# Mix Design Competition Report – Orbit Engineering Expo 2.0

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## ACKNOWLEDGEMENT:

We extend our heartfelt gratitude to Engineers Vlogs and Sagarmatha Engineering College for organizing **Mix Design Competition**, held from 20th November 2024 as a part of the **Orbit Engineering Expo 2.0** at Sagarmatha Engineering College; Sanepa, Lalitpur. The event provided a remarkable platform to showcase our knowledge, skills, and creativity in the field of engineering.

We sincerely thank Er. Nitesh Thakur, Program Coordinator of the Mix Design Competition, for his dedicated efforts in ensuring the smooth conduct of the competition. We are also deeply thankful to Er. Bipul Mainali, Event Coordinator, for his support and guidance throughout the event.

Furthermore, our sincere thanks go to the esteemed judges, whose expert guidance and constructive feedback played a crucial role in expanding our understanding of concrete mix design. We are deeply grateful to the whole organizing committee, coordinators, and supporting staff for their unwavering commitment and hard work in creating a stimulating, competitive, and collaborative environment for all participants.

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It is through the collaboration and dedication of everyone involved that we were able to complete this endeavor successfully and gain invaluable insights in the process.

# INTRODUCTION:-

Concrete is the backbone of modern infrastructure, yet achieving the perfect balance between strength, durability, and sustainability remains a significant challenge. The construction industry continually seeks innovative solutions to enhance the quality and efficiency of concrete. The Mix Design Competition held on 20$^{th}$ Nov, 2024 at Orbit Engineering Expo 2.0 at Sagarmatha Engineering College provided an excellent platform to address these critical issues by pushing the boundaries of traditional concrete mix designs.

## Objectives of mix design:-

The primary objectives were:

- To create a concrete mixture that meets desired compressive strength so that the deviation of results should be within permissible range.
- To optimize the mix for workability, making it easier to handle and place in various construction scenarios.
- To minimize the environmental impact by incorporating sustainable materials and practices.
- To achieve cost-effectiveness without compromising quality.

## Relevance to Competition and Practical Applications:

The mix design process is critical in the construction industry as it directly affects the quality and sustainability of the built environment. This competition provided a practical and competitive setting where participants could apply theoretical knowledge to real-world scenarios. By simulating real-life challenges faced in the field, the competition highlighted the importance of precision and innovation in mix design. The skills and insights gained through this experience are directly applicable to the industry, where efficient and sustainable concrete solutions are increasingly in demand.

The practical applications of mix design are pivotal in various aspects of construction and civil engineering:

- To ensure that concrete used in foundations, columns, beams, and slabs has the required strength and durability to support structural loads.
- By Customizing mix designs for roads, highways, and bridges we can enhance longevity and resistance to wear and tear.
- Specialized high-strength concrete mixes are designed to meet the demanding requirements of tall structures.

# DESIGN SPECIFICATIONS AND CONSTRAINTS:

## Design Specifications

The concrete mix design for this project was developed with the following specifications to ensure the resulting mix met both standard requirements and the desired performance criteria for structural applications:

1. **Grade of Concrete:**
   - The grade of concrete selected was **M25**, which indicates a characteristic compressive strength of **25 MPa** at 28 days. This grade is commonly used in structural applications such as foundations, slabs, beams, and columns.
2. **Type of Concrete:**
   - The concrete was designed as **Reinforced Cement Concrete (RCC)**, suitable for structures requiring high strength and durability. RCC is used in the construction of buildings, roads, and other civil engineering projects, where concrete is reinforced with steel to resist tensile stresses.
3. **Type and Grade of Cement:**
   - The **Ordinary Portland Cement (OPC)** of **43 Grade** was selected for this mix. This grade of cement is widely used in general construction and provides a balance between strength development and workability.
4. **Maximum Nominal Size of Aggregate:**
   - The nominal maximum size of aggregate used was **20 mm**, which is suitable for achieving the desired compressive strength while maintaining workability. The size was chosen in accordance with IS 456:2000, which specifies the appropriate aggregate size for different grades of concrete.
5. **Exposure Condition:**
   - The mix was designed for **Moderate Exposure Conditions** as per IS 456:2000, indicating that the concrete would be exposed to moderate weathering or environmental conditions. This exposure condition requires adequate reliability measures, such as: limiting the water-cement ratio to ensure the concrete can withstand wear, moisture, and temperature fluctuations.

6. **Fine Aggregate:**
   - **Zone II sand** was selected as the fine aggregate, which is generally used for standard concrete mixes and ensures good workability and strength. The fine aggregate has a **bulk density of 1500 kg/m³** and a **specific gravity of 2.65**.

7. **Coarse Aggregate:**
   - The coarse aggregate used was angular, with a **bulk density of 1600 kg/m³** and a **specific gravity of 2.65**. This type of aggregate improves the strength and structural integrity of the concrete.

8. **Water-Cement Ratio (w/c):**
   - The **water-cement ratio** was selected to be **0.486**, based on the desired target mean strength (TMS) and the durability requirements. A lower w/c ratio helps in achieving higher strength and reduced porosity in the concrete.

9. **Workability:**
   - The mix was designed to achieve a **slump value** between **25–75 mm**. This range ensures that the concrete is workable enough for handling and placement while maintaining a balance between strength and ease of use.

10. **Minimum Cement Content:**
    - The minimum cement content required was **300 kg/m³**, as specified by IS 456:2000 for reinforced concrete under moderate exposure conditions. This ensures that the mix provides sufficient durability and strength.

11. **Durability Considerations:**
    - The mix was aligned with IS 456:2000 guidelines for reinforced concrete, ensuring that it could withstand moderate exposure conditions and providing an optimal balance between strength, durability, and workability.

## Constraints

Several constraints were considered during the design and implementation of the concrete mix to ensure that it met the desired performance and practical requirements:

1. **Compressive Strength:**
   - The concrete mix had to meet the target mean strength (TMS) of **31.6 MPa**, as calculated through the IS 10262:2019 mix design procedure. This ensured that the concrete would be strong enough for structural applications and would comply with the M25 grade specifications.
2. **Durability:**
   - The concrete mix had to be durable enough to perform well under **moderate exposure conditions**. This constraint required the use of specific cement content and a controlled water-cement ratio to mitigate issues like cracking and degradation over time.
3. **Workability Range:**
   - Achieving a slump value within the desired range of **25–75 mm** posed a challenge, as the workability of the concrete mix is influenced by several factors, including aggregate grading, moisture content, and environmental conditions. In this case, external conditions, such as sunny weather, may have caused slight evaporation of water, leading to a deviation in the slump test results.
4. **Material Properties:**
   - The specific gravity and bulk densities of the aggregates, as well as the cement, were considered during the mix design. Variations in these properties can affect the final proportions of the mix. These material properties were essential for accurate volume-based calculations, and slight deviations could lead to variations in the final concrete performance.
5. **Environmental Impact:**
   - The design aimed to minimize the environmental impact by optimizing the use of materials. While sustainable practices, such as the incorporation of fly ash or recycled aggregates, were not implemented due to constraints in the provided data, this is an important consideration in modern mix designs.

6. **Cost Constraints:**

    ○ Balancing cost-effectiveness with the need for strength and durability was a significant consideration in the mix design. The use of high-quality materials, such as OPC, and maintaining a low water-cement ratio could lead to higher material costs, but it was essential to meet performance criteria without significantly exceeding budget constraints.

7. **Moisture Adjustments:**

    ○ It was assumed that the aggregates were in **saturated surface dry (SSD) condition**. Deviations from this condition could affect the moisture content of the aggregates and, consequently, the water-cement ratio. This is a common challenge in field conditions, where moisture content can fluctuate, affecting the mix proportions.

8. **Testing Limitations:**

    ○ Due to time constraints, the compressive strength tests were conducted at **14 days** rather than the standard 28 days, which limited the ability to directly compare the results to the target characteristic strength. This could introduce some variability, as concrete generally gains more strength after 28 days of curing.

9. **Site Conditions:**

    ○ The mixing process took place under **sunny conditions**, which could have led to water evaporation during the mixing process. This environmental factor influences the workability of the mix and could have affected the slump test results. To mitigate this, more controlled conditions would be beneficial in future mixes.

10. **Volume Considerations:**

    ○ The mix design had to account for allowances for **wastage**. The estimated volume of concrete to be prepared was adjusted for wastage, which included an additional 25% to the calculated volume to ensure sufficient material for casting the specimens.

These specifications and constraints guided the mix design process, ensuring that the concrete produced met the required strength and durability while addressing practical challenges such as material variability, environmental factors, and testing limitations.

# MATERIALS AND THEIR PROPERTIES:

## Cement

Cement is a material with adhesive and cohesive properties that enable it to bond mineral fragments into a compact mass. The primary constituents of cement are compounds of lime.

### Types of Cement

Cement is mainly classified into two groups based on its source and manufacturing process:

1. Natural Cement
2. Artificial Cement (Portland Cement)

**1. Natural Cement**

These are obtained from naturally occurring limestone containing clay and magnesia.

**2. Artificial Cement**

These are manufactured by controlled processing of limestone and clay, followed by heating and grinding. The types of Artificial cement are :

i) Ordinary Portland Cement (OPC)
ii) Portland Pozzolana Cement (PPC)
iii) Portland Slag Cement (PSC)

The Ordinary Portland Cement are available in 33, 43, and 53 **grades** based on compressive strength in MPa after 28 days. During our mix design competition OPC 43 grade cement was used.

## Properties:

1) Fineness:

   Cement is ground to a fine powder to ensure better reactivity and strength. The specific surface area of OPC is typically ≥ 225 $m^2/kg$.

2) Setting Time:

   Initial Setting Time: Cement starts hardening within 30 minutes after adding water.

   Final Setting Time: It should set completely within 10 hours.

3) Compressive Strength:

The strength of cement is measured after 28 days of curing. OPC is classified into 33, 43, and 53 grades, indicating compressive strength in MPa. For OPC 43 Grade Cement: Compressive strength is 43 MPa after 28 days.

4) Soundness:

Soundness ensures that the cement does not expand excessively after setting, which could cause cracks.

5) Heat of Hydration:

The chemical reaction of cement with water releases heat. Higher grades of cement (e.g., OPC 53) generate more heat, suitable for rapid construction but less ideal for mass concrete works.

6) Specific Gravity:

The specific gravity of cement is typically around 3.15.

## Fine Aggregate

Fine aggregate refers to aggregates where the majority of particles pass through a 4.75 mm IS sieve. It is commonly composed of sand and is a critical component of concrete mixes.

### Types of Fine Aggregate

- Natural Sand
- Manufactured Sand (M-sand)
- Crushed Stone Sand

#### Gradation

Gradation is determined through sieve analysis as per IS 383 or ASTM C33 standards. Fine aggregates are classified into Zone I to Zone IV based on particle size distribution, with Zone II being ideal for most concrete applications. Proper grading of fine aggregate ensures dense concrete, reduces voids, and minimizes the need for excess cement paste. The grading of fine aggregate is expressed in terms of the percentage by weight retained on or passing through a series of sieves. These sieves are arranged with square openings that progressively reduce in size by half, ensuring accurate classification.

The standard sieve sizes for fine aggregate are 4.75 mm, 2.36 mm, 1.18 mm, 600 microns, 300 microns, and 150 microns.

Well-graded fine aggregate helps achieve better workability, strength, and durability in concrete.

**Specific Gravity**

The specific gravity of fine aggregates generally ranges between **2.5 to 2.7**.

**Fineness Modulus (FM)**

The fineness modulus, an indicator of the coarseness or fineness of the aggregate, typically falls within the range of **2.2 to 3.2** for construction-grade sand.

**Other Properties:**

1) Bulk Density**:** Typically ranges from 1400 to 1700 kg/m$^3$.
2) Moisture Content: Varies based on environmental conditions; must be controlled to avoid affecting the water-cement ratio.
3) Should not contain silt, clay, or organic matter.
4) Proper gradation is essential to ensure good **workability** and **strength** in concrete.

## Coarse Aggregate

Coarse aggregate refers to aggregates retained on a 4.75 mm IS sieve and is an essential component of concrete mixes, providing strength and bulk to the structure.

### Types of Coarse Aggregate:

- Crushed Stone
- Gravel
- Recycled Concrete Aggregate

**Gradation:**

Gradation is determined through sieve analysis as per IS 383 or ASTM C33 standards. Proper grading of coarse aggregate ensures dense concrete, minimizes voids, and reduces the amount of fine aggregate and cement paste required. The grading of coarse aggregate is expressed in terms of the percentage by weight retained on or passing through a series of sieves. These sieves are arranged with square openings that progressively reduce in size by half, ensuring accurate classification.

The standard sieve sizes for coarse aggregate are 80 mm, 40 mm, 20 mm, 10 mm, and 4.75 mm.

Graded coarse aggregates are often described by their nominal size, such as 20 mm, 12.5 mm, or 10 mm. For example, a graded aggregate of nominal size 12.5 mm refers to an aggregate where most particles pass through the 12.5 mm IS sieve.

**Specific Gravity**

The specific gravity of coarse aggregates typically ranges from **2.6 to 2.9**.

**Other Properties:**

1) Bulk Density: Typically ranges from 1200 to 1750 kg/m³, depending on particle shape and compaction level.
2) Moisture Content affects the water-cement ratio and must be accounted for in the mix design.
3) Angular aggregates provide better bonding and strength compared to rounded aggregates.
4) Should have sufficient crushing strength to withstand loads and resist weathering.
5) Should not contain organic matter, clay, or other deleterious materials.

## Water

Water is one of the most critical and least expensive components of concrete. Its role extends beyond hydration to improving the workability of the mix by lubricating fine and coarse aggregates. Water is also essential for curing and cleaning aggregates, making it a vital element in all stages of concrete production.

### Sources of Water

The source of water used in concrete production significantly impacts its quality.

- **Natural Sources:** Rivers, lakes, groundwater, and wells are common sources but the water should be tested for impurities.
- **Recycled Water:** Treated water from industrial or municipal processes may be utilized if it meets quality standards.
- **Rainwater:** Can be used after ensuring it is free from contaminants.

### Quality Standards for Water

Ensuring the quality of water used in concrete is essential for achieving desired strength and durability. The following standards must be met:

1. Potability:
    - Water suitable for drinking is generally fit for use in concrete.
    - However, potable water with 0.05% sugar may delay cement setting and is unsuitable.
2. Chemical Composition:
    - Water must be free from harmful substances such as:
        - Acids, oils, and alkalis
        - Sugars and organic materials

        - Silt and suspended solids
    - Chlorides and Sulfates:
        - High chloride levels (from seawater) cause reinforcement corrosion.
        - Excess sulfates lead to delayed expansion and cracking.
3. pH Value:
    - The pH should be within the range of 6 to 8, ensuring neutrality and avoiding harmful reactions.
4. Compressive Strength Test:
    - Water is acceptable if concrete mixed with it achieves at least 90% of the strength compared to concrete mixed with distilled water.
5. Algae Presence:
    - Water containing algae should not be used, as algae reduce the bond strength between aggregates and cement paste.
6. Cement Setting Time:
    - Water should not alter the initial and final setting times of cement by more than ±30 minutes.

# MIX PROPORTIONING PROCESS

## For the mix design according to IS 10262:2019

1. Determination of Target Mean Strength (TMS).
   TMS = $f_{ck}$ + 1.65 * $\sigma$
   TMS = $f_{ck}$ + X
   Take whichever is greater .
   $\sigma$ is taken from table 2 ( clause 4.2 ) ; page no 3 of IS code 10262 : 2019 .
   X is taken from table 1 ( clause 4.2.1.3 ) ; page no 3 .

2. Find approximate air content based on nominal maximum size of aggregate from table 3 (clause 5.2 ) ; page no 3.

3. Estimate the free water cement ratio (w/c) according to grade of cement used and 28 days compressive strength of concrete from curve 1 ; page no 4 .
   Also check for durability condition
   Take whichever is small.

4. Determine water content (w) per cubic meter of concrete for nominal maximum size of aggregate from table 4 ( clause 5.3 ) ; page no 5.
   The table give water content for slump value 50 mm and angular aggregate . For other conditions correction is carried out in accordance.

5. Calculate cement content (cc).
   w/c = $\frac{w}{cc}$
   Also check for durability condition.
   Take greater value.

6. Determine volume of coarse aggregate per unit volume of total aggregate for different zones of fine aggregate for water cement ratio 0.5 from table 5 ( clause 5.5) ; page no 6.
   For other water cement ratio correction is done as per the code.

7. Find volume of fine aggregate per unit volume of total aggregate .
   Fine Aggregate = 1- Coarse Aggregate.

8. Perform mix calculation

   Total volume ( a ) = 1 $m^3$
   Volume of entrapped air form step 2 = b

$$\text{Volume of cement ( c)} = \frac{\text{mass of cement}}{\text{Specific gravity of cement} \times 1000}$$

$$\text{Volume of water ( d )} = \frac{\text{mass of water}}{\text{Specific gravity of water} \times 1000}$$

Volume of all in aggregate ( e ) = a-b-c-d
Mass of coarse aggregate = e × volume of coarse aggregate ( step 6 ) × Specific gravity of coarse aggregate
Mass of fine aggregate = e × volume of fine aggregate ( step 7 ) × Specific gravity of fine aggregate

9. Adjustment of moisture content is any .

10. From the mass value the mix design proportion is obtained .

**<u>Calculation for mix proportion based on data provided in field</u>**

GIVEN DATA

| | |
|---|---|
| Grade Designation | M25 |
| Type of concrete | RCC |
| Type of Cement | OPC |
| Grade of Cement | 43 grade |
| Maximum nominal size of aggregates | 20 mm |
| Exposure Condition | Moderate |
| Sand Zone | Zone II |
| Bulk Density of Coarse Aggregates | 1600 $kg/m^3$ |
| Bulk Density of Fine Aggregates | 1500 $kg/m^3$ |
| Bulk Density of Cement | 1440 $kg/m^3$ |
| Specific Gravity of Coarse Aggregates | 2.65 |
| Specific Gravity of Fine Aggregate | 2.65 |
| Specific Gravity of Cement | 3.15 |

1) <u>Target Mean Strength (TMS):</u>
*From table 2*, Standard Deviation ($\boldsymbol{\sigma}$) = 4 $N/mm^2$
*From table 1*, Value of X = 5.5 $N/mm^2$

a) TMS = $f_{ck} + 1.65 * \boldsymbol{\sigma} = 25 + 1.65 * 4 = 31.6$ $N/mm^2$
b) TMS = $f_{ck} + X = 25 + 5.5 = 30.5$ $N/mm^2$
*Note*: Adopt higher value. Therefore, TMS = 31.6 $N/mm^2$

2) Approximate Air Content:

*From table 3*, the approximate amount of entrapped air is 1.0 (i.e. 1% of Volume of Concrete) for 20 mm nominal maximum size of aggregates.

3) Selection of Water-Cement Ratio (w/c):

a) *From Fig. 1*, the free water-cement ratio required for the Target Mean Strength of 31.6 $N/mm^2$ corresponds to 0.486 from Curve-2 (43 grade OPC).
b) *From durability condition*; the maximum free water-cement ratio is 0.50, for the Reinforced Concrete having the moderate exposure condition.

*Note*: Adopt smaller value. Therefore, w/c = 0.486

4) Selection of Water Content (w):

*From table 4*, the water content is 186 kg (per Cubic metre of Concrete) for 20 mm nominal maximum size of angular aggregates.

5) Calculation of Cement Content (cc):

Water-Cement Ratio (w/c) = 0.486
Water Content (w) = 186 kg

a) Cement Content (cc) = $\frac{186}{0.486}$ = 382.716 $kg/m^3$

b) *From durability condition*; the minimum cement content for the Reinforced Concrete having the moderate exposure condition is 300 $kg/m^3$.

*Note*: Adopt higher value. Therefore, cc = 382.716 $kg/m^3$.

6) Proportion of Volume of Coarse Aggregates' Content:

*From table 5*, the proportionate volume of coarse aggregate corresponding to 20 mm size aggregates & fine aggregates confirming to the sand zone: II with water-cement ratio of 0.5 is taken as 0.62

But here in the present case, water-cement ratio is found 0.486, thus the corrections need to be applied.

Correction: When the water-cement ratio is less than 0.5, the volume of coarse aggregates is required to be increased, in order to decrease the fine aggregates' content & vice versa. Thus, for every 0.05 decrease in water-cement ratio from 0.5, the volumetric percentage of coarse aggregates increases by the rate of 0.01 & conversely.

- Decrease in water-cement ratio = 0.5 - 0.486 =0.014
- Increase in volume of coarse aggregates = $\frac{0.01}{0.05}$ * 0.014 = 0.0028
- Therefore, the corrected proportion of volume of coarse aggregates per unit volume of total aggregates = 0.62 + 0.0028 = 0.6228

7) Proportion of Volume of Fine Aggregates' Content:

The volume of fine aggregates' content per unit volume of total aggregates is calculated as : 1 - 0.6228 = 0.3772

8) Mix Calculations:

The mix calculations per unit volume of concrete shall be as follows:

a) Total volume of concrete = 1 $m^3$
b) Volume of entrapped air in wet concrete = 1% of 1 $m^3$ = 0.01 $m^3$
c) Volume of cement = $\frac{mass\ of\ cement}{specific\ gravity\ of\ cement * 1000}$

   $= \frac{382.716}{3.15 * 1000}$

   = **0.1215 $m^3$**
d) Volume of water = $\frac{mass\ of\ water}{specific\ gravity\ of\ water * 1000}$

   $= \frac{186}{1 * 1000}$

   = **0.186 $m^3$**
e) Volume of all-in aggregates = a - b - c - d

   = 1 - 0.01 - 0.1215 - 0.186

   = **0.6825 $m^3$**
f) Mass of coarse aggregates = e * Volume of coarse aggregates * specific gravity of coarse aggregates * 1000

   = 0.6825 * 0.6228 * 2.65 * 1000

   = **1126.4116 kg**
g) Mass of fine aggregates = e * Volume of fine aggregates * specific gravity of fine aggregates * 1000

   = 0.6825 * 0.3772 * 2.65 * 1000

   = **682.2134 kg**

9) Adjustment due to the moisture condition:

Since the aggregates shall be used in Saturated Surface Dry (SSD) condition, no adjustment is required.

10) Calculation of actual volume in the field:

- Test Specimen = Cube
- No. of Samples to be prepared = 3
- Dimension of a cube mould = 15 mm * 15 mm * 15 mm
- Total volume of 3 moulds = 3 * $(0.15)^3$
  = 0.010125 $m^3$
- Consider wastage volume content for compensation = 25%
- Total volume of concrete to be prepared = (1 + 0.25) * 0.010125 $m^3$
  = 0.01265625 $m^3$
  **≈ 0.01266 $m^3$**

➔ Thus, total wet volume = 0.01265625 * $10^6$
= **12656.25 $cm^3$**

➔ And, total dry volume = total wet volume - volume of water
= 12656.25 - (0.186 * 12656.25)
= **10302.1875 $cm^3$**

11) Calculation of actual mass required:

Total volume of concrete to be prepared = 0.01266 $m^3$

| S.N. | Ingredients | Mass in 1 $m^3$ of concrete (kg) | Calculations | Actual mass required (kg) |
|---|---|---|---|---|
| 1. | Cement | 382.716 | 0.01266 * 382.716 | **4.845** |
| 2. | Water | 186 | 0.01266 * 186 | **2.355** |
| 3. | Coarse Aggregates | 1126.4116 | 0.01266 * 1126.4116 | **14.261** |
| 4. | Fine Aggregates | 682.2134 | 0.01266 * 682.2134 | **8.637** |

12) Final Proportion of Design Mix:

From the mass of the ingredients as calculated above, the proportion of design mix is as follows:

➔ Cement : Fine Aggregate : Coarse Aggregates , Water
➔ 4.845 : 8.637 : 14.261 , 2.355

➔ $\frac{4.845}{4.845} : \frac{8.637}{4.845} : \frac{14.261}{4.845} , \frac{2.355}{4.845}$

➔ <u>**1 : 1.78 : 2.94 ; 0.486**</u>

# EXPERIMENTAL PROCEDURE:

## For Mixing

1. All required materials (cement, fine aggregate, coarse aggregate, and water) were gathered in the appropriate proportions as determined by the mix design.
2. Place The cement, fine aggregate, and coarse aggregate were placed in levelled dry surface
3. The dry materials were mixed thoroughly until a uniform color and texture were achieved.
4. The measured amount of water was gradually added to the dry mix making a depressing on the middle of  mixed materias .
5. Mixing process was continued until a consistent, homogeneous mix was achieved, ensuring no lumps or dry patches remain.

Further procedure for moulding and demoulding are explained in compression test.

## For Slump test

1. Prepare the concrete mix as per the specified mix design.
2. Place the slump cone on a firm, non-absorbent base plate.
3. Fill the cone in three layers, each approximately one-third of the height of the cone.
   - **First Layer:** Fill one-third of the cone and rod the layer 25 times with the tamping rod.
   - **Second Layer:** Fill the second third of the cone and rod this layer 25 times, ensuring the rod penetrates into the first layer.
   - **Third Layer:** Fill the cone to the top and rod this layer 25 times, penetrating into the second layer.
4. Smooth the top surface of the concrete and remove any excess. Carefully lift the cone vertically and slowly without any lateral or torsional movement.
5. Measure the difference between the height of the cone and the highest point of the concrete specimen.

## For Compression test

1) Specimens are cast in steel or cast iron moulds with dimensions of 150 mm × 150 mm × 150 mm.
2) The dimensions and planeness of the moulds should be within the specified tolerance limits.
3) The mould and its base must be securely clamped together during casting to prevent leakage.
4) A thin layer of mineral oil is applied to the inner surfaces of the moulds to prevent bonding between the mould and the concrete.

5) The cube is filled in three layers, and each layer is compacted using either a vibrator or a standard tamping rod.

6) After compaction, the top surface is levelled flush with the edges of the mould and finished using a trowel.
7) The finished surface is left undisturbed for 24 hours at a temperature of 20 ± 1°C and a relative humidity of not less than 90%.
8) After 24 hours, the mould is stripped, and the specimen is stored in water for curing, maintaining it for up to 28 days.
9) After 28 days, the specimen is removed from the water and tested using a uniaxial compression testing machine.
10) The load is applied at a uniform rate of 140 $kg/cm^2$ per minute until the specimen fails.
11) The compressive strength of the specimen is calculated using the formula:

$$\text{Compressive Strength} = \frac{\text{Load at Failure}}{\text{Area over which Load is Applied}}$$

# RESULT AND DISCUSSION:

## Slump test

- Initial Height of Cone = 300 mm
- Height of Concrete After Removal of Cone = 280mm
- Slump Value = 20mm

## Compressive Strength Test

- Age of Concrete (Days) =14
- Standard Compressive Strength (MPa) =22.5
- Average Compressive Strength (MPa )=22.306

## Water Absorption Test

- Average Dry Weight (W1) (kg) = 7.973
- Saturated Weight (W2) (kg) = 8.02
- Average Water Absorption (%) = 0.589

According to Is 456:2000
Validation criteria for test results

| Specimen | Compressive strength(14 days) (MPa) | Avg. Compressive Strength (MPa) | Variation from mean (%) | Remarks | Validation |
|---|---|---|---|---|---|
| 1 (Cube) | 20.85 | 22.306 | 6.53 | Within 15% | OK |
| 2 (Cube) | 22.46 | | 0.69 | Within 15% | OK |
| 3 (Cube) | 23.61 | | 5.84 | Within 15% | OK |

The samples pass the validation criteria.
According to IS 456:2000 the acceptance criteria for 28 days compressive strength is given . Since we conduct the test within 14 days , the criteria cant be used . So for acceptance , the deviation from standard strength for 14 days is calculated . The 14 days standard compression strength of the samples is taken as 90% of 28 days standard compressive strength ( 90% of 25 MPa = 22.5 MPa) . From the test result the mean compressive strength of the samples is found to be 22.306 MPa with deviation of 0.862% from its standard value . The deviation is within 2% . So the samples are accepted .
Similarly the water absorption test of sample shows the average result of 0.589% . This indicates the specimens were well compacted with minimal voids.
The slump test resulted the slump value of 20mm with true slump in shape . According to the standard guidelines for workable concrete, the slump should ideally be between 25mm and 75 mm . The result is slightly out of range . This may be due to unmatchable data provided for specific gravity of coarse aggregates and fine aggregates and some of our field assumptions on

mix design process . The governing factor for this may also be loss of water in evaporation since the mixing was carried out on sunny day in open area.
In overall analysis, the concrete's performance in compressive strength and water absorption indicates that the mix is generally well proportionated and suitable for practical use.

## CONCLUSION AND RECOMMENDATIONS:

The compressive strength test results for the samples indicate satisfactory performance, as the samples meet the validation criteria specified in IS 456:2000 . The mean compressive strength was calculated as **22.306 MPa**, which is within **2% deviation** from the expected standard value (22.5 MPa). The results also demonstrate good compaction and minimal void content, as validated by the water absorption test results (0.589%). However, the observed slump value of **20 mm** slightly falls below the ideal range for a well-workable concrete mix (25–75 mm), indicating a potential need for adjustments in mix design or site handling practices.
To improve workability and ensure consistency in future trials, adjustments in the water-cement ratio or the use of admixtures like superplasticizers are recommended to achieve a slump within the ideal range of 25–75 mm. Careful monitoring of material properties, including aggregate grading and specific gravity, should be maintained to minimize variability. Additionally, site conditions, such as exposure to direct sunlight during mixing, should be managed to reduce water loss. Finally, 28-day compressive strength tests should be conducted to verify compliance with the target characteristic strength.

# REFERENCES:

1) Indian Standards Institution. (2019). IS 10262:2019 - *Concrete mix proportioning – Guidelines*. Bureau of Indian Standards.
2) Indian Standards Institution. (2000). IS 456:2000 - *Code of practice for plain and reinforced concrete*. Bureau of Indian Standards.
3) Shetty, M. S. (2019). *Concrete Technology: Theory and Practice*. S. Chand & Company, New Delhi.

## APPENDICES:

The following photographs were clicked during mix preparation & hence the moulding of cube samples on the very first day of mix design, on 20th November, 2024 at Sagarmatha Engineering College; Sanepa, Lalitpur.

Photo-1: *Fixing and Lubricating of moulds*


Photo-2: *43 Grade OPC Cement*

Photo-3: *Weight measurement of ingredients used*

Photo-4: *Dry Mixing*

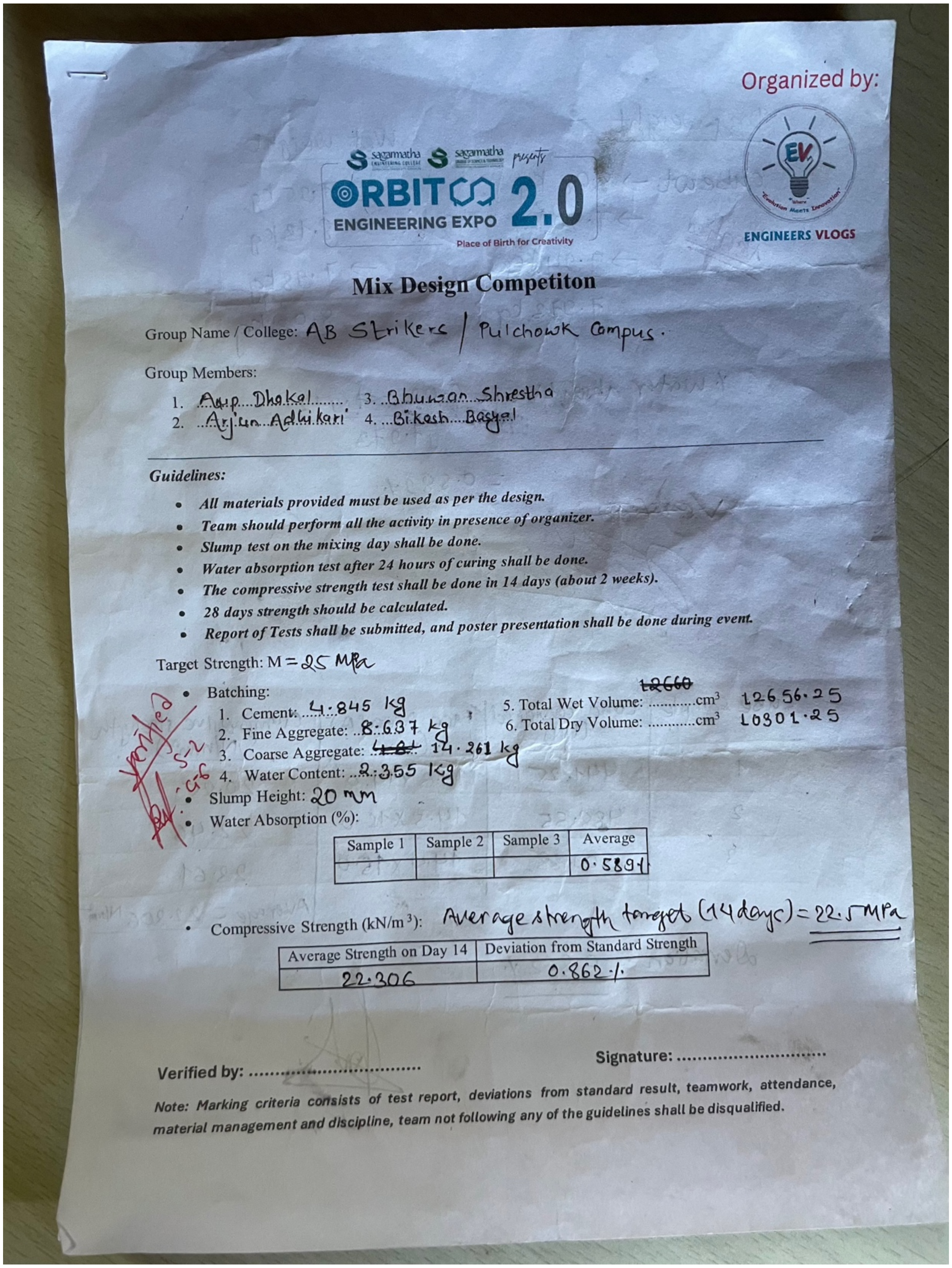

Photo-5: *Mixing works*

Photo-6: *Slump test of Workability*



Photo-7: *Group Photo with the prepared Cube Samples*

*From Left to Right:*
Bikash Basyal, Anup Dhakal, Bhuwan Shrestha, Arjun Adhikari
Team- AB Strikers, Pulchowk Campus



Organized by:

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ORBIT 2.0 ENGINEERING EXPO

Place of Birth for Creativity

ENGINEERS VLOGS

**Mix Design Competiton**

Group Name / College: AB Strikers / Pulchowk Campus.

Group Members:

1. Anup Dhakal 3. Bhuwan Shrestha
2. Arjun Adhikari 4. Bikesh Basyal

***Guidelines:***

- *All materials provided must be used as per the design.*
- *Team should perform all the activity in presence of organizer.*
- *Slump test on the mixing day shall be done.*
- *Water absorption test after 24 hours of curing shall be done.*
- *The compressive strength test shall be done in 14 days (about 2 weeks).*
- *28 days strength should be calculated.*
- *Report of Tests shall be submitted, and poster presentation shall be done during event.*

Target Strength: M = 25 MPa

- Batching:
  1. Cement: 4.845 kg
  2. Fine Aggregate: 8.637 kg
  3. Coarse Aggregate: ~~4.81~~ 14.261 kg
  4. Water Content: 2.355 kg
  5. Total Wet Volume: ~~12660~~ 12656.25 $cm^3$
  6. Total Dry Volume: 10301.25 $cm^3$
- Slump Height: 20 mm
- Water Absorption (%):

| Sample 1 | Sample 2 | Sample 3 | Average |
|---|---|---|---|
| | | | 0.5891 |

- Compressive Strength ($kN/m^3$): Average strength target (14 days) = 22.5 MPa

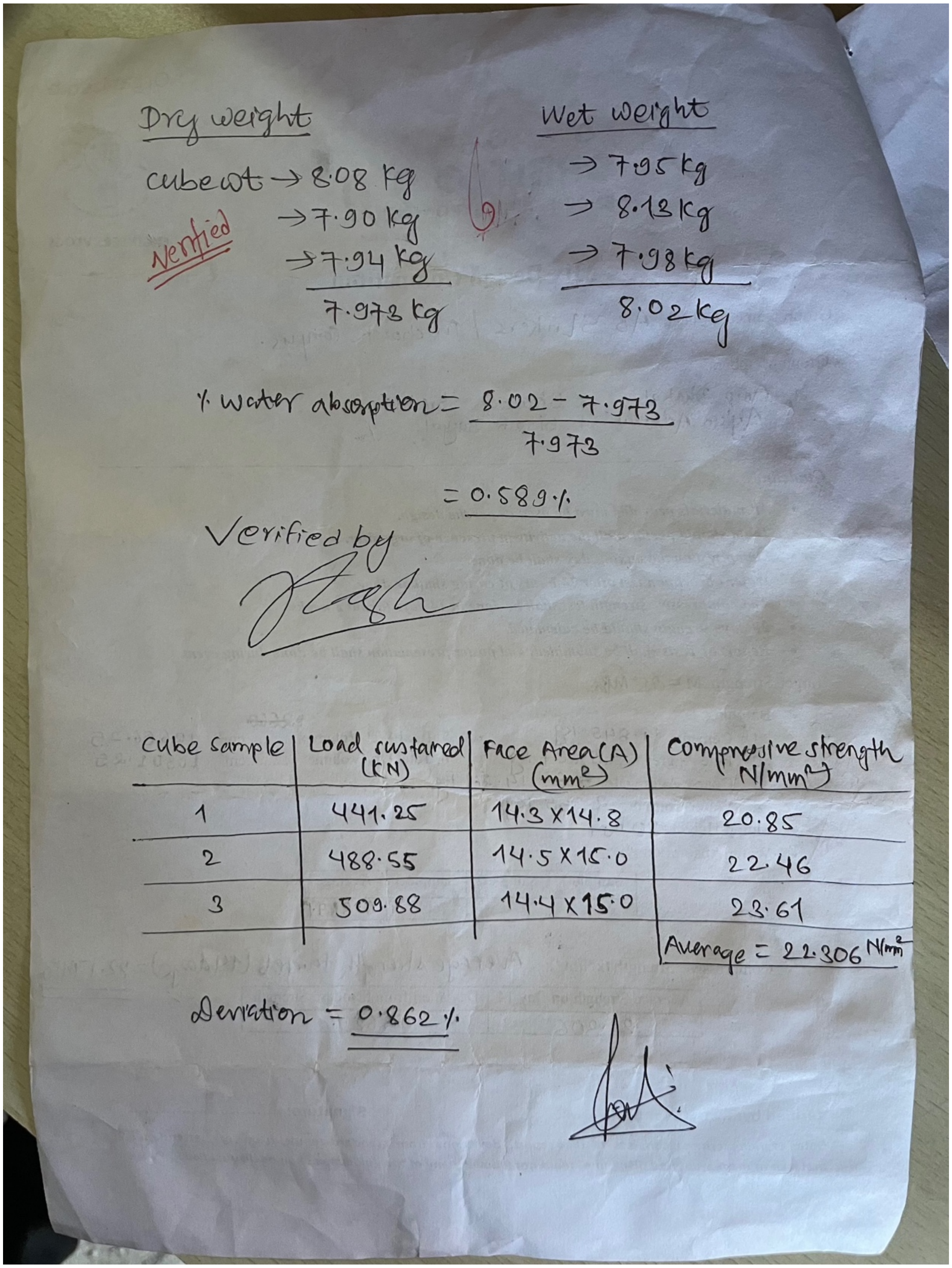
| Average Strength on Day 14 | Deviation from Standard Strength |
|---|---|
| 22.306 | 0.862 % |

Verified 5-2 ... 6-6

Verified by: ..............................  Signature: ..............................

Note: Marking criteria consists of test report, deviations from standard result, teamwork, attendance, material management and discipline, team not following any of the guidelines shall be disqualified.

Photo-8: Concrete Mix Field Observation Sheet



Dry weight

cube wt → 8.08 kg
→ 7.90 kg
→ 7.94 kg

7.973 kg

Verified

Wet weight

→ 7.95 kg
→ 8.13 kg
→ 7.98 kg

8.02 kg

% water absorption = $\frac{8.02 - 7.973}{7.973}$

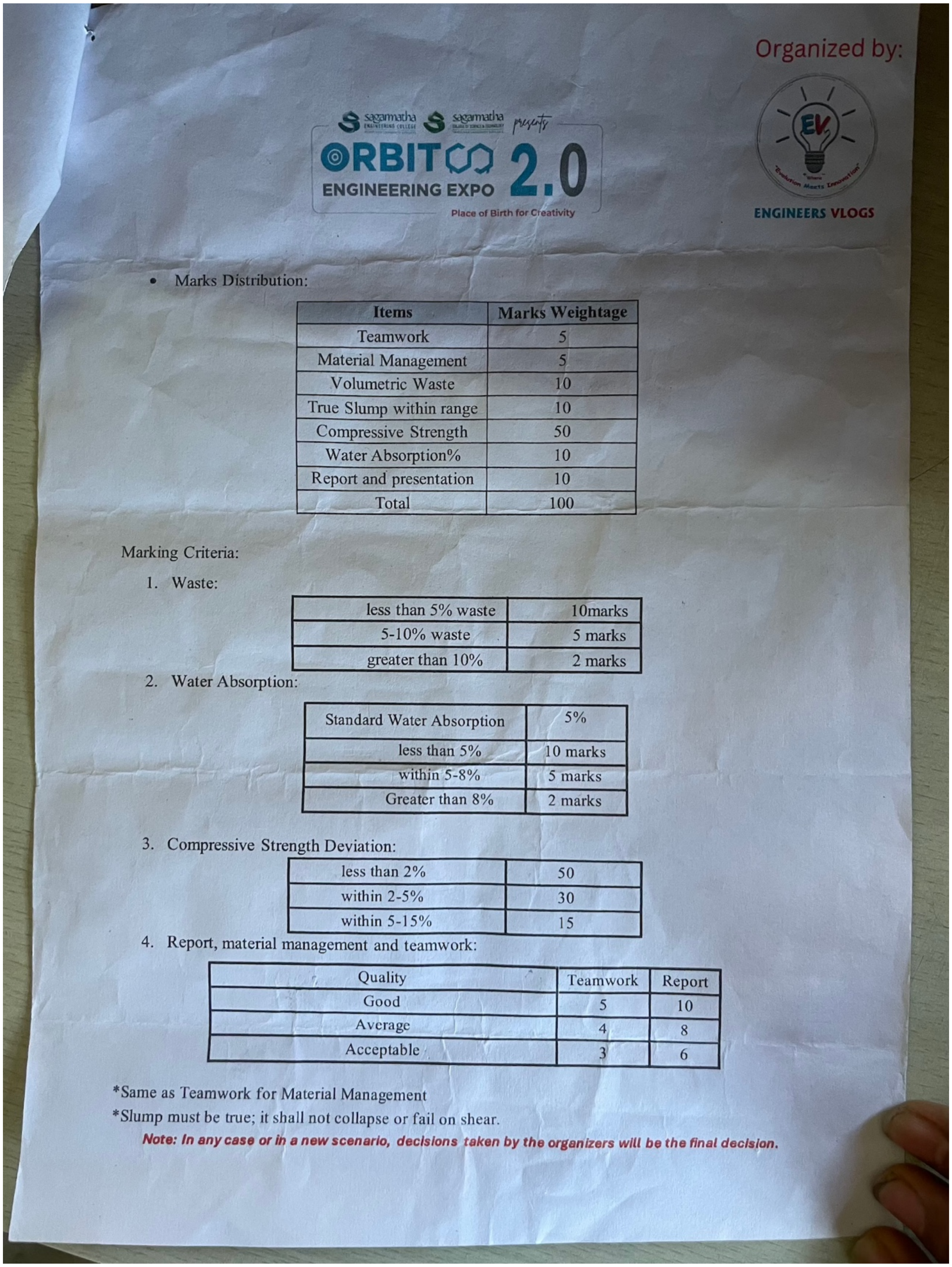
= 0.589 %

Verified by

| Cube sample | Load sustained (KN) | Face Area (A) (mm²) | Compressive strength N/mm² |
|---|---|---|---|
| 1 | 441.25 | 14.3 X 14.8 | 20.85 |
| 2 | 488.55 | 14.5 X 15.0 | 22.46 |
| 3 | 509.88 | 14.4 X 15.0 | 23.61 |
| | | | Average = 22.306 N/mm² |

Deviation = 0.862 %

Photo-9: Water Absorption and Deviation Calculation in the Field



Organized by:

sagarmatha sagarmatha presents

ORBIT 2.0

ENGINEERING EXPO

Place of Birth for Creativity

ENGINEERS VLOGS

- Marks Distribution:

| Items | Marks Weightage |
|---|---|
| Teamwork | 5 |
| Material Management | 5 |
| Volumetric Waste | 10 |
| True Slump within range | 10 |
| Compressive Strength | 50 |
| Water Absorption% | 10 |
| Report and presentation | 10 |
| Total | 100 |

Marking Criteria:

1. Waste:

| | |
|---|---|
| less than 5% waste | 10marks |
| 5-10% waste | 5 marks |
| greater than 10% | 2 marks |

2. Water Absorption:

| | |
|---|---|
| Standard Water Absorption | 5% |
| less than 5% | 10 marks |
| within 5-8% | 5 marks |
| Greater than 8% | 2 marks |

3. Compressive Strength Deviation:

| | |
|---|---|
| less than 2% | 50 |
| within 2-5% | 30 |
| within 5-15% | 15 |

4. Report, material management and teamwork:

| Quality | Teamwork | Report |
|---|---|---|
| Good | 5 | 10 |
| Average | 4 | 8 |
| Acceptable | 3 | 6 |

*Same as Teamwork for Material Management

*Slump must be true; it shall not collapse or fail on shear.

**Note: In any case or in a new scenario, decisions taken by the organizers will be the final decision.**

Photo-10: *Marks distribution and marking criteria*