Question (1): **(12 Points)**

An existing horizontal curve on a highway has a radius of 400 m, which restricts the maximum speed on this section of the road to only 75% of the design speed of the highway. Assume values of e = 7% and f = 0.15.

1) Determine the maximum speed allowed at this section in km/hr. **(1 point)**
2) Determine the value of design speed and state your answer in km/hr. **(1 point)**
3) The same curve is to be improved so that the maximum speed is now equal to the design speed. Assume that the superelevation is now 8% and the coefficient of side friction is the same as before. Determine the new radius of the improved curve. **(2 points)**
4) If the highway has two lanes with 7.2 m and normal slope of 2%, draw the superelevation diagram based on the new calculations for the radius and e of 8%. **(3 points)**
5) Determine the length of the superelevation runoff (spiral length). **(3 points)**
6) Assuming the station of TS is 100 + 00, calculate the station of CS. **(2 points)**

Solution

① $\because R = \frac{V^2}{127[e+fs]}$

$\therefore 400 = \frac{V^2}{127[0,07+0,15]}$ $\quad \therefore V_{max} = 105,72 \text{ km/hr}.$

② Design speed $= \frac{V_{max}}{0,75} = \frac{105,72}{0,75} = 140,96 \text{ km/hr}.$

③ $\because V_{max} = V_{design} = 140,96 \text{ km/hr}.$

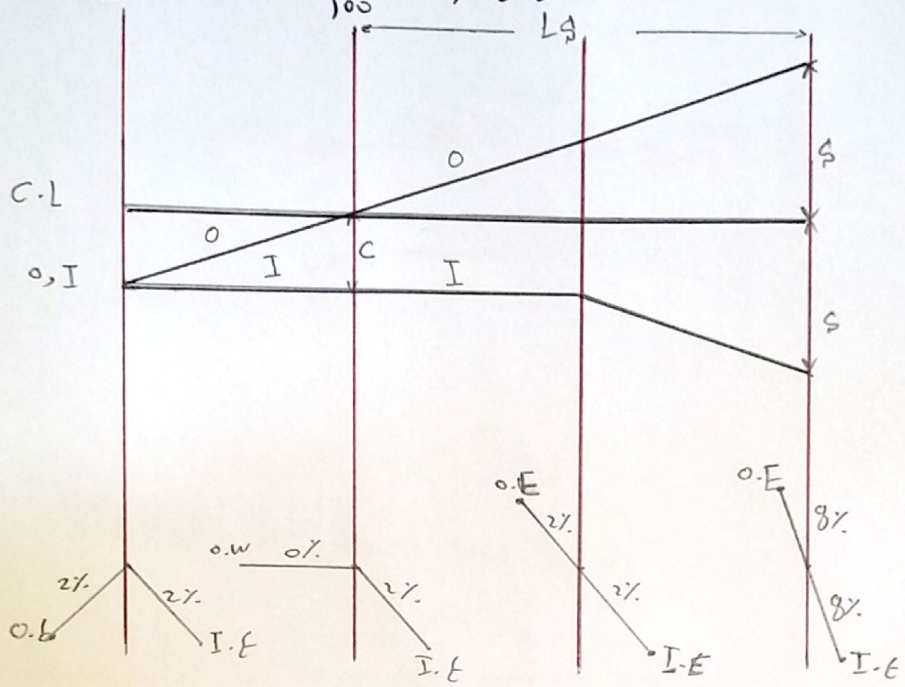
$\therefore R = \frac{V^2}{127[e+fs]} = \frac{140,96^2}{127[0,08+0,15]} = 680,2 \text{ m} \simeq 681 \text{ m}$

④ $\because$ normal slope = 2 % , $\because$ the highway has two lanes = 7,2 m

$\therefore W = 3,6$ $\quad \therefore C = \frac{2}{100} * 3,6 = 0,072 \text{ m}$

$\therefore e = 8\%$

$\therefore S = w * e = 3{,}6 * \frac{8}{100} = 0{,}288\ m.$



⑤ $\therefore L_s = \frac{1{,}6\ V^3}{R} = \frac{1{,}6 * \left(\frac{140{,}96}{1{,}61}\right)^3}{\frac{680{,}2}{0{,}3048}} = 481{,}18\ ft$

$\therefore L_s = 481{,}18 * 0{,}3048 = 146{,}66 \simeq 147\ m$

check

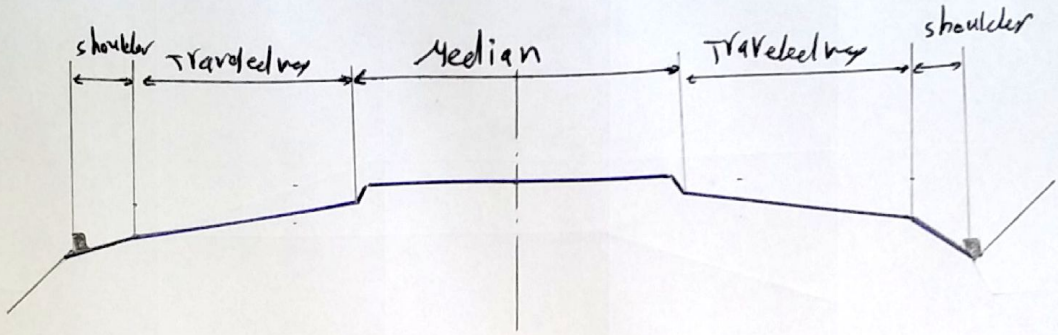
$\therefore \frac{S}{L_s} = \frac{0{,}288}{146{,}66} = 0{,}19 < 0{,}2 \therefore$ slope = 2%

$\therefore$

⑥ station of S_c = [100+00] + L_c + L_s = [100+00] + [1+47]

= [101+47] + L_c

Question (2): Draw neatly sketch of typical cross-section of a divided highway in urban area **(3 Points)**



"Divided highway cross-section Curbed"

Question (3): Classify material A according to the AASHTO classification system from the data given in the following table. **(5 points)**

Soil	19 mm	12.5 mm	#4	#10	#16	#40	#100	#200	LL	PL
A	100	89	45	30	20	15	10	2	26	23

① %P#200 = 2 % < 35 %.

∴ [A-1-a A-1-b A-3 A-2-4 A-2-5 A-2-6 A-2-7]

② %P#10 = 30 %

③ %P#40 = 15 % [A-1-a A-1-b A-2-4 A-2-5 - A-2-6 A-2-7]

④ %P#200 = 2 %.

⑤ L.L = 26 % [A-1-a A-1-b A-2-4 A-2-6]

⑥ $P_I = L.L - P.L = 26 - 23 = 3\%$. **A-1-a** stone fragments gravel and sand

$GI = 0{,}2a + 0{,}005\,a \cdot c + 0{,}01 \cdot b \cdot d.$

$\therefore a = \%P\#200 - 35 = 2 - 35 = \text{Zero}$ (0~40)

$b = \%P\#200 - 15 = 2 - 15 = \text{Zero}$ (0~40)

$c = LL - 40 = 26 - 40 = -14 = \text{Zero}$ (0~20)

$d = PI - 10 = 3 - 10 = -7 = \text{Zero}$ (0~20)

$\therefore GI = \text{Zero}$

∴ the soil is [A-1-a] [Zero]

Stone fragments gravel and sand.