfaces not yet exposed. This makes the top surface more hardened to a depth of only a few millimeters from the top surface hence it in turns makes the top surface much more denser than the corresponding lower layer underneath. This increase in weight in turns applies more pressure on the lower layer forcing them to shift to areas of lesser pressure. This resultant movement leads to the collapse of the cube on its own weight. This can be seen in the picture shown below. Since this has been observed an alternative way was devised to prevent the collapse of this cubes this is call step by step method of curing. The process involves the step by step partial removal of the mould.

1. Initially when this concrete is filled inside the mould, the top surface exposed to the air sets quickly than the other surface still inside the mould, hardens and gains some strength after about 78 hours.

2. A side of the mould is then removed while the remaining three sides and the base are still intact.

3 The position of the mould is now adjusted such that the side newly removed becomes the top surface and the already hardened surface (initial top surface) falls to the side. This ensures that the surface is exposed to air and it also hardens and gains sufficient strength to withstand the external pressure. Now while this is exposed and it hardens with increase in weight of the top few layers the pressure applied can be withstand by the already hardened side and the other three sides still supported by the mould hence the particle movement is prevented and the collapse of the cube on its own weight is prevented. The newly exposed surface should also be left for another 72 hours so as to gain sufficient strength.

Similar procedure is repeated for the other sides and finally the base. This ensures the cube is intact is shape and the collapse is prevented. This it is obvious that the from 7days strength test is actually not realistic as the de-moulding process alone takes about 18 days.

A

B

Fig A & B shows the step by step de- moulding of the cube

USES IN PRACTICAL CONSTRUCTION

The use of this kind of concrete for real construction of structural member whether beams or columns simply means the this kind of construction will be very slow as the removal of form work for use in other places may not be immediate except improvements are being made on this type of concrete is the latter future.

However a suggested way is that of the partial removal of the form work, but since it is impossible for the structural member to be repositioned the way the cube was the use of steel wire gazette with hole size of about 7mm is used of which the interior is overlaid with steel or polymer net of less than 2mm hole size. The reason while this polymer net is used is to prevent the passage of the polymer concrete through the 7mm hole of the steel net while it is freshly removed. The both nets (cut to the dimension of the structural member) should be braced at interval of few centimeters with a wooden pylon to ensure that the pressure applied from the uncured side does not deform the net which is in turn nailed lightly to the other form work yet to be removed so as to provide a good support. This is left in this position for some number of days to allow the curing by air to take place. It should however be noted that all these can only be done in area shielded from the scotching effect of the sun shine.

3.0 TESTS AND RESULTS

The **Compressive Strength**

All the cubes were tested in a 'Universal Testing Machine' to determine the compressive strength of the cubes. The procedure is as follows. Compression test of cube specimen are made as soon as practicable after air curing. Place the specimen centrally on the location marks of the universal testing machine and load is applied continuously, uniformly and without shock. The load is increased until the specimen fails and record maximum load carried by the each specimen during the test Compressive Strength =Average load/Area of cross section. The fig. 3 below shows failure of specimen under compressive strength.

The compression test result of the cast cubes was tested and the results obtained are shown in the table below for a 3% asbestos fibre by weight of the binder.

Table 1.0 compressive strength results for 3% asbestos fibre.

Specimen	Max Load (KN)	Asbestos fibre(%)	Compressive Strength (N/mm^2)
A	2995.4	3	0.2995

Table 2: compressive strength results for 1-3% rice husk fibre

Test	Specimen	Sample No.	Rice Husk Fibre Added (%)	No. of Specimens (28 days)
Compressive Strength Test	Cube	D	0	1
		A	1	1
		B	2	1
		C	3	1

Table 3: Compressive strength data at the age of 28 days

S/No	Specimen	Rice Husk Fibre Added	Force (KN)	Compressive Strength (MPa)
1	A	1%	2.22	0.222
2	B	2%	2.63	0.263
3	C	3%	2.99	0.299
4	D	0%	-	-

Table 4: compressive strength result for 1-3% cellulose wood fibre

Test	Percentage of fiber (%)	Loading (KN)	Compressive Strength (KN/mm^2)
1	1	0	0
2	2	1.48	0.148
3	3	1.31	0.131

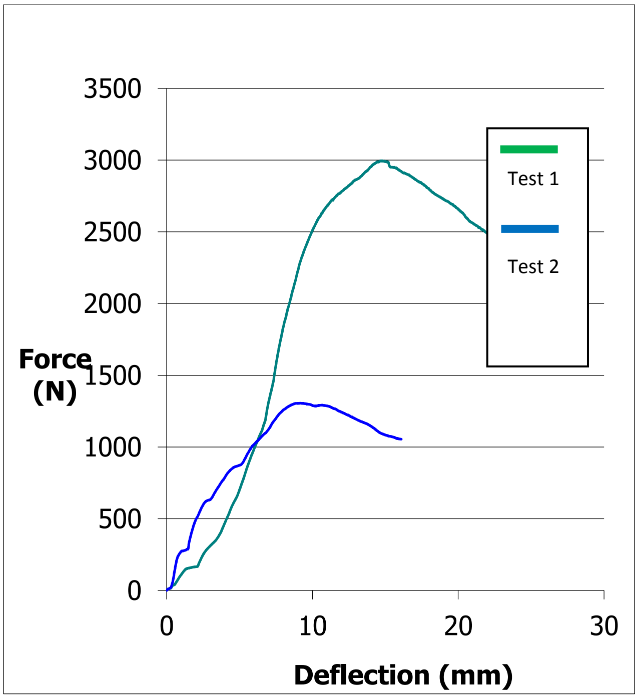

Fig 3.0 Graph of load against deflection for 3% asbestos fibre

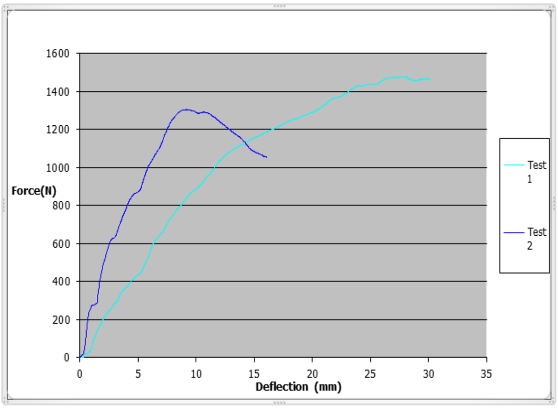

Fig 3.1 Combined compressive test graph for 2% and 3 % cellulose wood fibre

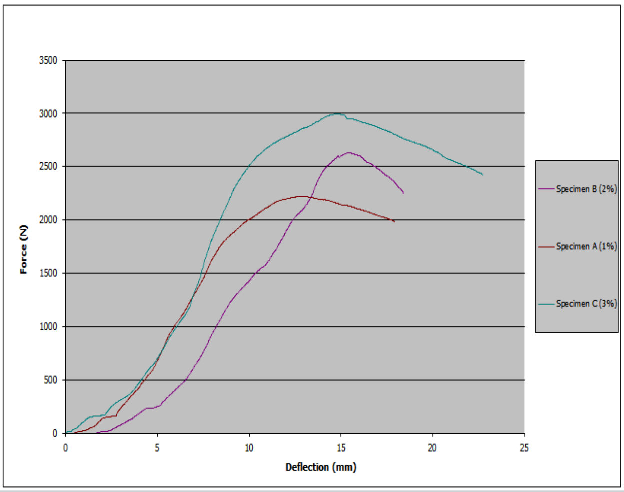

Fig 3.2 Combine compressive strength graph for 1%, 2%, 3% rice husk fibre

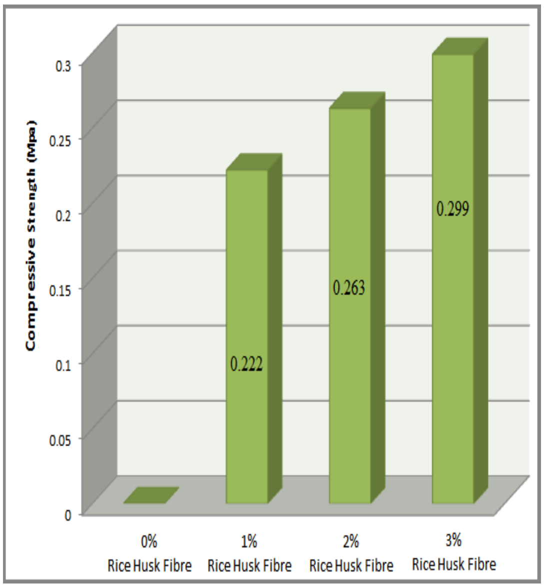

Figure 3.3: Comparison of Concrete Compressive Strength with Different Replacements by Rice Husk Fibre at 28 Days.

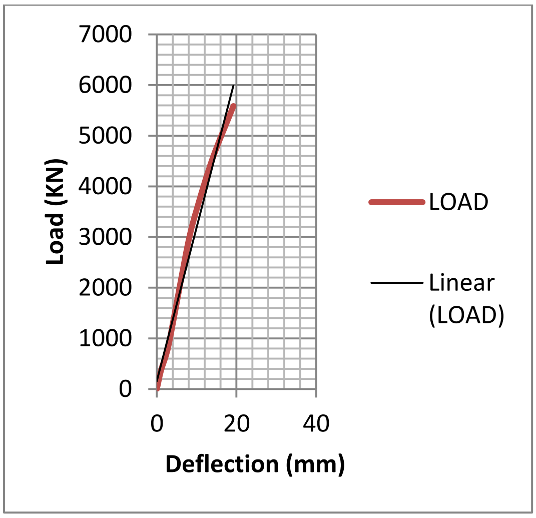

Fig 3.4 Graph of load against deflection for 3% asbestos fibre

3.1 RESULT DISCUSSION

For the compressive strength of concrete measured at the age of 28 days and shown in Table 3. It was observed that the compressive strength of concrete having 1% rice husk fibres was 0.222Mpa.It was observed also that the compressive strength of concrete having 2% rice husk fibres was 0.263MPa which showed a 0.041Mpa increase in the compressive strength of specimen B compared to specimen A.it was also observed that the compressive strength of concrete having 3% rice husk fibres was 0.299MPa which showed a 0.036Mpa increase in the compressive strength of specimen C compared to specimen B and a 0.77Mpa increase in compressive strength of specimen C compared with specimen A.

For the cellulose wood fibre the above results shown in table 4 shows that specimen with 1% fiber content collapse on its own weights due to insufficiently mixing ratio. It also shows that compressive strength has a decreasing trend with increasing fiber content in wood fiber polymer concrete i.e. the higher the fiber content in the mix, the lower the compressive strength. Thus, higher fiber content in wood fiber polymer concrete might have caused voids resulting in decreased compressive strength.

For the asbestos fibre polymer concrete the compressive strength test result as shown in the table 1 at 3% was found to be almost the same with that of rice husk at the same percentage. Also the polymer concrete containing the asbestos fibre shows the highest compressive strength when compared with other fibres used in the polymer matrix.

4.0 CONCLUSION

The use of this polymer concrete can only be applicable in cold weather regions because of the nature of the binder used. Also in the process of removing the form work care must be taken to ensure that adjacent form works are not removed as the difference in exposure during curing can cause the member to collapse on its own weight if the adjacent form works are removed.

- ❖ The replacement of 1% rice husk fibre,2% rice husk fibre and 3% rice husk fibre for specimen A, specimen B and specimen C shows an increase in the compressive strength of concrete cubes at 28 days.
- ❖ The replacement of 3% asbestos fibres of specimen showed the highest compressive strength of concrete cubes at 28 days when compared to other fibres used.
- ❖ It was observed that concrete at 7 days failed on its self-weight which prevented any further testing.
- ❖ It was observed that the compressive strength has a higher value with 2% cellulose fiber but the strength decreased with the increase in fiber content at 3%. So, the optimum results were found when 2% of fiber by weight of binder was used.
- ❖ It was observed that 25% mass of the binder made the concrete more viscous and had a significant effect on not having a higher compressive strength at early age (7 days).

RECOMMENDATIONS

- To avoid the unnecessary fluidity of the cast specimens curing should be strictly by air.
- The mould used should be that which allows all the cast surfaces to be exposed to air. This can actually be achieved by removing each side of the mould one after the other, the side removed is exposed to air for about 48 hours until it is strong enough before another side is removed.
- Care should be taken that the surface of the mould facing each other should not be removed following each other, rather adjacent sides of the mould should be removed in the step by step method of de-moulding for in that all the surface of the specimen are exposed to sufficient air.

REFRENCES

[1] Fowler, D.W. (1999), “Polymers in Concrete: a Vision for the 21st Century”, Cement and Concrete Composites, vol.21, no. 21, pp. 449 – 452.

[2] Kamran M.N. (2015) Fibre Reinforced Concrete. Publication of the University of Washington, 2015.

[3] Luke, M.S., Aldridge, H.G. and Robert, Y.N. (1972) “Polymer Concrete And Its Potential In The Construction Industry” Department of Civil Engineering, West Virginia University, Morgantown, West Virginia, and School of Civil Engineering and Environmental Science, University of Oklahoma Norman Oklahoma, page 160.

[4] Ohama Y., (1994) Concrete Admixtures Handbook (Properties, Science and Technology), Noyes publication, Park ridge, New Jersey,U.S.A.,1994.

[5] Rong,li .,Polymers in concrete ,Proc .First Asia symposium (I-EASPIC),Chuchion,

Koria,1994, pp.293-300

[6] Shivani R.B. and Yuvraj M.G. (2015) Polymer-Modified Concrete: Reviewed. International Journal of Research in Engineering and Techology, Vol. 4 No. 4, April, 2015.

7] Victor Y.G. and Vipulanandan C. (2003). Review of Polyester, Polymer Concrete Properties. Journal Materials in Civil Engineering, Vol. 5, No. 15, May, 2003.