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1 a. Viscosity indicates the stiffness and quality of the Binder, higher the viscosity, higher the quality.
In singapore, the average temperature is around 30°C
→ Binder A more viscous → better.

b. - Rough → provide skid resistance → no slip.
- Angular → better packing → Prevent aggregate from flying apart when exposed to high impulse.
- well graded (enough pores → Singapore has wet weather → Prevent fog

c. $VTM = 100 \times \frac{V_A}{V}$

$D = \frac{M}{V_{MM}}$

$2.480 = \frac{1250}{V_{MM}}$

$V_{MM} = 504.03\ cm^3$

$V = \frac{W_{air} - W_{water}}{\rho_{water}}$

$= \frac{1250 - 734}{1} = 516\ cm^3$

$V_A = V - V_{MM} = 516 - 504.03 = 11.97\ cm^3$

$VTM = 100 \times \frac{V_A}{V} = \frac{100 \times 11.97}{516} = 2.32\%$

VTM for proper design is 3% - 5%. Hence, not suitable.

2 a. Above 727° → Austenite (→ 0.8%C) + cementite → 6.7% C

$6.7\% \times Cementite + 0.8\% \times Austenite = 1.2\%$

$Cementite + Austenite = 1.$

$6.7\%\ Cementite + 0.8\% (~~ceme~~\ 1 - Cementite) = 1.2\%$

Cementite = 6.7%

Austenite = 93.3%

Below 727 → Cementite + Pearlite (→ cementite, → Ferrite.)

→ Austenite become pearlite → same carbon content (0.8%) → Calculation same

↳ Cementite = 6.7%.

Pearlite = 93.3%.

Find: Cementite (6.7%) + Ferrite (0.025%).

$6.7\%\ Cementite + 0.025\% (1 - Cementite) = 1.2\%$

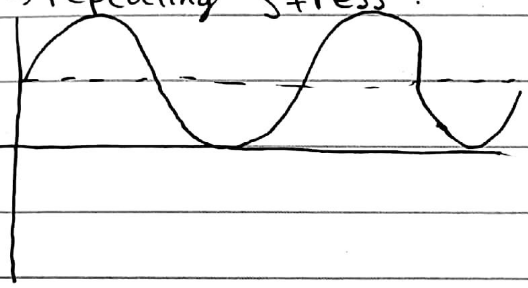
Cementite = 17.6% Ferrite = 82.4%.

→ Cementite in pearlite = 93.3 - 82.4 = 10.9%

along = 6.7%

2b i Fatigue failure is the result of processes of crack nucleation and growth or, for components which may contain cracks introduced during manufacture, growth only.

ii Trampoline → Subjected to repeated cyclic stresses
↳ repeating stress.



iii - increase critical crack length a_{cr} at failure
↳ Choose material with higher K_{IC}
↳ Reduce σ_{max}
- Reduce initial flaw size a_0
↳ improve inspection resolution
↳ Improve manufacturing / material quality control
- Lower stress range $\Delta\sigma$

C. Similarities → type of wood
→ Mechanical properties are not as limited by knots.
→ Dimensionally stable.

Differences → Plywood's grain at right angles to each other, glulam parallel.
→ glulam can be curved, plywood cannot.
→ glulam more expensive → need glue.

D. Similarities → increase strength, ductility, toughness
→ using fibre
→ No yielding

Differences → Polymer matrix Vs cementitious matrix.
→ in polymer → Fibre carries load, cementitious → load & ductility
→ in polymer, Fibre content is high, in cementitious, Fibre content is low.

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3 a.i Surfaces, such as roads and sidewalks, constructed from materials like concrete carry polluted storm water to storm drains, rather than allowing the water to percolate through soil.

ii flooding & water pollution.

iii concrete → low permeability → water cannot penetrate

Surface runoff

b i Each aspects in a composite which has its own function.

ii - Discrete phase → Aggregate → Economical filler.

→ responsible for ductility.

→ Provide dimensional stability.

- Continuous phase → cement paste → Binds the aggregate particles.

→ Provide strength & stiffness to concrete.

- Interfacial transition zone → weakest link of the chain.

c. Cement A:

$C_3S = 4.07C - 7.60S - 6.72A - 1.43F - 2.85SO_3$

$= 42.56\%$

$C_2S = 2.87S - 0.75C_3S = 30.84\%$. → more like type 4. (lower C_3S & C_3A content)

$C_3A = 2.65A - 1.69F = 11.51\%$

$C_4AF = 3.04F = 8\%$.

Cement B:

$C_3S = 52.5\%$

$C_2S = 20.97\%$

$C_3A = 11.96\%$

$C_4AF = 7.84\%$

3d i $BSG_{SSD} = \dfrac{W_{SSD}}{W_{pycn,w} + W_{SSD} - W_{pycn,w+s}}$

$= \dfrac{1000}{1390+1000-2000} = 2.564\ gr/cm^3$

ii $BSG_{SSD} = \dfrac{W_{SSD}}{W_{pycn,w} + W_{SSD} - W_{pycn,w+s}}$

$2.564 = \dfrac{W_{SSD}}{1390 + W_{SSD} - 1691}$

$W_{SSD} = 493.46\ gr.$

$A = \dfrac{W_{SSD} - W_{OD}}{W_{OD}} \times 100 = \dfrac{493.46 - 490}{490} \times 100\% = 0.71\%.$

$M = \dfrac{500 - 490}{490} \times 100 = 2.04\%$

Free Moisture $= M - A = 1.33\%$.

4a. Air-entraining uses Admixtures to produce tiny, dispersed bubble into the concrete. Air bubble become the lubricant in concrete to improve workability until it is "locked" into cement paste during hardening.

b. ① R → finer aggregate → higher surface area → less water for workability.

② I → act as lubricant because of round shape.

not sure ③ N → Ice is only used for controlling the cooling of concrete.

④ I → Rounded → less surface area → more water for workability.

c. lower the loading rate, lower the strength of conerete, it is because the crack needs time to propagate until failure, if ~~the~~ high rate, the crack doesn't have enough time to propagate resulting in higher strength.

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4d i A shrinkage that cannot be reversed even after the concrete re-stored in water.

ii Because ~~the~~ cracks have been formed because of the shrinkage.

(e) $R = \frac{PL}{bd^2} = \frac{4000 \times 400 \times 10^{-3}}{500 \times 10^{-3} \times (100 \times 10^{-3})^2} = 320000 \text{ Pa}$

not sure