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# PARTIAL REPLACEMENT OF CEMENT WITH WOOD ASH AND ADDITION OF EXPANDED POLYSTYRENE BEADS AND COCONUT FIBRE IN CONCRET

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**Abstract -** With growing construction, there is no shortage of tall buildings and structures. But there is one thing that is getting depleted, these are natural sources such as sand and aggregates. These material either require some alternate source or using waste material. The material need to be such that which are causing harm to the environment or available in abundancies beads is one of the material which is non-biodegradable and remains for longer time without any degradation or degradation. Also, coconut fiber is a natural source which is constantly getting produced. The use of these materials will also help in making concrete lightweight. The wood ash can contribute to reducing the heat loss rate of building was given their relatively low thermal conductivity compared to gypsum board. This research explains about the study methods for producing lightweight concrete by replacing Wood ash with cement addition of EPS beads and fiber reinforced. The main objective of this study is to determine the workability, compressive strength, tensile strength and flexure strength of lightweight concrete prepared by using polystyrene beads, coconut fiber and wood ash replace with cement. The tests will be conducted to find compressive strength, tensile strength and flexural strength. Based on the previous research work, a comparison of strength properties of Wood ash, EPS beads and fiber reinforced concrete is made with respect to conventional concrete. Different specimens of the material are tested for strength. The result show that workability of concrete is fine and in range after adding eps beads. The flow gets controlled due to addition of coconut fiber. The workability of mixture reduces with more eps beads. The wood ash, beads and coconut fires are mixable with other concrete aggregates. The strength parameters such as compression, tension and flexure also increases. Optimum value of strength in compression, split tensile and flexure came at EPS6:CF1.5:WA12 replacement of Wood ash with cement and addition of eps beads and coconut fiber. The strength of concrete increases up to the EPS6:CF1.5:WA12 replacement, after that there is decrease in the strength of the concrete. The maximum proportion of replacement has been found by conducting the following strength tests: Compressive strength test, Flexural strength test and Split Tensile Strength Test.

***Keywords – WA (Wood ash), EPS (Polystyrene Beads), CF (coconut fibre), Workability, Compressive strength, Split tensile strength, Flexural strength***

## 1. INTRODUCTION

The constant and ever going developmental activities in engineering and growing constructional activities have created a continuous demand for building materials which satisfy all the stringent requirements regarding the short-term and long-term performance of the structure. As the structures of tomorrow become taller and more complex, the materials of construction are need to be such that they fulfil the requirement criteria and standards of performance than those that are used now. The material are getting depleted so alternate material need to be tested so that they are a viable option used in construction. The building material are not going to increase as the natural materials that are used for construction are reaching a saturation level. It is required that alternate material must be used that can provide some benefit as well as reduce waste material.

### 1.1 LIGHT WEIGHT CONCRETE

Lightweight concrete is a good path in search of material which are low in weight as compared to their contemporaries for alternative building materials in current construction application. It greatly improves the technical, economical and ecological aspects of the construction sector. The use of light weight concrete considerably reduces the weight and load on the structure. Compared to ordinary concrete it has many advantages such as lower thermal conductivity, lower density, fire resistance and improved durability properties. Being low in weight it greatly reduces dead load on the structure while providing better properties in other aspects. However, this type of concrete is associated with lower mechanical properties and it requires higher water due to the porous nature of the lightweight concrete. But these voids can be covered by using cement paste or covering the outside portion by pasting or plastering as it covers the inside portion. The use of these material can provide us the opportunity to make full use of these material for sustainable development.

### 1.2 EPS [EXPANDE POLYSTYRENE] IN CONCRETE

Expanded polystyrene (EPS) appear as excellent choice to produce lightweight concrete since it has properties which are often required in concrete such as low density, moisture resistance, thermal resistance. It is a material usually used for packing of numerous products for protection purposes, insulation and impact absorbing nature. Mechanical robustness. It is present in various industrial fields and is most often released into nature after its use. However, being non-biodegradable, it does not disappear by natural means and remains present in nature for many years. PS is chemically inert as it does not react in normal atmospheric conditions. It is not poisonous in nature. It is also not a breeding ground for fungi and other bacteria. Since it is waste from packaging industry its use in making of lightweight concrete will not only reduce cost but also prove as an effective way of waste disposal.

### 1.3 COIR FIBRE IN CONCRETE

Coir fibre has applications in many fields. One of the unusual or more recent application of it is in the concrete. Since, concrete is a brittle material. It possesses very low resistance to cracking, low tensile strength and ductility. When stress is applied to the concrete, it develops crack due to various reasons such as shrinkage. Other factors also lead to the formation of cracks. Internal cracks are caused in concrete due to these reasons which propagates to the outer side causing external cracks in concrete which leads to brittle fracture in concrete. It also has low tensile strength which also leads to crack when subjected to tensile force, this opens up the crack. The inelastic deformation in concrete is caused by these cracks. So, natural fibres have been tried as reinforcement in cement mixtures to produce low cost concrete which can be used in structures. Coconut fibre is readily available in nature in plenty which makes it a good option to be used as reinforcement material. The use of coconut fibre will also result in generating revenue for the farmers who cultivate coconut trees.

### 1.4 WOODASH

There are several minerals in wood ash, which can be extracted for further use. A big ingredient calcium carbonate, which is 25% or even 45% (depending on feedstock and burning condition). Less than 10 percent is potash and less than 1 percent is phosphate; there are some elements of iron, manganese, zinc, copper and some metal parts. These numbers however, vary as combustion temperature is an important element for the determination of wood ash. Many of these are in the form of oxides, mainly. If we mix the ashes to water the insoluble silica and calcium carbonate will settle to bottom and sodium salt and soluble potassium will dissolve. We can then remove the water (containing the “good stuff”) and throw the insoluble ingredients’ away. To isolate soluble carbonates from chlorides, we will exploit the solubility of hot water

## 2. LITERATURE REVIEW

**V.Sai Uday,B.A jitha(2017)** conducted their experiments to obtain the effect of coconut fibers in concrete structures. Their experiment described the addition in property caused by using coconut fiber in the concrete. They found out that addition of fiber improves the strength of concrete. Addition of coconut fiber improves the compressive strength, flexural strength and split tensile strength of concrete. The experiment was conducted on high strength concrete with the addition of fiber with 5 mix proportions (1%, 2%, 3%,4%, and 5%) by the weight of cement. The compressive strength and split tensile strength of cured concrete evaluated for 3days, 7days and 28days.The fibers used in their experiment were collected from local temples. The fibers were presoaked in water for 24 hours before use. The study found the optimum fiber content to be at 1 %( by the weight of the cement).This results show coconut fiber can be used in construction.

**Batt and garg (2017)** Wood ash is created as waste from combustion in boiler, in pulp and paper mills, steam power plants and some other generating installations for thermal power. Wood is a renewable energy resource and an environmental friendly material. The increased demand for the use of waste wood for the purpose of energy production and thus creation of more ash waste from wood. The research focuses on wood ash incorporation in combination with ordinary Portland cement when using it for various structural works. The detailed study in sieve analysis, consistency, and water absorption, setting time and slump tests of wood ash produced important result to emphasize the detailed study process. Uncontrolled saw dust burning to form wood ash is used as a partial cement substitute, and therefore changing its physical and chemical properties in this way. Such properties are somewhat found the same as fly ash. The concrete mix are replaced with the amorphous wood ash as an admixture of cement having grain size less than 75 microns in proportions of 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. In this Study, a research work is conducted for determining the change in workability or consistency of concrete.

**Aman Mulla and Amol Shelake (2016)** did their study to find a concrete mix proportion which gave better result than Burnt Brick in compressive strength and density. They studied the properties such as density, compressive strength and splitting tensile strength of lightweight Expanded Polystyrene (EPS) beads concrete. Then its properties were compared with M20 grade conventional concrete. Their conclusions were that EPS concrete gave good workability. The finishing and compaction could also be done easily. They also found out that compressive strength of EPS concrete was less than normal concrete. The concrete mix have low density and it gives the strength more than burnt brick so the concrete mix proportion can be useful as lightweight concrete brick in construction work. The concrete mix proportion are also useful as precast concrete members with low density and more workability.

**Thomas Tamut, Rajendra Prabhu, Katta Venkataramana, Subhash C Yaragal (2014) investigated** various things with the use of Eps beads in concrete. Their experiment was based on replacement of coarse aggregates in the concrete mix with the eps beads in the proportion of 5%, 10%, 15%, 20%, 25%, 30%.The property of concrete such as compression and tension was compared with the normal concrete. The replacement they did was partial replacement of coarse aggregate. They found out that the property of concrete mixed with eps beads decrease with addition in percentage of eps beads. The grade of concrete used by them was M30.The workability of concrete increased with increase in percentage of eps beads. On the other hand, the compressive strength of concrete decreased with addition of the eps beads. The tensile strength also decreased with increase in the amount of the eps beads.

**(Chouw et al.,2012)** studied the viability of using coconut-fiber ropes as vertical reinforcement in mortar-free low cost housing in earth quake prone regions. The rope anchorage is achieved by embedding it in the foundation and top tie-beams. The bond between the rope and the concrete plays an important role in the stability of the structure and the rope tensile strength is also found to be fairly high. The rope tension generated due to earthquake loading should be less than both the pull out force and the rope tensile load to avoid the structure collapse. The study concluded that the pull out energy increases with an increase in embedment length, rope diameter, cement and fiber content in the matrix.

**Batt and garg (2017)** Wood ash is created as waste from combustion in boiler, in pulp and paper mills, steam power plants and some other generating installations for thermal power. Wood is a renewable energy resource and an environmental friendly material. The increased demand for the use of waste wood for the purpose of energy production and thus creation of more ash waste from wood. The research focuses on wood ash incorporation in combination with ordinary Portland cement when using it for various structural works. The detailed study in sieve analysis, consistency, and water absorption, setting time and slump tests of wood ash produced important result to emphasize the detailed study process. Uncontrolled saw dust burning to form wood ash is used as a partial cement substitute, and therefore changing its physical and chemical properties in this way. Such properties are somewhat found the same as fly ash. The concrete mix are replaced with the amorphous wood ash as an admixture of cement having grain size less than 75 microns in proportions of 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. In this Study, a research work is conducted for determining the change in workability or consistency of concrete.

## 3. MATERIALS

**CEMENT** In this project, one of the binding materials is used that is cement and also one of the important materials for building in today's construction world. The Ambuja cement 53 grade of ordinary Portland cement by IS: 8112-1989 is used in this project.

**3.1 FINE AGGREGATES** Aggregates consists of two types, fine aggregates and coarse aggregates. Fine aggregates consists of natural stone or crushed particles passing through 4.75mm size sieve. Aggregates which account for one –third percentage of the total volume of concrete, are divided into two separate categories-fine and coarse. Natural gravel and sand are typically dug or dredged from a pit, river, lake, or seabed. The crushing of big boulders, cobbles, quarry rock, and large size gravel also produces crushed aggregate. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions and economy. There is although always a variation of aggregate properties is expected, characteristics include durability, grading, particle shape and surface texture, abrasion and skid resistance, unit weights and voids, absorption and surface moisture.

**3.2 COARSE AGGREGATES** The particles which retains on the sieve and are larger than 4.75mm are referred to as coarse aggregates. For making a good mix of concrete aggregates need to be hard, clean and strong particles which are free of coatings of clay or any absorbed chemical and other fine materials that could cause the deterioration of concrete. Coarse aggregates are rounded or irregular gravel stones. It constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Coarse aggregates should be carefully handled to avoid dirt contamination. It should be clean and dry.

### 3.3 EPS [EXPANDE POLYSTYRENE]

| S.NO. | PROPERTIES | VALUES |
|---|---|---|
| 1. | Specific gravity | 0.011 |
| 2. | Bulk density | 6.86kg/m$^3$ |
| 3. | Particle size(spherical) | 4- 8 mm dia |

**Table -1**: **Properties of eps beads**

### 3.4 COIR FIBRE

| S.NO. | PROPERTY | VALUES |
|---|---|---|
| 1. | Length | 60-210mm |
| 2. | Diameter | 0.4-0.8mm |
| 3. | Moisture content | 10.60 |

| | | |
|---|---|---|
| 4. | Water absorption | 160% |
| 5. | Density | 480 kg/m³ |
| 6. | Colour | Brown |

**Table -2: Physical properties of coconut fibers**

### 3.5 WOODASH

| COMPONENT | MASS% |
|---|---|
| SiO2 31.8 | 31.8 |
| Al2O3 | 28 |
| 28 Fe2O3 | 2.34 |
| CaO | 10.53 |
| NaO | 6.5 |
| K2O | 10.38 |
| MgO | 9.32 |
| P2O5 | 1.17 |
| Loss of ignition | 27 |

**Table -3: Chemical properties of wood ash**

## 4. METHODOLOGY

**CASTING** In order to test compressive strength of concrete, concrete specimens of standard cubical mould of size 150*150*150mm were casted in eleven different batches having different replacement percentage of Rice Husk Ash and ESP. The specimen used for this test is cylindrical and its dimension is 150mm in diameter and 300mm in length. The test is made on the beam of size 700 mm× 150mm × 150mm.

**4.1 CURING** all the materials when mixed adequately to achieve homogeneous mixture. After mixing the concrete was checked for required slump and then filled into moulds of required tests. The mould filled with concrete was compacted by table vibrator to achieve proper compaction. Mould surface was finished with trowel and date of casting with mix designation number is marked on it. The concrete specimens were then removed from moulds after 24 hours and then placed in curing tanks for curing process for 7,14 and 28 days at normal room temperature.

**4.2 SLUMP CONE TEST** It can be used in site as well as in lab. This test is not applicable for very low and very high workability concrete. It consists of a mould that is in the form of frustum having top diameter of 10cm, bottom diameter of 20cm and height of 30cm. The concrete to be tested if fitted in the mould in four layers. The each is compacted 25 times with the help of tamping rod. After the mould is completely filled it is lifted immediately in the vertically upward direction which causes the concrete to subside

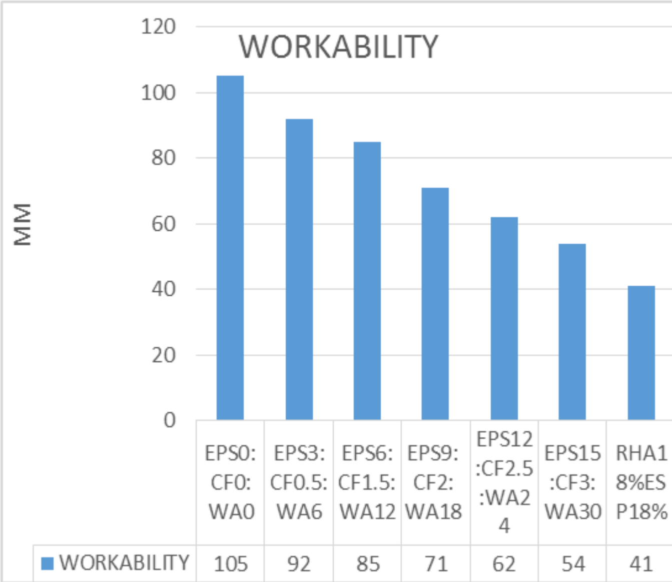



**Fig -1: SLUMP CONE TEST**

### 4.3 COMPRESSIVE STRENGTH TEST

Then fresh concrete is filled in mould in 4 layers and after filling each layer tamping should be done 35 times in case of cube and 25 times in case of cylinder by using standard tamping rod. Once the mould is filled then leveled top surface of concrete with trowel. After the day the mould will removed and specimen are dropped in the curing tank under standard temperature of 27±2° c. After 7,14 and 28 days in this research.

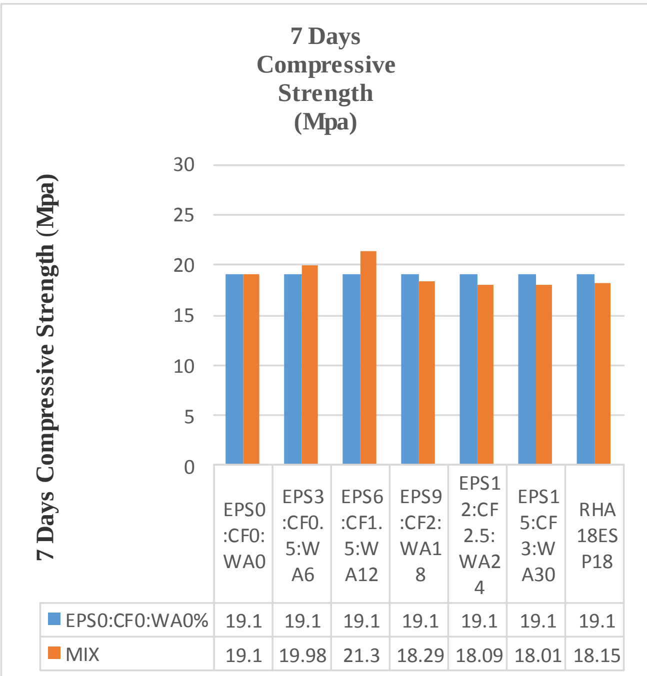
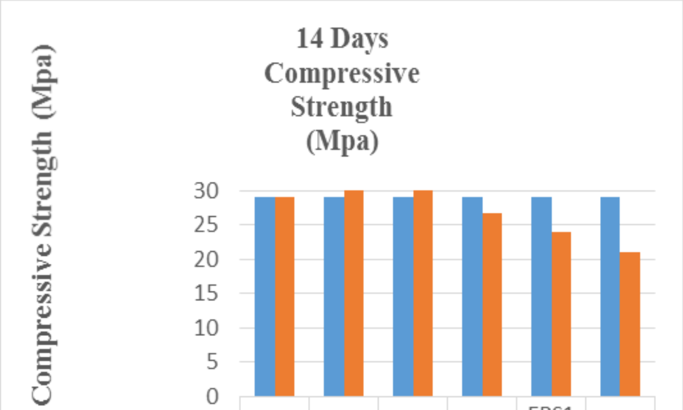
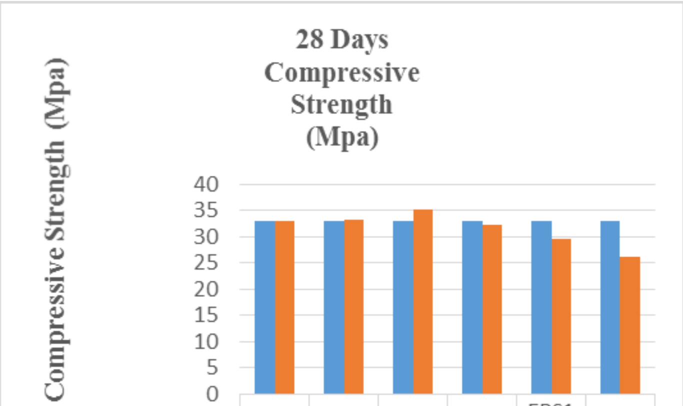



**Fig -2: COMPRESSIVE STRENGTH TEST 7 days**




| | EPS0 :CF0: WA0 | EPS3 :CF0. 5:W A6 | EPS6 :CF1. 5:W A12 | EPS9 :CF2: WA1 8 | EPS1 2:CF 2.5: WA2 4 | EPS1 5:CF 3:W A30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 |
| MIX | 29.1 | 30.2 | 30.58 | 26.7 | 24.07 | 20.98 |

**Fig -3: COMPRESSIVE STRENGTH TEST 14 days**

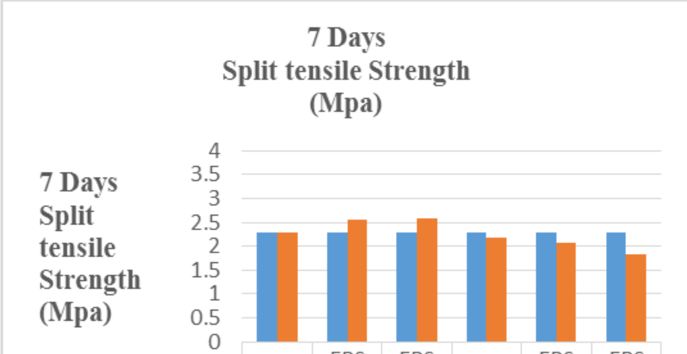



| | EPS0 :CF0: WA0 | EPS3 :CF0. 5:W A6 | EPS6 :CF1. 5:W A12 | EPS9 :CF2: WA1 8 | EPS1 2:CF 2.5: WA2 4 | EPS1 5:CF 3:W A30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 32.92 | 32.92 | 32.92 | 32.92 | 32.92 | 32.92 |
| MIX | 32.92 | 33.17 | 35.26 | 32.34 | 29.52 | 26.2 |

**Fig -4: COMPRESSIVE STRENGTH TEST 28 days**

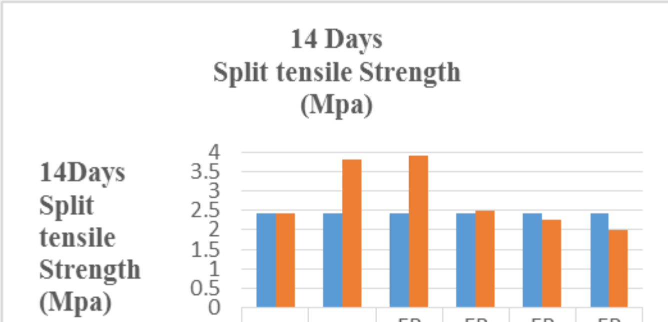
### 4.4 SPLIT TENSILE STRENGTH

The specimen used for this test is cylindrical and its dimension is 150mm in diameter and 300mm in length. The instrument used for this testing is universal testing machine. The fresh concrete is prepared in according to the required grades and respective mix proportion. The fresh concrete is filled in mould in layers and each layer is tamping with standard tamping rod with 25 blows for each layer. After the day the mould is removed and specimen is placed in the curing tank for 7,14 and 28 days in this research at the temperature 27+ 2°c. Then draw the line on the specimen



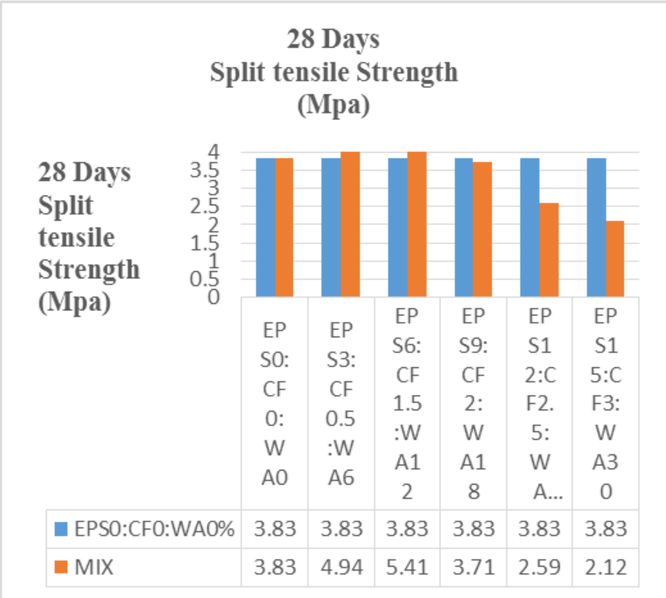

| | EPS 0:C F0: WA 0 | EPS 3:C F0. 5: WA 6 | EPS 6:C F1. 5: WA 12 | EPS 9:C F2: WA 18 | EPS 12: CF2 .5: WA 24 | EPS 15: CF3 :W A3 0 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 2.28 | 2.28 | 2.28 | 2.28 | 2.28 | 2.28 |
| MIX | 2.28 | 2.55 | 2.58 | 2.18 | 2.07 | 1.83 |

**Fig -5 SPLIT TENSILE STRENGTH 7 days**




| | EP S0: CF 0: W A0 | EP S3: CF 0.5 :W A6 | EP S6: CF 1.5 :W A1 2 | EP S9: CF 2: W A1 8 | EP S1 2:C F2. 5: W A... | EP S1 5:C F3: W A3 0 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 |
| MIX | 2.43 | 3.82 | 3.91 | 2.5 | 2.25 | 2 |

**Fig -6 SPLIT TENSILE STRENGTH 14 days**

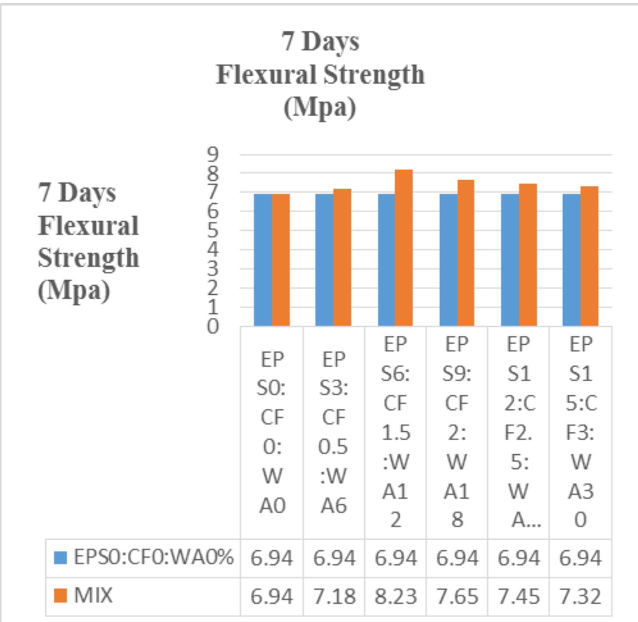



| | EPS0:CF0:WA0 | EPS3:CF0.5:WA6 | EPS6:CF1.5:WA12 | EPS9:CF2:WA18 | EPS12:CF2.5:WA... | EPS15:CF3:WA30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 3.83 | 3.83 | 3.83 | 3.83 | 3.83 | 3.83 |
| MIX | 3.83 | 4.94 | 5.41 | 3.71 | 2.59 | 2.12 |

**Fig -7 SPLIT TENSILE STRENGTH 28 days**

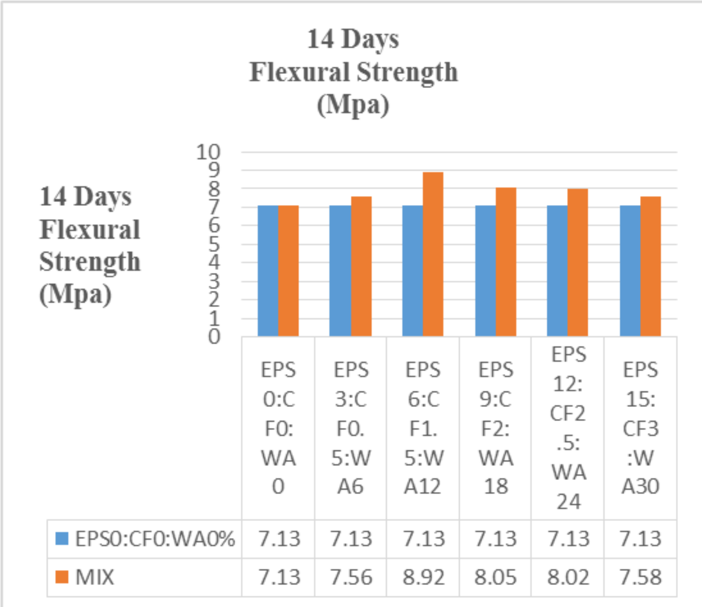
### 4.5 FLEXURAL STRENGTH TEST

The concrete is prepared at required rate of mass element the mould is filled with concrete in layers and blows 25 times with standard tamping rod. After the day or we can say 24 hours the mould is removed and specimen placed in the water tank for curing at a temperature of 27 + 2 C. Depending upon the requirement the test specimen is removed from the water tank and wipe it properly for 7,14 and 28 days for testing.




| | EPS0:CF0:WA0 | EPS3:CF0.5:WA6 | EPS6:CF1.5:WA12 | EPS9:CF2:WA18 | EPS12:CF2.5:WA... | EPS15:CF3:WA30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 6.94 | 6.94 | 6.94 | 6.94 | 6.94 | 6.94 |
| MIX | 6.94 | 7.18 | 8.23 | 7.65 | 7.45 | 7.32 |

**Fig -8 FLEXURAL STRENGTH 7 days**




| | EPS0:CF0:WA0 | EPS3:CF0.5:WA6 | EPS6:CF1.5:WA12 | EPS9:CF2:WA18 | EPS12:CF2.5:WA24 | EPS15:CF3:WA30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 7.13 | 7.13 | 7.13 | 7.13 | 7.13 | 7.13 |
| MIX | 7.13 | 7.56 | 8.92 | 8.05 | 8.02 | 7.58 |

**Fig -9 FLEXURAL STRENGTH 14 days**


| | EPS0:CF0:WA0 | EPS3:CF0.5:WA6 | EPS6:CF1.5:WA12 | EPS9:CF2:WA18 | EPS12:CF2.5:WA24 | EPS15:CF3:WA30 |
|---|---|---|---|---|---|---|
| EPS0:CF0:WA0% | 8.39 | 8.39 | 8.39 | 8.39 | 8.39 | 8.39 |
| MIX | 8.39 | 8.46 | 8.94 | 8.33 | 7.31 | 7.26 |

**Fig -10 FLEXURAL STRENGTH 28 days**

## 5. CONCLUSIONS

- 1. Workability results show that workability of concrete decreases a bit with increase in Wood ash eps beads and fibers. The workability of mixture reduces with more eps beads. The Wood ash, beads and coconut fibres are mixable with other concrete aggregates. All the concrete containing Wood ash, eps beads and coconut fibre show good enough workability to be easily compacted and finished.

- Compressive strength result show that partially replacement of cement with wood ash and addition of coconut fibre there is increase in compressive strength. After EPS6:CF1.5:WA12 volume replacement there is decrement of compressive strength.

- The maximum compressive strength is achieved at EPS6:CF1.5:WA12 Partially replacement of cement with wood ash, with Addition of eps beads and coconut fibre.

- The highest value of compressive strength was obtained at EPS6:CF1.5:WA12% replacement which is 5.2Mpa.

- The partial replacement of the partially replacement of cement with wood ash and addition of EPS and coconut fibre has shown +ve impact on split tensile strength up to EPS6:CF1.5:WA12% substitution.

- The highest value of tensile strength was obtained at EPS6:CF1.5:WA12% replacement which is 5.2Mpa.

- The flexure strength also showed maximum strength when EPS6:CF1.5:WA12% is being replaced by Partially replacement of cement with wood ash, with addition of eps beads and coconut fibre, increased the strength is 6.18MPA at 28$^{th}$ day.

- The optimum value of strength in compression, split tensile and flexure came at EPS6:CF1.5:WA12% replacement of Wood Ash by cement and addition of EPS, coconut fibre.

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