Critical Appreciation of Scientific Techniques for Assessment of Bricks made out of overburden mining waste

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Abstract-
Utilization of mine spoil for manufacture of constructional bricks will conserve precious soil used in making clay bricks. Mineral waste utilization as a construction material for making building bricks and blocks has already started in developed and developing countries. Utilization of mine spoil for constructional bricks and blocks will generate additional employment during and after mine operation. Waste rock utilization in coal mining area reduce environmental impact, more availability of land resource and reduction in mining cost, which occurs on the maintenance of mine spoil as reclamation, plantation, slope stability etc. The plantation will be more effective and cheap in plain land than unstable sloppy dumps. Utilization of mine spoil for manufacture of constructional bricks will also conserve precious soil used in making clay bricks.

Keyword: brick, Over Burden Dump, Mine, Waste, coal

Introduction-
India dominates the third position in the largest production of coal and has the fourth largest coal reserves approx. (197 Billion Tons). Overburden mine spoil is a byproduct and a mining waste. It is estimated that If only 60% of total overburden is utilized for making bricks, about 160524 million bricks may be constructed from 321 mm³ overburden per year. As mines are well dispersed in Andhra Pradesh, Assam, Chhattisgarh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Maharashtra, Orissa, West Bengal and Uttar Pradesh, there will be proper distribution of bricks made with overburden for building and other purposes. Utilization of mine spoil for manufacture of constructional bricks will also conserve precious soil used in making clay bricks.

Overburden is composed of mostly friable sandstone, a little shale, and fired clay and rarely conglomerate at few places. Textural analysis of overburden (sandstone) may divide mine-spoil as:

- coarse grain sandstone (> 5 mm grain size);
- medium grain sandstone (1-5 mm grain size);
- Fine grain sandstone (< 1 mm grain size).

Literature review:-

Mining waste includes overburden and waste rock excavated and mined form surface and underground operation. Waste rock is essentially wall rock material removed to access and mine ore. In coal mining, waste rocks are referred to as “spoils”.


Mining waste is heterogeneous geological material and may consist of sedimentary, metamorphic or igneous rock, soil and loose sediments. As a consequence, the particle sizes ranges from the clay size particles to boulder size fragments. The physical and chemical characteristic of mining waste vary according to their mineralogy and geochemistry, type of mining equipment, particle size of the mined material, and moisture content.

Utilization of mine spoil for constructional bricks and blocks will provide huge amount of employment during and after mine operation. Waste rock utilization in coal mining area reduce environmental impact, more availability of land resource and reduction in mining cost, which occurs on the maintenance of mine spoil as reclamation, plantation, slope stability etc.

Research methodology
Removal of impurities

Generally lots of impurities are present in overburden dump like lump of coal, rocks, particle of ore and fossil and chemicals impurities were also been found such as heavy metals etc. so while screening only those impurities were removed which can become barrier in making of bricks And those impurities are rocks and lumps of coal because they can create problem while casting of bricks these
impurities are removed by handing picking by spreading the ob dump all over the floor and then the rock and coal lumps were picked up by hands.

**Sieving of ob dump:** - After the screening of impurities the all the ob dump is thoroughly sieve with 4.75 mm (IS: 2720:1983) sieve in order to maintain evenness in the grain fines.

**Geotechnical Analysis of ob dump:** - Geotechnical property of the ob dump was analysed in the Geotechnical Laboratory by performing following test

- Specific Gravity
- Bulk Density
- Moisture Content
- Compaction
- Permeability
- Grain Size analysis
- Plastic Limit
- Shrinkage Limit

**Mixing of Water:** - After the geotechnical analysis Water is mixed in a ratio of 10% by weight and then thoroughly mixed with hands.

**Casting of Bricks:** - After mixing of water bricks are casted with the help of mould of standard size.

**Drying & burning of bricks:** - After the casting of bricks they are left in sun light for drying and when they get dry they are shifted to muffle furnace in order to burn them at a temperature at about 1100° C.

**Testing of suitability of Bricks:** - After the burning of bricks the testing for the suitability is to be done on them. The test performed on them are

- Compression Strength Test
- Water Absorption Test
- Efflorescence Test
- Impact Test
- Soundness Test
- Hardness Test
- Structure Test

**Obtaining of Results:** - After performing all the suitability test on bricks then results were obtained and on the basis of that results conclusion were made.

**Analysis**

Analysis of sample will be done in Geotechnical laboratory for Geotechnical parameter (IS: 2720:1983) by preparing the sample according to IS: 2720(part 1)-1983 and conducting the following test

a) **Specific gravity:**-
This test is done to determine the specific gravity of fine-grained Ob dump by density bottle method as per IS: 2720 (Part III/Sec 1) – 1980. Specific gravity is the ratio of the weight in air of a given volume of a material at a standard temperature to the weight in air of an equal volume of distilled water at the same stated temperature.

**Apparatus**
- Three density bottles of approximately 25ml capacity along with stoppers
- Weighing balance, with an accuracy of 0.001g
- Spatula

**Procedure:**
- The weight of empty density bottle along with stopper is taken \(W_1\).
- The weight of density bottle and Ob dump is taken \(W_2\).
- The distilled water is pour in the density bottle up to its neck and insert the stopper.
- Again the weight of Ob dump, water and density bottle is taken. \(W_3\).
- The density bottle is emptied, clean thoroughly and the density bottle is filled with distilled water.
- Again the density bottle is weighted. \(W_4\).
- At least two reading for such observations for the same sample is taken.

**Calculation**

\[
specific\ gravity = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}
\]

Where,

- \(W_1\) = Weight of empty specific gravity bottle
- \(W_2\) = Weight of bottle + bitumen
W3 = Weight of bottle + water

W4 = Weight of bottle + water + bitumen

b) **Bulk density**:

Soil bulk density is the mass of dry soil per unit of bulk volume, including the air space. Soil bulk density can vary substantially among different soil types and is affected by management practices. Incorporation of large amounts of organic matter into the soil will lower the bulk density, while processes that compact the soil will increase bulk density. It is done as per IS:2720 (part 2)-1973.

Apparatus required:
- Graduated cylinders.
- Balance.

Procedure:
- The weight of empty measuring cylinder is taken.
- The Ob dump sample is poured in the graduated cylinder and again weight is taken.
- The base of the cylinder is tapped; in such a way that Ob dump do not comes out of the cylinder.
- Reading off volume of sample in cc is taken.

Calculation:

\[ \text{Bulk density} = \frac{\text{mass (g)}}{\text{volume (cc)}} \]

- m = mass of sample in g
- V = volume of sample in cc

c) **Moisture content**

This method covers the laboratory determination of the moisture content of a soil as a percentage of its oven-dried weight. The method may be applied to fine, medium and coarse grained soils. The method is based on removing soil moisture by oven-drying a soil sample until the weight remains constant. The moisture content (%) is calculated from the sample weight before and after drying. It is analysed according to IS: 2720 (part 2)-1973.

Apparatus
- A hot air oven.
- A balance.
- Aluminium weighing tins with close fitting numbered lids.

Procedure
- Weigh is taken of clean and dry tin can along with lid (W1).
- A moist Ob dump sample was taken in the amount of 25 g.
- The Ob dump sample was poured in can and weight is taken (W2).
- The lid was tightly closed and was put in the hot air oven for 24 hours at a temperature of 105°C.
- The can was taken out of oven after 24 hours.
- Weigh of the tin and contents was taken (W3).
Calculations

Calculate the moisture content of the Ob dump as a percentage of the dry Ob dump weight.

\[
\text{Moisture content} = \frac{w_2 - w_3}{w_3 - w_1} \times 100
\]

- \( W_1 \) = Weight of can (g)
- \( W_2 \) = Weight of moist Ob dump + can (g)
- \( W_3 \) = Weight of dried Ob dump + can (g)

d) Compaction

Standard Proctor Compaction Testing can be performed in a lab. The testing first determines the maximum density achievable for the Ob dump and uses it as a reference for field testing. It also is effective for testing the effects of moisture on the soil's density. For soil with higher densities a Modified Proctor Compaction Test which uses higher values will be necessary. It was done as per IS: 2720(part 8)-1983

Apparatus
- Compaction mould.
- Rammer, mass 2.6 kg
- Detachable base plate
- Collar
- IS sieve, 4.75 mm
- Oven
- Weighing balance
- Large mixing pan
- Spatula
- Graduated cylinder.

**Procedure**
- A clean mould and the base plate is taken and was greased properly.
- The collar was attached to the mould and placed the mould on a base plate.
- About 2.5kg of the sieve Ob dump was taken and mixed 4% distilled water.
- Then Ob dump was placed in the mould in 3 equal layers. About one-third of quantity was taken first, and compacted it by giving 25 blows of the rammer.
- The top surface of the first layer was scratched with spatula before placing the second layer.
- The second layer was again compacted by 25 blows of rammer.
- Likewise, third layer was also placed and compacted it.
- Then the collar was removed and trims the excess sample.
- The Ob dump samples was taken out from the mould for the water content determination from the top, middle and bottom portions and then the water content is determine.
- The steps was repeated for 6% and 10% of water.

![Compaction mould](image)

**Calculation**

Calculate the moisture content of each layer of the Ob dump as a percentage of the dry sample weight.

\[
\text{Moisture content} = \frac{w_2 - w_3}{w_3 - w_1} \times 100
\]

- \(W_1\) = Weight of tin (g)
- \(W_2\) = Weight of moist Ob dump + tin (g)
- \(W_3\) = Weight of dried Ob dump + tin (g)

**e) Permeability**
In this test flow of water through a relatively short soil sample connected to a standpipe which provides the water head and also allows measuring the volume of water passing through the sample. The permeability of soil is also known as the falling head permeameter. The falling head permeameter is used to measure the permeability of relatively less pervious soils. Permeability is done by falling head method as per IS: 2720(part 17)-1986

Apparatus

- Permeability cell
- Burette Stand

Procedure:

- The collar of the mould was removed and all the measurement is taken including internal dimensions of the mould, Weigh the mould.

- A little grease was applied on the inside to the mould. The base plate and extension collar is clamped together and placed the assembly on a solid base.

- About 2.5 kg of the Ob dump sample was taken and about 6%, of water was thoroughly mixed and placed in the mould and then Ob dump is compacted.

- The filter paper was placed on the porous plate and then Ob dump sample was placed in the mould and then compacted and the filter paper was placed above the specimen and covered with porous plate and tighten properly.

- Then the water was poured in the burette and left for 24 hours for saturation.

- Stop cock is open at the top and allow the water to flow out till all the air in the mould is removed.

- The stop cock was closed and allow the water from the stand pipe to flow through the Ob dump specimen.

- The heights for permeability test of Ob dump was select, \( h_1 \) and \( h_2 \) and water was filled upto the height of \( h_1 \).

- The valve was open and start the stop watch to the record the time interval for the head to fall from \( h_1 \) to \( h_2 \)

- The above steps were repeated for four times after changing the heights \( h_1 \) and \( h_2 \).

- The flow of water was stopped. All the parts was disconnected.
The coefficient of permeability is given by

\[ k = \frac{2.3aL}{At} \log_{10} \left( \frac{h_1}{h_2} \right) \]

Where,
• $h_1 =$ initial head,
• $h_2 =$ final head,
• $t =$ time interval,
• $a =$ cross-sectional area of the liquid stand pipe,
• $A =$ cross-sectional area of the specimen,
• $L =$ length of specimen.

f) **Plastic limit**

The plastic limit of a soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm diameter. Plastic limit is done as per IS: 2720(part 5)-1958

**Equipment**
- Porcelain evaporating dish or a glass plate.
- Ground glass plate
- Metallic rod
- Oven
- Spatula or knife
- Moisture content can

**Procedure**
- About 30g of air dried Ob dump was taken and sieved through 425 micron and thoroughly mixed.
- Distilled water was mixed to the Ob dump in the evaporating disc and was made enough to shape into a small ball.
- About 8g of the Ob dump was taken from the ball and rolled with fingers on a glass plate till a thread was formed of 3mm diameter counting the stroke.
- It is rolled till the thread of 3mm breaks into smaller pieces.
- Pieces of broken thread was collected in the moisture content container.

**Calculation**

$$Plastic\ limit = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

- $W_1 =$ Weight of tin (g)
- $W_2 =$ Weight of moist Ob dump + tin (g)
- $W_3 =$ Weight of dried Ob dump + tin (g)

**g) Shrinkage limit**

The shrinkage limit is the water content of the soil when the water is just sufficient to fill all the pores of the soil and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the shrinkage limit. Shrinkage limit is done as per IS: 2720(part 5)-1958

**Apparatus**
- Shrinkage dish having flat bottom.
- Two large evaporating dishes with flat bottom.
- One small mercury dish.
- Two glass plate.
- Glass cup.
- IS sieve 425 micron
- Hot air oven.
- Weighing balance.
- Spatula
- Mercury

Procedure
- About 100g of sample was taken and sieved through 425 micron sieve.
- About 30g of sample was taken in evaporating dish and distilled water was mixed in it and makes it a creamy paste.
- Mass of shrinkage dish was taken and mercury was filled in it and excess mercury was removed by pressing the glass plate over its top and mass was taken.
- The inside of the shrinkage dish was put with a layer of grease. The Ob dump specimen is placed in the centre of the shrinkage dish about one-third the volume of the shrinkage dish. Then shrinkage disc is tap to allow the paste to flow to the edges.
- Then more Ob dump is added and continue the tapping till the shrinkage dish is completely filled. Then the mass of the wet Ob dump. (M₁)
- Then the Ob dump is left to dry and then the mass of the dry pat is taken. (M₅)
- Mercury is put in the glass cup and excess mercury is removed by pressing plate on it.
- Dry pat is taken out of the shrinkage disc and immerse in the glass cup filled with mercury.
- The displaced mercury is collected in the evaporating dish and weight is taken. The volume of the dry pat (V₂) is equal to the mass of the mercury divided by the specific gravity of the mercury.

Calculation

Shrinkage limit can be determined from the relation

\[
\text{shrinkage limit} = \frac{(M_1 - M_5) - (V_1 - V_2) \rho_w}{M_5}
\]

Where

\(M_1\) = initial wet mass,
\(V_1\) = initial volume
\[ V_2 = \text{final volume} \]

\[ M_S = \text{dry mass} \]

**h) Grain size analysis**

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles. The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil. Grain size analysis is done by sieve as per IS: 2720 (part 4)-1985.

**Apparatus**

- Balance
- Set of sieves
- Cleaning brush
- Sieve shaker

**Procedure**

- Weight of each sieve as well as the bottom pan is taken down
- The weight of the dry sample is taken.
- Sieve was assembled in ascending order and then pan was placed.
- Weight of each sieve as well as the bottom pan is taken down.
- Sample was poured in the sieve.
- Then the sieve stack is placed in the mechanical shaker and shake for 30 minutes.
- Sieve stack was removed from the mechanical sieve shaker and the mass was taken of the sample retained in the each sieve including pan.
Calculation

- The percentage of Ob dump retained on each sieve shall be calculated on the basis of total weight of Ob dump sample taken.
- Cumulative percentage of Ob dump retained on successive sieve is found.

Graph: - Graph is drawn between log sieve sizes vs. % finer. The graph is known as grading curve. Corresponding to 10%, 30% and 60% finer, obtain diameters from graph are designated as $D_{10}, D_{30}, D_{60}$.

5.1.2 Brick Analysis

1. Compression Strength Test

This test is performed to determine the compressive strength of bricks. It is additionally known as crushing strength test of bricks. Normally, 5 samples of bricks are selected and transported to the laboratory for testing. A brick sample is kept on the crushing machine and then the pressure is thoroughly applied axially until it breaks. The maximum pressure at which the
brick starts to crack is noted. The test is repeated with all 5 brick samples one by one and the average result is considered as the compressive strength or crushing strength of bricks.

Procedure

- Take five random bricks samples and immerse them in water for 24 hours at room temperature.
- After 24 hours, take them out, allow them to drain and then clean the surplus water.
- Now, fill their frogs (and any other voids) by a layer of standard 1:1 mortar (1 part cement and 1 part sand). Store these bricks under damp sacks for 24 hours (to allow setting of mortar).
- Place the bricks in water for seven days. (This is to allow the mortar to harden).
- Take the bricks out of the water, allow the water to drain and remove the surplus water. When surface dry, each brick is tested for compressive strength individually.
- Place the brick flat-wise, with frog end facing upward, between two plywood sheets.
- Brick so adjusted between the plywood sheets is placed on the bed of compressive strength of bricks testing machine and load is applied axially and at a uniform rate of 140 kg/cm²/minute.
- Note the load at which the brick fails (gets broken). This load (P) is divided by cross-sectional area (A) of the brick gives the compressive strength (Co).
  \[ Co = \frac{P}{A} \]
- The arithmetic mean of the compressive strength of bricks values of all the five bricks shall be taken as the compressive strength of that lot of bricks represented by the test samples, (and not for all the bricks of a kiln).
- The brick shall be classified accordingly on the basis of the (Co) obtained as above.

Compressive Strength of Bricks.
- Compressive Strength of first class brick is 105 kg/cm².
- Compressive Strength of 2nd class brick is 70 kg/cm².
- Compressive Strength of common building brick is 35 kg/cm².
- Compressive Strength of sun dried brick is 15 to 25 kg/cm².

2. Water Absorption Test

In this test, bricks are weighed first in dry condition (W1) and then they are fully submerged in water for 24 hours. After immersion of 24 hours, the bricks are collected and weighed again in wet condition (W2). The difference of weight between dry and wet condition is considered as the water absorbed by the bricks. Then the amount of water absorption is determined in percentage. The less water consumption by the bricks indicates their greater quality. A brick will be considered as good quality if it does not consume more than 20% water of its own weight.

Procedure

- Take five whole bricks randomly.
- Dry these samples to a constant weight by placing them in a ventilated oven at 110° C +/- 5°C. This may take 48 hours or more time.
- The specimens are weighed individually after cooling.
- The dry, weighed samples are then immersed in water, at room temperature, for 24 hours.
After 24 hours the samples are taken out. Each sample is wiped dry and weighed individually within three minutes after it is taken out from the water.

Absorption value is calculated by the simple relationship.

\[ \text{Absorption} \% = \frac{w2 - w1}{w1} \times 100 \]

Where

- \( W1 \) is dry weight,
- \( W2 \) is weight after immersion for 24 hours.

The average of five values for the five samples shall be taken as the water absorption of the brick.

- It shall be within the specified limits for the classification of the bricks.

3. **Efflorescence Test (ISS 1077-1970)**

This test is carried out to obtain the presence of alkaline substances in bricks. First, bricks are fully submerged in fresh water for 24 hours. After 24 hours they are collected from water and left them to dry. After completely dried the bricks are closely observed to find the presence of alkali. If a white or grey layer is formed on the brick surface, it means alkali is present in the brick.

- Take five bricks at randomly.
- Place each brick on end in a separate shallow flat bottom dish containing distilled water. Note that depth of immersion of bricks should not be less than 2.5 cm in each case.
- Keep the above dishes (containing water and bricks) in a warm (18°C to 30°C) room which has adequate Ventilation.(The water from the dishes will be lost due to absorption by bricks and subsequent evaporation).
- Add fresh quantity of distilled water when the bricks appear having dried.
- At the end of the second drying, each brick is observed for efflorescence; that is an appearance of any white patch of salt on the surface of the brick. **The efflorescence is reported only by qualitative words as follows:**
  - **Serious.** Salt deposition is all round and quite heavy and increases with repeated wetting and drying. Powdering of salt is prominent.
  - **Heavy.** Salt deposits cover more than 50 percent of the surface area. The tendency to powder is absent.
  - **Moderate.** Salt deposits cover 10-50 percent surface area. The salt forms thin layers without showing any tendency to peel off in flakes or become powdery.
  - **Slight.** Salt covers the surface area of less than 10 percent and forms only a very thin sticky layer.
  - **Nil.** There is seen no deposit of any salt even after repeated wetting.
It is required that efflorescence should not exceed than the specified degree in various classes of bricks.

4. Impact Test
In this test few bricks are dropped from 1-meter height. If bricks are broken it indicates low impact value and not acceptable for construction work. Good quality bricks do not break at all.

5. Soundness Test
In this test, two randomly selected bricks are hardly punched with each other. If they produce a clear metallic sound and remain unbroken then they are good quality bricks. Soundness test of bricks shows the nature of bricks against sudden impact. In this test, 2 bricks are chosen randomly and struck with one another. Then sound produced should be clear bell ringing sound and brick should not break. Then it is said to be good brick.

6. Hardness Test
This test is done to know the hardness of bricks. In this test, scratches are made on the surface of the brick by a hard thing. If it does not leave any impression on the brick surface then it will be considered as good quality bricks. A good brick should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick.

7. Structure Test
In this test, a brick is fractured and firmly investigated. If any flaws, holes or cracks are seen inside the broken brick, then it is considered as poor quality brick. To know the structure of brick, pick one brick randomly from the group and break it. Observe the inner portion of brick clearly. It should be free from lumps and homogeneous.

Results
The Ob dump sample was analyses in Geotechnology laboratory using standard laboratory protocols. For the geotechnical parameters analysis IS: 2720 was used and for the preparation of sample IS: 2720 (part 1) - 1983 was used.

Specific gravity

<table>
<thead>
<tr>
<th>Density Bottle (g) (W₁)</th>
<th>Density Bottle+ Ob dump (W₂)</th>
<th>Density Bottle+ Ob dump +water (W₃)</th>
<th>Density Bottle+ Water (W₄)</th>
<th>W₂-W₁</th>
<th>(W₄-W₁) (1)</th>
<th>(W₃-W₂) (2)</th>
<th>(1)-(2)</th>
<th>Result of specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.053</td>
<td>32.053</td>
<td>55.45</td>
<td>54.13</td>
<td>8</td>
<td>30.077</td>
<td>23.397</td>
<td>6.68</td>
<td>1.19760479</td>
</tr>
</tbody>
</table>

Bulk density

Weight of the cylinder 74.12 g

Weight of the cylinder and Ob dump together 109.72 g

Volume of Ob dump 29cm³

**Bulk density = mass / volume**

\[ \frac{(109.72-74.12)}{28} \]
Optimum Moisture content

The moisture content gives the idea of the state of the sample and the percentage of water present in the sample.

Table 6.2: Moisture content

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Sample No.</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weight of container with cap W₁ g</td>
<td>18 g</td>
<td>19 g</td>
</tr>
<tr>
<td>2</td>
<td>Weight of container with cap + Ob dump W₂ g</td>
<td>42 g</td>
<td>36 g</td>
</tr>
<tr>
<td>3</td>
<td>Weight of container with cap with dry Ob dump W₃ g</td>
<td>41.725</td>
<td>35.83</td>
</tr>
<tr>
<td>4</td>
<td>Moisture content / total weight of sample</td>
<td>1.159</td>
<td>1.05</td>
</tr>
</tbody>
</table>

The moisture content of the sample is = 1.1045%

Compaction test

- Diameter of the mould = 9 cm
- Height mould with collar = 17.5 cm
- Height of mould without collar = 23.5 cm
- Volume of the mould is 815.145 cm³

Table 6.3: Compaction

<table>
<thead>
<tr>
<th>Box weight(g)</th>
<th>before dry(g)</th>
<th>after dry(g)</th>
<th>Water(ml)</th>
<th>moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>36</td>
<td>32.984</td>
<td>3.016</td>
<td>20.1281</td>
</tr>
<tr>
<td>16</td>
<td>38</td>
<td>34.49</td>
<td>3.51</td>
<td>18.9832</td>
</tr>
</tbody>
</table>

The Compaction of the sample is = 19.5565%
Permeability

Table 6.4: Permeability

<table>
<thead>
<tr>
<th>h₁ (cm)</th>
<th>h₂ (cm)</th>
<th>h₁/h₂</th>
<th>t(s)</th>
<th>1.1012/t (t⁻¹)</th>
<th>log(h₁/h₂)</th>
<th>K (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>90</td>
<td>1.1111111111</td>
<td>83</td>
<td>0.012303614</td>
<td>0.045757491</td>
<td>0.000562983</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
<td>1.125</td>
<td>84</td>
<td>0.012157143</td>
<td>0.051152522</td>
<td>0.000621869</td>
</tr>
<tr>
<td>80</td>
<td>70</td>
<td>1.142857143</td>
<td>98</td>
<td>0.010420408</td>
<td>0.057991947</td>
<td>0.0006043</td>
</tr>
<tr>
<td>70</td>
<td>60</td>
<td>1.166666667</td>
<td>103</td>
<td>0.009914563</td>
<td>0.06694679</td>
<td>0.000663748</td>
</tr>
</tbody>
</table>

The value of permeability of Ob dump sample ~2.5 × 10⁻⁴ cm².

Grain size analysis

Table 6.5: Grain size analysis

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>% passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75</td>
<td>100</td>
</tr>
<tr>
<td>1.18</td>
<td>42</td>
</tr>
<tr>
<td>0.6</td>
<td>41</td>
</tr>
<tr>
<td>0.425</td>
<td>9</td>
</tr>
<tr>
<td>0.25</td>
<td>5</td>
</tr>
<tr>
<td>0.16</td>
<td>2</td>
</tr>
<tr>
<td>0.075</td>
<td>1</td>
</tr>
</tbody>
</table>

Graph 6.1: Grain Size log graph

D₁₀ = 0.28
D_{30} = 0.43
D_{60} = 0.58
Uniformity Coefficient (Cu) = 2.27
Coefficient of Gradation (Cc) = 1.016

**Plastic limit**

<table>
<thead>
<tr>
<th>S. no.</th>
<th>No of Blows</th>
<th>Wt. of Container (W_1)</th>
<th>wt. of container and ob. dump (W_2)</th>
<th>Wt. of Container and dry ob. dump (W_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>40</td>
<td>21</td>
<td>29.57</td>
<td>28.26</td>
</tr>
<tr>
<td>2.</td>
<td>20</td>
<td>22.30</td>
<td>30.90</td>
<td>29.69</td>
</tr>
</tbody>
</table>

The plastic limit was found to be 17.19%

**Shrinkage limit**

Mass of mercury = 307.551g
Volume of wet sample = 22.614 ml
Mass of wet sample = 42.556 g
Mass of dry sample = 32.855 g
Mass of mercury displace = 238.052 g
Volume of dried sample = 17.50 ml
Moisture content = 29.526%

Shrinkage limit of the sample was found to be 14%

**Discussion**

- Specific gravity, Bulk Density and Optimum Moisture Content of the over burden dump sample is found to be 1.197, 1.22 g/cm³ & 1.1045 %. Specific gravity and bulk density both are in normal range but optimum moisture content is very low which is good for brick making.
- Compaction results are found to be very high at 19.55% which give very good results.
- Permeability of the over burden dump sample is found to be 2.5 x 10^{-4} cm² which is very low and will perform well in brick making.
- Sieve analysis graph curve is not a total S curve which shows that the over burden dump sample is not a well grade sample with a Uniformity Coefficient (Cu) = 2.27 Coefficient of Gradation (Cc) = 1.016.
- Plastic limit and Shrinkage Limit values are found to be in normal range as plastic limit is 17.19% and shrinkage limit is 14% and these two property of the over burden dump sample will support brick making.
6.2 Testing on Ob Dump Brick

1. Compression Strength Test

Table 6.7 Compressive strength test

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Sample</th>
<th>Compressive Strength (kg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brick 1</td>
<td>67.3</td>
</tr>
<tr>
<td>2</td>
<td>Brick 2</td>
<td>73</td>
</tr>
<tr>
<td>3</td>
<td>Brick 3</td>
<td>69.2</td>
</tr>
<tr>
<td>4</td>
<td>Brick 4</td>
<td>64.7</td>
</tr>
<tr>
<td>5</td>
<td>Brick 5</td>
<td>61.9</td>
</tr>
</tbody>
</table>

The Average Compressive Strength is 67.22 kg/cm²

1. Water Absorption Test

Table 6.8: Water Absorption test

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Sample</th>
<th>Dry Weight of Brick (Kg)</th>
<th>Wet Weight of Brick (Kg)</th>
<th>Absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sample 1</td>
<td>3.529</td>
<td>4.340</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Sample 2</td>
<td>3.524</td>
<td>4.297</td>
<td>21.96</td>
</tr>
</tbody>
</table>

The Average Water Absorption of the brick samples are 22.48%

3. Efflorescence Test

Nil. There is seen no deposit of any salt even after repeated wetting.

4. Impact Test

Five bricks were chosen randomly and dropped from the height of 1 meter and not a single brick got break. So the brick are of good impact value and acceptable for construction work.

5. Soundness Test

Two bricks are chosen and they are struck with one another. Then sound produced was a clear metallic sound was heard and brick does not break.

6. Hardness Test

For this test finger nail is used and with the help of that we try to make scratches on the randomly chosen sample brick but no mark was made on the brick by the scratch action.

7. Structure Test

Five bricks were chosen randomly and they were fracture and closely examine. There were no holes or cracks were found on all the samples.
Conclusion

- Compressive Strength Test of the bricks was tested in a lot of five brick and a average value of the compressive strength of the bricks was calculated which was 67.22 kg/cm$^2$ and the compressive strength value of the second class brick is 70 kg/cm$^2$ and the compressive strength value of the bricks commonly used in building construction is 35 kg/cm$^2$.
- The water absorption was tested on two bricks and then average of both the values were calculated and it is 22.48% which is little bit high it should not exceed 20%.
- Nil efflorescence was found on the brick while testing the brick which is a very good result.
- The result for impact test was very good as after dropping all five bricks from one meter distance no brick got break.
- While striking two bricks with each other for soundness test, a sharp metallic sound was heard which shows that that quality of the brick is very good.
- After trying to put some scratches with finger nail for hardness test, no mark was made on the brick which shows that the quality of the bricks is very good.
- No hole or crack is found while examining for structure test this also shows that the quality of brick is very good.
- The overall brick is very good compressive strength is good which is very close to class second brick and all other tests such as impact test, soundness test, hardness test & structure test the results are very good but for water absorption test the value is little bit high (which can be subject of further study) but it can ignore for some area overall the bricks made from over burden dump can be used for construction.

REFERENCES


• IS: 1125- 1974, Method of test for determination of weather of natural building stones (BIS, New Delhi).


• Chatterjee, Amit. (2005), "Recent Developments in Ironmaking and Steelmaking." Iron and Steel making. 22:2 pp. 100-104.


- IS: 2720 -Part 39, Section 1. 1979. Indian Standard Methods of Test for Soils: Direct Shear Test For soil containing gravel more than 4.75 mm size, Bureau of Indian Standards.