* Different types of transportation:-

(i) Highway /road way
(ii) water way
(iii) Railway
(iv) Air way

Highway:-

→ Easy to construct and door to door service easy to communication.

* Different types of road:-

There are two catagory of road
(i) Rural road.
(ii) organ road.

* History of highway:-

→ first remain started construction of road in @ 312 BC

* main features of remain road:-

→ They will state road regardation of gradient.
→ Total thickness of the construction was 0.75m to 1.2 m.
→ They built the road after the subsoil was removed and they hard stradum was reached.
→ The wearing course consist of dressed large stoom loughts set time motton.

* tresagued construction:-

→ It is an improove method of construction Intrance during 764 AD

* main features:-

→ Thickness of the road was in order of 30cm
→ consideration are given to subgrade moisture condition and drainage of surface water.
→ Soldore stopping is also provided in order of 1 in 20 to drink the surface water.

* Tolbolt construction:-

→ It's work started in 19 century in englongl

* main futures:-

→ It's proposed a level subgrade of width 9m.
→ Thickness of foundation stone various from 70cm at edge to 22cm at the centre.
→ A binding loyer of wearing cource 4cm thick was provided with cross slope of 1 in 45.

$$f\left(\frac{v^2}{gR} - 0.07\right)$$

→ If the value of f thus calculated is less than 0.15 the super elevation of 0.07 is safe. If not calculated the respected speed.

Step - 4

The allowable speed at the curve is calculated by considering the design coefficient of lateral friction and the maximum super elevation.

$$e + f = \frac{V_a^2}{gR}$$

Q/ Design the rate of super elevation for a horizontal highway curve of radious 500m and speed of 100km/h

$$e = \frac{v^2}{225R}$$

$$= \frac{100^2}{225 \times 500}$$

$$= 0.08 = 0.07$$

friction :-

$$F = \frac{v^2}{gR} - 0.07$$

$$= \frac{100^2}{127 \times 500} - 0.07$$

$$= 0.08 = 0.15$$

$$0.07 + 0.15 = 0.22$$

$$e + F = \frac{v^2}{gR}$$

$$= 0.07 + 0.15 = \frac{v^2}{gR}$$

$$0.22 = \frac{v^2}{gR}$$

$$\sqrt{gR \times 0.22} = v^2$$

✱ Extra winding:-

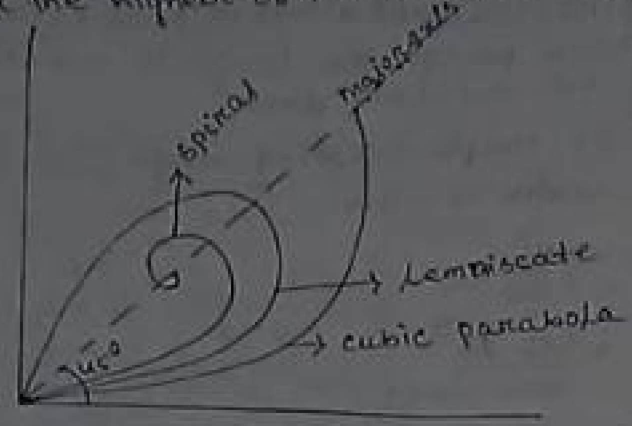
→ Additional width of carriage way that is required on horizontal curve is refered a extra winding.

✱ Resons to provide extra winding are:-

(i) To avoid of tracking due to rigidity of wheel base.
(ii) To contract trans verse sciding
(iii) To increse the visibility of curbe.
(iv) To encounter phychological tendency while overtaking operation.

(iii) minimum Length
IRC / empericalformula

(iv) The length of transition curve full fill in all the 3 condition (on the highest of the 3 value is generally excepted)



(i) Rate of change of centrifugal accelaration

$$Ls = \frac{v^3}{Rc}$$

c = Rate OCOCA
R = Radious
Ls = Rate of transition curve
v = velocity in m/s

$$c = \frac{80}{75+v} \rightarrow km/h$$

c value = 0.5 < 0.8

(ii) Rate of introduction of super elevation
(a) centre line :-

$$Ls = \frac{eN}{2}(\omega + we)$$

N = 150 to 160
ω = width of the pavement
we = extra winding

(b) Inner edge :-

$$eN(\omega + we)$$

(iii) Emperical formula :-
(a) plane or Rolling

$$Ls = \frac{2.7v^2}{R}$$

v = 80 km/h

Here deviation angle will be maximum when an ascending gradient meets with a descending gradient.

→ when a fast moving vehicle travels along a summit curve the centrifugal force will act upwards, against gravity and hence a part of the pressure on the types and spring of the vehicle suspensions is relieved. So there is no problem of discomfort to passengers

The only problem in designing summit curves is to provide adequate sight distances.

there are 2 cases to be considered in deciding the length of summit curve.

(i) when the length of the curve is greater than the sight distance (L > SSD).

that in $L = \frac{NS^2}{(\sqrt{2H}+\sqrt{2h})^2}$.

L = length of summit curve, m
S = stopping sight distance, (SSD), m.
N = deviation angle, equal to algebraic difference in grades. radians or tangent of the deviation angle.
H = height of eye level of driver above roadway surface, m
h = heigh of subject above the pavement surface, m.

According to IRC H = 1.2 m & h = 0.15 m

that $L = \frac{NS^2}{4.4}$

L < SSD

$$L = 2S - \frac{4.4}{N}$$

L > ID

$$L = \frac{NS^2}{9.6}$$

when L < ISD

when $2S - \frac{9.6}{N}$

Avrasion test :- this test are carried out to test the hardness property of stone and to deside weather their saitable for road construction or not.

It is the three types:-

(a) loss angless avrasion test.
(b) Devl avrasion test.
(c) Dorry avrasion test.

we used only lass angles avrasiontest fore bearing course test value should be less than 30% and for base course upto 50% are allowed.

Impact test :- This test is designed to evaluate the toughness of stone or the resistance of the aggregate to factore underepeceed impace.

The impact value should be 35% for bituminous macadam and 40% for WBM (water bound macadum) for base course, and should not axid 30% for surface course.

Soundness test :- This test is intended to stady the resistance of aggregate to weathering action by conducting the axilarated weathering test cycle.

→ It was Intended to study the resistance of aggregate to weathering action by conducting exilurated weathering test circle bere two Solution namely sodium sulphate or magnasium sulfule is used.

The average lass in waight of agregate to be used in pavement construction after 10 cycles should not axid 12% for sodium sulphate and 18% formagnasium sulphate.

(Date. 11.05.2020)

Design of highway pavement:-

→ The surface of the road way should be stable and non yielding to allow the heavy wheel loads of roads traffic to move with least possible rolling ~~are two~~ resistance.

→ There are two different type of pavement.

(i) Flexible pavement:-
(ii) Rigid. "

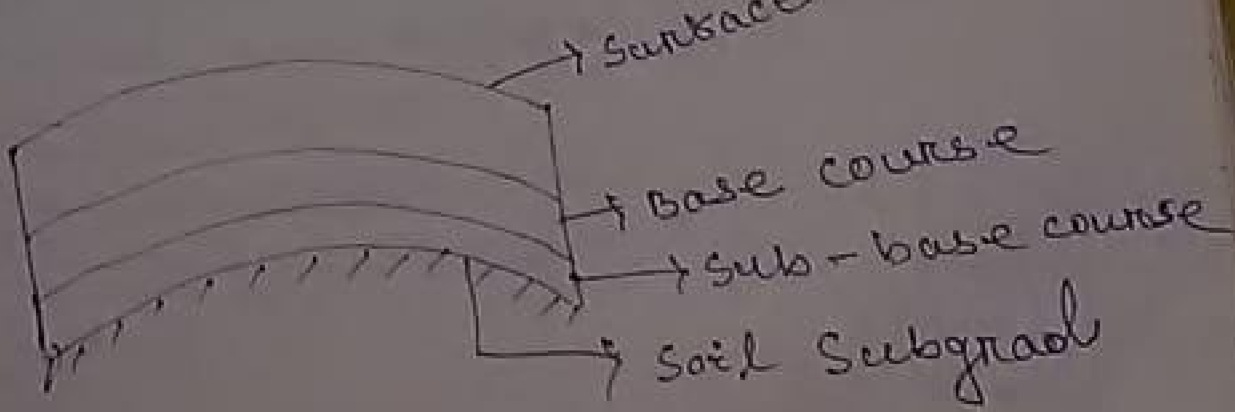
(i) Flexible pavement:-

These are those pavement which on the whole help low on negligible flexural strength and are weather flexible in their structural action. under the load.

→ There are 4 components of flexible pavement.

(I) soil subgrade
(II) Sub-base course
(III) Base course
(IV) wearing on surface course

→ Here in flexible pavement vertical or compressive stresses and transport by grain to grain through the point of contact in the granular



these expressions are applicable only when the CBR value of the subgrade soil is less than 12 percent.

Q/ CBR value of subgrade soil is 5%, calculate total thickness of a pavement using.
(i) design curve developed by california state highway department.
(ii) design chart recommended by IRC
(iii) design formula developed by the US Crops of Engineers
assume 4100 kg wheel load or medium light traffic of 200 commercial vehicles per day for design.

Tyre pressure = $6 kg/cm^2$
CBR value 5%.

$P = 4100$ kg
$p = 6 kg/cm^2$

$$t = \sqrt{P}\left[\frac{1.75}{CBR} - \frac{1}{p\pi}\right]^{1/2}$$

$$= \sqrt{4100}\left[\frac{1.75}{5} - \frac{1}{6\times\pi}\right]^{1/2}$$

$= 34.89$

CBR Method of pavement Design by cumulative standard Axle load:-

$$N_s = \frac{365A\left[(1+r)^n - 1\right]}{r} \times F$$

N_s = Cumulative standard Axle load
A = no. of commercial vehicles per day
r = annual growth rate of commercial vehicles.
n = design life of pavement, taken as (10 to 15 years)
F = Vehicle damage factor.

$$A = P\left[1+r\right]^{n+10}$$

P = no. of heavy vehicles per day at least count.

Q/ Calculate the at interior, edge & corner regions of a cement concrete pavement using westergaard's stress equations. Use the following data

wheel load, $P = 5100 kg$

$E = 3 \times 10^5 kg/cm^2$

$h = 18 cm$

$\mu = 0.15$

$k = 6.0 kg/cm^3$

$a = 15 cm$

$$l = \left[\frac{Eh^3}{12k(1-\mu^2)}\right]^{1/4}$$

$$= \left[\frac{3\times10^5 \times 18^3}{12\times6(1-0.15^2)}\right]^{1/4}$$

$$= 70.6 cm$$

$$b = \sqrt{1.6a^2+h^2} - 0.675h$$

$$= \sqrt{1.6\times15^2+18^2} - 0.675\times18$$

$$= 14.0 cm$$

$$S_i = \frac{0.316P}{h^2}\left[4\log_{10}(l/b) + 1.069\right]$$

$$= \frac{0.316\times5100}{18^2}\left[4\log_{10}\left(\frac{70.61}{14.0}\right) + 1.069\right]$$

=

Critical Load position :-

This stresses acting on a rigid pavement are:-
(i) wheel load stresses
(ii) temperature stresses.

temperature stresses :-

There are three typical locations namely the interior, edge and corner.

Equivalent Radius of Resisting section :-

$$b = \sqrt{1.6a^2 + h^2} - 0.675h$$

b = equivalent radius of resisting section, cm when a is less than 1.724 h.
a = radius of wheel load distribution. cm
h = slab thickness cm.
when 'a' is greater than 1.724 h, the value of b = a.

Q) compute the equivalent radius of resisting section of 20 cm slab, given that the radius of contact area wheel load is 15 cm.

$$b = \sqrt{1.6a^2 + h^2} - 0.675h$$

$a = 20cm$

$h = 15cm$

$$b = \sqrt{1.6a (15)^2 + 20^2} - 0.675 \times 20$$

$= 14.068 \simeq 14.7$

Interior Loading :-

$$S_i = \frac{0.316P}{h^2} \left[4 \log_{10}(l/b) + 1.069\right]$$

Edge Loading :-

$$S_e = \frac{0.572P}{h^2} \left[4 \log_{10}(l/b) + 0.359\right]$$

Corner Loading :-

$$S_c = \frac{3P}{h^2} \left[1 - \left(\frac{a\sqrt{2}}{l}\right)\right]$$

Design of Rigid pavements :-

modulus of subgrade reaction, 'k' is proportional to the displacement.

$$K = \frac{P}{\Delta}$$

Relative stiffness of slab :-

$$l = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4}$$

l = radius of relative stiffness, cm.

E = modulus of elasticity of cement concrete kg/cm^2

μ = poisson's ratio for concrete = 0.15

h = slab thickness, cm

k = modulus of subgrade reaction in kg/cm^3

Q// compute the radius of relative stiffness of 15cm thick cement concrete slab from the following data :

Modulus of elasticity of cement concrete = 210.000 kg/cm^2

poisson's ratio for concrete = 0.13

modulus of subgrade reaction, K = 7.5 kg/cm^3

Given data :-

l = 15 cm

E = 210.000 kg/cm^2

μ = 0.13

k = 3

$$l = \left[\frac{210.000 \times 15^3}{12 \times 3(1-0.13^2)}\right]^{1/4}$$

= 66.895 cm

(1) Tyre pressure.
(2) Inflation pressure.
(3) contact pressure.

→ Tyre pressure and inflation pressure are exact.

The contact pressure is found to be more than tyre pressure when the tyre pressure is less than $7 kg/cm^2$ and when the tyre pressure exceeds this value the value becous vice versa.

$$\text{contact pressure} = \frac{\text{Load on wheel}}{\text{contact area or area of imprint}}$$

The ratio of contact pressure to tyre pressure to rigidity factor.

Subgrade Modulus:-

Subgrade modulus computed plate bearing test data.

Boussinesq's equation:- for maximum vertical deflection Δ at the surface and the centre of a flexible plate is given by $\Delta = \frac{1.5 Pa}{E_s}$

for rigid pavement $\Delta = \frac{1.18 Pa}{E_s}$

~~design of flectio~~

design of flexible pavement:-

Various approaches of flexible pavement design of classified into three broad groups.

(a) Empirical methods
(b) semi - empirical methods
(c) Theoretical methods.

different method are either.

(i) Group Index method
(ii) CBR method
(iii) california R value or Stabilometer method.
(iv) Triaxial test method

(v) Mcleod method
(vi) Burmister method

Q// A soil subgrade sample collected from the site was analysed and the results obtained are as given below.
(i) Soil portion passing 0.074 sieve, percent = 50
(ii) Liquid limit, percent = 40
(iii) plastic limit, percent = 20
Design the pavement section by group index method for the anticipated traffic volume of over 300 commercial vehicles per day

$$GI = 0.2a + 0.005ac + 0.01bd$$

GI
0 - good
1-2 - faire
3-8 - poor
9-20 - very poor

$a = 50 - 35 = 15$
$b = 50 - 15 = 35$
$c = 0$
$d = 40 - 20$
$PI = 20 - 10 = 10$

$= 0.2 \times 15 + 0.005 \times 15 \times 0 + 0.01 \times 35 \times 10$
$= 6.5$

California bearing :-

$$t = \sqrt{P}\left[\frac{1.75}{CBR} - \frac{1}{p\pi}\right]^{1/2}$$

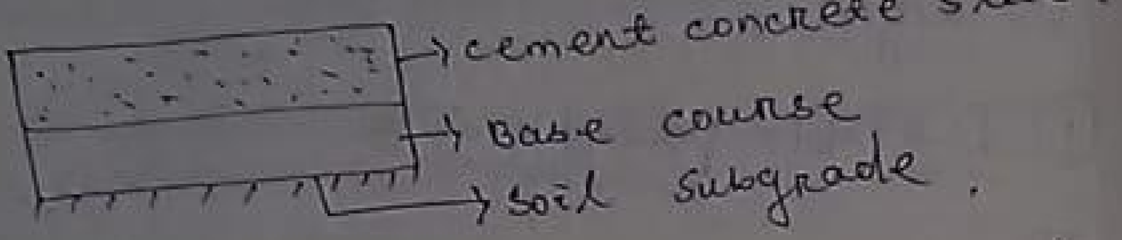
t = pavement thickness, cm
P = wheel load, kg
CBR = california bearing Ratio, percent.
p = tyre pressure, kg/cm^2
A = area of contact, cm^2

$$t = \left(\frac{1.75P}{CBR} - \frac{A}{\pi}\right)^{1/2}$$

(ii) Rigid pavement :-

Rigid pavement are those which posses note worthy flexural strength or flexural rigidity. Here the note not transition by grain to grain.

→ The rigid pavement are made up of partland cement concrete, reinforced or pre-stressed concrete.



Soil Subgrade and its Evaluation :-

Flash and fire point test :-

→ The flash point of a material is the lowest temperature at which the vapour of a substance momentarily takes fire.

Fire point :- It is the lowest temperature at which the material gets ignited and burns under specified conditions of test.

pensky - martens closed cup apparatus cup.

→ The minimum specified flash point of bitumen used in pavement construction in 175C.

Solubility test :-

Spot test :- This is the test for detecting the over heated or cracked bitumen.

Loss on heating test :-

When bitumen is heated it loses the volatiles and gets hardened.

Design of highway

→ The surface of
stable and non-y
wheel loads of n
possible rolling

→ There are two

(i) Flexible pa
(ii) Rigid.

(i) Flexible pa

These are th
help low on
are weather
action . und

→ There a
pavement.

(i) Soil
(ii) Sub-b
(iii) Base
(iv) Wea

→ Here
compress
to grai
granu

Viscosity test :- It is defined as inverse of fluidity viscosity defines the fluid property of bituminous material.

orifice type vicometer may be used to indirectly find the viscosity.

→ The viscosity of tar is determined as the time taken in seconds. for 50ml of the sample to flow through 10mm orifice of the standard tar viscometer at the specified temperature of 35, 40, 45, 55°c.

Float test :-

The consistancy of material is measured by float test value the higher the float test stiffer is the material.

Specific gravity test :-

→ The generally specific gravity of pure bitumen is in the rang of 0.97 to 1.02. and tars have specific gravity 1.10 to 1.25.

specific gravity biluminous materials is defined as the ratio of the mass of a given volume of substance to the same of an equal volume of water at specifice temperature (27°c).

Softening point test :-

It is the temperature at which the substance attains a particular degree of softening under specified conditⁿ of test, It is usually determined by ring and Ball test the softening for the ~~vary~~ various bitumen one usually between 35 to 70°c.

~~Bitumen adhesion test~~:-

Bituminous Materials:-

→ Bitumen is the petroleum produce obtained by the distillation of petroleum crude where- as road tar is obtained by the destructive distillation of coal or wood.

→ Bitumin as soluble in CS_2, CCl_4 carbon dioxid and carbon tetracloride.

→ there are two type of bitumen used in india.

(i) paving bitumen from Assam petroleum, denoted A-type and designate as grades A35, A90 etc.

(ii) paving bitumen from other sources denoted as S-type and designated as grades S35, S90 etc.

Tests on Bitumen:-

→ The various tests on bituminous materials are:-

(1) penetration test:-

The penetration test determines the hardness or softness of bitumen by measuring the depth in tenths of a millimetre to which a standard loaded needle will penetrate vertically in five seconds temperature of 25°c.

→ The range should be between 20 and 225 in hot climates a lower penetration grade bitumen like 30/40 bitumen is preferred.

Ductility test:-

Ductility test is carried out on bittumin to test the property of the brinder the test is belived to measure the receipt property of bitumin and it's ability to streach.

→ The ductility value of bitumin varry from 5 to over 100 for different bitumin grades.

→ minimum ductility value of 75cm. has been specified by ISI.

Viscosity te

viscosity det
material.

orifice type
Find the visc

→ The visco
in seconds..
orifice of th
temperature

Float test

The consi
float te
stiffer

Specific

→ The g
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gravity
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one

Shape tests :-

The evaluation of shape of the ~~pro~~ particles made interms of flakiness index, elongation index and ~~angula~~ angularity numbe.

Flakiness Index :-

The flakiness Index of aggregate is the percentage by weight of aggregate particles whose least dimension or thickness is less than the 3/5th or 0.6 of their mean dimension.

The test is applicable to sizes larger than 6.3mm it desirable that the flakiness index of aggregat used in road construction is less than the 15% and normally does not exceed 25%.

Elongation Index :-

The Elongation Index of an aggregate is the percentage by weight of particle whose greates dimension or length is greater than 1 and 4/5th or 1.8 times their mean dimension.

→ elongation index values in excess of 15%. ~~are~~ there is known recognised limits have been laid down for elongation index.

Specific gravity and water absorption tests :-

The specific gravity of an aggregate is considered to a measure of the ~~generally weaker~~ quality or strength of the material.

→ The specific gravity of rocks very from 2.6 to 2.9.

and
to 20).

* Stone agregate:-

Desirable properties of road agregate:-

Strength:-

A agregate to be used in Road construction should be sufficient strong to with stand the stress due to trafic wheel load.

They should couses sufficient strength resistance to crossing.

Hardness:-

The agregate used in the surface course are subjected to constant rubbing on avrasion due to moving trafic. They should be hard enough to resist the wear due to avrasive action of trafic.

(The matual rabbing of stones is called attrition)

Toughness:-

Aggregate in the pavement are also subjected to imput due to moving wheel load.

Durability:-

The stone used in the pavement construction should be durable and should resist disintegration due to the action of weather.

Adheston with betumin:-

The aggregate used in bituminous pavement should have less affinity with water when compaired with bituminous materials.

* Test for road aggregate:-

Crushing test:- The aggregate crushing value for good quality aggregate to be used in base coarsed shall not exid 45%. and the value of surface course shall be less than 30%.

d = Dead value of plasticity index ascending 10 and not more than 30. (Expressed as a hole no. from 0 to 20).
(Plasticity index = liquid limit - plastic limit)

* **Strength of soil subgrade :-**

Solid type :-

(i) Moisture content
(ii) Dry dencity
(iii) Internal structure of the soil.
(iv) The typend mood of stress application
(v) Evaluation of soil strength

→ There are 3 types of test are shear test, Bearing test, penitration test.

* **Shear Stress :-**

(i) Vane shear test
(ii) Direct shear test
(iii) Triaxial shear test.

* **Bearing test :-**

These are the loaded test carried out on subgrade soil in sita in the bearing area.

* **Penitration test :-**

CBR (Califonia bearing Ratio) test
It is expressed in persentage.

CBR % = Load or pressure substend by the speciment at 2.5 or 5mm penitration / Load or pressure substend by standard agregate at the carresponding penitration lable. × 100

2.5 standard loading value
= 1370 load.

5mm = 2055m
pressure 2.5mm = 70
5mm = 105

$= -0.073$

$\alpha = 2.5$

$s = vt + \frac{v^2}{2gf}$

$= 22.22 + \frac{22.22^2}{2 \times 9.81 \times 0.35}$

$= 127.449$

$= \frac{-0.073 \times 127.449^2}{2 \times 0.75 + 2 \times 27.449 \times \tan\alpha}$

$= -199.312$

(v = kmph)

Comfort $= L = 0.38\,(Nv^3)^{1/2}$

$= 0.38\,(-0.073 \times 80^3)^{1/2}$

$= 73.465$

* Highway material :-

→ Desirable properties of soil

(a) stability
(b) Incompressibility
(c) permanency of strength
(d) Good drainage
(e) easy to compaction
(f) minimum changes in valueme and stability under advance condition of wheather and ground water.

* Index property of soil

Group Index

$GI = 0.2\alpha + 0.005\,ac + 0.01\,bd$

where,

a = dead portion of material passing 0.05mm sieve, greaterthan 35 and not accending 75%. (expressed as a hole no from 40)

b = dead portion of material, passing 0.074 mm sieves greaterthan 15 and not accending 35%. (expn 0 to 40)

c = The value of liquid limit in excess of 40 and less than 60 (expressed as hole no from 0 to 20).

L < SS :-

$$S = \frac{1.5 + 0.035\,S}{N}$$

Q. A vertical summit curve is formed at the intersection of two gradients, +3.0 and −5.0 percent. Design the length of summit curve to provide a stopping sight distance for a design speed of 80 kmph. Assume other data.

Soln :-

$V = 80$ km/h $T = 2.5$

$N = +3 - (-5)$ $F = 0.35$

$= 8$

$$S = vt + \frac{v^2}{2gf}$$

$$S = 22.22 \times 2.5 + \frac{(22.22)^2}{2 \times 9.81 \times 0.35}$$

$= 127.449$ m $\simeq 128$ m.

$$L = \frac{NS^2}{44}$$

$$= \frac{0.08 \times 127.449^2}{4.4}$$

$= 295.332$ m (Approx)

Q. A valley curve is formed by a descending grade of 1 in 25 meeting an ascending grade of 1 in 30. Design the length of valley curve to fulfil both comfort condition and head light sight distance requirements for a design speed of 80 kmph.

Soln:-

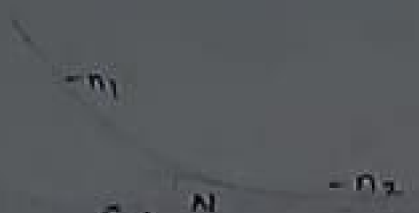
$$L = \frac{NS^2}{2h_1 + 2S\tan\alpha}$$

$= N = \pm n_1 - (\pm n_2)$

$$= -\frac{1}{25} - \left(\frac{1}{30}\right)$$

$$= -\frac{1}{25} - \frac{1}{30}$$

Valley curves :-



(a)

(b)

→ Valley curves or sag curves are formed in any one of the cases illustrated in . In all the cases the maximum possible deviation angle is obtained when a descending gradient meets with an ascending gradient . In this types of curve there is no problem of restriction to sight distance in valley curves during day light. However during night driving under head lights of vehicles the sight distance available at valley curve is decreased . The most important factors considered in valley curve design are .

(i) Impact - free movement of vehicles at design speed on the comfort to the passengers .

(ii) availability of stopping sight distance under head lights vehicles for night driving .

Length of valley curve :-

$L > SSD$

$$\Rightarrow \boxed{L = \frac{NS^2}{2h_1} + 2S\tan\alpha}$$

If the average height of the head light is taken as $h = 0.75\,m$ and the beam angle $\alpha = 1^\circ$, by substituting these in the above equation $\boxed{L = \frac{NS^2}{1.5 + 0.035S}}$

Gradient Compensation :-

This reduction in gradient at the horizontal curve is called grade compensation, which is intended to off-set the extra tractive effort involved at the curve. This is calculated from the relation.

Grade compensation, percent $= \frac{30+R}{R}$

and maximum value of $\frac{75}{R}$

R is the radius of the circular curve in metre.

Gradients :- 4 types

(1) Ruling gradient
(2) Limiting gradient
(3) Exceptional gradient
(4) minimum gradient.

→ Ruling gradient is the maximum gradient within which the designer attempts to design the vertical profile of a road. IRC - 1934 Ruling gradient value of 1 in 30 on plain and rolling terrain, 1 in 20 on mountainous terrain and 1 in 16.7 on steep terrain.

Q. While aligning a hill road with a ruling gradient of 6 percent, a horizontal curve of radius 60 m is encountered. Find the compensated gradient at the curve.

Sol^n :- $= \frac{30+R}{R}$

$GC = \frac{30+60}{60} = 1.5$

maximum limit of grade compensation $= \frac{75}{R}$

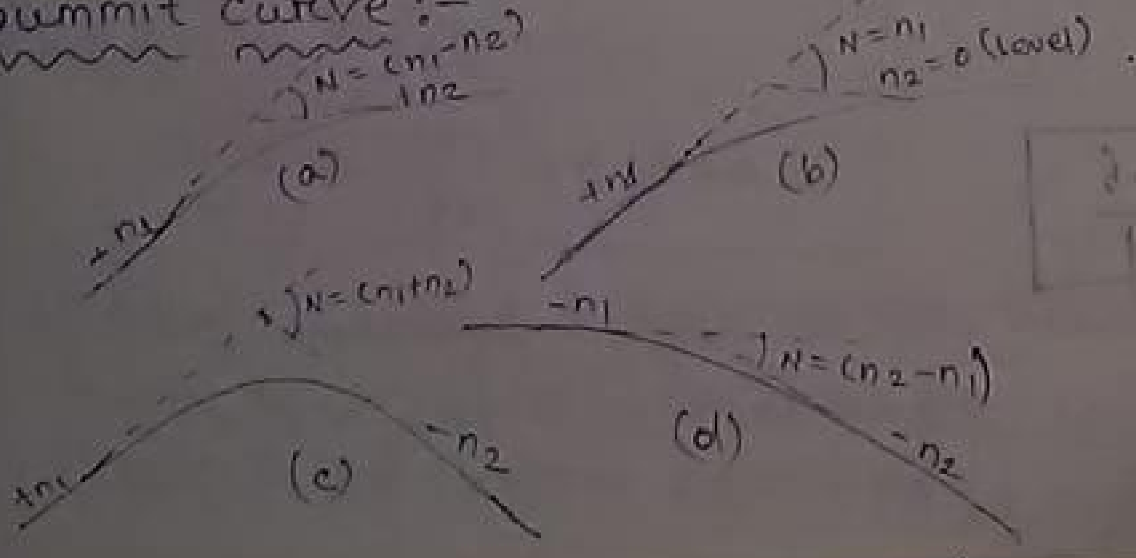
$= \frac{75}{60} = 1.25$

$= 6 - 1.25$

$= 4.75$ (Ans)

* Vertical curves is are 2 types
(1) summit curves with convexity upwards.
(2) valley curves with concavity upwards.

Summit curve :-



$$= \frac{3 \times 6^2}{2 \times 325}$$

$$= 0.16$$

$$wps = \frac{v}{9.5\sqrt{R}}$$

$$= \frac{65}{9.5 \times \sqrt{325}}$$

$$= 0.36$$

$$\text{Total winding} = 0.16 + 0.38$$

$$= 0.53$$

(iii) length of transition curve.

(a) $Ls = \frac{v^3}{Rc}$

$$= \frac{18.0^3}{325 \times 0.571}$$

$$= 31.42$$

$$c = \frac{80}{75 + v}$$

$$= \frac{80}{75 + 65} = 0.571$$

(a) $Ls = \frac{eN}{2}(w + we)$

$$= \frac{0.058 \times 100}{2} \times (10.5 + 0.49)$$

$$= 31.871 \, m$$

(iii) Emperical formula.

(a) $Ls = \frac{2.7 v^2}{R}$

$$= \frac{2.7 \times 65^2}{325}$$

$$= 35.1 \, m$$

(b) For mountaneous or steel.

$$L_s = \frac{v^2}{R}$$

Q. A National highway passing through rolling terrain in heavy rainfall area has a horizontal curve of radious 500m disign the length of transition curve assuming the suitable data.

v = 80 kmph – Rolling stage

width w = 7m

(i) $L_s = \frac{v^3}{Rc}$

$= \frac{22.22^3}{500 \times 0.51}$

$= 43.02\,m$

(ii) $L_s = \frac{eN}{2}(w + we)$

$e = \frac{v^2}{225R}$

$= \frac{80^2}{225 \times 500}$

$= 0.056$

$n = 2$

$l = 6$

$w_m = \frac{nl^2}{2R}$

$= \frac{2 \times 6^2}{2 \times 500}$

$= 0.072$

$w_{ps} = \frac{v}{9.5\sqrt{R}}$

$= \frac{80}{9.5\sqrt{500}}$

$= 0.37$

$we = w_m + w_{ps}$

$= 0.072 + 0.37$

$= 0.442$

(a) $L_s = \frac{0.056 \times 150}{2}(7 + 0.442)$

$= 31.2564\,m$.

(ii) Inner edge

$eN (\omega + \omega e)$

$= 0.056 \times 150 (740.443)$

$= 62.51$ (Approx)

(iii) plane Rolling:-

$$L_s = \frac{2.7 v^2}{R}$$

$$= \frac{2.7 \times 80^2}{500}$$

$$= 34.56$$

(b) mountaneous:-

$$L_s = \frac{v^2}{R}$$

$$= \frac{80^2}{500}$$

$$= 12.8$$

Vertical curve:-

→ vertical allignment of a road consist of vertical curve and gradients.

→ vertical curves are provided at the intersection of different grade smoothen the vertical profile.

Q. While a lining a highway in a build area it was necessary to provide a horizontal circular curve of radious 325m Design speed = 65 kmph

length of wheel base = 6 m

Pavement width = 10.5 m.

Rate of superelevation = 1 in 100

(i) super elevation (e)

(ii) Extra winding

(iii) length of transition curve

(i) Super elevation:-

$$e = \frac{v^2}{225R}$$

$$= \frac{65^2}{225 \times 325}$$

$$= 0.058$$

(ii) Extra winding

$$W_m = \frac{nl^2}{2R}$$

Total winding = 0.196 + 0.466
= 0.662 m.

Transition curve :-

Objective :-

(i) Gradual introduction of centrifugal force.
(ii) To avoid concern jark
(iii) Gradual introduction of super elevation and extra winding.
(iv) To enables the driver tern the storing for comfort an security.

→ Length of transition curve.
is required on a horizontal highway curves depends upon the following factors.
(i) Radious of circular curve (R)
(ii) Design speed (v)
(iii) allowable rate of change of centrifugal accelaration (c)
(iv) Allowable rate of introduction of supper elevation.
(v) Rotation of pavement cross-section either about the inner edge the centre line.
(vi) maximum amount of ~~peper~~ supper elevation 'e' which depends on the maximum rate of super elevation (e) and the total width of the payment (B) at the horizontal curve.

Plane or rolling = 7%
mountaneous & 10%
steep = 40%.

Different types of transition curve:-

(i) Spiral
(ii) Lemniscate
(iii) parabola.

Length of transition curve:-

Length of transition curve in design to full fill there foundation.

(i) Rate of change of centrifugal accelaration, to be develop gradually.
(ii) Rate of introddction of design super elevation to be at a resonable rate.

→ It is splits of into two parts
i) mechanical winding
→ It is provided due to the origidity of wheel base when a vehicle travels on a horizontal curve.

$$W_m = \frac{nl^2}{2R}$$

where,

L = length of wheel base
R = Radious of the curve
n = no. of lanes.

✻ Phycological winding :-

There is a dendency for the drivers to drive closer to the edges of the payments of curve so phychological winding is required.

→ IRC Propoced an emphcrical formula for the phychological winding.

$$W_{ps} = \frac{v}{9.5\sqrt{R}} \quad v = \text{Kmph}$$

Total winding = mechanical winding + phychological winding

Total winding
↓

$$W_P = W_m + W_{ps}$$

Q Calculate the extra winding required for a payment on within 7m curve of radious 250 m. If the longest wheel base of vehicle expected on a road compute the value obtained with IRC recomondation.

Data :-

speed = 70 Kmph

mechanical winding

$$W_m = \frac{nl^2}{2R}$$

$$= \frac{2 \times 7^2}{2 \times 250}$$

$$= 0.196$$

$$W_{ps} = \frac{v}{9.5\sqrt{R}}$$

$$= \frac{70}{9.5\sqrt{250}} = 0.466$$

✱ CURVE :-

→ curves are provided in highway in order that is change of direction at the intersection of state allignment whether is horizontal or vertical plane.

✱ Advantages of curve :-

→ The help to avoid mental strength induced by the monotony of continuous Journy along strength part.

→ They provide conbort to the pacenger.

→ The drivers become alot due to the change in direcⁿ.

✱ factors affecting the design of curve :-

(i) Design speed.
(ii) allowable friction
(iii) maximum permissible super elevation.
(iv) permissible centrifugal ratio.

✱ Design of horizontal allignment :-

Super elevation

→ In passing from a straight to a curve path a vehicle is under that influence of two forces.

(i) centrifugal force
(ii) weight of the vehicle

$$e + f = \frac{v^2}{gR}$$

e = super elevation
f = friction
f = 0.15 IRC recomonded.

Step-1

→ The super elevation for 75% of design speed is calculated neglating the friction.

$$e = \frac{(0.75v)^2}{gR}$$

Step-2

→ If the calculated value of e is less than 7% or 0.07. the value so obtained is provided

→ If the value of e exceeds 0.07 then provided of the maximum super elevation = 0.07 and proceed c further.

Step-3

→ check the coefficient of friction develop for the maximum value of e = 0.07 at the full value of design speed.

minimum Length of OSD = 3× OSD
maximum Length of OSD zone = 5 × OSD

Q Speed of overtaking and overtaken vehicles are 70 and 40 kmph on a two way traffic road & the accelaration of overtaking vehicle is 0.99 m/s²

(a) calculate the safe OSD
(b) minimum length of overtaking zone
(c) maximum length of overtaking zone.

Ans:-

$V = 70$ kmph $= 70 \times 5/18 = 19.44$ m/s

$V_b = 40$ kmph $= 40 \times \frac{5}{18} = 11.11$ m/s

$OSD = d_1 + d_2 + d_3$

$d_1 = V_b \times t$
$= 11.11 \times 2$
$= 22.22$

$S = 0.7 V_b + 6$
$= 0.7 \times 11.11 + 6$
$= 13.7$

$T = \sqrt{\frac{4S}{a}}$
$= \sqrt{\frac{4 \times 13.7}{0.99}}$
$= 7.43$

$d_2 = V_b \times T + 2S$
$= 11.11 \times 7.43 \times 2 \times 13.7$
$= 109.94$

$d_3 = V \times T$
$= 19.44 \times 7.43$
$= 144.43$

(i) $OSD = 22.22 + 109.94 + 144.43$
$= 276.59$

(ii) minimum length $= 3 \times OSD$
$= 3 \times 276.59$
$= 829.77$

(iii) maximum length $= 5 \times OSD$
$= 5 \times 276.59$
$= 1382.95$

d_1 = Distance travelled by overtaking vehicle A during the time 't' sec

d_2 = Distance traveleed by vehicle A during the actual overtaking operation in time T sec.

d_3 = Distance travelled by the vehicle C comes from the oposite direction.

kmph ← V_b = Speed of the slow moving vehicle.

→ It is the minimum distance visible to the driver during the overtaking slow moving vehicle without any collision.

IRC recorded that total reaction time t = 2 sec

$$OSD = d_1 + d_2 + d_3$$

$d_1 = v_b \times t$

$v_b = v - 4.5$ m/s

$v_b = v - 16$ km/h

$d_2 = v_b \times T + 2s$

$s = 0.7 v_b + 6$

$T = \sqrt{\frac{4s}{a}}$

$d_3 = v \times T$

Q/ Calculate the safe OSD for a design speed of 96 kmph assume all of the data

Data

$v = 96$ kmph $= 26.66$ m/s

$d_1 = v_b \times t$

$= 26.$

$= 44.32$

$d_2 = V_b \times T + 2s$

$T = \sqrt{\frac{4s}{a}}$

$s = 0.7 V_b + 6$

$= 0.7$

$d_3 = v \times T$

$OSD = d_1 + d_2 + d_3$

Breaking distance :-

→ It is the distance travel by the vehicle after applying the breaks

$$SSD = vt + \frac{v^2}{2gf}$$

v = velocity (unit m/s)

t = Time (unit sec)

g = Accelaration due to gravity (m/s^2)

f = friction.

Q. Data

velocity = 80 kmph

assume time = 2.5 sec

friction = 0.35

$$SSD = vt + \frac{v^2}{2gf}$$

$$= 22.22 \times 2.5 + \frac{22.22^2}{2 \times 9.81 \times 0.35}$$

$$= 127.448 \text{ (Ans)}$$

Q. Calculate the SSD on a highway at a decending gradient of 80 kmph. assume other data as for IRC calculation.

$n = 2\%$

$= 2/100 = 0.02$

$$vt + \frac{v^2}{2g(F \pm n\%)}$$

$$= 22.22 \times 2.5 + \frac{(22.22)^2}{2 \times 9.81 (0.35 - 0.02)}$$

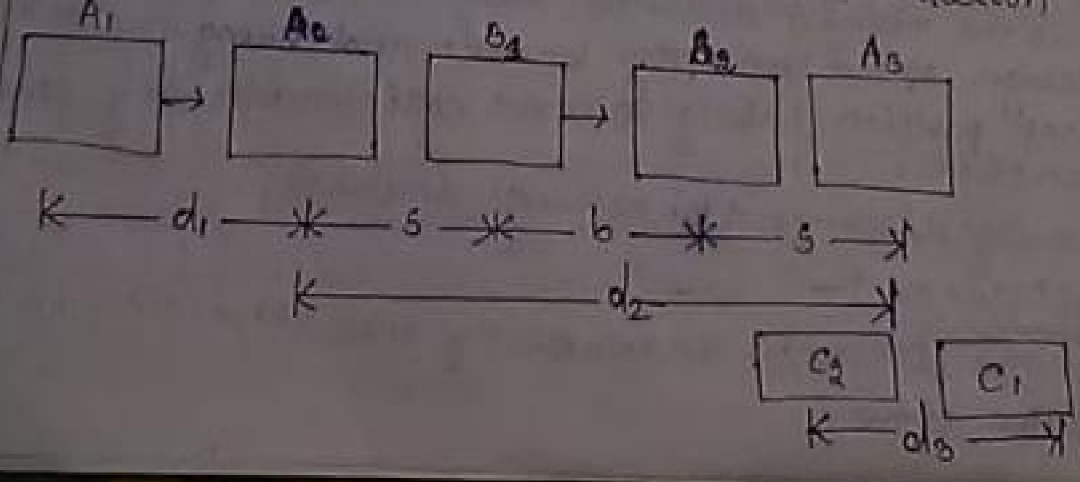
$= 131.8$ m

Intermediate sight distance :-

ISD = 2 × SSD

Overtaking sight Distance (OSD) :-

PIEV = perception Intelisation Emotion voilation



* **Metacles construction:-**

→ He has propose sum method which was not used now a days even his techniques was not could as compare to different method discuss about.

* **Mechadamic construction:-**

→ It is given various methods of road construction in 1815.

→ This was the 1st method based on phynsice thinking.

* **Main features:-**

→ Total thickness was kept uniform for edge to centre.

→ The size of boken stone for to top layer was devided of the based on stability on the animal drawn vehicle.

→ The importance of subgrade dranage and compaction was given so the subgrade was compacted and prepared with cross slope of 1 in 36.

→ He was the 1st person state that heavy foundation stones are not atom required to be placed at the bottom of layer.

* **Modern road development Reading:-**

→ In 1927 govement has proposed a plan to formed a organisation for the development or road an India.

→ In 1928 a community was formed JAYAKAR community.

* **Recomondation given by Jayakar commity:-**

→ Road development in the country should be consider as a national intrest.

→ An extra task should be levied on petrol from the road uses to develop a road development fond called CRF (central road fond). (1929 formation)

→ They kept more preferance to the long turn planning program for a period of 20 years.

* **Objective of IRC:-** (Indian road congress)

→ IRC was form the year 1934 in on the recomondation in Jayakar commity.

→ Sum of the objectives are:-

(i) To promot the construction of road building.

(ii) To advice the authority regarding the experiments and reserch connected with Road.

→ To hold pereoding meeting to discuss technical thinks regarding roads.

→ To provide a Forum for regular experience and Idea affecting the planning, construction and maintainance of road.

NHAI = National Highway Authority of India.

☆ 20 Years road Plan :–

Three type.

(i) Nagpur (1943-1963) But completed in 1961
(ii) Bumbay (1961 – 1981)
(iii) Lakhno (1981 – 2001)

☆ Motor vehicle act :– (MVA)

→ It was formed in year 1939. all the traffic rules and regulation given by MVA.

RTO :– Rigional transport office

CRRT :– central road reserch institude.

→ It was formed in the year 1950 all the development projects under taken by CRRI.

Ch-2

Geometric design of highway :–

→ A highway has many visible dimension and the design of visible dimension is known as geometric design.

Different types are :–

(i) Horizontal and vertical alignment.
(ii) sight distance consideration.
(iii) Intersection element
(iv) cross-sectional component.

Singl Lane = 3.75 width

slip :– rotational moment maximum

☆ Stopping sight Distance :– (SSD)

→ It is the minimum distance over which the driver travelling at design speed can apply breaks. and bring the vehicle to stop position safety without collision with any other obstraction.

SSD = Lag distance + Breaking distance.

☆ Lag distance :–

→ It is the distance travade by the veheicles in total reaction time.