CV1013 Civil Engineering Material

1\. a) Durability is the ability of asphalt to maintain it's original properties when exposed to weathering and ageing processes. The durability considerations are moisture damage and age hardening.

Moisture damage will cause stripping, which is loss of adhesion between asphalt and aggregate. It will also cause softening resulting loss in cohesion, strength, stiffness and other engineering properties.

For age hardening, asphalt cement loses its oily components thus resulting it to crack easily. Age hardening is mainly due to oxidation during plant mixing, lay-down, compaction, and time passes in its service life.

b) Functions of aggregates
- provide stability to mix by interlock
- provide rough surface texture with good skid resistance
- form a durable and abrasion resistant material
- accommodate imposed loads without failure and spread loads to lower layers

Physical properties
- rough surface texture
- resistance to polishing
- high toughness

c) i) To select best blend of aggregates and associated optimum asphalt content

ii) Stability is the maximum load carried by the specimen at a standard Marshall test temperature of 60°C

Flow is the deformation that the Marshall test specimen undergoes during loading up to the maximum load

iii) $V_G = \frac{1.2}{2650} = 4.53\times10^{-4}\,m^3$

$V_B = \frac{0.072}{1050} = 6.86\times10^{-5}\,m^3$

$V = \frac{W_a - W_w}{\rho_w} = \frac{(1.2+0.072)-0.732}{1000} = 5.4\times10^{-4}\,m^3$

$V_A = V - V_B - V_G = 5.4\times10^{-4} - 6.86\times10^{-5} - 4.53\times10^{-4} = 1.84\times10^{-5}\,m^3$

$VTM = 100\times\frac{V_A}{V} = 100\times\frac{1.84\times10^{-5}}{5.4\times10^{-4}} = 3.41\%$

$VMA = 100\times\frac{V_{BE}+V_A}{V} = \frac{6.86\times10^{-5}+1.84\times10^{-5}}{5.4\times10^{-4}}$ $V_{BE} = V_B$ (negligible binder absorption)

$= 16.1\%$

2. a) Strain hardening is plastic deformation below the recrystallization temperature where resistance to further deformation increases with increasing amounts of deformation. During strain hardening, the dislocation density of steel increases due to multiplication. This decreases the average distance between dislocations and causes the dislocations to block each other's motion. Besides that, formation of dislocations in different plane directions during strain hardening also helps to block dislocation motion and therefore increases the strength of steel.

b) Hardening – Rapid quenching of the steel from high temperature into water or oil.
Annealing – Heating of the steel at 30-55°C above the upper critical temperature, followed by slow cooling within a furnace
Normalizing – Heating of the steel at 30-55°C above the upper critical temperature followed by cooling in still air
Tempering – Heating of hardened steel within the range of 200-700°C to remove the internal stresses created by quenching, reduce the hardness, and increase the toughness of the steel

Normalizing is used.

c) Weldability is the capacity of a metal to be joined by welding into a structure that can perform in a satisfactory ~~level~~ manner for an intended service. "Carbon equivalent" formula is used to measure weldability in practice.

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Increasing contents of carbon and other alloying elements will decrease weldability. High CE value → Low weldability

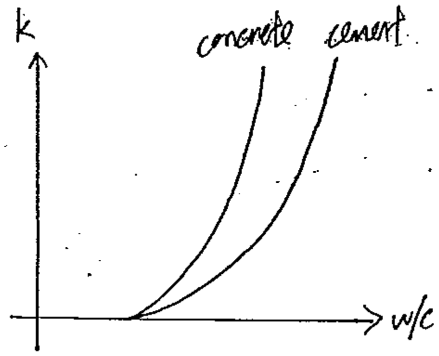
d) '275' is the minimum yield strength (in N/mm^2)
'S' signifying that the steel is for structural applications
'JR' – 'J' indicates the testing strength while 'R' indicates the testing temperature is room temperature

They are important for engineers to select the most suitable steel in designing structures – to meet characteristics requirement and stay economical

3 a) Yes it is possible. Replacing iron-bearing aluminosilicates raw materials with quartz will produce white Portland cement without affecting much of its properties. This is due to the reduction of iron content which would contribute to its grey colour.

3 a) White Portland cement does not differ much from grey Portland cement but it has an extra decorative ~~prote~~ property. However, it is not widely used as compared to grey Portland cement because of its higher manufacturing cost.

b)



For a given w/c ratio, concrete has higher permeability coefficient.

~~Cement gives~~

Concrete gives higher permeability than cement because concrete contains aggregates with much larger capillary pores than that of cement

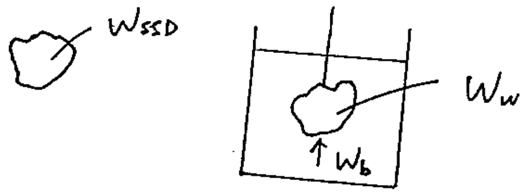
c) Bleeding is a form of segregation in which some of the water in mix tends to rise to the surface of freshly placed concrete. Most of the time bleeding is undesirable but a small amount of bleeding might help to reduce w/c ratio and densify the concrete. Excessive bleeding would lead to a porous and weak layer of non-durable concrete and zones of ~~f~~ poor bond between cement paste and large aggregate particles or reinforcement. Bleeding also cause other problems like blistering, scalling, and dusting surfaces.

d)
- w/c ratio
- type of curing
- type of cement used
- type of aggregate used, proportion of fine and coerse aggregates
- water content

e) NDT - Non-destructive test (Examination and compressive strength testing of concrete without damaging it)
- Concrete tested will not be damaged, unlike other core test

① Rebound hardness test
② Penetration resistance test
③ Pull out test
④ Ultrasonic pulse velocity test

4. a) $BSG_{OD} = \dfrac{W_{OD}}{V_{SSD}\rho_w}$



4a) $W_b = V_{SSD}\rho_w$

$W_w = W_{SSD} - W_b$

$= W_{SSD} - V_{SSD}\rho_w$

$V_{SSD}\rho_w = W_{SSD} - W_w$

$\therefore BSG_{OD} = \dfrac{W_{OD}}{W_{SSD} - W_w}$ shown

b) $M_M = 5300g$

$M_w = 3300g$

$BSG_{SSD} = 2.70$

$A = 1.80\%$

$BSG_{SSD} = \dfrac{W_{SSD}}{V_{SSD}\rho_w} = \dfrac{W_{SSD}}{W_{SSD} - W_w} = \dfrac{M_{SSD}}{M_{SSD} - M_w}$

$2.70 = \dfrac{M_{SSD}}{M_{SSD} - 3300}$

$M_{SSD} = 5241g$

$A = \dfrac{W_{SSD} - W_{OD}}{W_{OD}} = \dfrac{M_{SSD} - M_{OD}}{M_{OD}}$

$0.018 = \dfrac{5241 - M_{OD}}{M_{OD}}$

$M_{OD} = 5148g$

$M = \dfrac{W_M - W_{OD}}{W_{OD}} = \dfrac{M_M - M_{OD}}{M_{OD}} = \dfrac{5300 - 5148}{5148} = 0.03 = 3\%$

Free moisture content $= M - A = 3 - 1.8 = 1.2\%$

c) Adjustment to coarse aggregate content $= 1500 \times (1 + 1.2\%) = 1518 kg/m^3$

Adjustment to water content $= 200 - (1518 - 1500) = 182 kg/m^3$

e) Plywood consists layers of thin veneer glued together ~~in layers~~ with successive plies at right angles to each other. Glued-laminated timber is manufactured by gluing together a large number of relatively short pieces of dimensioned lumber with the grain directions parallel to each other.

Advantages over natural sawn timber:

Plywood - split resistant
- properties along the length of the sheet are similar to that of across the width
- shrinkage and swelling are minimized

Glued-laminated timber - easy to produce much larger sections that can be sawn as a single member, and the sections may be curved
- can be made to almost any size
- seasoning defects are minimized