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# Evolution Properties of Paver Blocks Using Waste Foundry Sand in Concrete

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## ABSTRACT

Solid unreinforced pre-cast cement concrete paver blocks is a versatile, aesthetically attractive, functional, cost effective and requires little or no maintenance if correctly manufactured and laid. Paver blocks can be used for different traffic categories i.e. Non-traffic, Light-traffic, Medium-traffic, Heavy-traffic and Very heavy traffic. In present study work paver blocks of M-40 grade of 80mm thickness for medium traffic with varying percentage of nylon fiber (0.1%, 0.2%, 0.3%, 0.4%, 0.5%) is used to improve the compressive strength is casted. After finding optimum percentage of nylon fiber, it has now become very important to look as for the alternative source for natural materials used in concrete i.e. gravels and natural sand. Waste foundry sand (WFS) is a propitious material that can be used as an alternative for the naturals and i.e.(fine aggregates )in concrete. The thesis demonstrates the potential of re-use for waste foundry sand i.e. industrial by-product as a substitute of a fine aggregate in concrete. The fine aggregates i.e. (natural sand) are replaced with WFS in Three different substitution rates i.e. (2.5%, 5%, 10 %,). Several tests were performed to examine the mechanical properties i.e. (compressive strength, and flexural strength)as well as the durability of concrete.

***KEYWORDS:*** *Waste foundry sand, materials, concrete, natural sand, compressive strength, flexural strength*

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## I. INTRODUCTION

Cement concrete tiles and paving blocks are precast solid products made out of cement concrete. The product is made in various sizes and shapes viz. rectangular, square and round blocks of different dimensions with designs for interlocking of adjacent tiles blocks. The raw materials required for manufacture of the product are Portland cement and aggregates which are available locally in every part of the country applications. Hence, the unit may be set up in urban and semi-urban areas, near the market. A lot of face-lift is being given to roads, footpaths along the roadside. Concrete paving blocks are ideal materials on the footpaths for easy laying, better look and finish. Whereas the tiles find extensive use outside the large building and houses, lots of these materials are also used in flooring in the open areas of public offices and commercial buildings and residential apartments.

Developments in India with regard to the use of precast paving blocks have been on lines different from those in some other countries. This is essentially because of differences in regard to economics, construction methods and uses. For some years now, the Central Road Research Institute has been engaged in developing different types of paving blocks for specific uses. The work at **C.R.R.I.** has been directed towards the following four uses.

1. Hollow hexagonal blocks paving for roads in desert areas.
2. Rectangular blocks paving for providing road access to small rural communities.
3. Hexagonal blocks for paving of footpaths add passenger shelters at bus stops.
4. Square blocks for paving of footpaths and passenger shelters at bus stops.

The raw materials require for manufactures of the product are Portland cement and aggregates which are available locally in every part of the country. Market potential cement concretes paving blocks find applications in pavements, footpaths, gardens,

passengers waiting sheds, bus stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi urban areas, near the market. Interlocking Pavers are the modern day solution for low cost outdoor application. Paver block is solid, unreinforced pre-cast cement concrete paving units used in the surface course of pavement. They are high strength concrete precast elements in various shapes, sizes & colors to suit the imagination of landscape architects & nature's essence. By improving its compressive strength it can be used in heavy traffic area also. Interlocking pavers are manufactured concrete product that is individually placed in a variety of patterns and shapes as per the requirement. They do not absorb water and can be placed so that excess water is taken away from the garden and patio area rather than over-saturating it. Color, texture and size options provide a virtually infinite array of design possibilities. Concrete block paving also allows for integrated navigation, hazard warning and zoning information. By using variations in color, texture and size, concrete block paving can mark parking spaces and pathways, vehicle access routes and loading zones. The range also includes integrated and complementary edging and kerbing options to achieve a consistent, high-quality finish. This type of pavement will absorb stress such as small earthquakes, freezes and thaws, and slight ground erosion by flexing.

## II. OBJECTIVES OF RESEARCH WORK:

The main objective of this research of is given below:

1. To study the effect of varying percentage of Nylon Fiber on compressive strength of paver block.
2. To examine the effect of waste foundry sand in M40 i.e. (high grade of concrete).
3. To attain the required specific strength in control mix.
4. To compare the mechanical properties i.e. (compressive strength, and flexural strength) of concrete containing waste foundry sand by partially replacing regular sand with conventional mix.
5. To find the optimum percentage of nylon fiber on which maximum compressive strength is achieved.
6. To study the compressive strength of paver block on effect of varying percentage of Waste foundry sand and optimum quantity of Nylon fiber.

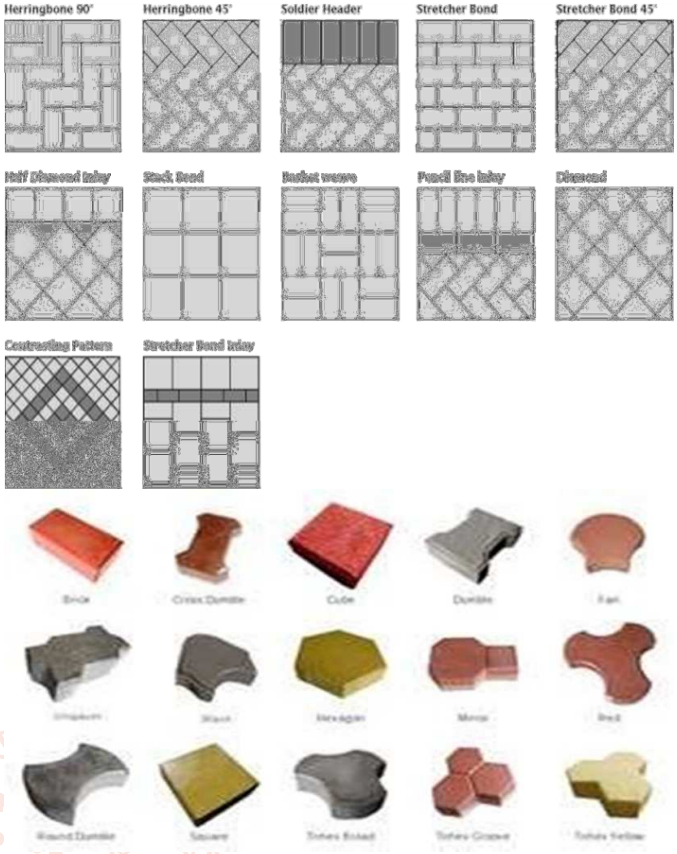



**Figure 1: Different types of paver blocks**

## III. LITRATURE RIVEW

**Akshay T. Gadhave et.al (2020)** Environmental issues bobbing up from the over- dredging of sand have caused regulations on its extraction throughout India, with direct financial affects on concrete production. A appropriate environmentally friendly opportunity to sand have to be discovered to in shape the huge call for from the concrete production industry. At the equal time, waste plastic is hardly ever recycled in India, with as a great deal as 40% left in landfill. The dumping of such substances which degrade at extraordinarily low charges meaning they persist within side the surroundings is a long- term environmental concern. To address each issue, it is proposed to procedure waste plastic to create a partial alternative for nice sand in a unique blend for structural concrete. Plastic waste and its low recycling charge make a full-size effect in the direction of the pollutants of the surroundings. Generation of waste foundry sand as by product of steel casting industries reasons environmental issues due to its wrong disposal. The parameters along with slump, compressive energy, flexural energy, splitting tensile energy and elastic modulus with alternative of plastic waste and Foundry sand has to be study

**Sheikh Mayesser Mushtaq et.al (2021)** Concrete being maximum considerably used creation cloth everywhere in the globe has resulted within side the over-exploitation of herbal sources including river-sand and gravels. Meanwhile, advancing industries

and growing populace have additionally result in an improved era of waste substances. Many of those waste substances have the ability for use in concrete. This take a look at has investigated the impact of 1 such waste cloth called Waste Foundry Sand (WFS) at the residences of concrete. Many researchers have studied the impact of WFS at the mechanical residences of concrete. However, no consensus has been reached but and really contradictory consequences had been reported. Moreover, shrinkage of concrete containing WFS has now no longer obtained lots of the researchers' interest and really confined literature is to be had associated with this property. This take a look at explores the workability, compressive power, cut up tensile power and drying shrinkage of such concretes. WFS became used as partial substitute of exceptional mixture and the substitute tiers had been various from zero to 50% in identical increments of 10%. It became located that the compressive power and cut up tensile power of concrete reduced with the addition of WFS. However, the combination true WFS3 (30% WFS) confirmed the power very much like that of manage concrete. A giant boom of 16.7%, 23.44%, 29.05%, 36.35% and 45.18% with admire to manipulate concrete on the age of 28 days became located within side the value of drying shrinkage whilst the quantity of WFS in concrete became various from 10 to 50%. Furthermore, it became visible that the to be had shrinkage prediction fashions couldn't be implemented to the concrete containing waste foundry sand.

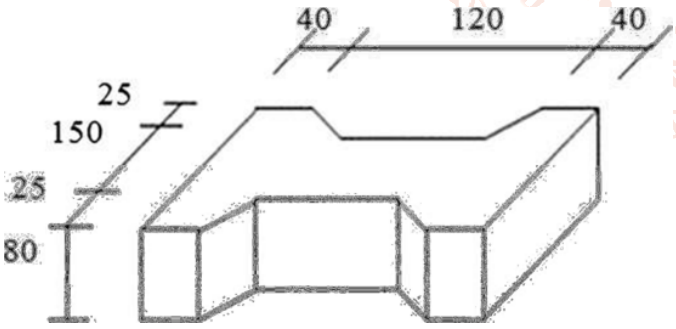



**Figure 2: Dimension of Paver Blocks (All Dimensions are in mm)**

## METHODOLOGY

### Manufacturing of paver blocks

In this chapter how paver block is manufactured for experimental work is described. 80mm thick Paver block of M-40 grade is cast for the experimental work. For manufacturing of paver blocks certain Steps is followed which is given below.

### Size of the paver blocks

For manufacturing of paver block first we have decide that size of the paver block, which is according to manufacturer is given below:

Shape: I section Length: 200 mm

Width: 160 mm Thickness = 80 mm

Aspect ratio (L/T) = 200/80 = 2.5 < 4.0 as per IS 15658: 2006

### Plan Area (Asp) (Method 1)

The test specimen shall be weighted, while suspended by metal wire, and completely submerged in water, and the weight shall be recorded in **N** to nearest 0.01N ($W_a$). They shall be removed from water and allowed to drain for one minute by placing them on a 10mm coarser wire mesh. Visible water on the specimen shall be removed with a damp cloth. The specimen shall be immediately weighed and the weight for each specimen noted **N** to the nearest 0.01N ($W_W$). the volume of specimen shall be calculated as follows:

Volume = $(W_W - W_a)\ 10^{-3}\ m^3$

The volume shall be divided by thickness to obtain plan area in $mm^2$. Volume = $0.0002\ m^3$

Area= $28589.32\ mm^2$

## SELECTION OF INGREDIENT

### Cement

According to IS 15658: 2006 Ordinary Portland Cement of Grade 53 is used, which conforming IS 12269. 53 grade cement of ultra tech with a remarkably high cs3 (tricalcium providing long-lasting) durability to concrete structures. Produces highly durable and sound concrete due to very low percentage of alkalis chlorides, magnesia Cement used in the experimental work is Ordinary Portland cement of grade 53 conforming to IS 12269The physical properties of the cement obtained on conducting appropriate tests as per IS: 269/4831.

### Foundry Sand

The foundries are originated from the region of Mesopotamia and from Iraq and Syria. Fire pits and casting of clay worked to make shapes of silver, copper and gold[18]. The shape of WFS is sub-angular to round suitably, and it has an immense thermal conductivity which is helpful in using it for casting and moulding operations. The foundry sand contains bentonite clay presents in very less amount and it also acts as binder material. Furthermore, foundry sand also contains chemical binders which acts to create sand cores. Foundry sand is used and recycled various times in metal casting industries for mouldings and casting operations to a certain point where it can no longer be reused and when it is no longer be reused is expelled from the operation, and the new sand is introduced and imported to this cycle. Then, the expelled sand from the casting operations and foundries is known as WFS. WFS is a by-product

of metal casting industries i.e. (ferrous and non-ferrous) which contain silica in high amount.

In metal casting industries, waste foundry sand (WFS) is mainly characterized on the basis of binders and binder's system. Green sand and chemically bonded sand are the sand used in casting process.

**Nylon Fiber**

The synthetic fiber using in the present investigation is Nylon fiber. A manufactured fiber in which the fiber forming substance is a long-chain synthetic polyamide in which less than 85% of the amide-linkages are attached directly (-CO-NH-) to two aliphatic groups. A synthetic thermoplastic fiber (Nylon melts/glazes easily at relatively low temperatures) Round, smooth, and shiny filament fibers, cross sections can be either trilobal to imitate silk. Its most widely used structures are multifilament, monofilament, staple or tow and is available as partially drawn or as finished filaments. Regular nylon has a round cross section and is perfectly uniform. The filaments are generally complete transparent unless they have been delustered or solution dyed. Thus, they are microscopically recognized as glass rods. Molecular chains of nylon are long and straight variations but have no side chains or linkages. Nylon is related chemically to the protein fibers silk and wool. They both have similar dye sites but nylon has many fewer dye sites than wool.

**Water**

Water used in paver blocks is conforming the specification of IS 456: 2000. Water used for mixing is free from injurious amount of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

**Aggregates**

Natural aggregates used in the manufacture of concrete paving blocks should meet the requirements for aggregates for concrete given in IS 383 Aggregates from natural sources – Aggregates for concrete. Slag aggregates may also be used if they can be shown to be physically and chemically sound. Waste materials, or materials not in demand, are often sought after as these are generally relatively cheap. But the use of such materials could be at the expense of quality or result in increased costs due to the need to use higher cement contents to maintain quality. These materials might also create compaction difficulties which could adversely affect productivity and durability. The performance of aggregates at the molding stage and in the hardened block depends on the combined effects of particle size, grading, particle shape, and hardness. Each of these properties is discussed below.

**Size**

The recommended maximum nominal size of aggregate is 12 mm. However, the maximum size generally used is 10 mm. smaller sizes (4.75 mm) may be used to suit circumstances or may be specifically selected to obtain a particular surface texture. Generally, the use of coarse particles results in savings in binder provided the mix is properly proportioned. If coarse aggregate particles are too big, or if too much coarse aggregate is used in the mix, it may be difficult to achieve good compaction and acceptable surface texture.

**Coarse Aggregates**

The aggregates which remained on 4.75mm IS Sieve is called coarse aggregates, coarse aggregate is uncrushed gravel or stone which results from the natural disintegration of rocks, crushed gravel or stone when it results from crushing of gravel or hard stone. Coarse aggregates which is used in paver blocks is confirmed by IS 383. As far as possible crushed/ semi crushed aggregates shall be used. For ensuring adequate durability, the aggregate used for production of blocks shall be sound and free of soft or honey combed particles.

Other type aggregates such as slag and crushed and, over burnt brick or tile which may be found suitable with regard to strength, durability of concrete and freedom for harmful effects may be used in preparation of concrete for production of paver blocks. however such aggregates shall not contain more than 0.5 % of sulphates as SO3 and shall not absorb more than 2 percent of their own mass of water. Heavy weight aggregates of light weight aggregates such as bloated clay aggregates may also be used provided the purchaser is satisfied with the data on the properties of concrete made with them. The nominal size of coarse aggregates used in production of paver blocks shall be 12 mm.

**Fine Aggregates**

Aggregate which passed from 4.75 mm sieve and contains only so much coarser material as permitted, fine aggregate is natural sand which is resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies, it is also crushed stone sand which is produced by crushing hard stone, it is also crushed gravel sand which produced by crushing natural gravel.

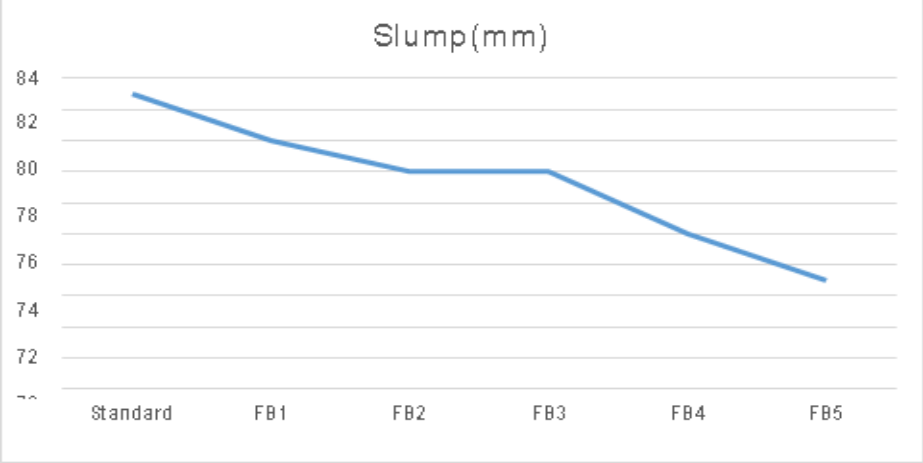
## RESULT AND DISCUSSION

**Workability of Nylon Fiber Paver Blocks**

Table 1 and graph 1 shows workability of the concrete with nylon fiber and it has been observed that nylon fiber decreases workability of the concrete.

| Mix | Slump (mm) |
|---|---|
| Standard Concrete | 83 |
| FB1 | 80 |
| FB2 | 78 |
| FB3 | 78 |
| FB4 | 74 |
| FB5 | 71 |

**Table 1: Workability of Concrete with Nylon fibers**




**Graph 1: Workability of Concrete with Nylon fibers**

**Workability of waste foundry sand Paver Blocks with Nylon Fiber**

Table 2 and graph 2 shows workability of the concrete with waste foundry nylon fiber and it is clearly shows that waste foundry with nylon fiber increases the workability of the concrete

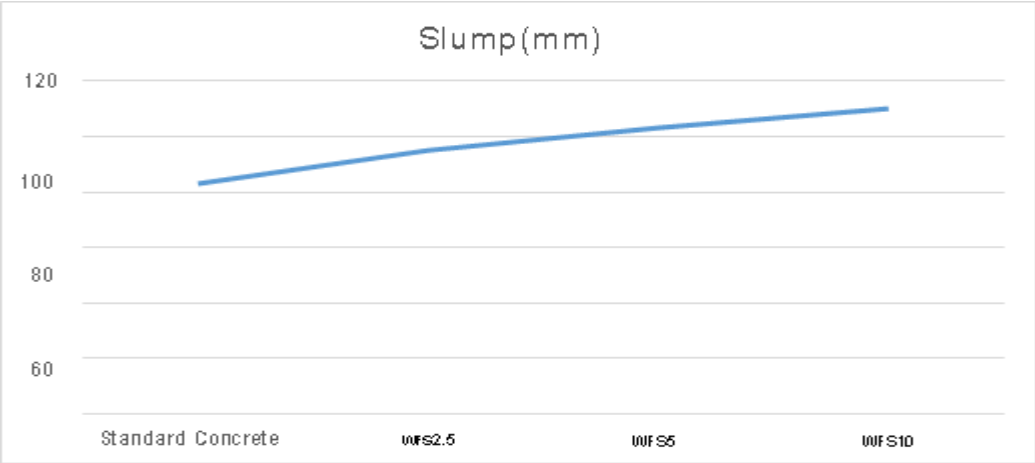
| Mix | Slump (mm) |
|---|---|
| Standard Concrete | 83 |
| WFS2.5 | 95 |
| WFS 5 | 103 |
| WFS10 | 110 |

**Table 2: Workability of Concrete with Nylon fibers and waste found**

## IV. CONCLUSION

Following conclusion is carried out from present study.

1. After performing compressive strength test on the paver blocks with varying percentage of nylon fiber, it is observed that by addition of 0.3% nylon fiber gives the maximum compressive strength at 7, 14 and 28 days.
2. It is concluded that addition of nylon fiber in the construction of concrete paver block increases its compressive strength up to 4.55% as compared to standard mix.
3. The inclusion of waste foundry sand with fine aggregates in concrete enhance the strength properties with increasing content of WFS up to certain replacement level and further the strength properties also improved with the increase in curing age.
4. Compressive strength of concrete increased and after that there is a systematic decrease in strength, flexural strength of concrete increased and after that there is systematic decrease in strength at 28 day of curing age.
5. The maximum strength was observed at 5% WFS of inclusion with fine aggregates in concrete at all curing ages in mechanical properties i.e. (compressive strength, and flexural strength).The increment in strength can be observed because WFS contains silica content in high amount which helps in the formation of C-S-H gel and this is due to the packing behavior of matrix particles.
6. From following observation, it was observed that 5 % of waste foundry sand replacement level can be successfully used to make concrete and in various applications of concrete like concrete paver blocks, whereas beyond this replacement level is not beneficial

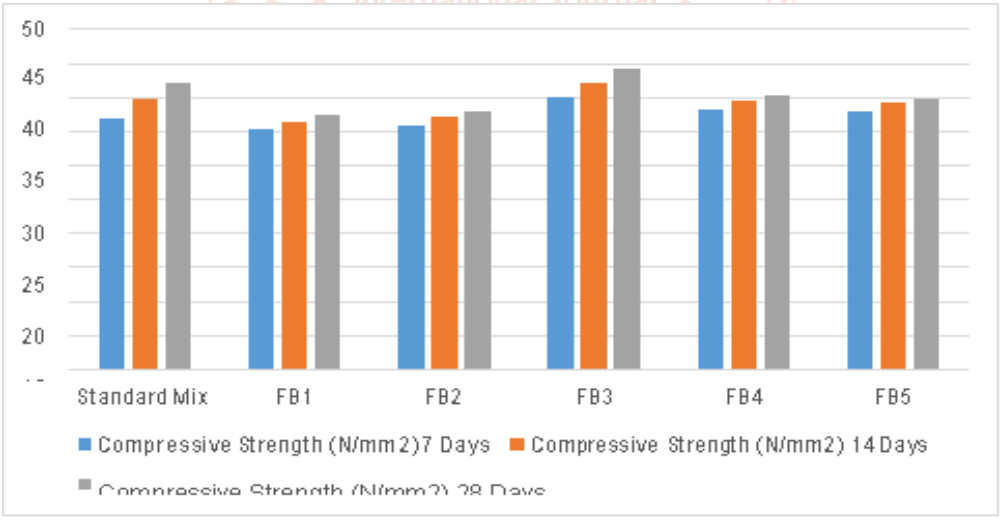



**Compressive Strength of Nylon Fiber Paver Blocks**

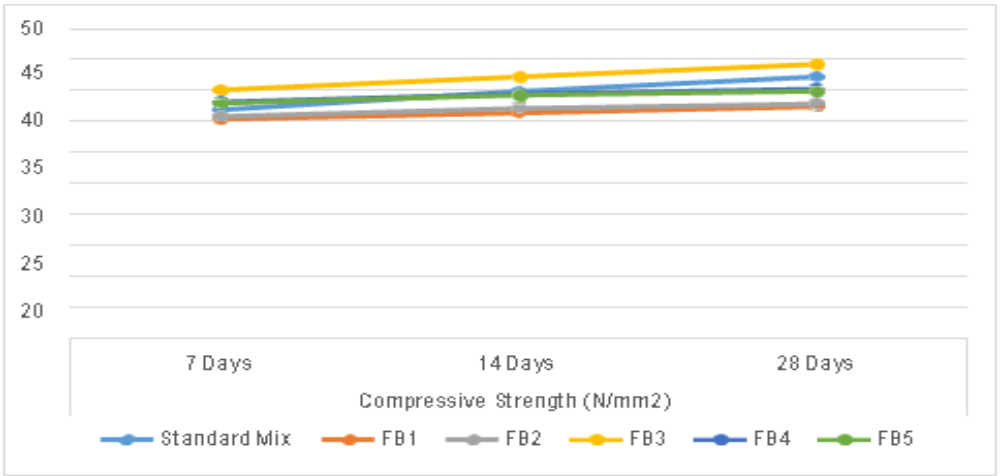
Wh en a nylon fiber paver block is tested for their compressive strength their FB3 mix gives highest result. Compressive strength test is given in table 3 and graph 4-5.

| MIX | COMPRESSIVE STRENGTH (N/MM$^2$) | | |
|---|---|---|---|
| | 7 Days | 14 Days | 28 Days |
| STANDARD MIX | 36.9 | 39.87 | 42.24 |
| FB1 | 35.414 | 36.423 | 37.439 |
| FB2 | 35.834 | 37.143 | 37.849 |
| FB3 | 40.121 | 42.245 | 44.258 |
| FB4 | 38.094 | 39.423 | 40.209 |
| FB5 | 37.944 | 39.243 | 39.899 |

**Table 3: Compressive Strength of Nylon Fiber Paver Blocks**




**Graph 4: Compressive Strength of Nylon Fiber Paver Blocks**




**Graph 5: Compressive Strength of Nylon Fiber Paver Blocks**

**Corrected Compressive Strength of Nylon Fiber Paver Blocks**

As per IS 15658 compressive strength of paver blocks is corrected, 1.18 is multiplied with calculated compressive strength for arrised and chamfer blocks and their compressive strength result is given table 4 and graph 6-7.

| MIX | COMPRESSIVE STRENGTH (N/MM$^2$) | | |
|---|---|---|---|
| | 7 Days | 14 Days | 28 Days |
| STANDARD MIX | 43.542 | 47.0466 | 49.8432 |
| FB1 | 41.7885 | 42.9791 | 44.178 |
| FB2 | 42.2841 | 43.8287 | 44.6618 |
| FB3 | 47.3428 | 49.8491 | 52.2244 |
| FB4 | 44.9509 | 46.5191 | 47.4466 |
| FB5 | 44.7739 | 46.3067 | 47.0808 |

**Table 4: Corrected Compressive Strength of nylon fiber paver blocks as per IS 15658**

## CONCLUSION

Following conclusion is carried out from present study.

1. After performing compressive strength test on the paver blocks with varying percentage of nylon fiber, it is observed that by addition of 0.3% nylon fiber gives the maximum compressive strength at 7, 14 and 28 days.
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