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Ph.: 9021300500
E-mail: infomep@madeeasy.in
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Civil Services Main Examination Previous Years Solved Papers : Civil Engineering (Paper-II)

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Preface

B. Singh (Ex. IES)

Civil Service is considered as the most prestigious job in India and it has become a preferred destination by all engineers. In order to reach this estimable position every aspirant has to take arduous journey of Civil Services Examination (CSE). Focused approach and strong determination are the pre-requisites for this journey. Besides this, a good book also comes in the list of essential commodity of this odyssey.

I feel extremely glad to launch the revised edition of such a book which will not only make CSE plain sailing, but also with 100% clarity in concepts.

MADE EASY team has prepared this book with utmost care and thorough study of all previous years papers of CSE. The book aims to provide complete solution to all previous years questions with accuracy.

On doing a detailed analysis of previous years CSE question papers, it came to light that a good percentage of questions have been asked in Engineering Services, Indian Forest Service and State Services exams. Hence, this book is a one stop shop for all CSE/IRMSE, ESE, IFS and other competitive exam aspirants.

I would like to acknowledge efforts of entire MADE EASY team who worked day and night to solve previous years papers in a limited time frame and I hope this book will prove to be an essential tool to succeed in competitive exams and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

With Best Wishes

B. Singh (Ex. IES)

CMD, MADE EASY Group

Previous Years Solved Papers of

Civil Services Main Examination

Civil Engineering : Paper-II

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1 Building Materials and Construction Technology

1. Concrete

1.1 (i) Explain how fly-ash can be used in the production of bricks.
(ii) Discuss briefly the applications of fibre reinforced concrete in buildings.

[1996 : 20 Marks]

Solution:

(i) Fly-ash building bricks :

- The chemical composition of clays and fly-ash do not differ very much and the residual carbon content in the fly-ash brings economy in the fuel consumption during firing of bricks.
- The process involves the use of fly-ash, lime, sand and a small quantity of magnesium chloride as chemical accelerator. The fly-ash, sand and lime are mixed approximately in the ratio of 80 : 13 : 7. The hydraulic press is used for making these bricks and ultimately, the semi-dried bricks are cured in a steam chamber at appropriate pressure and temperature.
- The fly-ash buildings are superior to the conventional burnt bricks in shape, technical specifications, compressive strength and impermeability. They are also 20% light in weight and about 10 to 15% cheap as compared to the conventional bricks.

(ii) Applications of fibre reinforced concrete :

- The plain concrete fails suddenly when the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand fibre-reinforced concrete (FRC) continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete.
- Steel FRC (SFRC) is very ductile and particularly well suited for structures which are required to exhibit:
  (a) high fatigue strength, resistance to impact and shock loads.
  (b) shrinkage control of concrete
  (c) very high flexural strength, tensile strength and shear strength
  (d) Erosion and abrasion resistance to splitting
  (e) High thermal resistance
  (f) Earthquake resistance
- The largest application of SFRC is in floor slab construction.
- Glass FRC(GFRC) is used in facing panels, piping for sanitation network systems, and decorative non-recoverable framework.
- Asbestos fibres have thermal, mechanical and chemical resistance making them suitable for sheet product, piles, tiles and corrugated roofing elements.

1.2 Calculate quantities of various ingredient (by weight) of 1 : 2 : 4 cement concrete required to prepare 4 cylinders of 10 cm diameter and 30 cm height.

[1996 : 15 Marks]

Solution:

$$\text{Volume of concrete required} = 4\times\left(\pi\times\frac{d^2}{4}\times h\right) = 4\times\pi\times\frac{(0.1)^2}{4}\times 0.3$$

$$= 9.4248\times 10^{-3}\ \text{m}^3$$

Assume the following :

Cement : specific gravity 3.15 (G_c)

Sand : Specific gravity 2.65 (G_s)

Coarse aggregate : Specific gravity 2.80 (G_G)

Water-cement ratio = 0.5

$$\text{Volume of concrete} = \text{volume of voids} + \text{volume of solids}$$

$$\text{Assume volume of air} = 0$$

$$\Rightarrow \quad \text{volume of voids} = \text{volume of water}$$

$$V_c = V_w + V_c + V_s + V_G$$

or,
$$V_c = \frac{M_w}{\rho_w} + \frac{M_c}{G_c.\rho_w} + \frac{M_s}{G_s.\rho_w} + \frac{M_G}{G_a.\rho_w}$$

or,
$$V_c = \frac{1}{\rho_w}\left[0.5M_c + \frac{M_c}{3.15} + \frac{2.M_c}{2.65} + \frac{4.M_c}{2.8}\right]$$

or,
$$9.4248\times 10^{-3} = \frac{1}{1000}\times[3.007M_c]$$

$$\Rightarrow \quad M_c = 3.1408\ \text{kg}$$

$$\therefore \quad M_w = 1.5704\ \text{kg;}$$

$$M_s = 6.2816\ \text{kg;}$$

$$M_G = 12.5632\ \text{kg}$$

1.3 Find the quantity of cement, sand and coarse aggregates required for 15 m^3 of 1 : 5 : 10 plain cement concrete and 50 m^2 of 1 : 5 cement plaster 1.25 cm thick

[1999 : 20 Marks]

Solution:

$$\text{Volume of concrete} = 15\ \text{m}^3$$

$$W_c : W_s : W_a = 1 : 5 : 10$$

Let water-cement ratio be 0.50 and percentage air voids be 3%

$$\text{Net volume of concrete} = 15 - \frac{3}{100}\times 15 = 14.55\ \text{m}^3$$

Let specific gravity of cement be 3.15

Let specific gravity of sand be 2.60

Let specific gravity of coarse aggregates be 2.8

$$\Rightarrow \quad 14.55 = \text{volume of water} + \text{volume of solids}$$

or,
$$14.55 = \frac{0.5W_c}{1000} + \frac{W_c}{G_c\times 1000} + \frac{W_s}{G_s\times 1000} + \frac{W_a}{G_a\times 1000}$$

or,
$$14.55\times 1000 = 0.5W_c + \frac{W_c}{3.15} + \frac{5.W_c}{2.60} + \frac{10W_c}{2.8}$$

$$\Rightarrow \quad W_c = 2305.14\ \text{kg}$$

$$\therefore \quad W_s = 11525.73\ \text{kg}$$

$$W_a = 23051.4 \text{ kg}$$

$$\text{Volume of plaster} = 50 \times \frac{1.25}{100} = 0.625 \text{ m}^3$$

Considering 25% more due to losses,

$$\therefore \quad \text{Volume of mortar} = 0.625 + 0.25 \times 0.625 = 0.78125 \text{ m}^3$$

[Assuming 1 : 5 as ratio by volume]

$$\text{Quantity of cement required} = \frac{0.78125}{6} = 0.13021 \text{ m}^3$$

$$\text{1 bag of cement} = 0.0347 \text{ m}^3$$

$$\therefore \quad \text{Number of bags} = \frac{0.13021}{0.0347} = 3.75 \simeq 4 \text{ bags}$$

$$\text{and} \quad \text{Quantity of sand} = 0.13021 \times 5 = 0.65105 \text{ m}^3$$

1.4 **Materials required per cu.m. of freshly mixed cement concrete are : 312 kg of dry cement, 855 kg of sand, 1010 kg of gravel and 145 kg of fresh water. Bulking, when mixing in the mixer, is 5%. What would be the density of the freshly mixed and poured cement concrete? What would be the total volume of fresh concrete that can be produced in a nominal 6 cu.m. mixer, in which loading during mixing can be only 65% of nominal capacity, per hour if its working cycle is : charging –35 seconds, mixing 170 seconds, discharging 30 seconds and lost time 18 seconds.**

[2004 : 12 Marks]

Solution:

Let specific gravity of cement be 3.15, of sand be 2.60 and of aggregate be 2.50.

$$\text{Volume of freshly mixed concrete} = \frac{W_w}{1000} + \frac{W_c}{G_c \times 1000} + \frac{W_s}{G_s \times 1000} + \frac{W_a}{G_a \times 1000}$$

$$= \frac{145}{1000} + \frac{312}{3.15 \times 1000} + \frac{855}{2.60 \times 1000} + \frac{1010}{2.5 \times 1000}$$

$$= 0.977 \text{ m}^3$$

$$\text{Density of freshily mixed concrete} = \frac{312 + 855 + 10110 + 145}{0.977} = 2376.66 \text{ kg/m}^3$$

Bulking is 5%,

$$\therefore \quad \text{Volume of poured cement concrete} = 1.05 \times 0.977 = 1.02585 \text{ m}^3$$

$$\text{Density of fresh concrete} = \frac{312 + 855 + 1010 + 145}{1.02585} = 2263.489 .489 \text{ kg/m}^3$$

$$\text{Operating cycle} = 35 + 170 + 30 + 18 = 253 \text{ sec.}$$

$$\text{Number of cycles in 1 hour} = \frac{3600}{253} = 14.229 \simeq 14$$

$$\text{Quantity produced in one cycle} = 0.65 \times 6 = 3.9 \text{ m}^3$$

$$\therefore \quad \text{Quantity produced in one hour} = 3.9 \times 14 = 54.6 \text{ m}^3$$

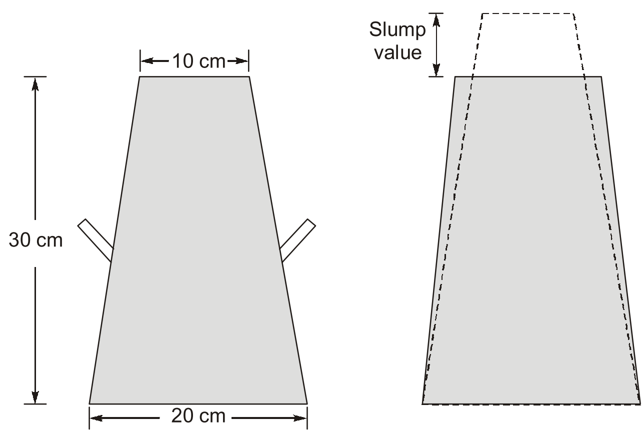
1.5 **What is slump? How is it measured? What are the generally recommended maximum and minimum magnitudes of slump for (i) RCC foundation for walls and footings, (ii) Plain footings, (iii) RCC beams and reinforced walls, and (iv) columns in buildings?**

[2005 : 12 Marks]

Solution:

Slump is a relative measurement in concrete consistency. It is not an indicator of quality of the material. Slump test is the most common method used to find the workability of the concrete in the field and in laboratory. This test is suitable for concrete having medium to high workability.

- The apparatus of this test consists of metallic mould in the shape of frustum of cone having bottom diameter of 20 cm, top diameter of 10 cm, and height of 30 cm, and a damping rod of height 60 cm and diameter 16 mm.
- In order to perform this test, mould is placed over the level ground and concrete is filled in it in four layers, where each layer is properly compacted with the help of the tamping rod by subjecting it to 25 number of blows.
- When the mould is completely filled, it is lifted in vertically upward direction that causes the concrete to subsidise, where this subsidence is referred as slump value, and it is further used to indicate the workability of the concrete.
- In order to measure the slump value, difference in the level of height of the mould and when the top surface of concrete is subsidised, is noted.



Type of concrete	Slump value (mm)	
	Maximum	Minimum
RCC foundation for walls and footings	75	25
Plain footings	75	25
RCC beams and reinforced walls	100	50
Columns in buildings	100	75

1.6 Calculate the quantities of water, cement, sand and coarse aggregate, by weight, required for a concrete batching plant of 5.0 cubic metre capacity from the following data :

S.No.	Item	Bulk density	Specific Gravity
1.	Cement	1500 kg/m^3	3.15
2.	Sand	1700 kg/m^3	2.60
3.	Coarse aggregate	1600 kg/m^3	2.50

Concrete mix proportion is to be 1 : 1.5 : 3 by weight and water-cement ratio is 0.5 by mass. Percentage of air entrained is 2 by volume.

[2007 : 15 Marks]

Solution:

$$W_c : W_s : W_a = 1 : 1.5 : 3$$

$$W/C = 0.5$$

$$\text{Air content} = 2\ \%$$

$$\text{Total volume of concrete} = 5\ m^3$$

$$G_c = 3.15\ ;\ G_s = 2.60;\ G_a = 2.50$$

Let weight of cement be W_c,

Let weight of sand be W_s,

Let weight of aggregate be W_a,

$$\text{Net volume of concrete} = \text{total volume} - \text{volume of air in concrete}$$

$$= 5 - \left(\frac{2}{100} \times 5\right) = 4.9\ m^3$$

$$4.9 = \text{volume of water} + \text{volume of solids}$$

$$4.9 = \frac{0.5 \times W_c}{1000} + \left[\frac{W_c}{G_c \times 1000} + \frac{W_s}{G_s \times 1000} + \frac{W_a}{G_a \times 1000}\right]$$

$$4.9 = \frac{0.5W_c}{1000} + \frac{W_c}{3.15 \times 1000} + \frac{1.5 \times W_c}{2.60 \times 1000} + \frac{3 \times W_c}{2.50 \times 1000}$$

$$4900 = 2.5944\ W_c$$

$\Rightarrow$ $$W_c = 1888.6954\ \text{kg}$$

$\therefore$ $$W_s = 2833.0431\ \text{kg}$$

$$W_a = 5666.0862\ \text{kg}$$

$$\text{Volume of cement} = \frac{1888.6954}{1500} = 1.2591\ m^3$$

$$\text{Volume of sand} = \frac{2833.0431}{1700} = 1.6665\ m^3$$

$$\text{Volume of coarse aggregate} = \frac{5666.0862}{1600} = 3.5413\ m^3$$

1.7 Which two main parameters are defined for fibres in fibre reinforced concrete?

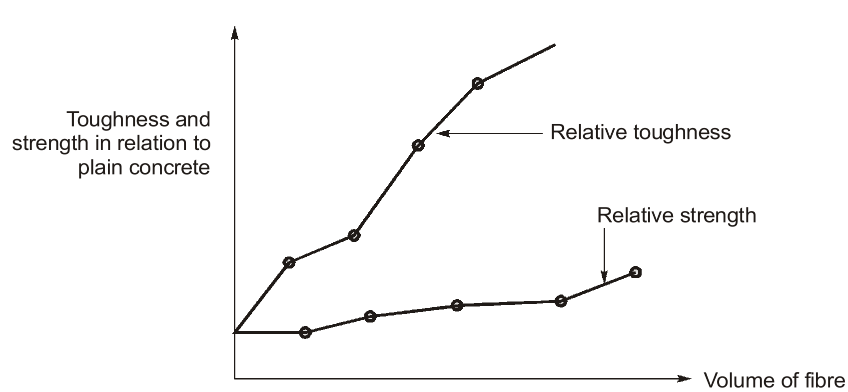
[2007 : 6 Marks]

Solution:

Two main parameters defined for fibres are :

(i) **Aspect ratio of the fibre :** It is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

(ii) **Volume of fibres :** The strength of the composite largely depends on the quantity of fibres used in it. It can be seen from the figure that the increase in the volume of fibres, increase approximately linearly, the tensile strength and toughness of the composite. Use of higher percentage of fibre is likely to cause segregation and harshness of concrete and mortar.



Other parameters are :

- Type of fibre, i.e., the material, and the texture
- orientation of the fibre in the matrix

1.8 Prepare a rate analysis for a 1 : 5 : 10 mix of cement concrete made with graded brick ballast, 40 mm down, for foundation work. Brick ballast required is 0.985 cu.m per cu.m of laid and finished work in this case.

Cost of brick ballast : ₹1800 /- per cu.m;

Medium sand : ₹970/- per cu.m

Cost per bag of cement : ₹170/-

Labour required per 10 Cu.m of finished work :

Senior mason : 1/2 number @ ₹320/- per day;

Mason : 6 number @ ₹275/- per day;

Men labour : 16 numbers @ ₹150/- per day.

[2008 : 12 Marks]

Solution:

Assume the following:

Cement : Specific gravity 3.15 and weight in each bag 50 kg.

Sand : Specific gravity 2.65 and unit weight 16 kN/m^3 when dry.

Coarse aggregate : Specific gravity 2.80 and unit weight 15 kN/m^3 when dry.

Water-cement ratio be 0.5

let total laid and finished work = 1 m^3

$$\therefore \quad 1\text{ m}^3 = \frac{0.5W_c}{1000} + \frac{W_c}{3.15\times1000} + \frac{5W_c}{2.65\times1000} + \frac{10W_c}{2.8\times1000}$$

(We have assumed 0% air content)

$$\Rightarrow \quad W_c = 159.34\text{ kg}$$

$$W_s = 796.7\text{ kg}$$

$$W_a = 1593.4\text{ kg}$$

$$\text{Number of cement bags} = \frac{159.34}{50} = 3.18\text{, say 4}$$

$$\text{volume of sand} = \frac{796.7\times9.81}{16\times10^3} = 0.49\text{ m}^3$$

$$\text{Volume of coarse aggregate} = \frac{1593.4\times9.81}{15\times10^3} = 1.042\text{ m}^3$$

{We have assumed coarse aggregate used is same as brick ballast}

$\therefore$ Total volume of brick ballast = 1.042 + 0.985 = 2.027 m^3

Item	Quantity	Rate	Cost
Cement	4 bags	170/-	₹680
Sand	0.49 m^3	970/-	₹475.3
Ballast	2.027 m^3	1800/-	₹3648.6
			₹4803.9/m^3 of work

Labour	Number (per m^3)	Rate (₹/day)	Cost (₹)
S.mason	0.05	320/-	16
Mason	0.6	275/-	165
Men	1.6	150/-	240
			₹421

Total cost for cu.m of finished work = ₹(4803.9 + 421) = ₹5224.9

1.9 Explain in detail the need and procedure for conducting water absorption test for coarse aggregate to be used in cement concrete.

[2009 : 6 Marks]

Solution:

The water absorption of an aggregate is the percentage by weight of water absorbed in terms of oven dry weight of specimen and it is an accepted measure of porosity. For aggregates normally used in construction, the water absorption value varies from 0.1 to 2%.

Procedure :

(i) The sample of not less than 2000 g should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32°C.

(ii) After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + 1/2 hrs afterwards.

(iii) The basket and aggregates should then be removed from the water, after which the aggregates should be gently emptied from the basket. The aggregates should be surface dried and weighed (A).

(iv) The aggregates should then be placed in an oven at a temperature of 100 to 110°C for 24 hours. It should then be removed from oven, cooled and weighted (B).

$$\text{Water absorption} = \left(\frac{A-B}{B}\right)\times 100$$

1.10 How does water cement ratio affect the strength of concrete?

[2010 : 5 Marks]

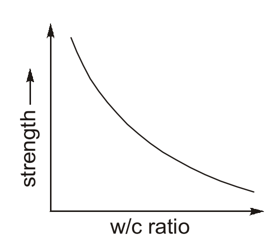
Solution:

The water in concrete has to perform the following two functions :

(i) The water enters chemical action with cement and this action causes the setting and hardening of concrete

(ii) Water makes the concrete workable.

The minimum quantity of water should be used to have reasonable degree of workability. The excess water occupies space in concrete and on evaporation, the voids are created in concrete. Thus the excess water affects considerably the strength and durability of concrete. In general, it may be stated that addition of one extra litre of water to the concrete of one bag of cement will reduce its strength by about 1.47 N/mm^2. In other words, the strength of concrete is inversely proportional to the water-cement ratio.



1.11 Describe in brief the advantage of hollow concrete masonry.

[2011 : 15 Marks]

Solution:

(i) **Rapid execution of work :** Hollow concrete block are of uniform and regular size and it has less weight. This facilitates rapid execution of work.

(ii) **Increase in Floor Area :** It is possible to construct thin walls using hollow blocks. Therefore it helps to save space and increase floor area.
(iii) **Reduce Construction Cost :** It helps in saving construction materials.
(iv) **Better Insulation Properties :** Hollow concrete block have good insulating properties against sound, heat and dampness.
(v) **More durable :** It requires no protective covering.
(vi) **Employment of unskilled labour :** As construction is easy, therefore unskilled labour can be employed.
(vii) Good bonding of mortar and plaster due to presence of rough surface on concrete blocks.

1.12 (i) Which cement would your recommend for
- **mass concrete**
- **low permeability concrete**
- **high strength concrete?**

(ii) Which type of cement concrete you will recommend for 'blast resistance purpose' and why?

[2012 : 5 Marks]

Solution:

(i) Mass concrete → Low heat cement
Low permeability concrete → Portland slag cement
High strength concrete → Rapid hardening cement or 53 grade OPC

(ii) Blast load is applied to concrete structures as an impulsive load of extremely short duration with very high pressure and heat. Therefore, a new material with high-energy absorption capacity and high resistance against impact is a better material for blast resistant design. Ultra-high performance concrete (UHPC) is a new type of concrete that is being developed by agencies. UHPC is characterized by being a steel fibre-reinforced cement composite material with compressive strengths in excess of 150 MPa. It is also characterized by its constituent material make-up, typically fine grained sand, silica fume, small steel fibres and special blends of high strength portland cement.

1.13 Name and discuss at least three advantages of adding appropriate polymer as admixture in cement concrete.

[2013 : 10 Marks]

Solution:

Plasticizers are usually based on lignosulphates, which is a natural polymer, derived from wood processing in the paper industry. These admixtures are used for following purposes :
(i) To achieve a higher strength by decreasing the water cement ratio at the same workability as in admixture free mix.
(ii) To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete.
(iii) To increase the workability so as to ease placing in accessible locations
(iv) Water reduction more than 5% but less then 12%

Action involved :

(i) Dispersion : Surface active agents alter the physical chemical forces at the interface. They are adsorbed on the cement particles, giving them a negative charge which leads to repulsion between the particles. Electrostatic forces are developed causing disintegration and free water become available for workability.
(ii) Lubrication : As these agents are organic by nature, thus they lubricate the mix reducing the friction and increasing the workability.
(iii) Retardation : A thin layer is formed over the cement particles protecting them from hydration and increasing the setting time. Most normal plasticizers give some retardation, 30 – 90 minutes.

1.14 What kind of special attention is necessary for maturing concrete made with fly ash cement as per BSI codal provision?

[2013 : 5 Marks]

Solution:

- Fly ash shall have its chemical characteristics and physical requirements, etc. conforming to **IS : 3812 (Part-I)** and shall be duly certified.
- As per **IS : 1489 (Part-I)** maximum 35% of OPC by mass is permitted to be substituted with flyash conforming to **IS : 3812 (Part-I).**
- When tested by air permeability method, the specific surface of portland-pozzolana cement shall not be less than 300 m^2/kg.
- When tested by **Le Chatelier's** method and **Autoclave test,** unaerated portland-pozzolana cement shall not have an expansion of more than 10 mm and 0.8% respectively.
- Typically, concrete made with fly ash will be slightly lower in strength than plain cement concrete upto 28 days, equal strength at 28 days, and substantially higher strength within a year's time. Developing sustainable concrete to last more than 100 years requires extending the 28 day specifications. Extended age parameters can assure more durable concrete.

1.15 What are the standards given in IS : 456 – 2000 to produce good quality concrete ? Distinguish between repair, restoration and rehabilitation.

[2014 : 10 Marks]

Solution:

Section 10.1 (page 23) of **IS 456 : 2000** provides quality assurance measures to produce good quality concrete.

- Quality assurance measures are both technical and organizational.
- The job of quality control and assurance would involve quality audit of both the inputs as well as outputs.
- Inputs are in the form of materials for concrete; workmanship in all stages of batching, mixing, transportation, placing, compaction and curing; and related plant machinery and equipment; resulting in the output in the form of concrete in place.
- To ensure proper performance, it is necessary that each step in concreting which will be covered by next step is inspected as the work proceeds.
- Each party involved in the realization of a project should establish and implement a quality assurance plan.
- Such documentation should generally include :
  (a) test reports and manufactures certificate for materials, concrete mix design details;
  (b) pour cards for site organization and clearance for concrete placements.
  (c) record of site inspection of workmanship, field tests;
  (d) non-conformance reports, change orders;
  (e) quality control charts
  (f) statistical analysis.
- Volume batching may be allowed only where weight batching is not possible.
- The accuracy of the measuring equipment shall be within ± 2% of the quantity of cement being measured and within ± 3% of quantity of aggregate, admixtures and water being measured.
- Concrete shall be mixed in a mechanical mixer. The mixing time shall be atleast 2 min.

Repair : The main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve structural strength of building. e.g. : Patching up of defects such as cracks.

Restoration : It is the restitution of strength the building had before the damage occurred. The main purpose is to carry out structural repairs to load bearing elements. It may involve cutting portions of elements and rebuilding them, inserting temporary supports, etc. e.g. : injecting epoxy like material, which is strong in tension, into the cracks, in walls, etc.

Rehabilitation : Rehabilitation methods, in addition to restoring structural integrity and shape, mitigate or stop the process responsible for the damage. Because rehabilitation includes addressing the cause of the problem itself, the repairs last significantly longer.

1.16 State the significance of "Rate Analysis' in Estimating and costing of building. Calculate the quantities of cement, sand and coarse aggregate for preparing 1 cu.m of concrete of 1 : 2 : 4 proportion. Also calculate the number of bricks required of size 20 × 10 × 10 for constructing 1 m^2 of brick masonry wall. Explain any one method of building valuation.

[2014 : 20 Marks]

Solution:

At various stages in the project management, we need to know,

- How much is cost of executing unit amount of work.
- How many equipment or labour are required to execute unit amount of an item of work.

These things are required for the purpose of eliminating cost of construction, material planning, labour and equipment allocation in the scheduling etc. Obtaining the cost of unit amount of an item is called rate analysis. To obtain the rate of an item, generally following cost are considered.

- Cost of material
- Cost of labour
- Cost of equipment, plant tools etc.
- Overhead cost
- Profit

$$\text{Volume of concrete} = 1 \text{ m}^3$$

$$W_c : W_s : W_a = 1 : 2 : 4$$

Let water cement ratio be 0.5 and % air content be 3%.

Let us assume specific gravity of cement, sand and coarse aggregate equal to 3.15, 2.60 and 2.50 respectively.

$$\text{Net volume of concrete} = 1 - \frac{3}{100} \times 1 = 0.97 \text{ m}^3$$

$$\frac{0.5W_c}{1000} + \frac{W_c}{G_c \times 1000} + \frac{W_s}{G_s \times 1000} + \frac{W_a}{G_a \times 1000} = 0.97$$

or,

$$0.5W_c + \frac{W_c}{3.15} + \frac{2.W_c}{2.60} + \frac{4.W_c}{2.50} = 0.97 \times 1000$$

$$\Rightarrow \quad W_c = 304.391 \text{ kg (weight of cement)}$$

$$\therefore \quad \text{Weight of sand} = 2W_c = 608.782 \text{ kg}$$

$$\text{Weight of coarse aggregate} = 4W_c = 1217.564 \text{ kg}$$

Let us assume one brick thick wall, i.e. t = 20 cm

$$\Rightarrow \quad \text{Number of bricks} = \frac{\text{Brickwork volume}}{\text{volume of 1 brick}} = \frac{20 \times 1 \times (100)^2}{20 \times 10 \times 10} = 100 \text{ bricks}$$

Methods of building valuation :

(i) Rental method

(ii) Profit based method

(iii) Depreciation method

Rental method of valuation :

- In this method, net income by way of rent is found out by deducting all out goings from the gross rent.
- A suitable rate of interest as prevailing in the market is assumed and year's purchase is calculated.

- This net income multiplied by Y.P. gives the capitalized value or valuation of the property.
- This method is applicable when the rent is known or probable rent is determined by enquiries.

1.17 Write short notes on the following:

(i) Acid attack (ii) Sulphate attack (iii) Alkali attack

On cement concrete

[2014 : 15 Marks]

Solution:

(i) **Acid Attack :** Portland cement is not acid resistant and acid attack may remove part of the set cement. Acids are formed by the dissolution in water of carbon dioxide or sulphur dioxide from the atmosphere. Acids can also come from industrial wastes. Good dense concrete with adequate cover is required and sulphate-resistant cements should be used if necessary.

(ii) **Sulphate Attack :** Sulphate are present in most cement and some aggregates. Sulphates may also be present in soils, groundwater and sea water, industrial wastes and acid rain. The products of sulphate attack on concrete occupy a larger space than the original material and this causes the concrete to disintegrate and permits corrosion of steel to begin. Sulphate-resisting portland cement should be used where sulphates are present in the soil, water or atmosphere and come into contact with concrete. Super-sulphated cement, made from blast furnace slag, can also be used.

(iii) **Alkali Attack :** A chemical reaction can take place between alkali in cement and certain forms of silica in aggregate. The reaction produces a gel which absorbs water and expands in volume, resulting in cracking and disintegration of the concrete. The reaction only occurs when the following thing are present together:

(a) a high moisture level in the concrete.

(b) cement with a high alkali content or some other source of alkali content.

(c) aggregate containing an alkali-reactive constituent.

1.18 What is meant by proportioning of concrete? Discuss its properties. Describe different methods of proportioning concrete.

[2015 : 15 Marks]

Solution:

The process of selection of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning of concrete.

In general, the proportions of coarse aggregate, fine aggregate, cement and water should be such that the resulting concrete has the following properties :

(i) when concrete is fresh, it should have enough workability so that it can be placed in the framework economically.

(ii) The concrete must possess maximum density or in other words, it should be the strongest and most watertight.

(iii) The cost of materials and labour required to form the concrete should be minimum.

Different methods of proportioning concrete:

1. **Arbitrary method :**
   - The proportions of cement, sand and coarse aggregate are fixed arbitrarily such as 1 : 2 : 4 or 1 : 3 : 6 etc.
   - Usually, the fine to coarse ratio is 1 : 2
   - In this method, there is no rigid control over the strength of the concrete mix.
2. **Fineness modulus method :**
   - The fineness modulus of sand aggregates is determined by the standard tests carried out with a set of ten BIS sieves and dividing the sum by 100.
   - It is found from various experiments that certain values of fineness modulus for fine and coarse aggregates and mixed aggregates give better workability with less quantity of cement.

- The aggregates are mixed in such a proportion that the recommended fineness modulus of the combined aggregates is obtained.

3. Minimum Voids Method :
   - The voids of coarse aggregate and fine aggregate are determined separately and to get the dense concrete, it is so arranged that the quantity of fine aggregate completely fills the voids of the coarse aggregate;
   - the quantity of cement completely fills the voids of fine aggregate
   - sufficient water is added to make the mix workable.
4. Maximum density method :
   - It is based on the principle that the densest concrete is achieved by proportioning its aggregates in such a manner that the heaviest weight of concrete for same volume is obtained.
   - A box is filled with varying proportions of fine and coarse aggregates. The proportion which gives heaviest weight is then adopted.
5. Water-cement ratio method :
   - The lower water content produces stiff paste having greater binding property and hence the lowering of water-cement ratio within certain limits results in the increased strength.
   - The higher water content increases the workability. But it is not useful for the chemical action. The excess water evaporates leaving pores in the concrete. Thus the increased water-cement ratio lowers the strength of concrete.
   - Thus optimum water-cement ratio for the concrete of required compressive strength is decided from graphs and expressions developed from various experiments.

1.19 From workability and strength considerations, it is found that a concrete should have a unit water content and water-cement ratio of 180 kg/m^3 and 0.50, respectively. Also, from a durability point of view, the maximum water-cement ratio allowed is 0.45.

Now, assuming that the mortar content of the mix should be 60% (by volume), determine the content of cement, sand and coarse aggregate in kg/m^3 of concrete. Take specific gravity of cement, sand and coarse aggregate to be 3.14, 2.65 and 2.71, respectively, and ignore air content.

[2016 : 10 Marks]

Solution:

Given, water content = 180 kg/m^3

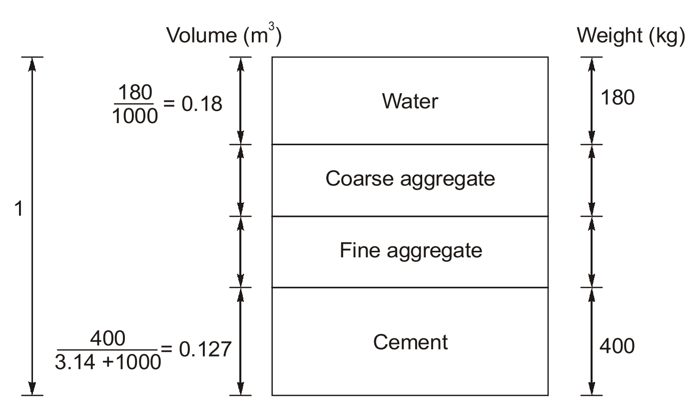
From durability point of view,

Maximum water cement ratio = 0.45

∴ In 1 m^3 of concrete (180 kg) water is present

$$\therefore \quad \text{Cement content in 1 m}^3 \text{ of concrete} = \frac{180}{0.45} = 400 \text{ kg}$$

Neglect air void as per question



$\therefore \quad V_{CA} + V_{FA} = 1 - 0.18 - 0.127 = 0.693 \text{ m}^3 \quad \text{...(i)}$

Now, it is given that mortar content is 60% by volume

i.e., $V_w + V_{cement} + V_{FA} = 0.6$

$0.18 + 0.127 + V_{FA} = 0.6$

$V_{FA} = 0.293 \text{ m}^3$

From eq. (i)

$V_{CA} = 0.693 - 0.293 = 0.40 \text{ m}^3$

$\therefore$ Mass of sand/FA $= 2.65 \times 1000 \times 0.293 = 776.45$ kg

Mass of coarse aggregate $= 2.71 \times 1000 \times 0.40 = 1084$ kg

$\therefore$ In 1 m^3 of concrete

Cement content = 400 kg

Fine aggregate = 776.45 kg

Coarse aggregate = 1084 kg

1.20 Define fibre reinforced concrete. Briefly explain how the presence of fibres in the matrix affects the properties of concrete.

[2016 : 15 Marks]

Solution:

Fiber reinforced concrete: In case of plain concrete, the presence of micro-cracks at the interface of mortar and aggregate is mainly responsible for its weakness. This weakness is overcome by adding fibres in the mix. These fibres help to transfer the load at the internal micro-cracks. This type of concrete is called as fiber-reinforced concrete.

- These added fibres interlock and entangle around the aggregate particles and thus reduce the workability but the mix becomes more cohesive and less prone to segregation.
- The required fibres are obtained from steel, glass, organic polymers etc.

Effect of fibres in the matrix on the properties of concrete: In fibre reinforced concrete, the fibres are randomly oriented in the matrix. The tensile cracking strain of cement matrix is much lower than the yield or ultimate strain of steel fibres.

- Therefore when a fibre reinforced concrete is loaded, the matrix will crack long before the fibres can be fractured.
- Once the matrix is cracked, the fibre reinforced concrete continues to carry the increased tensile stress. The peak stress and the peak strain of the fibre reinforced concrete are greater than those of the matrix alone.
- In fibre reinforced concrete, the fracture is a continuous process in which the cracking occurs over a wide range of loading and the de-bonding of fibres occurs over many stages.
- The pull-out resistance (i.e. bond) of fibres depends on the average bond strength between the fibres and the matrix, the number of fibres crossing the crack, the length and diameter of the fibres etc.
- Improvement in the structural performance of fibre reinforced concrete depends on the strength of fibres itself, volume of fibre reinforcement, dispersion and orientation of fibres, their shape and aspect ratio (i.e. l/d).
- Higher strength, larger volume, larger length and smaller diameter of fibres have been found independently to improve the strength of fibre reinforced concrete.
- Unidirectional fibres uniformly distributed throughout the volume are most efficient in uniaxial tension.
- Flexural strength depends on unidirectional alignment of fibres dispersed away from the neutral plane.
- Flexural shear strength demands random orientation of fibres.
- Proper shape and a higher aspect ratio are also required to develop adequate bond between the concrete and the fibres so that fracture strength of fibres may be fully utilized.