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Praveen Kumar

#2 Educator in ESE - Civil Engineering

##STAR EDUCATOR##

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HIGHWAY

① रट्टे मार (Roman > Tresguet > Telford > Macadam)

⇒ John Macadam was first person who suggested that heavy stone are not required for roads.

⇒ He provides stone of sizes 5mm to a uniform thickness of 10cm at the bottom insted of heavy stones.

ROADS DEVELOPMENT PLANS :- (नाबोलु)

	1st 20yr plan (1943-61)	2nd 20yr-plan (1961-1981)	3rd 20yr plan (1981-2001)
Venue	Nagpur	Bombay	Lucknow
Target Area	16Km / 100Km²	32Km / 100m²	82Km / 100m²
In length	5.32 lakh	10.57 lakh	27.02 lakh
Road Categori	5-categories NH, SH, MDR, ODR, VR	Express ways + 5 categories	3 categories Primary → Express, NH Sec. → SH, MDR 3rd → ODR, VR

⇒ In Frist 20year plan star and grid pattern was adopted.

STEP OF HIGHWAY ALINGMENT

(i) Map survey
(ii) Reconnaissance survey (Fly Surying)
(iii) Preliminary Survey
(iv) Detailed Survey & final location

MRP

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DESIGN Speed

Road Consideration	Plain terrain Speed in Kmph (Terrain)	Rolling terrain (in KMPH) (Terrain)
NH & SH	100	80
MDR	80	65
ODR	65	50
VR	50	40

Terrains

⇒ Plain → Slope (<10%)
⇒ Rolling → (10-25%)
⇒ mountains → (25-60%)
⇒ Steep → (>60%)

Friction

⇒ IRC, long. Friction → 0.35-0.40
transverse (lateral) → 0.15

SKID :- long movement > Rotational movement
SLIP :- Rotational movement > long movement

Uneveness Index measured by Bump Integrater

⇒ A Good pavement Uneveness should not exceed = 150 cm/km
⇒ permissible upto 100Kmph = 250 cm/km.
⇒ Highway unsatisfactory even on 50Kmph = 350 cm/km.

Slope provided in trasverse dirn to drain of rain water.

⇒ Camber is expressed as 1 in n
(1 → Vertical, n → Horizontal)

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Triangle camber $\boxed{y = \frac{w}{2n}}$

Parabolic camber $\boxed{y = \frac{2x^2}{nw}}$

Camber table

Pavement	Camber: Heavy Rain	Camber: light Rain
1) Concrete Road	2% (in 50)	1.7% (in 60)
2. Thin bituminous Road	2.5% (1in 40)	2% (1in 50)
3. water bound Macadam (Gravelly road)	3% (in 33)	2.5% (1in 40)
4. Earthen Road	4% (1in 25%)	3% (1 in 33

⇒ Camber depends on type of pavement and intensity of rainfall

⇒ For cement concrete road straight line camber is provided

⇒ Parabolic camber are prefarred by fast-moving vehicle for over-taking operation

⇒ Relation b/w gradient & camber $\boxed{G = 2C}$ ★

⇒ Cross-slope of shoulder should be 0.5% steeper than camber of Roads.

minimum →	3%
Maximum →	5%

Width of Pavement

⇒ 1 Lane Road → 3.75m

⇒ 2 lane Road without Kerb → 7m

⇒ 2 lane Road with Kerb → 7.5 m

⇒ multilane Road → 3.5m

⇒ intermidiate Road → 5.5m

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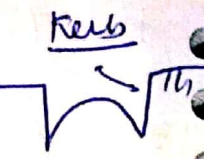
⇒ Width of vehicle as per IRC = 2.44 m

Kerb :- Vertical portion b/w pavement & shoulder



TYPES OF KERB

1. low kerb / mountable kerb = 10cm
2. Semi barrier kerb = 15cm
3. barrier kerb → 20 cm

Traffic seperator (Median)

⇒ As per IRC minimum desirable width of 5m traffic seperator for rural highway which may be reduced to 3m, where land is restricted.

⇒ on long brides → medin → 1.2m to 1.5m

⇒ Desirable min → 5m

⇒ Absolute min → 1.2m

Desirable shoulder width = 4.6m

⇒ Is per IRC, minimum width = 2.5m is recommand for 2-lane rural highway.

GUARD RAIL

Provided when fill is More than > 3m

Bus-bay

→ should be atleast 75m away from intersection.

Parking lanes

⇒ IRC recommand 3m parking lane, when used for Parallel parking.

⇒ safe parking → 45°

⇒ सबसे ज्यादा वाहन खड़े करने हो = 90°

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Width OF Formation

⇒ Acc. to nagpur, the width of formation of ideal national highway in hard rock cutting is 7.9 m

⇒ Width OF Formation

Highway	Plain & Rolling Terrain	mountain & steep terrain
(NH & SH)	12m	6.25 – 8.0
MDR	9m	4.75
ODR	7.5–9m	4.75
VR	7.5m	4.0

⇒ minimum Roadway width on single lane bridge is 4.25m.

$\boxed{SSD = \text{lag distance} + \text{braking distance}}$

$\left\{ \begin{array}{c} \text{Perception time} \\ + \\ \text{brake reaction time} \end{array} \right\} \Rightarrow 2.5$ sec.

⇒ PIEV Theory

⇒ P → Perception time
I → intellection time
E → Emotion time
V → Volition time

[0.5 sec. to 4.5 sec]

⇒ $\boxed{SSD = V \cdot t + \frac{v^2}{2gf}}$ $f =$ ~~0.35~~, longitudinal friction (0.35 – 0.40)
$v = m/s$ } $km/hr \rightarrow \frac{5}{18} \times m/s$

n% gradient $\boxed{SSD = vt + \frac{v^2}{2g(f \pm 0.01n)}}$

η_b efficiency brake $\boxed{SSD = vt + \frac{v^2}{2gf \cdot \eta_b}}$

Both $\boxed{SSD = vt + \frac{v^2}{2g(f \pm 0.01n) \cdot \eta_b}}$

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⇒ For calculating of SSD height of driver eye is consider as 1.2m, and height of obstruction is 0.15m.

II For single lane, two way movement :-

$$\boxed{\text{min SSD} = 2 \times \text{SSD}}$$ ★★

III Intermediate sight distance

$$\boxed{\text{ISD} = 2 \times \text{SSD}}$$ ★

IIII OVER TAKING SIGHT DISTANCE (OSD)

[as per IRC, $t \rightarrow 2$ sec.] ★

$$\boxed{s = 0.7 v_b + 6}$$ ★

s → min spacing.

$$\boxed{T = \sqrt{\frac{4s}{a}}}$$ ★

⇒ For over taking

1-way traffic → $\boxed{OSD = d_1 + d_2}$

2-way traffic :- $\boxed{OSD = d_1 + d_2 + d_3}$ ★

⇒ effect of grade on safe over taking side distance is increase it in both accending & decending grades.

IIII

$$\boxed{\text{Desirable OSD} = 5 \times \text{OSD}}$$ ★

$$\boxed{\text{Min OSD} = 3 \times \text{OSD}}$$ ★

IIII

Sight distance	H.t of driver	H.t. of Object
SSD	1.2m	0.15m
OSD	1.2m	1.2m
ISD	1.2m	1.2m

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Horizontal curve

$$\boxed{\text{Centrifugal Ratio} \Rightarrow \frac{P}{W} = \frac{v^2}{gR}}$$

(A) Overturning case:-

$$\boxed{\frac{P}{W} = \frac{b}{2h}}$$

(B) for lateral skidding:-

$$\boxed{\frac{P}{W} = f}$$

⇒ To avoid overturning $\frac{P}{W} < \frac{b}{2h}$

⇒ To avoid lateral skidding $\frac{P}{W} < f$

⇒ To avoid both $\frac{P}{W} <$ (min of $\frac{b}{2h}$ & f)

⇒ if overturning is occuring prior to skidding $\boxed{\frac{b}{2h} < F}$ *

⇒ if lateral skidding is occuring prior to overturning $\boxed{f < \frac{P}{2h}}$ *

Superelevation:-

Raising of outer edge of pavement w.r.t inner edge to counter act the centrifugal force and reduce the tendency of vehicle to overturn.

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

f = lateral friction

v = m/s.

⇒ Superelevation $\underline{e}$

* ⇒ Urban Road → 4%
* ⇒ plain & Rolling terrain → 7%
* ⇒ For mountaineous & steep → 10%

* ⇒ maximum value of super elevation on plain & rolling terrain 7% (0.07) and minimum value of lateral friction = 0.15 It means contribution of lateral friction is counter acting centrifugal force is much higher than countribution of super elevation.

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$$\boxed{e_{min} = \text{Camber}}$$

Eq^m of super elevation :- (ये case जब Friction मिले ही नहीं)

It is that super-elevation which is provided to the road as that there will be equal pressure at inner and outer wheel.

$$\boxed{e+f = \frac{v^2}{gR}} \quad f=0 \Rightarrow \boxed{e_{eqm} = \frac{v^2}{gR}} \Rightarrow \boxed{e_{eqm} = \frac{v^2}{127R}}^{*}$$

Rulling Radius

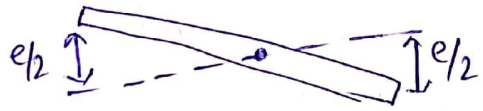
$$\boxed{R_{rulling} = \frac{v^2}{0.22g} = 0.46v^2} \Rightarrow (e+f) = \frac{v^2}{gR} \Rightarrow R = \frac{v^2}{(e+f)g} = \frac{v^2}{(0.07+0.22)g}$$

⇒ To calculate minimum value of Rulling Radius of Horz. Curve in plains the design speed is 16 Km/h

Rotation of outer edge

(i) With respect to inner :-

(ii) W.r.t. center



⇒ Drainage problem ज्यादा होगी।

⇒ For a mixed traffic condition superelevation is design for 75% off design speed then e_{design}.

$$e_{design} = \frac{(0.75v)^2}{127R} \qquad \boxed{e_{design} = \frac{v^2}{225R}}$$

$v = \text{Kmph}$

$R \rightarrow \underline{\underline{m}}$

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Design of super elevation :-

⇒ For high speed vehicle, provide higher super-elevation without considering coeff. of friction is safe. It means centrifugal force is fully counterbalanced by the super elevation of wt. of vehicle.

⇒ For slow moving vehicle, providing lower super elevation considering coeff. of friction is safe it means centrifugal force is counter acted by super elevation and coeff of friction.

⇒ For max. value of e (0.07) & f (0.15), speed of vehicle is restricted

$$\Rightarrow \quad e+f = \frac{V_a^2}{127R} = 0.07 + 0.015 = \frac{V_a^2}{127R}$$

$$\boxed{V_a = 5.28\sqrt{R}} \; ★$$

EXTRA-WIDENING :-

- → OFF tracking (गाड़ी बाहर ना जाये)
- → psychological.

Extra widening (we) = Off tracking + psychological

$$\boxed{we = \frac{n l^2}{2R} + \frac{V}{9.5\sqrt{R}}} \; ★$$

V = Kmph
R = m
n = no. of lanes.
l = length of vehicle

Off tracking does not depend V ★

⇒ R < 300m ⇒ extra widening

⇒ If R < 50m ⇒ EW ⇒ On inner side

⇒ 50 < R < 300 ⇒ EW = on both side

⇒ On hilly Road → on inner side.

★

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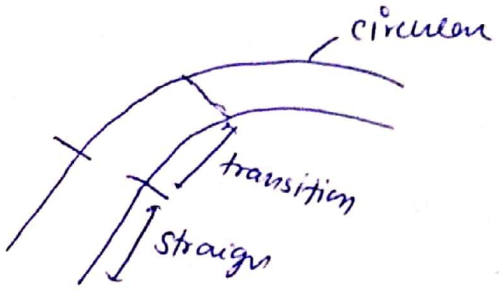
⇒ For the construction of the highway on plain rolling is done from edge to centre and on super-elevated curve rolling is done from inner to outer edge.

Transition curve :-



⇒ This curve is introduced b/w straight and circular shape so that radius changes from ∞ to R *

⇒ To introduce super elevation and extra widening gradually

* ~~SHAPE~~ IRC recommand Ideal shape of transition curve is spiral or Clothoid.

Length of transition curve :→

(A) Based on rate of change of centrifugal acc^n –

$$\boxed{L_s = \frac{v^3}{CR}}$$

IRC →

$$\boxed{C = \frac{80}{75+V}}$$

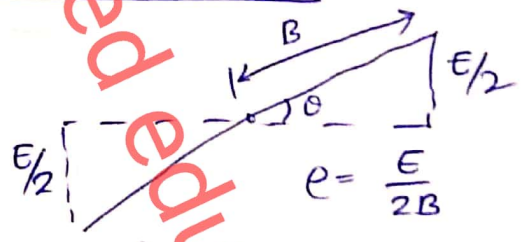
V = KMPH

$$\boxed{C \rightarrow 0.5 \text{ to } 0.8} \rightarrow C = cm/sec^2$$

(B) On the Basis of rate of change of super-elevation –

(i) if outer edge is rotated about centre –

$$\boxed{L_s = \frac{eN(w+w_e)}{2}} \; *$$



(ii) if outer edge is rotated about inner edge –

$$\boxed{L_s = eN(w+w_e)} \; *$$

$$\boxed{N = 150 \text{ for plains [IRC]}} \; *$$

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Empirical Relations :-

(i) For Plain & Rolling terrain -

$$\boxed{L_s = \frac{2.7 V^2}{R}}$$ ★

(ii) For mountaineous & steep terrain -

$$\boxed{L_s = \frac{V^2}{R}}$$ ★

Shift

$$\boxed{S = \frac{L_s^2}{24R}}$$

L_s = length of transition curve M.
R = Radius of curve.

Effect of Gradient on horz. curve :-

gradient → resistance is increase. ★

$$\boxed{\text{Compensated Gradient} = \text{Gradient} - \text{Compenstion}}$$

$$\text{Grade Compenstion} = \left.\begin{aligned} &\frac{75}{R}\% \\ &= \frac{30+R}{R}\% \end{aligned}\right\} \text{Min}$$

★ There is no need of gradient compenstation on when the gradient is less than 4% ★

vertical Aligment

- Gradient (Rise or fall wrt horz)
  - * Rulling Gradient
  - * limiting "
  - * Exceptional "

  } steep

- vertical curve

* Min gradient
  ⇓ It is for drainage purpose
* ★ min gradient for cement concrete road = $\frac{1}{500}$ ★

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Terrain	Rulling gradient	limiting	exceptional
1) Plain and Rolling terrain	3.3%	5%	6.7%
mountaineous & steep terrain (<3000m above MSL)	5%	6%	7%
mountaineous & steep terrain (>3000m above MSL	6%	7%	8%

⇒ Square parabola is generally prefer for submit curve due to best riding quality, simplicity of calculation and uniform rate of change of gradient.

⇒ Circular shape is assumed to be ideal bcz sight distance is uniformly available throughout the curve.

Length of summit curve :-

(i) $L_c > SD$

$$L_c = \frac{NS^2}{[\sqrt{2H}+\sqrt{2h}]^2}$$ *

N - alegebric diff. b/w gradient
S - sight distance
H - Ht. of driver
h - ht. of object.

For SSD

$$L_c = \frac{NS^2}{4.4}$$

H = 1.2m, h = 0.15m

ISD

$$L_c = \frac{N \cdot S^2}{9.6}$$

H = h = 1.2m

Case-2 $SD > L_c$

SSD = $$L_c = 2S - \frac{4.4}{N}$$ *

ISD/OSD = $$L_c = 2S - \frac{9.6}{N}$$ *

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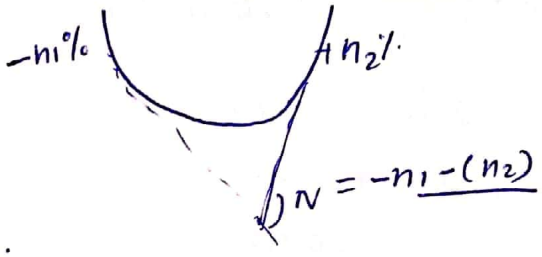
Valley curve

Cubic parabola is generally preferred.



Length of valley curve :-

(i) Based on comfort condⁿ :-

$$\boxed{L_v = 2\sqrt{\frac{N \cdot v^3}{C}}}$$

$C = 0.6\ m/s^3$ *

$$\boxed{L_v = 0.38\sqrt{N \cdot V^3}}$$

$V \rightarrow$ kmph

(ii) Based on Head light sight distance

$L_v > HSD$

$$\boxed{L_v = \frac{Ns^2}{1.5 + 0.0355 \times S}}$$

$L_v < HSD$

$$\boxed{L_v = 2S - \frac{1.5 + 0.0355 \times S}{N}}$$ *

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HIGHWAY Material :-

Surface course → concrete + bitumen

BASE course } = soil + gravel

Sub-BASE

Sub-Grade → soil

① CBR value test
↳ (California Bearing test) -

→ It is penetration test.

- In most cases CBR decreases as penetration increases.

→ $$CBR = \frac{\text{load corresponding to penetration (2.5mm or 5mm)}}{\text{Standard load on crushed stone to penetration}}$$

→ The load value on standard crushed stone are 1370 kg and 2055 kg. corresponding to 2.5mm & 5.0mm penetration respectivelly.

⇒ Two value of CBR is obtained
* CBR at 2.5mm
* CBR at 5mm

(i) if CBR at 2.5mm penetration > CBR at 5mm
then adopt CBR at 2.5mm

(ii) if CBR at 5mm penetr. > CBR at 2.5mm
↳ Repeat the test
if same value is gained again
then adopt CBR value at 5.0mm

② PLATE Bearing Test :-

⇒ Findout → modulus of subgrade reaction (K) in westgard's analysis

→ K :- is define as pressure sustain per unit deformation using specified plate size.

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⇒ Standard size of plate for plate bearing test is 75cm

$$\boxed{K = \frac{P}{\Delta}} \quad \frac{Kg/cm^2}{cm} = \frac{Kg}{cm^3}$$

Stard plate = 75 cm

$$\boxed{K = \frac{P}{\Delta} = \frac{P}{0.125} = 8P}$$

Aggregates :- (Test on)

(i) Crushing value :- [12.5mm P, 10mm R] Ags - W_1

measure → resistance to crushing under gradually Apply load.

Crushing value test machine

⇒ 4 tonne/min → 10 min → Total load = 40 tonne

⇒ sieve → 2.36 mm IS sieve → passed material - W_2

$$\boxed{\text{Crushing value} = \frac{W_2}{W_1} \times 100}$$

C.V ≯ 30%	→ for surface course
C.V ≯ 45%	→ For base course

(ii) Impact value :-

↳ measure toughness against impact loading

I.V ≯ 30%	→ surface course
≯ 35%	→ base course & (bituminous course)
≯ 40%	→ WBM (water Bond Macadam)

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③ **Abrasion Value**

↳ measure hardness / wear & tear resistance

Test Name:-

Los angeles, Devel, Dorry tests. ★

A.V ≯ 30%	→ Surface course
A.V ≯ 50%	→ Sub base

IMP AVQ

$$\text{Hardness coeff} = 20 - \frac{\text{loss of wt (gm)}}{3}$$ → Dorry test

④ **Soundness test**

↳ resistance against weathering

- Immerse in Na_2SO_4 or $MgSO_4$ soln for 16-18 hours.
  - → Dry at 105°C
  - → Repeat this cycle → 10 times. ★
- → Total loss ≯ 12% → if Na_2SO_4 is used
- → Total loss ≯ 18% → if $MgSO_4$ soln is used.

⇒ water absorption ≯ 0.6% by wt.

⇒ S.p. Gravity 2.6 – 2.9 for good quality.

⑤ **SHAPE TEST :-**

- → Flakiness test
- → Elongation Index
- → Angularity no.

Flakiness test :-

↳ applicable for agg. More than 63 mm size.

$$d_{least} < \frac{3}{5} \times d_{mean}$$ ★

$$F.I \not> 15\%$$ ★

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Elongation Index :-

$$d_{greatest} > 1.8 \times d_{mean}$$

9/5

E.I > 15%

Angualarity No :-

Angularity no. varies b/w = 0-11

$$\text{Angularity No} = 67 - \frac{100\,W_a}{W \cdot G}$$

W_a = wt. of Agg.
W = wt of water
G = specific gravity.

Bitumen

Bitumen	Tar
* It is soluble CS_2 & CCl_4	* It is soluble kerosence & toluence
* Bitumen has less resistance to temp. It means less temp. susseptibility	* More resistance to temp.
* More water resistance	* less water resistane.
* free carbon is less	* free carbon is more

Cut-back bitumen :-

⇒ if the viscosity of bitumen is reduce by valtile Diluent is known as cut-back bitumen.

→ used in the colder region

Penetration test :-

Bitumen grade is specified in terms of penetration value = 80-100

eg:- 80/100 = It means penetration is 8 to 10 mm

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Bitumen emulsion :-

⇒ It is a condition in which bitumen is suspended in aquous medium used in Patch-up work.
(गड्ढे)

Ductility Test :- [Ductilometer]

Briquette size = 10mm x 10mm
Pull = 5cm/min.

⇒ minimum ductility value according to IRC is equal to 75cm for 45 grade at it should be not less than 50cm for any grade in road construction.

Float Test :-

measure consistency at material for which penetration or viscosity test can't be done.

NOTE :- * Float Test & viscosity test has the measurement in terms of time.

Sp. Gravity → Pycnometer.

*

pure bitumen → 0.97 – 1.02
Tar → 1.10 to 1.25

Softening Point

↳ Ring & ball test used

→ Ball Penetration is 2.54 cm
→ Softening point lies b/w 35 - 70°c

*
→ If the penetration value is More, softening point will be less.

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FLASH point:-

- According to IRC standard flash point = 175°C
- Pensky Martin apparatus is used.
- wt. reduced by burn ≯ 0.2%

FIRE point

- lowest temp. which bitumen gets ignited & burned.
- Generally fire point is 300°C

⇒ To check the purity of bitumen solubility test is done.

⇒ Solubility of bitumen in tetraethylene measured to the purity of bitumen.

⇒ And minimum value of solubility is required at 99%

Spot test

2gm bitumen + 10gm. of Naptha.

TYPES OF cut-back bitumen:-

- Rapid curing ⇓ {Bitumen is fluxed with Naptha}
  - RC→0
  - RC→1
  - RC→2
  - ↓ viscosity
- medium Curing ⇓ {Bitumen is mixed with Kerosence}
- Slow curing ⇓ {Bitumen is mixed with high boiling point diluent}

Tar

RT-1, RT-2, RT-3, RT-4, RT-5 → viscosity

- RT-1 → surface painting
- RT-3 → used for pre-mixing tar macadam in base course
- RT-5 → Grouting.

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TYPES OF Emulsion

Rapidset → used for surface dressing
medium set → Used in premixing with coarse agg.
slow set → use in premixing with fine Agg.

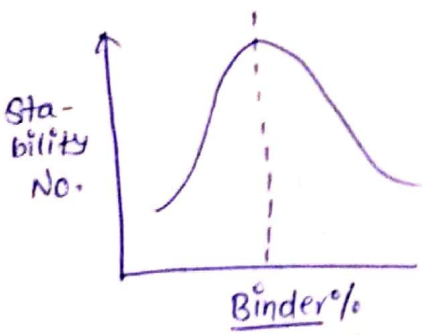
METHODS TO DESIGN MIX

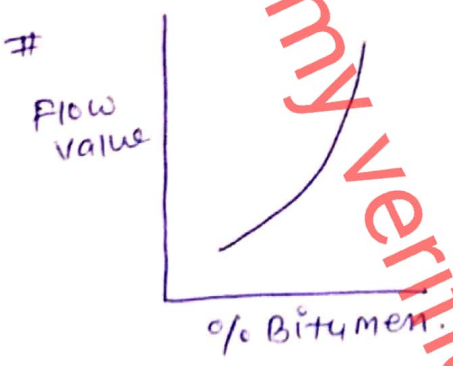
1. Marshall Stability method
2. Hveen method
3. Hubbort Stabilometer method
4. super-pave design method.

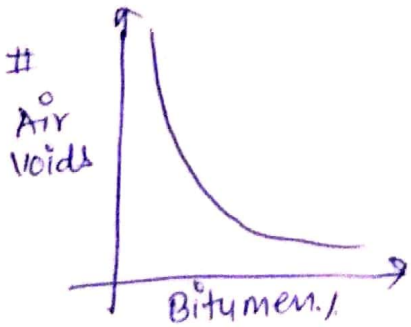
Marshall Stability NO → Max. load corresponding to failure ★

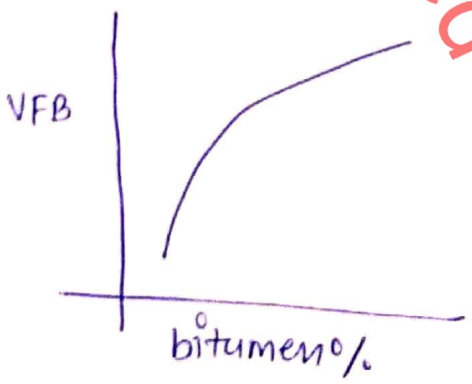
Flow value → Deformation in units of 0.25mm

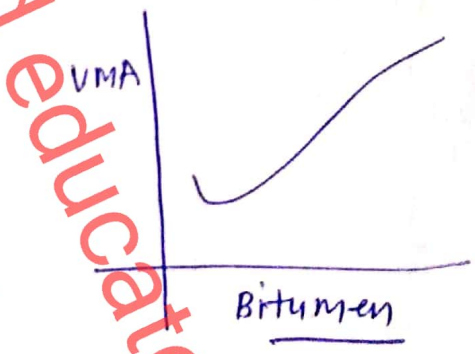
Graphical plots











VFB = Voids Filled with bitumen
VMA = Voids in mineral method.

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⇒ Mix with very high stability value and low flow value are not desirable as the pavement constructed with such mix are likely to fail (develops crack). due to heavy moving load.

Test property	value
* Stability No →	340kg
* Flow value (0.25mm)	8-16
% Air Void →	3-5
VFB % →	75-85

PAVEMENTS

Flexible pavement (Bituminous concrete)	Rigid pavement (cement-concrete)
→ load transferred grain to grain	→ * Slab Action (layer to layer)
→ IRC 37-2012	→ IRC 58-2012
→ No Expansion & contraction Joint is provided	* contraction & expansion Joint is provided.
→ Neglibile Flexural strength	→ consider

Sub-base → For drainage purpose.

Base-course → Sustain the wheel load and dispersed the wheel load stresses to larger Area.
= Enhance load carrying capacity.

Surface layer

(A) Thin bituminous layer → 2cm thick
→ used for water proofing

(B) thick bituminous layer
→ It provides smooth riding surface and takes wear and tear.

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⇒ Normally soling coat is always laid but only those places are left where the road is on hard soil surface / ROCK.

⇒ Agg. required for 1 km length of WBM per meter width For 10mm thickness is $12m^3$.

STABILIZATION :-

- Soil lime → Black-cotton soil
- Soil-cement → For gravelly soil
- Soil-Bitumen → For Fine sand & silt

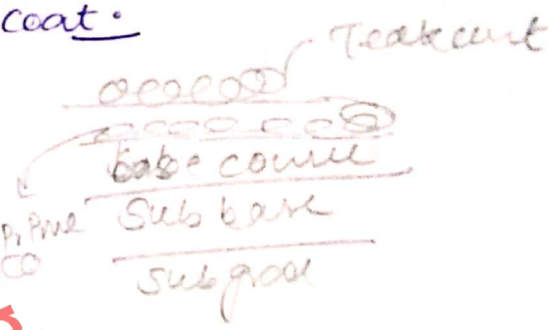
⇒ Hydraulic lime is used is soil stabilization.

PRIME COAT :- Spraying of liquid bituminous binder of low viscosity over a granular base course

Tack coat :- binder of low viscosity over either a primed Granular surface.

→ To ensure a bond b/w new construction and old surface.

⇒ Prime coat is less viscous then tack coat.



⇒ VG-10 → (80-100) → Penetration.
VG-20 → (70-80)
VG-30 → (60-70)

Design OF Flexible Pavement

(i) Standard Axle load = 8170kg., single wheel load = 4085kg.

(ii) $$\text{Contact pressure } p = \frac{\text{Wheel load (P)}}{\text{Contact Area (A)}}$$

iii) Stresses due to wheel load :-

$$\sigma_z = P\left[1 - \frac{z^3}{(a^2+z^2)^{3/2}}\right]$$

: Rigidity Factor

$$R.F = \frac{\text{Contact pressure}}{\text{Tyre pressure}}$$

As per Equivalent single wheel load contact pressure $= 7 kg/cm^2$

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Tyre pressure	R.F
7 kg/cm²	1
>7 kg/cm²	<1
<7	>1

Design methods of Flexible pavement :-

- Empricial method
  - Based on soil properties shear-strain behaviour
  - * Group-Index method
  - * CBR - method
  - * California resistance value method
- Semiempirical method
  - based on stress strain behaviour
  - * Triaxial method.
- Based on mathematical computation (Analytical method)
  - Burmister elastic theory

① Group Index method

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

$a = P - 35 \not> 40$
$b = P - 15 \not> 40$
$c = W_L - 40 \not> 20$
$d = I_P - 10 \not> 20$

P → % finer through 75μ sieve
W_L = liquid limit

G.I → 0 to 20 *

G.I ↑ → poor soil *

② CBR method:-

$$T(cm) = \sqrt{\frac{1.75P}{CBR\%} - \frac{P}{p\pi}}$$

P - ESWL → kg
p - contact pressure.

⇒ CBR method is applicable when CBR of sub grade soil ≤ 12%

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CALIFORNIA Resistance value method :-

- Stabilometer R-value → density show करता है
- cohession meter c-value

$$T(cm) = \frac{K \cdot (T.I)(90-R)}{C^{1/5}}$$

T.I → traffic Index
K = 0.166 T-thickn

$$TI = 1.35 (EWL)^{0.11}$$ ★

if two layer system is considered

$t_1 \rightarrow c_1$, $t_2 \rightarrow c_2$

$$\frac{t_1}{t_2} = \left(\frac{c_2}{c_1}\right)^{1/5}$$ ★

Triaxial method :-

$$\frac{t_1}{t_2} = \left(\frac{E_2}{E_1}\right)^{1/3}$$ ★

Es → modulus OF Elasticity

BURMISTER Elastic theory :-

Surface course	Esc
Base course	EBC
Sub base	Esb
Sub-Grade	Esm

$$E_{sc} > E_{BC} > E_{sb} > E_{sm}$$

displacement relationship given by burmister –

For flexible

$$\Delta = \frac{1.5pa}{E_s} \times F_2$$

F2 = deflection factor

For Rigid

$$\Delta = \frac{1.18pa}{E_s} \times F_2$$

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Relative stiffness of slab w.r.to Sub Grade

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

cm

Critical position of loading

(a) corner (b) Edges, (c) Interior.

Equivalent Radius of Resisting section (b)

$$b_{(com)} = \begin{cases} \sqrt{1.6a^2 + h^2 - 0.675} & a < 1.675h \\ a & \text{otherwise} \end{cases}$$

h = thickness of slab

a = radius of contect Area.

Joints :-

(i) Expansion Joint

(ii) Contraction Joint

(iii) Construction Joint — longitudinal Joint

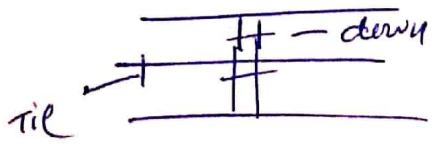
① Expansion Joint

- thickness is 2.5 cm
- Generally provide at 18-20 m spacing
- max^m spacing is 140m

② contraction Joint ⇒ max^m spacing 4.5m

⇒ Tie bars are provided to in longitudnal Joint to Join two slab.

⇒ down bars are design at expansion Joint to combine the slab in transverse dirn.



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Road in cutting 1:1 to 0.5:1 IRC

Road overfill 1:5:1 [H:V] IRC

⇒ In hill road side drains are provide at hill side (inner) and this drain is called catch water drain.

⇒ Sharp turn (U-turn on will road) in ~~at~~ hill area is known as hair pin bend design speed is 20kmph

⇒ The wall which are provided necessary on hill side of roadway where earth has to be retain from slipping is known as Breast wall.

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Traffic Engg.

(A) Traffic volume studies -

↳ Vol → No. of vehicle /hr
No. of vehicles / Day

Measurement of traffic volume:-

→ mannual method
→ Mechanical method
- → Automatic counter cum Classifier
- → Pneumatic hose
- → magnetic detector method
- → Radar Tech.

① Annual avg. daily traffic

$$= \frac{\text{volume in 1 year}}{365} = \frac{\text{traffic vol/hr in 1 year}}{365}$$

② Avg. daily traffic

⇒ When the traffic volume counts are carried out only for few days such as 3 days to 7-days, avg. daily traffic volume is called Avg. daily traffic.

Trend chart :- (भविष्य में कितना volume)

→ showing volm trend over years

⇒ It is helpful in predicting the traffic, future expansion design and ~~regulation~~ regulation.

Variation chart :- (season के हिसाब से)

→ variation charts showing daily, monthly, and seasonal variation of traffic.

→ It helps in regulation on traffic and to set-up the street light.

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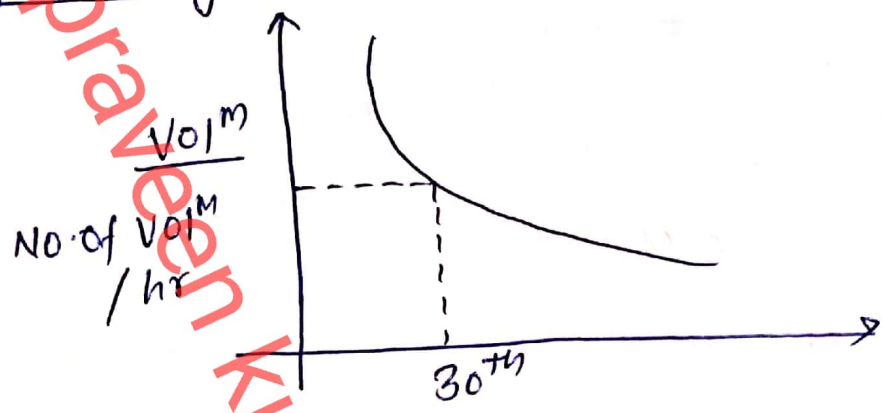
Design hourly volm :-



30th hourly volm :- (एक साल मे 29 बार इससे ज्यादा volume रह सकता है)

travel time :- It is resiprocal of speed & a mea of efficiency of road.

→ For most efficient road travel time should be minimum.

Spot ~~time~~ :- It is the instantaneous speed of a vehi speed at a particular section or locations. (किसी एक क्षण पर vehicle की speed)

Avg. speed
(A) time mean speed
(B) Space mean speed

⇒ It is the avg. of spot speed of all vehicles passing o given point on highway.

Methods to measure spot speed :-
- Endoscope method*
- photographic method
- Electronic method
- Radar method.

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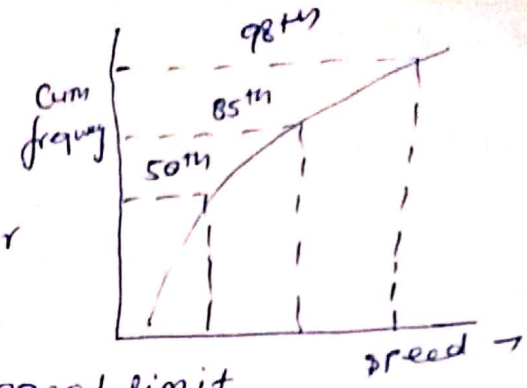
Presentation of spot speed :-

98th speed का मतलब है इसे ऊपर 2% vehicle की speed ज्यादा है।



98th percentile speed :- design speed for geometric design of highway

85th percentile speed :- upper safe speed limit

50th :- median speed.

15th → minimum speed to avoid conjection.

Methods for delay & speed :-

* Floating car method
⇒ Licence plate method
⇒ Interview Technique
⇒ Post card method
⇒ photographic method.

Origin & Destination study :- (Road में फेर बदल करना है कहाँ की curve कहाँ देना ये सब)

→ This study is mostly use in highway planning & upgradation of existing road.

Desireline :-

straight line joining origin and destination and thickness of these lines show the comparsion b/w traffic volm over those origin and destination stretches.

Traffic density [space के साथ study 1 km में कितने vehicles है।]

Traffic density = No. of vehicle per km

* traffic vol. = vehicles / hr
  Traffic Density = vehicles / km
  Traffic speed = km/hr

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$$\boxed{\text{traffic vol.} = \text{Traffic density} \times \text{Speed}}$$ ★

Traffic capacity (क्षमता)

⇒ It is represented as vehicles / hr / lane

→ volume represents actual rate of flow.

→ capacity represent max. rate of flow.

Basic capacity

in ideal condition max. volume that can be possible on is known as basic capacity

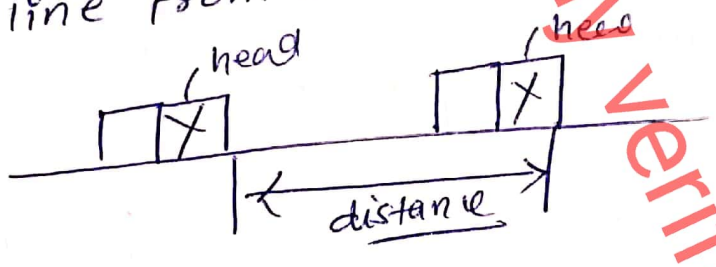
Based on space head way

$$\boxed{C = 1000 \frac{V}{S}}$$ ★

C – Basic capacity
V – head of vehicle kmph
S – speed head way

Spacehead way

It is space interval b/w successive vehicle moving in same line from head to head as they pass the point.

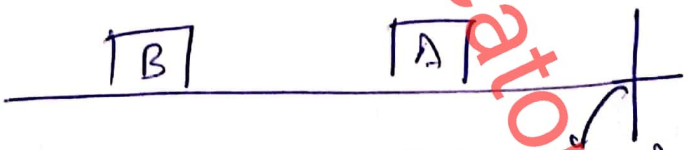


Time head way :-

Time interval b/w passage of sucessive vehicle moving in same lane measured from head to head as the pass a point on the road.

$$\boxed{C = \frac{3600}{H_t \text{ (sec)}}}$$

time headway



इस point को cross दोनों इस time पर

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Possible capacity

$$\boxed{0 \le PC \le \text{Basic capacity}}$$ ★

Passanger car unit :-

$$PCU = \frac{\text{Capacity of roadway when their are passenger car only}}{\text{Capacity of Road way when there are any other type of traffic.}}$$

vehicle

vehicle	PCU
Scooter, motorcycle →	0.5
car, Auto →	1
Cycle & Riksha →	1.5
Bus, truck →	3
Horse driven vehicle →	4
Small Bullock cart →	6
large bullock cart →	8

⇒ 45° angle parking is consider based for all considera

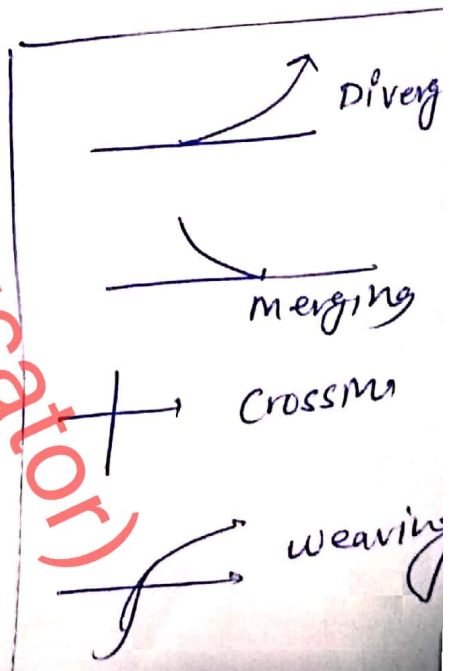
⇒ maximum vehicle can be park with 90° parking.

Parallel parking

$$\boxed{N = \frac{L}{6.6}}$$ ★

45° parking ⇒ $$\boxed{N = \frac{L-2}{3.6}}$$ ★

90° parking ⇒ $$\boxed{N = \frac{L}{2.5}}$$



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Both Road 2-way 2-lane

No. of conflicts = 24

merging
crossing
weaving

(B) One Road, 2lane - 2way
Other Road, 2lane - 1way] — (11) — total No. of conflicts

(C) One Road (1-way) - 2lane
Other Road 1way - 2lane] → (6) No. of conflicts

(D) T-Roads - 2way - 2

= 18

Design of signals

(a) Trial & error method
(b) webester method.

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4.9

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