Nepal Engineering Council Licensure Examination

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MSC. IN TRANSPORTATION ENGINEERING
PULCHOWK CAMPUS

TRANSPORTATION ENGINEERING SYLLABUS OF NEC LICENSE EXAM

9. Transportation **(ACiE09)**

9.1 Highway planning and survey: Modes of transport, history of road development in Nepal; classification of roads; road survey; highway alignment and controlling factors; evaluating alternate alignments; Road Standards of Nepal. (ACiE0901)

9.2 Geometric design of highway: basic design control and criteria; elements of highway cross-section; highway curves; super elevation; average and ruling gradients; stopping sight distance; design considerations for horizontal and vertical alignments, extra widening, and set back distance; design of road drainage structures; design considerations for hill roads. (ACiE0902)

9.3 Highway materials: types of aggregates and tests on their gradation, strength, durability; binding materials and their tests; design of asphalt mixes; evaluation of subgrade soil. (ACiE0903)

9.4 Traffic engineering and safety: impact of human and vehicular characteristics on traffic planning; traffic operations and regulations; traffic control devices; traffic studies (volume, speed, O&D, traffic capacity, traffic flow characteristics, parking, accident, flow); road intersections (types, configurations, design); traffic lights; factors influencing night visibility, road safety measures. (ACiE0904)

9.5 Road pavement: different types of pavement; design methods for flexible and rigid pavements (DOR Guidelines); loads and other factors controlling pavement design; stress due to load, temperature. (ACiE0905)

9.6 Road construction & maintenance: activities, techniques, tools, equipment and plants used in road construction; preparation of road subgrade; field compaction control and soil stabilization; construction of asphalt concrete layers; construction procedure for penetration macadam, bituminous bound macadam and plain cement concrete pavements; road maintenance, repair and rehabilitation. (ACiE0906)

Calculation of CBR Value(EMPERICAL METHOD)

(I) Calculation of CBR value

- CBR is the penetration test developed by California Division of Highways.
- This test is done for calculating the stability of soil subgrade and other flexible pavement materials.

CBR (%) = (Load sustained by the specimen at 2.5 or 5 mm penetration)/(Load sustained by the standard aggregates at the corresponding penetration value) * 100 %

- The CBR values of 2.5 mm penetration is higher than that of 5 mm
- If the CBR values of 5 mm penetration is higher than that of 2.5 mm, then the test is repeated.
- **Three test** is conducted and the average of three is CBR values

$$CBR_{\delta} = \frac{P_{\delta} \text{ of soil}}{P_{\delta} \text{ of standard crushed aggregate}} \times 100$$

δ = displacement in mm

P_{δ} = Load corresponding to 'δ' settlement

P_s = Load for standard crushed aggregate:

δ (mm)	P_{SCA} (kg)	P_{SCA} (kg/cm^2)
2.5	1370	70
5	2055	105

If CBR 2.5 > CBR 5 → Test Accepted

If CBR 5 > CBR 2.5 → Test Repeated

Empirical Method

- CBR Method
- It was introduced by California Division of Highways in USA in 1928
- The design curves provides thickness of pavement required for a given CBR of subgrade and for a given design load to be taken by the pavement. Three curves for *design wheel load* 3175 kg, 4082 kg and 5443 kg were developed
- The CBR method is based on the principle of requirement of sufficient thickness of material for a given CBR.

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

$$\sqrt{P}\left[\frac{1.75}{CBR} - \frac{1}{p\pi}\right]^{0.5}$$

Where P is wheel load in kg
And p is tyre pressure in kg/cm²

Empirical Method (CBR method continue)

- IRC recommended (IRC: 37-1970), 7 curves for different volume of commercial heavy vehicles whose laden weight is greater than 3 tonnes
- To calculate the number of design commercial vehicle for the design year, it is recommended to use

$$A = P(1 + r)^n \text{ in commercial vehicle per day, CVPD}$$

3 tonnes
commercial
heavy
veh

$A = P(1+r)^n$

IRC Method(Semi Emperical)

$$N = \left(\frac{365*((1+r)^n-1)}{r}\right) * A * D * F$$

Where,

r = annual growth rate of commercial traffic

n = design life in year

A = Initial traffic at the end of construction period,

$$A = P(1+r)^m$$

P= number of traffic at the beginning of construction

m = construction period

D = lateral distribution factor

F = Vehicle damaging factor

After obtaining the cumulative traffic and CBR values, the total thickness of pavement from sub-grade is calculated reading from graph given by IRC.

Theoretical Methods:

- It is the methods based on pavement response such as stress or strain due to loads.

(A) Boussinesq's Theory

- The vertical displacement at the surface under the centre of applied load is given by:

$$\Delta = \frac{2Pa}{E}(1 - v^2)$$

Where,

Δ = vertical displacement

v = Poisson's ratio

E = Modulus of elasticity of sub-grade soil

For v = 0.5

$$\Delta = \frac{2Pa}{E}(1 - 0.5^2)$$

$$\Delta = \frac{1.5\,Pa}{E}$$

The above equation is applicable for flexible plate only. For rigid plate, $\Delta = \frac{1.18\,Pa}{E}$

(II) Semi-Empirical Methods:

The final form of equation is given below:

$$Tp = \left(\left(\sqrt{\frac{3*P*x*y}{2*\pi*Es*\Delta}}\right)^2 - a^2\right)\left(\frac{Es}{Ep}\right)^{1/3}$$

Where,

Tp = thickness of pavement

P = wheel load

Es = Modulus of elasticity of sub-grade soil

Ep = Modulus of Elasticity of pavement materials

a = radius of contact area

Δ = design deflection (0.25 cm)

x = traffic coefficient = 1.5

y = rainfall coefficient = 0.9

$\left(\frac{Es}{Ep}\right)$ = stiffness factor

Asphalt Institute Method:

$$\frac{tb}{tsc} = \left(\frac{Esc}{Eb}\right)\Lambda^{1/3} \qquad \frac{tsb}{tsc} = \left(\frac{Esc}{Esb}\right)\Lambda^{1/3}$$

Where,

tsc = thickness of surface course

tb = thickness of base course

tsb = thickness of sub-base course

Esc = Elastic modulus of surface course

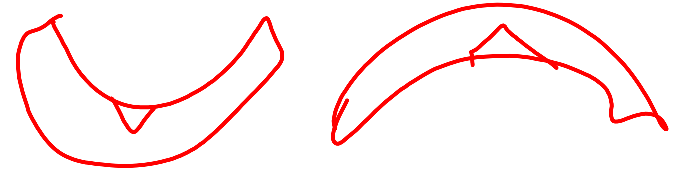
Eb = Elastic modulus of base course

tsb= thickness of sub-base course

Rigid Pavement

Design of Rigid Pavement

Stresses

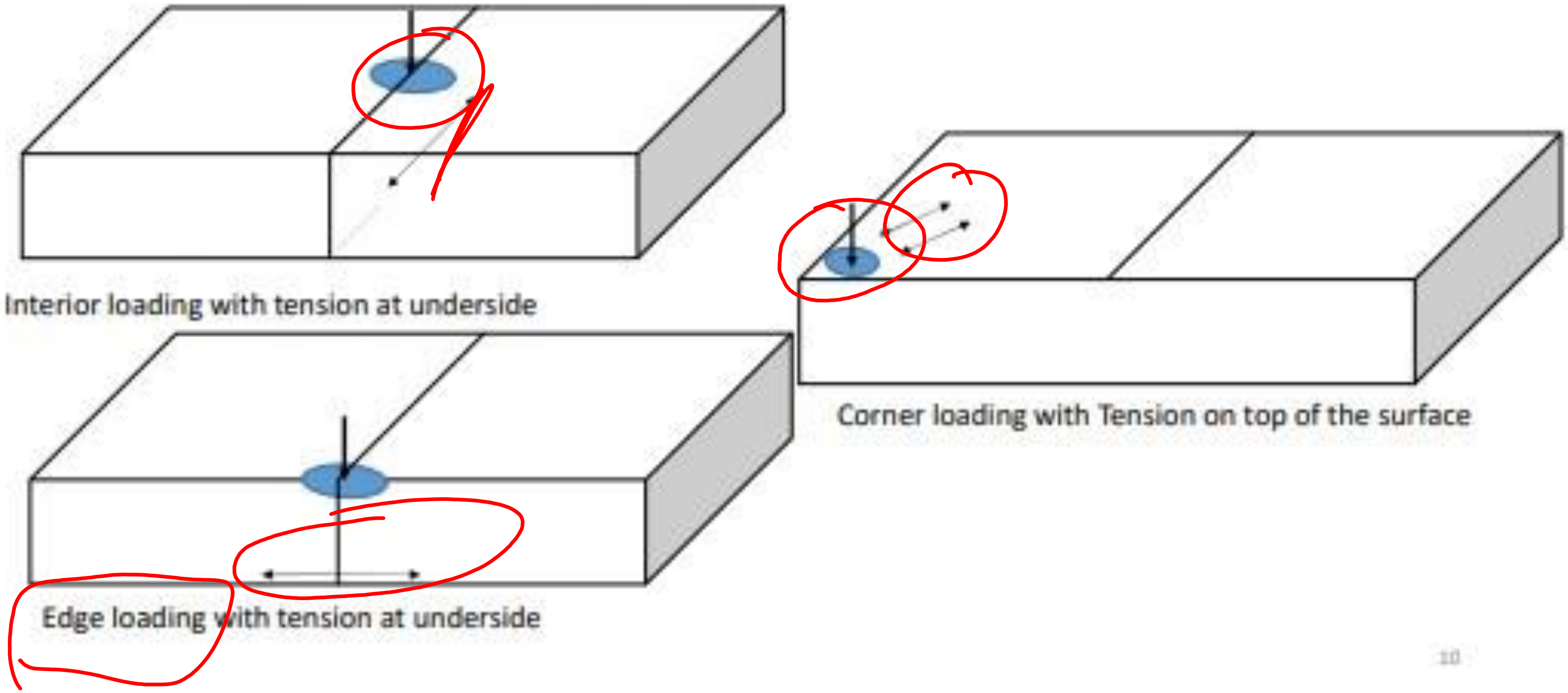


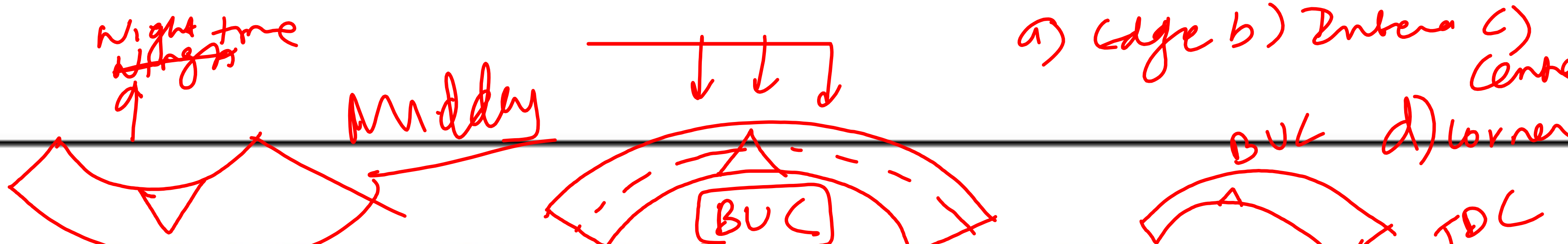
- Stresses at different locations in rigid pavement occurs due to
  - Due to wheel load (traffic load)
  - **Temperature Stress**
    - Due to warping
    - And friction between pavement and the subgrade
- The critical combination is taken for the maximum stresses at different locations which should not exceed the strength of the concrete
- The load location usually for critical combination is taken as edge

1. Traffic Stresses

- On application of the traffic load, the slab tends to deflect like a beam and flexural stresses comes into play
- Westergaard considered three critical loading
  - Interior loading,
  - Edge loading,
  - Corner loading,
- At both the cases of interior and edge loading maximum tensile stress is acted on the bottom of the slab
- For corner loading maximum tensile stress is acted on the top of the slab

Location of tensile stresses generated for the three critical wheel load postion





3.Warping Stress (Temperature Stress)

- Temperature differential between the top and bottom of the slab causes curling (warping) stress in the pavement
- If the temperature of the upper surface of the slab is higher than the bottom surface then top surface tends to expand and the bottom surface tends to contract resulting in curl downward, and vice-versa
- The restraint due to weight, friction provides restraint to the curling producing stresses
- For interior region of the slab $\sigma = \frac{E\alpha_t t}{2(1-\mu^2)}(C_x + \mu C_y)$
- For edge region of the slab , $\sigma = Max\left(\frac{C_x E\alpha_t t}{2}, \frac{C_y E\alpha_t t}{2}\right)$
- For corner region of the slab, $\sigma = \frac{E\alpha_t t}{3(1-\mu)}\sqrt{\frac{a}{l}}$

4. Critical combination of stress

- During summer

At edges during mid day-

At the bottom fiber – load stress tension , warps downward resulting in tension in bottom and frictional stress being compressive

So, critical combination at edge : Load stress + Warping stress – Frictional stress

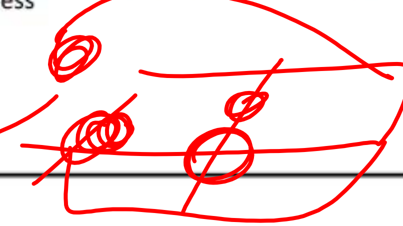
4. Critical Combination of stress

- During winter

At edges during mid day will be the most critical combination where

At the bottom fiber – load stress tension , warps downward resulting in tension in bottom and frictional stress being tensile

So, critical combination at edge : Load stress + Warping stress + Frictional stress



4. Critical combination of stress

- At corner

It occurs at night

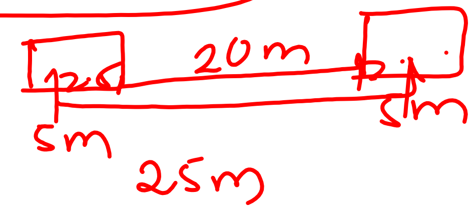
At the top load stress at corner is tensile and warping stress when warping upward (facing upward) tensile stress is at the top

Most critical combination at corner – load stress + warping stress

[Here, frictional stress is not developed at the corner]

On a highway, if the velocity of a moving vehicle on a lane is 40 km/h, stopping distance is 20 m and average length of vehicles is 5 m, what is the basic capacity of the lane?

1. 2000 vehicles per hour
2. 2400 vehicles per hour
3. 1200 vehicles per hour
4. 1600 vehicles per hour



$C = \frac{1000 \times 40}{25}$ = 1600 vehicles/hr/lane

The lost time due to starting delay on a traffic signal is noted to be 3 s. the actual green time is 25 s, and yellow time is 3 s. How much is the effective green time?

1. 31 s
2. 22 s
3. 28 s
4. 25 s

Effective green time:

The effective green time denotes that in the given total time (green time and amber time) saturation flow occurs only for a small length of time. The initial delay for the start of the first vehicle and clearance of vehicles in the amber time causes the flow to be reduced. Or in other words the time during which a given traffic movement or set of movements may proceed; it is equal to the cycle length minus the effective red time.

Thus the effective green time;

Effective green time (G_{eff}) = G + Y - L

Effective green time (Geff) = 25 + 3 - 3

Effective green time (Geff) = 25 sec

The relation between maximum theoretical capacity of a traffic lane (C) and the minimum time headway (H_t) is given by:

1. $C = \frac{4500}{H_t}$
2. $C = 4500 \times H_t$
3. $C = \frac{3600}{H_t}$
4. $C = 3600 \times H_t$

The free mean speed on a roadway is found to be 80 km/h. Under stopped condition, the average spacing between vehicles is 9 m. Determine the capacity flow.

1. 1964 vehicles/hour/lane
2. 2222 vehicles/hour/lane
3. 4230 vehicles/hour/lane
4. 3430 vehicles/hour/lane

Maximum flow or capacity flow (q_{max}):

$$q_{max} = \frac{K_j}{2} \times \frac{u_f}{2}$$

$$K_j = \frac{1000}{S}$$

$$q_{max} = \frac{1000}{2S} \times \frac{u_f}{2}$$

$$q_{max} = \frac{250 \times u_f}{S}$$

Where,

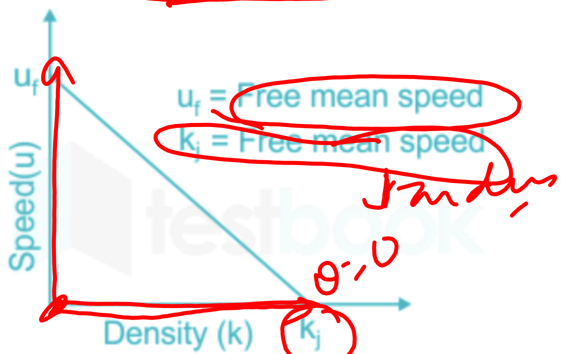
K_j = Jam density

u_f = Free mean speed

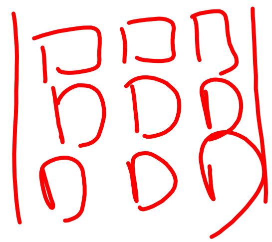
S = Spacing between vehicles

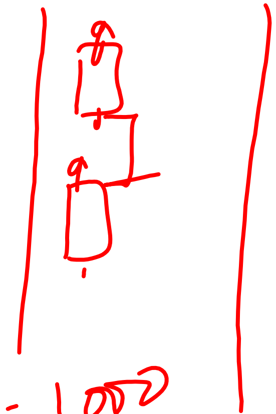
Free Mean Speed:

From the speed-density diagram, it can be defined as the maximum speed at which the number of vehicles in a unit length is zero i.e. density is zero.



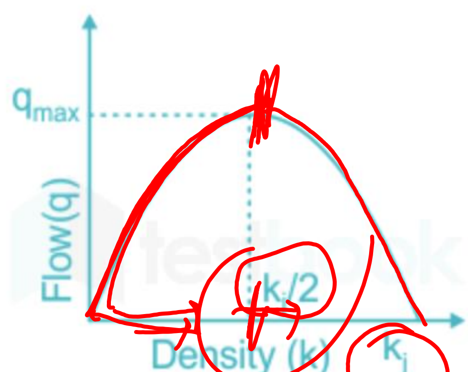
Speed Density Diagram



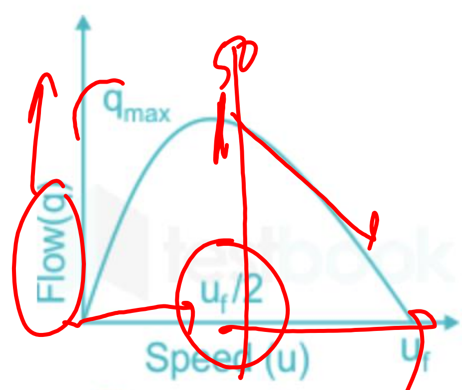


Density:: It can be defined as the number of vehicles per unit length. The unit of measurement is vehicles/km.

Jam Density: From speed-density relation and flow-density curve, it can also be seen that it is the maximum density at which there is no flow on the road.



Flow-density curve (Parabolic)



Flow-speed curve (Parabolic)

Traffic Flow: The number of vehicles passing through a particular point in certain time interval is defined as traffic flow. Also, number of vehicles counted in one hour is called traffic flow (q).

If the jam density is given as k_j and the free flow *speed* is given as u_f, the maximum flow for a linear traffic speed-density model is given by which of the following options?

1. $k_f u_f/4$
2. $k_f u_f/3$
3. $3k_f u_f/5$
4. $2k_f u_f/3$

Flow (q) = Density (k) × Velocity (V)

For Greenshields's Model (Linear Traffic Speed Density M

$$V = V_f \times \left(1 - \frac{k}{k_j}\right),$$

Where,

V = Velocity at any instant

V_f = Free mean velocity

k = Density of the flow

k_j = Jam density of the flow

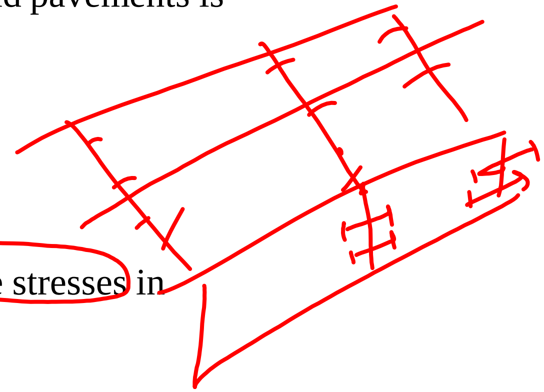
Maximum capacity (q_{max}) = $V_{max} \times K_{max}$

As per Greenshields's model

$$Vmax = \frac{V_f}{2} \;\&\; k_{max} = \frac{k_j}{2}$$

Maximum capacity ⇒ $(q_{max}) = \frac{V_f}{2} \times \frac{k_j}{2} = \frac{V_f k_j}{4}$

1. The maximum thickness of expansion joint in rigid pavements is
   a. 0
   b. 25 mm
   c. 50 mm
   d. 100 mm



1. Temperature variation produce heavy temperature stresses in
a. Flexible pavement
b. Rigid pavement
c. None
d. All of these

As per I.R.C, the maximum spacing of contraction joints is .... in reinforced cement concrete slab of thickness 20cm.

- 4.5m
- 14m
- 45m
- 60 m

Categories of slab	Slab Thickness (cm)	Maximum Contraction Joint Spacing (m)
Unreinforced Slabs	20	4.5
	10	7.5
Reinforced Slabs	15	13.0
	20	14.0

1. As per flexible pavement guideline 2021, The VDF for vehicle type heavy two axle vehicle is taken as

a. 6.50
b. 4.75
c. 1.0
d. 0.35

Vehicle type	VDF	Remarks
Heavy truck (three axle or more)	6.50	
Heavy two axle	4.75	hilly terrain 3.5
Mini truck/tractor	1.0	
Large bus	0.50	
Bus	0.35	

1. Stage construction is not possible in

a. Flexible pavement
b. Semi-rigid pavement
c. Rigid pavement
d. None of these

1. The Maximum axle load for design of road pavement for Nepal is taken as

a. 10.2 tonnes
b. 8.2 tonnes
c. 8.16 tonnes
d. 82 tonnes

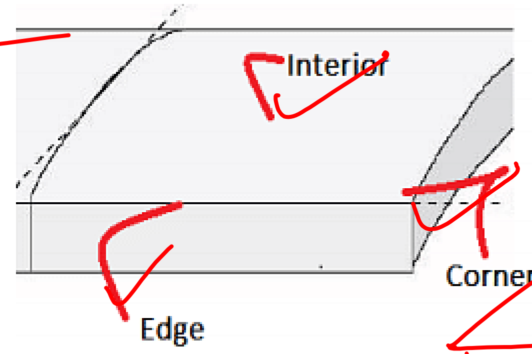
The permissible axle loads in Nepal is taken as 10.2tonnes, 18tonnes and 24 tonnesfor single axles, tandem axles and tridem axles respectively.

1. The permanent deformation along the wheel path in flexible pavement is known as

a. Fatigue cracking
b. Rutting
c. Thermal cracking
d. Frost heave

1. Which of the below is not a critical load position?
   a. Interior
   b. Corner
   c. Edge

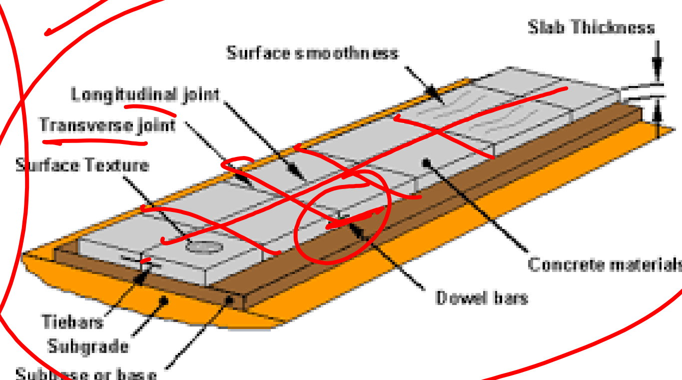
   d. Center



Concrete Pavement slab

2. If there are two wheels on one side of the axle, then it must be converted into
   1.EWL
   2.ESL
   3.ESWL
   4.EL

3. The dowel bars are provided ______
   1. Longitudinally
   2.Laterally
   3.Any direction required
   4.In base of pavement



Activities

Earthwork

- Site Clearance
- Earthwork in filling for embankment
- Excavation for cutting
- Excavation for borrow pit
- Excavation for structural foundation
- Excavation for surface drains
- Disposal of surplus earth

Drainage Works

- Side drains
- Culverts
- Sub-surface drain
- Causeways
- Minor bridges
- Other water management structures

Activities

Structural Works

- Earth retaining structures
- Gully control works
- Landslide stabilization works
- River training works
- Bridge Protection works
- Anchor wall

Pavement Works

- Sub-grade preparation
- Sub-base course
- Base course
- Wearing course

Activities

Miscellaneous Works

- Road furniture
- Traffic sign/signal/marking etc
- Bio-engineering works

Tools, Equipment and Plants Used

- For Capital Intensive projects require equipment, plants to complete the project on time
- For labor intensive projects, generally of small scale could be cost effective than using hand held equipment

Tools

- Shovel,
- chisel,
- peak,
- hammer,
- brushes,
- trowel,
- wheel barrow





Equipment

- **Paving Equipment**
  - Binder storage tank with heating device
  - Binder spreader
  - Aggregate spreader
  - Cement Concrete Mixture
  - Bituminous Mechanical Paver
  - Cement Concrete Paver
- **Lifting Equipment**
  - Backhoe, Loader (for Low Loads)
  - Crane (different capacity)
- **Transporting Equipment**
  - Dumping Trucks (Tippers)
  - Trucks (flat body)
  - Mini dumpers

Equipment

- **Earth Moving Equipment**
  - Dozer
  - Scraper
  - Loader
  - Excavator
  - Backhoe
  - Dragline
  - Clamshell
  - Trench digger
- **Compaction Equipment**
  - Smooth wheel roller
  - Vibrating roller
  - Pneumatic roller
  - Sheep foot roller
- **Leveling Equipment**
  - Motor Grader







Vibrating roller compacting base course



Earthwork

Embankment for filling

Materials

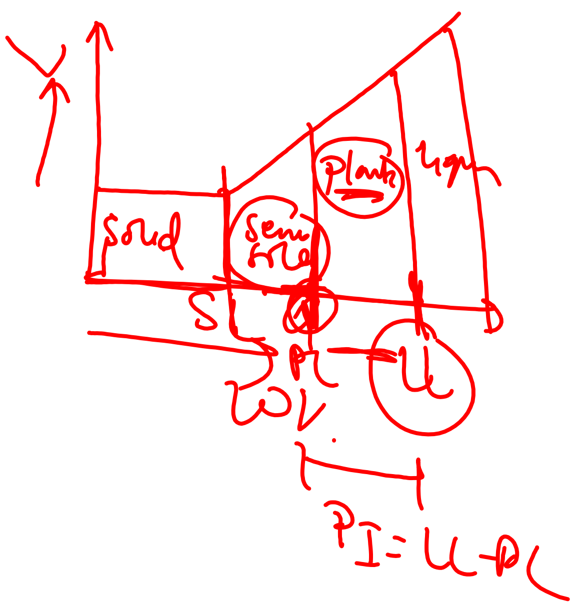
- LL <75% and PI < 40%

Equipment.

- Grader; Roller; tipper and water tanker or manually for small projects

LL.

PI → P index = LL-PL



Earthwork

Excavation for Cutting

The design elements in highway excavation for cutting are:

- **Depth, Stability of foundation, stability of slopes, accommodation of road side drain**

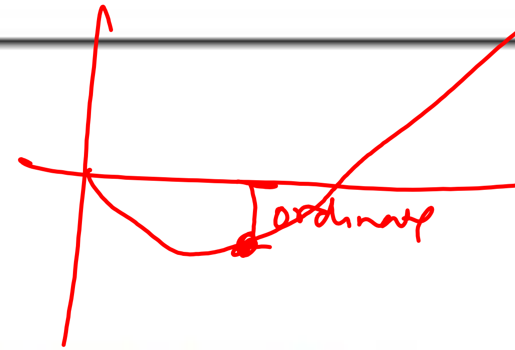
Materials

- LL<75%, PI<40%

Equipment

- Grader, Roller, Tipper, water tanker

Planning of Earth Movement



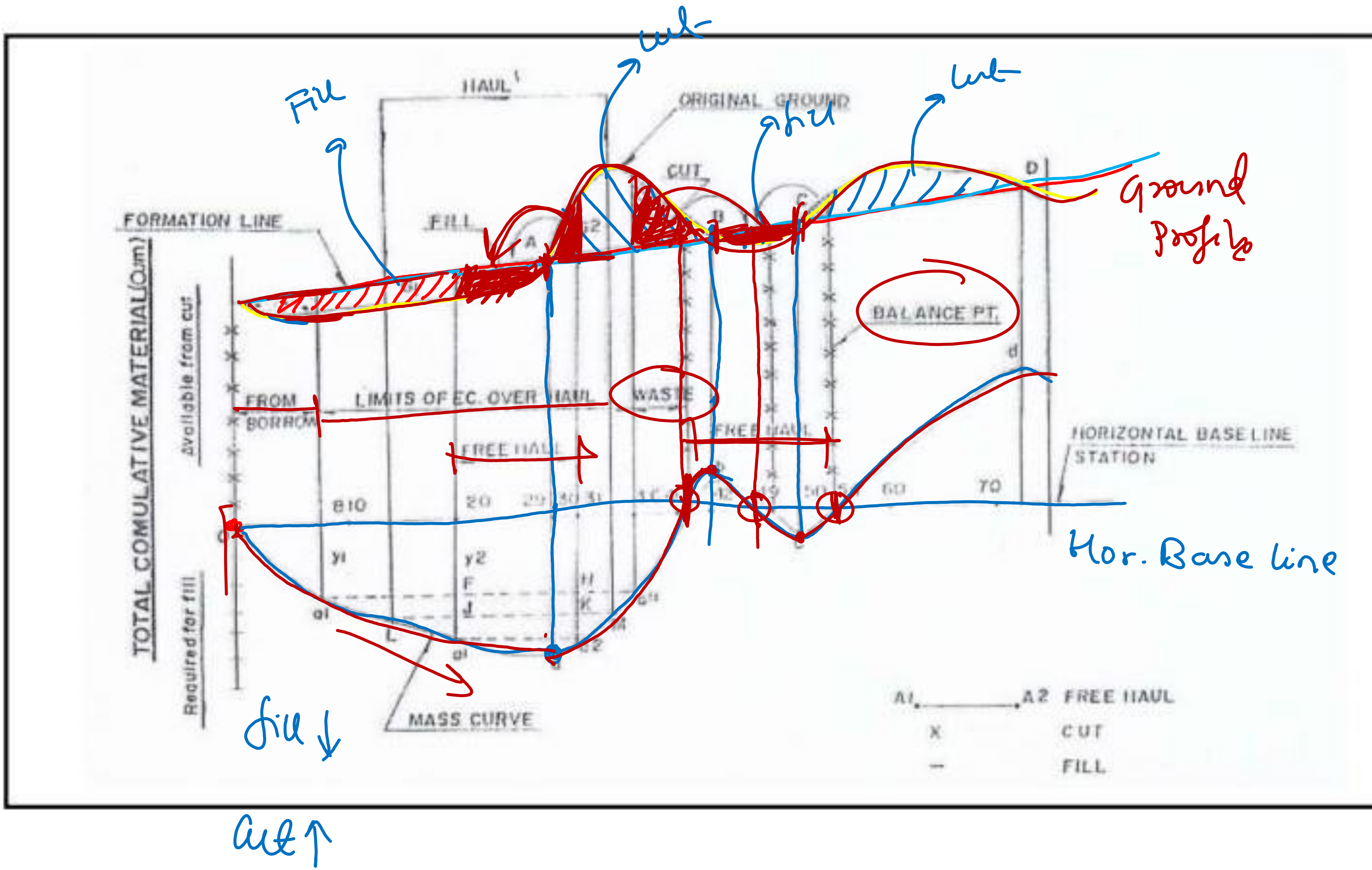
Characteristics of Mass Haul Diagram

- The ordinate at any chainage along the curve represents the earthwork accumulation to that point
  - Maximum ordinate (+) – change from cut to fill
  - Minimum ordinate (-) – change from fill to cut
  - Rising curve – excess of excavation
  - Depressing curve – excess of filling
- **Loops concave upwards** indicate a direction of haul from right to left and loops concave downwards indicates a direction of haul from left to right.
- The algebraic difference between any two ordinate is a measure of total earthwork in that section. Thus $y_2 - y_1$ gives quantity of earthwork in between chainage

Planning of Earth Movement

Mass Haul Diagram

- **Haul**:- In earthwork calculations the term haul has dual meaning. It is used to describe the distance over which material is moved and also the volume distance of material used.
- **Free haul**:- It is the distance to which the contractor is supposed to move the earth without any additional charge. The charge for free haul is covered by the unit rate of earthwork
- **Over haul**: It is the distance in excess of free haul for which the contractor will be paid extra for each unit of haulage.
- **Economic haul**:- When the haul distance are large it may be more economical to waste excavation material and borrow from a more convenient Source than pay for overhauling. Economic haul is a distance to which material from


HAUL
ORIGINAL GROUND
CUT
FILL
FORMATION LINE
TOTAL COMULATIVE MATERIAL (Cum)
Available from cut
Required for fill
FROM BORROW
LIMITS OF EC. OVER HAUL
WASTE
FREE HAUL
BALANCE PT.
HORIZONTAL BASE LINE
STATION
MASS CURVE
A1 A2 FREE HAUL
X CUT
— FILL
Fill
Cut
Ground Profile
Hor. Base line
fill ↓
cut ↑

Planning of Earth Movement

Mass Haul Diagram

a= cost of road way cutting per m^3

b= cost of over haul and tipping per m^3 per km

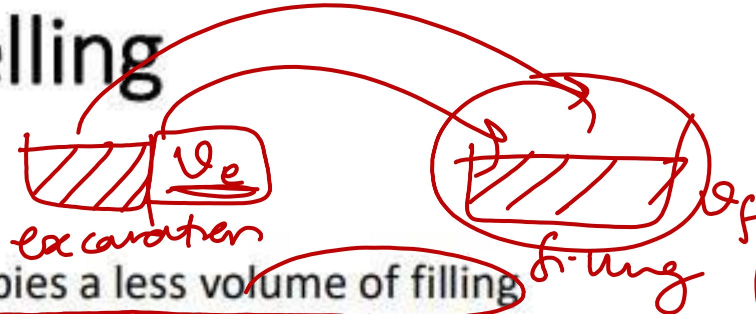
c= cost of borrow material per m^3

L= economic overhaul distance in km

$$a + b * L = c + a \text{ for critical condition}$$
$$L = c/b$$

If F km is the free haul, L is the overhaul distance (maximum overhaul)then, the economic – haul distance = F + L = F + c/b

Shrinkage and Swelling



Shrinkage Factor

- When a given volume of soil occupies a less volume of filling
- Small for sand and gravel and large for clayey soil

$$SF = \frac{V_f}{V_e} = \frac{\frac{W}{D_f}}{\frac{W}{D_e}} = \frac{D_e}{D_f}$$

Swelling Factor

- When a given volume of cutting occupies a greater volume of filling it

$$SF = \frac{V_e}{V_f} = \frac{\frac{W}{D_e}}{\frac{W}{D_f}} = \frac{D_f}{D_e}$$

Subgrade

- Could be over embankment or excavation or on the existing ground profile
- Subgrade as per vertical alignment
- Site should be cleared off and grading is necessary (profile, gradient and cross slope)
- Required dry density has to be achieved

Subgrade

Construction Steps

- Leveling of the completed earthwork to the designed grade and shape by cutting or filling normally up to 20 cm with the help of grader.
- Checking of moisture content and spreading o,f water if necessary'
- Compaction of the leveled sub-grade layer. Compaction is started from edge to centre on straight section and from inner edge to outer edge on super elevated section. This process will be followed during compaction of any pavement layer.
- Checking for camber and grade
- Checking for field moisture and field dry density (95% maximum)

Subgrade

Materials

- LL<75%, PI <40%

Equipment

- Grader, Roller, Tipper, Water tanker

Base Course

- Before prime coat/tack coat or wearing course
- Compacted over sub-base course
- Requirement of compaction in desired density and level (grades) and required cross slopes

Materials

- Clean, hard, strong, tough, durable gravel or crushed stones
- PI – Non Plastic, CBR>80%, FI<30% , LAA<40% and gradation requirement

Equipment

- Grader, Roller, Tipper and Water Tanker

Sub-base Course

- Sub-base course activity includes all activities after subgrade preparation and before base course preparation
- Requirement of compaction in desired density and level (grades) and required cross slopes

Materials

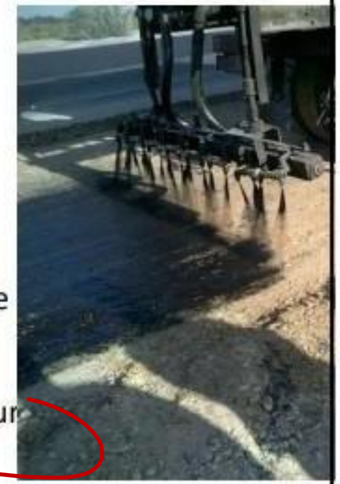
- Clean, hard, strong, tough, durable gravel or crushed stones
- River bed materials or soil mixed quarry gravel or CRM are also suitable
- LL<25%, PI<6%, CBR>30%, FI<30%

Equipment

- Grader, Roller, Tipper and Water Tanker

Prime Coat

- Liquid low viscous bitumen used
- Applied over an porous layers
- Over gravel, water bound macadam and stabilized road
- Usually Medium Curing to Slow Curing Cutbacks of suitable (depends upon void or the surface)
- 0.73 to 1.46 kg/m²
- The prime coat is allowed to be cured for at least of 24 hours



Purpose

- Such that water cannot enter the pavement
- Plug the capillary voids
- Coats and binds dust and loose materials

Seal Coat

- The layer which is applied over porous bituminous surface to seal against the water
- May be provided over a worn bituminous pavement
- Usually
  - single layer surface dressing or
  - premixed sand bitumen (hot mix) seal coat

Purposes

- To seal the Surfacing against the ingress of water
- To develop skid resistance surface

Tack Coat

- High viscosity like the hot bitumen to create bonds between exisiting
  - (old layer of bituminous surface or
  - WBM which has already been treated with prime coat)+
  - With the new bituminous layer
- Spraying rate is 0.49 to 0.98 kg/m²
- Sometimes Emulsion could be used

Grouted or Penetration Macadam

- Aggregates grouted by Bitumen
- Compacted Coarse Stone aggregates is grouted with bitumen followed by the spreading and compacting of key aggregates (intermediate aggregates)
- **Full Grout** – Bitumen Penetrates through the full depth
- **Semi-Grout** – Bitumen Penetrates through half depth
- Full grout in case of heavy rainfall area
- Semi grout in case of average rainfall and traffic
- **Full grout thickness** – 7.5 cm
- **Semi grout thickness** – 5 cm

Grouted or Penetration Macadam

- It is used as a base course
- 25 to 30% of extra bitumen is required as compared to bituminous macadam
- Uniform coverage is not ensured

Grouted or Penetration Macadam

Materials

Bitumen

- 80/100 grade Straight Run Bitumen
- 5 kg/m^2 for 50 mm thickness – Full grout
- 6.8 kg/m^2 for 75 mm thickness – full grout

Aggregate

- LAA – 40%
- AIV – 30%
- Flakiness Index (FI) – 25%
- Stripping Value – 25%
- Gradation – 7.5 cm thick is 63 mm down (Coarse), 25 mm down (Key)
  5cm thick – 50 mm down and 20 mm down

Grouted or Penetration Macadam

Procedure

1. **Preparation** and **intensive cleaning** of the existing surface by broom and air compressor.
2. **Spreading of coarse aggregate** as per the specified rate of application.
3. **Dry rolling** of the spread coarse aggregate at least with 10 ton roller.
4. **Spreading of bitumen** as per specified rate of application.
5. Spreading of **key aggregate** as per specified rate of application.
6. **Rolling of key aggregate** at least with 10 ton roller.
7. Application of **seal coat**.
8. Opening to traffic

Bituminous Bound Macadam

- A premix with coarser aggregate used in binder course or in base course with large void contents
- Open graded aggregates with high **void content** of **20-25%** with **large size aggregates**
- Stability is due to the **interlock** of the **aggregate particles and** the **frictional resistance**
- **Dense Bituminous Macadam** in **Binder course** generally has **less voids of 5 to 10%** contains dense graded aggregate

Bituminous Bound Macadam

Materials

Bitumen

- VG-10, VG – 30 or VG-40, quantity required for premix, 3.5 to 4.5 % by weight
- NO mix design procedure is available

Aggregate

- LAA – 40%
- AIV – 30%
- Flakiness Index (FI) – 25%
- Stripping Value – 25%

Materials

Aggregate Gradation

- For 75 mm thickness of BBM, 37.5 mm nominal size of aggregate is selected
- For 50 mm thickness 19 mm nominal size of aggregate is selected

Bituminous Bound Macadam

Construction Procedure

- Cleaning by brushing, sweeping and air compressor
- Depressed portions are filled up with precoated aggregates and rammed up
- **Tack coat** is applied prior to the application of premix
- **Hot mix method** is used for which is Hot mix plant is used
- Both the aggregate and bitumen are brought together which is heated for 140-160 C (bitumen) and aggregate (100-150 C)
- Mixing for 1 min till a homogenous mix is obtained

Bituminous Bound Macadam

- Through paver paving is done, and laying temp. should be in a range of 110-135 C
- Rolling is done by the **8-10** smooth wheeled or **vibratory roller** (rolling done till no impression is made in the pavement)
- Immediate rolling is done by the **pneumatic tyred roller**
- The finish rolling is done by **6-8 ton smooth wheel tandem roller**

Asphalt Concrete

Materials

Bitumen

- VG-10, VG – 30 or VG-40, quantity required for premix, Has to design for OBC (Max. unit weight, design void content, max. stability)

Coarse Aggregate (Nominal size of 20 mm for 50 mm thick, or 13.3mm for 40-50 mm thick)

  - LAA – 30%
  - AIV – 30%
  - Flakiness Index (FI) – 25%
  - Stripping Value – 25%
  - Soundness – 12%
- The aggregate should be clean, hard, strong and durable
- Requires appropriately proportioned aggregate

Asphalt Concrete

Materials

Fine Aggregate (<4.75mm)

- Free from clay, silt ,organic and other deleterious matter
- Non plastic
- Should be made crushed rock of LAA not more than 30
- Soundness < 12%
- Sand equivalent >60

Filler Material(<0.075 mm)

- Lime stone, hydrated lime, OPC, fly ash or other non-plastic material
- 75% should pass through 75μ sieve

Asphalt Concrete

- Checking of temperature of mix before delivering, during laying and before compaction. The temperature difference should not be greater than 10°C in each activity.
- During the laying of the asphalt concrete mlx, a good coordination between the equipment and labors is very important and shall be maintained.
- Checking the loose thickness manually.
- Follow up level corrections by skilled labors.
- Finishing the asphalt concrete layer before compaction by skilled and corrections at joints while laying on next lane.
- Initial compaction of the asphalt concrete layer by smooth wheel roller.

Asphalt Concrete

- Follow up compaction by pneumatic roller. The rolling shall be continued until the voids measured in the completed layer are within the appropriate range.
- Average density after compaction shall not be less than 98 %. No individual density shall be below 95 % of the average of the laboratory specimens
- Cutting the edge of previously laid mix with edge cutter for laying mix on next lane. The edge cut should be perfectly vertical
- Core sample of the previously laid mix is taken out with the help of core cutter for further necessary laboratory tests