Materials & Basic Civil Engineering

Quantity Surveying

(1) Eight cube of 6"×6" is made of concrete with ratio of 1:3:6 . calculate the requirement of cement. [BWDB'18]

Soln: Total concrete mix volume of 6inch cube

$= 8 \times 6 \times 6 \times 6 = 1728\ in^3 = \frac{1728\ in^3}{(12)^3} = 1\ cft$

Dry volume [before mix] of concrete $= 1.54 \times 1 = 1.54$

cement required $= \frac{1}{1+3+6} \times 1.54 = 0.154\ cft$

$= \frac{0.154}{1.25} = 0.12\ bag$

$= 0.12 \times 50\ kg$

$= 6\ kg$

BWDB'20 MCQ ← [1 bag cement = 1.25cft = 50kg]

* $1m^3 = 1440\ kg$ cement

(2) Determine the number of bags of cement required to cast two 30ft long span beam with 12"×18" section . Use 1:1½:3 mix design ratio [BGFCL'17, ERL'

Soln: Dry volume of concrete $= 1.54 \times \left(2 \times 30 \times \frac{12 \times 18}{144}\right) = 138.6\ cft$

cement required $= \frac{1}{1+1.5+3} \times 138.6 = 25.2\ cft \approx 20\ bags$

(3) 550cft concrete is mixed in 1:2:4 ratio. Find the no of cement bag required for this mix [JOCL'18]

Soln: cement bag required $= \frac{1}{1+2+4}\left(1.54 \times 550\right) \times \frac{1}{1.25}$

~~1.54 [illegible] = 550cft concrete [illegible]~~ ≈ ~~32 bags ≈ 63 bag~~

actually 1 bag cement = 1.226 cft ≈ 97 bags.

(4) Determine the volume of cement, sand & stone chips of 100cft of cement concrete mix with ratio (1:1.5:3) [BPDB'18] [DESCO'19] [BD-China-16] [Titas'21] [BGDCL'21] [PGCB'21] [Petrobangla'22] [CPGCBL'22]

M20 Grade ✗ ✓

Soln: Dry volume of concrete = 1.54 X 100 cft
= 154 cft

cement required = $\frac{1}{1+1.5+3}$ X 154 = 28cft ≈ 22.5 bags

volume of sand required = $\frac{1.5}{1+1.5+3}$ X 154 = 42 cft

volume of stone chips = 28 X 3 = 84 cft Ans

* BD-China তে stone এর বদলে brick chips দিলো, দেওয়া।

M20 = 1:1.5:3 ; M15 = 1:2:4
(এই দুইটির বেশি আসবে)

M20 → 20MPa

1 MPa = 1 N/mm² = 145 Psi

volume of brick chips = 84cft
∴ No of brick required = ~~84~~ X $\frac{830}{100}$
= 697 Nos

100cft khowa এর জন্য 830টি ইট লাগে

5) Calculate the amount of cement, coarse aggregate, fine aggregate & reinforcement (take 0.75%) of the footing size (10ft X 10ft) & thickness 18" (HBRI'19)

Soln: Assume mix ratio = 1:2:4

~~dry~~ wet volume = 10 X 10 X $\frac{18}{12}$ = 150 cft =

~~Wet~~ Dry volume = 1.54 X 150 = ~~255~~ = 231 cft

cement required = $\frac{1}{7}$ X 231 = 33 cft ≈ 26.5 cft

CA required = $\frac{2}{7}$ X 231 = 66 cft

FA required = 33 X 4 = 132 cft

Reinforcement required = 0.75% of concrete mix volume
= $\frac{0.75}{100}$ X 150 = 1.125 cft

Steel unit weight = 7850 kg/m^3 = 490 lb/ft^3

Reinforcement required = 1.125 cft = 490 × 1.125 = 551.25 lbs

[1 kg = 2.205 lbs] ≈ 250 kg

* reinforcement এর কথা বলা থাকলে must be mix volume থেকে বাদ দিতে হবে। dry অবস্থায় যে সব concrete area এর সাথের reinforcement calculation করা হয় না।

(6) 5 columns having 7/2 ft diameter & 7m height need to be casted. Mix proportion 1:2:4. Find the ingredients. [PGCB '18]

Soln: Total concrete volume = 5 × ($\pi r^2 h$)

$= 5 \times [\pi \times (\frac{7}{4})^2 \times 7 \times 3.28]$

= 99.84 cft

~~Wet volume = 1.54 × 153.76 =~~

Wet volume = 1.54 × 99.84 = 153.76 cft

cement = $\frac{1}{7} \times 153.76$ = 21.965 cft ≈ 18 bags

CA = $\frac{2}{} \times 21.965$ = 43.93 cft

FA = 4 × 21.965 = 87.86 cft Ans

*GAP: If a column consists 6ft long & 18 inch diameter & used steel area 2.5 in^2 then steel ratio is 0.985%. [CPGCBL '21]

Ans: Column x-sectional Area = $\frac{\pi}{4} \times (18)^2$ = ~~1017.87 in^2~~ 254.47 in^2

ratio = $\frac{2.5}{\cancel{1017.87}\ 254.47} \times 100$ = 0.985%

No use of length

7) The length, width & height of singly reinforced beam was 13m, 0.435m & 1m respectively. Reinforcement ratio 2.5%. Mix ratio 1:1.5:3. Determine the amount of cement, sand, aggregate & rod (in kg) used in the beam [MIST MSc]

~~Soln: Dry Wet volu~~

Soln: Wet volume of concrete mix = 13×1×0.435 = 5.655 m^3

Dry volume = 1.54×5.655 = 8.71 m^3

Cement required = $\frac{1}{1+1.5+3} \times 8.71$ = 1.584 m^3
= 1.584×1440 kg
= 2296.3 kg
≈ 46 bags

Sand required = 1.584×1.5 = 2.376 m^3

Aggregates required = 1.584×3 = 4.752 m^3

rod required = 5.655× $\frac{2.5}{100}$ = 0.1413 m^3
= (0.1413×7850) kg
= 1109.79 ≈ 1110 kg

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(8) For a compressive strength test, 8 sample prepared with mix ratio 1:3:4. Find the required number of cement bags. [51 BMA]

Soln: cylinder size for concrete compressive strength test according to ASTM C39 is 6in (150mm) dia by 12in (300mm) height

Concrete mix volume = $8 \times \frac{\pi}{4} \times (0.5)^2 \times 1$ = 1.571 cft

Dry volume = $1.54 \times 1.571 = 2.42$ cft

cement required $= \frac{1}{1+3+4} \times 2.42 = 0.3025$ cft $= 0.242$ bag cement

এটা হচ্ছে concrete compressive Strength test করার জন্য
cement এর- compressive strength জানার জন্য ASTM use করে হয়- cement mortar এর-
অর্থাৎ 2inch এর (50mm) cube 2"x2"x2"

⑨ Find out required number of bricks for brick work volume of 7.5 m3 ? [BCIC'16]

$1m^3 = 35.315$ cft

PWD standard brick size = 9.5" x 4.5" x 2.75"

BSTI standard brick size = 10" x 5" x 3"

- Morter mix ratio —

For 4.5" wall (5" with ~~[illegible]~~ plastering) - 1:4

For 9" brick masonry wall (10" with ~~[illegible]~~ plastering) - 1:6

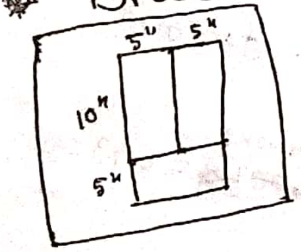
For 100cft brick works —

* For 100cft brick works ~~[illegible]~~ 45cft of mortar are required (dry volume)

1200Nos of bricks & ~~[illegible]~~ 45cft of mortar are required

* for 100cft khoa, 830 Nos bricks are required

- Brick flat soling (BFS)



$1ft^2 = 3$ NOS
$1m^2 = 31$ NOS
Sand required = $0.015 m^3/m^2$
$= 0.05 ft^3/ft^2$ (5" wall)

Herring bone brick ~~Herringbone bond~~ Soling
$1ft^2 = 5$ টি
$1m^2 = 52$ NOS

* যদি বলে 100sft brick work এ ইট লাগবে কয়টি? তখন 100sft এর সাথে ইটের একপাশের dimension 5" multiply করে দিতে হবে। $100 sft \times \frac{5}{12} = 41.67$ cft. ইট লাগবে $= 41.67 \times 12 = 500$ টি

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9 soln: brick work volume = ~~7.5m3~~ = $7.5 \times 35.315 = 264.86$ cft

∴ brick required = $264.86 \times 12 \approx 3178$ NOS Ans

~~1cft [illegible] 12টা~~

Break require $= \frac{7.5 \times (3.28)^3 \text{ cft}}{\frac{10 \times 5 \times 3}{12 \times 12 \times 12}}$
$= 3049$ N

**(10) Partition wall 5inch thick, width 25ft height 10ft. Using standard brick size, determine amount of brick, cement & sand. Mortar ratio 1:3
[BUET MSc'19]

Soln: Brickwork volume = $\left(\frac{5}{12}\times 10\times 25\right)$ cft

$\frac{104.167}{\frac{10\times5\times3}{12\times12\times12}}$ = 1200 Nos

= 104.167 cft

Brick required = 104.167 × 12 = 1250 Nos

Mortar volume = 104.167 × 0.45 = 46.875 cft

∴ Cement required = $\frac{1}{1+3}\times 46.875$ = 11.718 cft
≈ 9.375 bags

Sand required = 11.718 × 3 = 35.154 cft

Morter wet volume 35cft for 100cft brick work
Morter dry volume = 35 × 1.3 ≈ 45 ~~.5~~ for 100cft brick work
unlike 1.54 for concrete shrinkage

*Calculate the ingredients of 1m³ concrete. Mix proportion (1:2:4). Density of cement = 1500 kg/m³, shrinkage factor = 1.5. 1 bag cement = 50kg. [NESCO'21]

Soln: cement = $(1\times1.5)\times\frac{1}{7}$ = 0.214 m³ = 0.214 × 1440kg ~~1500 kg~~ = 6.43 bags

FA = $\frac{2}{7}\times(1\times1.5)$ = 0.429 m³

CA = $\frac{4}{7}\times(1\times1.5)$ = 0.857 m³

(13) For a building construction, total beam length is 1650m. 5-20mm steel bars are used throughout the beam. If per metric ton steel costs 48000 taka, then estimate total costs for steel bars. [BUET MSc]

<u>Solⁿ:</u> Total volume $= 5 \times \left[\left(\frac{20}{1000}\right)^2 \times \frac{\pi}{4} \times 1650\right]$

$= 2.592 m^3$

Steel bar weight $= 2.592 \times 7850 = 20345.74$ kg

$= 20.35$ tonnes

$\therefore$ Total cost $= 20.35 \times 48000 = 976595.5$ Tk <u>A</u>

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Steel bar unit weight

7850 kg/m^3

490 lb/ft^3 $\approx$ 490 lb/ft^3

Weight of rebar*

$= \frac{D_{mm}^2}{162.2}$ kg/m ***

ex: 8mm bar weight $= \frac{8^2}{162.2}$

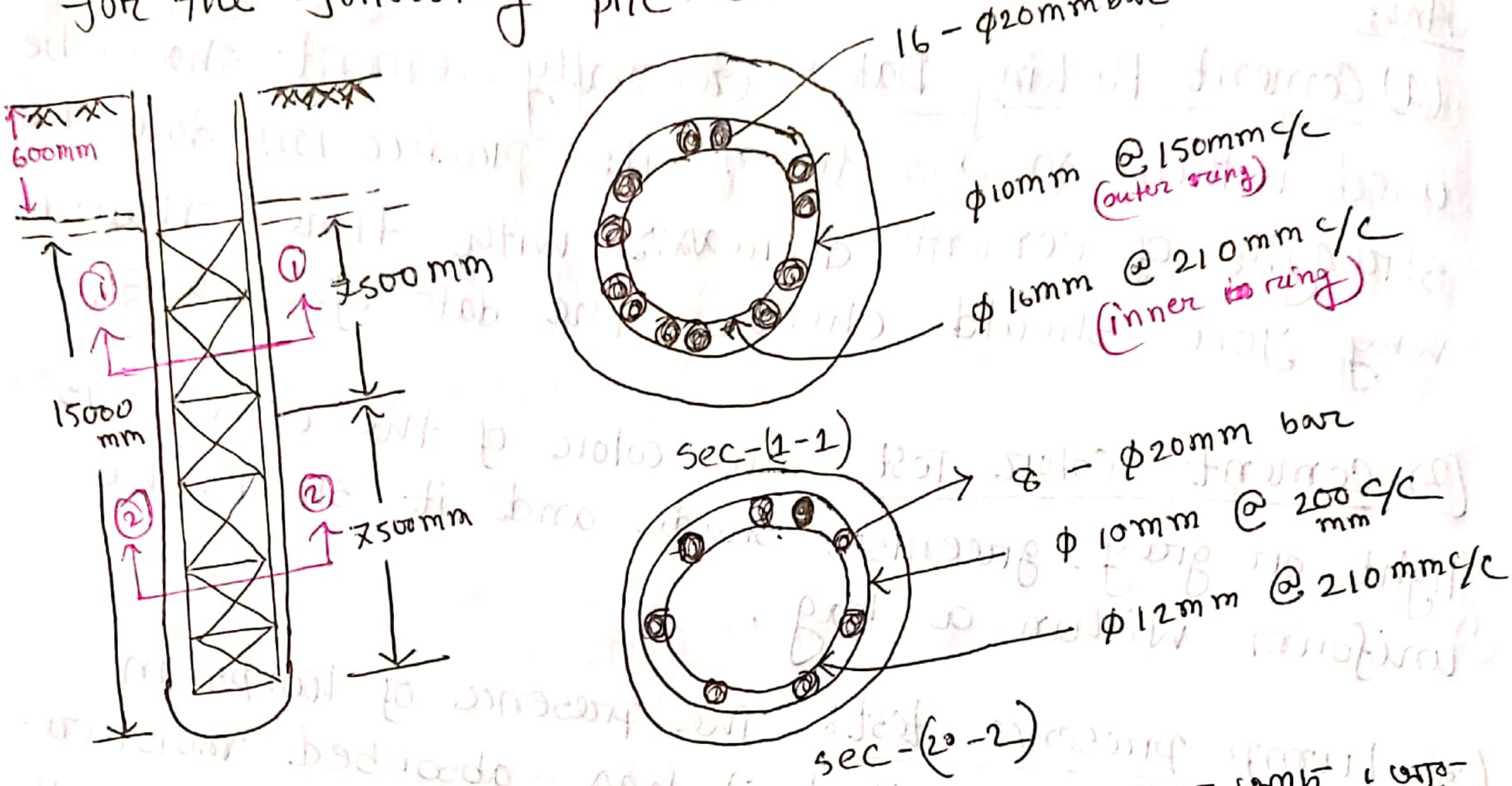
$= 0.395$ kg/m

$= 1.21 \times (d_{in})^2$ kg/ft → less important

ex: #3 bar weight $= 1.21 \times \left(\frac{3}{8}\right)^2$

$= 0.17$ kg/ft

* Estimate the quantity of longitudinal reinforcement for the following pile. ~~[PGCB'2~~ [PGCL'21]



Solnº 8 টা rod একেবারে top to bottom জুড়ে আছে। আর
উপরের (7500+600) mm অংশে extra আছে 8 টা অর্থাৎ
16 টা rod আছে। 8 টা rod (15000+600) mm জুড়ে আছে,
top to bottom যেই 8 টা rod তাই একটার rod এর লম্বা হবে,
(সেজন্যে lapping লাগবে। [Lapping = 40D]

$$\therefore L_1 = 8[15000+600+40\times20]$$

$$= 8\times16400 = 131.2m$$

$$L_2 = 8[7500+600] = 64800\,mm = 64.8m$$

$$\therefore \text{Weight} = \frac{d^2}{162.2}\times(131.2+64.8) \qquad \boxed{d \text{ in } mm}$$

$$= \frac{20^2}{162.2}\times196$$

$$= 483.35kg$$

(18)

Unit weight (kg/m3)			
water	Cement	CA	FA
187	397	---	636

specific gravity of cement, sand, CA & FA are 2.9, 2.67 & 2.6 Air content is 2% [Combined Bamkia

(i) Find the missing value in chart:

volume of water $= \frac{187}{1000} = 0.187 m^3$

volume of cement $= \frac{397}{2.9 \times 1000} = 0.137 m^3$

volume of FA $= \frac{636}{2.6 \times 1000} = 0.245 m^3$

volume of CA $= (1-0.02) - [0.187 + 0.137 + 0.245]$

$= 0.4114 m^3$

Unit weight of CA $= 0.4114 \times 2.67 \times 1000 = 1098.446$ kg/m3

A

ii) Find the w/c

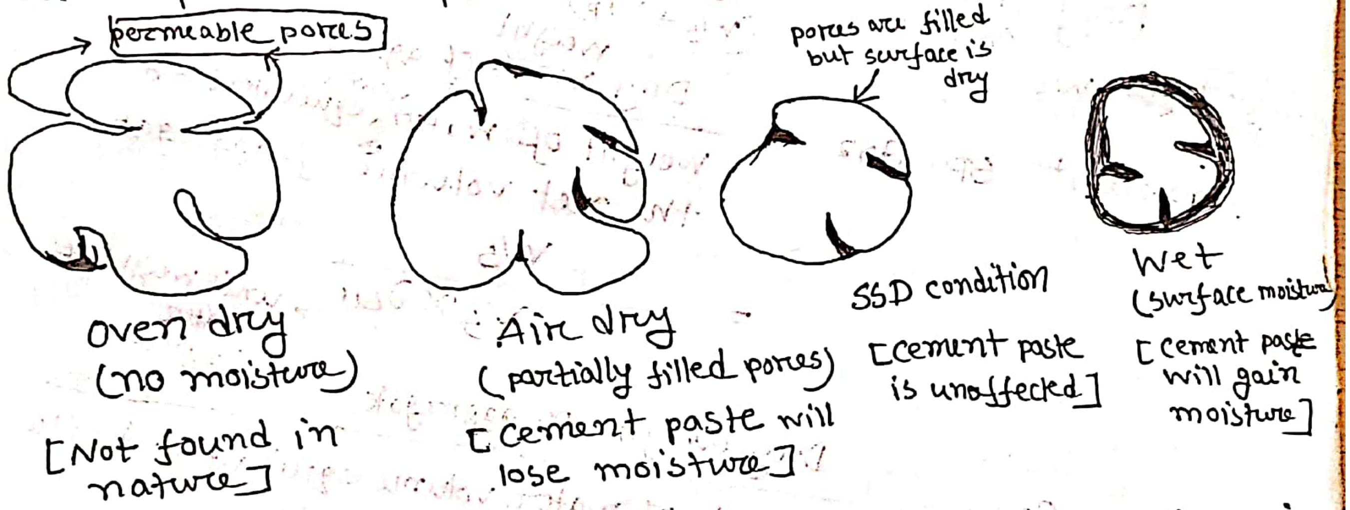
$w/c = \frac{187}{397} = 0.47$

ii) Find unit weight of concrete

$\gamma_c = 187 + 397 + 1098.44 + 636 = 2318.44 kg/m^3$

Aggregate moisture

Though they look solid, all aggregates particles have pervious pores that can absorb water.



when designing a ~~portland~~ cement concrete mix, it is crusial to maintain the design quantity of water in the mix. Any addition or absorption of water in design mix may affect the desired strength of concrete.

So aggregates are assumed to be in SSD condition in mix design ~~so that~~ as in this condition no water is added or absorbed from mix.

How to achieve SSD state?

Aggregate কে 24 ঘন্টার জন্য temperature এ ডিস্টিল্ড-ওয়াটা হয় যাতে pervious (পারভিয়াস) pore গুলি water দিয়ে- পূর্ণ হয়ে যায়। এরপর পানি থেকে তুলে aggregate কে তোয়ালে দিয়ে মোছা হয় যাতে surface এ কোন পানি লেগে না থাকে। এটাই saturated surface dry condition

Practically কীভাবে particle volume বের করা হয়?

* Aggregate পানিতে ফেললে যেটুকু 2~~[illegible]~~ যত গ্রাম(gm) পানিকে অপসারিত করবে aggregate এর volume ততো cm^3 [$\because \gamma_w = 1g/cc$]

* অথবা aggregate কে পানিতে ওজন দিয়েও বের করা যায়।

বস্তুর বায়ুতে ওজন − বস্তুর পানিতে ওজন = অপসারিত পানির ওজন (gm) = বস্তুর আয়তন (cm^3)

Lab test formula for specific gravity

G_A

Apparent SP. Gr. = $\frac{A}{A-C}$

bulk SP. Gr. = $\frac{A}{B-C}$

bulk SSD SP. Gr. = $\frac{B}{B-C}$

Absorption capacity(%) = $\frac{B-A}{A} \times 100$

pore volume count করা হয় নাই

A = oven dry weight

B = SSD weight

C = SSD weight in water

(19) The air dry weight of a sample aggregate is 120kg & SSD weight is 152 kg. The oven dry weight is 102 kg. If the weight of aggregate in water is 92kg. calculate the bulk specific gravity & % of absorption?

[BCIC-17, JOC-18, ERL-17]

Soln:

$$G_A = \frac{102}{102-92} = 10.2$$

$$G_B = \frac{102}{152-92} = 1.7$$

$$G_{SSD} = \frac{152}{152-92} = 2.53$$

$$\text{Absorption capacity} = \frac{152-102}{102} \times 100 = 49.02\%$$

A

20) A dry mass of a sample of aggregates is 1982g. The mass in a saturated surface dry condition is 2006.7gm. The net volume g the aggregate is 734.4cm3. Find the apparent specific gravity, bulk specific gravity & the absorption capacity. [NWPGCL'15]

<u>Soln:</u> weight of pore water = (2006.7 − 1982)gm

$= 24.7 gm$

$$G_{Apparent} = \frac{1982}{734.4} = 2.7$$

$$\boxed{24.7gm}$$

$$G_{Bulk} = \frac{1982}{734.4+24.7} = 2.61$$

$$G_{SSD} = \frac{2006.7}{734.4+24.7} = 2.64$$

$$\text{Absorption capacity} = \frac{2006.7-1982}{1982} \times 100 = 1.25\%$$

<u>Ans</u>:

(21) Dry weight of a sample is 1206gm. SSD weight is 1226.4gm. The volume of water exerted by the sample is 440.6cm3. Find bulk & apparent sp. gravity & absorption capacity of sample [BPDB'16] [NPCBL'17]

<u>Soln:</u>

$$G_A = \frac{1206}{440.6} = 2.74$$

weight of pore water

$= (1226.4 - 1206)g$

$= 20.4$

$$G_B = \frac{1206}{440.6+20.4} = 2.62$$

$$\text{Absorption capacity} = \frac{20.4}{1206} \times 100$$

$= 1.7\%$ Ans.

(4) In a laboratory, water temperature is 24.5°c and unit weight of water is 62.2 lb/ft^3. Weight of water to fill the bucket is 9.33 lb, weight of fine aggregate to fill the bucket is 14.8 lb and absorption of fine aggregate is 2.65%. Bulk sp. gravity (oven dry) is 2.72. Find dry unit weight & SSD unit weight.

BAPEX 23

Soln:

$A =$ dry weight $= 14.8$ lb

$B =$ SSD weight $= ?$

$$\text{Volume} = \frac{9.33\text{ lb}}{62.2\text{ lb/ft}^3} = 0.15\text{ ft}^3$$

$$\text{absorption} = \frac{B-A}{A}$$

$$\Rightarrow \frac{2.65}{100} = \frac{B-14.8}{14.8}$$

$$\Rightarrow B = 15.192\text{ lb}$$

$\therefore$ Dry unit weight, $\gamma_d = \frac{14.8}{0.15} = 98.67\text{ lb/ft}^3$

SSD unit weight, $\gamma_{SSD} = \frac{15.192}{0.15} = 101.28\text{ lb/ft}^3$

(22) A pycnometerr filled with 500ml of clean water has a mass of 660g. After adding 495g of SSD sand and ~~reff~~ refilling it to the 500-ml mark, it has a mass of 965g. After oven drying overnight, the sand has a mass of 489g. Find G_A, G_B & G_{SSD}.

Solⁿ: $G_A = \frac{A}{(A+D)-C} = \frac{489}{(489+660)-965} = 2.66$

$G_B = \frac{489}{(B+D)-C} = \frac{489}{(495+660)-965} = 2.57$

$G_{SSD} = \frac{405}{(495+660)-965} = 2.61$

Absorption capacity $= \frac{495-489}{489} \times 100 = 1.226\%$

A

(23) Determine the specific gravity of a bitumenous material from pycnometer test. Given data-

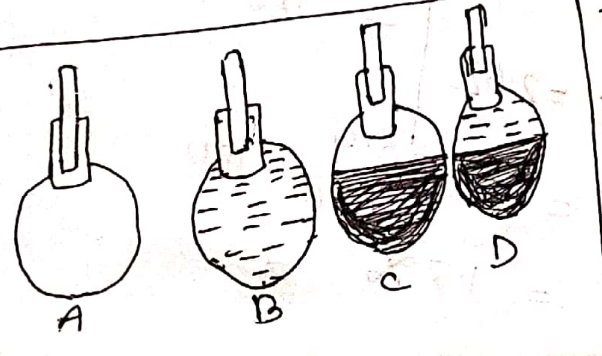
Mass of pycnometer = 30.48gm

Mass of pycnometer + water = 57.66gm

Mass of pycnometer filled 3/4 part with bitumen

Mass = 57.68gm

[BADC'20]



A = weight of pycnometer

B = weight of pycnometer filled with water

C = weight of pycnometer partially filled with bitumen

D = weight of pycnometer + partially filled bitumen + remaining portion of water

$\therefore$ specific gravity $= \dfrac{\text{weight of bitumen having specific vol.}}{\text{weight of water of the same volume}}$

$$= \frac{C-A}{(B-A)-(D-C)}$$

Solⁿ: $G_s = \dfrac{57.68-30.48}{(57.66-30.48)-(64.475-57.68)}$

$= 1.33$

$D = 57.68 + \frac{1}{4}(57.66 - 30.48)$

বিটুমেন 3/4 সুতরাং জল $\frac{1}{4}$

$= 64.475g$

partially filled না হলে pycnometer এর যত অংশ bitumen দিয়ে ভর্তি থাকে তাহার সমান আয়তনের সাপেক্ষেই Gs বের করতে হয়। যেমন এই অঙ্কের ক্ষেত্রেই,

$G_s = \dfrac{(57.68-30.48)}{\frac{3}{4}(57.66-30.48)}$ → এইর 3/4 th of picnometer তাই water এর volume ও 3/4 th of pycnometer ধরা হইছে

1.33 Ans

(24) Calculate the angularity number of aggregate.
Given data –
Relative density / sp gr. of aggregate = 2.8
Mass of water required to fill cylinder = 2500gm
Mass of cylinder filled with compacted aggregate = 5150gm
Mass of cylinder = 1100gm [PGCB'15, DNCC'16, BPDB'18]

Solⁿ: Angularity Number $= 67 - \dfrac{100 W_{aggregate}}{W_w G_s}$

Here,

w = weight of aggregate

$= (5150 - 1100)$ gm

$=$ 4050 gm

c = weight of water equivalent to cylinder volume $=$ 2500 gm

G_s = sp. gr. of aggregate $= 2.8$

$$\therefore AN = 67 - \frac{100 \times 4050}{2500 \times 2.8}$$

$= 9.14$

≈ 9 (পূর্ণসংখ্যায় হত হবে।)

(9.5^{+} হলে 10 ধরবো)

☑ **Good to know:**

* Angularity Number varies between 0–11

0 → highly rounded gravel

11 → freshly crushed angular aggregates

Fineness Modulus (FM).

(25) What is FM? [Rajuk'16, BD-China'16]

Ans: Fineness Modulus (FM) is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each ASTM standard sieve is summed up & then dividing this by 100 gives the value of fineness modulus.

(26) Write Down the standard sieves (in mm) to determine FM of fine aggregates. [ERL'17]

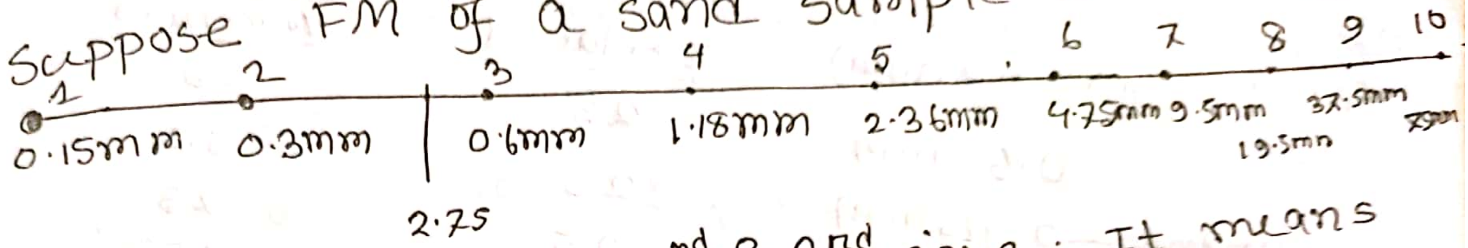
Ans: ASTM standard sieve for fine aggregates —
#4 (4.75mm), #8 (2.36mm), #16 (1.18mm),
#30 (0.600mm), #50 (0.30mm), #100 (0.15mm)

ASTM standard sieve for coarse aggregate or combined aggregate in mix —
Fine set + 3/8in (9.5mm), 3/4in (19.0mm),
1.5in (37.5mm), 3in (75.0mm)

Good to know:

* How can we understand the average size of particle from FM value?

Suppose FM of a sand sample is = 2.75



2.75 lies betwn 2nd & 3rd sieve. It means average value of aggregate is in between the 2nd and 3rd sieve which means ~~0.3mm to 0.6mm~~ is 0.3mm to 0.6mm.

Average ~~va~~ size of the particle is 0.6mm

* According to ASTM C33, FM of fine aggregates (sand) in concrete mix must be between 2.3 – 3.1

* FM of local sand = 1.5 – 2.2

* FM of Sylhet sand = ~~2.~~ 2.3 – 2.9 (generally above 2.5) ~~use 2.5 [SAFEL 17, 20]~~

Gap → ভালমত ≥ 2.5 use করো!

(27) 25% retained on each sieve of 0.60mm, 0.425mm, 0.30mm & 0.15mm. Find FM of this sand sample. [BGFCL'17] [SGFCL'20] [BIFPCL'21]

Solⁿ:

Sieve size (mm)	% Retained	Cumulative % retained
0.60mm	25	25
No standard — 0.425mm	25	50
0.30mm	25	75
0.15mm	25	100

$$\therefore FM = \frac{25+75+100}{100} = 2.00$$

Pro tips : Cumulative % retained যেকোনো standard, non standard হইতেই নেওয়া value count করতে হবে তবে FM এর formula তে শুধু standard sieve এর value বসবে।

(28) 25% retained on each of 1.18mm, 0.60mm, 0.425mm & 0.3mm sieve. Determine FM [DWASA'17] [EERL'17] [~~BDW~~. [BPDB'21]

Sieve size	% retained	Cumulative % retained
1.18m	25	25
0.60mm	25	50
# 0.425mm	25	75 — Non std
0.30mm	—	100
0.15 mm		100

$$FM = \frac{25+50+100+100}{100} = 2.75$$

Pro tips : প্রশ্নে সবগুলো standard sieve দেয়া না থাকলে- সবগুলো standard sieve আনতে হবে calculation এ.

(29) 25% retained on each of #4, #8, #40 & #50 sieve. calculate FM.

Soln:

বাদ যাই এগু-
উল্লেখ করলাম

Sieve NO	% retained	Σ% retained
#4	25	25
#8	25	50
#16	0 –	50
#30	0 –	50
#40	25	75 – Not std
#50 ~~#100~~	25	100
#100	–	100

$$\therefore FM = \frac{25+50+50+50+100+100}{100} = 3.75 \quad \underline{A}$$

(30) Sieve analysis was performed for a course sand & it has been found that 100% of the sample retained on 0.30mm sieve. FM = ?

Solⁿ:

Sieve size (mm)	% retained	Σ% retained
0.30mm	100	100
0.15mm	—	100

$$\therefore FM = \frac{100+100}{100} = 2 \quad \underline{Ans}$$

(31)

Sieve size	#4	#8	#16	#30	#40	#50	#100	#200	Pan
% retained	0	1	4	12	13	30	34	4	2

Find FM & % of silt and clay [SGFCL'20] [PGCB'20], [JGTDSL'21] [MGMCL'22] [GTCL'18], [BPDB'15], [BCIC'17] [PGCB'21] [CPGCBL'22]

Solⁿ:

	Sieve size	% retained	Σ% retained
	#4	0	0
	#8	1	1
	#16	4	5
	#30	12	17
x –	#40	13	30
	#50	30	60
	#100	34	94
x –	#200	4	98
	# Pan	2	100

$$FM = \frac{1+5+17+60+94}{100} = 1.77$$

% silt & clay = 2% [size less than 0.075mm or #200]

#200 (0.075mm) sieve দিয়ে pass করে যে সেগুলো silt & clay

(32) Find FM of fine aggregate & % of silt & clay.
[JOCL'18] ~~BEPZA'16~~

Sieve size (mm)	80	40	20	10	4.75	2.36	1.18	0.60	0.30	0.15	0.075	Pan
Amount retained (gm)	175	175	150	10	8	3	6	24	7	18	1	3

FM of fine aggregate

Sieve size (mm)	Amount retained (g)	% retained	Σ% retained
4.75mm	8	11.4	11.4
2.36mm	3	4.3	15.7
1.18 mm	6	8.6	24.3
0.60mm	24	34.3	58.6
0.30mm	7	10	68.6
0.15mm	18	25.7	94.3
0.075mm	1	1.4	95.7
Pan	3	4.3	100
	Total = 70g		

$$FM = \frac{11.4 + 15.7 + 24.3 + 58.6 + 68.6 + 94.3}{100} = 2.73$$

(33) In a sieve analysis, the percentage of passing of 4.75mm sieve & 0.075mm sieve is 30 & 2 respectively. Find the percentage of FA, CA. ~~&~~ and silt & clay. [BCIC'15]

CA = (100 - 30)% = 70%

*** FA = $(30 - \underline{2})\%$ = 28%

Silt & Clay = 2%

* 100% passes through #100 sieve : FM ___0___ [BPDB'21]

(34) For a sand sample, 20% retained on each of #16, #30, #40 & #50 & rest ~~20%~~ 20% retain on #100 and #200 sieve equally. Find the FM of this sample [CPGCBL'18]

Solⁿ:

Sieve size	% retained	Σ% retained
#16	20	20
#30	20	40
× #40	20	~~60~~ ×
#50	20	80
#100	10	90
#200	10	100

$$FM = \frac{20+40+\cancel{60}+80+90}{100} = 2.3$$

(35) Calculate FM

#Sieve size 3/8" 4 8 16 30 50 100 150 200 Pan
Retained(gm) 0 20 10 30 40 30 40 20 10 0
[BWDB'20, Titas'18, BEPZA'16, BPDB'16]

Sieve size	Retained (gm)	% retained	Σ% retained
~~#~~3/8"	0	0	0 ×
#4	20	10	10
#8	10	5	15
#16	30	15	30
#30	40	20	50
#50	30	15	65
#100	40	20	85
#150	20	10	95 ×
#200	10	5	100 ×
Pan	0	0	100 ×
	Total=200		

$$FM = \frac{10+15+30+50+65+85}{100} = 2.55$$ Ans

WI

(36) Determine FM for this coarse aggregate.

sieve size	2"	1.5"	3/4"	3/8"	#4
% retained	7	23	35	25	10

[MSc'11]

Soln:

Sieve size	% retained	Σ% retained
2"	7	7 × Not std
$1\frac{1}{2}$"	23	30 ~~std~~
3/4"	35	65
3/8"	25	90
#4	10	100
#8	–	100
~~30+65+90~~		100
#16	–	100
# 30	–	100
# 50	–	100
# 100	–	

WI

~~FM =~~

Std. sieve না থাকলেও হিসাব করতে হবে

লো দেওয়া না থাকলেও চলবে যদি মাঝে space না থাকে। বাকি সব মান হিসাব করে FM calculation এ বসিয়ে দিতে হবে।

$$FM = \frac{30+65+90+100+(5\times 100)}{100} = 7.85$$ Ans

~~** Minimum Range~~

(37) FM range of sand for plastering work
1.5 - 2.2

FM range of sand for cement concrete mix = 2.3 – 3.1 (According to AASTHO & ASTM)
= 2.5 – 3.0 (USBR) - US Bureau of Reclamation

[RRI'14]

⊞ Good to know:

Minimum FM of sand is 0.00 & Maximum FM = 5.00

In case of min^m. FM,

No retaining in any of the specified sieve from #4 to #100 because of very fine particles.

Therefore FM = 0

For Max^m. FM

Assume, 100% particles passes through #4 sieve (#sieve এ 100% CA হবে।)
retain হইলে (ধরি তাও fine aggregate থাকবে,
but retain 100% in #8 sieve.

∴

#sieve	% retained	Σ% retained
#4	0	0
#8	100	100
#16	100	100
#30	–	100
#50	–	100
#100	–	100

$$\therefore FM = \frac{5 \times 100}{100} = 5$$

* FM of cement = 0 (∵ cement particles finer than #100 sieve or (0.015mm))

*

Date : ___/___/___

Sun | Mon | Tue | Wed | Thu | Fri | Sat

(3) Find the Fineness Modulus of the fine aggregate, percentage of silt and clay & coefficient of uniformity. [BAPEX '23] [BPDB '23]

Sieve Size	#4	#8	#16	#30	#40	#50	#100	#200	Pan
% retained	0	1	4	12	23	30	20	6	4

Soln:

Sieve size	#4	#8	#16	#30	#40	#50	#100	#200	Pan
Σ% retained	0	1	5	17	40	70	90	96	100
% finer	100	99	95	83	$\underset{//}{60}$	30	$\underset{//}{10}$	4	0

$$\therefore FM = \frac{0+1+5+17+70+90}{100} = 1.83$$

percentage of silt & clay = 4% (Pan)

$$\text{Coefficient of uniformity} = \frac{D_{60}}{D_{10}} = \frac{\text{size of } \#40}{\text{size of } \#100}$$

$\boxed{\#40 = 0.425}$

$$= \frac{0.425}{0.150}$$

$$= 2.83 \text{ A}$$

~~* Sylhet Sand FM~~ More than

* FM of Sylhet Sand ≥ 2.5 ***

[BAPEX 23]

Good to know:

* How much fine aggregate of FM 3.25 ~~example 1~~ should be added to the coarse aggregate of ~~example~~ FM 7.85 to end up with a combined aggregate of FM 6.8 .

Soln: Fine aggregate required, $x = \frac{F_{CA} - F_{com}}{F_{com} - F_{FA}} \times 100$

$= \frac{7.85 - 6.8}{6.8 - 3.25} \times 100$

$= 29.6\%$

∴ FA should be mixed 29.6% by weight of CA .

∴ আর FA : CA mix ratio বলতে হলে —

$$\text{Ratio} = \frac{F_{CA} - F_{com}}{F_{CA} - F_{FA}} \times 100$$

$= \frac{7.85 - 6.8}{7.85 - 3.25} \times 100$

$= 23\%$

∴ FA : CA = 23% : 77%

P.T.O

* A 1200gm sand is the mixture of two different types of sand from sunamganj (FM = 2.28) and sand from Pabna (FM= 2.74) were mixed together to get a combined fineness modulus is 2.51. Find the amount of each sand. [CAAB'22]

Soln:

$$F_c = \frac{F_1 M_1 + F_2 M_2}{M_1 + M_2}$$

$$\Rightarrow 2.51 = \frac{2.28 \times M_1 + 2.74 \times (1200 - M_1)}{M_1 + (1200 - M_1)}$$

$\therefore M_1 = 600gm$

$\therefore$ Sunamganj sand 600 gm.

Pabna sand = (1200 - 600) gm

= 600 gm

Let,
Sunamganj sand weight $= M_1$

$\therefore$ Pabna sand weight $= 1200 - M_1$

Sunamganj FM, $F_1 = 2.28$

Pabna FM $F_2 = 2.74$

u

Date : / /

Sun | Mon | Tue | Wed | Thu | Fri | Sat

* Three types of Sand A, B and C are mixed in the ratio of 1:2:3. The FM of A, B and C sand are 2.62, 2.32 and 2.80. Compute the combined FM.

Answer:

$$\text{combined FM} = \frac{(1\times2.62 + 2\times\cancel{2}2.32 + 3\times2.80)}{1+2+3}$$

$$= 2.61 \text{ Ans}$$

# Types of Sand	FM Range
Fine sand	2.2-2.6
Medium Sand	2.6-2.9
Coarse sand	2.9-3.2

CDDL'23

(38) Specific gravities of three different aggregates are 2.8, 2.4 & 2.2 respectively. They are mixed with a ratio of 1:2:3 by their weight. Carry out the sp. gravity of mixed aggregate.
[DNCC '20]

Soln

Formula - ⓐ $\frac{1}{G_{blend}} = \frac{\frac{W_a}{W_{blend}}}{G_A} + \frac{\frac{W_b}{W_{blend}}}{G_B} + \cdots$

weight ratio, $\frac{W_a}{W_{blend}} = f_A$, $\frac{W_b}{W_{blend}} = f_b$, ...

Soln:

$$\frac{1}{G_{mix}} = \frac{\frac{1}{6}}{2.8} + \frac{\frac{2}{6}}{2.4} + \frac{\frac{3}{6}}{2.2}$$

$$\frac{1}{G_{mix}} = 0.4257$$

$$\therefore G_{mix} = 2.35$$ An

Similar Numerical :

* Material A sp. Gr = 2.8 , Material B sp.Gr = 2.4

mix ratio = 25% : 75%

$$\therefore \frac{1}{G_{mix}} = \frac{0.25}{2.8} + \frac{0.75}{2.4} = 0.402$$

$$\therefore G_{mix} = 2.5$$ An

Grain size distribution Curve

Mainly part of geotech as it is done in case of soil particles.
But It is discussed here, because sieve analysis is required for this distribution curve. curve তাই তার ~~কীভাবে~~ grain size distribution curve হয় ?

Sieve size	Soil retain (gm)	Σ retain (gm)	Σ % retain	Σ % passing
#4 (4.75mm)	25.87	25.87	5.174	94.826
#8 (2.36mm)	56.3	82.17	16.434	83.566
#16 (1.18mm)	133.42	215.59	43.118	56.882
#30 (0.60mm)	167.85	383.44	76.688	23.312
#50 (0.30mm)	64.68	448.12	89.624	10.376
#100 (0.15mm)	49.18	492.3	98.46	1.54
#200 (0.075mm)	4.9	497.2	99.44	0.56
Pan	2.8	500	100	

Gravel (%) = 5.2%

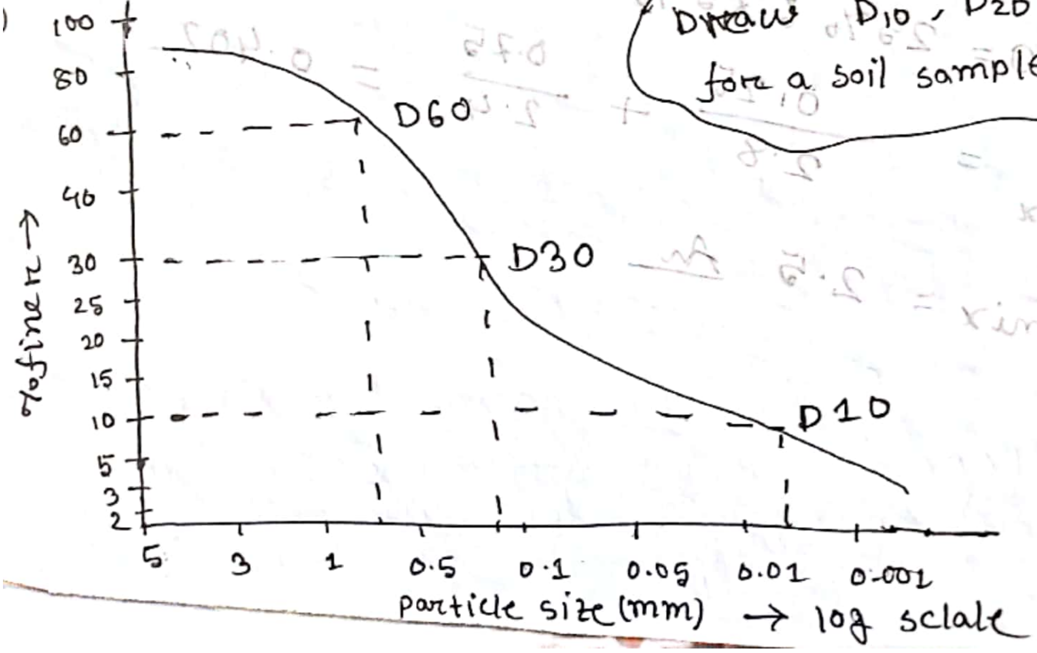
Sand = 100 − 5.2 − 0.56 = 94.24%

Silt & clay = 0.56% [#200 sieve দিয়ে যা pass করেছে silt & clay]

sieve size = particle size

cumulative % passing ≈ % finer than this

Draw D_{10}, D_{20}, D_{50} graph for a soil sample [BWDB'18]



D60 = a certain diameter of soil, 60% of the soil particles are finer than that diameter

D30 = 30% of the particles are finer than this size (dia)

D10 = 10% of the particles are finer than this size

For example, if you have 100 particles of dia ranging from 1mm to 100mm, D60 is 61mm (below which 60% of particles are there)

$$\boxed{\text{Uniformity coefficient, } C_u = \frac{D_{60}}{D_{10}}}$$

For well graded soil (having varity of size range distributed well) Cu must be ~~much~~ greater than 4 [$C_u > 4$ - for gravel, $C_u > 6$ - for sand]

* $C_u = 1$ means, uniformly graded soil (soil এর সব particle একই সাইজের)

* $1 < C_u < 4$ means, ~~poor~~ gap graded soil (soil particle এর মাঝে-মাঝে সাইজের missing)

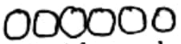
$$\boxed{\text{Coefficient of curvature/gradation, } C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}}$$

for single sized/uniformly graded soil $C_c = 1$

For ~~uniformly~~ well graded soil, $1 < C_c < 3$

∴ For well graded sand $C_u > 6$, $1 < C_c < 3$
gravel $C_u > 4$, $1 < C_c < 3$


Well graded


uniformly graded

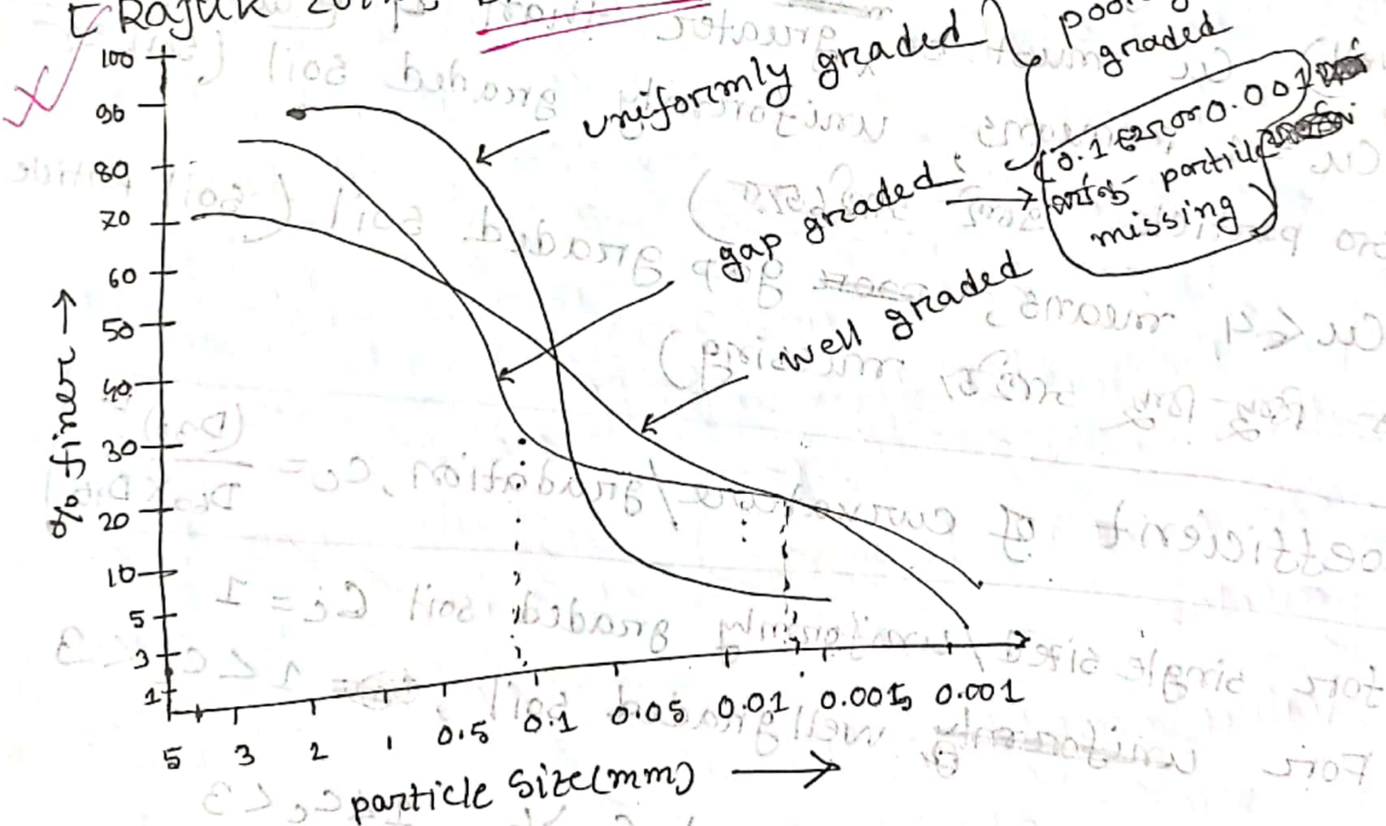

gap graded

* Why D10 is called effective diameter?

As per the numerous experiments done by Allen Hazen on soil properties, he found the D10 diameter can be related to most of the soil properties such as liquid limit, plasticity index, unconfined compressive strength etc. Hence is is called effective diameter.

The higher the effective size (D_{10}), the coarser the soil & better the hydraulic conductivity or drainage characteristics.

(40) Different particle size distribution curve: [Rajuk'2017, DNCC'20, MSc'11, Titas'14, DMLC'6]



* Why logarithmic graph is used? 0.0001 mm পর্যন্ত হতে পারে-
আবার particle size 20mm থেকে শুরু করে- বিভিন্ন size এর হয়ে থাকে। তাই
এর plain graph এ plot করতে হলে
semi-log graph use করা হয়।

(41)
GAPS:

(i) The effective size of a soil is D10 (BPDB'2013)

(ii) $D_{10} = 0.1$, $D_{60} = 0.3$. Uniformity coefficient, Cu = 3 [GTCL'16, DNCC'16, BIWTA'19, NHA'19]

(iii) $D_{10} = 0.152$ mm, $D_{30} = 0.321$ mm, $D_{60} = 0.521$, coefficient of uniformity 2.1 coefficient of curvature 1.3 [PGCB'18]

(42)

Particle size (mm)	% finer
0.05	10%
0.3	30%
0.4	60%

find the uniformity coefficient & coefficient of curvature. Is the soil well graded? [PGCB'19]

$$C_u = \frac{D_{60}}{D_{10}} = \frac{0.4}{0.05} = 8$$

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(0.3)^2}{0.05 \times 0.4} = 4.5$$

For well graded soil, $C_u > 4$ & $1 < C_c < 3$

$\because C_c = 4.5$, so it is not well graded soil.

(43) ~~4 lab tests of coarse Aggregate [NZPDCL'16]~~

Soln: ~~(i) Los Angeles Abrasion test~~

(ii)

MGMCL '2022. (Gaps)

* Weight of hammer is SPT test 63.5 kg

* ~~Calculate discharge, Q - given C, I, A~~

* Permissible amount of ~~Fe~~ feacal coliform according to BD std. 0 /100 ml

* Initial setting time is not less than 45 minutes

* Land area is given in 1 acre, runoff coefficient 0.5, intensity 40 in/hr find discharge ______ ft³/sec
~~635 110~~ b

1 acre = 43560 ft²
43560 ft²

Cement

(43) Write short note on Portland Cement
[53BMA]

Soln: Portland cement is a type of hydraulic cement as it turns into a solid product in the presence of water in the air. It is known as "portland" due to its resemblance in color & quality to Portland stone which was found in Dorset, England. Portland cement is extensively used in almost all types of construction works. ~~Praimarri~~ Primarily five types of portland cement are used worldwide. However, in Bangladesh two types of portland cement is produced known as CEM I & CEM II. CEM I is ordinary portland cement (OPC) with no SCM (supplementary siliceous ~~Siliceous~~ materials such as ~~as~~ fly ash, slag, silica fume etc.). CEM II is the portland composite cement (PCC) where SCM or pozzolona is added by replacing the clinker. Though OPC attains initial (28days) high strength, but PCC is more durable. PCC must be used in ~~coasts~~ coastal or other adverse environmental areas. ~~where~~

28days strength

OPC

BDS EN 197-1:2003 CEM I/52.5N → Normal Strength gain

52.5N → 52.5 N/mm²
→ 52.5MPa

Clinker 95-100%

Gypsum 0-5%

slag-fly ash-lime

PCC

BDS EN 197-1:2003 CEM II/A-M(S-V-L) 42.5N

V= fly ash

Clinker: 80-94%

S-V-L : 6-20%

Gypsum : 0-5%

BDS EN 197-1:2003 CEM II/B-M(S-V-L) 42.5N

Clinker : 65-79%

SVL : 21-35%

Gypsum : 0-5%

*** যদিও 28 দিনে OPC বেশি strength দেখায় কিন্তু 90 দিন পর OPC, PCC উভয়ের হয়, হয় বরং তেমন PCC বেশি strength ~~বেশি~~ দেখায়।

*** SVL যুক্ত cement কে pozzolona cement বলে। আমাদের দেশের PCC কেই india তে অন্য দেশে ভেদে Portland Pozzolona cement বা PPC নামকরণও হয়।

* BDS EN 197-1:2003 এর

Q(44) Write down the constituents of cement [BEPZA'19, BSEC'18]

Sol^n: Major components/constituents of cement.

(1) Clinker
- → Tricalcium silicate (C_3S) – $3CaO \cdot SiO_2$
- → Dicalcium silicate (C_2S) – $2CaO \cdot SiO_2$
- → Tricalcium Aluminate (C_3A) – $3CaO \cdot Al_2O_3$
- → Tetracalcium Aluminoferrite (C_4AF) – $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$

(2) Fly ash (4) limestone

(3) Blast furnace slag

(5) Gypsum ($CaSO_4 \cdot 2H_2O$)

Composition of this constituents in OPC [BD standard CEM-I]

Clinker: 95-100%
Gypsum: 0-5%

OPC contains 0 percent of fly ash [BWDB'14]

In PCC [BD standard CEM-II/A]

Clinker : 80-94%
S-V-L : 6-20%
Gypsum : 0-5%

Good to know:

Clinker : The manufacture of cement consists of grinding of raw materials (limestone,

contains lime ~~calcium carbonate type~~
calcareous & argillaceous stones containing silica, alumina & irone oxide) and mixing them intimately in a certain portion. It is then brunt in a large rotary <u>kiln</u> at a temperature about 1500°c. Then the materials fuse into balls of diameter 3-25mm known as Clinker.

<u>Fly ash:</u> Fly ash is a byproduct from burning pulverized coal in electric power generation ~~company~~ plants. During combustion, mineral impurities in the coal (clay, fledspar, quartz & shale) fuse (গলিত হয়) in suspension & float out of the combustion chamber with the exhaust gases. As the fused materials rises, it cools & solidifies into spherical glassy particles called fly ash.

<u>Blast furnace slag:</u> Blust furnace slag is a calcium-aluminium-silicate based product remove from the top of molten iron during its extraction from ore (আকরিক) in a blast furnace

* which kind of rock is marble? <u>Ans:</u> limestone (ACI'19)

(45) Functions of different cement components:

Lime (CaO): Lime is the main constituents for manufacturing of cement which imports cementing property to cement. The cement contain about 63% of lime in it. To form the required silicates and aluminated of calcium (C_3S, C_2S, C_3A, C_4AF) a sufficient quantity of lime must be present. Lime imparts strength & soundness to the cement. If it is present in excess quantity, it makes the cement unsound (casuses it to expand & disintegrate).

Deficiency of lime in cement reduces it strength & causes it to set quickly.

[মোট 3 lime] C_3S, C_2S, C_3A, C_4AF [সবগুলোর মধ্যে এই ৪টি আমাদের কাছে: → prime compound] সিমেন্টের জন্য এই prime compound সবগুলোর • exam এ আসলে এর সবগুলোর লিখতে হবে, দরকার নাই! C_3S ছাড়া ...

Tricalcium Silicate (C_3S)

→ Hardens rapidly and largely responsible for initial set & early strength

→ The increase in percentage of this compound will cause the early strength of portland cement to be higher.

→ A higher percentage of this compound will produces higher heat of hydration & accounts for faster gain in strength.

Functions of Dicalcium silicate (C_2S)

→ Hardens slowly.

→ It effects on strength increase occurs at ages beyond one week.

→ Responsible for long term strength.

Functions of Tricalcium Aluminate (C_3A)

(ISTT'15)

→ It imparts quick setting property to cement because it is the first compound to hydrate.

→ It turns out higher heat of hydration and contributes to faster strength development in the first few days.

→ But it results in poor sulfate resistance & increase the volumetric shrinkage upon drying.

→ Cement with low C_3A contents usually generate less heat, develop higher strength & show greater resistance to sulfate attacks

→ It is reactive with soils and water containing moderate to high sulphate concentration so it's least desirable.

---

hydration :— cement + water বিক্রিয়া ঘটে শক্ত হয়ে যাওয়ার এসময় heat generate হয়, যেহেতু এটি একটি তাপোৎপাদী বিক্রিয়া।

Functions of Tetracalcium Aluminoferrite (C_4AF)

→ Assists in the manufacture of portland cement by allowing lower clinkering temperature.

→ Also act as a filler

→ contributes very little strength of concrete even though it hydrates very rapidly.

→ Also responsible for grey color of ordinary portland cement.

MCQ: Al_2O_3 (C_3A) imparts quick setting property of cement.

MCQ: Gypsum is added to cement to increase initial setting time [4ZBMA]

Functions of Gypsum ($CaSO_4.2H_2O$) ***

The main purpose of adding gypsum in the cement is to slow down the hydration process of cement once it is mixed with water.

When water is added to cement, it starts reacting with the C3A and hardens. The time taken in this process is very less which doesn't allow time for transportation, mixing & placing.

Gypsum slows this process ~~to~~ Therefore concrete remains plastic & workable.

(46) Why fly ash is added in cement? [BSEC'14]

Solⁿ: Salient advantage of using fly ash in cement concrete –

***(i) Reduction in heat of hydration & thus reduction of thermal cracks and improves soundness of concrete mass.

***(ii) Improved workability by reducing water requirements for a given slump.

(iii) converting released lime from hydration process into additional binding material – contibuting additional strength to concrete mass.

***(iv) Fly ash help increasing initial setting time.

*(v) Fly ash in cement increases fines volume & decreases water content in concrete and thus reduces bleeding of concrete.

***(vi) fly ash improves impermeability in concrete. Improved impermeability increases resistance against ingress of moisture & harmful gases results in increased durability (moisture ঢুকতে পারে ফলে reinforcement এ জং ধরে না)

***(vii) Though 28 days strength is decreased due to fly ash, but after 90 days strength of cement concrete with fly ash exceeds the strength of OPC

***
(viii) Due to adding fly ash, requirement of cement clinker is reduced for same strength thus the cost of cement is also reduced.

(ix) Using fly ash is also eco-friendly as fly-ash based cement requires less clinker. ~~Clinker~~ It saves limestone, coal and other minerals. Besides, It reduces CO_2 emissions as about 1 tonne of CO_2 is emitted in manufacturing of 1 tonne of clinker.

(47) Write down the differences between OPC & PPC (Portland Pozzolona Cement) [BSEC'14]

Sl No	Particulars	OPC	PPC
1	Components	A mixture of limestone and other raw materials like argillaceous, calcareous gypsum is grinded to prepare OPC	PPC is prepared by adding pozzolanic materials (fly ash, blast furnace slag etc) to OPC
2	Strength	Initial strength is higher than PPC	PPC has higher strength than OPC over a longer period of time
3	Heat of hydration	Generates more heat than PPC	Generates less heat than OPC
4	Mass concrete	less suitable for mass concreting due to higher heat generation.	More suitable for mass concreting.
5	Durability	less durable in adverse weather	More durable in adverse weather
6	workability	lower than PPC	Higher than OPC
7	Chemical Resistance	lower resistance against alkalis, sulfates, chlorides etc.	Higher resistance against alkalis sulfates, chlorides etc
8	cost	Costlier than PPC	~~Costlier than~~ Cheaper than
9	Environmental impacts	Emits very large quantity of CO_2 during manufacturing process	It constitutes industrial wastes like fly ash, BF slag which makes it eco-friendly

Sl. particulars	OPC	PPC
10 setting time	lower than PPC. ~~Initial setting time is 30mins & final setting time is 280mins. Its faster setting time helps faster construction~~.	Higher than OPC ~~Initial = 30mins, final = 600mins~~ higher initial setting time is desirable
11. Available grades	In Bangladesh, 52.5 grade OPC cement is available. It conforms to the BD standard CEM-I	42.5 grade conforms to BD standard CEM-II/A-M, CEM-II/B-M
12. Shrinkage cracks	More cracks due to high heat of hydration	Less shrinkage cracks

Ideal applications of OPC

High rise buildings, commercial & industrial complexes, roads, bridge & flyovers, heavy defence structures

Ideal applications of PPC

Plastering works, RCC works in residential buildings, marine works, mass concrete work (dam, sluice gates etc)

*** Viva questions: which cement is used in structure built in water?

Ans: Portland composite cement

~~High alumina cement~~ (quick setting cement)

→ quick setting time (gains almost full strength within [illegible]

→ more resistant to sulphate

→ not affected by water

(48) Define setting time of cement? [PMO'15]
Difference between initial & final setting time
[PGCL-17]

Sol

Soln: **Setting time of cement:** When water is mixed with cement, a smooth paste is produced that remains plastic for a short time. During this period, the paste can be disturbed and remixed without injury. As the reaction between water and cement continues, the plasticity of the cement paste is lost. This early period in the hardening of cement is known as "setting of cement".

Initial Setting time: The time at ~~which~~ when cement paste starts hardens and ~~completely~~ started ~~loses~~ losing its plasticity is called initial setting time.

* Or, the time required to obtain 25mm penetration by 1mm dia needle of Vicat appratus according to ASTM.
* needle 1mm dia, 50mm length . cement surface থেকে 50mm উপর থেকে ছেড়ে দিয়ে penetration করানো।

Untill this time, cement paste can be moulded, remixed without losing it strength.

According to ASTM, initial setting setting time for both OPC & PPC cement is not less than (≥45) 45 minutes. [PGCB'15]

A larger initial setting time is always preferred so that mixing, transporting and placing of concrete can be done easily before cement looses its plasticity.

Final setting time:

Final setting time of cement is the time when the cement paste completely loses its plasticity and hardens sufficiently to attain the predefine shape in which it is casted. After the final setting time, scaffolding or form is removed from concrete structure. ~~Or, the time required when the needle does not sink visibly into the paste~~

Lab test: Replace the needle of the Vicat apparatus by the needle with an circular attachment. The cement shall be considerd as finally set when upon applying the needly to the surface of the test block, the attachment fails to do circular impression on the specimen surface.

**According to ASTM, final setting time ~~for~~ of OPC PPC cement is not more than 375 mintures (≤375).

*A smaller value of the final setting time is always preferred in order to avoid large expenditures on the formwork (বড় খরচগুলো (ফর্মা খাতে)

(49) Engineering Importance of initial and final setting time [NPCBL'19].

Sol^n: Significance of setting time:

→ Initial setting time gives the indication of cement when it starts losing its plasticity. Loss of plasticity means cement cannot be moulded in any other shape once it crosses the initial setting time duration. So initial setting time is important to know that how quick we shall place the concrete at required location to attain a desired shape.

→ Final setting time indicates the time at which cement completely losses its plasticity and becomes sufficiently stiff to bear some load (i.e. self weight). Final setting time is important aspect in order to know the minimum duration to remove the shuttering and formwork.

*** Initial setting time খুবই কম হলে concrete cast করার আগেই plasticity হারিয়ে ফেলবে। Admixture use করে initial setting time বাড়ানো যায়।

◻ Uses of Admixtures :

Admixtures are primarily used for —

- → To reduce water content in concrete i.e. keep water cement ratio as less as possible.
- → To increase compressive strength and durability of concrete
- → To enhance the workability and give more time for mixing, transportation & placing.
- → To control the shrinkage cracks
- → To impart specific property of concrete or to create favorable condition during placing.
- → Decrease permeability
- → To ensure quality of concrete during mixing, transporting, casting and during in adverse condition.

◻ Soundness Test of Cement:

Soundness of cement can be defined as its ability to withstand any changes in its volume after setting and hardening.

In simple words, sound cement is the one that does not changes its volume much after its gets hardened.

P.T.O

Lab test procedure

Method used: Le-chatelier method / Autoclave Method

প্রথমে La-chatelier mould এ cement paste কে 24hr room temperature এ পানিতে ডুবিয়ে রাখা হয় → (Curing), তারপর mould এর গ্যাপ মাপা হয়।
তারপর 3 ঘন্টা 100°C তাপমাত্রায় পানিতে mould ডুবিয়ে রেখে পুনরায় মাপা হয়। তাপমাত্রার কারণে volume expansion মাপা হয়ে থাকে। Sound cement এর জন্য গ্যাপের ঊর্ধ্ব সীমা 10mm এর বেশি হবেনা।

(৫০) Significance of soundness test of cement.
[NPCBL'19]

Cement is a composition of lime, silica, alumina, magnesia, alkaline, sulfur trioxide, iron oxide and calcium sulfate. Among which, lime is constitues 60 to 70%. If lesser lime is used in the cement than it would set or set quicker but the excess lime $(CaCO_3)$ or magnesia $[Mg(OH)_2]$ content in cement are responsible for the unsoundness of cement. ~~and it will~~

Unsound cement expand more after hardening and it will cause cracks in concrete body and had severe impact on the structure due to which the durability of structure would be uncertain.

**Soundness test is conducted to assess the excess amound of lime which causes the volume expansion of cement. Through this test, it is ensured that the cement won't undergo any sort of expansion due to the presence of excess amount of lime.

(51) Write down the name of tests for cement
[47BMA, 56BMA]

(i) Normal Consistency test
(ii) Initial & final setting time test
(iii) Soundness test
(iv) compressive strength test
(iv) Heat of hydration test
(v) Fineness test (চালন টেস্ট)
(vi) Loss on Ignition test
(vii) Desity & sp. gravity test

* **Normal consistency test:** The amount of water content that brings the cement paste to a standard condition of wetness is called normal consistency.

The normal consistency of cement paste is defined as that consistency (% of water) which will permit the vicat planger* to penetrate 10mm in 30sec from the top of the vicat mold.

**The usual range of values being between 22~30% of water by weight of dry cement.

***moisture content in standard consistency 22-30% [BMA]

*vicat planger → needle না, আগাগোড়া মোটা, গোল লোহার needle দণ্ড, dia 10mm, height 50mm

(52) Special types of cements & their uses:

(i) **Rapid Hardening cement:** Rapid hardening cement attains high strength in the early days. It is used in concrete where formworks are removed at an early stage. ~~and~~ This cement has increased lime content and contains higher C_3S content which gives higher strength development than OPC at an early stage. The strength of rapid hardening cement at the 3 days is similar to 7 days strength of OPC with the same w/c ratio. Therefore ~~was~~ formwork can be removed earlier which increases the rate of construction and decreases the cost of construction.

Uses: prefabricated concrete construction, road works etc.

(ii) **Quick Setting Cement:** [NPCBL'17]

It is a special type of cement which has ~~very~~ very quick ~~fast~~ setting time like initial setting time is 5-10 mins & final setting time is 20-30 minutes where ordinary portland cement has initial setting time not less than 45 minutes.

Though this cement has very quick setting time but the rate of gain of strength is similar to OPC.

The main difference between Quick setting and rapid hardening cement is later one has faster rate of strength gain. Form-works in both cases can be removed earlier.

This type of cement is produced by increasing the percentage of alumina in clinker and decreasing the percentage of gypsum.

This type of cement is mainly used in underwater construction because faster work is necessary in this case. Besides this type of cement has more resistance against sea water.

It is also used in rain and cold weather conditions where fast strength (setting) is required in a short time.

It is also used in high temperature where water evaporates easily as this cement required less amount of water for hydration.

(iii). Low heat cement: (NPCBL'17)

Low heat cement is a special type of cement which generates low heat of hydration during setting.

It is manufactured by maintaing the percentage of C_3A below 6% and by increasing the percentage of C_2S (46%).

Low heat cement is suitable for mass concreting like gravity dam construction as the low heat of hydration prevents the cracking of concrete due to heat. Since the cracking of concrete is severely affects the serviceablility and durability of structures like dams, it is very important to avoid cracking.

Though initial strength gain is slow but it gets higher strength with the time.

Besides It has excellent resistance to weather and chemical attack hence it is highly durable.

(iv) Expansive cement: (NPCBL'17)

Expansive cement is a special type of cement when mixed with water which forms a paste that tends to increase in volume significantly greater degree than portland cement paste after setting. The expansion of the cement mortar or concrete is compensated (সংকুচিত হওয়া রিপ্লেস করে দেয়) for the shrinkage losses. Therefore it ~~minimizes~~ eleminates the cracks due to drying shrinkage.

Expansive cement are manufactured by adding C_4A_3S, $CaSO_4$ & lime (CaO) to portland cement clinkers.

Uses of Expansive cement:

→ Pre stressed concrete components (expansion এর জন্য prestressed হয়)

→ Used in grouting of anchor bolts (anchor এর bolt কে grouting এর concrete paste দিয়ে আটকানোর উদ্দেশ্যে)

→ Used for construction of water ~~retaining~~ retaining structure (shrinkage crack হয় না তাই water leakage এর সম্ভাবনা নেই)

→ This cement is used in large continuous floor slabs without joints.

(v) Sulphate Resisting Cement:

~~Sulphate resisting cement is a type of Portland cement in which the amount of C_3A is restricted to lower than 5% and.~~

Sulphate resisting cement is a type of cement that has low tricalcium aluminate (C_3A) & tetracalcium aluminoferrite (C_4AF) content and high tricalcium silicate (C_3S) content ~~than the normal chemical composition of~~ OPC which reduces the formation of sulphate salts. The reduction of sulphate salts lower the possibility of sulphate attack on the concrete.

Uses of sulphate resisting cement -

→ Foundations
→ Piling works
→ construction in contact with soils or ground water having higher percentage of sulphate salts
→ coastal protective works such as sea walls, break waters, tetrapods [সমুদ্রের পানিতে সবচেয়ে বেশি sulphate salt থাকে]
→ Effluent treatment plant
→ Buildings near seacost

Next পাতায়

(vi) Air Entraining Cement:

Air entraining cement is a special type of cement which has air bubbles introduced in the cement or concrete that provides the space for expansion of minute (অতি ক্ষুদ্র). droplets of water in the concrete due to freezing & thawing and protects from cracks and damage of concrete. This type of cement is produced by adding indigenous air-entraining agents such as resins, glues, sodium salts of sulfates etc during the grinding of clinker. It is suitable for freezing environment as it improves forst resistance of concrete.

(vii) High Alumina Cement (HAC):

High alumina cement is composed of calcium aluminates unlike protland cement which is composed of calcium silicates mainly (C_3S, C_2S মিলিয়ে 65-85% থাকে). It is manufactured from limestone and bauxite (special clay having high alumina content).

→ ***It is refractory material i.e. it can withstand very high temperature. Therefore it is used in constructing furnaces, boilers, kilns & chimneys.

→ The initial setting time of this cement is more than 3.5 hours where the final setting time is about 5 hours only. It therefore allows more time for mixing and placing operations.

→ It is rapid hardening cement (3.5 hrs থেকে 5 hrs এ final setting time হওয়ায় 6 hr এ সর্বোচ্চ প্রয়োজনীয় strength gain করে থাকে)

→ It is highly resistant to chemical attacks and microbial attacks.

*** → Due to rapid hardening and chemical resistance properties it is widely used in sewer infrastructure and marine infrastructures.

→ It can be used in very low temperature as forst action is low as the heat evolved is more during setting.

(53) The crushing load on 28 days of cement mortar is found 12600 lb. As per ASTM C150 is this load satifactory or not? [BCIC-16] [BIFPCL-15]

Similar math, load = 15 tons

Soln: 28 days compressive strength $= \frac{12600}{2'' \times 2''}$

$$P = \frac{\phi E}{A}$$

$= 3150$ psi < 4000 psi (not satisfactory)

for 15 tons, strength $= \frac{15 \times 9.81 \times 1000}{50 \times 50}$ [1 ton = 9.81 kN]

$= 58.86$ N/mm^2 > 28 MPa (satisfactory)

Field tests of cement. [CAAB 2022].

Ans:

(1) Cement Packing Date: Generally, cement should be used within 90 days from its production date. The strength of cement decreases with time. That is why you should check the date of packing.

(2) Cement Color Test: The color of the cement is light or grey, greenish shade and it should be uniform within a bag.

(3) Lump presence test: The presence of lumps in cement indicates that it has absorbed moisture. So, you should reject cement bags that contain small and hard lumps. The lumps suggest that the cement setting took place.

(4) Smoothness test: When a cement is rubbed in between fingers, it should provide a smooth feeling. Rough feeling is a sign of cement adulteration with sand.

(5) Cement Temperature Test: Immerse your hand into a bag of cement; you should get a cool feeling. The cool feeling shows that cement hydration has not taken place yet.

(6) Cement Float Test: When you through a small amount of cement on water the cement particle should remain on the water surface for a while.

(7) Cement setting Test: Take a certain quantity of cement and mix it ~~not~~ with water. Then put the mix on a piece of glass plate and submerged it in water for 24 hrs. The cement paste should set, not crack.

Concrete

(55) What is concrete? [BSEC'14, Rajuk'14]

Soln: Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete. Besides cement, other types of binding materials also used. Such as lime for lime concrete & bitumen for asphalt concrete which is used for road construction.

(56) Short notes on fine & coarse aggregate? [BSEC'14, Rajuk'14]

(ইটের মিহি গুড়া) → [illegible] ব্যবহার করা হ:

Fine Aggregates: Sand and surki are commonly used as fine aggregate in Bangladesh. The fine aggregate should not be larger than 3/16 inch (4.75mm) in diameter.

There are two type of sand available in Bangladesh

Local sand → FM 1.5-2.2

Sylhet sand → FM 2.3-2.9

→ Shall be free from deleterious substance (25%)

⇒ ***According to ASTM C33, FM of fine aggregates in concrete must be between 2.3 to 3.1.

→ The fine aggregate shall not pass 45% from a single sieve and retained on the next consecutive sieve.

→

Coarse Aggregate: Khoa, crushed stones, gravels, pebbles of size greater than 3/16 inch are commonly used as coarse aggregate in Bangladesh. Maximum size of aggregate to be used is generally depend on the thickness of section & quantity of reinforcement. Generally 3/4 inch (20mm) downgraded aggregates are used for residential concrete works. Sometimes, for well gradation, 1/2 inch downgraded aggregates are mixed with 3/4 inch downgraded aggregate in 40% (1/2" ch) : 60% (3/4" down) ratio.

Why well graded aggregate is required for concrete?

→ Concrete should possess the desired amount of workability i.e. concrete should be sufficiently plastic to be easily mixed, transported, placed, compacted & finished without segragation.

→ Concrete should be economical

→ The required amount of the concrete paste is depended upon the amount of void space that must be filled and the total surface area → ([illegible]) that must be covered. When the particles are of uniform size, the spacing is the greatest but when a range of sizes is used the void space are ~~filled~~ the minimum.

→ Therefore, a compact fitting of aggregate particles reduces the paste requirement & leads to economical concrete with high strength & durability.

→ Besides due to lesser void space, excess paste will be available to give better lubricating effect. Due to excess paste, the mixture gets cohesive & prevent segragation. It also makes it get compacted easily i.e. increase the workability

→ If the aggregates do not have good grading, the desired workability cannot be achieved. In such as case, ~~if the~~ to make the concrete workable, the amount of mixed water is increased. i.e. w/C ratio of the mix will be increased, causing the strength & durability of the concrete to be decreased.

(~~[illegible] Describe workability of concrete? [RAJUK-10]~~

(~~50 [illegible] article [illegible] [illegible]~~)

***Viva Question

Proportion of Local sand & Sylhet sand in concrete?

Ans: Sylhet sand : Local sand = 3 : 2 (60%) : (40%) or 2 : 1 (67%) : (33%)

(57) What is bulking of sand? [DMLC'16]

Ans: Bulking of fine aggregates or sand is the phenomenon of increase in sand volume due to the increase of moisture content.

The moisture content in the sand makes thin films around sand particles. Hence each particles exerts pressure. Due to this each other pressure, they move away from each other causing increasing in volume. The bulking of the aggregates is dependent on two factors:

→ The fineness of the aggregates

→ percentage moisture content

As shown in the figure, the bulking in the sand increase with the increase of mc to a certain extent. Beyond this, any additional moisture content will decrease the volume. A fully saturated fine aggregate doesn't show any bulking.

Besides, the rate of bulking is inversely proportional to the size of the aggregates. Hence, fine aggregates bulk more compared to coarse aggregates.

Date : ___ / ___ / ___

Sun Mon Tue Wed Thu Fri Sat

⇒ Factors affecting the strength of concrete [DNCC'22]

⇒ Water/cement ratio:

→ inversely proportional to strength of concrete

→ but at the same time lower w/c decreases the workability of concrete.

→ Therefore a w/c ratio of 0.45~0.6 is used considering all aspects

⇒ Compaction of concrete

→ higher the compection, greater the strength

⇒ mix ratio & quality of ingredients

⇒ Shape, size & grading of coarse aggregate

→ Flaky, elongated & flat aggregates are bad

→ well graded aggregates have less amount of void, hence provide higher strength

→ 20mm downgraded aggregates are used for concrete

⇒ Curing ~~of~~ of concrete

→ essential to prevent shrinkage & temperature cracks, strength development & durability. , 7-14 days of curing required atlest .

⇒ Weather condition

⇒ Temperature

→ with the certain degree of temperature increase, the rate of hydration process increases which facilitates strength gain.

→

→ sudden temperature changes create a thermal gradient which causes cracking.

⇒ The rate of Loading

→ The strength of concrete increase with the increase in the rate of loading because at the high rates of loading, there is less time to creep.

⇒ Age of concrete

(59) What are the functions of water in concrete? [Rajuk-18]

<u>Ans</u> Functions of water in concrete –

- → Hydration of cement
- → to make concrete workable
- → to attain sufficient strength of concrete
- → to make a homogeneous mix of ~~con~~ different aggregates and cement in concrete

(60) Draw the compressive strength vs w/c ratio Diagram [DNCC'20] [DWASA'17] [RRI'21]

or, How w/c ratio affect concrete strength? [BSEC'14]

or, workability (w/c) vs compressive strength diagram?

<u>Sol^n:</u> The following figure explains the relation between w/c ratio (i.e. workability) & compressive strength of concrete.

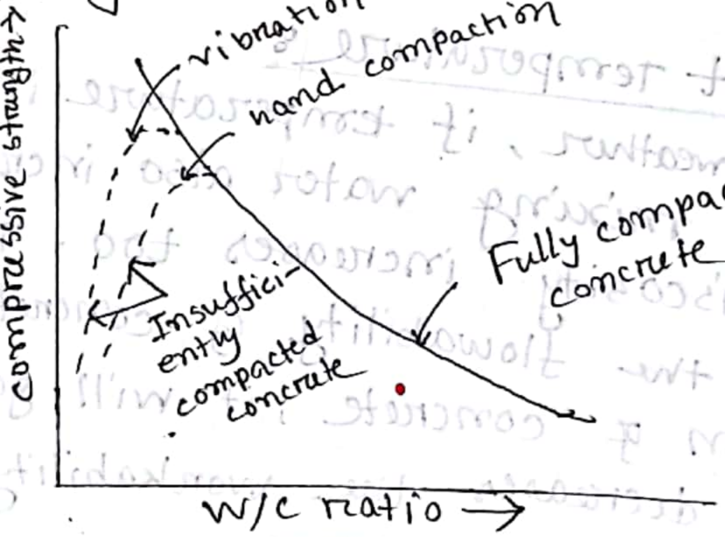
* vibrator macine দিয়ে ভালো compaction ভালো হয়, strength বাড়ে। হাতে ভালো তত ভালো হয় না,

— Fully compacted

---- কম compacted

এবং বৃদ্ধির দিকে-

কম compacted fully compacted line এর সাথে মিলন হয়-



(61) What is slump test? [BSEC'14, Titas'14, 56BMA] Why slump test is conducted? [WZPDCL'19]. Describe [BSEC'14, 56BMA], ~~Draw~~ Draw a slump cone with dimensions [Titas'14]

Soln: The slump test is a means of assessing the consistency of freshly mixed concrete at laboratory or at construction site. Consistency is degree of wetness of concrete. Therefore, slump test is used, indirectly, as a means of checking the correct water content in a batch of concrete.

(PGCB'15)

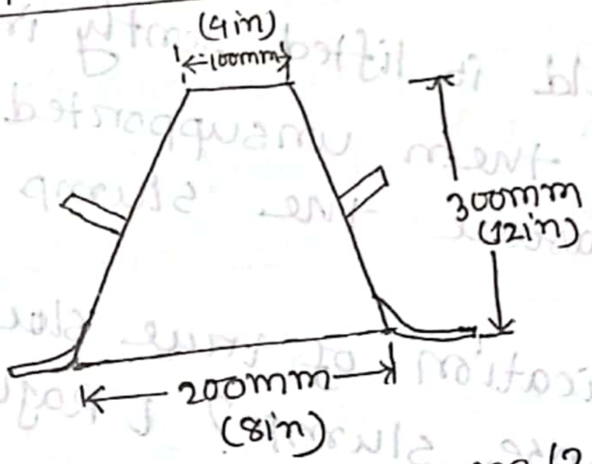
"Slump" is the distance measured ~~by~~ in inches or milimeter, the concrete settles after the slump cone is removed.

A concrete batch with high slump is an indication that the concrete has to much water in it and will likely be weak when fully cured. A low slump value indicates dry mix which has very low workability. The ideal mix will not be too stiff or too soft, but will have a slump of about 4" (100mm). (~~2"-4" or 50-100mm~~)

desirable range 4"-6" (100-150mm) (BPDB'21)

The slump test is ~~has~~ carried out from batch to batch to check the uniformity of concrete during construction. It is the most simple test of consistency, involve low cost and provides immediate results. Due to this fact, it has ~~beed~~ been widely used for consistency tests.

Slump cone with Dimension (ASTM C143)



Tampping rod - 600mm (24inch) ~~high~~ length, 15mm (5/8)" ~~(5/8 inch)~~ dia

Test procedure

Step 1: The internal surface of the mould (cone) is cleaned carefully. oil can be applied on the surface

Step 2: The mould (cone) is then placed on a base plate. The base plate should be clean, smooth, horizontal & non-porous

P.T.O

Step-3 The mould is filled with fresh concrete in three (3) layers. Each layer is tamped 25 times with a steel rod of dia 5/8 inch (15mm). The tamping should be done uniformly. Each layer should be tamped to its full depth, allowing the rod to penetrate through into the layer below.

Step-4 After filling the ~~mould~~ cone, excess concrete should be removed and the surface should be leveled.

Step-5 Then the mould is lifted gently in the vertical direction and then unsupported concrete will slump. Then measure the slump value.

(62) What is the indication of true slump, shear slump & collapse slump? [Rajuk'14]

Solⁿ: When the cone is removed, the slump may take one of the ~~tree~~ three forms.

(1) True slump

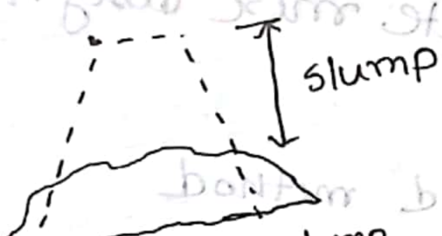
(2) Shear slump

(3) ~~CP~~ Collapse slump

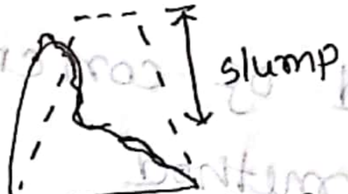
True slump: In true slump, the concrete simply subsides, maintaining its general form. True slump is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed.

(DNCC'22)

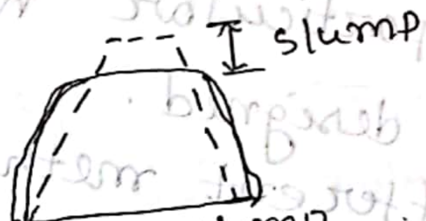
Shear slump: In a shear slump, the top portion of the concrete shears off and slips sideways. If a shear slump is achieved, a fresh sample should be taken and the test is repeated. If two consecutive tests shows shearing off of a portion of the concrete, the concrete probably lacks necessary plasticity and cohesiveness for the slump test to be applicable.



collapse slump



shear slump



true slump

(DNCC'22)

Collapse slump: The concrete collapse completely, likely from the mix being too wet.

(64) Short note on admixture [Titas'14] [Rajuk 14] [DMLC'16],

or

What is admixture? Uses of admixture [56BMA_BA'14]

Sol^n: An admixture is a substance added to concrete to achieve or modify its properties in the plastic or hardened state as required in structures.

Admixtures are added to the concrete in addition to cement, water and aggregates typically immediately before or during the mixing process.

Admixtures can be used to reduce the cost of buildings with concrete, to modify setting properties, workability & quality of cured concrete.

If problems arise with the concrete during the construction process, admixtures can be used as an emergency measure to try and prevent failures.

Main functions of admixtures:

① Water reducing: can reduce the water content needed to reach a required slump by 5-10%

(2) Retarding admixture: slow the setting rate of concrete, keeping its workable and are often used to counteract the accelerating effect of hot weather.

* Types of admixtures [DNCC'22]

water reducing, retarding ...

[illegible]

(3) Accelerating: Increase the rate of early-strength development and reduce the time required for curing.

(4) Superplasticizers: also known as plasticizers or high-range water reducers (HRWR), can reduce water content by 12-30% to make a highly fluid but workable form of concrete known as flowing concrete.

(5) Corrosion-inhibiting: Used to slow the corrosion of reinforcing steel in concrete. Often used in marine structures, bridges and others that will be exposed to chloride in high qualities.

(6) Air-entraining: Small bubbles of air formed uniformly through the concrete mix to increase cohesion and resistance to freeze-thaw degradation.

These are the main functions of admixtures.

Besides –

(i) Improving the curing of concrete
(ii) Providing waterproofing properties
(iii) To improve hardness
(iv) providing colour
(v) reducing shrinkage
(vi) Alkali-silica reactivity reduction
(vii) reducing chemical reaction

#Types of admixtures [DNCC'22]

→ water reducing

→ Retarder

→ Accelerating

→ Superplasticizers

→ Corrosion-inhibiting

→ Air-entraining

→ Shrinkage reducing

→ Corrosion inhibiting

(65) Define curing of concrete [PMO-15]. Why curing is necessary and how long? [Rajuk'16] What are the different methods of curing.

Soln: Curing: Curing of concrete is defined as providing adequate moisture, temperature and time to allow hydration and pozzolanic reactions of cement to occur in concrete mix so that the potential properties of the mixture may develop.

This would mean maintaining a relative humidity in the concrete of greater than 80%, a temperature greater than 50°F & for a time typically ranging from 3 to 14 days depending on the specific application.

Why curing is necessary? (ব্যাখ্যাও এখানে। Rajuk'16 এর answer এর)

→ Water is one of the most important ingredient of concrete. Water cause the chemical reaction with cement which is called "hydration reaction"

→ The hydration reaction cause the concrete to set and develop strength

→ It is essential that water has to remain in the concrete till it attains it's full strength

→ When the formwork for the RCC members are removed the concrete gets exposed to the air. The water from the concrete starts to evaporate to the atmosphere.

→ The hydration reaction is an exothermic reaction. Due to this, temperature of concrete rises and cause evaporation of the water inside the concrete.

→ Hence there can be loss of water due to two reasons —

(i) Exposure to the atmosphere

(ii) Due to heat generated by hydration

→ It is therefore necessary to cure concrete.

→ To prevent evaporative losses and to ~~keep~~ ~~on the~~ maintain required temperature for hydration. ***

→ When evaporation occurs, it results in slowing down or stopping hydration process and development of ~~[illegible]~~ shrinkage cracks may occurs.

(66) Write Short note on segragation [56 BMA]
or, Define segragation . cause of it and how to avoid it [47 BMA] [DSCC'21]
or, Describe the reason of segragation of concrete [MSc'18]
or, Differences between segragation and bleeding [Titas'14]

Soln: segragation of concrete is the separation of cement paste and aggregates of concrete from each other during handling and placement. The segragation of concrete is primarily caused due to the differences in the size of particles and in the specific gravity of the mix ~~concrete~~ constituents . But it can be controlled by doing the grading of concrete and by handling the concrete in proper way .

Generally, segragation occurs when we don't mix concrete ingredients in correct proportion or do not take care while handling, transporting or placing of concrete. Segragation creates porous concrete which reduces the strength of the concrete. It also leads to the voids in concrete, which causes leakage in house and accelerate the process of corrosion.

Types of segragation:

There are three forms of segragation in concrete -

(i) separation of grout (water + cement) from the rest of the particles due to lower specific gravity. This type of segragation of concrete may occur if the concrete mix is too wet.

(ii) separation of coarse aggregate from the concrete mixture due to havier sp. gravity. This type of segragation of concrete may occur if the concrete mix is too dry.

(iii) separation of water from the cement mix which is also known as bleeding.

Causes of segragation of concrete:

→ Use of high w/c ratio. This generally happens in the case of concrete mixed at the site by unskilled workers.

→ Excessive vibration of concrete makes havier particles settle at the bottom and ligher cement paste comes on top.

→ when concreting is done from a height more than 1·5m causes concrete to segregate

→ The root cause of segragation of concrete is the difference in specific gravity and size of its constituent material. The specific gravity of water is 1·0. The specific gravity of cement is around 3·15 while that of aggregate is 2·6 to 2·7. Due to differences in specific gravity, ligher particles have a tendency to move upward and havier particles tend to move downwards. This results in the segragation of concrete.

→ Improper grading of concrete aggregates.

→ Bad practice in handling and transporting.

How to prevent concrete segragation?:

→ proper mix design

→ accurate water / cement ratio as prescribed in mix design.

→ proper way of handling, placing, transporting and compaction.

→ ~~well~~ Properly graded aggregate should use.

***→ whenever depth of concrete is more than 1·5m, it should be placed through temporary inclined chutes

The angle of inclination may be kept between 1:3 and 1:2 so that concrete from the top of chute travels smoothly to the bottom.

→ Formwork should be made watertight to prevent leakage.

→ Using air entraining admixtures to enhance the viscosity (flow resistance property) in concrete.

What is bleeding of concrete? Write two measures to stop bleeding of concrete [PGCL' 21] (4 marks)

Bleeding of Concrete:

Bleeding is a form of segregation where some of the water in the concrete tends to rise to the surface of the freshly placed materials. This arises due to the inability of the solid components of the concrete to hold all of the mixing water when they settle downwards. (water being the lightest of all the mix constituents). Bleeding process continues until the cement paste has stiffened enough to end the sedimentation process.

Process of bleeding is a normal phenomena if it is at normal rate but can create weaker and less durable concrete if occurs at higher rate.

~~The free water of surface forms a paste with cement known as "laitance".~~

This upward movement of water also carries fine particles of cement with it and forms a paste at top surface known as "laitance". The top surface will not have good wearing quality. To avoid this, the finishing operation can be delayed until the bleed water has evaporated.

//Methods of Reducing Bleeding: (PGCL '21)

(i) Add minimum water content in the concrete mix, use chemical admixtures to reduce demand to water for a required workability.

(ii) Design the concrete mix properly.

(iii) Add extra cement in the mix

(iv) Using air entraining admixture is very effective in reducing the bleeding.

(v) Increase the amount of fine aggregate if sand is coarser (FM 2.5 to 2.8 best suited) in mix and reduce aggregate proportionally.

Concrete Laitance [DSCC'21]

Laitance is the weak, milky or powdery layer of cement dust, lime and sand fines that appear on the surface of concrete. Laitance is caused by bleeding of concrete. In case of bleeding, only water accumulates at the top of the surface; but in case of laitance, along with water certain quantity of cement and fines also comes to the surface, forming a thin layer of cement paste at the surface. This formation of cement paste is known as laitance.

(68) Write down 4 lab tests of concrete. [WZPDCL'16]

Solⁿ: (I) Concrete slump test (consitency test)

(ii) Air content of fresh concrete ~~by~~ (ASTM ~~C-138~~)
(ASTM C231)
(pressure air method / ~~Gravimetric method~~)

(iii) concrete compressive strength test using cylindrical specimen (ASTM C39)

(iv) Splitting Tensile strength test of cylindrical concrete specimens (ASTM 496)

(v) Static modulus of Elasticity and Poisson's ratio of concrete in compression (ASTM C469) b

Bricks

(69) Standard size of bricks (BSTI) 9.5"x 4.5"x 2.75"
[WRGCL'14, BPDB'21]

* BSTI উল্লেখ থাক বা না থাক, brick size সবসময়- এটাই দিবে।

* mortar সহ size = 10"x 5"x 3"

(70) Writedown BD standard dimension, weight, water absorption percentage of 1st class Bricks
[CoxDA'19]

Soln: (i) Brick standard dimension = 9.5"x 4.5"x 2.75"

(ii) When ~~bric~~ immerged in water for 24hrs, brick should not absorb more than $\frac{1}{5}$ times their own wt. of water.
(15 to 20% of dry weight)

(iii) ~~brick weight is generally 6lbs per brick~~.
The weight per cubic ft should not be less than 125 lbs (brick unit weight ≥ 125 lb/ft³)

(71) In half brick test, the maximum compressive load is found 15 tons and area of brick $21.5\ in^2$. Determine compressive strength and classify the brick (BEPZA'19)

$1kg = 2.2046\ lb$
$1ton = 2.2046\ kip$

Soln: compressive load $= 15$ tons
$= 15 \times 2.2046$
$= 33.069$ kip

$\therefore$ compressive strength $= \frac{33.069}{21.5} = 1.54$ ksi

The compressive strength of 1st class bricks should be in the range of 5 to 8 ksi

$\therefore$ It is 3rd class brick Ans

(72) Write down the characteristics of 1st class bricks [BSEC'18] [BSEC'14]

Soln: characteristics of good bricks/1st class bricks-

(i) Bricks should be uniform in color, size and shape

(ii) They should be sound and compact.

(iii) They should be free from cracks and other flaws such as bubbles, stone nodules etc

(iv) They should not absorb more than 1/5 of their own weight of water when immerged in water for 24 hours (15 to 20% of dry wt.)

(v) The compressive strength of bricks should be in the range of 5000 to 8000psi.

(vi) The percentage of soluble salts (sulphates of calcium, magnesium, sodium and potassium) should not exceed 2.5% in brunt bricks, because the presence of excess soluble salts causes efflorescence.

(vii) They should be neither overbrunt or underbrunt.

(viii) The weight should be generally 6 lbs per brick and the weight per cubic ft should not be less than 125 lbs.

(ix) They should have low thermal conductivity as it is desirable for buildings to keep inside cool in summer and warm in winter.

(x) They should be non-flammable and incombustible.

(xi) Brick should not change in volume when wetted.

* **Efflorescence:**

Efflorescence is a deposit of water soluble salts formed on the surface of concrete and brick masonry due to movement of water through pores. When water gets evaporated, efflorescence is formed as the dissolved salts gets deposited on the surface. Efflorescence occurs due to excess amount of salts present in bricks. ~~or other~~ ~~materials~~.

(73) Describe field tests of brick [PMO'15] [BA'14]

Soln: Field tests of bricks:

(i) Take a brick and try to make mark on the surface by nail. If you can make it, it is not good brick. Otherwise, it is very hard and compact brick.

(ii) Take a brick and strike it with hammer. (or two bricks are strucked with each other) If it gives clear ringing or metallic sound, it is a good brick. If not, then it is bad one.

(iii) Take two bricks and form a tee (T) and drop from a height of 6ft on a solid surface. If they breaks, they are not good bricks.

(74) Name three laboratory tests for bricks.
[COXDA'19], [BSEC'18 & '14], [53 BMA]

Solⁿ: Brick laboratory tests:

(i) Absorption test
(ii) Crushing strength test
(iii) Efflorescence test (presence of soluble salts)

* Efflorescence test:

A good quality brick should not contain any soluble salts in it. If soluble salts are there, then it will cause efflorescence on brick surfaces. To know the presence of soluble salts in a brick, placed it in a water bath for 24hrs and dry it in shade. After drying, observe the brick surface thoroughly. If there is any white or grey color deposits, then it contains soluble salts and not useful for construction.

(77) Right down laboratory tests of reinforcing bars / steel [WZPDCL'16] [Rajuk'19] [BGFCL'17]

Ans: (i) Tensile strength test
(ii) Yield ~~strength~~ stress test
(iii) Bend & Rebend test
(iv) Chemical analysis test

Yield stress test

(0.002×100) = 0.2%

Yield stress test কে 0.2% proof stress ও বলে, steel 0.002 strain পর্যন্ত ~~plasti~~ elastic deformation show করে। এর পর থেকেই ধীরে plastically deformed হতে থাকে অর্থাৎ yield হয় বলে।

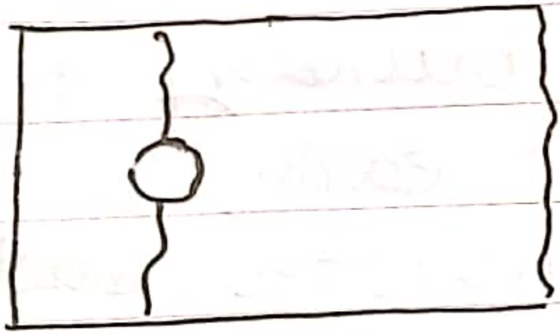
Shortnote : Retrofitting [BEPZA'21]

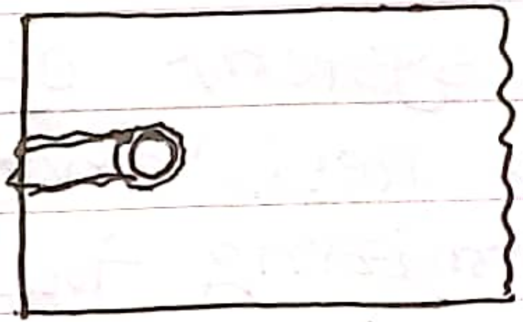
Retrofitting is technical interventions in structural systems of a building that improve the resistance to earthquake ~~[illegible]~~ by optimizing the strength, ductility & earthquake loads.

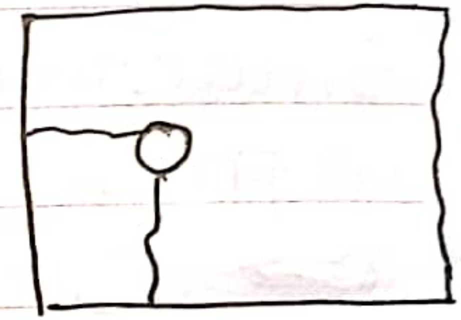
Types of retrofitting:

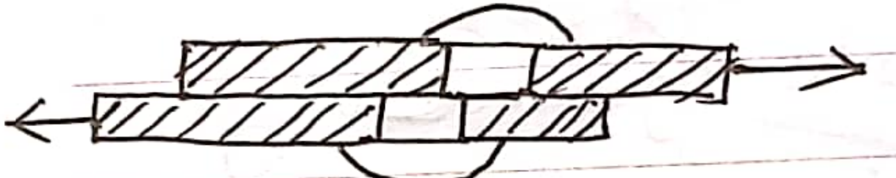
(1) Reinforcement concrete jacketing
(2) wrapping column with CFRP
CFRP = concrete Fiber Reinforced Polymer
(3) steel jacketing of column
~~(4) Steel caging~~
(4) Steel bracing
(5) Adding new shear wall
(6) base isolation
(7) epoxy injection method
(8) cement grouting in cracks
(9) Crack stitching in plaster

* States different kinds of failure modes in rivet joints [EGCB '20] [দেড় ঘন্টার প্রশ্ন]


Tensile failure in parent material


shear failure


cleavage


rivet shear


Pull out (bearing)