Internal Assessment Test III – Mar. 2018
Solution

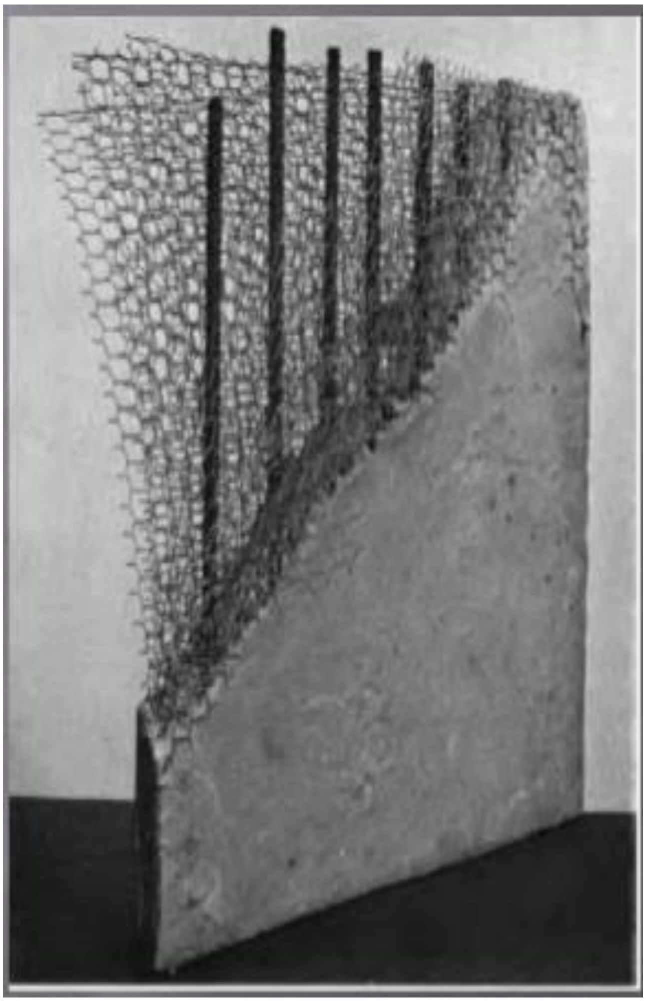
Sub:	Advance Concrete Technology	Sub Code:	10CV81	Branch:	Civil

1 What is ferro cement? Explain in detail with advantages and applications.

Ferro cement is a type of thin wall reinforced concrete, commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials."

Mortar provides the mass and wire mesh imparts tensile strength and ductility. When building Ferro-cement structures the sand/cement mortar is applied to the reinforcing wire with a trowel, never poured like common concrete work. Often a form is used to provide the desired shape.

Ferrocement is a super reinforced concrete. It differs from conventional concrete in that there is a higher ratio of steel to cement mortar. By altering the cement/steel ratio to make ferrocement we actually produce a material, which exhibits properties, superior to either steel or cement separately. Ferrocement has many of the properties of steel and yet it will not rust. Although it looks and feels like concrete it can flex without cracking.



- **SKELETON STEEL**
- It support the steel wire mesh
- 3 to 8 mm steel rods are used
- Thickness varies from 6-20mm according to loading condition
    - Generally mild steel or Fe 415 or Fe 500 bars are used
    - Spacing 7.5cm to 12m
- Used to impart structural strength in case of boats, barges etc.
- Reinforcement should be free from dust, rust and other impurities.
- **STEEL MESH REINFORCEMENT**
- Consists of galvanized steel wires of diameter 0.5 to 1.5 mm, spaced at 6 to 20mm centre to centre
- Welded wire mesh has hexagonal or rectangular openings
- Expanded-metal lath is also used Made from carbon, glass etc.
- **PROPERTIES OF FERRO CEMENT**
- It is very durable, cheap and versatile material.
- Low w/c ratio produces impermeable structures.
- Less shrinkage, and low weight.
- High tensile strength and stiffness.
- Better impact and punching shear resistance.
- Undergo large deformation before cracking or high deflection.
- **ADVANTAGES OF FERRO-CEMENT**
- It is highly versatile and can be formed into almost any shape for a wide range of uses
- 20% savings on materials and cost
- Suitability for pre-casting
- Flexibility in cutting, drilling and jointing
- Very appropriate for developing countries; labor intensive
- Good fire resistance
- Good impermeability
- Low maintenance costs
- Thin elements and light structures, reduction in self weight & Its simple techniques require a minimum of skilled labor
- Reduction in expensive form work so economy & speed can be achieved
- Only a few simple hand tools are needed to build any structures
- Structures are highly waterproof & Higher strength to weight ratio than R.C.C
- APPLICATIONS OF FERRO CEMENT

  1. Marine Applications
- Boats, fishing vessels, barges, cargo tugs, flotation buoys
- Key criteria for marine applications: light weight, impact resistance, thickness and water tightness

  2. Water supply and sanitation
- Water tanks, sedimentation tanks, swimming pool linings, well casings, septic tanks etc.

  3. Agricultural
- Grain storage bins, silos, canal linings, pipes, shells for fish and poultry farms

  4. Residential Buildings
- Houses, community centers, precast housing elements, corrugated roofing sheets, wall panels etc.

  5. Rural Energy
- Biogas digesters, biogas holders, incinerators, panels for solar energy collectors etc.

6. Miscellaneous uses

- Mobile homes
- Kiosks
- Wind tunnel
- Silos and bins
- Bus shelters
- pedestrian bridges
- soil stabilization
- chemical resistant treatment
- Precast ferrocement structures
- Boats, fishing vessels, barges, cargo tugs

2 **Explain different types of fibers with its properties.**

The weak matrix in concrete, when reinforced with steel fibres, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from conventional concrete. Because of the vast improvements achieved by the addition of fibers to concrete, there are several applications where Fibers Reinforced Concrete (FRC) can be intelligently and beneficially used.

The principal fibers in common commercial use for Civil Engineering applications include steel (SFRC/SFRS), glass, carbon and aramid. These fibers are also used in the production of continuous fibers and are used as a replacement to reinforcing steel. High percentages of steel fibers are used extensively in pavements and in tunnelling. This invention uses Slurry Infiltrated Fiber Concrete (SIFCON). Fibers in the form of mat are also being used in the development of high performance structural composite. Continuous fiber-mat high performance fiber reinforced concrete (HPFRCs) called Slurry Infiltrated Mat Concrete (SIMCON) is used in the production of High performance concrete.

- Steel Fiber
  - Aspect ratios of 30 to 250.
  - Diameters vary from 0.25 mm to 0.75 mm.
  - High structural strength.
  - Reduced crack widths and control the crack widths tightly, thus improving durability.
  - Improve impact and abrasion resistance.
  - Used in precast and structural applications, highway and airport pavements, refractory and canal linings, industrial flooring, bridge decks, etc.

- Glass Fiber
  - High tensile strength, 1020 to 4080 N/mm^2
  - Generally, fibers of length 25mm are used.
  - Improvement in impact strength.
  - Increased flexural strength, ductility and resistance to thermal shock.
  - Used in formwork, swimming pools, ducts and roofs, sewer lining etc.

- Synthetic fibers
  - Man- made fibers from petrochemical and textile industries.
  - Cheap, abundantly available.
  - High chemical resistance.
  - High melting point.
  - Low modulus of elasticity.

- It's types are acrylic, aramid, carbon, nylon, polyester, polyethylene, polypropylene, etc.
- Applications in cladding panels and shotcrete.

- Natural fibers
  - Obtained at low cost and low level of energy using local manpower and technology.
  - Jute, coir and bamboo are examples.
  - They may undergo organic decay.
  - Low modulus of elasticity, high impact strength.

3 Explain the different Nondestructive tests in detail.

ULTRASONIC* PULSE VELOCITY METHODS

Objectives:

- **To introduce the UPV methods**
- **To briefly explain the theory of pulse propagation through concrete**
- **To explain equipments, procedures, calibrations, interpretations, applications and limitations of UPV methods**

*Ultrasound refers to sound waves with frequencies above the audible range, which is generally taken to be about 20 kHz.

INTRODUCTION

- UPV measurement through concrete was initiated in the USA in the mid 1940s and later adopted everywhere as NDT on concrete
- UPV methods basically consists of transmitting the mechanically generated pulses (in the frequency ranges of 20-150/s) through concrete with the help of electro-acoustic transducers and measuring the velocity of the longitudinal waves generated by the applied pulses
- UPV is correlated to many desirable information pertaining to concrete, such as:
  - Elastic modulus, strength, and uniformity of concrete
  - Layer thickness, cracking, honeycombing, and deterioration of concrete
- The UPV measurements on concrete may reveal the above information if appropriate calibration charts are available

THEORY OF PULSE PROPAGATION THROUGH CONCRETE

- Following three types of waves are generated by an impulse applied to a mass:
  - Surface waves having an elliptical particle displacement and slowest
  - Shear or transverse waves with particle displacement at right angles to the direction of travel and faster than the surface waves
  - Longitudinal or compressive waves with particle displacement in the direction of travel and fastest providing more useful information
- Electro-acoustical transducers used for UPV measurements on concrete produce longitudinal waves which, as mentioned above, are fastest and provide more useful information
- UPV depends primarily upon the elastic properties of the material and found to be almost independent of geometry

THEORY OF PULSE PROPAGATION THROUGH CONCRETE

- For an infinite, homogenous, isotropic elastic medium, the compression wave velocity is given as:

$$V = \sqrt{\frac{K E_d}{\rho}}$$

Where:

V = compression wave velocity (km/s)

$K = \frac{(1-\nu)}{(1+\nu)(1-2\nu)}$

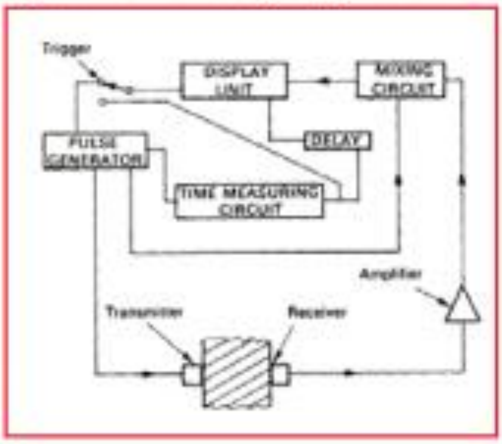
E_d = dynamic modulus of elasticity (kN/mm^2)

ρ = density (kg/m^3)

ν = dynamic Poisson's ratio

UPV TEST EQUIPMENT

- The UPV equipment is used for the following purposes:
  - Generating a pulse mechanically
  - Transmitting the generated pulse through concrete
  - Receiving and amplifying the pulse
  - Measuring and displaying the transit time
- The circuitry of a typical UPV testing equipment is shown below:



UPV TEST EQUIPMENT

Commercially available UPV equipments are shown below:

PUNDIT Equipment with flat transducers popularly used for UPV test

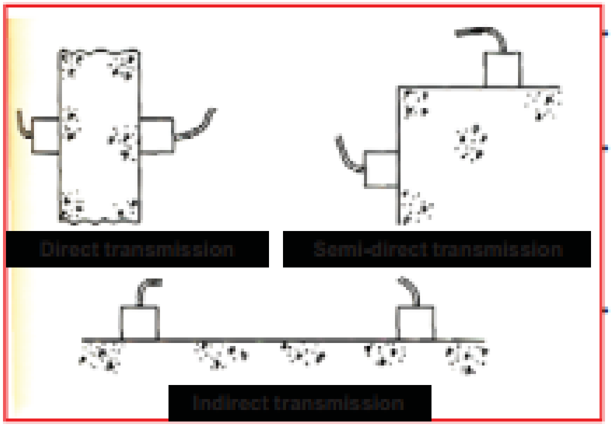
Exponential probe transducers used for UPV test on rough or curved surfaces

UPV TEST PROCEDURE: Coupling of transducers

- A good acoustic coupling between the concrete surface and the face of the transducers is essential for reliable results
- Coupling is provided by a medium such as petroleum jelly, liquid soap or grease
- Air pockets must be eliminated, and it is important that only a thin separating layer exists-any surplus must be squeezed out
- A light medium such as petroleum jelly or liquid soap is found to be the best for smooth surfaces
- A thicker medium such as grease is recommended for rough surfaces which have not been cast using smooth shutters
- In case of very rough or uneven surfaces, grinding or preparation with plaster of Paris or quick-setting mortar may be necessary before coupling

UPV TEST PROCEDURE: Arrangement of transducers

- Following are three basic ways in which the transducers my be arranged:
  - Transducers coupled on opposite faces (direct transmission)
  - Transducers coupled on adjacent faces (semi-direct transmission)
  - Transducers coupled on same faces (indirect transmission)
- The above mentioned arrangements of transducers are shown below:



- The direct method is the most reliable from the point of view of transit time measurement as well as path length measurement
- The semi-direct method is less reliable than the direct method and should only be used if the angle between the transducers is not too great, and if the path length is not too large
- The indirect method is the least accurate because received signal is subject to errors due to scattering of pulse by discontinuities

UPV TEST PROCEDURE: Velocity determination

- Determination of pulse velocity requires measurement of the transit time using the UPV equipment with an accuracy of ± 0.1 μs and measurement of path length with an accuracy of ± 1%

- The transit time readings are repeated by complete removal and reapplication of transducers to obtain a minimum value for the transit time, which is taken as final reading

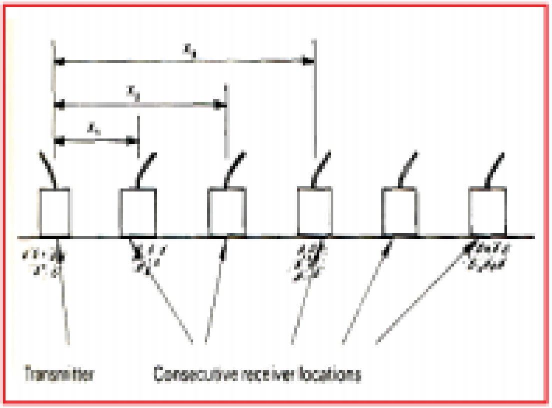
- Once the transit time and the path length are measured, the pulse velocity is determined by dividing the path length by the transit time, as follows:
  V = path length/transit time

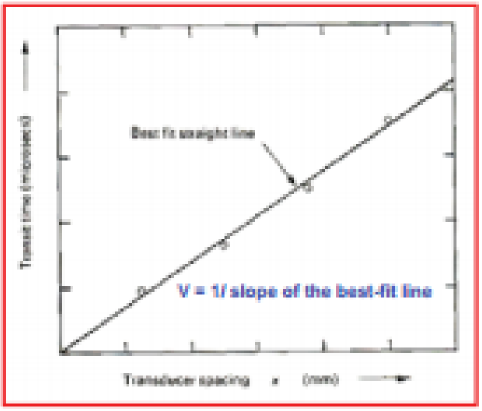
- In case of direct transmission, the path length is just the thickness of the member under test.

- In case of semi-direct transmission, the path length is taken as distance between center to center of transducer faces

UPV TEST PROCEDURE: Velocity determination

- In case of indirect transmission, the pulse velocity is determined by recording the transit times by placing the receiver at different distances from the fixed position of the transmitter and then obtaining the mean pulse velocity as inverse of slope of a best fit line plotted using spacing versus transit time data, as follows:





CALIBRATION AND INTERPRETATION OF UPV TEST RESULTS: Compressive strength

- Coarse aggregate type, shape, size, quantity; sand type; cement type; w/c ratio; and maturity of concrete are the important factors which affects the correlation between pulse velocity and strength

- Therefore separate strength calibration charts are needed for accurate interpretation of the test results for strength, considering the effect of each of the above factors

- Following are few typical strength calibration charts taking the effect of aggregate types and proportions:

4 **Explain the detail procedure for testing the concrete for compressive strength.**

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc.

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials ASTM C39/C39M provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

Procedure: Compressive Strength Test of Concrete Cubes

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Following is the procedure for testing Compressive strength of Concrete Cubes

Apparatus for Concrete Cube Test

Compression testing machine

Preparation of Concrete Cube Specimen

The proportion and material for making these test specimens are from the same concrete used in the field.

Specimen

6 cubes of 15 cm size Mix. M15 or above

Mixing of Concrete for Cube Test

Mix the concrete either by hand or in a laboratory batch mixer

Hand Mixing

(i)Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color

(ii)Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch

(iii)Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

Sampling of Cubes for Test

(i) Clean the mounds and apply oil

(ii) Fill the concrete in the molds in layers approximately 5cm thick

(iii) Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)

(iv) Level the top surface and smoothen it with a trowel

Curing of Cubes

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

Precautions for Tests

The water for curing should be tested every 7 days and the temperature of water must be at 27+-2oC.

Procedure for Cube Test

(I) Remove the specimen from water after specified curing time and wipe out excess water from the surface.

(II) Take the dimension of the specimen to the nearest 0.2m

(III) Clean the bearing surface of the testing machine

(IV) Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

(V) Align the specimen centrally on the base plate of the machine.

(VI) Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

(VII) Apply the load gradually without shock and continuously at the rate of 140 kg/cm^2/minute till the specimen fails

(VIII) Record the maximum load and note any unusual features in the type of failure.

5 Design a concrete mix of M_{40} grade for the following data:

Data for proportion

Max size of aggregate:	20mm, Crushed aggregate		
Min/max cement content	320/450 kg/m^3		
Mac w/c	0.50		
Exposure condition	Moderate		
Workability	50mm slump		
Method of placing	Pumping		
Quality control	Good		
Type of chemical admixture	Super plasticizer (Sp gr-1.145)		
Test data of materials:			
1. Cement	OPC 43 grade IS 8112		
2. Specific gravity of cement	3.15		
3. Flyash	30% of cementations material confirming to IS:3812		
4. Sp gr of Flyash	2.2		
	Sp gr	Water absorption	surface moisture
Coarse agg (Table 2)	2.74	0.5%	Nil
Fine agg (Zone I)	2.74	1.0%	Nil

TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65\, s$$

From Table 1 standard deviation, s = 5 N/mm^2

Therefore target strength = 40 + 1.65 x 5 = 48.25 N/mm^2

SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, maximum water cement ratio = 0.45

Based on experience adopt water cement ratio as 0.40 0.4 < 0.45, hence ok

SELECTION OF WATER CONTENT

From Table-2, maximum water content = 186 liters

(for 25mm – 50mm slump range and for 20 mm aggregates)

Estimated water content for 100 mm slump = 186 + 6/100 x186 = 197 liters

As superplsticiser is used, the water content can be reduced up to 20 percent and above Based on trials with SP water content reduction of 29 percent has been achieved.

Hence the water content arrived = 19 x 0.71 =140 liters

CALCULATION OF CEMENT CONTENT
Water cement ratio = 0.40 Cement content = 140/0.40 = 350 kg/m^3
From Table 5 of IS: 456, minimum cement content for severe exposure condition = 320 kg/m^3 350 kg/m^3 > 320 kg/m^3,
hence OK

For proportioning fly ash concrete, the suggested steps are;

Decide the percentage of fly ash to be used based on project requirement and quality of materials

In certain situations increase in cementitious material content may be warranted. The decision on increase in cementitious material content and its percentage may be based on experience and trial.

The example is with increase of 10% of cementitious material content
Cementitious material content 1.1 x 350 = 385 kg/m^3
Water content = 140 kg/m^3
Water cement ratio = 140/385 = 0.364 ≈0.40
Let us use fly as at 30 percent of cementitious material content in addition to cement Fly ash = 385 x 0.3 = 115 kg/m^3

Cement =385-115=270 kg/m^3

(Saving of cement compared to previous design = 350-279 = 80 kg/m^3 and fly ash utilization = 115 kg/m^3)

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT
From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 =0.60

In the present case w/c= 0.40. The volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As w/c ratio is lower by 0.10, increase the coarse aggregate volume by 0.02 (at the rate of -/+ 0.01 for every +/- 0.05 change in water cement ratio).

Therefore, corrected volume of coarse aggregate for w/c of 0.40 =0.62.

Note: In case the coarse aggregate is not angular, then also the volume of CA may be required to be increased suitably based on experience

For pumpable concrete these values should be reduced by 10 percent
Therefore volume of coarse aggregate = 0.62 x 0.9 = 0.56
Volume of fine aggregate content = 1- 0.56 = 0.44

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

h) Volume of concrete = 1 m^3

i) Volume of cement $= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

j) Volume of fly ash = [115/2.2] x [1/1000] = 0.052 m^3

k) Volume of water = [140/1] x [1/1000] = 0.140 m^3

l) Volume of chemical admixture (SP 2%by mass of cementitious material) = [7.7/1.145] x [1/1000] = 0.007 m^3

m) Volume of all in aggregates (e) =a – (b + c + d)
= 1 – (0.086 + 0.052 + 0.140 + 0.007) = 0.715 m^3

n) Volume of coarse aggregates = e x Volume of CA x specific gravity of CA
= 0.715 x 0.56 x 2.74 x 1000 = 1097 kg

o) Volume of fine aggregates = e x Volume of FA x specific gravity of FA
= 0.715 x 0.44 x 2.74 x 1000 = 862 kg

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement	= 270 kg/m^3
Fly ash	= 115 kg/m^3
Water	= 140 kg/m^3
Fine aggregate	= 862 kg/m^3
Coarse aggregates	= 1097 kg/m^3
Chemical admixture	= 7.7 kg/m^3
Water cement ratio	= 0.364