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# Evaluation of Fine Sand through Soil Stabilization with Square Pieces of Waste Plastic as Admixture for Design of Flexible Pavement in Construction of Roads

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***ABSTRACT :*** *The main object of the present investigation is to study the strength characteristics of fine sand of western Rajasthan stabilized with cheap and readily available material like plastic waste. As per Indian standard classification system of soils, the fine sand has low compressive strength and high permeability and thus has nil cohesion; fine sand is not immediately acceptable for supporting flexible pavements as sub grade for construction of roads. The analysis is to achieve the possibility of fine sand stabilization with waste plastic as admixture for construction of design of pavement in roads. Present research has been taken up by addition of 5mm×5mm square pieces of waste plastic as admixture. The varying percentage 0%, 0.15%, 0.25, 0.50%, 0.75%, and 1% of square pieces of plastic waste were mixed with fine sand of different densities 1.51gm/cc, 1.54gm/cc and 1.58gm/cc (M.D.D.). All the California Bearing Ratio Tests were conducted at different mix compositions of square pieces of plastic waste and fine sand of different dry densities as arrived from Standard Proctor Test. Falling-Head Permeability Tests were also performed on different mix compositions. On the basis of the experiments performed, it is determined that the stabilization of fine sand using square pieces of plastic waste as admixture improves the strength characteristics of the fine sand so that it becomes usable as a base material for flexible pavement in construction of roads.*

***Keywords –*** *C.B.R., fine sand, permeability, square pieces of plastics*

## I. INTRODUCTION

Soil stabilization is technique introduced many years ago with the main purpose to render the soils capable of meeting the requirements of the specific engineering projects. Soil stabilization can increase the shear strength of soil mass, thus upgrading the load bearing capacity of base or base coarse in the pavement of the roads. In western Rajasthan fine sand is reachable in ample, which is infrequently advisable for construction of flexible pavement of roads and necessitate either advancement available fine sand or improving good quality mineral aggregate.

Fine sand stabilization using the square pieces of waste plastic as admixture has great extent for the base coarse in the construction of flexible pavement for roads. The amount of waste plastic has increased year by year and the disposal becomes a serious problem. Particularly recycling ratio of the plastic wastes in life and industry is low and many of them have been reclaimed for the reason of unsuitable ones for incineration. It is necessary to utilize the wastes effectively with technical development in each field. This study presents simple way of recycling plastic waste in the field of civil engineering as admixture in soil stabilization. Fine sand stabilization with square pieces of waste plastic in an efficient and reliable technique for improving the strength and stability of the soils and are also cost effective technique. The technique is used in a variety of applications, ranging from embankments to sub grade stabilization beneath footings and pavements. The laboratory tests studies have been done on by direct admix of fine sand with pieces of plastic waste. Many researchers like Purohit D.G.M. et al. (2009), Awad ALKarni et al. (2012), jain O.P. et al. (1979), V. Mallikarjuna et al. (2016), Kevin M. (1978) and Wayal A.S. et al. (2012) have worked on stabilization of soils.

## II. MATERIALS USED FOR PRESENT STUDY

### 2.1 Fine Sand

Fine sand is found in ample in western Rajasthan. The sand used in current study was brought from location near Dangiyawas-Banar villages, at about 30-35 km away from Jodhpur on Jodhpur-Jaipur Road. Fine sand is uniform clean sand as per Unified Soil Classification System. Particles size ranges between 75μ to 1.0 mm i.e. fine coarse sand, round to angular in particle shape as per Indian Standard Classification System.

### 2.2 Plastic Waste

Plastics are considered as one of the important invention which has remarkably assisted in different aspects of life whether it might be in scientific field or others. The use of plastic has been enormously increasing these days. But now, plastic has become the significant pollutant of Environment because of the Use and Throw mechanism and everyone should think about this in the present scenario. The admixture used in present study was Polyethylene or polythene, as it is also known, as a polymer, produced by the polymerisation of ethylene gas, a derivative of the petroleum industry. The polymer consists essentially of long-chain molecules of very high molecular weight, made up of many thousands of the -CH2- repeating unit. The plastic waste used is of 4$^{th}$ type that is LDPE (Low Density Polyethylene) left after domestic, industrial etc. The plastic waste brought for the research work is a square of 5mm x 5mm pieces cut from plastic sheets by scissor and shredding machine. This plastic waste was availed from a manufacturing unit near Jodhpur, Rajasthan (India). Fig.1 shows the square pieces of plastic waste admixture which is used for present research. Physical and engineering properties of plastic waste material are shown in table 1.

**Figure 1 Square Pieces of Plastic Waste Admixture**

**Table 1: Summary of the physical properties of the tested Square Pieces of Plastic Waste material**

| Physical and Engineering Properties | |
|---|---|
| Density | 0.910-0.925 gm/cm$^3$ |
| Water Absorption | Slight |
| Crystallinity | 50-65% |
| Yield strength | 4-16 MPa |
| Melting temperature | 115ºC |

## III. TEST PROGRAM AND PROCEDURE

The laboratory investigation on fine sand stabilization with square pieces of plastic waste as admixture was performed. This work is done for beneficial utilization of square pieces of plastic waste and a mix proportion that can be mixed with fine sand as a best stabilizer with limited detrimental effects.

The objective of the present study is to evaluate the use of fine sand as a construction material after stabilizing it with square pieces of plastic waste as admixture. The objectives of present study are given below:

1. To study the effect of moisture content on dry density of fine sand.
2. To study the CBR values of fine sand of different dry densities by mixing square pieces of plastic waste in different proportions in unsoaked and soaked conditions.
3. To study the changes in permeability of fine sand by mixing with square pieces of plastic waste in different proportions.

### 3.1 Test Program

The test program included the preliminary tests for fine sand and mix compositions of fine sand with square pieces of plastic waste. Following tests were carried out:

1. Determination of particle size distribution of fine sand.
2. Standard Proctor Test (Proctor Compaction Test) for determining different dry densities for fine sand.
3. CBR Test to determine CBR value for fine sand and mix compositions with square pieces of plastic waste.
4. Permeability by Variable Head Permeability Test of fine sand and mix composition with square pieces of plastic waste.

**Table 2: Variables Investigated**

| S. No. | Effect of | Variables | Range Investigated |
|---|---|---|---|
| 1 | Moisture content in sand | Dry density | 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc |
| 2 | square pieces of plastic waste on different properties of sand | Square size | Plastic are 5mm square size |
| 3 | Mix square pieces of plastic waste by dry weight of sand | Proportion percentage | 0.15%, 0.25%, 0.50%, 0.75% and 1% |

### 3.1.1 Particle Size Distribution or Gradation Test of Fine Sand

The particle size distribution test or gradation test was carried out with Indian Standard Sieve size 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 425 µ, 300 µ, 150µ, 75µ, pan and weigh balance in the laboratory.

A typical sieve analysis involves a nested column of sieve with wire mesh cloth (screen). A representative sample of 1000 gm is poured into the top sieve which has the largest screen opening of 4.75 mm. Each lower sieve in the column has smaller opening than the one above. The base is a round pan, called the receiver. The sample was shaken vigorously for 10 minutes on sieve shaker. After the shaking, the weight of material retained on each sieve was weighed. Percentage passing through each sieve was calculated and plotted against particle size. Since percentage passing 75 µ is within 1% only, hydrometer analysis was not done.

$$\text{Percentage (\%) Retained} = \frac{W_{sieve}}{W_{total}} \times 100\%$$

where $W_{sieve}$ is the weight of aggregate in the sieve in gm

$W_{total}$ is the total weight of the aggregate in gm

The cumulative percentage passing of the aggregate is found by subtracting the percent retained from 100%.
Percentage (%) Cumulative Passing = 100% - Percentage (%) Cumulative Retained
The results of particle size distribution have been shown in table 3, table 4 and figure 2.

**Table 3: Particle Size Distribution of Fine Sand**

| S.No. | Sieve Size | Weight Retained (gm) | % Weight Retained | Cumulative % Weight Retained | Cumulative % Weight Passing | % Finer |
|---|---|---|---|---|---|---|
| 1. | 4.75 mm | 2.0 | 0.2 | 0.2 | 99.8 | 99.8 |
| 2. | 2.36 mm | 2.0 | 0.2 | 0.4 | 99.6 | 99.6 |
| 3. | 1.18 mm | 2.0 | 0.2 | 0.6 | 99.4 | 99.4 |
| 4. | 600 µ | 1.0 | 0.1 | 0.7 | 99.3 | 99.3 |
| 5. | 425 µ | 2.0 | 0.2 | 0.9 | 99.1 | 99.1 |
| 6. | 300 µ | 2.0 | 0.2 | 1.1 | 98.9 | 98.9 |
| 7. | 150 µ | 904.0 | 90.4 | 91.5 | 8.5 | 8.5 |
| 8. | 75 µ | 82.0 | 8.2 | 99.7 | 0.3 | 0.3 |
| 9. | Pan | 3.0 | 0.3 | 100 | 0 | 0 |

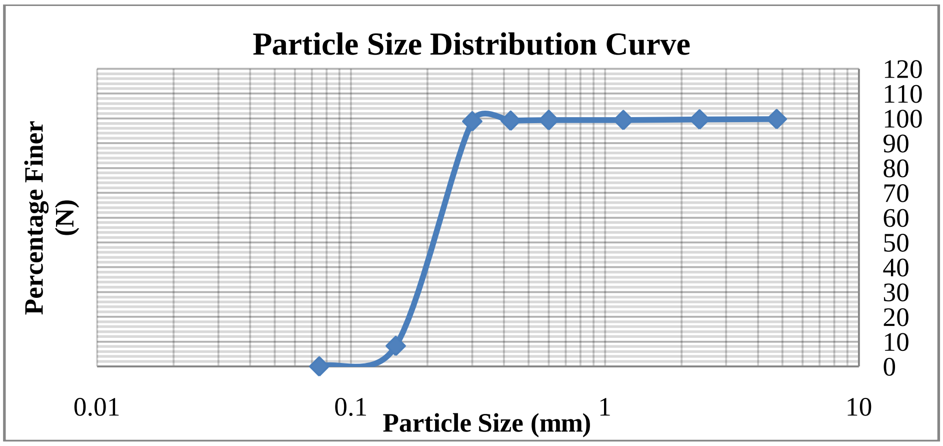


**Figure 2: Particle Size Distribution Curve**

**Table 4: Results of Particle Size Distribution**

| S. No. | Property | Test Media (Fine Sand) |
|---|---|---|
| 1. | Coefficient of Uniformity ($C_u$) | 1.31 |
| 2. | Coefficient of Curvature ($C_c$) | 1.08 |
| 3. | Mean Diameter ($D_{50}$) mm | 0.20 |
| 4. | Effective Size ($D_{10}$) mm | 0.16 |
| 5. | Fine Soil Fraction (75 µ) | 0.10% |

### 3.1.2 STANDARD PROCTOR TEST

Standard proctor covers the determination of the relationship between the moisture content and density of soils. The standard proctor test was performed in accordance with IS 2720 (Part VII) on fine sand. In this test, a standard mould of 100 mm internal diameter and an effective height of 127.3 mm, with a capacity of 1000 ml are used. The mould had a detachable base plate and a removable collar of 50 mm height at its top. The soil was compacted in the mould in 3 equal layers; each layer was given 25 blows of 2.6 kg rammer falling through a height of 310 mm.

The result represented in figure 3 shows that on increment of moisture content, dry density first decrease and then increase. In the curve dry density first decrease due to bulking of sand. After reaching maximum dry density on optimum moisture content, dry density again decreases. The variation of dry density with moisture content shows that the required dry densities 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc for the experiments occur at 4%, 12% and 18% moisture content.

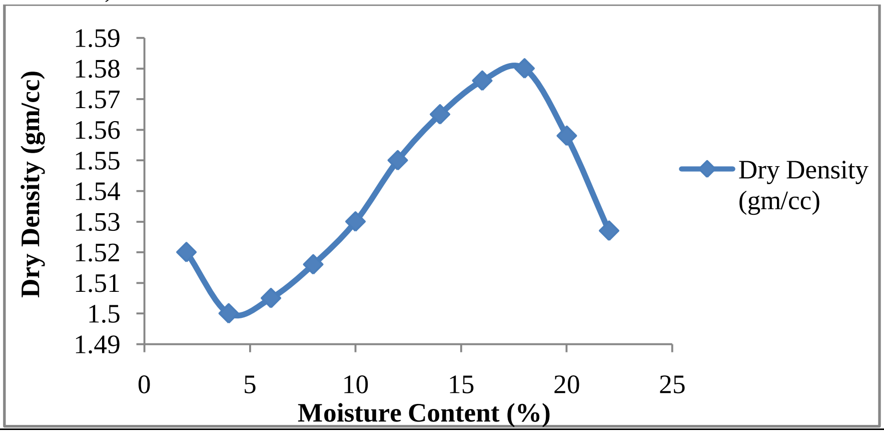


**Figure 3: Dry Density v/s Moisture Content Curve**

### 3.1.3 CALIFORNIA BEARING RATIO (C.B.R.) TEST

In CBR test, 5 kg of soil was taken and mixed with water corresponding to required dry density and proportion of square pieces of plastic waste. The mix was compacted in 2250 ml CBR (150 mm diameter and 127.3 mm height) using light compaction. The mix was compacted in three equal layers; each layer being given 56 uniformly distributed blows of 2.6 kg hammer. Top surface of the specimen was finished properly to make it for even loading test. For the soaked condition, the samples were tested for the determination of CBR values on the next day.

For obtaining the CBR values of unsoaked and soaked samples, penetration tests were done. The mould, containing the specimen was mounted on the testing machine and a surcharge weight equal to 5 kg (two spacer discs) was placed on the top of specimen before starting the penetration test. After setting the plunger on the surface of specimen, setting the load and penetration measuring dial gauge to read zero, the load was applied. Load readings at every 0.5 mm penetration were noted and a graph was drawn between the actual load (ordinate) and penetration (abscissa). In most of the tests the curve was either straight or convex upwards in the initial portion. In such cases the test load corresponding to 2.5 mm and 5.0 mm were read from the curve. In the case of the initial upward concavity, the corrected zero is obtained by drawing a tangent to the curve at the point of the greatest curvature. The corresponding to 2.5 mm and 5.0 mm penetration are measured from the corrected zero.

Test results obtained show that CBR value increases with increase in dry density of sand. The CBR value also increases with increase in percentage of square pieces of plastic waste for same dry density sand. The test results are shown in tables and graph.

#### 3.1.3.1 Comparative Study

The variation in CBR values have been tabulated and graphically represented in table 5, figure 4, for unsoaked condition and in table 6. and figure 5. for soaked condition. On the graph, at abscissa (X-axis) dry density of fine sand varying 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc has been marked and on ordinate (Y-axis) CBR values in % have been plotted for mix compositions of square pieces of plastic waste of different percentage 0%, 0.15%, 0.25%, 0.50%,0.75% and 1%.

It can be seen that on increment of dry density, the CBR value of the mix composition increases. The CBR value of the mix composition also increases as the percentage of admixture increases for both unsoaked and soaked conditions. Hence it can be concluded that to use the mix compositions in base and sub base construction, the CBR values can be increased or decreased as needed.

The variations in CBR values at 1.58 gm/cc dry density and different percentage of mix compositions also show that increase in CBR values is more at unsoaked condition than that compared with soaked condition.

**Table 5: CBR Value Variation in Mix Compositions in Unsoaked Conditions**

| Dry Density (gm/cc) | CBR (%) | | | | | |
|---|---|---|---|---|---|---|
| | Mix Composition | | | | | |
| | 0% Admixture | 0.15% Admixture | 0.25% Admixture | 0.50% Admixture | 0.75% Admixture | 1% Admixture |
| 1.51 | 2.384 | 2.86 | 2.623 | 3.099 | 6.437 | 6.286 |
| 1.54 | 2.384 | 2.861 | 3.099 | 3.338 | 7.153 | 7.868 |
| 1.58 | 3.815 | 4.292 | 4.386 | 4.53 | 7.51 | 8.226 |

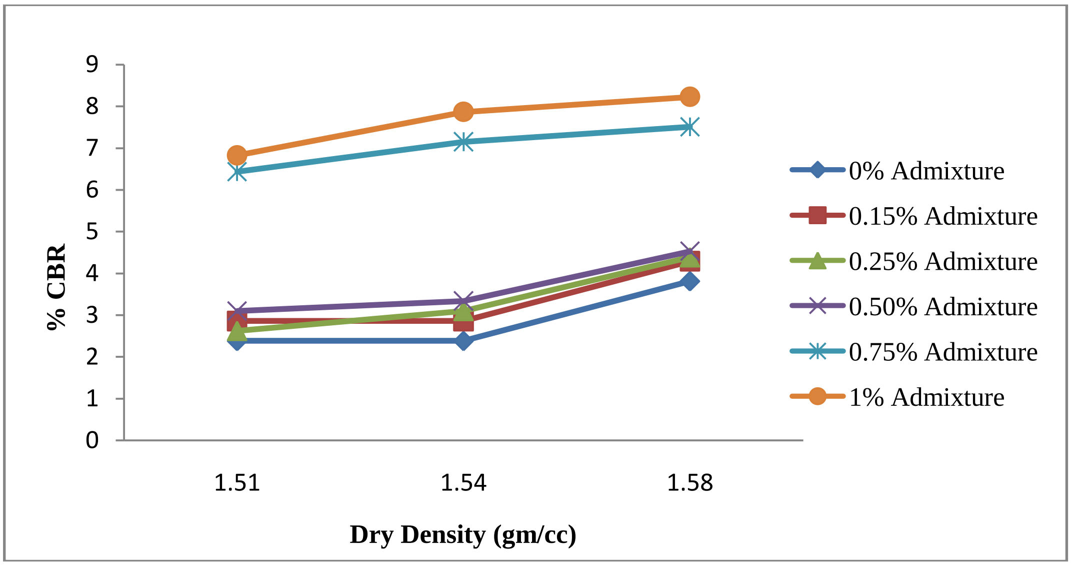


**Figure 4: CBR Value Variation in Mix Compositions in Unsoaked Conditions**

**Table 6: CBR Value Variation in Mix Compositions in Soaked Conditions**

| S.No. | Mix Composition | CBR (%) |
|---|---|---|
| 1. | 1.58 gm/cc dry density sand mixed with 0% Admixture | 1.07 |
| 2. | 1.58 gm/cc dry density sand mixed with 0.15% Admixture | 1.43 |
| 3. | 1.58 gm/cc dry density sand mixed with 0.25% Admixture | 1.67 |
| 4. | 1.58 gm/cc dry density sand mixed with 0.50% Admixture | 1.92 |
| 5. | 1.58 gm/cc dry density sand mixed with 0.75% Admixture | 1.92 |
| 6. | 1.58 gm/cc dry density sand mixed with 1% Admixture | 2.38 |

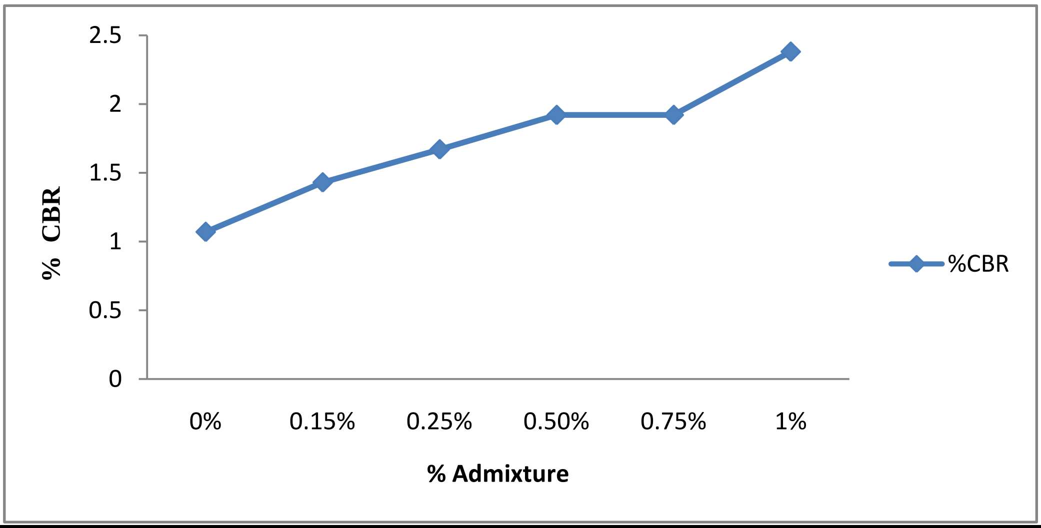


**Figure 5: CBR Value Variation in Mix Composition in Soaked Conditions**

### 3.1.4 Variable Head Permeability Test

Permeability is the measure of the ease with which water can flow through a soil sample. The tests were conducted in variable head permeameter according to IS 2720 (Part XVII). Test investigations were carried out on variable head permeameter with mix compositions of 1.58 gm/cc dry density fine sand and square pieces of plastic waste in varying percentages of 0.15%, 0.25%, 0.50%, 0.75% and 1%.

A conclusion from the test results obtained that coefficient of permeability (k) increases with increase in percentage of square pieces of plastic waste.

**Table 7: Variation of Coefficient of Permeability k (cm/sec) with Mix Composition**

| S.No. | Percentage (%) Admixture | Coefficient of Permeability (cm/sec) |
|---|---|---|
| 1. | 0.15% | $1.51 \times 10^{-3}$ |
| 2. | 0.25% | $1.57 \times 10^{-3}$ |
| 3. | 0.50% | $1.76 \times 10^{-3}$ |
| 4. | 0.75% | $1.86 \times 10^{-3}$ |
| 5. | 1% | $2.04 \times 10^{-3}$ |

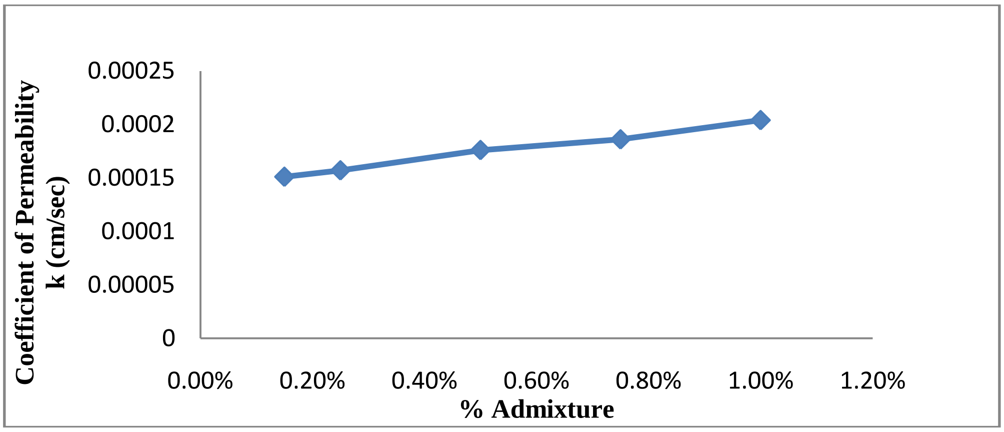


**Figure 6: Variation of Coefficient of Permeability k (cm/sec) with Mix Composition**

## IV. CONCLUSIONS

In this investigation we have used square pieces of plastic waste in different proportions to study its effect on various geotechnical properties of fine sand of Western Rajasthan. The results of the testing program clearly show that the engineering properties of the fine sand improved considerably due to stabilizing with square pieces of plastic waste. In the present investigation, as we are increasing the quantity of admixture of square pieces of plastic waste, the CBR value increases. So we have stopped the further increment of admixture. Further study can be done by addition of more amount of admixture.

***A few generalized conclusions are summarized below:***

1. CBR tests were performed on mix compositions of fine sand and square pieces of plastic waste as admixture. square pieces of plastic waste of varying percentage 0.15%, 0.25%, 0.50%, 0.75%, and 1% were mixed with fine sand of different densities 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc. A linear increment was observed in CBR values in both unsoaked and soaked conditions. For unsoaked condition, CBR values are greater than that of soaked condition for same dry density of sand and same quantity of admixture. As the CBR value is increasing, the required thickness for flexible pavement is reduced.
2. Permeability Tests were performed for mix composition of 0.15%, 0.25%, 0.50%, 0.75% and 1% of ceramic tile waste and fine sand of 1.58 gm/cc dry density. The coefficient of Permeability k (cm/sec) increases with increase in the percentage of square pieces of plastic waste mixed to fine sand. Greater the percentage of square pieces of plastic waste more was the mix composition permeable. Hence, the impermeable material should be used in the mix composition to reduce the permeability.
3. After this experimental investigation we conclude that square pieces of plastic waste can successfully be used as admixture for fine sand stabilization. So the waste plastic can be used as a admixture in soil stabilization for the design purpose of flexible pavement in road construction.

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