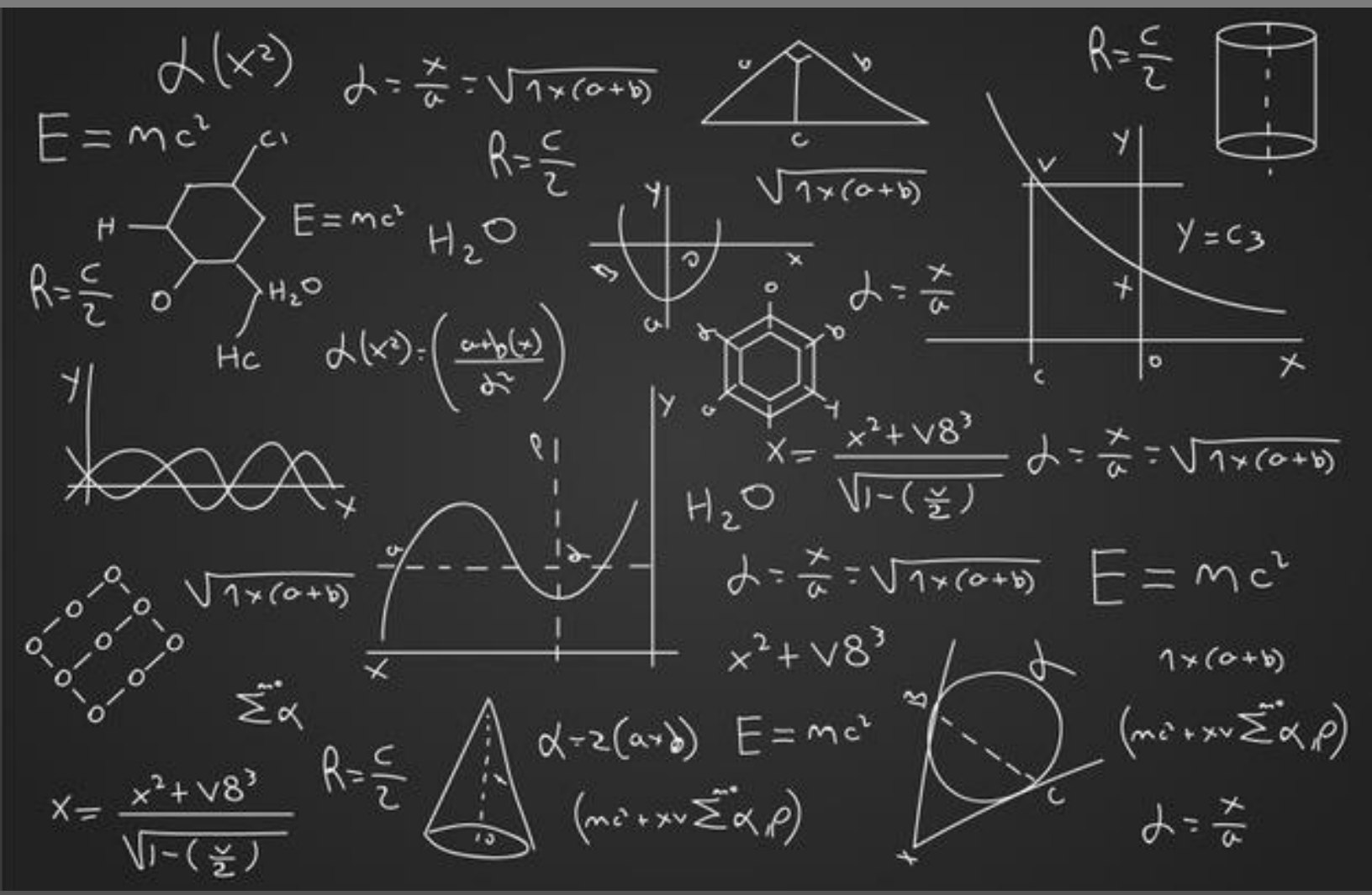
A Handwritten Note on

Quiz

7th Semester



by **Farhad Hossain**

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Never give up hope of Allah's Mercy (Quran: 12:87)

Special THANKS to-

My friend

SAYEM AHAMEED

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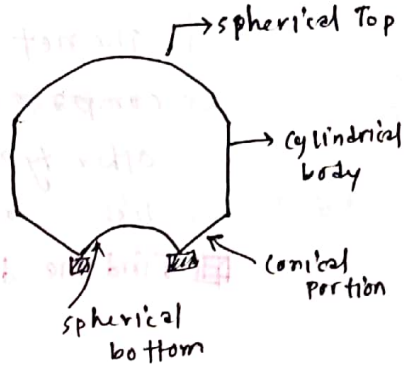
Intze-Type Water Tank Quiz

Intze Type Water Tank:

A liquid containing shell of compound geometry, usually comprising a spherical top, a cylindrical body, a conical transition in the lower part and a spherical bottom.



Classification of water Tank:

According to position of tank:

(i) Under ground water tank.
(ii) water tank resting on ground.
(iii) Over head water tank.

According to shape and design aspect:

(i) Rectangular
(ii) Circular
(iii) conical
(iv) suspended
(v) Intze type
(vi) Spherical

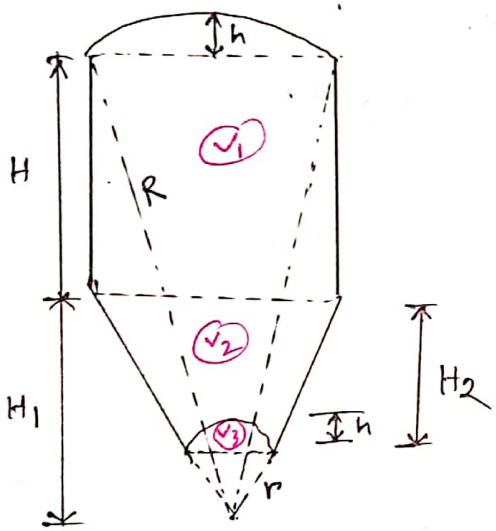
Requirments of water tank:

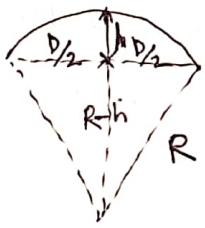
(i) plain concrete with sufficient stress
(ii) leak proof
(iii) Impervious concrete
(iv) concrete free from crack
(v) valve concontrolled over flow and washout pipe.

Advantages:

In case of Intee tank, The compressive meridional action on either side oppose each other on the horizontal projection, as a result The net lateral thrust is minimized. This brings economical compared to other water tank. This is the main advantages over other types of water tank. Due to spherical bottom, the deflection is less compared to straight beam.

Find the dimensions of an ISI Tank of capacity 20,0000 gallons.





Let,

$h = \frac{1}{8} D$

$H = \left(\frac{1}{3} D \text{ to } \frac{2}{3} D\right) \simeq \frac{D}{2}$

$H_1 = \frac{D}{2}$

$d = \frac{5}{8} D$

Now,

$$R^2 = (R-h)^2 + \left(\frac{D}{2}\right)^2$$

$$\Rightarrow R = \frac{h^2 + \left(\frac{D}{2}\right)^2}{2h} = \frac{17}{16} D$$

$$r^2 = (r-h)^2 + \left(\frac{d}{2}\right)^2$$

$$\Rightarrow r = \frac{h^2 + \left(\frac{d}{2}\right)^2}{2h} = \frac{29}{64} D$$

$$H_2 = H_1 - (r-h)$$

$$= \frac{D}{2} - \left(\frac{29}{64} D - \frac{1}{8} D\right)$$

$$= \frac{11}{64} D$$

Volume of ① cylindrical portion, $V_1 = \frac{\pi}{4} D^2 H$

$= \frac{\pi}{4} D^2 \times \frac{D}{2}$

$= 0.3927 D^3$

(ii) conical portion, $V_2 = \frac{\pi}{12} \times \left[D^2 H_1 - d^2 (r-h) \right]$

$= \frac{\pi}{12} \times \left[D^2 \times \frac{D}{2} - \left(\frac{5}{8}\right)^2 \times \left(\frac{29}{64} D - \frac{1}{8} D\right) \right]$

$= 0.0973 D^3$

(iii) bottom dome portion, $V_3 = \frac{\pi}{3} h^2 (3r-h)$

$= \frac{\pi}{3} \times \left(\frac{D}{8}\right)^2 \times \left(3 \times \frac{29}{64} D - \frac{D}{8}\right)$

$= 0.0202 D^3$

$\therefore$ Total Volume, $V = V_1 + V_2 - V_3$

$= (0.3927 D^3 + 0.0973 D^3 - 0.0202 D^3)$

$= 0.4698 D^3$

Hence,

$0.4698 D^3 = \frac{200000}{6.23}$ ft^3

1 Gallon $= \frac{1}{6.23}$ ft^3

$\Rightarrow D = 31.78$ ft $\simeq 32$ ft

$1 m^3 = 219$ gallon

$\therefore h = \frac{32}{8} = 4$ ft $\quad \because$

$H = \frac{32}{2} = 16$ ft

$H_1 = \frac{32}{2} = 16$ ft

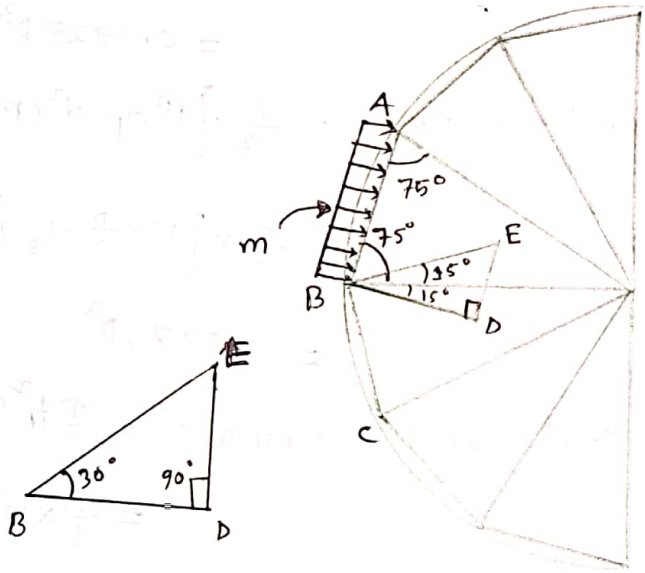
$d = \frac{5}{8} \times 32 = 20$ ft

$R = \frac{17}{16} \times 32 = 34$ ft

$r = \frac{29}{64} \times 32 = 14.5$ ft

$H_2 = \frac{11}{64} \times 32 = 5.5$ ft

Prove that when ~~wind~~ wind acts perpendicularly on a span, maximum effect will occur in the adjacent span of Bracing.



Assume, the wind effect 'm' acts perpendicularly on AB.

In the figure,

$AB \perp BD$

$BE \perp BC$

Hence

The wind along BD is m.

Now, $\cos 30° = \frac{BD}{BE}$

$\Rightarrow BE = \frac{m}{\cos 30°}$

$\therefore BE = 1.15\,m$

The wind effect along $BE > BD$ which is perpendicular to span BC.

and BC is the adjacent span of AB. $\therefore BE > BD$

Hence,

It is clear that, when wind acts perpendicularly on a span, maximum effect will occur in the adjacent span of bracing.

[4] Reynold Hand Book: Table 7(b)

Section	B.M.	T.M	Shear Force
support	$\downarrow$ 0.062	3 $K_{w1}R$ (Negligible)	$\downarrow$ 0.28
point of contraflexure	Negligible	$\downarrow$ 0.001	$\downarrow$ 0.2
Mid span	$\downarrow$ 0.01	–	–

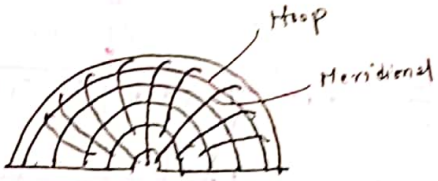
Steel Structural
* upto 0.25% carbon – mild steel
(0.25 – 0.45)% carbon – medium C steel
(0.45 – 1.5)% carbon – high C steel

500 C TMT → Thermomechanical treatment → 500 Mega pascal → Fe 500 grade steel

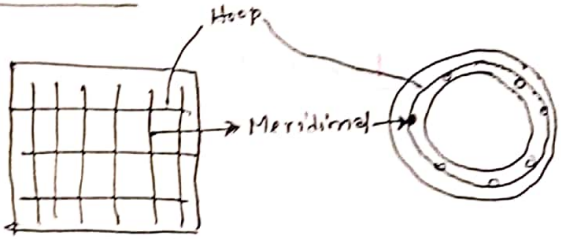
Cr (Minimum 10% of Cr) → Stainless steel

Working Diagram:

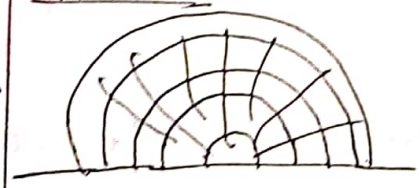
Lantern Roof:



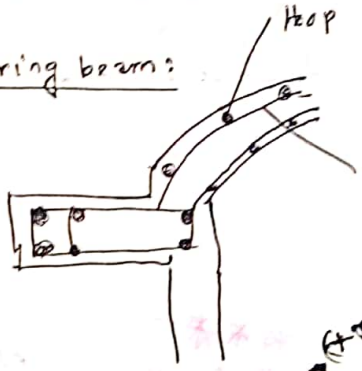
Lantern wall:



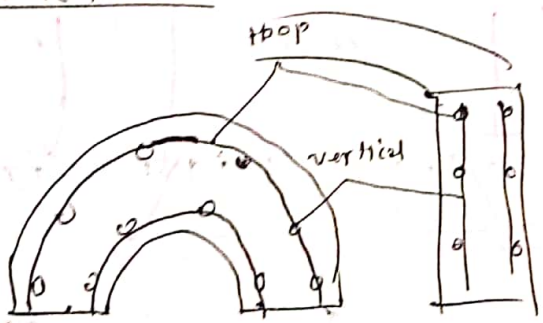
Upper dome:

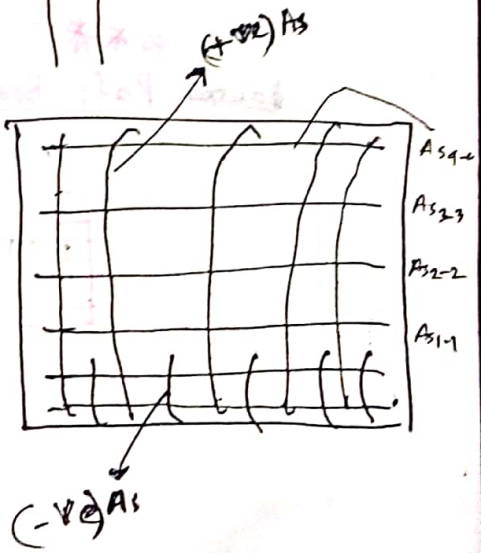


Upper ring beam:

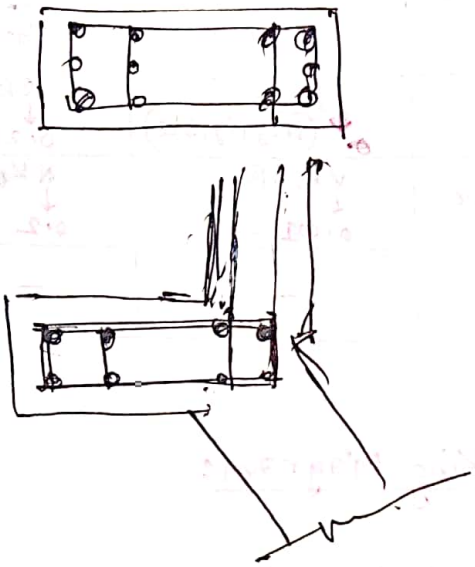


Cylindrical wall:

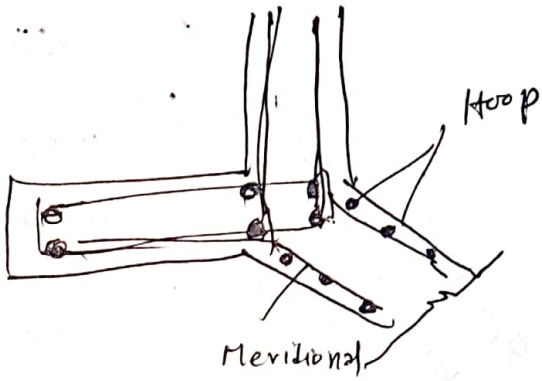




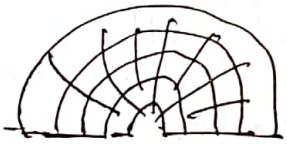
Middle Ring Beam:



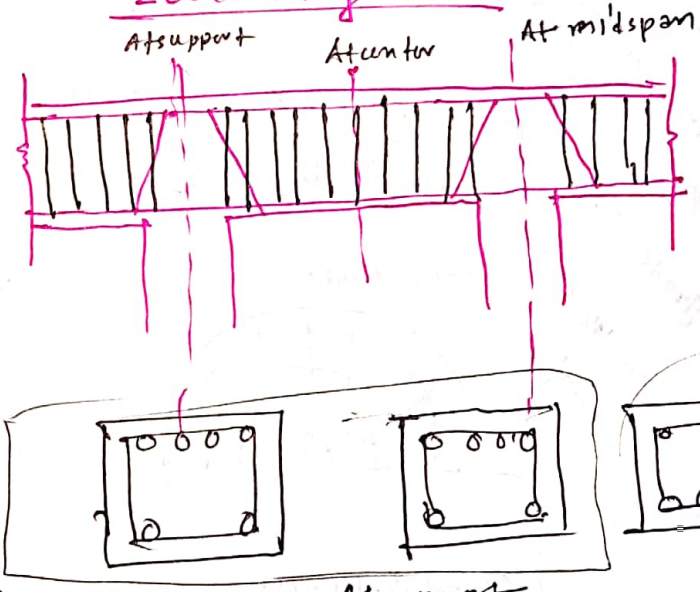
Conical walls



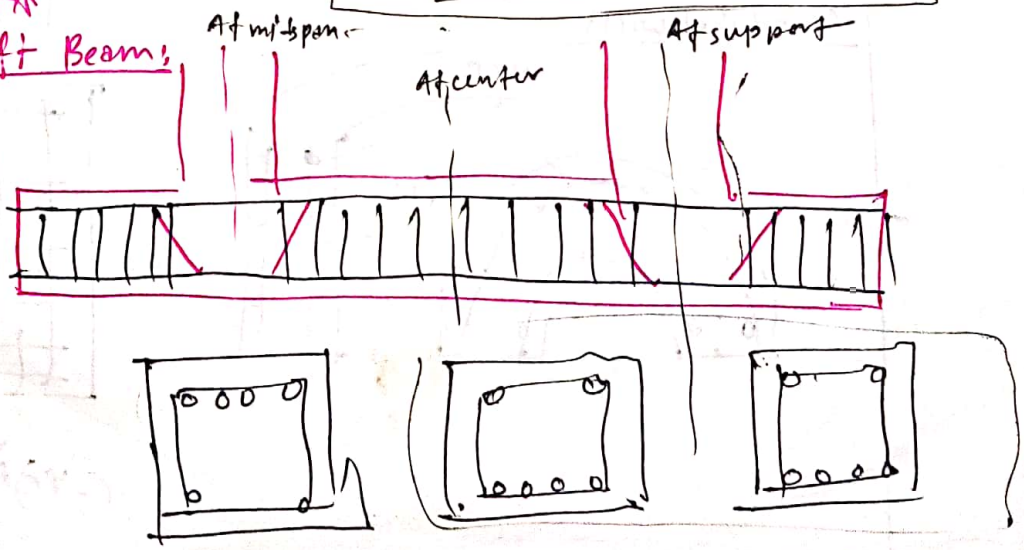
Lower dome:



*** Lower Ring Beam:



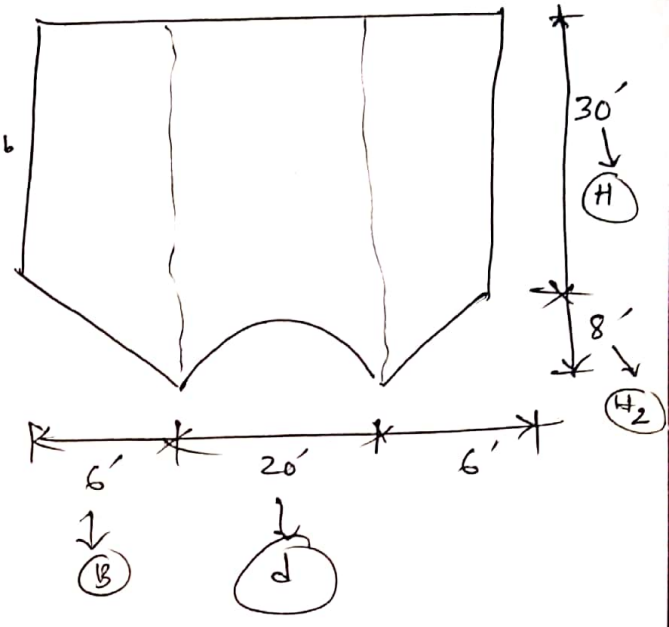
*** Raft Beam:



Determine the thickness of conical wall

Given, W_T per feet = 350001b/ft

load coming from top = 8000001b



$$D_{avg} = \left(\frac{D+d}{2}\right)$$

Solution:

$$H_{avg} = \left(H_1 + \frac{H_2}{2}\right)$$

(i) weight of water above conical portion,

$$W_1 = \pi D_{avg} \cdot H_{avg} \cdot B \cdot \gamma_w$$

$\gamma_w \rightarrow 62.4$

$$= \square$$

load coming from top

(ii) $W_2 = 800000$ (Given)

(iii) Self weight of conical wall $= \frac{t}{12} \times 150 \times D_{avg} \times \sqrt{B^2 + H_2^2}$

$$= \square \times t$$

Now,

$$W_T \text{ per feet} = \frac{W_T}{\pi D_{avg}} = (i) + (ii) + (iii)$$

$$\Rightarrow \frac{35000}{\pi D_{avg}} = \square + 800000 + \square \times t$$

$$\Rightarrow t = \square$$

California Bearing Ratio Test

Introduction:

* CBR test was developed by the California Division of Highway
* A method of classifying and evaluating soil subgrade and base course material for flexible pavement.

* **California Bearing Ratio (CBR):** The CBR is a measure of resistance to penetration of standard plunger under controlled density and moisture condition.

$$CBR\ (\%) = \frac{\text{Unit load carried by sample at defined penetration level}}{\text{unit load carried by standard crushed stones at above penetration level}} \times 100$$

* **Standard load values:**

penetration, mm	2.5	5.0	7.5	10.0	12.5
unit load, kg/cm²	70	105	134	162	183
load (kg)	1370	2055	2630	3180	3500

Apparatus:

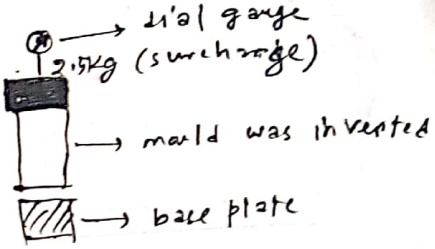
① Loading machine ② Cylindrical mould ③ Compaction rammer ④ Annular weight ⑤ sieve ⑥ Adjustable stem ⑦ Dia Gauge ⑧ Filter paper ⑨ Oven ⑩ Balance

Preparation of a specimen:

* 5 kg fine Granular soil was mixed with water upto OMC (12% by wt.) (14%) ↓ in lab
* The soil is compacted in five equal layers

* Blows — 56
* Rammer weight — 4.89 kg
* specimen height — 125 mm
* surcharge weight — 2.5 kg

* Arrangement:



* mould was placed in a water tank for soaking (96 hours)

Because full saturated condition is the weakest condition

Test Produre:

(i) Determination of Expansion ratio:

$$\text{Expansion ratio, (\%)} = \frac{(d_f - d_i)}{h} \times 100$$

d_f → dial gauge reading after soaking
d_i → initial gauge reading before soaking
h → initial height of specimen

(ii) Determination of CBR value:

* the sample was taken out of water tank and allowed to drain for 15 minutes.
* placed under penetration plunger of loading machine.
* Plunger area = 19.635 cm^2.
* Load readings:

penetration (mm)	(P)	Unit load (kg/cm^2) (P/A)
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
4.0		
5.0		
7.5		
10.0		

* Then plotted in the normal Graph

Unit load (kg/cm^2) vs. penetration (mm)

* If initial portion of curve is concave upward, correction is needed.

* Generally CBR value at 2.5 mm penetration > CBR value at 5.0 mm penetration.

This value is adopted.

* if not, the test is repeated.

* if again the CBR value of 5.00 mm is higher, then this value should be adopted for the sample as CBR Value.

Discussion:

* CBR Test — Arbitary strength Test

* The test is meant for soil and Granular base course material for flexivale pavement.

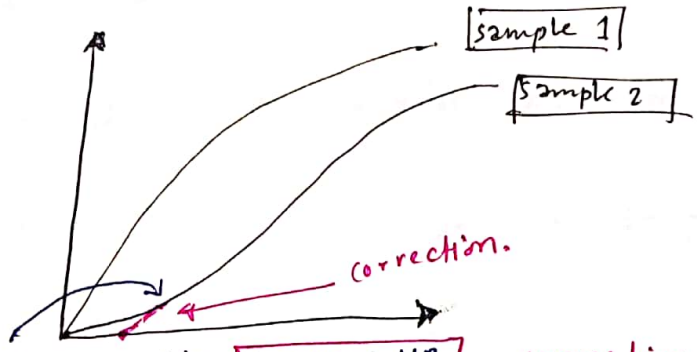
* not suitable for semi-rigid material like soil-cement.

* compaction specifications:

  (i) Height of the specimen.

  (ii) Equality thickness of five compacted layer

  (iii) uniformity of distribution of blows.



* initial portion concave up, correction is needed

Application of CBR Test:

(I) In designing of pavement of road (flexible pavement)

(II) for classifying and evaluating the soil subgrade and base course materials.

Objectives of soaked CBR Test:

Full saturated condition is the weakest condition of pavement. This is why the test is done for soaked condition. In soaked condition, expansion or swelling of the soil may occur. To know the expansion ratio, the test specimen is kept in the water tank for soaking upto 96 hrs. Because in rainy season, ~~soaked~~ soil expand and pavement gets damaged. To ensure safety against such soaked condition, soaked CBR Test is performed.

Bituminous mix Design:

* **Bituminous mix:** Bituminous mix is a type of mix in which the aggregates are bounded together by bituminous material.

* Consists of —
  - (i) Coarse Aggregate (CA): crushed Basalt passing 25 mm sieve & Retained on 2.36 mm sieve
  - (ii) Fine Aggregate (FA): coarse sand passing 2.36 mm sieve & retained on 0.075mm sieve
  - (iii) Mineral Filler (MF): Fine sand passing 0.075 mm sieve

* Good Bituminous mix should exhibit —
  - (i) stability
  - (ii) Durability
  - (iii) Workability
  - (iv) Skid resistance
  - (v) Economy.

* Bituminous mix having the following characterestics:
  - (i) sufficient Bitumen content to coat aggregate particle thoroughly for proper bond.
  - (ii) sufficient stability to satify traffic requirement without distortion and displacement.
  - (iii) sufficient Voids to provide space for expansion of bitumen.
  - (iv) sufficient workability so that may be placed in pavement with ease and efficiently.

* Design Procedure:

(i) selection of material & determination of specific gravity of materials

(ii) Selection of aggregate grading.

(iii) preparation of specimen:

* 1200 gm aggregate is required to prepare one specimen of
  — 101.4 mm (4") diameter
  — 63.5 mm (2.5") thick

* bitumen content is used with increments of 0.5% for stone chips
  1.0% for brick chips.

* Temperature of mix — 180°

* add aggregate at 150°c uniformly.

* compaction: Blows — 50 (for medium Traffic)
  Blow
  → 35 — light traffic
  → 75 — heavy "
  hammer weight — 4.5 Kg
  Free fall — 45.7 cm

* cooled for 30 minutes.

(iv) Determination of bulk specific gravity (G_{mb})

(v) Make stability test for the specimen:

* immerged in controlled water bath at a temperature of 60°C for 30 minutes.

* Marsull stability & Flow — measured
  ↓
  Measured & Adjusted → from stability correlation ratio

(vi) Determination of % V_a, % VMA and % VFB:

* Max. Sp. gravity for 5.5% BC., $G_{mm} = \dfrac{W_1}{W_1 + W_2 - W_3}$

where,

W_1 = weight of loose sample (in air)

W_2 = weight of (dessicator + full water)

W_3 = weight of (dessicator + mix + water)

* $G_{se} = \dfrac{P_{mm} - P_b}{\frac{P_{mm}}{G_{mm}} - \frac{P_b}{G_b}}$; $(P_{mm} = P_s + P_b = 100\%)$

$P_b \rightarrow 5.5\%$

$G_b \rightarrow$ (given) step-(i)

* For 4.5%, $G_{mm} = \dfrac{P_{mm}}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}}$; $P_s = (100 - 4.5) = 95.5$, $P_b = 4.5$, $P_{mm} = 100$

Similarly, 5.0%

6.0%

,

!

* % V_a (4.5%) = Total air void in mix $= \dfrac{G_{mm} - G_{mb}}{G_{mm}} \times 100$ ← G_{mb}: step (iv)

Bulk sp. gr. of Total aggregate

* $G_{sb} = \dfrac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}}$

P_1 (CA)	→	G_1
P_2 (FA)	→	G_2
P_3 (MF)	→	G_3

Given — step (i)

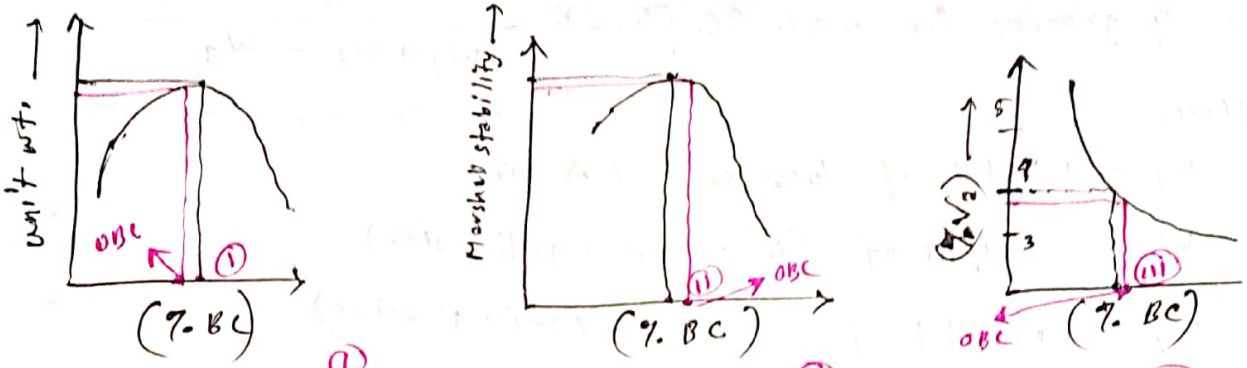
Voids in Mineral Aggregate

* % VMA $= \left[100 - \dfrac{G_{mb}}{G_{sb}} \times P_s\right]$ ← $P_s = 95.5$

Voids filled with Bitumen

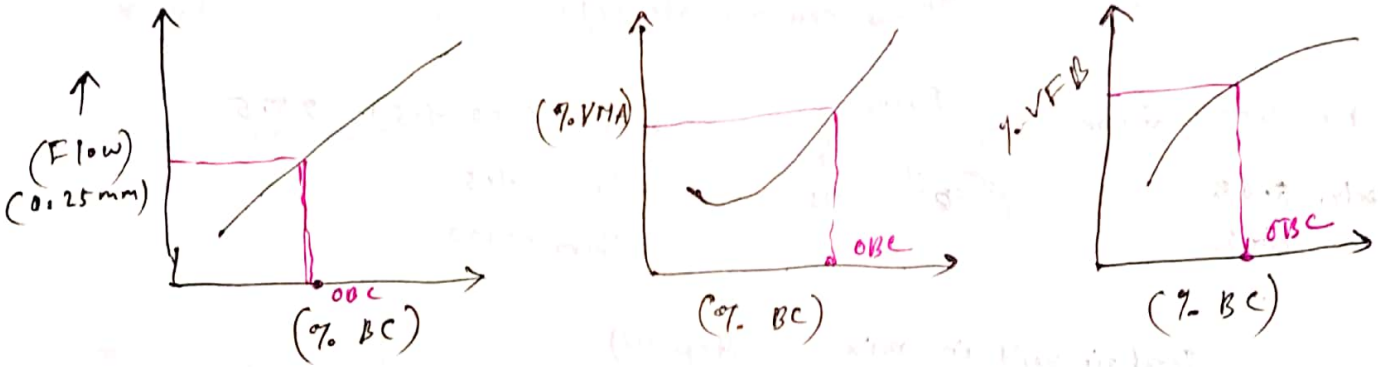
* % VFB $= \dfrac{VMA - V_a}{VMA} \times 100$

(vii) selection of OBC from the obtained data:



$$OBC = \frac{\text{BC for Max. unit wt.}^{(i)} + \text{BC for Max. Stability}^{(ii)} + \text{BC for 4\% air voids}^{(iii)}}{3}$$

Then,



(viii) Check Marshall Design criteria:

Apparatus:

* Water Bath — for controlled temperature 60°C ± 1°C
  - 480 mm × 360 mm × 250 mm
  - * Test specimen should atleast 50 mm above the bottom of water bath
* Vacuum Desiccator — for determination of Gmm
  - capacity - 2000 ml
* Compression test Machine — for preparation and testing of specimen
  - loading capacity 1000 kN
  - * minimum reading — 1kN

Function of Bitumen:

(i) It is used as a binder in the mix to bind the aggregates.

(ii) To protect the aggregate from sliding by interlocking with each other.

(iii) To impart cohesion to the mix and thus increasing the stability

(iv) To lubricate all particles for a dense mix

(v) To prevent entry of water in the mix.

Why 4% air voids is taken for determination of OBC:

Some space is provided in the bitumen mix for the expansion of Bitumen at high temperature. There should be kept 3 to 5% air voids in the Bituminous mix according to AASHTO. Thus An average value of 4% air void is taken for the determination of OBC.

Why medium Traffic is taken for the mix design:

Traffic condition of Bangladesh is medium Traffic and its design Equivalent Axel load is 10^4 to 10^6 in design period. and CVPD is 50 to 300. This is why medium traffic is taken for the mix design.

Specific gravity: It is defined as the ratio of weight per unit volume of the material to the weight of the equal volume of water at specified temperature.

$$S.G = \frac{A}{B-C} \quad \text{(Bulk)}$$

$$= \frac{B}{B-C} \quad \text{(Bulk SSD)}$$

$$= \frac{A}{A-C} \quad \text{(Apparent)}$$

A = Dry wt.
B = SSD wt.
C = wt. in water

Marshall stability: It is defined as a maximum load carried by a compacted specimen at a standard temperature at 60°C

Marshall stiffness: The resistance to deformation of Bituminous mixes under application of load after the preparation of specimen is known as Marshall stiffness. It can be calculated as:

$$\text{Marshall stiffness} = \frac{\text{Marshall stability (KN)}}{\text{Flow Value (0.25mm)}}$$

VMA: voids in mineral aggregates. The volume in the total bituminous mix that occupied by air and bitumen is defined as VMA.

$$\%\ VMA = 100 - \frac{G_{mb}}{G_{sb}} \times P_s$$

Flow: The flow is the deformation of the marshall test specimen undergoes during the loading, up to the maximum load, in 0.25 mm unit.

Abbreviations:

ASTM — American Society for Testing and Materials.

AASHTO — American Association of State Highway and Transportation officials.

LGED — Local Goverment Engineering Department

RHD — Roads and Highway department

IRC — Indian Road Congress.

BSI — Bangladesh standard Institute.

CBR TEST (Problem)

Calculate the design CBR value of subgrade soil from the following data:

Penetration (mm)	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5	10
Unit load (Kg/cm^2)	0.05	0.1	0.3	0.6	1.0	1.5	2.1	2.6	3.10	3.5

Solution: We know,

$$\text{CBR value} = \frac{\text{unit load carried by sample at standard penetration level}}{\text{unit load carried by standard crushed stone at above penetration level}} \times 100$$

So,

CBR for 2.5 mm penetration $= \frac{1.0}{70} \times 100 = 1.43\%$.

for 5.0 " " $= \frac{2.6}{105} \times 100 = 2.48\%$. ✓

for 7.5 " " $= \frac{3.10}{134} \times 100 = 2.31\%$.

for 10 " " $= \frac{3.5}{162} \times 100 = 2.16\%$.

Hence, Design CBR value = 2.48%. But,

CBR for 2.5 mm penetration < CBR for 5.0 mm penetration.

So, Test should be repeated.

(Ans.)

2012

Ascertain the accepted CBR value from the following Data:

penetration (mm)	Total load (Kg)	
	Test (Initial)	Test (Repeated)
2.5	50	52
5	76	80

Solution:

For initial Test,

For 2.5 mm penetration, CBR value $= \frac{50}{1370} \times 100 = 3.65\%$

For 5 " " , CBR value $= \frac{76}{2055} \times 100 = 3.7\%$

Then, For Repeated Test,

For 2.5 mm, CBR value $= \frac{52}{1370} \times 100 = 3.8\%$

For 5.0 " , CBR value $= \frac{80}{2055} \times 100 = 3.9\%$

Since, For Repeated test, CBR value for 2.5 mm penetration < CBR value for 5.0 mm penetration

Hence, The design CBR value = 3.9 %.

(Ans.)

Bituminous Mix Design - (Problem)

(#) For 1200 gm weight of aggregate, what will be the total weight of mix for 7% Bitumen content?

Solution:

Required Bitumen for 7% Bitumen Content $= \frac{1200 \times 7}{(100-7)} = 90.32$ gm

∴ Total weight of bituminous mix $= (1200 + 90.32)$ gm

$= 1290.32$ gm

(Ans.)

(#) If the weight of specimen is 1161 gm, SSD weight of specimen 1165 gm, weight in water 658 gm. what will be the unit weight of specimen?

Solution: Given that, $A = 1161$ gm

$B = 1165$ gm

$C = 658$ gm

∴ specific gravity of specimen $= \frac{1161}{1165-658} = 2.289$

∴ unit weight of specimen $= (2.289 \times 1000) = 2289$ kg/m^3

(Ans.)

% Va, % VMA, % VFB

(#) Calculate the ^ from the following data and show the relationship Between % Va and % BC.

CA = 58 %, FA = 38 %, MF = 4 %

$G_1 = 2.774$, $G_2 = 2.461$, $G_3 = 2.436$ and $G_b = 1.022$

$G_{mm} = 2.297$ (for 8%)

% BC	7	7.5	8	8.5	9
Bult sp.gr. of Mix (G_{mb})	2.146	2.162	2.215	2.204	2.199

Solution: G_{mm} (8%) = 2.297

Now,

$$G_{se} = \frac{P_{mm} - P_b}{\frac{P_{mm}}{G_{mm}} - \frac{P_b}{G_b}} = \frac{100 - 8}{\frac{100}{2.297} - \frac{8}{1.022}} = 2.577$$

Now,

For 7% BC, $$G_{mm}(7\%) = \frac{P_{mm}}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}} = \frac{100}{\frac{100-7}{2.577} + \frac{7}{1.022}} = 2.329$$

similarly, $$G_{mm}(7.5\%) = \frac{100}{\frac{92.5}{2.577} + \frac{7.5}{1.022}} = 2.313$$

$$G_{mm}(8\%) = \frac{100}{\frac{92}{2.577} + \frac{8}{1.022}} = 2.297$$

$$G_{mm}(8.5\%) = \frac{100}{\frac{91.5}{2.577} + \frac{8.5}{1.022}} = 2.282$$

$$G_{mm}(9\%) = \frac{100}{\frac{91}{2.577} + \frac{9}{1.022}} = 2.267$$

Now, $$G_{sb} = \frac{58+38+4}{\frac{58}{2.774} + \frac{38}{2.461} + \frac{4}{2.436}} = 2.348$$

% BC	$\% V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$	$\% VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$	$\% VFB = \frac{VMA - V_a}{VMA} \times 100$
7	$\frac{2.329 - 2.146}{2.329} \times 100 = 7.86$	$100 - \frac{2.146}{2.346} \times 93 = 15.1$	$\frac{15.1 - 7.86}{15.1} \times 100 = 47.95$
7.5	6.53	14.83	55.97
8	3.57	13.21	72.98
8.5	3.42	14.11	75.76
9	3.0	14.77	79.7

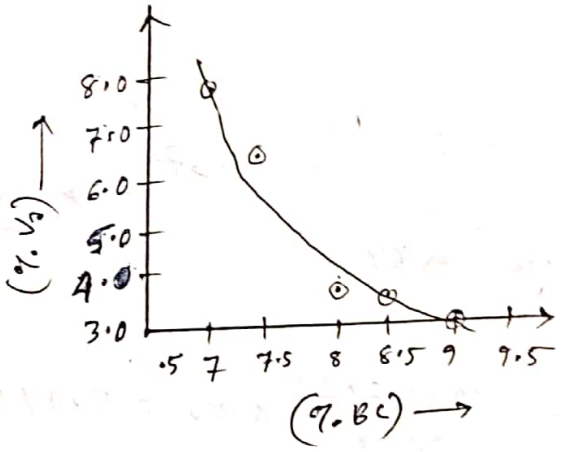


Fig. Relationship between % Va and % BC

* concave up
* Slope (-ve)

2012

(#) Calculate the % V_a and % VMA, % VFB for 6% Bitumen content in Mix from the following Data:

$G_1 = 2.75$, $G_2 = 2.46$, $G_3 = 2.62$, $G_{mm} = 2.38$, dry weight of specimen = 1250 gm, weight in water = 700 gm, and weight of water absorbed by specimen = 2gm. Ratio of MF : FA : CA = 1 : 7 : 12 in mix

Solution: Given, $A = 1250$ gm

$B = (1250 + 2) = 1252$ gm and $C = 700$ gm

$$\therefore G_{mb} = \frac{A}{B - C} = \frac{1250}{1252 - 700} = 2.26$$

$G_{mm} = 2.38$ (Given)

$$G_{se} = \frac{P_{mm} - P_b}{\frac{P_{mm}}{G_{mm}} - \frac{P_b}{G_b}} = \frac{100 - 6}{\frac{100}{2.38} - \frac{6}{1.02}} = 2.50$$ → no need

$$\% V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100 = \frac{2.38 - 2.26}{2.38} \times 100 = 5.04\%$$

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}} = \frac{60 + 35 + 5}{\frac{60}{2.75} + \frac{35}{2.46} + \frac{5}{2.62}} = 2.63$$

Here,

$P_3 = \frac{1}{20} \times 100 = 5$

$P_2 = \frac{7}{20} \times 100 = 35\%$

$P_3 = \frac{12}{20} \times 100 = 60\%$

$$\therefore \% VMA = \left(100 - \frac{G_{mb}}{G_{sb}} \times P_s\right) = 100 - \frac{2.26}{2.63} \times 94$$

$$= 19.22$$

$$\% VFB = \frac{VMA - V_a}{VMA} \times 100 = \frac{19.22 - 5.04}{19.22} \times 100 = 73.78\%$$

(Ans.)

(#) 2015, 2018 Calculate the %. V_a, %. VMA and %. VFB of the compacted Bituminous mix specimen for 6% BC from the following data:

- $G_1 = 2.27$, $G_2 = 2.46$, $G_3 = 2.44$, $G_b = 1.02$, $G_{mm} = 2.29$

dry weight = 1160 gm, wt. in water = 639 gm, and absorbed water weight = 3 gm, $P_1 = 58\%$, $P_2 = 38\%$ and $P_3 = 4\%$

Solution:

$$G_{mb} = \frac{A}{B - C} = \frac{1160}{(1160+3) - 639} = 2.214$$

$G_{mm} = 2.29$ (given)

$$\therefore \%. V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100 = \frac{2.29 - 2.214}{2.29} \times 100 = 3.32\%$$

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}} = \frac{58 + 38 + 4}{\frac{58}{2.27} + \frac{38}{2.46} + \frac{4}{2.44}} = 2.345$$

$$\therefore \%. VMA = \left(100 - \frac{G_{mb} \times P_s}{G_{sb}}\right) = 100 - \frac{2.214}{2.345} \times 94 = 11.25\%$$

(Ans.)

ENVIRONMENT QUIZ

Exp No. 01: Sampling of water and waste water for Bacterial Test.

* **Bottles:**

(i) cleaned, rinsed with distilled water and sterilized.

(ii) Two types of Bottles: * Clean sterile Bottles

* Clean sterile Sodium thiosulphate treated bottles.

(iii) Sample containing residual chlorine (→ pool water) should alway be collected in sodium thio-sulfate treated bottles.

(iv) Bottle size: 4 to 8 oz (ounce) [1oz = 29.574 mL]

* **Collection of Samples:**

(i) Bottles should be filled to three-quaters of their capacity. ($\frac{3}{4}$)

From Water System:

(i) Before collecting the sample, tap and piping should be thoroughly flushed.

(ii) collect from the tap that are in frequent use.

(iii) Avoid sampling from - taps in lavatories
- wet taps.
- Rubber hose

From pools, Lakes Rivers:

(i) collect from at a depth of 3inch or more

(ii) collect from a point which represent average conditions. (যেখানে মানুষ গোসল করে)

1-3

Pools: (i) collecting during periods of use. (At the time of bathing)
(ii) samples should be collected in sodium-thiosulfate treated bottles.

Lakes: (i) never be collected from the shore
(ii) collected at a distance of atleast 25 ft or more from the shore.

Rivers: (i) can be collected from the bank but at a distance of at least 1 ft.
(ii) In meandering stream (आंकाबाका नदी), collected near the center at the point of greatest depth.

sewage and sewage effluents:
(i) collected directly from sewage / sewage effluent into the sample bottle.
(ii) when composite samples are desired, samples should be collected in sterile container.
(iii) composite sample bottle should be stored at a temperature of 6° to 10°C during the period of collection.

Transportation and storage samples:
(i) All samples should be tested as soon as possible.
(ii) Time of transportation: * For Impure water : not exceeds 6 hr
* For Pure water : not more than 12 hr.
(iii) sample stored longer than 24 hr. should be discarded.
(iv) In warm weather Time of Transportation : > 1 hr.
sample should be iced.

Exp. No. 02: Test for thermotolerant (Faecal) Coliforms by Membrane filtration Method (MFM)

Principle:

(i) MFM gives a direct count of total coliforms and thermo tolerant coliforms present in sample.

* **Membrane Filter:** it consists of a cellulose compound (dia – 47-50 mm) with a uniform pore diameter of 0.45 µm or 0.2 µm.

Volume of water sample for filtration:

* The optimum number of colonies is between 20 and 80, with maximum 200.

* The choice of volume of sample to be filtered will depend on the type of water.

Equipment and Glassware:

(i) Membrane filtration apparatus: *(an electric/hand powered vacuum pump) *(a vacuum flask) * (a filter support)

(ii) Reusable petri dishes

(iii) Blunt-ended forceps: for picking up membrane filter.

(iv) Reusable (autoclave) bottles: For culture media.

(v) A magnifying lens: (x4 or x5)

(vi) A boiling bath: (for disinfection of filter apparatus)

(vii) Sterile pipettes: 1mL - 10mL

(viii) A graduated cylinder: 100mL

* Membrane filter
* Nutrient absorbent pads : Filter paper disc (1 mm thick), dia. same as membrane filter.
* Culture media
* Wax pencils : for lebeling petri dishes.
* polythye bag : to prevent drying of sample and media.

Culture Media & Dilution Water:

Culture media: ✓ Lactose Tergitol agar
✓ Lactose TTC Tergitol agar
✓ Membrane lauryl sulfate lactose broth * for coliform organisms at 35°c or 37°c. * for thermotolerant coliform organisms at 44°c or 44.5°c

* Membrane ~~Filtration~~ Faecal coliform (MFC) broth should be used only at 44 or 44.5°c for thermotolerant coliform counts.

MFC
(sulfate lauryl Broth + hot water)
Red colour
→ Reusable Bottles

procedure :

(i) Food supply of Bacteria:

(ii) Sterilization of the equipment:

* For sterlization of membrane filtration unit : Methanol with flaming
→ Formaldehyde
→ strong disinfectant

* Nutrient absorbent pad is placed in petri dish. broth medium
* Add sulfate lauryl Broth to saturate the pad.

*iii) collecting water sample

(iv) Filtration.

* Membrane filter is placed on filtration unit using forceps (ethanol ↑ sterile by flaming.)

* shaking the sample water so that bacteria are evenly distributed.

* pour the sample (100mL)

* Attaching hand-pump (vacuum) for water filtration.

* Then Remove filter and placed over ~~petri dish~~ absorbent pad in petridish (no air bubble trapped beneath it) (careful)

(v) Growing the bacteria:

* Leave the petridish for 2–4 hrs at 35° – 37°C, for resuscit of stressed microbes.

* Place the petridish in to incubation unit (or, water proof plastic bags in water bath) for 24 hrs (18-24) hrs at 44°C. with 100% humidity.

$$\text{Thermo-tolerant Coliform per 100ml} = \frac{\text{no. of themotolerant colonies counted} \times 100}{\text{no of ml. of sample filtered}}$$

Coliform Bacteria: Coliforms are bacteria that are always present in digestive tracts of animals, including human and are found in their wastes. They are also found in ~~soil~~ plant and soil particles.

Total Coliform: Total coliform are a group of related bacteria that are not harmful to humans. A variety of bacteria, parasites and viruses, known as pathogens, can potentially cause health problem, if human ingest them.

EPA considers total coliforms a useful indicator of other pathogens for drinking water. Total coliform are used to determine the adequacy of water treatment and the integrity of the distribution system.

Faecal Coliforms: Faecal coliform are the group of the total coliforms that are considered to be present specially in the gut and feces of warm-blooded animal. Faecal coliforms are considered a more accurate indication of animal or human waste than total coliforms.

Why we use Coliform as indicator:

(i) Coliforms may be associated with the sources of pathogens contaminating water.

(ii) The analysis of drinking water for coliforms is relatively simple, economical and effluent.

Exp-03:

* After a specified incubation time at a given temperaturatue, each tube showing gas formation is regardes as "presumptive positive" since, the gas indicates the possible presence of coliforms.

* gas may also be produced by other organisms, so a subsequent confirmatory test is essential.

* Two test · (i) Presumptive Test
(ii) Confirmatory Test

* Most probable number (MPN) Method: The most probable number of bacteria present can be estimated from the number of tubes inoculated and the number of positive tubes obtained in the confirmatory test, using specially devised statistical Tables, This technique is Known as the MPN method.

For unpolluted and Treated water:

- water in Distribution system
- In this case, It is recommended that, Should be inoculated in to tubes.

* Inoculation -
one (50 ml) plus
five (10 ml) volumes of water
↓
of double strength Medium

For Polluted Water:

✓ Water from raw water source

* Inoculations: containing 10 mL

(i) 10 mL of sample (five tubes) → Double strength Medium

(ii) 1.0 mL of sample (five tubes) → single strength Medium

(iii) 1.0 ml of a 1:10 dilution of sample (≃ 0.1 mL of sample)

→ single strength Medium

* If the work load is very heavy and the time available is limited, the number of tubes can be reduced to three in each series.

Equipment and supplies:

(i) Auto clave : (For sterilizing the cultur media . not more than 30 minutes)

(ii) Incubator

(iii) ~~Water~~ Balance

(iv) water distillation apparatus, hose and container

(v) pipettes.

(vi) Test Tubes & racks

(vii) Bottles.

(viii) Media preparation ~~Tube~~ Equipment

(ix) Gas burner

(x) ~~cul~~ Durham tubes

(xi) Inoculation loop and holder

(xii) Dispenser

(xiii) safety equipment

culture media for MPN :

- MacConkey Broth ✓
- Lauryl Tryptose Broth
- Improved formate lactose glumate medium
- Brilliant green lactose broth ✓
- Tryptone water.

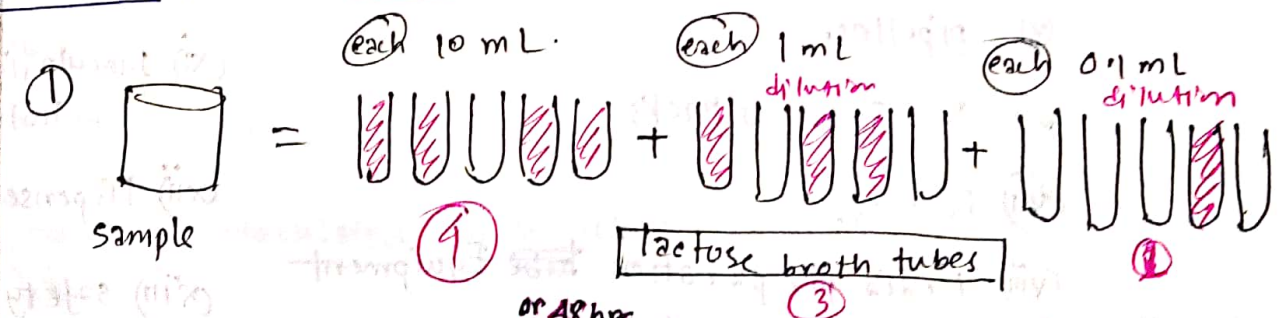
uses

* presumptive solution of water — incubator Temp. 35 ± 0.5°C, 37 ± 0.5°C
* confirmation of thermotolerant / confirmation of Escherichia Coli — 44°C

1 MPN = 1 CFU = 1 viable cell (living)

CFU = Colony forming unit

For polluted water:



(ii) incubate for 24 hrs. or 48 hrs

(iii) Read Results. (change color)

1st	2nd	3rd
4	3	1

Results: 4-3-1

→ From Table-3 → MPN = (33 per 100 ml)

95% confidence limit (11-93 per 100 ml)

* Heavy Polluted Water → coded result (5-5-5)

From Table-3 → >1800 / 100 ml MPN value

→ Does not give a definite value.

⇒ in this case, it is usual to inoculate more than three dilution in series of factor 10.

5 Dilution → (5 X 1.0 mL
5 X 0.1 mL
5 X 0.01 mL
5 X 0.001 mL
5 X 0.0001 mL)

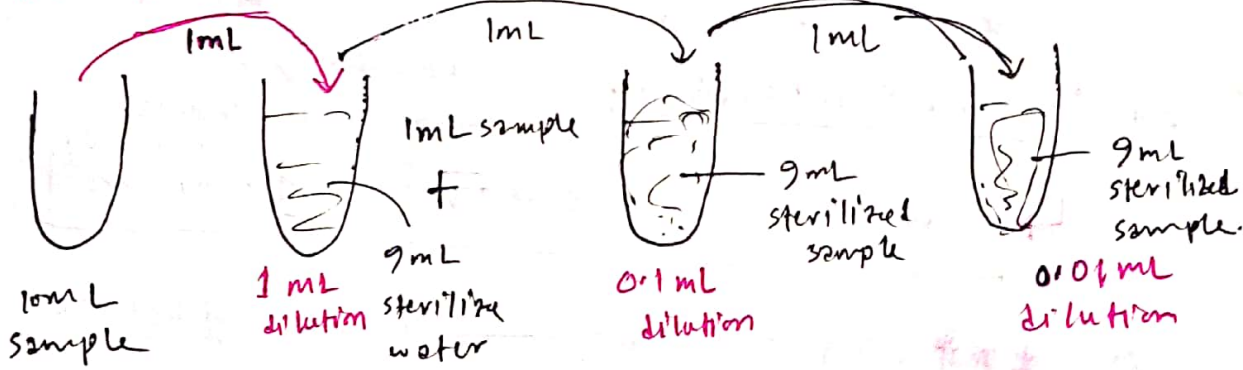
Coded Result
5-5-4-1-0

Chosen code
5-4-1
Multiply factor – 100

From Table – 170 X 100
= 17000 per 100 ml

Dilution

1mL Dilution = 1 mL sample + 9 mL sterilize water



For Un polluted Waters

① presumptive test: (i) 50 mL + 10 mL

(ii) Add broth (Macconkey Broth)

(iii) incubate at 35°C for 24 hrs.

durham Tube → if gas formation → (+ve test)

if not foram

↓

again incubate for 24 hrs at 35°C

gas foram → +ve tube

not form → -ve tube

(ii) confirmatory test: (for +ve tube)

+ve tube → +ve tube sample + green bile broth

incubate for 24 hrs & at 44°C ± 0.5°C

Brilliant

if gas form → (+ve) confirmatory → ther motolerant coliform

if not (ii) → (-ve) → coliform

+ve tube sample + kryptom water + 0.01 mL of Kovacs

→ Ecoli (indole)

→ not Ecoli (not indole)

If time is not available:

3 × 10mL + 3 × 1mL + 3 × 0.1 mL

Largest Bactoria → Thiomargarita Namibiensis

smallest " → Mycoplasma Pneumoniae

Ex-04: Water Supply system design.

purpose of wss:

(i) To make water available in close proximity to the consumers.

(ii) To supply water in adequate quantities according to the demand of consumers.

(iii) To supply water in adequate pressure

(iv) To regulate water supply as per requirement.

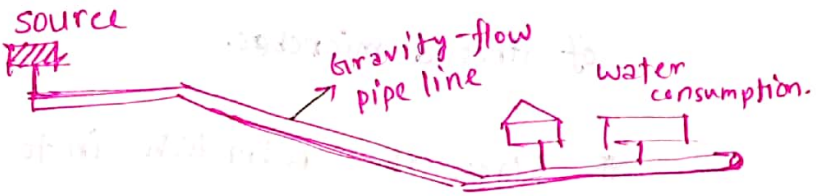
classification of wss:

(i) Gravity flow system.

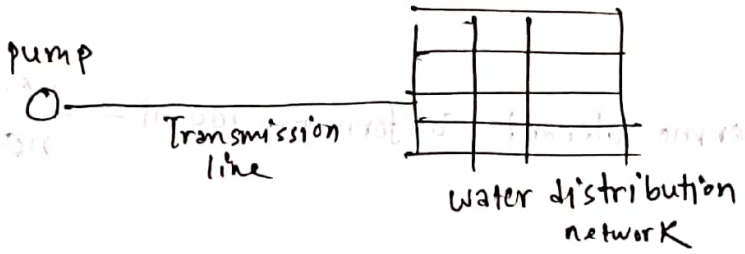
(ii) System with direct pumping.

(iii) System with pumping and storage.

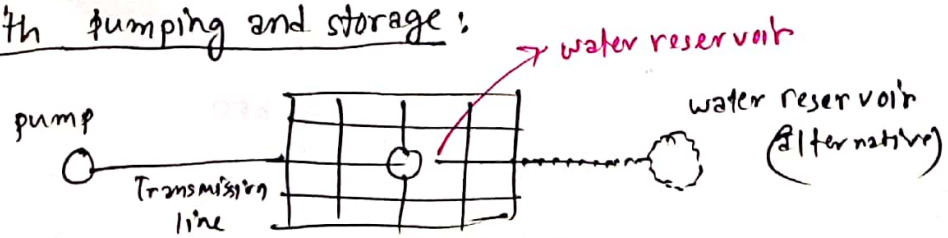
(i) Gravity flow system:



(ii) system with direct pumping:



(iii) system with pumping and storage:



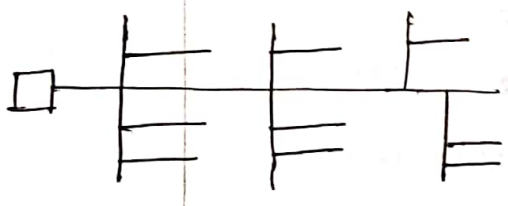
Distribution of WSS Network:

(i) Branched Distribution network (Dead end system)

⇒ suitable for developing areas with an irregular pattern of road network

(ii) Looped Distribution network (improvement of Dead end system)

⇒ suitable for well developed areas with a definite pattern of road network.



Peak factor: varies between 1.3 to 1.5

Water consumption in Bangladesh:

Areas	Water Consumption (lpcd)	peak factor, K
Rural	50	3
Upazilla town	100	2
Town	120	2
City Corporation	180	1.5

Design Flow:

water consumption, Future population

$$Q = \frac{f\, q\, P_f}{1 - 0.01\, W}$$

- Q: m^3/sec
- f: peak factor
- W: water loss (%)
- q: water consumption
- P_f: Future population

$Q = AV$, $A = \frac{\pi}{4} D^2$ → 1 m/sec.

$f = \square$ (1.5)

$P_f = P_p (1 + p)^n$ → design periods

- P_p: present population
- p: annual growth

Hazen william Equation:

$$Q = 3.7 \times 10^{-6}\, C\, D^{2.63} \left(\frac{H}{L}\right)^{0.54}$$

- Q: (l/sec)
- C: roughness co-efficient (100–140)
- D: (mm)
- H: (m)
- L: (m)

$C = 120$, $\frac{H}{L} = 1.59 \times 10^6 \frac{Q^{1.85}}{D^{4.87}}$

$C = 130$, $\frac{H}{L} = 1.39 \times 10^6 \frac{Q^{1.85}}{D^{4.87}}$

pipe sizes:

	pipe dia	length
Main	(100–150) mm	400 m
Submain	(50–75) mm	200 m
Branch	(25–50) mm	100 m.

Problem:

* Height of water tank = 20m (supply pressure head)
* Annual population growth = 2%.
* Average per capita water consumption = 130 lpcd
* Design period = 25 years.
* Roughness co-efficient = 120
* Peak factor, f = 1.5
* water loss = 20%.
* pipe length = 100 m
* Required pressure head = 15 m
* population = 30 (5 × 3)
  - ⇒ (5) storey Building
  - ⇒ (6) person / storey

Solution:

Present population, $P_p = 30$

Future population, $P_f = P_p(1+r)^n$

$= 30 \times (1+0.02)^{25}$

$= 49.22 \simeq 50$

Peak Design flow per day,

$$Q = \frac{f q P_f}{1 - 0.01W}$$

$$= \frac{1.5 \times 130 \times 50}{1 - 0.01 \times 20}$$

$= 12187.5$ lpcd

$= \frac{12187.5}{24 \times 60 \times 60} = 0.14106$ l/sec

$= 1.4106 \times 10^{-4}$ m³/sec.

Now, $Q = AV$

$\Rightarrow 1.4106 \times 10^{-4} = \frac{\pi}{4} D^2 \times 1$

$\Rightarrow D = 0.0134$ m

$\therefore D = 13.4$ mm

provide market available dia of 25 mm.

For C=120,

$$\frac{H}{L} = 1.59\times10^{-6}\frac{Q^{1.85}}{D^{4.87}} = 1.59\times10 \times \frac{(0.14106)^{1.85}}{(25)^{4.87}} = 6.6043\times10^{-3}$$

$\therefore$ Total Head loss $= (6.6043\times10^{-3}\times100) = 0.66$ m

$\therefore$ Available Head $= (20-0.66) = 19.34$ m > 15 m

(OK)

Hence, use 25 mm dia. pipe for that branch.

(Ans)