# Behaviour of Natural Fibres in Rigid Pavement

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**Abstract:** ***Concrete is weak in tension and has a brittle character. The concept of using fibres to improve the characteristics of construction materials is old. Early applications include addition of straws to mud bricks, horse hair to reinforce plaster and asbestos to reinforce property. The modern development of fibre reinforced concrete (FRC) started in the early sixties. Addition of fibres to concrete makes it a homogenous and isotropic material. When concrete cracks, the randomly oriented fibres start functioning, arrest crack formation and propagation, and thus improve strength and ductility. The objective of this study is to investigate the effects on stress development in pavements and on critical design factors substituting natural fibre reinforcement for conventional steel reinforcement in pavements to determine the performance characteristics of the natural fibre reinforced concrete pavements. the result of this study target the design of pavement with natural fibres. They propose feasible natural fibre design to be constructed. The natural fibres reinforce the concrete as much as steel reinforcing does in conventional concrete. This results in product with higher flexural and tensile strength than normal concrete, allowing its use in thin-wall casting applications. NFRC is a light weight, durable material that can be cast into nearly unlimited shapes, colours and textures. This project includes various tests on soils, aggregates and various concrete tests and mix design for each layer of the rigid pavement. NFRC is a specialized form of concrete with many applications. It can be effectively used to create façade wall panels, fireplace surroundings, vanity tops and concrete countertops due to its unique properties and tensile strength. One of the best ways to truly understand the benefits of NFRC is a unique compound.***

**Keywords:** FRC, Coir fibre, FDD, FSI, Liquid limit, Plastic limit, MDD, OMC, CBR, Flakiness, Elongation, WMM

## 1. Introduction

Fibre reinforced concrete (FRC) is a concrete (uniform paste of cement, aggregate and water) containing fibrous material which increases its structural integrity. It contains short discrete fibre that are uniformly distributed and randomly oriented. Fibres are a class of hair like materials that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread or rope. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt.

## 2. Aim of the Project

To determine the compressive strength of concrete by adding fibre as reinforcement. This project shows the difference in compressive strengths when fibres are used as reinforcement.

## 3. Fibre Reinforced Concrete

More recently micro fibres, such as those used in traditional composite materials have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. FRC is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. Fibres help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks.

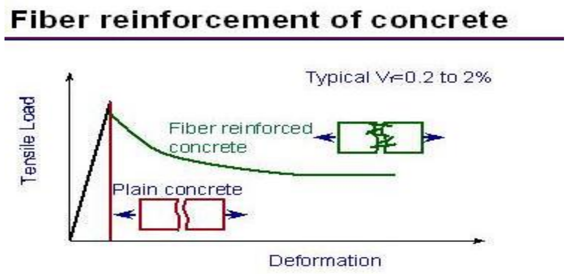


**Figure 1:** Tensile Load v/s Deformation for Plain and Fibre Reinforced Concrete

### 3.1 Applications of Fibre Reinforced Concrete Limitations of Fibre Reinforced Concrete

Fibre work with concrete utilizing two mechanisms the spacing mechanism and the crack bridging mechanism. The spacing mechanism requires a large number of fibres well distributed within the concrete matrix to arrest any existing micro crack that could potentially expand create a sound crack. For typical volume of fractions of fibres utilizing small diameter of fibres or micro fibres can ensure the required no of fibres for micro crack arrest. The second mechanism termed crack bridging requires larger straight fibres with adequate bond to concrete. Steel fibres are considered a prime example of this fibre type that is commonly referred as large diameter fibres or micro fibres

### 3.2 Coconut Fibre

Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibres are commercial available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used. they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean.

**Table 1:** Chemical Composition of Coconut / Coir Fibre Grain Size Analysis

| | |
|---|---|
| Lignin | 45.84% |
| Cellulose | 43.44% |
| Hemi-Cellulose | 00.25% |
| Pectin's and related Compound | 03.00% |
| Water soluble | 05.25% |
| Ash | 02.22% |

**Table 2:** Physical Properties of Coconut / Coir Fibre

| | |
|---|---|
| Length in inches | 6-8 |
| Density (g/cc) | 1.40 |
| Tenacity (N/tex) | 10 |
| Breaking elongation% | 30% |
| Diameter in mm | 0.1 to 1.5 |
| Rigidity of Modulus | 1.8924 dyne/cm$^2$ |
| Swelling in water (diameter) | 10% |
| Moisture at 65% RH | 10.50% |

## 4. Concrete Grades Tests Conducted

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

## 5. Lab Tests

The various tests conducted on the sample are as follows

### 5.1 Soil Tests

Soil tests are done to ensure that the soil is suitable for construction of the pavement or not. The soil tests are

#### 5.1.1 Grain Size Analysis

Soil sample of 1 kg is weighed using balance and the sieve sizes used for test are 75mm, 20mm, 4.75mm, 2mm, 425µm, 75µm.

Analysis:
i. 4.75mm is for Gravel
ii. 2mm& 425µ for Sand
iii. 75µ for Silt & Clay

**Table 3:** Grain Size Analysis Calibration of Apparatus

| *IS SIEVE (mm)* | *Weight Retained (gm)* | *Cumulative Weight(gm)* | *Cumulative %Retained* | *Cumulative % Passing* | *Remarks* |
|---|---|---|---|---|---|
| 75 | - | - | - | - | Gravel |
| 20 | - | - | - | - | Gravel |
| 4.75 | 95 | 95 | 9.5 | 90.5 | Gravel |
| 2 | 156 | 251 | 25.1 | 74.9 | Sand |
| 0.425 | 319 | 570 | 57 | 43 | Sand |
| 0.075 | 147 | 717 | 71.7 | 28.3 | Sand |
| Pan | | | | | Silt & Clay |

#### 5.1.2 Field Dry Density

The dry density of the compacted soil or pavement materials is a common measure of the amount of the compaction achieved during the construction of the pavement. Knowing the field density and the moisture content, the dry density is calculated.

The method used in finding field dry density is the sand replacement method

Sand passing through 1mm sieve and retained on 600µ sieve is taken. Cone which is of height 19.5cm and diameter of 15cm is taken

**Table 4:** Calibration of Apparatus

| *S. No* | *Description* | *Determination* |
|---|---|---|
| 1 | Mean weight of sand in cone (of pouring cylinder) ($w_2$g) | 450 |
| 2 | Volume of calibrating container (v) ml | 980 |
| 3 | Weight of sand +cylinder, before pouring ($w_1$) gm | 11040 |
| 4 | Weight of sand +cylinder, after pouring ($w_3$) gm | 9120 |
| 5 | Weight of sand to fill calibrating container(wa=w1-$w_3$-$w_2$) in g | 1470 |
| 6 | Bulk density of sand=wa/v x1000kg/cu-m | 1500 |

**Table 5:** Measurement of Soil Density

| *Sl. No* | *Observations & Calculations* | *Trail 1* | *Trail 2* | *Trail 3* |
|---|---|---|---|---|
| 1 | Weight of wet soil from the hole (Ww) | 2310 | 2400 | 2280 |
| 2 | Weight of sand +cylinder before pouring (W4) in gm | 11040 | 11042 | 11037 |
| 3 | Weight of sand +cylinder after pouring (W4) in gm | 8840 | 8752 | 8882 |
| 4 | Weight of sand in the hole (Wb=w1-w4-w2) in gm | 1750 | 1840 | 1705 |
| 5 | Bulk density =Ww/Wb (bulk density of sand) | 1980 | 1956.5 | 2005 |
| 6 | Water content(w)% | 18.48 | 18.81 | 19.26 |
| 7 | Dry density | 1671.17 | 1646.75 | 1681.87 |

Average dry density value is 1667kg/m$^3$

#### 5.1.3 Free Swelling Index

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.
Free swell index = [Vd – Vk] / Vk x 100%
Vd = volume of soil specimen read from the graduated cylinder containing distilled water.

Vk = volume of soil specimen read from the graduated cylinder containing kerosene.
Note: free swelling index test is to know which type of soil is used.

Conclusion
Volume in the water added jar has slightly increased as that of soil will not be absorbed by kerosene or diesel. The increased height of soil is 10mm. This proves that the soil is good for construction.

### 5.1.4 Liquid Limit And Plastic Limit Maximum Dry Density

**Liquid Limit**

The liquid limit (LL) is conceptually defined as the water content at which the behaviour of a clayey soil changes from plastic to liquid. However, the transition from plastic to liquid behaviour is gradual over a range of water contents, and the shear strength of the soil is not actually zero at the liquid limit.

**Table 6:** Liquid Limit

| *Sl. No* | *Description* | *Trial 1* | *Trail 2* | *Trail 3* |
|---|---|---|---|---|
| 1 | No of blows | 30 | 35 | 38 |
| 2 | Container number | 4 | 4 | 6 |
| 3 | Wt of container + wet soil | 23.30g | 10.40g | 21.49g |
| 4 | Wt of container + dry soil | 20.86g | 9.38g | 20.50g |
| 5 | wt of water (3-4) | 2.44g | 1.02g | 0.99g |
| 6 | Wt of container | 9.65g | 3.90g | 13.76g |
| 7 | Wt of dry soil (4-6) | 11.21g | 5.48g | 6.74g |
| 8 | Moisture content (5/7) | 0.21g | 0.18g | 0.14g |
| 9 | Moisture content (%) | 21 | 18 | 14 |

**Plastic Limit**

The plastic limit (PL) is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface. The procedure is defined in ASTM Standard D 4318. If the soil is at moisture content where its behaviour is plastic, this thread will retain its shape down to a very narrow diameter.

The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch). A soil is considered non-plastic if a thread cannot be rolled out down to 3.2 mm at any moisture.

**Table 7:** Plastic Limit

| *Sl. No* | *Description* | *Trail 1* | *Trail 2* | *Trail 3* |
|---|---|---|---|---|
| 1 | Container number | 5 | 5 | 1 |
| 2 | Wt of container + wet soil | 4.73 | 11.69 | 6.54 |
| 3 | Wt of container + dry soil | 4.42 | 11.64 | 5.58 |
| 4 | wt of water (3-4) | 0.31 | 0.05 | 0.96 |
| 5 | Wt of container | 3.76 | 10.17 | 3.93 |
| 6 | Wt of dry soil (4-6) | 0.66 | 1.47 | 1.65 |
| 7 | Moisture content (5/7) | 0.46 | 0.03 | 0.58 |
| 8 | Moisture content (%) | 46 | 30 | 58 |

### 5.1.5 Maximum Dry Density

To determine moisture content and dry density relationship using heavy compaction or modified compaction method as per IS-2720-Part-8.
i. 6Kgs of soil sieved by 19mm is collected
ii. According to ISA we add 2% of water to the soil and mix well (120ml of water).

**Table 8:** Determination of Modified Proctor Compaction Test

| *S. No* | *Description* | *Trail 1* | *Trail2* |
|---|---|---|---|
| 1 | Wt of mould +compacted wet soil(W2) in gm | 5.309 | 5.309 |
| 2 | wt of compact wet soil w=w2-w1 | 5 | 5 |
| 3 | Wet density of soil(g/cu-m) | 12.62 | 12.67 |
| 4 | Bin no | 6 | 1 |
| 5 | Empty wt of bin | 13.79g | 13.79g |
| 6 | wt of bin +wet soil in gm | 43.35g | 40.08g |
| 7 | Wt. of bin + dry soil in gm | 40.369g | 35.23g |
| 8 | Wt. of water (6) - (7) | 2.99 | 4.75 |
| 9 | Wt. of dry soil (7) - (5) | 11.25 | 0.2057 |
| 10 | Moisture content (8/9) | 0.1125 | 0.2057 |
| 11 | Moisture content (%) | 11.25 | 20.57 |
| 12 | Dry density | 1.03 | 0.587 |

### 5.1.6 California Bearing Ratio

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road sub grades and base courses. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material.

6Kg of soil and add 510ml is taken (O.M.P by 8.52)
8.5/100×6000=510

Fill the soil into the mould divide the soil into five layers, give 10 blows for each layer.

Collect some amount of soil compacted sample into the empty box and weigh.

Keep it in the oven for 24hours, later the total mould in the water for 4 days(96hours).

Later after the duration the mould in transferred to the C.B.R testing machine

**Table 9:** Dial Gauge Readings

| *DIAL GAUGE* | *A* | *B* | *C* |
|---|---|---|---|
| 0.5mm | 0 | 0 | 0 |
| 1mm | 1.5 | 3.2 | 2.2 |
| 1.5mm | 3 | 9.4 | 3.6 |
| 2mm | 4 | 13.9 | 4.2 |
| 2.5mm | 5.25 | 16.5 | 5.2 |
| 3mm | 6..20 | 19 | 6 |
| 4mm | 8 | 20.5 | 7.17 |
| 5mm | 10.5 | 26.9 | 8.4 |
| 7.5mm | 13.12 | 39.1 | 12.2 |
| 10mm | - | - | - |

**Table 10:** CBR Value

| *Penetration (mm)* | *10blows Proving readings* | | *30 blows Proving Readings* | | *65 blows Proving Reading* | |
|---|---|---|---|---|---|---|
| 0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.0 | 1.5 | 21.89 | 3.2 | 47.0 | 2.2 | 32.11 |
| 1.5 | 3.0 | 43.79 | 9.5 | 138.68 | 3.6 | 52.55 |
| 2.0 | 4.0 | 58.39 | 13.9 | 202.91 | 4.2 | 61.31 |
| 2.5 | 5.25 | 76.64 | 16.5 | 240.87 | 5.2 | 75.91 |
| 3.0 | 6.2 | - | 19.0 | - | 6.0 | - |
| 4.0 | 8.0 | - | 20.5 | - | 7.17 | - |
| 5.0 | 10.5 | - | 26.9 | - | 8.4 | - |
| 7.5 | 13.12 | - | 39.1 | - | 12.2 | - |

### 5.2 Aggregate Tests

Aggregates tests are done to ensure that the aggregates are suitable for the construction of the concrete pavements.

#### 5.2.1 Aggregate Impact Test

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used for determining aggregate impact value test is Impact testing machine conforming to IS: 2386 (Part IV)- 1963, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, a cylindrical metal measure of 75mm dia. and 50mm depth, a tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.

Take 10mm size aggregate sieve it from 12.5&10mm sieves
Fill in the mould in 3 layers, for each layer give 25tampings
Weigh the mould and note the readings, shift the aggregates to other mould
Again give 25blows and place the mould in A.I.V machine
Give 15blows by A.I.V and sieve the sample then the value of retained aggregate and weigh it.

**Table 11:** Aggregate Impact Value

| *Description* | *Test1* | *Test2* | *Test3* |
|---|---|---|---|
| Weight of surface dry sample passing 12.5mm&retained on 10mm15 sieve W1 (Gm) | 352 gm | 348 gm | 365 gm |
| Weight of fraction passing through 2.36mm sieve after the test W2 (Gm) | 25 gm | 37 gm | 29 gm |
| Weight of fraction retained on 2.36mm sieve after test W3 (Gm) | 326gm | 337 gm | 346 gm |
| Aggregate Impact Value=( $W_{2/}$ $W_1$) * 100 % | 7.10 | 10.6 | 7.94 |

#### 5.2.2 Shape Tests (Flakiness And Elongation Index)

**Flakiness Index**

It is the percentage by weight of flaky particles in a sample. A flaky particle is the one whose least dimension (thickness) is than 0.6 times the mean size. These are the materials of which the thickness is small as compared to the other two dimensions. Limit of flaky particles in the mixes is 30%. If the flaky particles are greater than 30% then the aggregate is considered undesirable for the intended, use.

Collect 20mm and 10mm aggregate stones
Separate 10mm-200stones
20mm-200stones
Flakiness Gauge
From the flakiness gauge pass all the 10mm and 20mm stones.
Collect the stones which are passed and weigh them

**Elongation Index**

It is the percentage by weight of elongated particles in a sample. The Elongated index is calculated by expressing the weight of Elongated particles as percentage of total weight of the sample. These are the particles having length considerably larger than the other two dimensions and it is the particle whose greater dimension is 1.8 times its mean size. Limit of elongated particles in the mixes is 45%. Thus, if the elongated particles are greater than 45%, then the aggregate is considered undesirable for the intended use.

Collect 20mm and 10mm aggregate stones
Separate 10mm-200stones
20mm-200stones
Elongation Gauge
Take the same stones which are passed by flakiness.
Pass the stones from the elongation gauge and take the weigh them and note the readings.

**Table 12:** Aggregate Shape Tests (Flakiness and Elongation)

| *Passing* | *Retained* | *Weight of sample not less than 200pieces for testing* | *Aggregates passing in flaky gauge* | *Weight of sample retained on flaky gauge* | *Weight of aggregates retained on elongation gauge* |
|---|---|---|---|---|---|
| 63 | 50 | - | - | - | - |
| 50 | 40 | 2442 | 2200 | 242 | - |
| 40 | 31.5 | 2117 | 1224 | 837 | - |
| 31.5 | 25 | 1995 | 942 | 1053 | - |
| 25 | 20 | 1665 | 1462 | 203 | - |
| 20 | 16 | 1540 | 1482 | 58 | 33 |
| 16 | 12.5 | 1026 | 1013 | 13 | 59 |
| 12.5 | 10 | - | - | - | 1180 |
| 10 | 6.3 | - | - | - | 632 |
| | Total | A=10785 | B=8343 | C=2442 | D=1904 |

#### 5.2.3 Fine Aggregates Of Sand

1-5kgs of sand and sieves 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm, 0.075mm are taken. Sieve the sand and collect the retained sand and weigh it and will know the type of zone the soil.

**Table 13:** Sieve Analysis of Fine Aggregate for Sand

| *Sieve size (mm)* | *Weight retained in (gm)* | *Cumulative wt retained (gm)* | *% Retained* | *% Passing* | *Specification Zone-1* | *Limits As per Zone-2* | *MORT & H Zone-3* |
|---|---|---|---|---|---|---|---|
| 10 | 0 | 0 | - | - | 100 | 100 | 100 |
| 4.75 | 168 | 168 | 5.57 | 94.43 | 90-100 | 90-100 | 90-100 |
| 2.36 | 209 | 377 | 12.520 | 87.47 | 60-95 | 75-100 | 85-100 |
| 1.18 | 898 | 1275 | 42.344 | 57.65 | 30-70 | 55-90 | 75-100 |
| +0.600 | 853 | 2128 | 70.67 | 29.32 | 15-35 | 35-59 | 60-79 |
| 0.300 | 600 | 2728 | 90.60 | 9.4 | 5-20 | 8-30 | 12-40 |
| 0150 | 120 | 2848 | 94.586 | 5.41 | 0-10 | 0-10 | 0-10 |
| 0.075 | 5 | 2853 | 94.75 | 5.24 | <3% | <3% | <3% |
| Pan | 0 | 0 | 0 | 0 | | | |

## 6. Compressive Strength of Concrete

The compressive strengths of normal concrete cubes and fibre reinforced concrete cubes after 7 days of curing are as follows
NORMAL CONCRETE MIX

**Table 14:** Normal Concrete Mix

| *S. No.* | *Weight of Cube* | *Density* | *Max. Load* | *Ultimate Strength* | *Mean Ultimate Strength (N/mm²)* |
|---|---|---|---|---|---|
| 1 | 8288 | 2.456 | 690 | 30.67 | 31.11 |
| 2 | 8145 | 2.413 | 700 | 31.11 | |
| 3 | 8200 | 2.430 | 710 | 31.56 | |
| 4 | 8231 | 2.439 | 700 | 31.11 | |

**Fibre Reinforced Concrete Mix**

In this fibre reinforced concrete mix the amount of coir fibre used is 24 grams ie;0.3% of total mix.

**Table 15:** Fibre Reinforced Concrete Mix

| *S. No.* | *Weight of Cube* | *Density* | *Max. Load* | *Ultimate Strength* | *Mean Ultimate Strength (N/mm²)* |
|---|---|---|---|---|---|
| 1 | 8198 | 2.468 | 730 | 33.33 | 33.41 |
| 2 | 8194 | 2.433 | 740 | 33.78 | |
| 3 | 8217 | 2.443 | 740 | 32.89 | |
| 4 | 8233 | 2.449 | 750 | 33.67 | |

## 7. Granular Sub-Base in Construction of Concrete Roads

Take the aggregate of 20mm, 10mm, 6mm, stone dust according to the specifications of grade-2 sieve the aggregates and take the weigh collected in each sieve.

On a well compacted sub-grade, spread 10 to 20 cm size boulders or broken stones, or over burnt bricks in layers of 15 cm thickness and total width of the sub-base to be kept 60 cm wider than pavement width, projecting 30 cm on each side. The sub-base should be compacted by a roller to provide an even surface.

The mixing of the gravel should be done according to the MORT & H specifications of Pavement Design.

**Table 16:** MORT&H specification

| *Sieve Size* | *Grade -1* | *Grade -2* | *Grade -3* | *Grade -4* | *Grade -5* | *Grade -6* |
|---|---|---|---|---|---|---|
| 75mm | 80-100 | - | - | - | 100 | - |
| 53 | 80-100 | 100 | 100 | 100 | 80-100 | 100 |
| 26.5 | 55-90 | 70-100 | 55-75 | 50-80 | 55-90 | 75-100 |
| 9.5 | 35-65 | 50-80 | - | - | 35-65 | 55-75 |
| 4.75 | 22-55 | 40-65 | 10-30 | 15-35 | 25-50 | 30-55 |
| 2.36 | 20-40 | 30-50 | - | - | 10-20 | 10-25 |
| 425µ | 10-15 | 10-15 | - | - | 0-5 | 0-8 |
| 75µ | <15 | <5 | <5 | <5 | - | 0-3 |

**Table 17:** Gradation for Granular Sub Base Grade-1 for 20mm

| *Sieve (mm)* | *Wt. retained (gm)* | *Percentage retained (%)* | *Cumu lative perce ntage (%)* | *Percentage of passing* | *Specifica tions limits (%/)* |
|---|---|---|---|---|---|
| 75 | - | - | - | 100 | 100 |
| 53 | - | - | - | 100 | 80-100 |
| 26.5 | 305 | 305 | 61 | 93.9 | 55-90 |
| 9.5 | 4631 | 4936 | 98.72 | 1.28 | 25-65 |
| 4.75 | 33 | 4969 | 99.38 | 0.62 | 25-55 |
| 2.36 | - | - | - | - | 20-40 |
| 425µ | - | - | - | - | 10-25 |
| 75µ | - | - | - | - | 3-10 |
| Pan | - | - | - | - | - |

**Table 18:** Gradation for Granular Sub Base for 10mm

| *Sieve (mm)* | *Wt. retained (gm)* | *Percentage retained (%)* | *Cumu lative perce ntage (%)* | *Percentage of passing* | *Specifica tions limits (%/)* |
|---|---|---|---|---|---|
| 75 | - | - | - | 100 | 100 |
| 53 | - | - | - | 100 | 80-100 |
| 26.5 | - | - | - | - | 55-90 |
| 9.5 | 1880 | 1800 | 37.6 | 62.4 | 25-65 |
| 4.75 | 3105 | 4985 | 99.7 | 0.3 | 25-55 |
| 2.36 | - | - | - | - | 20-40 |
| 425µ | - | - | - | - | 10-25 |
| 75µ | - | - | - | - | 3-10 |
| Pan | - | - | - | - | - |

**Table 19:** Gradation for Granular Sub Base for 6mm

| *Sieve (mm)* | *Wt. retained (gm)* | *Percentage retained (%)* | *Cumu lative perce ntage (%)* | *Percentage of passing* | *Specifica tions limits (%/)* |
|---|---|---|---|---|---|
| 75 | - | - | - | 100 | 100 |
| 53 | - | - | - | 100 | 80-100 |
| 26.5 | - | - | - | - | 55-90 |
| 9.5 | - | - | - | - | 25-65 |
| 4.75 | 4320 | 4320 | 86.4 | 13.6 | 25-55 |
| 2.36 | 590 | 4910 | 98.2 | 1.8 | 20-40 |
| 425µ | 64 | 4974 | 99.48 | 0.52 | 10-25 |
| 75µ | - | - | - | - | 3-10 |
| Pan | - | - | - | - | - |

**Table 20:** Gradation for Granular Sub Base for Dust

| *Sieve (mm)* | *Wt. retained (gm)* | *Percentage retained (%)* | *Cumu lative perce ntage (%)* | *Percentage of passing* | *Specifica tions limits (%/)* |
|---|---|---|---|---|---|
| 75 | - | - | - | - | 100 |
| 53 | - | - | - | - | 80-100 |
| 26.5 | - | - | - | - | 55-90 |
| 9.5 | - | - | - | - | 25-65 |
| 4.75 | - | - | - | - | 25-55 |
| 2.36 | 178 | 178 | 17.8 | 82.2 | 20-40 |
| 425µ | 530 | 708 | 70.8 | 29.2 | 10-25 |
| 75µ | 282 | 990 | 99 | 1 | 3-10 |
| Pan | - | - | - | - | - |

**Table 21:** Blending Sheet

| Sieve Size | 20 mm | 10 mm | 6 mm | Dust | 20 % | 24 % | 16 % | 40 % | Total |
|---|---|---|---|---|---|---|---|---|---|
| 75 | - | - | - | - | - | - | - | - | - |
| 53 | - | - | - | - | - | - | - | - | - |
| 26.5 | 93.9 | - | - | - | 18.78 | 24 | 16 | 40 | 98.78 |
| 9.5 | 1.28 | 62.4 | - | - | 0.256 | 14.97 | 16 | 40 | 71.22 |
| 4.75 | 0.62 | 0.3 | 13.6 | - | 0.124 | 0.07 | 2.17 | 40 | 42.36 |
| 2.36 | - | - | 1.8 | 82.8 | - | - | 0.28 | 32.88 | 33.16 |
| 0.425 | - | - | 0.52 | 29.2 | - | - | 0.08 | 11.68 | 11.76 |
| 0.075 | - | - | - | 1.0 | - | - | - | 0.4 | 0.4 |

This layer is laid for 200mm.

## 8. Wet Mix Macadam

Macadam is a type of road construction pioneered by Scottish engineer John Loudon McAdam around 1820. The method simplified what had been considered state of the art at that point. Single-sized aggregate layers of small angular stones are placed in shallow lifts and compacted thoroughly. A binding layer of stone dust, crushed stone from the original material may form; it may also, after rolling, be covered with a binder of fines and small crushed rock.
McAdam's road building technology was applied to roads by other engineers. One of these engineers was Richard Edgeworth, who filled the gaps between the surface stones with a mixture of stone dust and water, providing a smoother surface for the increased traffic using the roads.

Aggregates used are of the smaller sizes, varies between the 4.75 mm to 20 mm sizes and the binders (stone dust or quarry dust having PI (Plasticity Index) not less than 6%) are premixed in a batching plant or in a mixing machine. Then they are brought to the site for overlaying and compaction.

**Table 22:** Gradation of Wet Mix Macadam for 20mm

| *Sieve size* | *Weight retained(gm)* | *Percentage retained (%)* | *Cumulative percentage (%)* | *Percentage of passing* | *Specifications Limits (%)* |
|---|---|---|---|---|---|
| 53.0 | - | - | - | - | - |
| 45.0 | - | - | - | - | - |
| 22.4 | 2.142 | 2142 | 42.84 | 57.16 | - |
| 11.2 | 2804 | 4964 | 98.92 | 1.08 | - |
| 4.75 | - | - | - | - | - |
| 2.36 | - | - | - | - | - |
| 0.60 | - | - | - | - | - |
| 0.075 | - | - | - | - | - |
| Pan | - | - | - | - | - |
| Wash loss | - | - | - | - | - |

**Table 23:** Gradation of Wet Mix Macadam for 10mm

| *Sieve size* | *Weight retained(gm)* | *Percentage retained (%)* | *Cumulative percentage (%)* | *Percentage of passing* | *Specifications Limits (%)* |
|---|---|---|---|---|---|
| 53.0 | - | - | - | - | - |
| 45.0 | - | - | - | - | - |
| 22.4 | - | - | - | - | - |
| 11.2 | 340 | 340 | 0.068 | 99.932 | - |
| 4.75 | 4660 | 5000 | 100 | 0 | - |
| 2.36 | - | - | - | - | - |
| 0.60 | - | - | - | - | - |
| 0.075 | - | - | - | - | - |
| Pan | - | - | - | - | - |
| Wash loss | - | - | - | - | - |

**Table 24:** Gradation of Wet Mix Macadam for 6mm

| *Sieve size* | *Weight retained(gm)* | *Percentage retained (%)* | *Cumulative percentage (%)* | *Percentage of passing* | *Specifications Limits (%)* |
|---|---|---|---|---|---|
| 53.0 | - | - | - | - | - |
| 45.0 | - | - | - | - | - |
| 22.4 | - | - | - | - | - |
| 11.2 | - | - | - | - | - |
| 4.75 | 3935 | 3935 | 78.7 | 21.3 | - |
| 2.36 | 766 | 4701 | 94.02 | 5.98 | - |
| 0.60 | 240 | 4941 | 98.82 | 1.18 | - |
| 0.075 | 58 | 4999 | 99.98 | 0.02 | - |
| Pan | - | - | - | - | - |
| Wash loss | - | - | - | - | - |

**Table 25:** Gradation of Wet Mix Macadam for Dust

| *Sieve size* | *Weight retained(gm)* | *Percentage retained (%)* | *Cumulative percentage (%)* | *Percentage of passing* | *Specifications Limits (%)* |
|---|---|---|---|---|---|
| 53.0 | - | - | - | - | - |
| | | | | | |
| 45.0 | - | - | - | - | - |
| 22.4 | - | - | - | - | - |
| 11.2 | - | - | - | - | - |
| 4.75 | - | - | - | - | - |
| 2.36 | 160 | 160 | 16 | 84 | - |
| 0.60 | 421 | 581 | 58.1 | 41.9 | - |
| 0.075 | 200 | 781 | 78.1 | 21.9 | - |
| Pan | - | - | - | - | - |

## 9. Results

1) The average dry density of the soil is 1667 kg/m3 or 1.67 g/$cm^3$.
2) The CBR value of the soil is 60.34.
3) The aggregates impact value is 23.33%.
4) The slump of the concrete is 25mm that is true slump.
5) The result of Vee-Bee consistometer is 27 seconds.
6) The Compressive strength of normal concrete cube is 31.11N/$mm^2$
7) The Compressive strength of natural fibre reinforced concrete cube is 33.41 N/$mm^2$

## 10. Conclusions

The inclusion of the natural fibres in the concrete mix results in increase of the compressive strength of the concrete. Therefore increase of compressive strength may increase the life span of the pavement.

The above values are within the Indian Standard Limits.

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