CV 2003 Civil Engineering Materials

Semester 2 Examination 2010-2011

1. (a) At low temperature (below approximately 25^{0}C) and high temperature (above approximately 100^{0}C) Type B asphalt has lower viscosity (stiffness) than Type A asphalt. At low temperature, the lower viscosity of Type B asphalt makes it usable even without supply of additional heat, which makes it more energy efficient than Type A asphalt. Also, Type B asphalt is more temperature susceptible, making it more superior than Type A asphalt. At high temperature during hot climates, rutting problems will occur. The lower viscosity of Type B asphalt at high temperature gives it higher temperature susceptibility. Also, cold weather leads to cracking problems. The lower viscosity of Type B asphalt at low temperature also gives it higher temperature susceptibility. Type B asphalt which is more flexible in varying temperature leads to lower risk of fatigue cracking which is caused by contraction and expansion during cold weather and hot weather. The mixing temperature of asphalt concrete cannot be too high to minimize aging of the concrete. This brings greater advantage to Type B asphalt as low viscosity can be obtained under lower temperature than Type A asphalt. In general, Type B asphalt is more flexible, workable and temperature susceptible than Type A asphalt.

(b) Good affinity for asphaltic binder (or moisture susceptibility) is important to prevent moisture damage. Hydrophobic aggregate which means good affinity for asphalt like limestone has lower risk to moisture damage while hydrophilic aggregate which means poor affinity for asphalt like granite is more prone to moisture damage.

As for good resistance against polishing, it is important to have asphalt concrete which is durable against weathering throughout its service duration. Mineral aggregates polish under traffic, especially under heavy traffic and tight road geometries like curves. Thus, mineral resistance against polishing is important under these circumstances to provide higher durability.

(c) VTM (voids in total mix) limits fall in between 3% to 5% as VTM cannot be too high to provide sufficient strength to the asphalt mix while the VTM values cannot be too low to avoid bleeding of binder to provide higher skid resistance to the asphalt concrete mix.

Granite Aggregate = 1180 g
Bulk Relative Density = 2.65 g/cm^3
Binder Absorption = 0.5 %
Asphalt = 65 g
Density of Asphalt = 1.10 g/cm^3
Specimen = 700 g in water

Mass of Specimen in air = 1245 g
Volume of Specimen = (1245-700)/1.0 = 545 cm^3
Volume of Binder = 65/1.10 = 59.09 cm^3
Bulk Volume of Aggregate = 1180/2.65 = 445.28 cm^3
Effective Volume of Aggregate = 445.28 – 0.005 x 1180/ 1.10 = 439.92 cm^3

Volume of Air = 545 – 59.09 – 439.92 = 45.99 cm^3
VTM = V_A / V = 8.43%

The VTM value of this mix exceeds the limit which is 5%. This means that the voids in this asphalt mix is too high and might lead to low strength of the concrete mix.

2. (a) The three main mechanisms are the introduction of interstitial and substitutional atoms (alloying), the generation and concentration of dislocations (work or strain hardening), and the formation of additional grain boundaries (heat treatment). Dislocations are areas where the atoms are out of position in the crystal structure. The movement of dislocations when a stress is applied allows slip-plastic deformation to occur. The generation and concentration of dislocations impedes the motion of dislocations. As for strengthening by grain boundaries, dislocation pileups at grain boundaries indicate these boundaries are very strong obstacles to dislocation motion.

(b) Failure by yielding happens on some metals which are highly ductile with considerable plastic deformation before failure. To minimize the possibility of excessive deformation or failure by yielding in service, it is usual in design to limit the maximum stress under service load to the yield or proof strength divided by a safety factor.

Failure by fracture occurs on metals which contain internal cracks and other defects, and these can act as points of local stress concentration. When a material is subjected to a stress, any cracks within it can propagate and may lead to catastrophic fracture before the yield condition. This is prevented by minimize the cracks and defects in the material.

(c) Factors to be considered in selecting an appropriate grade of structural steel are type of the steel products, the carbon content in the material, their way of manufacturing and forming, tensile yield strength required, impact toughness, ductility, the availability and cost, as well as the arbitrary local conditions.

(d) FSP is he moisture content at which the cell wall is saturated with bound water and at which no free water is present. Addition or removal of water below FSP has a pronounced effect on practically all wood properties. As for addition or removal of water above the FSP, it has almost no effect on any wood properties.

(e) The glued-laminated timber (Glulam) is manufactured by gluing together a large number of relatively short pieces of dimension lumber to build up timbers, which many be up to at least 40m in length and up to over 2m deep. The pieces are glued together so that the grain directions in all of them are essentially parallel. The mechanical properties are thus not as limited as knots or other imperfections as they would in sawn timber, hence the design stresses are actually higher than those of the selected structural grade of sawn timber.

Glulam are easier to produce much larger sections than sawn timber, and the sections can be curved. They can be made to almost any sizes. They can be straight or curved, depending on the design suit aesthetically or to be more efficient. Besides, it is also possible to use material of lower grade in those sections which are lesser stressed.

3. (a) (i) C : FA : CA : W = 1: 2: 4: 0.6

Wet density = 2380 kg/m^3

V = (1+2+4+0.6) x W/ (2380) =3.193 x 10^{-3} W m^3

Cement Content = 1xW /V

= 313 kg/m^3

(ii) Heat of Hydration = 370 kJ/kg at 7 days

Specific Heat of water = 4.18

Specific Heat of Solids = 0.22 x water = 0.9196

T = adiabatic temperature rise

Heat output = Heat input

1 x 0.9196 x T + (2+4) x 0.9196 x T + 0.6 x 4.18 x T = 1 x 370

T = 41.4 ^{0}C

(iii) The two options are reduce the cement content of the concrete. Secondly, reduce heat output content by replacing the cement by fly ash. Also, crushed ice can be used for mixing.

(b) Pozzolanic material is one that contains active silica and is not cementitious in itself reactive, but will in a finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form cementitious compounds.

(c) (i) There are four types of moisture states of concrete aggregates.

- Oven-dry (Bone Dry) – 0% moisture content
- Air-dry – Below saturation, Moisture content < Absorption capacity, Surface dry, Effective absorption (MC- AC)
- Saturated Surface Dry (SSD) – Fully saturated, No surface moisture, Absorption capacity (AC)
- Wet – Over saturation, MC > AC, Surface moisture (MC-AC)

(ii) 25kg Cement, 40kg wet sand, 12kg water, MC = 6%, AC = 2%, Weight of dry sand = W, Extra water in wet sand = W_E

AC = 0.02

Water in wet sand = 0.02 x W = 0.02 W kg

$0.02\ W + W_E + W = 40$ kg $\qquad W_E = 40 - 1.02\ W$

$MC = W_w / W_s = 0.06 = (0.02\ W + W_E) / W = (0.02\ W + 40 - 1.02W) / W$

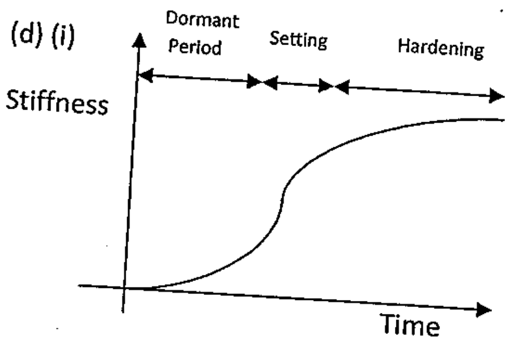
$0.06\ W = 40 - W \qquad 1.06\ W = 40 \qquad W = 37.74$ kg

$W_E = 40 - 1.02\ W = 1.51$kg

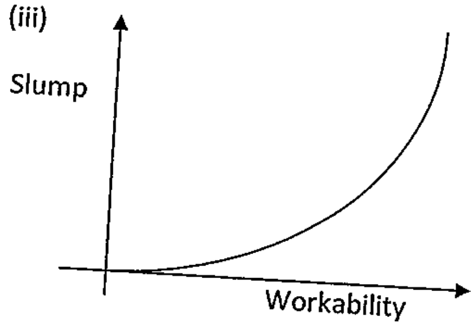
Free water = W_E + 12kg = 13.51kg

Free water: cement = 13.51: 25 = 0.54

(d) (i)



(iii)



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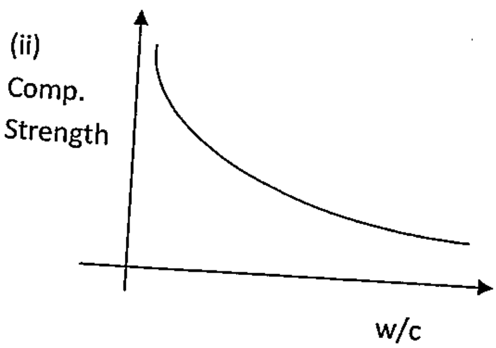

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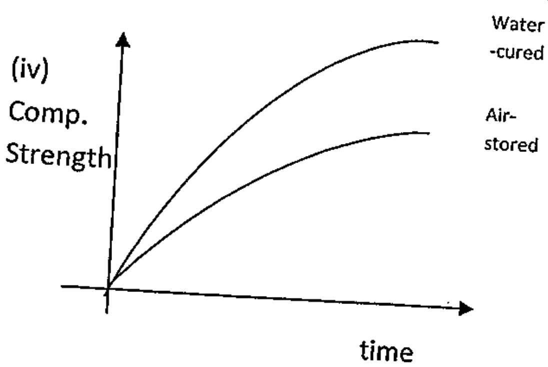
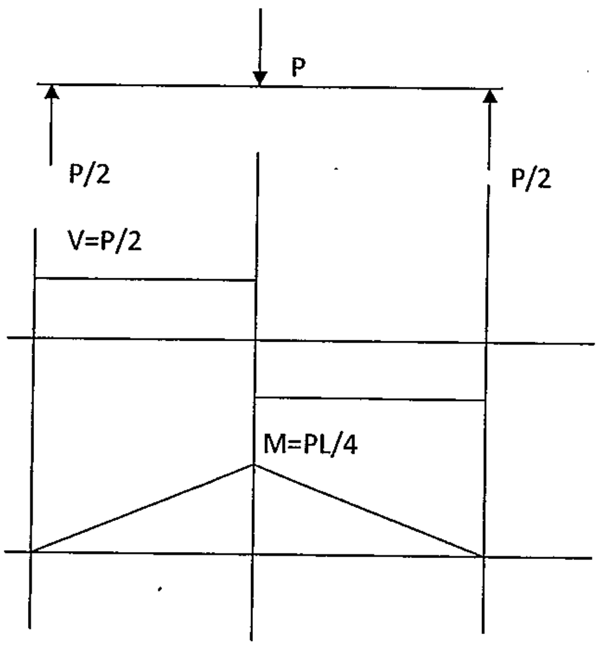
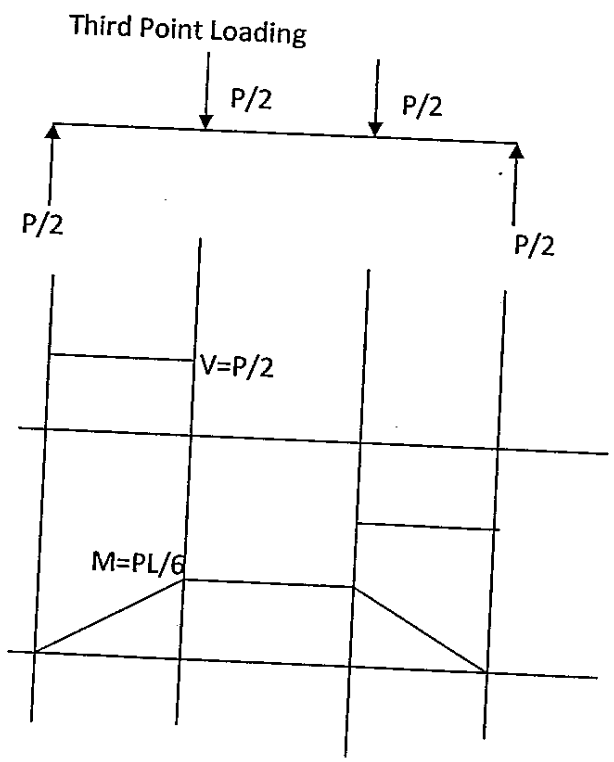


4. (a) Extra water is harmful to fresh concrete in the sense that it delays stiffening or finishing of the concrete. It also increases bleeding, shrinkage, and reduces its density. On the other hand, water is good for concrete after it reaches its final set as this curing approach maintains the presence of water in the concrete. Curing the concrete helps sealing the surface so mix water can't escape. Curing is done immediately after final set to avoid surface damage of the concrete.

(b) (i) The modulus of rupture obtained from central point load is higher than that from third point load. This means that more material in tension surface is subjected to maximum stress. Also, the probability of presence of weak element is higher. Besides, central point flexural test has higher variability than the third point flexural test.

(ii) Central Point Loading





(c) (i) Self-consolidating concrete is a highly flowable, nonsegregating concrete that can spread into place, fill the formwork and encapsulate the reinforcement, without any mechanical consolidation.

(ii) The properties of SCC are its flowability and stability, which is the resistance to segregation. These properties are achieved by using superplasticizer (high-range water-reducing admixture) combined with a relatively high content of powder materials in terms of Portland cement, mineral additions, ground fillers and/or very fine sand.

(iii) Flowability is measured by the slump flow test. Stability is measured by the visual stability index (VSI). VSI is based on bleed water observed at the edge of spread. Viscosity is measured by the rate at which the concrete spreads.

GOOD LUCK ^.^