Internal Assessment Test 2–June-2022
(Academic Year 2021-22-Even)
(Solution and Scheme of Valuation)

Sub:	Pavement Design			SubCode:	18CV825/17CV833/15CV833		Branch:	Civil
Date:	04/6/2022	Duration:	90min	MaxMarks:	50	Sem/Sec:	VIII– A, B, C	marks

1 Calculate the design repetitions for 20 years period for various wheel loads equivalent to 2268 kg wheel load using the following traffic survey data on a four lane road. 20 CO2 L3

Wheel load, kg	Average Daily traffic (both directions)	% of total traffic volume
2268	Total volume 215	13.17
2722		15.3
3175		11.76
3629		14.11
4082		6.21
4536		5.84

Solution:

Wheel load (kg)	ADT	% of total traffic volume	Traffic volume/day ((3)/100)*(2)	Traffic volume/ year (4)*365	Traffic volume for 20 years (5)*20	EWLF	(6)*(7)
2268	Total volume 215	13.17	28.3155	10335.16	206703.2	1	206703.2
2722		15.3	32.895	12006.68	240133.5	2	480267
3175		11.76	25.284	9228.66	184573.2	4	738292.8
3629		14.11	30.3365	11072.82	221456.5	8	1771652
4082		6.21	13.3515	4873.298	97465.95	16	1559455
4536		5.84	12.556	4582.94	91658.8	32	2933082
Sum							7689451

Total traffic for four lanes = 7689451
Traffic per lane = 7689451/4 = **1,922,363 repetitions per lane**

2 Explain frost action. What are the measures adopted to reduce its effects? 15 CO1 L2

Frost action: Frost action can be quite detrimental to pavements and refers to two separate but related processes:

- Frost heave. An upward movement of the subgrade resulting from the expansion of accumulated soil moisture as it freezes.
- Thaw weakening. A weakened subgrade condition resulting from soil saturation arises within the soil melts.

Frost heave: Frost heaving of soil is caused by crystallization of ice within the larger soil voids and usually a subsequent extension to form continuous ice lenses, layers, veins, or other ice masses. An ice lens grows through capillary rise and thickens in the direction of heat transfer until the water supply is depleted or until freezing conditions at the freezing interface no longer support further crystallization. As the ice lens grows, the overlying soil and pavement will "heave" up potentially resulting in a cracked, rough pavement (see Figure 1). This problem occurs primarily in soils containing fine particles (often termed "frost susceptible" soils), while clean sands and gravels (small amounts of fine particles) are non-frost susceptible (NFS). Thus, the degree of frost susceptibility is mainly a function of the percentage of fine particles within the soil.

The three elements necessary for ice lenses and thus frost heave are:

- Frost susceptible soil.
- Sub freezing temperatures.
- Water.

Differential heave is more likely to occur at locations such as:

- Where sub grades change from clean not frost susceptible(NFS) sands to silty frost susceptible materials.
- Abrupt transitions from cut to fill with ground water close to the surface.
- Where excavation exposes water-bearing strata.
- Drains, culverts, etc., frequently result in abrupt differential heaving due to different backfill material or compaction and the fact that open buried pipes change the thermal conditions(i.e., remove heat resulting in more frozen soil).
- Ground water table
- Temperature gradient
- Mobility of water

Frost penetration: This indicates the formation of ice lenses in a sub grade. This makes the sub grade strong during winter and weak during summer because of the melting of ice lenses.

Freezing index: Severity of frost action can be expressed in terms of degree days. One negative degree day defines one day with a mean air temperature of 1°C be low freezing. Similarly, one positive degree day is one day with a mean air temperature of 1°C above freezing.

Thaw Weakening: Thawing is essentially the melting of ice contained with in the sub grade. As the ice melt sand turns to liquid it cannot drain out of the soil fast enough and thus the sub grade becomes substantially weaker (less stiff) and tends to lose bearing capacity. Therefore, loading that would not normally damage a given pavement may be quite detrimental during thaw periods (e.g., spring thaw).

Measures adopted to reduce damage due to water and frost action

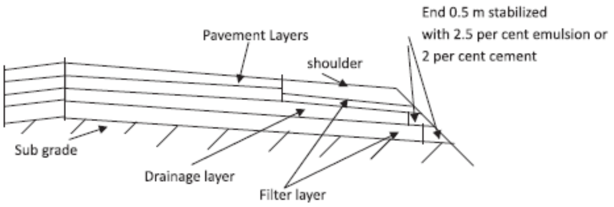
- Install proper surface and sub-surface drainage system
- Construction of base, sub-base and top layer of sub grade. up to the desired depth, by granular and non- frost susceptible material with good drainage characteristics.
- Requirement of filter layer is as follows:

$$\frac{D_{15} of\ filter\ layer}{D_{15}\ of\ subgrade} \geq 5$$

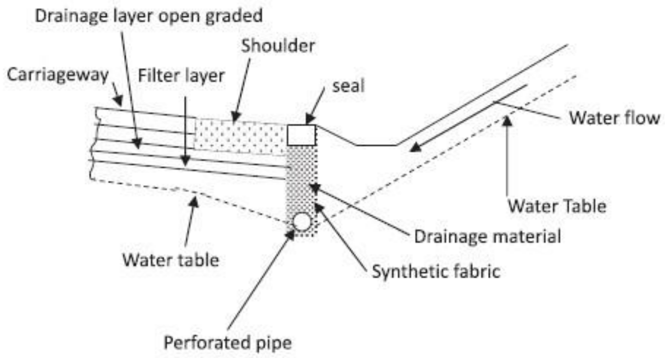
$$\frac{D_{15} of\ filter\ layer}{D_{85}\ of\ subgrade} \leq 5$$

To prevent entry of soil particles into the drainage layer:

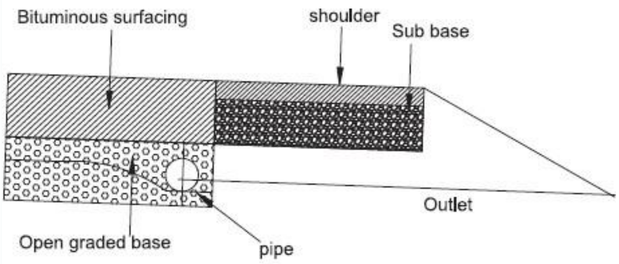
$$\frac{D_{50} of\ filter\ layer}{D_{50}\ of\ subgrade} \leq 25$$



Pavement with Filter and Drainage Layers



Pavement along a Slope



Longitudinal Pipe at the Edge of the Drainage Layer with Outlet Pipe

Reduce adverse effects of frost action by soil stabilization so that the soil will be able to withstand the adverse climatic conditions of alternate wet – dry and freeze–thaw cycles

Salts like calcium chloride or sodium chloride when mixed with sub grade soil lowers the freezing temperature of the soil – water and hence temporarily decreases the intensity of frost action.

3 Define ESWL. How ESWL is determined for dual wheel load assembly using equal stress and deflection criteria. Explain briefly. 15 CO2 L2

ESWL: Equivalent single wheel load (ESWL) is the single wheel load having the same contact pressure and contact radius, which produces same value of maximum vertical stress and deflection at the desired depth.

ESWL- Equal stress criteria:

$[\sigma_z]_{ESWL} = [\sigma_z]_{Dual\ Wheel}$

$[[\sigma_z/q_s] x q_s]_{ESWL} = [[\sigma_z/q_d]\ x q_d]_{Dual\ Wheel}$

Since the area remains same

$[[\sigma_z/q_s] x P_s]_{ESWL} = [[\sigma_z/q_d]\ x\ P_d]_{Dual\ Wheel}$

$\mathbf{P_s/P_d = [\sigma_z/q_d] / [\sigma_z/q_s]}$

ESWL- Equal deflection criteria

Deflection due to single wheel (W_s) = $q_s a F_s / E$

Deflection due to dual wheel (W_d) = $q_d a F_d / E$

Since a, E and total deflection remains constant

$W_s = w_d$

Or

$Q_s F_s = q_d F_d$

=> $(P_s/a)/F_s = (P_d/a)/F_d$

=$\mathbf{P_s/P_d = F_d/F_s}$