MUZAFFARPUR INSTITUTE OF TECHNOLOGY, MUZAFFARPUR, BIHAR – 842003

(Under the department of Science & Technology, Bihar, Patna)

B.Tech 3rd Semester Mid-Term Examination, 2018

BUILDING SCIENCE

Time: 2 hours **Full Marks: 20**

Subject Code: 011303

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1. **a) Enlist the different types of building with examples as per National Building Code of India.**

Solution: As per National Building Code of India different types of building are:

a) Assembly Buildings: Restaurant, Cinema hall, Theater, Gymnasium, etc.

b) Business Buildings: Bank, Dispensaries and clinic, Libraries, Insurance agencies, Fire station, etc.

c) Educational Buildings: School, Colleges, Training Institutes, etc.

d) Factory Buildings: Gas Plants, Power Stations, Refineries, etc.

e) Hazardous Building: factories manufacturing fireworks, hydrogen peroxide, cyanide, etc.

f) Institutional Buildings: Hospitals, Old age homes, Nursing homes, etc.

g) Mercantile Buildings: Shopping mall, Grocery Store, Departmental store, etc.

h) Residential Buildings: Apartments, Flats, Hotels, Hostels, etc.

i) Storage Buildings: Garage, Warehouse, Cold storage, etc.

b) Explain the different types of loads acting on a building with IS codes.

Solution:

Types of loads acting on a structure are:

j) Dead loads

k) Imposed loads

l) Wind loads

m) Snow loads

n) Earthquake loads

o) Special loads

a) Dead Loads: IS 875 (part 1)–1987

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials.

b) Imposed Loads or Live Loads: IS 875 (part 1)–1987

The second vertical load that is considered in design of a structure is imposed loads or live loads. Live loads are either movable or moving loads without any acceleration or impact.

c) Wind loads: IS 875 (part 3)–1987

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface.

d) Snow Loads: IS 875 (part 4) – 1987

Snow loads constitute to the vertical loads in the building. But these types of loads are considered only in the snow fall places.

e) Earthquake Loads: IS 1893– 2014

Earthquake forces constitute to both vertical and horizontal forces on the building. The total vibration caused by earthquake may be resolved into three mutually perpendicular directions, usually taken as vertical and two horizontal directions.

f) Special loads: IS 875 (part 5) – 1987

It consists of Impact loads, Settlement loads, etc.

2. a) Differentiate between shallow and deep foundation.

Solution: Differences between shallow and deep foundation are given:

	Sources	Shallow Foundation	Deep Foundation
1	Definition	Foundation which is placed near the surface of the earth or transfers the loads at a shallow depth is called shallow foundation.	Foundation which is placed at a greater depth or transfers the loads to deep strata is called deep foundation.
2	The depth of foundation	The depth of shallow foundation is generally about 3 meters or the depth of foundation is less than the footing with.	Greater than shallow foundation.
3	Cost	Shallow foundation is cheaper.	Deep foundations are generally more expensive than shallow foundation.
4	Feasibility	Shallow foundations are easier to construct.	The construction process of a deep foundation is more complex.
5	Mechanism of load transfer	Shallow foundations transfer loads mostly by end bearing.	Deep foundations rely both on end bearing and skin friction, with few exceptions like end bearing pile.
6	Advantages	Construction materials are available, less labor is needed, construction procedure is simple at an affordable cost etc.	Foundation can be provided at a greater depth, Provides lateral support and resists uplift, effective when foundation at a shallow depth is not possible, can carry huge load etc.
7	Disadvantages	Possibility of a settlement, usually applicable for lightweight structure, weak against lateral	More expensive, needs skilled labors, complex construction procedure, can be time-consuming and some types of deep

	Sources	Shallow Foundation	Deep Foundation
		loads etc.	foundations are not very flexible etc.
8	Types	Isolated foundation, strip foundation, mat foundation, combined foundation etc.	Pier foundation, pile foundation, caissons etc.

b) What is bearing capacity of soil? List the various methods of improving the bearing capacity of soil.

Solution:

Bearing capacity of soil: The maximum load per unit area which the soil or rock can carry without yielding or displacement is termed as the bearing capacity of soils. Soil properties like shear strength, density, permeability etc., affect the bearing capacity of soil.

The following techniques can be used for improving bearing capacity of soil as per the site condition.

a) Increasing depth of foundation
b) Draining the soil
c) Compacting the soil
d) Confining the soil
e) Replacing the poor soil
f) Using grouting material
g) Stabilizing the soil with chemicals

3. a) What are the different types of cements? Explain any two.

1) RAPID HARDENING CEMENT :→

It is the type of cement which develops higher rate of gain of strength & must not be confused with quick setting cement.

→ This cement attains the strength at the age of 3 days equivalent to the strength of O.P.C. in 7 days

→ This higher rate of gain of strength is attributed due to higher fineness. (Specific surface area ≯ 3250 cm²/gm) higher proportion of C_3S (approx 56%) & lower proportion of C_2S. (approximately 5%).

→ This cement find its application :—

(i) Cold weather concreting.
(ii) Road repair work.
(iii) Pre fabricated construction.
(iv) Where formwork is to be reutilized for speedy constructions.

(2) EXTRA RAPID HARDENING CEMENT.

:→ It is obtained by intergrinding Rapid Hardening Cement Clinckers with Calcium Chlorites.

→ Under normal condition, Calcium chloride should not be greater than 2%.

→ This cement must be mixed transported, placed, Compacted, & finished within 20 minutes of its prepration.

→ This cement posses 25% more strength than rapid hardening cement at the age of 1 (or) 2 days. 10-15% more strength at the age of 7 days.

→ This rate of gain of strength in this cement reduces with time and at the age of 90 days strength of cement is same as that of O.P.C.

(3) SULPHATE RESISING CEMENT :→

O.P.C. is susceptible to the attack of Sulphate, especialy to that of Magnesium Sulphate. which reacts with both calcium hydroxide & Calcium alluminate to form Calcium Sulphate & Calcium-Sulpho-Alluminate volume of which is 227% more than original constituent.

→ In order to prepare this cement, proportion of C_3A & C_4Af is reduced such that C_3A should not be greater than 5% & twice of $C_3A + C_4Af$ should not be greater than 25%.

$$C_3A \not> 5\% \quad \& \quad 2C_3A + C_4Af \not> 25\%$$

It can be used in following constructs →
(i) Sewerage line. (Sewage consists of sulphate).
(ii) Sea water (Marine Construction).
(iii) Foundation (Soil consists of sulphate) basement construction
(iv) Sewage treatment work.
(v) Construction of pipes to be laid in marshy area.

(4) PORTLAND SLAG CEMENT.

This cement is produced by intergrinding cement clinkers with Gypsum & granulated Blast furnace slag in definite proportion.

→ This cement offers low heat of hydration, better refinement of Pore structure & higher resistance against the attack of Chloride & sulphate.

→ This cement find its application in water retaining structure, hydraulic structures, sewage treatment works.

(5) SUPER SULPHATED CEMENT.

↳ It is prepared by intergrinding 80-85% granulated blast furnace slag, 10-15% of gypsum & 5% of cement clinkers.

→ This cement offers very high resistance against the attack of sulphate.

(6.) IRS-T40 CEMENT:

It is the type of Cement which is obtained by grinding the Cement upto higher extent & increasing the proportion of C_3S. so as to develope higher rate of gain of strength as required in the manufacturing of concrete sleepers for Indian Railway.

(7) HYDROPHOBIC CEMENT.

It is the type of cement which is obtained by intergrinding cement clinkers with water repelents. film forming substances like Steric acid & Oleic acid.

→ This water repelant film which is formed around the cement particles reduces the rate of deterioration of cement due to long storage & transportation period.

(8) LOW HEAT CEMENT.

→ This cement is produced by reducing the proportion of C_3A & C_3S & increasing the proportion of C_2S (C_3A approx. 5% ; C_3S approx 40% ; C_2S approx 46%)

→ This cement offers low rate of gain of strength & is used where mass concreting is to be done.
e.g:- DAMS.

→ Heat of hydration of this cement at the age of 7 days is not greater than 65 cal./gm. & at the age of 28 days is not greater than 75 cals/gm.

(9) QUICK SETTING CEMENT :-

This cement is produced by adding small amount of Aluminum sulphate during the grinding of the cement clinker and reducing the proportion of Calcium sulphate.

→ This cement find its application in :-
(i) Grouting operation.
(ii) Underwater concretting

(10) PORTLAND POZZOLONA CEMENT. (P.P.C.)

→ Pozzolona is essentialy siliceous & aluminices compound which in itself don't posses any cementing property but when finaly grinded in the presence of water reacts with calcium hydroxide formed during hydration process & results in the formation of a cementeous compound.
(e.g. Granulated blast furnace slag, ricehusk ass, surkhi etc.)

Pozzolonic material (Non-Cementous Compound) + Water + $Ca(OH)_2$ → C-S-H (Gel) (Cementous Compound)

→ This cement possess.

(i) higher resistance against the attack of sulphate.
(ii) lesser permeability
(iii) higher resistance against expansion.
(iv) less heat of hydration.
(v) higher plasticity & workability.
(vi) higher tensile strength
(vii) attains compressive strength with age.
(viii) is more economical.

→ This cement finds its application in :—

(i) Hydraulic structure
(ii) Water Retaining structures.
(iii) Marine Constructions.

DATE
18th MARCH 2015

II> HIGH ALUMINA CEMENT :→

This cement is produced by intergrinding Bauxite with lime. (Bauxite is an ore of Aluminium).

→ %ge of Alumina in this cement should not be less than 32% & the ratio of Alumina to lime is in the range of 0.85 to 1.3.

→ The cement possess high initial setting time. (approx 3.5hrs.) & comparatively lower final setting time (approx 5hrs).

3 b) List the tests used for measurement of workability of fresh concrete. Explain any two briefly.

MEASURMENT OF WORKABILITY.

Workability can be determined by any of the following tests:—

1) SLUMP TEST:→ It is the most common test which is used to find the Workability of the concrete. However it doesn't includes the affect of all the factors over which workability is dependent, but since it is very convinent to perform, it is prefered over the other test.

→ Slump test can't be used to measure the workability of the concrete in the cases when it is either very low or ~~very~~ comparatively high.

→ This test consists of a metalic mould in the shape of the frustum having the bottom

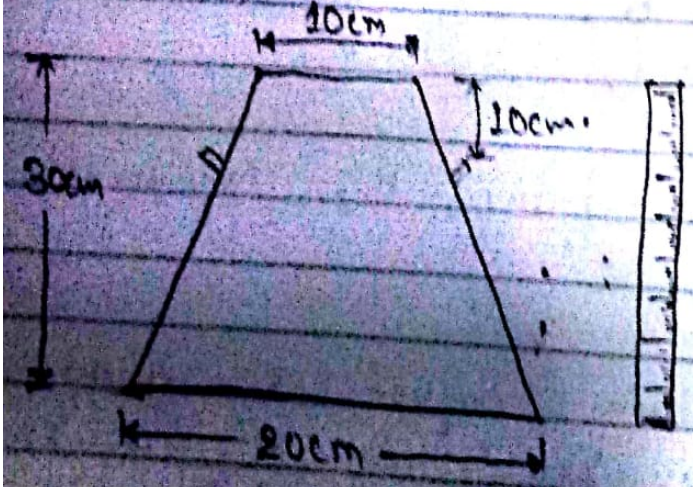
diameter of 20cm, top diameter of 10cm & height of 30cm & a tamping rod.

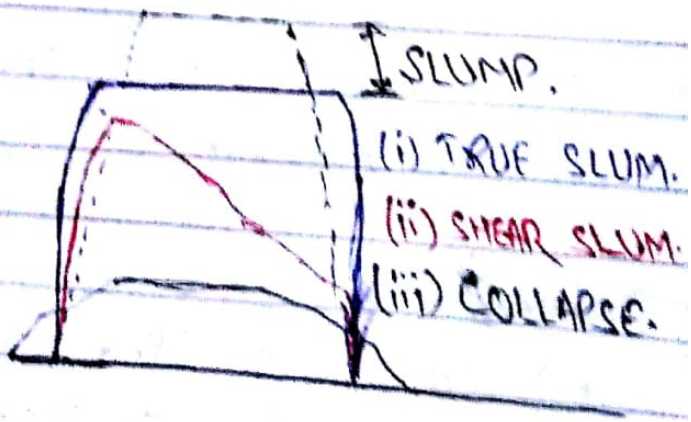
→ Concrete to be tested is filled in the mould in four layers, where in each layer is tamped 25 no. of times by the tamping rod

→ When the mould is completely filled it is removed immediately by lifting it slowly in vertically upward direction which causes concrete to subside that is refered as 'slump'.

→ The difference in the level of the height of the mould & the top surface of the subsided concrete is noted, which is termed as slump value which is used to represent the workability of the concrete.

→ The pattern of the slump obtained during the test represents the characteristics of the concrete apart from the slump value.





(2) COMPACTION FACTOR TEST :→

This test is more precise & sensitive than slump test & can be used to measure the workability of the concrete in the cases when it is comperatively low but is not applicable for the testing of highly workable concrete.

→ The principal of this test is based upon finding the degree of compaction achived by the standard amount of work done by allowing the concrete to fall through standard height.

→ The degree of compaction refered as compaction factor is then measured in terms of density ratio which is the ratio of density of the concrete obtained during the test & density of fully compacted concrete.

→ In order to perform this test, concrete is placed in the upper conical hopper & is allowed to fall into the lower one by opening the trap door & further into the cylinderical jar placed at the bottom.

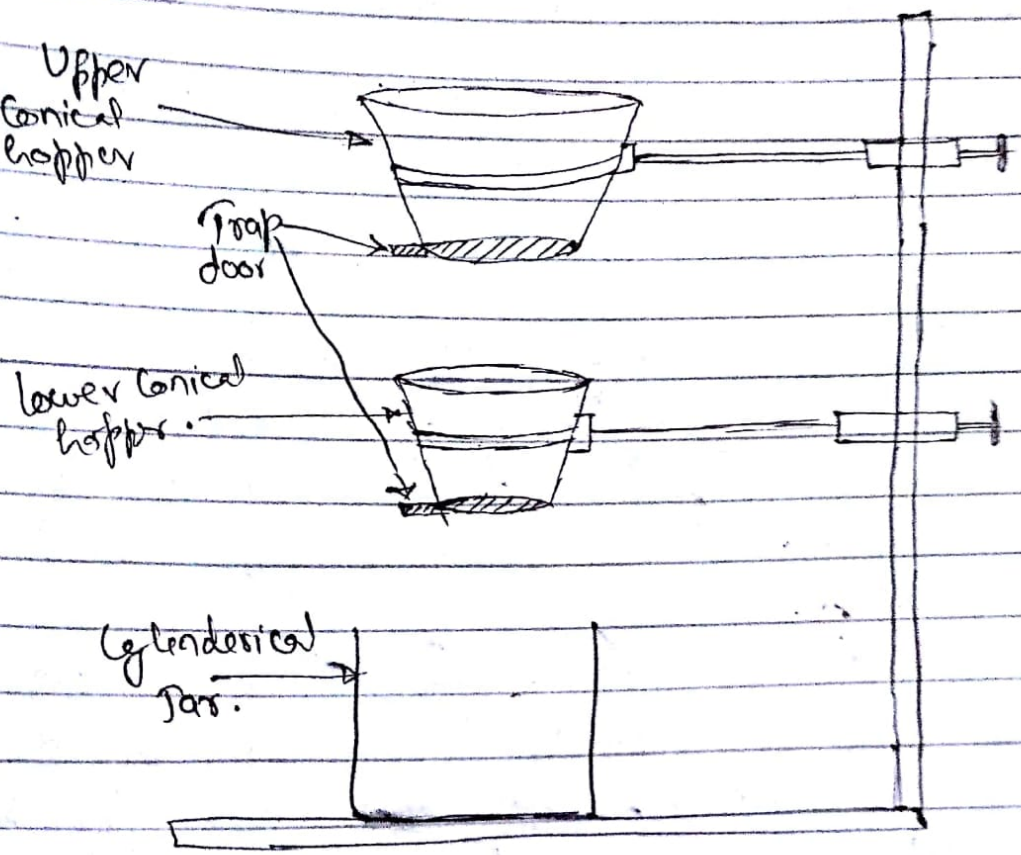
→ Mass of the concrete filling the cylinderical jar is noted.

→ Cylinderical jar is completely emptied & is again refilled with the same sample of the concrete which is fully compacted. Mass of this fully compacted concrete is noted to reffer the workability in terms

of compaction factor.

* Compaction factor = Density of concrete obtained during test / Density of fully compacted concrete.

* Compaction factor = Mass of concrete obtained during test / Mass of fully compacted concrete.



Degree of workability	Slump Value (mm)	Compaction factor	Use of Concrete	OTHERS.
Very low	—	0.78 - 0.80	Road Const.	(Compaction factor test is used
Low	25 - 75	0.85 - 0.86	Light Reinforced	:- Foundation
Medium	50 - 100	0.92 - 0.935	Medium "	:- Slab
High	100 - 150	0.95 - 0.97	Heavy "	:- Flat slab.
Very high	—	—	Transit Concrete.	:- flow table test is used.

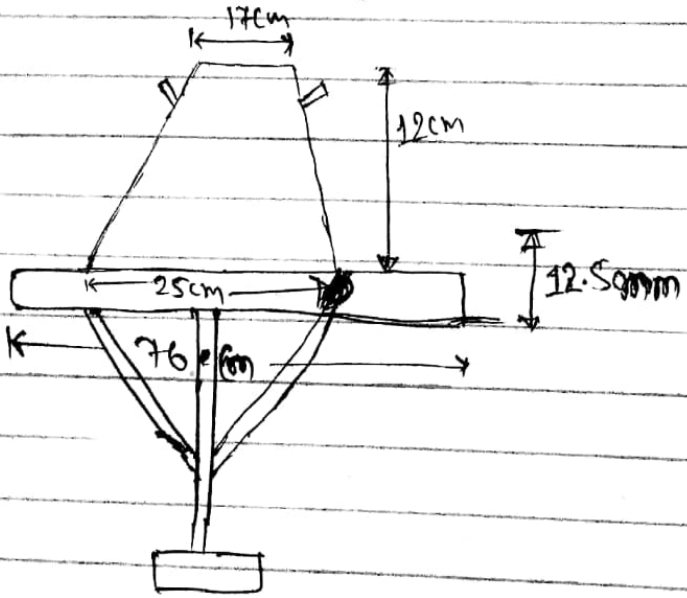
(B) FLOW TABLE TEST. → This test is used to find the workability of highly workable concrete, for which the slump test or Compaction factor test is not applicable.

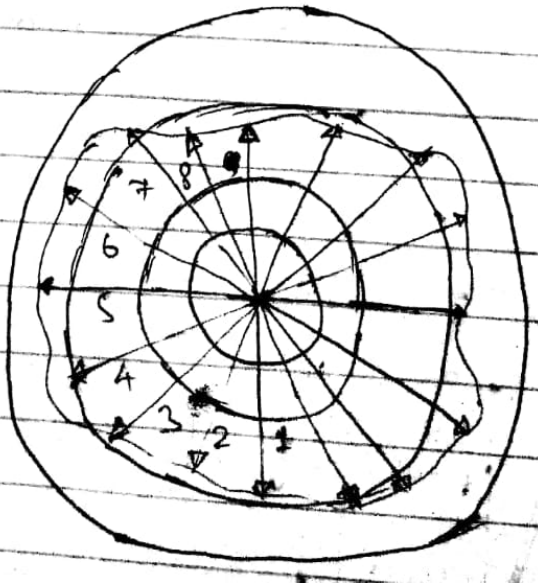
→ This test consists of a flow table circular in plan having the diameter of 76 cm. & a metalic mould in the shape of the foustum having the bottom diameter of 25cm & top diameter of 17cm & height of 12 cm.

→ The metalic mould is centered over the flow table & concrete to be tested is filled in it in two layers. when the mould is completly filled, it is removed immediately & table is raised & dropped by 12.5mm, 15 times in 15 seconds. which Causes the

- Concrete to flow over the table. Spread of the concrete over the table is then measured in atleast 6 (six) directions. Workability of the sample in this test is represented in terms of flow %ge. which is defined as percentage increase of the avg diameter of the spread of concrete over the base diameter.

→ Flow %, generaly varies b/w 0 to 150%.





Flow Value

$$= \frac{(\text{Spread of concrete (cm)} - 25)}{25} \times 100$$

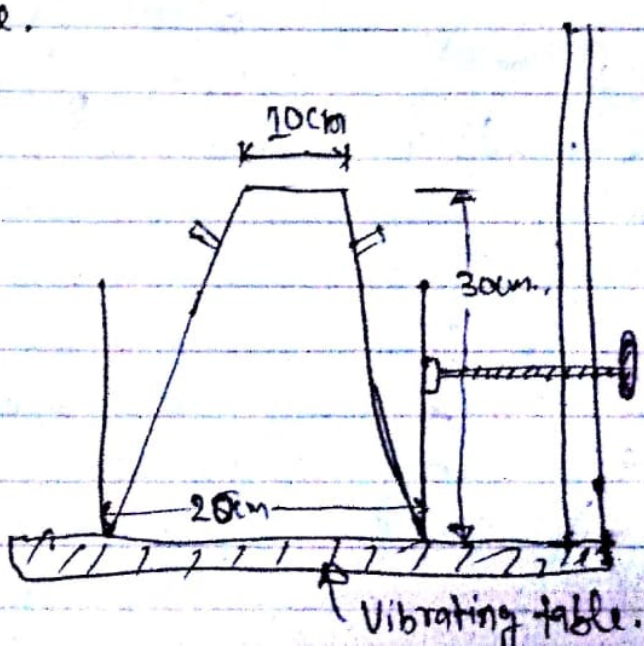
(A) VEE-BEE CONSISTOMETER TEST.

This test consists of a vibrating table. over which cylinderical jar is placed having metalic mould in it in the shape of frustum with bottom diameter of 20cm, top diameter of 15cm & height of 30cm.

→ Concrete to be tested is filled in the metalic mould in two layers & when the mould is completely filled, it is removed immediately. along with the subsiquent initiation of the vibration.

→ The time required by the concrete sample to assume the cylinderical shape is noted & is referred as Vee-Bee degree. which is used to represent the workability of the concrete.

→ This test is suitable for the concrete having low workability & is not used for the concrete having slump value greater than 50mm. as vibrations are too vigrous which causes segregation of the sample.



4. Write name of Bouge`s compounds. Explain their purpose in cement. Arrange them in ascending order of heat of hydration.

BOUGES COMPOUNDS

When water is added in the cement, it reacts with the ingridents of the cement chemicaly and results in the formation of complex chemical compounds referedas as BOUGES COMPOUNDS.

→ These compounds are not being formed simultaneously

1) Tri Calcium Aluminate ($3CaO.Al_2O_3$) ($3C_3A$) (4 - 14 %) OPC

→ It is formed within 24hrs of the addition of the water into the cement.
→ It is responsible for evolution of maximum heat during the hydration process.
→ It is responsible for early setting.

2) Tetra Calcium Alumino ferrate ($4CaO.Al_2O_3.Fe_2O_3$) (C_4AF) (10-18%) OPC

→ It is also formed within 24hrs of the addition of the water into the cement.
→ It is responsible for higher heat of hydration in the initial ages of the fricpriction of the cement.

3) Tri Calcium Silicate ($3CaO.SiO_2$) (C_3S) (45-65%) OPC

→ It is formed within a week or so after the addition of the water into the cement.
→ It is responsible for the strength of the cement in the initial stages.

→ Depending upon the requirment of the construction, proportion of C_3S can be altered.

→ for higher earlier strength, its proportion is increased, as required in:-

(i) Pre fabricated construction
(ii) Road Repair work.
(iii) Cold weather concreting.
(iv) Where form work is to be reutilized for speedy construction.

OPC.

4) Dicalcium silicate ($2CaO \cdot SiO_2$) (C_2S) (15-35%)

It is formed within an year or so after the addition of water into the cement & is responsible for progressive strength in it.

→ The proportion of C_2S is increased if higher strength is required in the later stages of the construction.

* Heat of Hydration (Cal/gm) at different stages of these compounds are as follows:-

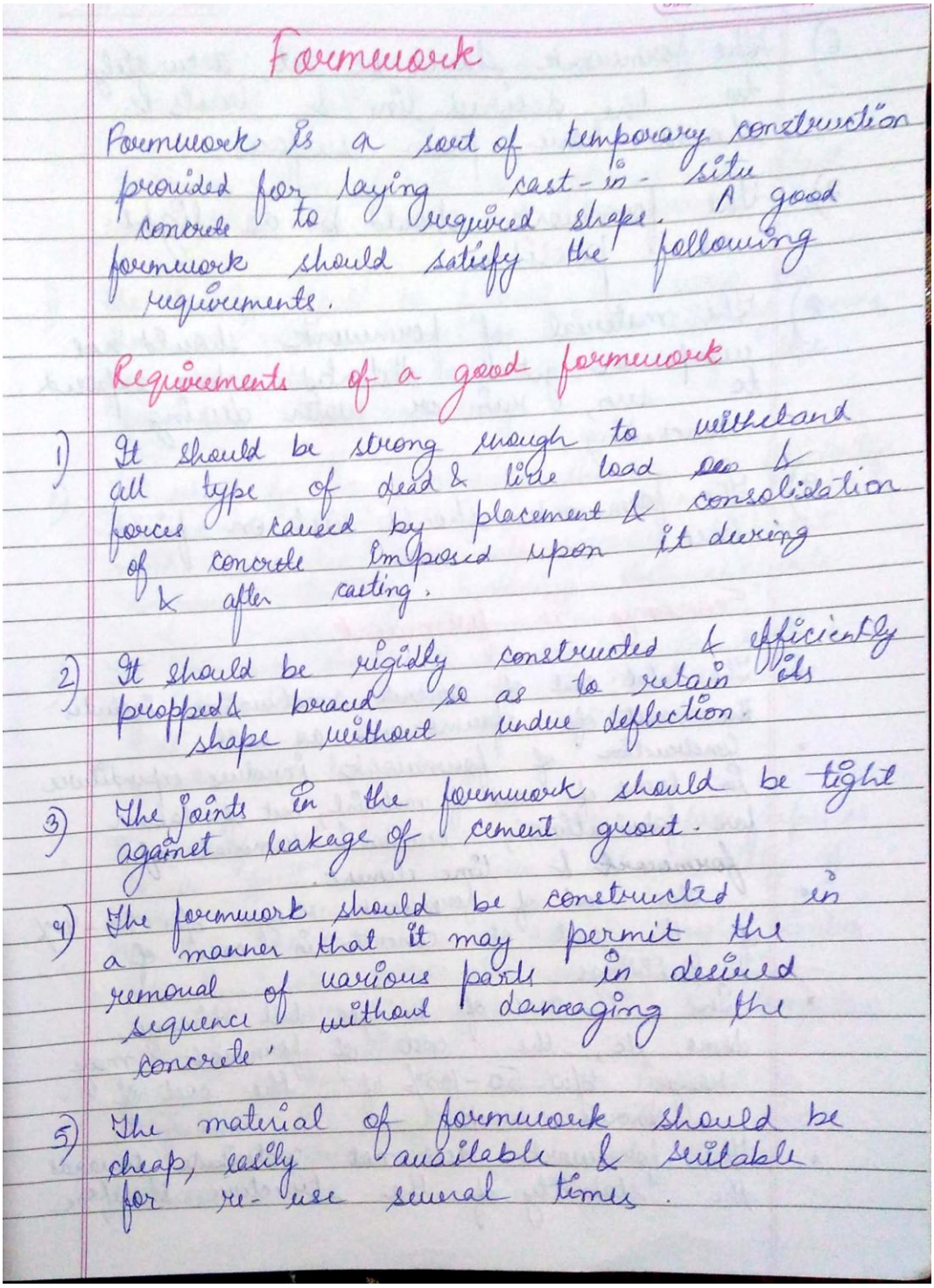
Heat of Hydration (Cal/gm)		
3 Days	90 Days.	
210	310	C_3A
70	100	C_4AF
60	105	C_3S
10	40	C_2S

$C_3A > C_4AF > C_3S > C_2S$ | $C_3A > C_3S > C_4AF > C_2S$

$H_{cement} = aA + bB + cC + dD$

a, b, c, d → % or proportion.
A, B, C, D → heat of hydration of respective comp.

5. Define formwork. What are the requirements of a good formwork? How economy is maintained in formwork?



Formwork

Formwork is a sort of temporary construction provided for laying cast-in-situ concrete to required shape. A good formwork should satisfy the following requirements.

Requirements of a good formwork

1) It should be strong enough to withstand all type of dead & live load & forces caused by placement & consolidation of concrete imposed upon it during & after casting.

2) It should be rigidly constructed & efficiently propped & braced so as to retain its shape without undue deflection.

3) The joints in the formwork should be tight against leakage of cement grout.

4) The formwork should be constructed in a manner that it may permit the removal of various parts in desired sequence without damaging the concrete.

5) The material of formwork should be cheap, easily available & suitable for re-use several times.

6) The formwork should be set accurately to the desired line & levels & should have plain surfaces.

7) The formwork should be as light as possible.

8) The material of formwork should not warp or get distorted when exposed to sun, rain or water during concreting.

9) The formwork should rest on firm base.

Economy in formwork

- The total cost of concrete construction includes the cost of formwork as well.
- Construction of formwork involves expenditure in terms of cost of material, cost of labour for fabrication, erection & removal of formwork & time element.
- The cost of formwork ranges b/w 30-40% of the cost of concrete in case of buildings
- In case of bridges, tall chimneys, dams, etc, the cost of formwork may range b/w 50-100% of the cost of concrete work.
- The formwork does not contribute towards the stability of the structure therefore

its cost should be kept lowest minimum consistent with safety.

Following steps should be followed to effect economy in the cost of formwork :-

1) The building should be planned in a way that there are minimum variations in the size of rooms, floor area, etc. so as to permit re-use of the formwork moulds repeatedly.

2) The scheme of the formwork should be efficiently planned & suitably designed to determine the most economical but safe sizes of different components including the supports.

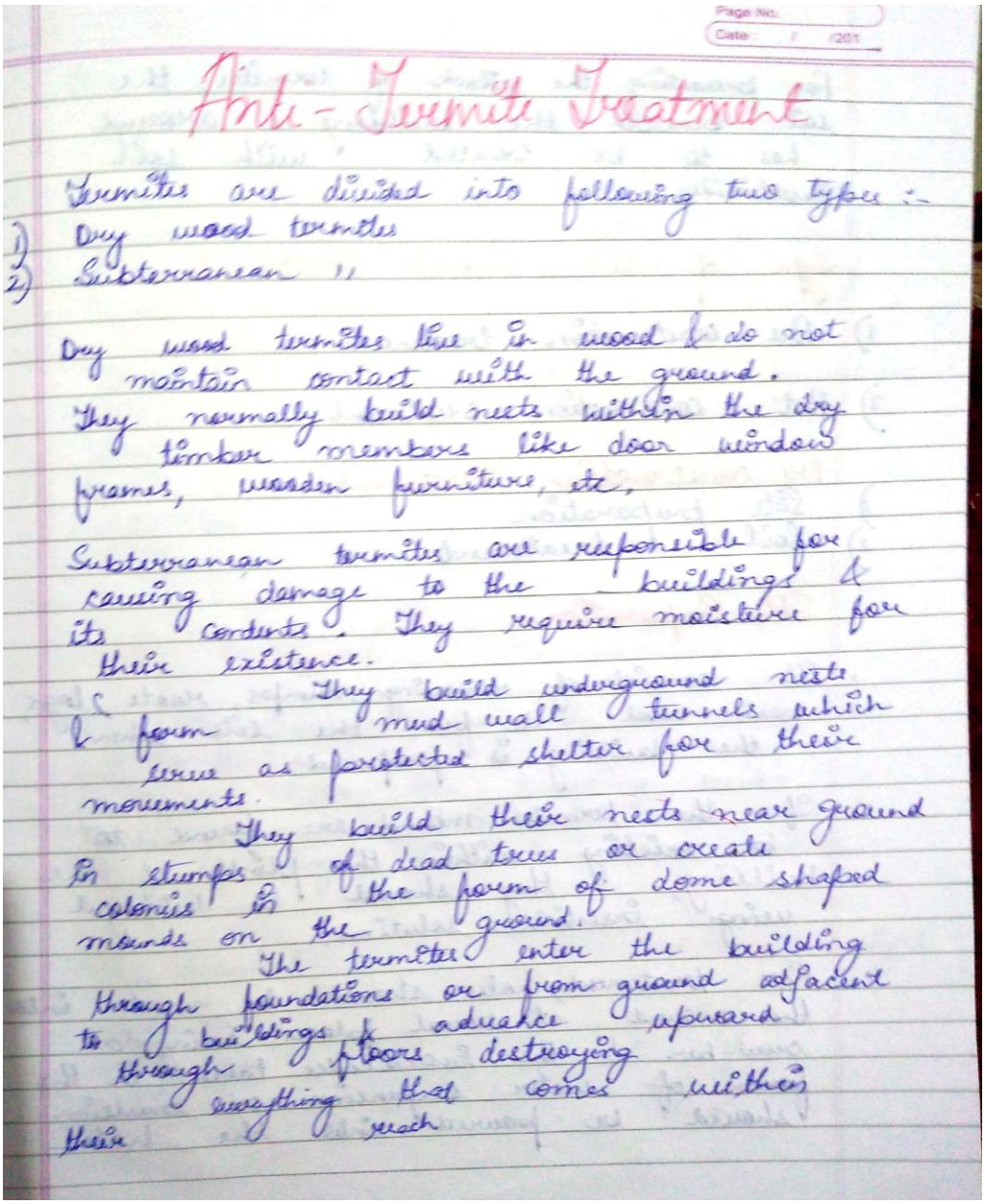
3) The formwork should be constructed in such a way that timber is cut to the minimum & it can be struck off with ease & re-used with least damage.

- The quality of finished concrete surface depends to a great extent upon the quality of formwork used.
- If the formwork is made out of rough timber & is not constructed properly, the resultant concrete surface will be irregular & full of defects
- The expenditure that will be involved in rectification is invariably more than the saving made in the cost of formwork.

6. a) Pre-construction anti-termite treatment

b) Post construction anti-termite treatment

c) Write short note on termite. (Attempt any two)



Anti-Termite Treatment

Termites are divided into following two types :-

1) Dry wood termites
2) Subterranean "

Dry wood termites live in wood & do not maintain contact with the ground. They normally build nests within the dry timber members like door window frames, wooden furniture, etc.

Subterranean termites are responsible for causing damage to the buildings & its contents. They require moisture for their existence.

They build underground nests & form mud wall tunnels which serve as protected shelter for their movements.

They build their nests near ground in stumps of dead trees or create colonies in the form of dome shaped mounds on the ground.

The termites enter the building through foundations or from ground adjacent to buildings & advance upward through floors destroying everything that comes within their reach

3.

For preventing the attack of termites, the soil beneath the building & around has to be treated with soil insecticides.

Types of anti-termite treatment

1) Pre construction treatment
2) Post construction treatment

Pre construction treatment

1) Site preparation
2) Soil treatment

Site Preparation

- It consists of removing stumps, roots, logs, waste wood etc from the site where the building is proposed.
- If the termites mound are found to be existing within the plinth of the building, they should be destroyed using insecticide solution.
- For treatment, holes should be made into the mound at several places using a crow-bar & the insecticides taken in the form of water suspension or emulsion should be poured into the holes.

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The quantity of insecticide solution to be used depends on the size of mound.

For a mound having volume of about 1 cu.m, 4 litres of emulsion in water of one of the following chemicals may be used:

Chemical	Concentration by weight
DDT	5%
BHC	0.5%
Aldrin	0.25%
Heptachlor	0.25%
Chlordane	0.5%

Soil treatment

In this operation, the soil underneath the building is poisoned & also around the foundation of the building with solution consisting of any of the following chemicals in water emulsion.

Chemical	Concentration by weight
Aldrin	0.5%
Heptachlor	0.5%
Chlordane	1%

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The soil treatment should be applied in the following stages :-

1) Treatment of wall trenches, column pits & excavation for basements.

2) Treatment of top surface of plinth filling (if the chemical does not seep) (50-75mm dup holes at 150m c/c)

3) Treatment of junctions of the wall & floor

4) Treatment of soil along external periphery of building.

5) Treatment of soil surrounding pipes & conduits

6) Treatment of expansion joints.

Post Construction Treatment

This treatment is applied to existing buildings which have already been attacked by termites.

The various operations involved in eradicating termites from an existing building can be summarised as :-

1) Inspection
2) Soil treatment for foundations. (500 mm approx. dep. (12mm to 18 mm dia @ 150mm c/c (top of footing or 50mm whichever is less)
3) Soil treatment under floor (12 mm dia at 300 mm c/c) (not more than 1 litre/hole)
4) Treatment of voids in masonry (12mm dia holes @ 300mm c/c)
5) Treatment of wood work. (6mm dia @ 150mm c/c), woodwork not affected by termite should be sprayed over with chemical emulsion to prevent possible attack.