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# Utilization of Light Weight Concrete to Mitigate Soil Settlement.

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**ABSTRACT**

Lightweight concrete, developed in the 1920s, has revolutionized construction by reducing density while maintaining strength. Unlike conventional concrete, it minimizes foundation loads, improving efficiency and sustainability. It incorporates lightweight aggregates like pumice, expanded clay, and expanded polystyrene (EPS) beads. EPS beads significantly lower weight while enhancing thermal insulation, reducing energy consumption in buildings. A major advantage of lightweight concrete is its role in mitigating soil settlement, especially in weak soils like black cotton soil. By reducing self-weight, it minimizes stress on the soil, preventing foundation failure. This ensures safer, more resilient structures in settlement-prone areas. Additionally, EPS-based lightweight concrete supports sustainability by using recycled materials and reducing the carbon footprint. Its cost-effectiveness and construction efficiency make it ideal for weight-sensitive applications. Addressing structural and geotechnical challenges, lightweight concrete ensures durable and stable buildings across diverse conditions.

Keywords: Lightweight concrete, Structural efficiency, Sustainability, EPS beads, Thermal insulation, Soil settlement mitigation, Black cotton soil, Foundation stability, Recycled materials, Carbon footprint reduction, Construction efficiency, Geotechnical applications, Differential settlement, Energy-efficient buildings, Low-density aggregates

## 1 INTRODUCTION

### *1.1 Introduction of Lightweight Concrete*

Lightweight concrete (LWC) refers to structural concrete with a lower density compared to conventional concrete, typically ranging from 1440 to 1840 kg/m³, whereas normal-weight concrete has a density between 2240 to 2400 kg/m³. LWC blocks are an essential addition to masonry units and have seen significant advancements since their early development in the 1920s. This innovative concrete utilizes lightweight aggregates such as pumice, expanded clay, and expanded polystyrene (EPS) beads, reducing density while maintaining structural integrity.

Soil settlement is a common issue in construction, occurring when underlying soil compresses under structural loads, potentially leading to uneven settlement and damage. One effective solution is the use of lightweight concrete, which reduces the load on the soil while preserving structural stability.

LWC is produced by incorporating lightweight aggregates like EPS, expanded clay, or perlite, significantly reducing density compared to traditional concrete. This lower weight exerts less pressure on the soil, thereby minimizing settlement risks. Additionally, LWC enhances insulation, speeds up construction, and is widely used in urban and high-rise projects.

By integrating lightweight concrete in foundations, pavements, and embankments, engineers can mitigate soil settlement, increase structural durability, and support sustainable construction by reducing material consumption and energy use. As urbanization progresses, the role of LWC in addressing soil settlement will become increasingly critical.

### *1.1.1 Future of Lightweight Concrete (LWC)*

1. Growing demand due to urbanization and sustainable construction trends.
2. Advancements in material science leading to stronger and more durable LWC mixtures.
3. Increased use of recycled materials such as EPS beads and industrial by-products.
4. Key role in smart city projects and energy-efficient buildings.

5. Preferred for earthquake-resistant structures due to its lower mass and improved ductility.
6. Research on self-healing and Nano-modified LWC for enhanced longevity.
7. Increasing adoption in major infrastructure projects like bridges, high-rises, and transportation systems.

### *1.1.2 Scope of Lightweight Concrete (LWC)*

1. Widely used in precast construction, reducing transportation and installation costs.
2. Gaining popularity for thermal and sound insulation applications.
3. Potential applications in aviation and marine industries for lightweight components.
4. Expansion in earthquake-prone areas due to lower seismic loads.
5. Driving demand in sustainable construction initiatives for eco-friendly materials.
6. Applications in retrofitting and rehabilitation of aging structures.
7. Growing role in 3D printing and modular construction for innovative building solutions.

### *1.1.3 Applications of Lightweight Concrete Construction*

- Residential & Commercial Buildings: Used in floors, walls, and roofs to reduce weight.
- High-Rise Structures: Reduces structural load in multi-story buildings.
- Bridges, Decks & Piers: Lightweight materials enhance bridge decks and structural supports.
- Precast Constructions: Used for wall panels, floors, beams, and roof slabs.

Thermal Insulation

- Insulating Concrete: Used in walls, floors, and foundations for improved energy efficiency.
- Heat-Resistant Ceramic Tiles: Lightweight concrete is used to manufacture heat-resistant tiles.
- Heat-Insulated Light Wall Panels: Reduces thermal conductivity, improving insulation in buildings.

Geotechnical Engineering

- Lightweight Road Bases & Fills: Reduces soil settlement in roads and highways.
- Bridge Approach Embankments: Lightweight concrete enhances embankment stability.
- Foundation Fills: Reduces structural load on weak or expansive soils.

### *1.2 Composition of Lightweight Concrete*

LWC consists of a cement binder, water, and lightweight aggregates (LWA) such as expanded clay, pumice, or perlite. The key components include:

1. Lightweight Aggregate (LWA): Materials like expanded clay, shale, pumice, and fly ash.
2. Portland Cement: The primary binding agent ensuring strength and stability.
3. Sand: Fine aggregate, sometimes replaced with lightweight alternatives.
4. Water: Essential for hydration and strength development.

### *1.3 Examples of Using Lightweight Concrete*

A common application of lightweight concrete is in the construction of high-rise buildings, floors, and roofs, where reducing dead load is essential. It is also used in bridge spans, retrofitting old structures, and adding floors to existing buildings without overloading foundations.

### *1.4 Advantages of Lightweight Concrete*

1. Easier Handling: Lower weight simplifies transportation and construction.
2. Lower Structural Load: Reduces dead weight, leading to cost savings on foundations and supports.

3. Better Thermal Insulation: Air pockets enhance energy efficiency in buildings.
4. Reduced Transportation Costs: Lighter weight results in lower logistics expenses.
5. Improved Fire Resistance: Higher resistance due to the presence of air voids.

### *1.5 Environmental Impact of Lightweight Concrete*

LWC is considered a sustainable material due to:

- Reduced raw material consumption and lower carbon footprint.
- Use of EPS beads and recycled aggregates to promote a circular economy.
- Enhanced energy efficiency, reducing long-term environmental impact.

### *1.6 Economic Benefits of Lightweight Concrete*

1. Lower Construction Costs: Reduces need for heavy reinforcement and deep foundations.
2. Reduced Maintenance Costs: Improved durability lowers long-term repair expenses.
3. Faster Construction: Easier handling speeds up project timelines, reducing labor costs.

### *1.7 Challenges and Limitations of Lightweight Concrete*

Despite its advantages, LWC faces challenges:

- Lower Compressive Strength: Requires optimized mix design for improved performance.
- Higher Water Absorption: Some LWAs are more porous, necessitating additional waterproofing measures.
- Cost of LWAs: Lightweight aggregates can be expensive, depending on availability and production costs.

### *1.8 Innovations in Lightweight Concrete*

Recent research focuses on enhancing LWC with cutting-edge technologies:

- Self-Healing LWC: Utilizes bacteria-based healing to repair cracks automatically.
- Aerogel-Based LWC: Incorporates aerogels for superior thermal insulation.
- Graphene-Enhanced LWC: Improves strength, durability, and thermal properties through nanotechnology

## OBJECTIVES OF THE STUDY

The primary objectives of this study on lightweight concrete (LWC) are:

1. To analyze the effectiveness of lightweight concrete in reducing structural loads while maintaining adequate strength for construction applications.
2. To evaluate the role of EPS beads as a partial replacement for coarse aggregates in improving the properties of lightweight concrete.
3. To assess the impact of lightweight concrete on soil settlement, especially in weak and expansive soils like black cotton soil.
4. To compare settlement behavior of structures built with lightweight concrete against those using conventional M20 concrete.
5. To determine the compressive strength and density variations of concrete with different EPS replacement percentages (15%, 20%, and 25%).
6. To explore the economic and environmental benefits of using lightweight concrete in construction projects.
7. To study the feasibility of using LWC in different construction applications, including high-rise buildings, bridges, road bases, and embankments.
8. To investigate the long-term durability and sustainability of EPS-modified concrete in structural applications.
9. To propose lightweight concrete as a viable alternative for mitigating soil settlement issues in areas prone to differential settlement.
10. To contribute to sustainable construction practices by reducing material consumption and promoting energy efficiency.

## 2. REVIEW OF LITERATURE

Lightweight concrete (LWC) has been extensively studied due to its low density, reduced structural load, and improved thermal insulation properties. Researchers have explored various lightweight aggregates, such as expanded polystyrene (EPS) beads, pumice, and expanded clay, to determine their influence on concrete performance. Several studies highlight the potential of LWC in mitigating soil settlement, making it a viable solution for construction on weak and expansive soils.

### *2.1 Effect of EPS Beads on Concrete Properties*

A study by Alicia San-Antonic-Gonzalez et al. (2015) examined the use of EPS waste in lightweight concrete and found that while EPS improves thermal insulation and reduces density, it may lead to reduced mechanical strength. However, the addition of reinforcement materials like latex and plasticizers improved overall strength and workability. Similarly, Deng and Yang Xiao (2010) conducted triaxial compression tests on EPS-sand mixtures, revealing that higher EPS content decreased shear strength but enhanced volumetric strain, making it suitable for specific geotechnical applications.

### *2.2 Mechanical Behavior and Structural Performance of LWC*

Research by Fang Peng-Fei et al. (2012) explored the static and dynamic properties of EPS-based lightweight concrete. Their findings indicate that EPS-modified concrete exhibits lower compressive strength than conventional concrete but performs well under cyclic loading conditions, making it suitable for road embankments and foundation applications. Additionally, Changi Wang and David Arellano (2014) compared the mechanical properties of recycled EPS geofoam with non-recycled EPS, demonstrating that recycled EPS meets engineering standards and can be used in infrastructure projects, reducing polystyrene waste.

### *2.3 Soil Settlement Mitigation Using Lightweight Concrete*

Several studies emphasize the role of lightweight concrete in reducing soil settlement. R.K. Yadav et al. (2019) found that LWC can reduce soil settlement by up to 50%, making it an effective solution for mitigating differential settlement in weak soils. Another study by J. Liu et al. (2020) reviewed experimental and numerical analyses on LWC for soil stabilization, confirming its potential in foundation design, road bases, and embankments.

## 3. MATERIALS TO STUDY

The materials used in this study on lightweight concrete (LWC) with EPS beads are carefully selected to achieve the desired balance of strength, durability, and reduced density. The primary materials studied include:

1. Cement

- Type: Ordinary Portland Cement (OPC) 43 grade.
- Purpose: Acts as a binding agent, providing strength and cohesion to the concrete mix.
- Properties: Compressive strength, setting time, and durability are key factors evaluated.

2. Fine Aggregate (Sand)

- Type: Natural river sand (Zone II as per IS 383:2016).
- Purpose: Enhances workability and contributes to the overall strength of the mix.
- Tests Conducted: Specific gravity, water absorption, and sieve analysis.

3. Coarse Aggregate

- Type: Crushed stone with sizes ranging from 10mm to 20mm.
- Purpose: Provides structural stability and improves load-bearing capacity.
- Tests Conducted: Specific gravity, impact value, and water absorption.

4. Expanded Polystyrene (EPS) Beads

- Type: Pre-expanded, lightweight, and closed-cell EPS beads.
- Purpose: Replaces a portion of coarse aggregate to reduce concrete density and improve insulation.
- Tests Conducted: Density, water absorption, and gradation analysis.

5. Water

- Type: Potable water free from impurities.
- Purpose: Essential for the hydration of cement and the chemical reaction required for strength development

## 4. TESTS ON BLACK COTTON SOIL

Black cotton soil (BC soil) is a highly expansive clayey soil known for its high shrink-swell potential, which makes it problematic for construction. To assess its properties and suitability for foundation work, several tests are conducted:

1. Particle Size Analysis (Sieve & Hydrometer Test)

- Purpose: Determines the grain size distribution of soil.
- Method:
  - o Sieve analysis is used for coarse-grained fractions.
  - o Hydrometer analysis is used for fine-grained fractions (clay and silt).
- Significance: Helps classify soil as sand, silt, or clay based on IS 2720 (Part 4).

2. Atterberg's Limits (Consistency Limits)

These tests determine the moisture levels at which the soil changes its consistency:

a) Liquid Limit Test

- Purpose: Defines the water content at which soil changes from plastic to liquid state.
- Method: Conducted using the Casagrande apparatus.
- Significance: Higher liquid limit indicates high plasticity and expansive nature.

b) Plastic Limit Test

- Purpose: Determines the minimum water content at which soil remains plastic.
- Method: Soil is rolled into threads until they break at 3mm diameter.
- Significance: Helps in assessing the plasticity index (PI) (PI = LL - PL), which indicates the soil's swelling potential.

c) Shrinkage Limit Test

- Purpose: Determines the lowest water content at which soil does not shrink further.
- Significance: Helps in understanding the volume change behavior of BC soil.

3. Specific Gravity Test

- Purpose: Determines the density of soil particles.
- Method: Conducted using a pycnometer.
- Significance: Helps in soil classification and strength assessment.

4. Proctor Compaction Test (Standard & Modified Proctor Test)

- Purpose: Determines the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of soil.
- Method: Soil is compacted in layers using a rammer and dry density is plotted against moisture content.
- Significance: Helps in evaluating soil's load-bearing capacity and compaction characteristics.

5. California Bearing Ratio (CBR) Test

- Purpose: Measures the strength and load-bearing capacity of soil.
- Method: A plunger is pressed into the soil sample at a uniform rate and penetration resistance is measured.
- Significance: Essential for designing pavement thickness and foundation stability.

6. Unconfined Compressive Strength (UCS) Test

- Purpose: Measures the compressive strength of soil without lateral confinement.
- Method: A cylindrical soil sample is compressed until failure.
- Significance: Helps determine soil stability and suitability for construction.

7. Swelling Pressure Test

- Purpose: Determines the expansive nature of black cotton soil when exposed to moisture.
- Method: Soil is placed in an oedometer and swell pressure is recorded.
- Significance: Helps in designing foundation systems resistant to heaving and settlement.

## 4. EXPERIMENTAL SETUP

Gradation Requirements

Graduation requirements for lime stabilized base and sub-base courses are presented as:

| Type Course | Sieve Size | Percent Passing |
|---|---|---|
| Base | 1½ in. | 100 |
| | ¾ in. | 70-100 |
| | No. 4 | 45-70 |
| | No. 40 | 10-40 |
| | No. 200 | 0-20 |
| Subbase | 1½ in. | 100 |
| | No. 4 | 45-100 |
| | No. 40 | 10-50 |
| | No. 200 | 0-20 |

Table Gradation Requiremen

## *4.1 RESULTS & DISCUSSION*

### 4.1 Particle Size Analysis

#### 4.1.1 Dry Sieve Analysis with 0 % lime content

##### 4.1.1.1 Observation Table

RESULT OF TEST-1

| S.N. | IS Sieve | Particle size D (mm) | Mass retained (g) | % retained | Cumulative % retained | Cumulative % finer (N) |
|---|---|---|---|---|---|---|
| 1 | 4.75 mm | 4.750 mm | 41.70 | 10.43 | 10.43 | 89.58 |
| 2 | 2.36 mm | 2.360 mm | 55.61 | 13.90 | 24.33 | 75.67 |
| 3 | 1.78 mm | 1.780 mm | 53.30 | 13.33 | 37.65 | 62.35 |
| 4 | 1.18 mm | 1.180 mm | 51.60 | 12.90 | 50.55 | 49.45 |
| 5 | 600 micron | 0.600 mm | 68.60 | 17.15 | 67.70 | 32.30 |
| 6 | 300 micron | 0.300 mm | 61.60 | 15.40 | 83.10 | 16.90 |
| 7 | 150 micron | 0.150 mm | 41.80 | 10.45 | 93.55 | 6.45 |
| 8 | 90 micron | 0.090 mm | 3.00 | 0.75 | 94.30 | 5.70 |
| 9 | 75 micron | 0.075 mm | 4.40 | 1.10 | 95.40 | 4.60 |
| 10 | pan | | 18.39 | 4.60 | 100.00 | 0.00 |

RESULT OF TEST-2

| S.N. | IS Sieve | Particle size D (mm) | Mass retained (g) | % retained | Cumulative % retained | Cumulative % finer (N) |
|---|---|---|---|---|---|---|
| 1 | 4.75 mm | 4.750 mm | 43.00 | 10.75 | 10.75 | 89.25 |
| 2 | 2.36 mm | 2.360 mm | 49.70 | 12.43 | 23.18 | 76.83 |
| 3 | 1.78 mm | 1.780 mm | 59.60 | 14.90 | 38.08 | 61.93 |
| 4 | 1.18 mm | 1.180 mm | 53.70 | 13.43 | 51.50 | 48.50 |
| 5 | 600 micron | 0.600 mm | 67.00 | 16.75 | 68.25 | 31.75 |
| 6 | 300 micron | 0.300 mm | 60.80 | 15.20 | 83.45 | 16.55 |
| 7 | 150 micron | 0.150 mm | 41.00 | 10.25 | 93.70 | 6.30 |
| 8 | 90 micron | 0.090 mm | 3.40 | 0.85 | 94.55 | 5.45 |
| 9 | 75 micron | 0.075 mm | 5.30 | 1.33 | 95.88 | 4.13 |
| 10 | pan | | 16.50 | 4.13 | 100.00 | 0.00 |

RESULT OF TEST-3

| S.N. | IS Sieve | Particle size D (mm) | Mass retained (g) | % retained | Cumulative % retained | Cumulative % finer (N) |
|---|---|---|---|---|---|---|
| 1 | 4.75 mm | 4.750 mm | 40.20 | 10.05 | 10.05 | 89.95 |
| 2 | 2.36 mm | 2.360 mm | 60.40 | 15.10 | 25.15 | 74.85 |
| 3 | 1.78 mm | 1.780 mm | 54.70 | 13.68 | 38.83 | 61.18 |
| 4 | 1.18 mm | 1.180 mm | 50.40 | 12.60 | 51.43 | 48.58 |
| 5 | 600 micron | 0.600 mm | 65.20 | 16.30 | 67.73 | 32.28 |
| 6 | 300 micron | 0.300 mm | 57.30 | 14.33 | 82.05 | 17.95 |
| 7 | 150 micron | 0.150 mm | 40.30 | 10.08 | 92.13 | 7.87 |
| 8 | 90 micron | 0.090 mm | 3.10 | 0.78 | 92.90 | 7.10 |
| 9 | 75 micron | 0.075 mm | 7.90 | 1.98 | 94.88 | 5.12 |
| 10 | pan | | 20.50 | 5.13 | 100.00 | 0.00 |

AVERAGE OF TEST

| TEST -1 | TEST-2 | TEST-3 | AVERAGE |
|---|---|---|---|
| Cumulative % finer (N) | Cumulative % finer (N) | Cumulative % finer (N) | Cumulative % finer (N) |
| 89.58 | 89.25 | 89.95 | 89.59 |
| 75.67 | 76.83 | 74.85 | 75.78 |
| 62.35 | 61.93 | 61.18 | 61.82 |
| 49.45 | 48.50 | 48.58 | 48.84 |
| 32.30 | 31.75 | 32.28 | 32.11 |
| 16.90 | 16.55 | 17.95 | 17.13 |
| 6.45 | 6.30 | 7.87 | 6.87 |
| 5.70 | 5.45 | 7.10 | 6.08 |
| 4.60 | 4.13 | 5.12 | 4.62 |
| 0.00 | 0.00 | 0.00 | 0.00 |

Table 4.1 Dry Sieve Analysis

**RESULT:-**

From the curve calculate uniformity coefficient (Cu) and coefficient of curvature (Cc).

Uniformity coefficient (Cu):-

$$Cu = \frac{D60}{D10} = \frac{1.8}{0.2} = 9 \ (5\text{-}15)$$

From the graph and IS code soil is Medium graded soil

Coefficient of curvature (Cc):-

$$Cc = \frac{(D30)2}{D10 * D60} = \frac{(0.55)2}{0.2 * 1.8} = 0.84$$

From the graph and IS code soil is poorly graded soil

***4.2 Hydrometer Test***

Observation table

| Size of particles (in mm) | % Finer |
|---|---|
| 0.043 | 80.3 |
| 0.0313 | 77.08 |
| 0.0227 | 73.876 |
| 0.0169 | 64.24 |
| 0.0119 | 54.604 |
| 0.0089 | 49.786 |
| 0.0063 | 44.968 |
| 0.0043 | 38.54 |
| 0.0033 | 32.12 |
| 0.0025 | 28.12 |
| 0.0012 | 25.03 |
| 0 | 0.00 |

Table 4.2 Hydrometer Analysis

Gradation Curve

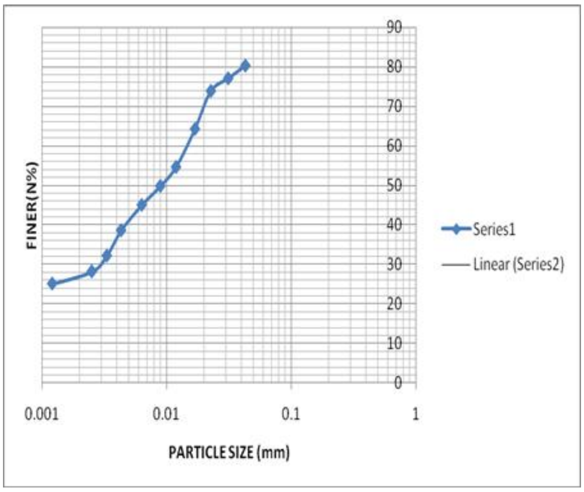



Fig 4.2 Hydrometer Analysis

***4.3 Liquid Limit***

Observation Table

| NO OF BLOWS | WATER CONTENT (%) |
| --- | --- |
| 28 | 53.80 |
| 33 | 51 |
| 24 | 59.88 |

Table 4.3 liquid limit with 0% lime content

***4.3.1 Flow Curve***

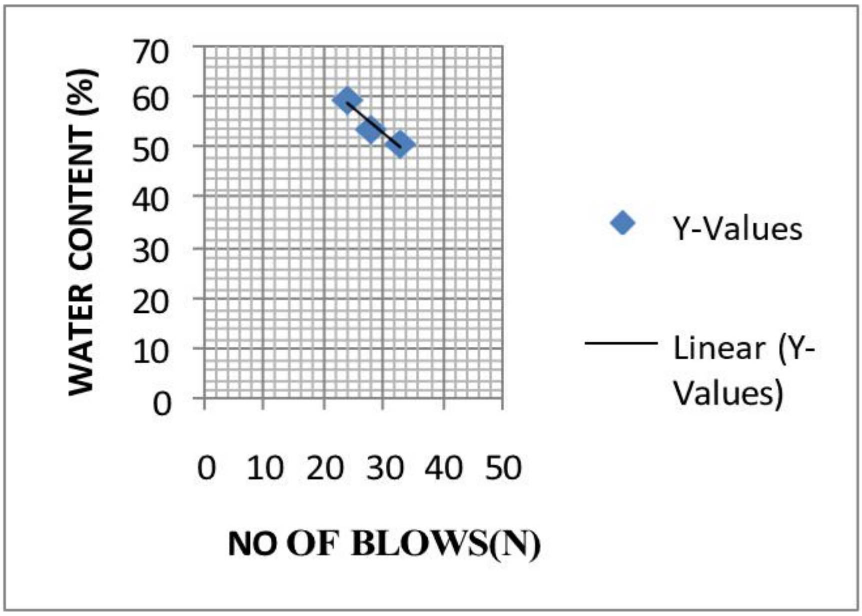



Figure 4.3.2 Graph for Liquid Limit with 0% lime content

***4.4 Plastic Limit***

Observation Table

| Container No. | 1 | 2 | 3 |
|---|---|---|---|
| Wt. of container , W1 (gm) | 8.8 | 8.5 | 8.2 |
| Wt. of container+ wet soil sample,W2(gm) | 15.3 | 14.4 | 15.5 |
| Wt. of container+ dry oil sample,W3(gm) | 13.5 | 12.7 | 13.1 |
| Water content (%)={(W2-W3)/(W3- W1)}*100 | 28.2 | 23.61 | 32 |
| PLASTIC LIMIT (MEAN VALUE, %) = 28% | | | |

Table 4.4 Plastic limit with 0% lime content

### *4.4.1 Plasticity index (Ip) :*

$I_P = W_L - W_P = 58 - 28 = 30$

So soil is a high plasticity clay.

It is also determine from the IS plasticity chart.

As per the plasticity chart we obtained that the soil is above A- line and CH or OH group. So soil is highly clay or high plasticity

Liquid limit is = 58% PLASTIC LIMIT = 28%

Plasticity index= 30

### *4.4.2 Liquidity index ($I_L$):-*

LI = (W-PL)/(LL-PL) = (35-28)/(58-28)

= 24%

4.2.1.1 Activity of soil (A):- A=Ip/F =28/6

= 4.66 >4

So it means soil is highly active clay soil.

**CONCLUSION:-**

As per the Atterberg‟s limit we determined the liquid limit , plastic limit , plasticity index , activity of soil.We get the value of that by the experiments and which is prosperity of the black cotton soil. Due to those properties soil is highly clay and highly plasticity. So we cannot construct any structure or pavement design and need to stabilization. So we stabilized that soil by lime, sisal fibre or sand. So we need to improve the black cotton soil by various methods.

### *4.5 CBR Test*

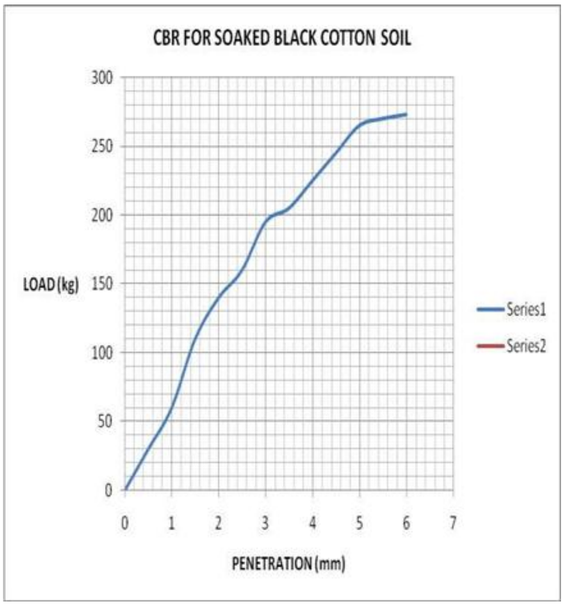
Observation Table

| Penetration (in mm) | Load (in kg) |
|---|---|
| 0 | 0 |
| 0.5 | 30 |
| 1 | 60 |
| 1.5 | 110 |
| 2 | 140 |
| 2.5 | 160 |
| 3 | 195 |
| 3.5 | 205 |

| | |
|---|---|
| 4 | 225 |
| 4.5 | 245 |
| 5 | 265 |
| 5.5 | 270 |
| 6 | 273 |

Table 4.5 CBR with 0% lime content

#### *4.5.1 CBR Graph*




RESULT:-

From laboratory test results we get value of C.B.R at different readings. for design of flexible pavement as per I.R.C 37-2001,value of C.B.R is very poor is less than 4%.

And the swelling pressure is 9 kg/cm2.

The experimental values for black cotton soil were taken from the journal "Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using Lime**."** Various tests, including Atterberg's limits, CBR, UCS, and swelling pressure**,** were conducted to assess soil behavior. The results helped evaluate the expansive nature and load-bearing capacity of BC soil. These findings were crucial in analyzing the effectiveness of lightweight concrete in mitigating soil settlement**.**

## 5. COMPRESSIVE STRENGTH OF LIGHTWEIGHT CONCRETE

The compressive strength test was conducted to evaluate the structural performance of lightweight concrete (LWC) with varying EPS bead replacements (15%, 20%, and 25%) for coarse aggregates. The tests were performed at 7, 14, and 28 days to observe strength development over time.

1. Nominal M20 Concrete:
   - Achieved an average compressive strength of 27.33 MPa at 28 days, meeting the target strength requirements.
2. Lightweight Concrete with EPS Bead Replacement:
   - 15% EPS replacement**:** Strength at 28 days was 26.8 MPa**,** slightly lower than nominal M20.
   - 20% EPS replacement**:** Strength reduced to 26.98 MPa**,** showing a balance between weight reduction and strength retention.
   - 25% EPS replacement: Strength dropped further to 26.27 MPa, indicating a trade-off between density reduction and load-bearing capacity.

The results confirmed that while replacing coarse aggregate with EPS beads reduces density, the compressive strength remains within an acceptable range for low to medium-load structural applications

## 6. SETTLEMENT CALCULATION

Settlement calculations were performed to compare the effects of nominal M20 concrete and lightweight concrete (LWC) with 25% EPS bead replacement on black cotton soil (CBR = 4%). A single-room building (3m × 3m × 3m) was considered for analysis.

**1. Settlement for Nominal M20 Concrete:**

- Total Load on Soil: 216.8 kN
- Applied Contact Pressure: 54.2 kN/m²
- Final Settlement (Terzaghi's Consolidation Formula): 130 mm

**2. Settlement for LWC (25% EPS Replacement):**

- Total Load on Soil: 179.0 kN (due to reduced concrete density)
- Applied Contact Pressure: 44.75 kN/m²
- Final Settlement: 115 mm

**Conclusion:**

The LWC structure exhibited lower settlement (115 mm) compared to nominal M20 concrete (130 mm), confirming that reducing structural weight helps mitigate soil settlement. This highlights the effectiveness of lightweight concrete in weak soil conditions like black cotton soil.

## 7. CONCLUSION

Some clayey sand mixes with determined gradations, abundant in northern India, was his study evaluated the effectiveness of lightweight concrete (LWC) with EPS bead replacement in reducing soil settlement and maintaining structural strength. The experimental results confirmed that increasing EPS bead content reduces concrete density, leading to lower applied stress on the foundation soil.

Key findings include:

- Compressive strength decreased with higher EPS replacement, but remained within acceptable limits for structural applications.
- Settlement analysis showed that LWC (25% EPS replacement) reduced soil settlement from 130 mm (M20 concrete) to 115 mm, proving its effectiveness in weak soils like black cotton soil.

The use of EPS-based LWC promotes sustainable construction, reducing material consumption and enhancing energy efficiency.

Overall, lightweight concrete is a viable solution for mitigating soil settlement, offering both structural stability and environmental benefits, especially in expansive soil regions.

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