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CONCRETE MATERIALS LABORATORY

PRACTICAL REPORT ON CONCRETE MATERIALS;

THE QUANTITIES OF MATERIALS IN ONE CUBIC METER (1 m^3) OF CONCRETE USING DIFFERENT MIX RATIOS.

BY

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CERTIFICATION

We certify that this report has been conducted by all the listed members of the group under the supervision of Engr. Buba A. Umdagas of Civil and Water Resources Engineering, Faculty of Engineering, University of Maiduguri.

DEDICATION

This Practical Report is dedicated to Almighty God, Our Lovely Parents and Guardians.

ACKNOWLEDGEMENT

First of all, we thank Almighty God who has given us ability to sail through the undulating pathways. May his peace and blessings be upon on us and our families. Our ample thanks and inevitable appreciation with great honour to goes to our parents, for their unending supports and prayers, care and non-fading love from cradle to adulthood. Our profound gratitude and appreciation goes to our erudite lecturer and supervisor, Engr. Buba A. Umdagas. We will not forget our friends and colleagues, indeed you have inspired something into our work and life.

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ABSTRACTS

A Concrete structure may consist of beams, slabs, columns and foundations etc. based on type of structure. The volume of concrete required for concrete structure can be calculated by summing up the volumes of each structural member or each part of members. The volume of a rectangular cross sectional member can be calculated as length x width x height (or depth or thickness). Quantity of materials such as cement, sand, coarse aggregates and water required per cubic meter of concrete and mortar varies with the mix design of the concrete and mortar respectively. The experimental was able to gives the estimated quantity of materials required per cubic meter of mortar and concrete for various nominal mixes. The method of calculation for the quantities of materials for concrete takes into account the mix proportions from design mix or nominal mixes for structural strength and durability requirement.

AIMS AND OBJECTIVES

- To enable students to know the quantities of materials that makes up one cube meter of concrete at different mix ratios.
- To enable student to be able to calculated and mix design.
- To know the weight and volume of a bag of cement, head pan and wheel barrow.

INTRODUCTION

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as cement fondué. However, asphalt concrete, which is frequently used for road surfaces, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer (<http://en.wikipedia.org>).

When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete (<http://en.wikipedia.org>).

Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are strong in tension (often steel). The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop. Concrete has a very low coefficient of thermal expansion, and as it matures concrete shrinks. All concrete structures will crack to some extent, due to shrinkage and tension. Concrete which is subjected to long-duration forces is prone to creep (<http://en.wikipedia.org>).

The formula for calculation of materials for required volume of concrete is given by:

$$V_c = \frac{W}{1000} + \frac{C}{1000S_c} + \frac{F_a}{1000S_{fa}} + \frac{C_a}{1000S_{ca}}$$

Where, V_c = Absolute volume of fully compacted fresh concrete

W = Mass of water

C = Mass of cement

F_a = Mass of fine aggregates

C_a = Mass of coarse aggregates

S_c , S_{fa} and S_{ca} are the specific gravities of cement, fine aggregates and coarse aggregates respectively. The air content has been ignored in this calculation.

METHODOLOGY

APPARATUS

a. Wheel Barrow.

b. Head Pan.

c. Graduated cylinder.

d. Shovel.

e. Weighing balance.

MATERIALS USED

a. Cement.

b. Fine sand.

c. Coarse sand.

d. Gravel.

e. Water.

PROCEDURE

Mix Design for M15 (1:2:4) Grade Concrete

M15 – M represents Mix and 15 N/mm² is the characteristic compressive strength of concrete cube at 28 days.

Required data M15 Grade Concrete

Grade of concrete = M15

Characteristic compressive strength of concrete at 28 days = 10 N/mm²

Nominal maximum size of aggregate = 20 mm

Specific Gravity of cement = 3.15

Specific gravity of fine aggregate = 2.6

Specific gravity of Coarse aggregate = 2.65

Step 1: Calculation of Target Strength

Target mean strength of concrete is derived from the below formula

$$f_t = f_{ck} + 1.65 s$$

Where S = standard deviation which is taken as per below the IS 456-2000 table = 3.5

Grade of concrete	Standard deviation (N/mm ²)
M10	3.5
M15	3.5
M20	4.0
M25	4.0
M30	5.0
M35	5.0
M40	5.0
M45	5.0
M50	5.0

Source: IS 456-2000.

Characteristic compressive strength after 28 days $f_{ck} = 15\text{N/mm}^2$

$$f_t = 10 + 1.65 \times 3.5$$

Therefore, target mean strength $f_t = 20.775\text{ N/mm}^2$

Step 2: Selection of Water-Cement Ratio

Water- cement ratio is selected from the graph plotted between 28-day compressive strength and water-cement ratio which is as per IS10262-2009

So, W/C ratio = 0.45

From table 5 of IS 456-2000, maximum free water –cement ratio for moderate exposure is

W/c ratio = 0.50

Final water cement ration will be taken as minimum of the above two values,

Therefore, W/C ratio = 0.48

Step 3: Air Content Calculation

Nominal maximum size of aggregate taken is = 20mm

Nominal maximum size of aggregate	Air content (% of volume of concrete)
10mm	5%
20mm	2%
40mm	1%

Source: IS 456-2000.

So, from the table entrapped air content in % of volume of concrete = 2%

Step 4: Water Content Calculation

For nominal maximum size of aggregate of 20mm, the required water content is selected from the table and it is

W = 186 liters

Nominal maximum size of aggregate	Maximum water content
10mm	208
20mm	186
40mm	165

Source: IS 456-2000.

The aggregate nominal maximum size is 20mm and they belong to zone 2. So, Adjustment for compacting factor is to be applied.

Therefore, water content = $186 + (186 \times 3/100) = 191.6 \text{ lit / m}^3$ of concrete.

Step 5: Cement Content Calculation

From step 2, Water cement ratio = $W/C = 0.48$

From step 4, Water content W = 191.6 liters = 191.6kg

$$191.6 / C = 0.48$$

Finally, $C = 399.17 \text{ Kg / m}^3$ of concrete

But from table 5 of IS456-2000, Minimum cement content required for moderate exposure condition for M10 grade concrete is $= 240 \text{ Kg/m}^3$ of concrete.

Greater of above two values will be the cement content.

Hence, $C = 399.17 \text{ Kg}$

Step 6: Aggregate Ratio for Concrete

From the IS 456-2000 table, ratio of volume of coarse aggregate to volume of total aggregate, for 20mm nominal maximum size aggregate and zone-2 fine aggregate.

Therefore, $P = 0.62$

Step 7: Aggregate Content Calculation

Volume of concrete (with entrapped air) $= 1 \text{ m}^3$

From step 3, Entrapped air % $= 2\% = 0.02$

Therefore, volume of concrete (without air content) $= 1 - 0.02 = 0.98 \text{ m}^3$

Fine aggregate content F.A is determined from below formula,

$$V = [W + C/G_c + (1 / (1 - P) \times (F.A) / G_f)] \times 1/1000$$

$$0.98 = [191.6 + 399.17/3.15 + (1 / (1 - 0.62) \times (F.A) / 2.6)] \times 1/1000$$

Therefore, amount of fine aggregate F.A = 799.81kg

Similarly, Coarse aggregate content C.A is derived from

$$V = [W + C/G_c + (1/(1-P)) \times (C.A)/G_f] \times 1/1000$$

$$0.98 = [191.6 + 399.17/3.15 + (1/(1-0.62)) \times (C.A)/2.65] \times 1/1000$$

Therefore, amount of coarse aggregate C.A = 1330kg

Step 8: Final Mix Proportions of Ingredients

W/C ratio = 0.48

Cement quantity = 399.17Kg = 400kg

Fine aggregate quantity = 799.81kg = 800kg

Coarse aggregate Quantity = 1330.01 kg = 1340kg

Mix proportion = Cement: F.A: C.A = 1:2:3.4

QUANTITIES OF MATERIALS FOR ONE CUBIC METER OF CONCRETE USING 1:3:6 MIX RATIOS

Step 1: volume required is 1m^3 .

Step 2: at a ratio 1:3:6 ($1+3+6 = 10$).

Step 4: Considering 2% entrained air, the actual volume of concrete is;

- 2% of $1\text{m}^3 = \frac{2}{100} \times 1\text{m}^3 = 0.02\text{m}^3$.
- $1\text{m}^3 - 0.02\text{m}^3 = 0.98\text{m}^3$. (This means after compaction it will be 0.98m^3).
- To avoid shortage after compaction, add 0.02m^3 ($1\text{m}^3 + 0.02\text{m}^3 = 1.02\text{m}^3$).

Step 3: Calculate the Volume of materials;

- Volume of cement required is just 1 part of 10 --- $\frac{1}{10} \times 1.02 = 0.102\text{m}^3$
- Volume of fine sand required is 3 parts of 10 --- $\frac{3}{10} \times 1.02 = 0.306\text{m}^3$
- Volume of coarse sand required is 6 parts of 10 --- $\frac{6}{10} \times 1.02 = 0.612\text{m}^3$

Step 5: Convert required volume to weight by multiplying their densities;

- weight of cement required is ---- $0.102\text{m}^3 \times \frac{1440\text{kg}}{\text{m}^3} = 146.88\text{kg}$
- weight of fine sand required is ---- $0.306\text{m}^3 \times \frac{1600\text{kg}}{\text{m}^3} = 489.60\text{kg}$
- weight of coarse sand required is ---- $0.612\text{m}^3 \times \frac{1650\text{kg}}{\text{m}^3} = 1009.80\text{kg}$
- weight of water required is ---- $146.88\text{kg} \times 0.50 = 73.44\text{kg}$

Step 6: For true water content multiply by the average specific density of the most water absorbing aggregate (in this case 2.6);

- True water content ---- $73.44kg \times 2.60 = 190.94kg$ (190.94 litres).

Step 7: $1m^3$ concrete has a density of $2500kgm^3$.

- Weight of $1m^3$ at 1:3:6 is $(146.88 + 489.60 + 1009.80 + 190.94 = 1837.22kg)$.

The steps above were repeated in order to calculate for other mix ratios.

RESULTS OF THE EXPERIMENT

Table 1: Cement weight and volume in different containers

<i>Containers</i>	<i>Weight (kg)</i>	<i>Volume (m³)</i>	<i>Density (kg/m³)</i>
<i>Bag of cement</i>	50	0.0347	1440
<i>Head pan</i>	25	0.0174	1440
<i>Wheel barrow</i>	100	0.0694	1440

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Observations from the table 1:

It can be observed that by multiplying the volume of each container by the density of cement, the result is the true weight of the cement in that container.

- **One** bag of cement is equivalent to **two** head pans.
- **One** wheel barrow of cement is equivalent to **four** head pans.
- **One** wheel barrow of cement is equivalent to **two** bags of cement.

Table 2: Fine Sand weight and volume in different containers

<i>Containers</i>	<i>Weight (kg)</i>	<i>Volume (m³)</i>	<i>Density (kg/m³)</i>
<i>Trip lorry of Fine Sand</i>	6096	3.1	1600
<i>Head pan</i>	28	0.0174	1600
<i>Wheel barrow</i>	111	0.0694	1600

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Observations from the table 2:

It can be observed that by multiplying the volume of each container by the density of Fine Sand, the result is the true weight of the fine sand in that container.

- **One** trip lorry of fine sand is equivalent to **218** head pans.
- **One** trip lorry of fine sand is equivalent to **55** wheel barrow.
- **One** wheel barrow of fine sand is equivalent to **four** head pans.

Table 3: Coarse Sand weight and volume in different containers

<i>Containers</i>	<i>Weight (kg)</i>	<i>Volume (m³)</i>	<i>Density (kg/m³)</i>
<i>Trip lorry of Fine Sand</i>	6287	3.1	1650
<i>Head pan</i>	29	0.0174	1650
<i>Wheel barrow</i>	115	0.0694	1650

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Observations from the table 3:

It can be observed that by multiplying the volume of each container by the density of coarse sand, the result is the true weight of the coarse sand in that container.

- **One** trip lorry of fine sand is equivalent to **217** head pans.
- **One** trip lorry of fine sand is equivalent to **55** wheel barrow.
- **One** wheel barrow of fine sand is equivalent to **four** head pans.

Table 4: Gravel weight and volume in different containers

<i>Containers</i>	<i>Weight (kg)</i>	<i>Volume (m³)</i>	<i>Density (kg/m³)</i>
<i>Trip lorry of Fine Sand</i>	9030	3.1	2370
<i>Head pan</i>	41	0.0174	2370
<i>Wheel barrow</i>	165	0.0694	2370

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Observations from the table 4:

It can be observed that by multiplying the volume of each container by the density of gravel, the result is the true weight of the gravel in that container.

- **One** trip lorry of fine sand is equivalent to **219** head pans.
- **One** trip lorry of fine sand is equivalent to **55** wheel barrow.
- **One** wheel barrow of fine sand is equivalent to **four** head pans.

Table 5: Quantities of Materials for One Cubic Meter of Concrete for Difference Mix Ratios

<i>Mix Ratio</i>	<i>Cement (kg)</i>	<i>Fine Sand (kg)</i>	<i>Coarse Sand (kg)</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	146.88	489.60	1009.80	190.94	2057.54
1:2:4	210.04	467.20	960.30	141.98	1993.06
1:1.5:3	267.84	444.80	917.40	133.92	1964.12

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Table 6: Quantities of Materials by Head Pan for One Cubic Meter of Concrete for Difference Mix Ratios

<i>Mix Ratio</i>	<i>Cement</i>	<i>Fine Sand</i>	<i>Coarse Sand</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	3 bags	18 pans	35 pans	191	2058
1:2:4	4 bags	17 pans	33 pans	142	1993
1:1.5:3	5 bags	16 pans	32 pans	134	1964

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Table 7: Quantities of Materials by Wheel Barrow for One Cubic Meter of Concrete for Difference Mix Ratios

<i>Mix Ratio</i>	<i>Cement</i>	<i>Fine Sand</i>	<i>Coarse Sand</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	3 bags	4 Wheel Barrows	9 Wheel Barrows	191	2058
1:2:4	4 bags	4 Wheel Barrows	8 Wheel Barrows	142	1993
1:1.5:3	5 bags	4 Wheel Barrows	8 Wheel Barrows	134	1964

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

Table 8: Quantities of Materials for One Cubic Meter of Concrete for Difference Mix Ratios

<i>Mix Ratio</i>	<i>Cement (kg)</i>	<i>Fine Sand (kg)</i>	<i>Coarse Sand (kg)</i>	<i>Gravel (kg)</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	147	490	505	725	191	2058
1:2:4	210	467	482	692	142	1993
1:1.5:3	268	445	459	659	134	1964

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

**Table 9: Quantities of Materials by Head Pan for One Cubic Meter of Concrete for
Difference Mix Ratios**

<i>Mix Ratio</i>	<i>Cement</i>	<i>Fine Sand</i>	<i>Coarse Sand</i>	<i>Gravel</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	3 bags	18 pans	17 pans	18 pans	191	2058
1:2:4	4 bags	17 pans	17 pans	17 pans	142	1993
1:1.5:3	5 bags	16 pans	16 pans	16 pans	134	1964

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

**Table 10: Quantities of Materials by Wheel Barrow for One Cubic Meter of Concrete for
Difference Mix Ratios**

<i>Mix Ratio</i>	<i>Cement</i>	<i>Fine Sand</i>	<i>Coarse Sand</i>	<i>Gravel</i>	<i>Water Content at 0.50 (litre)</i>	<i>Weight of concrete (kg)</i>
1:3:6	2.94 bags	4 Wheel Barrows	4 Wheel Barrows	4 Wheel Barrows	191	2058
1:2:4	4.2 bags	4 Wheel Barrows	4 Wheel Barrows	4 Wheel Barrows	142	1993
1:1.5:3	5.4 bags	4 Wheel Barrows	4 Wheel Barrows	4 Wheel Barrows	134	1964

Source: University of Maiduguri, Faculty of Engineering, Department of Civil and Water Resources, Laboratory Test and Measurements, 2017.

CONCLUSION

We were able to complete the experiments and measure the various capacities of containers usually used in measuring and transporting materials at construction sites. We were able to estimate the volume as well as the weight of all the materials most commonly used in concrete namely; cement, fine sand, coarse sand, gravel etc. We were able to estimate the quantities of materials required for one cubic meter of concrete using various measuring techniques.

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