Munir Sir

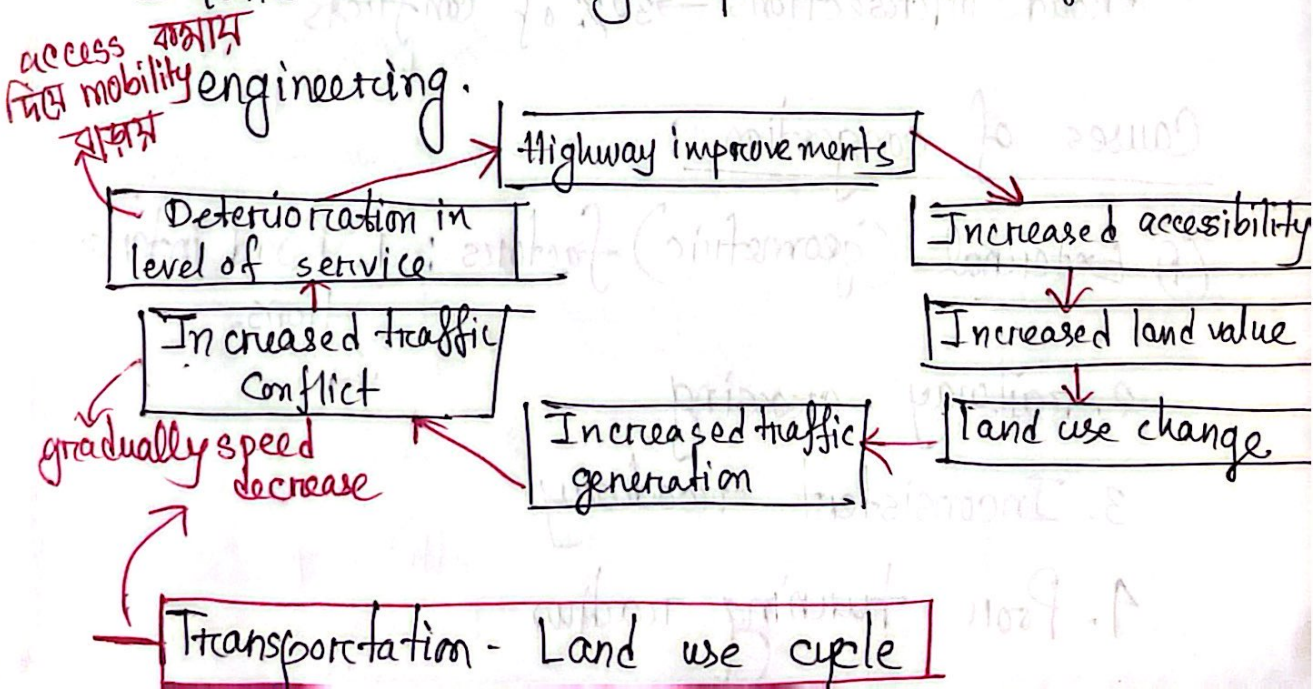
25.04.24

Lecture-01:

Reference books:

1. Transportation engg and Transport planning 7th ed. → L.R. Kadiyali
2. Highway capacity manual.
3. Pavement

Traffic engineering:
→ movement of all types of vehicles
- is the science of measuring traffic and travel.
-
- land use is very important in traffic engineering.



RHD → Roads and Highways department

STP → strategic transport plan (2005)
↓
RSTP → Refined strategic transport plan (2016)

Objectives of Traffic engg.

- improve overall road capacity
- ensure safety

(*) Why traffic engg. is very important now-a-days?

— Bottlenecks → causes of congestion (jam)
  - side entry
  - railway crossing
  - road intersections → 32 points of conflicts

Causes of congestion:

(I) External (geometric) factors: 1. Road intersections.
2. railway crossing
3. Inconsistent roadway
4. Poor turning radius
5. Scattered parking
6. Bus stop/parking near junctions
7. Poor roadway discipline.

(II) Internal factors

Lecture-02: (06.05.24)

Important

Traffic engg. Tools:

(I) Physical measures
(II) Regulatory measures

Physical measures:

(1) To control vehicular movement
- Road signals/markings
- Road divider / channelisation / Islands
- exclusive turning lane / flaring
- ~~Slip road~~ → traffic signal না থাকলে sign use করা হয়
- service road → local traffic এর জন্য parallely slow moving road.
- Bus lay by
- Speed breaker / speed hump
- segregated bus lane

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- Grade separation → urban area / entry to urban area

(ii) To control standing vehicles
- On/off parking
- off street loading/unloading for freight vehicle
- Bus station

(iii) To control pedestrian movement
- Guard rail/median/barrier
- Side walk
- cross walk
  - Grade sperated
  - Overpass

Regulatory measures:
- Banning right turn → right turn-এ jam তৈরি হয়
- One way operation
- (*) Why right turn is banned?
  ⇒ traffic congestion কমানোর জন্য use করা হয়
- speed control
- parking ∪
- ~~Access~~ Road pricing → গাড়ি চালানো বন্ধ করতে তোল টাকা pay করতে হয়।

Traffic volume:

Vph → vehicle per hour
Vpd → vehicle per day

Volume / flow:
- actual number of vehicles observed or predicted to pass a point during a given interval: volume → 1h-এ actual যে গাড়ি চলছে / 1 দিনে যে গাড়ি চলছে
- Rate of flow → 15 mins এর জন্য যতগুলো vehicle যাচ্ছে তা নিয়ে hour-এ convert করা হয়।
- 4 টা 15 min এর data নিয়ে highest টাকে 1h-এ convert করবে।

four counts → 1000, 1200, 1100, 1000

1200 veh / 0.25 h = 4800 veh/h

- Congestion তৈরি হলে তার effect পড়তে থাকবে → ripple effect / flow breakdown → flow যে slow করে দেয় এটা sudden event হতে পারে
- (*) Why 15 mins?
  ⇒ optimization easy

Peak hour flow factor (PHF):

$$PHF = \frac{\text{Hourly volume}}{\text{Peak flow rate (within the hour)}}$$

Capacity: 1h-এর মধ্যে reasonably একটা lane এর traffic condition:

↳ 6টা level of service -এ divide করা হয়।

There are 6 levels of service:

↳ directly related to capacity

(i) Free flow traffic → কোন vehicle দ্বারা affected না

(ii) Steady Traffic → affected হওয়ার কিছুটা কম

(iii) Steady traffic but limited → affected হয়

(iv) Steady traffic at high density → গাড়ি বেড়ে যাবে।

(v) Traffic at saturation → movement কমে গেছে (capacity of that particular road)

(vi) Congestion → stop and go

LOS Urban street:

- based on avg-through vehicle travel speed for the segment or for the entire street under consideration.

Slip road: It is a road traffic lane provided at an intersection to allow vehicles

Service lane: Local traffic হিসেবে use করবে, কিন্তু গাড়ি main road দিয়ে না গেয়ে পাশের রাস্তা দিয়ে যাবে। এটাই service lane.

Lecture-03: 09.05.24

Average Daily Traffic (ADT): The volume during a given time period (in the whole days greater than one day but less than one year) divided by the number of days in that time period and expressed in terms veh/day or Vpd

Average annual daily traffic (AADT): It is the total yearly volume divided by the number of days in a year and expressed in terms of Vpd.

$$AADT = \frac{\text{Total yearly volume}}{\text{number of days in a year}}$$

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Design hourly volume: Economic hourly flow of future year → geometric design এর জন্য use করা হয়।

Scope of traffic volume studies:
- proportions of vehicle in the traffic stream
- hourly/daily/yearly/seasonal variation of flow.
- magnitude (কতগুলো গাড়ি যাচ্ছে), classification (কী ধরনের গাড়ি যাচ্ছে), time (কখন যাচ্ছে), directional split (কোনদিকে যাচ্ছে)

V.V.I

Objectives of traffic volume studies:

(i) Design purpose →
- যেখানে heavy veh যাচ্ছে সেটার structure এবং যেখানে light veh " " " different হবে, Geometric design ও different হবে। (→ radius, turning radius, width)
- Intersection design (including minimum turning path, channelization, flaring) (normal intersection space টাকে flaring দিয়ে বাড়িয়ে দেয়া হয়)

(ii) Improvement purpose →
- বর্তমানে কী অবস্থায় আছে তা examine করা
- traffic control device লাগবে কিনা দেখা।
- কী ধরনের improvement measure লাগবে তা দেখা
- effectiveness of traffic control

(iii) Planning purpose → accurate information on the amount of traffic/veh.

(iv) Dynamic traffic management purpose → signal design নাকি junction improvement দরকার তা দেখা। network productivity

(v) Other purposes →
- estimation of highway use
- measurement of current demand of a facility.

Types of flow:

(1) Interrupted flow → গাড়ি বারবার থেমে আবার চলে
(2) Uninterrupted flow → flow smooth, বারবার থামতে হয়না
(3) Saturation flow → কোনো signal-এ maximum hourly rate. গাড়ির flow যেটা signal মেনে চলে।
(4) Service flow rate → একঘন্টায় specific condition-এ max যত গাড়ি যেতে পারে। যেমন রাতে গাড়ি কম, দিনে বেশি।
(5) Free flow → no restriction, নিজস্ব speed এ গাড়ি চালাতে পারবে যেমন খুশি।

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⑥ Forced flow → lane changing opportunity কম থাকে যখন traffic volume বেশি হয়। সামনের গাড়ি আস্তে চললেপেছনেরও আস্তে চলতে হবে, lane change করা যাবেনা।

⑦ Stable/steady flow → Avg. flow rate almost constant থাকে, demand capacity কে exceed করেনা।

⑧ Unstable flow → Demand capacity কখনো exceed করে ফেলে বা প্রায়শই exceed করে। Avg. rate fluctuate করে।

⑨ Peak flow → flow at peak periods

⑩ Off-peak flow → flow at off-peak/lean periods

⑪ Contra flow → divided highway এ repair কাজের জন্য একটা lane বন্ধ রাখলে অপর lane দিয়ে সবাই যায়। এটা contra flow। এছাড়াও এটা একটা special arrangement on one way road only for bus যেখানে bus opposite direction-এ যেতে পারবে

⑫ Tidal flow → সকালবেলা city center (office এর দিকে) traffic volume বেশি থাকে। Office time কেটে গেলে কমে থাকে। আবার evening-এ বেড়ে যায় office back করার time হলে। এইসে flow condition এটা tidal flow। সময়ের সাথে depend করে tidal flow

⑬ Induced flow → যে flow কোনো facility improve করার জন্য হয়। যেমন— কোনো একটি জায়গায় shopping mall হলে সেখানে flow বেড়ে যায়।

Methods of counting:

① Manual → কোনো location-এ দাঁড়িয়ে physically count করে। tally sheet, mechanical count board use করা হয়।

② Automatic → Pavement-এ loop (inductive loop) করা হয় এবং সেখানে sensor লাগিয়ে count করা হয়।

- Video image processor → Camera দিয়ে video করে পরে সে video দিয়ে count করে। Count করার জন্য specific algorithm use করা হয়।
- Remote traffic microwave sensor (RTMS) → microwave use করে। Radar, ultrasonic এসব দিয়েও data collect করা যায়।

Traffic volume studies:

Counting period → যত সময় ধরে count করবো।

- short duration → roadway improvement ও maintenance এর জন্য।
- long duration → Planning and design এর জন্য

Daily volumes and their use:

- Planning-এ use করা হয়।
- Weekday traffic বলতে working day traffic বুঝায়

Hourly volume: for design and operational analysis, road management.

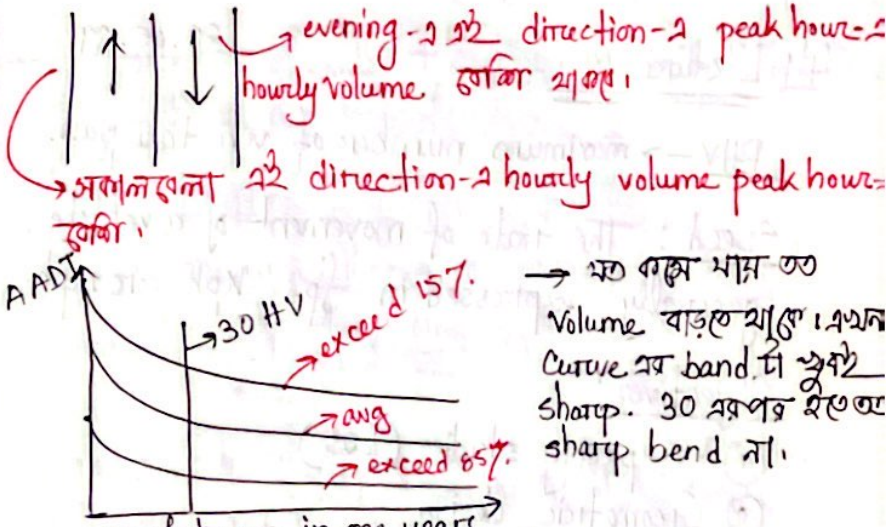
- Hourly volume fluctuate করে কারণ সারাদিন same পরিমাণ গাড়ি চলে না। Morning ও evening হলো peak hour। highest volume যাকুলে এটা peak hour। আর peak hour একটা direction-এ হওয়ার কারণে এটাকে directional design hour volume (DDHV) বলে।

$$DDHV = AADT \times K \times D$$

Where, D = proportion of peak hour travelling in peak direction (decimal)

K = proportion of daily traffic occurring during the peak hour (decimal)

→ সারাবছরের 30th highest peak hour-এ যেই volume পাওয়া যায়



→ এত কম্বা সময় ধরে এত Volume বাড়তে থাকে। এখন Curve এর band টা খুবই sharp. 30 এরপর হতে এত sharp bend না।

V.V.I

(*) Why 30th highest hour?

⇒ economical design এর জন্য 30th highest hour নেয়া হয়। এই 30th hour এর আগের ২৩ hours পর্যন্ত যানজট (Congestion) বেশি থাকে অনেক। যেমন → এদের time-এ গাড়ি অনেক বেশি থাকে normal time-এর চেয়ে। এমন হিসাব করার time এ যদি এই value use করি তবে রাস্তার width, material cost অনেক বেড়ে যাবে। এই 30th hour use করলে এটা economic ও হবে আবার smooth flow ও পাওয়া যাবে।

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Lecture-04:

23.05.24

PHV → maximum number of veh that pass.

Speed: The rate of movement of a vehicle, generally expressed in fps, kph or mph.

Objectives:

(i) Capacity studies (LOS)
(ii) Geometric design
(iii) Accident analysis
(iv) Economic studies

Primary elements of traffic flow:

(i) flow
(ii) Density
(iii) Speed.
(iv) The gap or headway between two veh in a traffic stream.

Flow: (q) is the number of veh passing a specified point during a stated period of time. It is expressed as veh per hour.

$$q = \frac{n \times 3600}{T} \text{ veh/h}$$

q → equivalent hourly flow

n → The number of veh passing a point in the roadway in T sec.

Density: (k) sometimes referred to as concentration. The number of veh traveling over a unit length of highway at an instant.

Types of speeds:

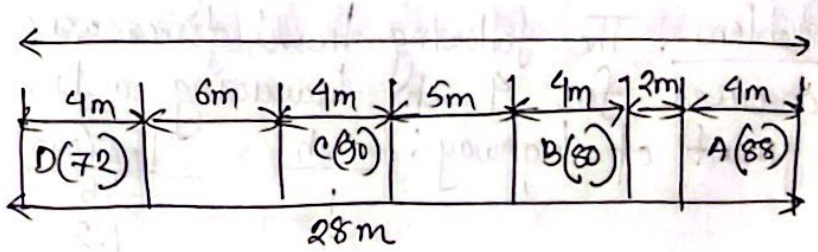
(i) Time mean speed → arithmetic mean
→ সবগুলোকে যোগ করে mean করে।

$$V_t = \frac{1}{m}\sum_{i=1}^{m} V_i$$

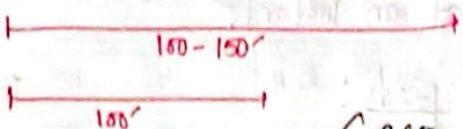
(ii) Space-mean speed → Harmonic mean
→ Unusual data বাদ দিয়ে mean করে।

$$V_s = \left\{ n / \sum_{i=1}^{n} (1/V_i) \right\}$$

Problem: four veh are travelling at constant speeds betn sections X and Y with their positions and speeds observed at an instant in time. An observer at point X observes the four vehicles passing point X during a period of 15 seconds. The speeds of the veh are measured as 88, 80, 90 and 72 km/hr respectively. Calculate the flow, density, time mean speed and space mean speed of the veh.



- highspeed-এ গাড়িগুলো move করবে বড় লাইন অংশ দেখাবে।
- কম speed-এ ছোট লাইন অংশ।



Solution: (i) flow: $q = N\left(\frac{3600}{t_{measured}}\right)$

$= 4\left(\frac{3600}{15}\right) = 960$ veh/h

(ii) Density: $K = \frac{N}{L} = \frac{4}{28\times10^{3}} = 142$ veh/km

→ Whole number নিয়ে হবে

→ m থেকে km-এ নিলে /ft অথবা mile-এ নিবে।

(iii) Time mean speed:

$\bar{V}_t = \frac{1}{N}\left(\sum_{n=1}^{N} V_n\right) = \frac{1}{4}(72+90+80+88)$

$= 82.5$ km/h

(iv) Space-mean speed:

$\bar{V}_s = \frac{N}{\sum_{n=1}^{N}\frac{1}{V_t}} = \frac{4}{\frac{1}{72}+\frac{1}{90}+\frac{1}{80}+\frac{1}{88}} = 81.86$ km/h

Problem: The following travel times were observed for 4 veh traversing a 1 mile segment of highway:

veh	Time (min)
1	1.6
2	1.2
3	1.5
4	1.7

Calculate the space and time mean speeds of the veh.

Soln: (i) Time mean speed:

$\frac{1\text{ mile}}{1.5\text{ min}}$ = speed হিসেবে add করবো

$\bar{V}_t = \frac{1}{4}\left(\frac{1}{1.6}+\frac{1}{1.2}+\frac{1}{1.5}+\frac{1}{1.7}\right) = 0.68$ mpm

$= 40.8$ mph

(ii) Space mean speed:

$\bar{V}_s = \frac{4}{(1.6+1.2+1.5+1.7)} = 0.67$ mpm

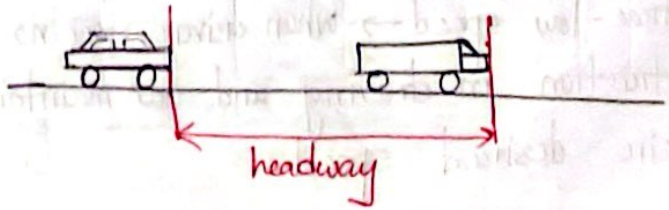
$= 40$ mph

Headway:

- roadway capacity যের করার জন্য এবং level of service এর জন্য লাগবে।

(i) Time headway → difference between the time একটা গাড়ি একটা point cross করলো পরের গাড়ি ঐ point কত time-এ cross করবে, সেই time difference টা।

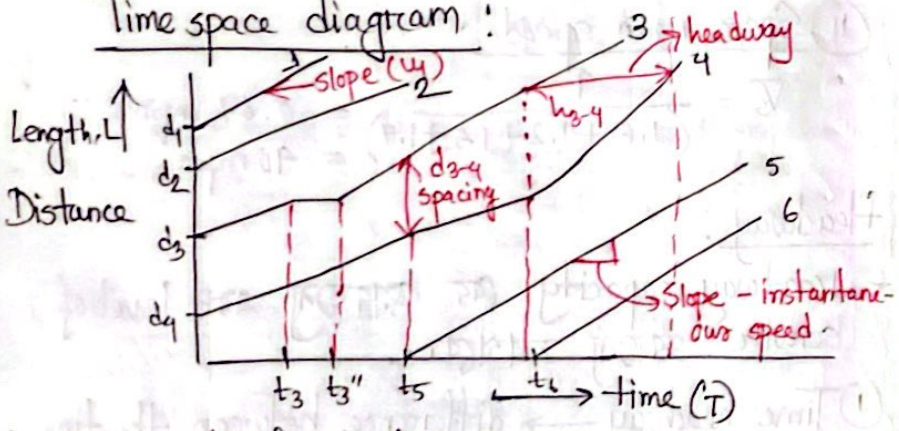
(ii) Space headway → distance between the front of a vehicle and the front of the following vehicle.



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(iii) Spacing or distance headway → distance between successive vehicles in a traffic stream as measured from two corresponding points on the vehicles (eg. front bumpers)

Time space diagram :



Different form of speed :

(i) Spot speed → instantaneous speed

(ii) Running speed → avg. speed while in motion
(চলার সময় journey speed বলে)

(iii) Journey speed → Overall speed including stops.

(iv) free flow speed → when drivers face no restriction in driving and can maintain their desired speed.

(v) Operating speed → the speed at which drivers are observed operating their vehicles during free flow conditions.

Different forms of Speed :

1. Safe speed → 85th percentile speed
(বেশি বেশিবার আক্সিডেন্ট 85 এর speed)
2. Design speed → 98th " "
3. Median " → 50th " "
4. Speed limit → upper limit → 85th percentile
lower " → 15th "
5. Modal speed → speed at the highest frequency
6. Pace → একটা range এর মধ্যে সেখানে বেশির data
পাওয়া যায় 10 km

- Speed data free flow condition-এ collect করা হয়।

Math : following data was collected →

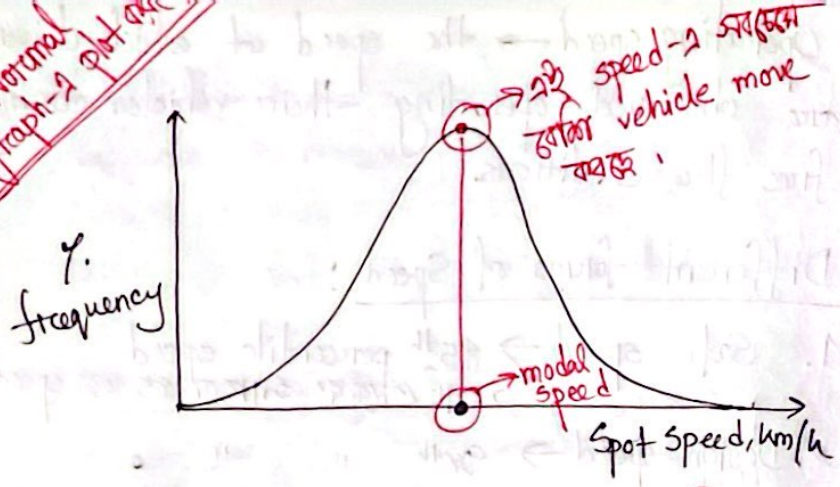
$$\text{frequency} = \frac{\text{no of vehicle observed}}{\text{total vehicle}} \times 100$$

$$\text{Mild speed} = \frac{\text{sum of speed range}}{2}$$

$$V_{avg} = \frac{\text{sum}(f \times v)}{\text{sum}(f)}$$

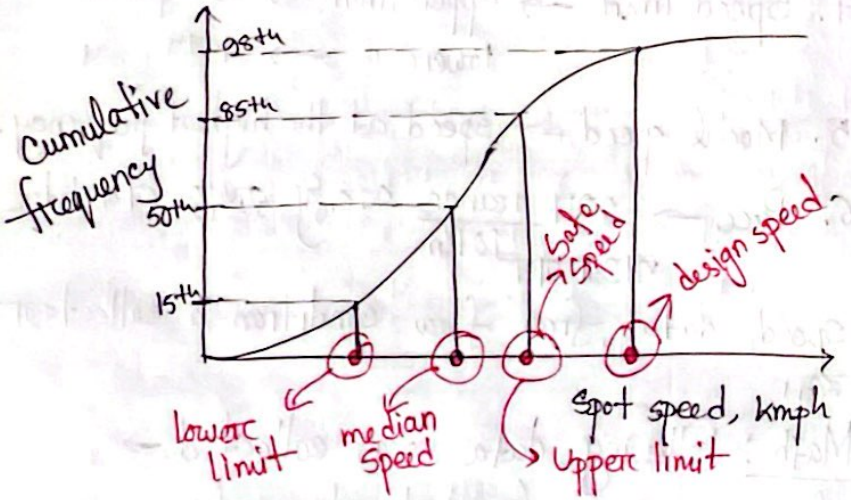
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Normal graph-এ plot করে



এই speed-এ সবচেয়ে বেশি vehicle move করছে।

Pace → কোন 10 km এর মধ্যে data বেশি হয়?



Lecture-05:

30.05.24

Design speed → 98th

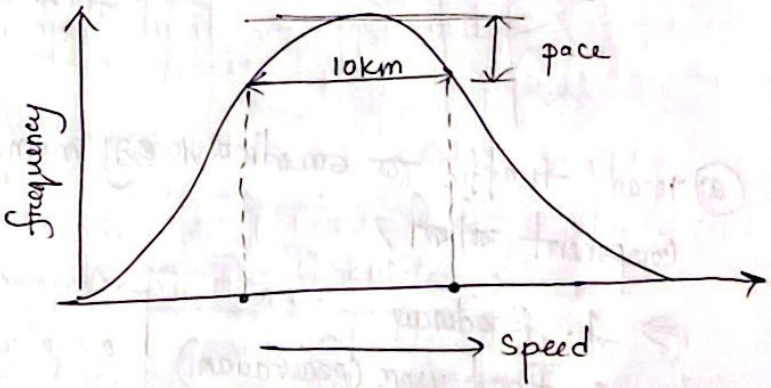
Safe speed → 85th

Median " → 50th

Modal " → highest frequency

Lowest speed → 15th

pace → যে 10 km এর মধ্যে সবচেয়ে বেশি data পাওয়া যায়



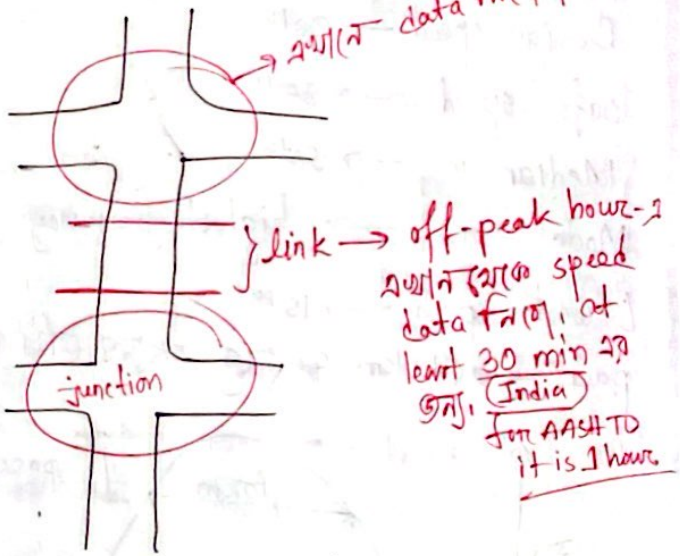
Spot speed → instantaneous speed of the vehicle.

(*) What is the importance of spot speed?

⇒ 1. Speed zoning → speed limit করার জন্য

2. frequency of accident যেখানে বেশি → Crash study (curve, sharp band area)

Speed data : কোন কোন জায়গায় data নিবে ?



→ এখানে data নিবেনা

→ off-peak hour-এ এখান থেকে speed data নিবে, at least 30 min এর জন্য। (India) for AASHTO it is 1 hour.

④ road traffic কে smooth করার জন্য main component কীকী ?

⇒ 1. Roadway
2. Road user (pedestrian)
3. Vehicle
4. Roadway environment

→ Components of a highway

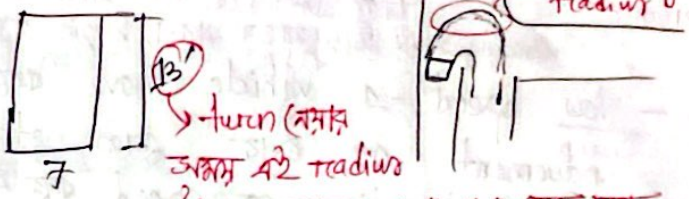
→ রাস্তার condition খারাপ, smooth traffic ensure করে কিনা।

Design vehicle :

- design vehicle is that vehicle that is the highest configuration

① highest/largest vehicle which will use the highway on frequent basis

② Its dimension (length, width, turning radius) will dictate the road.



→ turn নেয়ার সময় বড় radius হলে মায়, 1.4 গুণ বেড়ে যায়।

Parameters of Design vehicles :

- AASHTO → 19টি vehicle কে different road এর জন্য design vehicle হিসাবে নিয়েছে।

Road traffic system criteria :

→ road design কে influence করে।

Vehicle static characteristics that influence the highway design:

turning radius, parking lot ← ① Length → road এর turning radius কে influence করে, parking lot কে affect করে

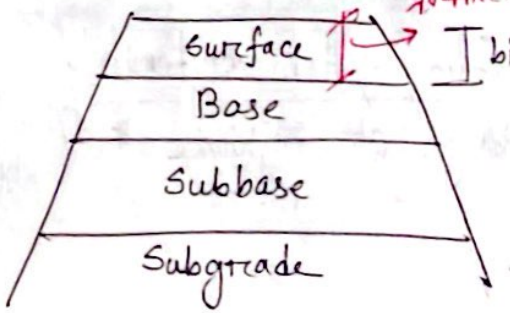
② Weight → structural design of the road, bridge, tunnel কে affect করে

lane width ← ③ Width (রাস্তার lane width কে influence করে)

design of the pavement (thickness)

overhead clearance ← ④ Height → রাস্তার উপরে কোনো bridge থাকলে height টাকে influence করে। height বেশি হলে bridge গুলি দিয়ে যাওয়া যাবেনা, bypass করে যেতে হবে।

- low speed (Creep) - এ vehicle move করলে pavement এর উপর বেশি stress দিবে। junction কে speed কমে যায়। toll plaza তে speed কমে যায়। এই এলাকা গুলোর structural design আরও strong করতে হবে, thickness বাড়াতে হবে।





Online class:

Cumulative graph থেকে → 98th, 85th, 15th, 50 এগুলো পাবো।

⑤ When are spot speed studies needed?

Data collection:

- free flow condition, usually during off peak hours for 1 hour at least 30 vehicles
- weekday তে data নিবে।

Sample size of speed data:

- কতটুকু precision (confidence level) চাই তার উপর depend করে।
- level of significance, α = (100 − confidence level)

- যদি কোনো data - এর confidence level 90% হয় তবে এর error 10% এর বেশি হবে না।

error = 100 − confidence level

- accident এর ক্ষেত্রে commonly used confidence level 95% → এটাকেই sample data বলা হয়।

$$N = \left(\frac{z\sigma}{d}\right)^2$$

N = minimum sample size of a data
(lowest number of data)

z = number of standard deviations corresponding to the required confidence level.

95% - এ	z = 1.96
99% - এ	z = 2.58

→ memorise
must memorise

σ = standard deviation (mi/h)

d = limit of acceptable error in the avg speed estimate (mi/h)

Example: As part of a project, a group of students collected a total of 120 spot speed samples at a location and determined from this data that the standard variation of the speeds was ±6 mi/h. If the project required that the confidence level be 95% and the limit of acceptable error was ±1.5 mi/h. Determine whether the students satisfied the project requirement.

Soln:

যদি z = 99% এর জন্য হয় তবে z = 2.58 বসে N = যেই value পাবো সেটাও requirement fullfill করবে।

z = 1.96
σ = ±6
d = 1.5

$$\therefore N = \left(\frac{1.96 \times 6}{1.5}\right)^2$$

$$= 61.45 < 120$$

Hence, the requirement fullfills.

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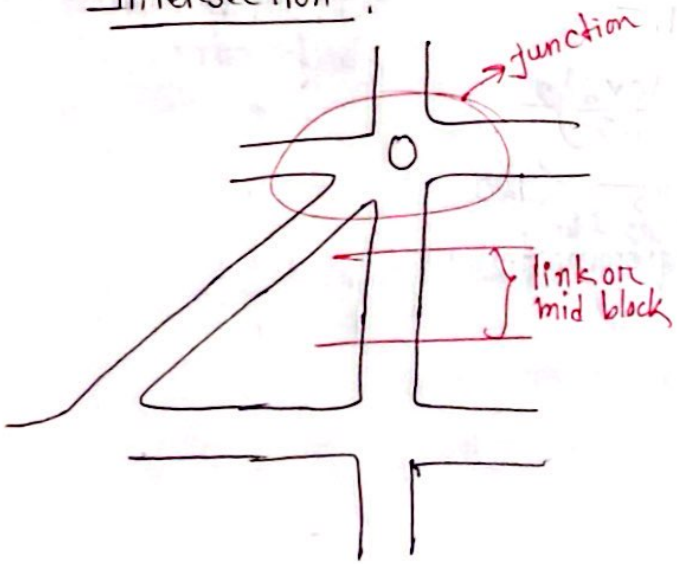
Road Traffic system:

- four components →
  - (I) Road
  - (II) Vehicles
  - (III) Road users
  - (IV) Environment

Road:

1. for moving traffic
   - at grade
   - grade separation

Intersection:



- bridge শুরু হওয়ার আগে থেকে শেষ আরও উঁচু থাকা রাস্তা কে viaduct বলে।

for stationery traffic:

- parking areas
  - Bus lay-by
- Terminals
- loading /unloading areas

Roadway furniture:

- Median
- Divider
- Channel
- Island

19 design vehicle in AASHTO greenbook

Vehicular characteristics:

Design vehicles:

- larger physical dimension
- frequently যে large vehicle চলে তা design vehicle
- cars, buses, trucks, recreational vehicles → design vehicle

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(iv) What should be the design vehicle?

- In design vehicle selection example →

(i) parking lot → passenger car

(ii) Residential street → Single unit truck

(iii) local or country road → large school bus

(iv) WB67 →

Critercia that influence vehicle characteristics

(i) Static characteristic
(ii) dynamic "
(iii) kinematic "

Static/physical characteristics :

(i) Axle load
(ii) Width of vehicle
- 1/3rd load → সামনের wheel-এ
- 2/3rd load → পিছনের wheel-এ

(iii) Length → long vehicle বাড়লে রাস্তার capacity কমবে।

(iv) Height

(v) Radius of curvature. → high speed-এ curve বড় রাখতে হবে।

Length of vehicle :

Affects : length বাড়লে capacity কমবে

- Gantry

- Minimum turning path :
- is defined by the outer trace of the front overhang and the path of the inner rear wheel.

→ Internal criteria of vehicle which control its Kinematic characteristics : motion

- কারণের কোনো force কে consider না করে vehicle এর নিজের force (acceleration / deceleration) এর জন্য যদি move করে।

Importance :

- passing maneuvers
- Gap acceptance

(i) সামনের গাড়ি স্লো high speed-এ move করতে হবে cross করার জন্য
(ii) Opposite direction থেকে আসা কোনো গাড়ি একটা গাড়ি আরেকটা গাড়িকে cross করার সময়

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high speed → distance বেশি
low speed → distance কম
} Gap distance.

- Safe passing distance
- Max deceleration rate is required to know safe stopping distance.

PIEf time → কতটুকু safety distance এ car stop করবে।

- inbuilt criteria of vehicle → কতক্ষণ move করতে পারবে, stop হতে পারবে।

Dynamic characteristics:

- air resistance → Very important for aircraft
- Grade " → Grade যত sharp হবে energy তত বেশি লাগবে।
- Rolling " → কতবার direction change করতে হবে
- Curve " → curve sharp হলে
- friction " → rough road - এ resistance বেশি।

06.06.24

Lecture-06:

Traffic control device:

- signal sign
- road sign
- barrier
- sign/Markings

includes:

- Signs
- Markings
- Signals

purpose:

- to regulate
- to warn
- To guide traffic

Traffic control devices should: (requirement)

- fullfill a need → must be reasonable and appropriate for the traffic requirements at the locations used.
- Command attention & respect of drivers and pedestrians
- Convey a clear and simple meaning - legible at long range and understandable at a glance.
- Give users time for proper response.

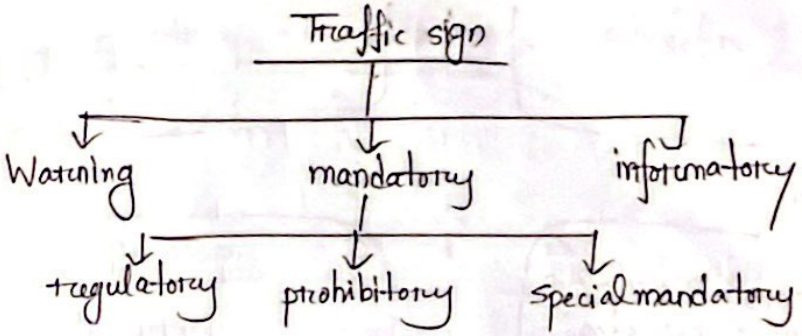
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- be uniform in design and application → the size, shape, color of the device / letter / symbol, mounting height and lighting should be uniform and consistent
- be visible at day and night (both).
- be maintained at high standard
- used conservatively
- should not be used alone.

Design
placement
Chiformity
Operation
maintenance

Traffic signs :

- mainly used to →
  - inform drivers about regulation
  - adjust their lane position and speed
  - guide them to reach their point of interest



Warning or Cautionary signs : (Should follow)

- purpose is to warn
- crossroads → আমাদের রাস্তা আরো আলাদা বা নির্দেশ দেয়।

Mandatory signs : (shall follow)

- Inform users about law and regulations of traffic

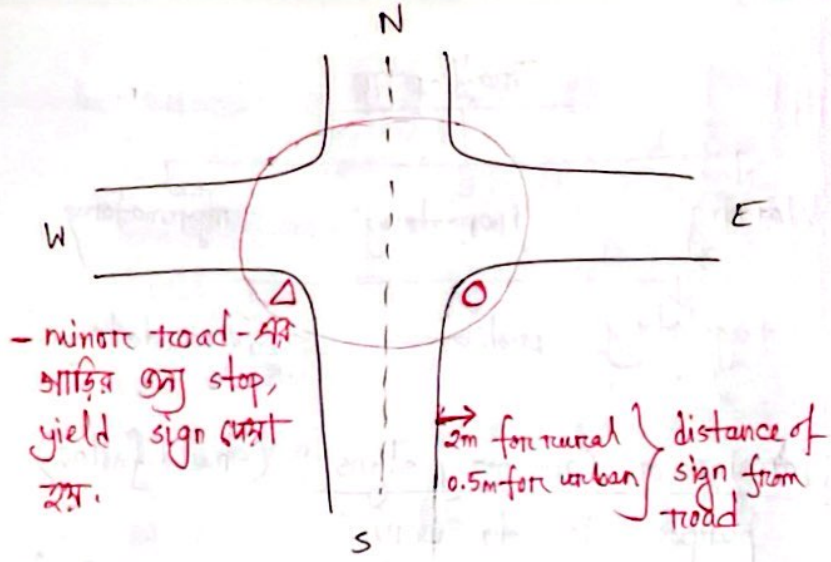
regulatory → কোনো কিছুর নির্দেশ দিচ্ছে

Prohibitory → কোনো কিছু নিষেধ করা হচ্ছে

Special mandatory → yield, stop



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North - south → major road
east - west → minor road

- yield sign দেখালে vehicle slow down করতে হবে এবং major road check করতে হবে। যদি major road এ কোনো গাড়ি না থাকে তবে intersection cross করা যাবে। যদি major road - এ গাড়ি থাকে তবে stop করতে হবে।

- Stop sign দেখালে intersection - এ stop করতে হবে। কারণ এতে sight distance is not clear.

Informatory or guide sign: (may follow)

- information দেয়.

Sign dimension:

- placement:
  - left side of the road
  - Open/rural → not more than 2m away
  - Urban → " " " 0.5m "

Suplementary plate:

- sign যাতে ভিন্নভাবে বুঝতে পারে তাই নিচের দিকে (sign এর) আরেকটা plate দেয়া হয়.

- Sign vandalism

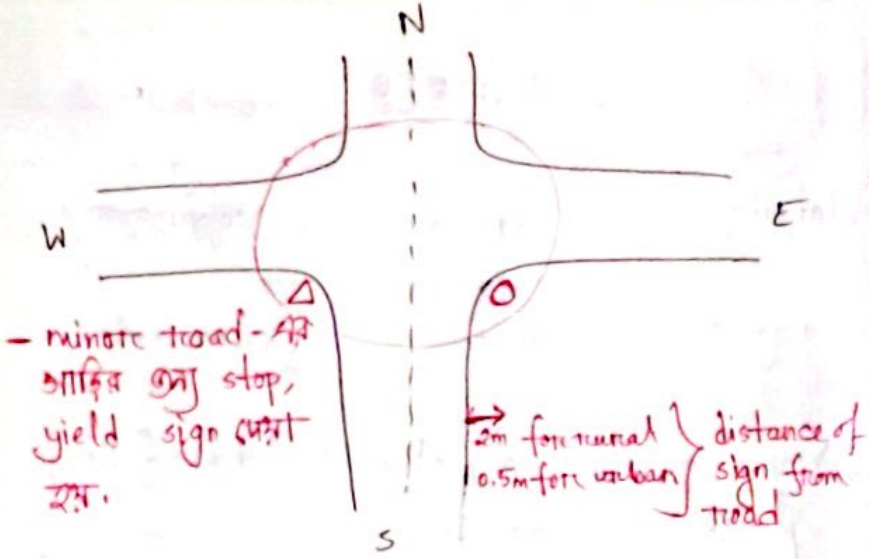
VMS (Variable message sign):

- real-time information দেয়

Chevron arrows:

- retro reflecting material use করা হয়। এতে light পড়লে reflect করবে.

Scanned with CamScanner



North - south ⟶ major road
east - west ⟶ minor road

- yield sign যেখানে vehicle slow down করতে হবে এবং major road check করতে হবে। যদি major road এ কোনো গাড়ি না থাকে তবে intersection cross করা যাবে। যদি major road - এ গাড়ি থাকে তবে stop করতে হবে।

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Sign problems in BD:

- existance of misguiding sign

V.V.I

Traffic signals:

- is a physical device

advantage:

- Provide orderly movement of traffic
- handling capacity → increase
- Reduce frequency of accident

Disadvantage

- increase certain type of accident
  - → pedestrian accident

Types of signal controllers:

- Fixed-time controller (offline system)
  - → isolated (for a single intersection)
  - → linked/ coordinated
    - → simultaneous
    - → progressive



simultaneous → সবগুলো intersection-এ একসাথে একই signal দেয়া।

progressive → intersection এ আলাদা আলাদা signal দেয়া।

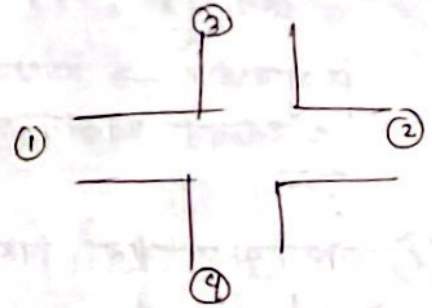
(i) কীভাবে বুঝবো কোনটা দিব? ⇒ (i) traffic flow (ii) Distance of intersection

- Vehicle actuated controller
- Modern computer based area coordinated controllers
  - → Area traffic control (ATC)
  - → Adaptive/ self optimizing
    - → AI use করা হয়

Warrants for the use of traffic signals:

- traffic flow

→ flow on major road (1+2) ≥ 900 veh/hour
and " " minor " (3/4) ≥ 100 veh/hour



— average of the 4 busiest hours over any weekday / one eight hours on an average day.

Lecture-07: 27.06.24

Isolated traffic signal Design:

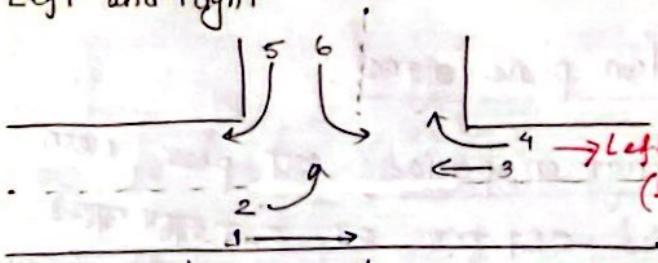
- Sequence → Green > Amber (yellow) > Red > Red/Amber
- Phase
- filter signal

Phasing:

(*) What is phasing?

⇒ A phase is the sequence of conditions applied to one or more streams of traffic which during the cycle receive simultaneous

Left and right



→ Left hand drive (ইউরোপের বেশির ভাগ দেশে এই ব্যবস্থা)

1, 3, 4 active in phase-1 — কাদের সবুজ বাতি জ্বলবে
1, 2 active in phase-2 তা depend করে volume
5, 6 active in phase-3 of traffic এর উপর

Potential phase diagram:

— The timing for traffic is defined

Signal aspects (Amber period):

— The amber period is given a standard duration of 3 seconds (High speed junction 3-6 sec) and the red/amber 2 seconds.

Colors	red	red amber	Green	Amber
Signal indication				
Meaning	Stop & keep Stopping	Prepare to go but do not move	Go	Clear the intersection but do not cross the stop line
Duration (s)		2		3

A two phase signal:

Intergreen period: একটা phase green period যখন শেষ হয় তখন আমরা আরেকটা phase-এর green period শুরু হয়না। মেই time পরে শুরু হয় সেটাই intergreen period.

All red period: সব phase-এ red দেখানো হয়। red + red/amber এর timing

- Intergreen period এর মধ্যে All red period আছে।

- All red period → is a red period between the amber and red/amber shown to all approaches in order to allow vehicles to clean the junction safely before starting

Junction size
traffic condition
Vehicle flow
Geometric design
} All red period depends on these things.

- Intergreen period মানে হলো একটা phase এর green শেষ হলে আরেকটা phase-এর green শুরু হতে যে সময় লাগবে।

Intergreen period: range between 5 to 12s for a distance of 9 to 74m for straight ahead movement.

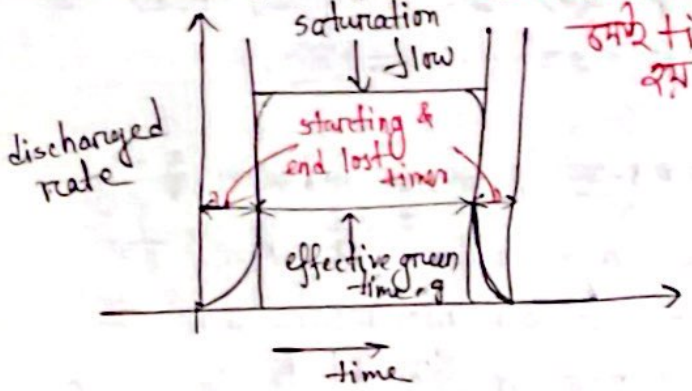
Saturation flow (→ maximum allowable flow): is the maximum flow expressed in pcu's (Passenger Care Unit), that can be discharged from a traffic lane when there is a continuous green indication and a continuous queue on the approach. off-peak hour-এ data নেয়।

- The saturation flow is independent of traffic and control factors.

- যে ধরনের care থাকুক সেটাকে passenger care এর অনুপাতে count করাকে pcu বলে। rickshaw এর pcu = 2

Effective green period :

→ saturation flow তাই time-এ বদল।



- saturation flow তে যেই vehicle move করছে তার timing কে effective green time বলে।
- green period এর শুরুতে গাড়ি slow movement শুরু করে জোগে initial lost time বলে।

Green + Amber = g + Lost time ($L_i + L_e$)

Lost time :

lost time per phase = starting lost time + end lost time

≈ 2 seconds

Amber time ≈ 3 secs.

effective green time

$g = G + A - \text{lost time}$

$g = G + 3 - 2$

Cycle time and delay :

- cycle time বেশি হলে proportion of lost time will be more.
- cycle time খুববেশি হলে stop line এ clear করে যাওয়া stop line এ বসিবে।

(25s to 120s) → range of cycle time.

Optimum cycle time (C_o) :

- The cycle time which gives the least average delay to all vehicles using the intersection.

Degree of trafficking :

- denoted as (y)

$y = \frac{\text{The flow on the approach}}{\text{saturation flow of the approach}}$

(8) How to determine the optimum cycle time (C_o)?

$$C_o = \frac{1.5L + 5}{1 - Y} \text{ seconds}$$

$L \rightarrow$ total lost time per cycle

$Y \rightarrow$ is the sum of the max y value for all phases comprising the cycle as explained above

Signal sequence → G → A → Red → R/A

filter signal → Suppose, কোন্ direction এর জন্য red দেয়া কিন্তু বাম্পার বা ডানে যাওয়ার জন্য green দিয়া থাকে।

Terminology পড়তে হবে।

Mid syllabus → Lec (9-5) পর্যন্ত slide pdf 35 page-এর পড়তে হবে।

Graph এর বড় math আসবেনা, ছোট ছোট math আসতে পারে।

(*) কখন all red দেয়া হয়?

⇒ pedestrian scramble

⇒ চারদিকের veh stop থাকবে, একদিকে veh যেকোনো দিকে যেতে পারবে।

Lecture-08: 04.07.24

Terminology imp all definition: formula imp for math

(1) Cycle time, $C = \int (S, q, L)$

(2) Intergreen period, $I = a + \text{all-red}$

(3) Cycle time, $C = \Sigma G + \Sigma I$

(4) Green period, $G = g + L_i + L_t - a$

(5) Total lost time cycle = Σ all-red + Σ lost time (initial and end lost time)

(6) Right of way = G + A + g + lost time

⑦ Maximum/dominant ratio of flow (q) to saturation flow (s) for a given phase of lane, $y = q/s$

⑧ Optimum cycle, $C_o = (1.5L+5)/(1-Y)$ in seconds

sum of all max y values ← $Y = y_1 + y_2 + \cdots + y_n$

⑨ For optimum conditions,

$$q_1/q_2 = y_1/y_2 = (C_o - L)/Y$$

V.V.V.I

Problem-1: Design a two phase signal of an isolated cross-junction for the following data:

traffic flow, speed এগুলোর data

Ambere	= 3s
Red/ambere	= 2s

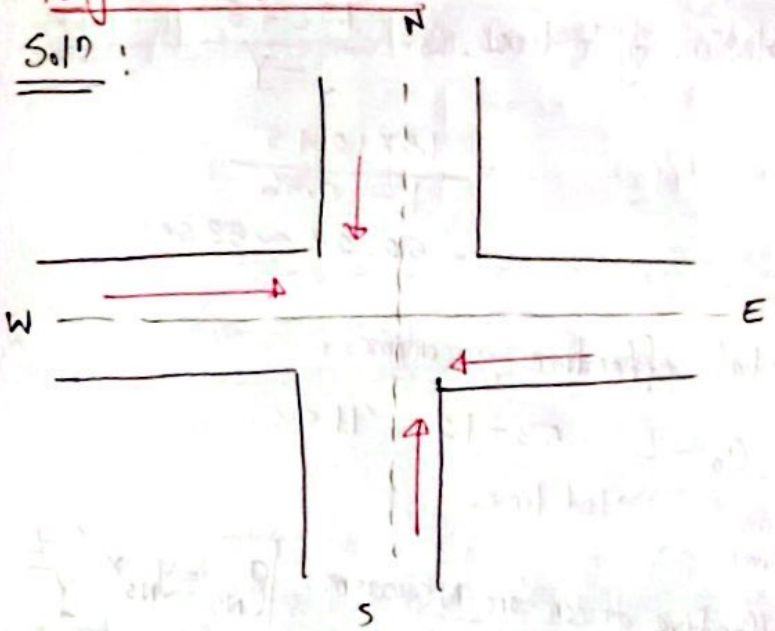
নিচে set করা হয়

	N-S	E-W
Intergreen in (s) =	6	7
Lost time in (s) =	3	2

	North	South	East	West
Arrival flow (PCU/hr)	400	450	560	458
Saturation flow (PCU/hr)	1800	1780	1850	1780

figure আঁকতে হবে

Soln:



- Degree of traffic বের করতে first - 2

$$y = \frac{\text{flow}}{\text{saturated flow}}$$

$y_{north} = \frac{400}{1800} = 0.22$

$y_{south} = \frac{450}{1780} = 0.25$

$y = \text{flow/sat.flow}$ = North 0.22 < South 0.25 → 0.25; East 0.30 > West 0.26 → 0.3

$y_{dominating}$ → design এর জন্য যত y নিতে N-S, E-W এর কোনটা the max y value

$Y = y_{NS} + y_{EW} = 0.56$

L → total lost time = all red + green ends lost times

$= \frac{\text{sum}(i-a) + \text{sum}(l)}{(6-3)+(7-3)+3+2}$

$= 12s$

i = intergreen time
a = ambere time
l = lost time

Optimum cycle time, $C_o = \frac{1.5L + 5}{1 - Y}$

$= \frac{1.5 \times 12 + 5}{1 - 0.56}$

$= 52.27 \sim 53$ sec

Total effective greentime,

$C_o - L = 53 - 12 = 41$ sec

(C_o → Optimum cycle time; L → lost time)

Effective green for NS (North-south) arm, $g_{NS} = Y_{NS} \times \frac{C_o - L}{Y}$

$= 0.25 \times \frac{41}{0.56}$

$= 18.30 \sim 19$ sec

Effective green for EW (east-west) arm,

$g_{EW} = Y_{EW} \times \frac{C_o - L}{Y}$

$= 0.30 \times \frac{41}{0.56}$

$= 21.96 \sim 22$ sec

$G + A = g + L$

$g = G + A - L$

Green + Amber period for NS arm $= G_{NS} + A$

$= g_{NS} + l$

$= 19 + 3 = 22$ sec

$\therefore G_{NS} = 22 - A = 22 - 3 = 19$ sec

(G_{NS} → Green aspect of the signal)

Green + Amber period for EW arm $= G_{EW} + A$

$= g_{EW} + l$

$= 22 + 2$

$= 24$ sec

$\therefore G_{EW} = 24 - A = 24 - 3 = 21$ sec

(G_{EW} → Green period)

G_{NS}	=	19s
Intergreen NS	=	6s
G_{EW}	=	21s
Intergreen, EW	=	7s
Cycle time, C_o	=	53s

42 math-এর কাছে rounding করলে always higher value নিবে. ex- 20.1 ~ 21 নিবে

এটা বেশি হয়ে যাবে কারণ rounding করে math করা হয়েছে।

eqn দ্বারা বের করা C_o এর সাথে মিলতে হবেনা। কখন এটা মিলতেও পারে নাও পারে। তাই এখানে যোগ করে যেই C_o পাবো সেটি ans.

V.V.I.P

Problem-2 → H.W

Lecture-09: 11.07.24

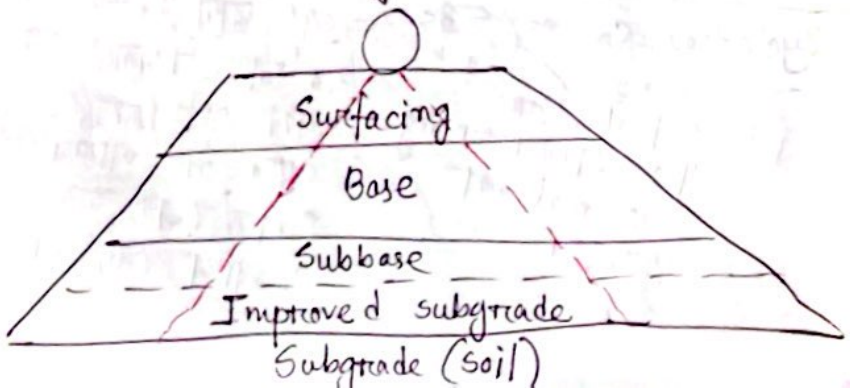
L-10

Pavement Design:

- Transportation engg -এ অত্যন্ত important pavement design.

Pavement: A multi-layer system that distributes the vehicular loads over a larger area.

- Pavement gradually load একটা layer থেকে আরেকটা layer এ transfer করে শেষে subgrade(soil)-এ distribute করে দিবে।



- soil-এ যখন load পাঠালে তা soil এর bearing capacity এর মধ্যে থাকতে হবে।

function of pavement:

(i) Wheel load

(ii) Temperature change এর কারণে load আসতে, stress develop করবে

Desirable characteristics of pavement:

- sufficiently thick হতে হবে যাতে load distribute safely করতে পারে।
- thickness is depended on vehicle
- structurally sound enough to withstand the stresses
- dust free হতে হবে।
- riding quality ভালো হতে হবে।
- smooth হতে হবে। খুবেবেশি smooth হলে slip করতে পারে সমাধান roughness থাকতে হবে।
- low friction, roughness থাকতে হবে।

Types of Pavement : 3types

(i) flexible → layered system
↳ black top road
HMA → Hot Mixed Asphalt
AC → Asphalt Concrete
high type bitumen

(ii) Rigid → load from flexural strength
↳ Mostparking lot এবং রাস্তায়
CC
Concrete

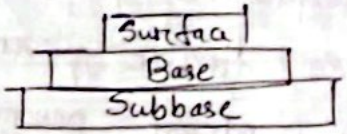
(iii) Composite/semi-rigid → consists of HMA and PCC
↳ নিচে rigid উপরে flexible pavement
PCC → Portland Concrete cement

Basic structural elements of flexible Pavement ;

(i) Surface course → bitumen এর সাথে small, fine agg mix করে top layer তৈরি করা হয়।

(ii) Base course → brick/agg/stone এর তৈরি।

(iii) Subbase course → sand/crushed stone দিয়ে তৈরি।



flexible pavement ;

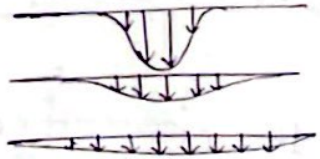
- load বেশি আসলে HMA use করে।
- load কম " BST " "
  BST → Bituminous Surface Treatment
- 50mm এর Asphalt তৈরি করা হয়, district অনুযায়ী vary করে।
- Depending on the temperature at which it is applied asphalt is catagorized as →
  (i) Hot mix asphalt
  (ii) Warm " "
  (iii) Cold " "

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- aggregate interlock এর মাধ্যমে load distribute করে.

- Hot Mix asphaltic pavements are classified as flexible pavement কারণ load আসলে pavement bend করবে।

- top surface → angular aggregate use করা হয়, যার ফলে Compaction বেশি হয় এবং load bearing capacity বেশি সবচেয়ে বেশি load আসবে। তাই top layer-এ সবচেয়ে ভালো material দিতে হবে। যত নিচে দিবে ততো quality drop করবে।



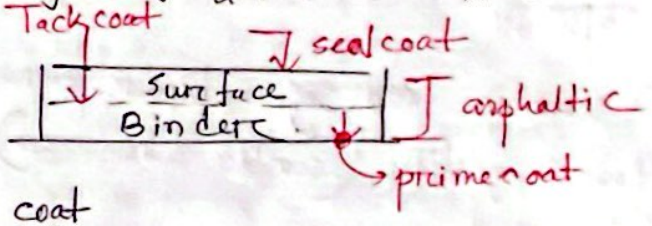
যত নিচে যাবে area বাড়বে, stress intensity কমবে।

Types of flexible pvt:

(i) Conventional pvt → widely used
(ii) Contained rock asphalt mat (CRAM)
(iii) Full depth Asphalt pvt

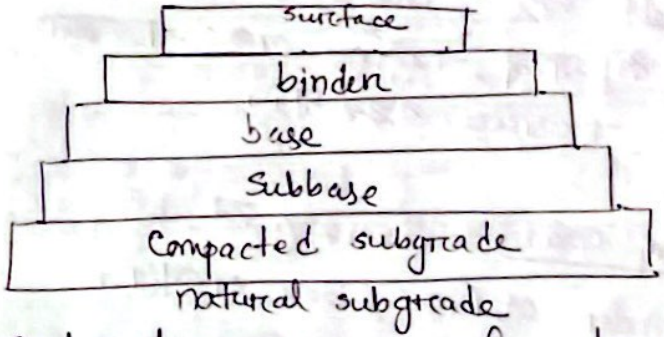
Conventional pavement:

- Top layer কে দুইভাগে ভাগ করা হয়।



Seal coat

tack coat → দুইটা asphaltic layer কে একসাথে রাখে



Seal coat: thin surface treatment used to water-proof the surface and to provide skid resistance.
→ Slip করবেনা।

Tack coat: binder এবং surface course এর মাঝামাঝি। It is a very light application of asphalt, usually asphalt emulsion diluted with water.

① 50 mm (or, 75 mm) এর বেশি pit thickness হলে asphalt কে একসাথে layer করা যায়না।

② economic করার জন্য binder course low quality (surface course থেকে) use করা হয়।

- destructive distibtion of crude oil থেকে asphalt পাই : crude oil কে সরাসরি use করা যায়না, refine করে হয় ফলে অনেক residue পাওয়া যায়।

Prime coat :⇒ Viscosity কম থাকে.
penetrate করে
- binder এর নিচে, base এর উপরে।
- absorbent surface হিসেবে কাজ করে।
- base course (agg layer)
- binder (asphaltic layer)
- base course এর void বন্ধ করে prime coat উপরে দিয়ে চলে আসে এবং binder course এর আগে layer তৈরি করে।

PCC → Rigid concrete

⑧ Difference between prime coat and Tack coat?

Surface course :
- Dense graded asphalt concrete
  ↳ সব size এর particle uniformly থাকে

Base, course : - load distribute করে।
- drainage, frost resistance হিসেবে কাজ করে।
- pore এর মধ্যে পানি থাকলে শীতকালে তা অনেক বরফ হলে volume বৃদ্ধি করে ফলে pore pressure বাড়বে। তা resist করে।

Lecture-10 : 22.08.24

Subbase course : ① properties of HMA
- সবচেয়ে lower quality material use করা হয়।
- original soil ভালো হলে subbase লাগেনা।
- CBR value বেশি হলে soil নিজেই load carry করতে পারে।
- minimize intrusion of fines

Subgrade : 95% compaction করা হয় for desired density
↳ moisture content বেশি করে দেয়া হয় যাতে void কমে, load bearing capacity বাড়ে।

CRAM → asphalt বেশি use করা হয়।
- contained rock asphalt mats

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asphalt layer → high quality
aggregate layer → dense / open graded
asphalt layer → low quality

→ cost বেশি — asphalt surface এ বেশি থাকে (13-15%)

full depth asphalt :- base-এ কম থাকে (2-5%)
- subgrade এর উপর direct place করা হয়।
- top layer-এ asphalt বেশি থাকে। (5-6% upto 11%)
- base-এ 3% এর নিচে asphalt থাকে।

Types of pavement : based on gradation →
(i) Dense graded → high stability (best)
(ii) Open " → fines কম (drainage layer হিসেবে parking lot-এ use হয়)
(iii) Uniformly " → limited use
(iv) Gap graded → middle sized agg. নাই
rutting prevent করে।

Rutting → highway তে lane বরাবর wheel যেখান দিয়ে যায় heavy load এর কারণে wheel path বরাবর depression হয়।

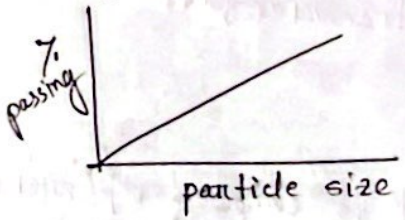
- Rigid pavement কে concrete pavement ও বলে।

HMA → hot mixed asphalt
AC → Aphalt concrete
→ Flexible pavement

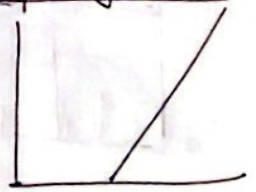
Lecture-11 :

03.09.24

Dense graded : best for road construction



Open graded : parking lot এর জন্য ব্যবহৃত হয়

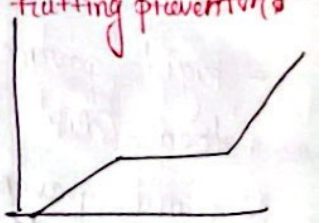


Uniform graded :

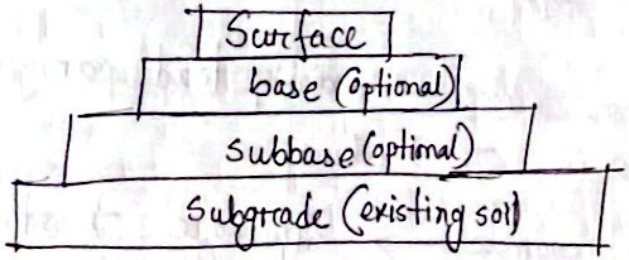
use করা হয়না



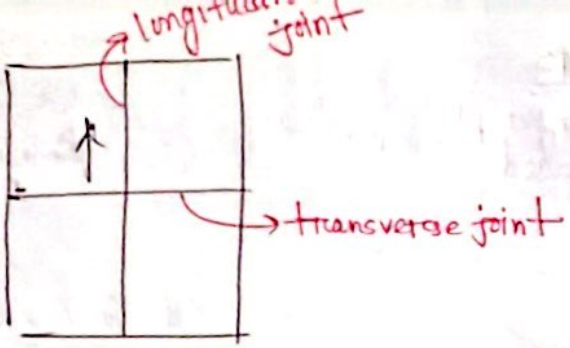
Gap graded : rutting prevention এ



Rigid pavement :



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- A rigid pavement is composed of hydraulic cement concrete surface course.
- rigid pavement beam হিসাবে কাজ করে → load নেয়।
- rigid pavement - A অনেক বড় area তে load carry করে কম pressure এর।
- soil quality low হলে rigid pavement use করবে।
- Surface course → mainly load carry করে
  ↳ 6-12 in এর thickness
- Base course → drainage, frost resistance এর জন্য important

reasons to use base course:

(i) Control of pumping → serious problem
(ii) " " frost action → salt দিয়ে minimize করে।
(iii) " " Shrinkage and Swell
(iv) Drainage
(v) Expedition of construction

- Subbase → frost action, drainage

Where rigid pavements are warranted?
⇒ Where extra performance (due to stationary, slow loading condition, stopping & starting area)

- Bus pull out/layby
- Junction

Rigid pavements are 4 types:

(i) JPCP → Jointed plane Concrete pavement
(ii) JRCP
(iii) CRCP
(iv) PCP → খুবকোর use হয় commercially.

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– Dowel bar → transverse joint এর নিচে একবারথেকে অন্য বারে load transfer এর জন্য use করা হয়।

Lecture-12 : 10.09.24

(*) Comparison between flexible pavement and Rigid pavement.

	FP	RP
1. Design method	Empirical method	Elastic theory
2. Material	granular	Cement concrete
3. Flexural strength	খুবই negligible	high rigidity
4. Bending	সহজেই bend হয়	সহজে bend হয়না
5. Normal loading	Elastic deformation	beam এর cantilever হিসেবে কাজ করে
6. Excessive loading	local depression	cracks
7. Stress	Vertical and compressive in lower layer	Tensile stress
8. Temp	No stress	Stress is produced দিনে sagging curve
9. Force of friction	Less	high → 21 days লাগে
10. Surfacing	Rolling of surface needed	not needed
11. load distribution	Grain to grain	No such phenomenon
12. Economy → life cycle cost analyes করা হয়	construction cost less but maintenance cost high	life cycle অনুযায়ী best construction cost high but maintenance cost less
13. Design life	Low	high
14. Opening to the traffic	Roads can be used for traffic within 24h of construction	Road cannot be used until 14 days of curing
15. Types of road Construction	Constructed in number of layers	laid in slab with steel reinforcement

V.V.I

Pavement Design factors :

- Objectives of structural design of pavements →
  1. to determine total thickness of pavement structure
  2. to determine the individual layers thickness

V.V.I

- Performance (life cycle) of pavement depends upon →
  - (I) Traffic forecasting
  - (II) Weather "
  - (III) Pavement design
  - (IV) Construction control
  - (V) Maintenance practices
  - (VI) Overweight veh control

- Performance period → flexible pavement → 3/4 টি performance period থাকবে

এরজন্য, যদি pavement টির short period এর জন্য design করা হয় then upper layers আবার change করতে হয়।

- এমন pavement যখন তৈরি হয় তখন তার condition কে initial serviceability বলা হয়। 4.5 to 5

রাস্তা ০০ বছরের জন্য design করা হলে এর মধ্যে এমন একটা পর্যায়ে আসে যখন রাস্তা আর deteriorate করলে ব্যবহার উপযোগী থাকেনা।

- terminal serviceability 2 to 2.5

- Analysis period → performance period থেকে ছোট হয়।

Design factors : 4 catagory

1. Traffic and loading
2. Environment
3. Material
4. Failure criteria

The traffic and loading to be considered include :

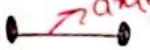
1. Axle loads
2. Number of repetitions
3. Contact area
4. Veh speed

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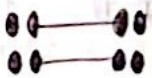
Axle load:

- structural design করতে heavy veh কে বিবেচনা করা হয়।

Axle configuration:



Single axle with single wheel



Tandem axle dual tires



Single axle with dual wheel



Tridem axle

- সব configuration কে standard-এ নেয়া হয়েছে।



Standard axle

- Standard এর সাথে তুলনা করে calc করা হয়।

Number of repetitions:

damaging factor

Small veh 2000 repetitions < heavy veh 1 repetitions

Equivalent axle load factor: (EALF)

- standard axle একবার রাস্তায় চললে যে damage হয় তাকে standard ধরে calc করা হয়। এরজন্য একটা factor আছে।
- সেকোনো veh রাস্তায় চললে 18kip (80kN / 8 tonnes) single axle load এর তুলনায় যে পরিমাণ damage হয়তে সেটাই EALF (its a ratio)
- 18kip এর তুলনায় small veh এর EALF 1 থেকে কম হবে।
- 18kip এর তুলনায় large veh এর EALF 1 এর বেশি হবে।

(ESAL) Equivalent single axle load: total no of passes of standard axle load during the design period.

$$ESAL = \sum_{i=1}^{m} f_i n_i$$

m = no. of axle load groups

f_i = is the EALF of the ith-axle load group

Suppose, 10 years design period-এ total কতগুলো diff pass হচ্ছে, সবগুলো standard axle এর তুলনায় কতগুলো axle load আসছে।

n_i = no of passes of the ith-axle load group

-design period-এ যতগুলো গাড়ি চলবে তাদের standard axle load এ convert করলে ESAL পাবো।

$$EALF = \left(\frac{L_x}{18}\right)^4$$ → for single axle load

L_x → load in kip on a single axle

for tandem / tridem axles,

$$EALF = \left(\frac{L_x}{L_s}\right)^4$$

→ L_s is the load in kip on standard axle which have the same number of axles as L_x.

Ex-6.9:

Determine the EALF for 5000 lb (22.3 KN) and 50000 lb (223 KN) single axles. If the EALF of a 32 kip (142 KN) standard for tandem tandem axle is 0.857, determine the EALF for 15000 lb (66.8 KN) and 80000 lb (356 KN) tandem axles.

Soln:

Single axle, $EALF = \left(\frac{L_x}{18}\right)^4$ → always in kip

$$= \left(\frac{5}{18}\right)^4 = 0.006$$

$$EALF = \left(\frac{50}{18}\right)^4 = 59.59$$

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for tandem axles, $L_x = 15$, $L_s = 32$

$$EALF = \left(\frac{L_x}{L_s}\right)^4 = \left(\frac{15}{32}\right)^4 = 0.0483$$

$L_x = 80$, $EALF = \left(\frac{80}{32}\right)^4 = 39.06$

to obtain the equivalent factor between tandem axles and 18 kip - single axle,

15 kip, 80 kip

$$EALF = 0.0483 \times 0.857 = 0.041$$

$$EALf = 39.06 \times 0.857 = 33.47$$

23.05.24

Types of speeds:

(i) Type Time mean speed → arithmetic mean

সব গুলোকে যোগ করে mean করে

$$V_t = \frac{1}{m} \sum_{i=1}^{m} V_i$$

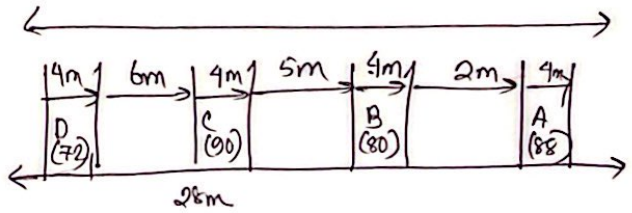
(ii) Space-mean speed → Harmonic mean

unusual data বাদ দিয়ে mean করে

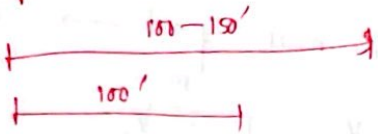
$$V_s = \left(n / \sum_{i=1}^{n} (1/V_i) \right)$$

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Problem: four vehicles are travelling at constant speeds between sections X and Y with their positions and speeds observed at an instant in time. An observerc at point X



- highspeed-এ গাড়িযেখানে move করবে সেখানে বড় লাইন আঁকব
- কম speed-এ ছোট লাইন আঁকব



Solution:

① **flow:** $q = N\left(\frac{3600}{t_{measured}}\right)$

$= 4\left(\frac{3600}{15}\right)$

$= 960$ veh/hr

② **Density:** $k = \frac{N}{L} = \frac{4}{(28\times10^{-3})} = 142$ veh/km

↳ m থেকে km-এ নিলে / ft থেকলে mile-এ নিবে

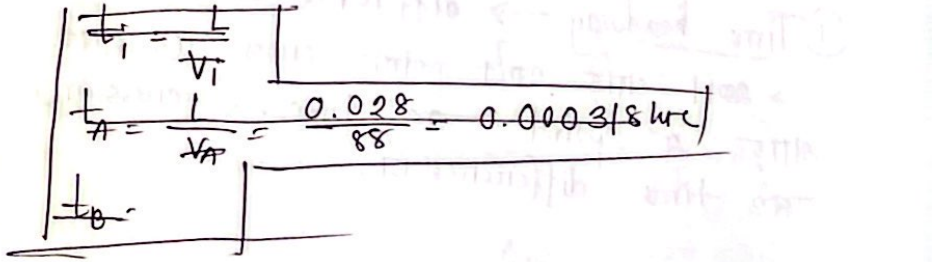
③ **Time-mean speed:**

$$\bar{V}_t = \frac{1}{N}\left(\sum_{n=1}^{N} V_n\right) = \frac{1}{4}(72+90+80+88)$$

$= 82.5$ km/hr

④ **Space-mean ~~time~~speed:**

$$\bar{V}_s = \frac{N}{\sum_{i=1}^{N}\frac{1}{V_t}} = \frac{4}{\frac{1}{72}+\frac{1}{90}+\frac{1}{80}+\frac{1}{88}} = 81.86$$



Problem: The following travel times were observed for 4 vehicles traversing a 1 mile segment of highway:

Vehicle	Time (min)
1	1.6
2	1.2
3	1.5
4	1.7

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Calculate the space and time mean speeds of the vehicles.

Soln:

$\frac{1 \text{ mile}}{1.6 \text{ min}}$ = speed এর মান add করতে।

(i) Time mean speed = $\frac{1}{4}\left(\frac{1}{1.6} + \frac{1}{1.2} + \frac{1}{1.5} + \frac{1}{1.7}\right)$

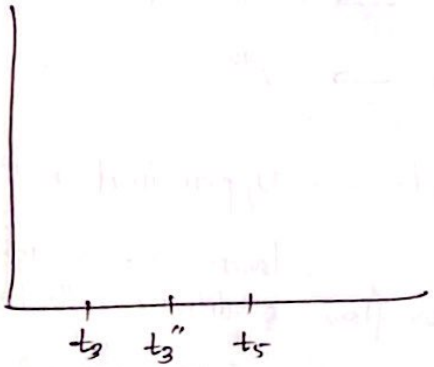
Headway: → roadway capacity এবং roadway level of service এর উপর নির্ভর করে।

(i) Time headway → difference between the time
↳ একটা গাড়ি একটা point cross করলে পরের গাড়ি ঐ point এ কত time এ cross করবে, তার time difference ই T.

(ii) Space headway → distance between the front of a vehicle and the front of the following vehicle.

(iii) Spacing or distance headway → distance between successive vehicles in a traffic stream

Time space dia



Different form of speed:

(i) Spot speed → instantaneous speed

(ii) Running speed → Avg. speed while in motion
↳ কখনো একে journey speed বলে।

(iii) Journey speed → Overall speed including stops.

(iv) free flow speed → when drivers face no restriction in driving and can maintain their desired speed.

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(v) Operating speed → the speed at which drivers are observed operating their vehicles during

1. Safe speed → 85th percentile speed.
2. Design " → 98th " "
3. Median " → 50th " "

4. Speed limit → Upper limit → 85th percentile
   lower " → 15th "

- speed data free-flow condition-এ collect করা হয়।

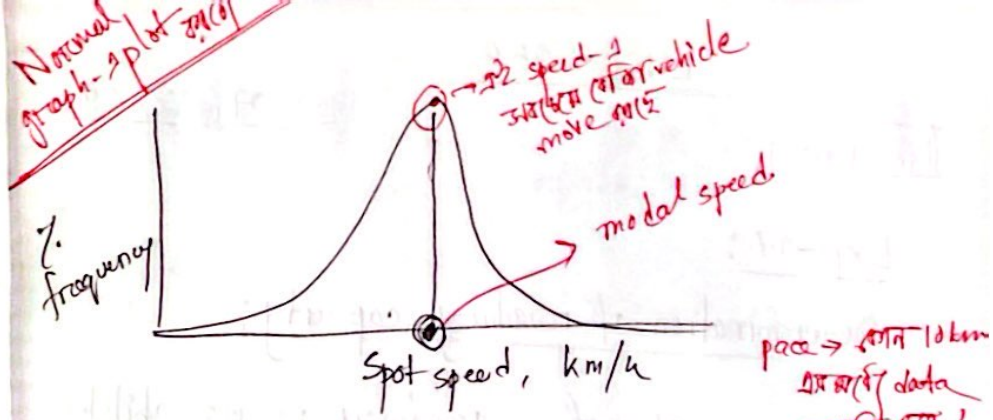
Pace: একটা range এ অধিক সংখ্যক গাড়ির data পাওয়া যায়।
10km

Math: following data was coll

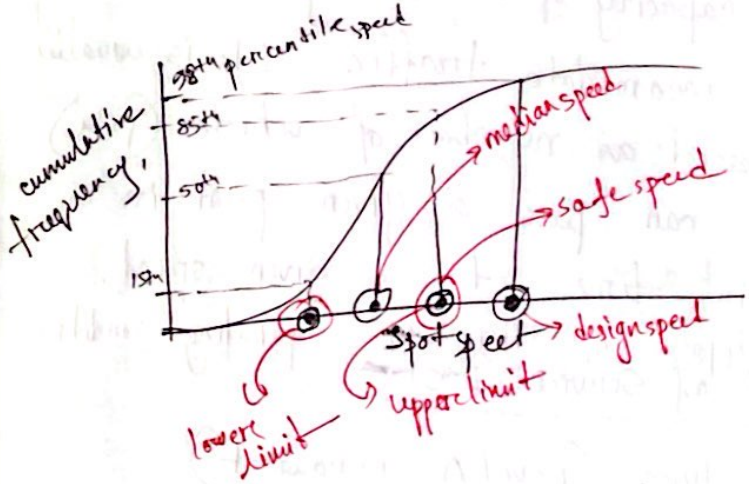
$$\text{frequency} = \frac{\text{no of vehicle observed}}{\text{total vehicle}}$$

$$\text{Mild speed} = \frac{\text{sum of speed range}}{2}$$

$$V_{avg} = \frac{\text{sum}(f \times v)}{\text{sum}(f)}$$



pace → কোন 10km এর মধ্যে data বেশি হবে।



EWCE- 352

09.07.24

Nishat Miss:

Exp-07:

Determination of roadway capacity:

The capacity of a roadway is its ability to accomodate traffic. It is usually expressed as number of vehicles (pcu) that can pass a given point in a certain time at a given speed.

→ easily pass করতে পারে কিনা — operating condition

Level of Service (LOS):

- Six type (Level A through F)

(I) A represent free flow

(II) B " stable flow with restrictions (কমলো)

(III) C → কিছুটা stable আছে, driver যখন তখন pass করতে পারবে denotes stable flow with more restricting

lab report - এ লিখা

(IV) D → little freedom

(V) E

(VI) F → সবচেয়ে খারাপ

Capacity of roadway:

→ adjustment factors use করা হয় modify করার জন্য

- modifying the capacity of the roadway under Ideal conditions
  - কোনো interference হলে side traffic থাকে
  - uninterrupted flow
  - 12 ft. wide traffic lane
  - providing operation at 70 mph
  - no restriction of passing sight distance

Roadway type	Capacity (passenger car/hr
Multilane free flow	2000 per lane
Two lane, two way (laburport)	2000 total both direction
Three lane, twoway	4000 " " "

prevailing → existing condition

1. Roadway factors
2. Traffic factors

} adjustment factors.

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Table-7.2

PSD → 80/60/40/ক্যাটাগরি

AHS → Average highway speed

- PSD যত বেশি basic limiting value ও বেশি এবং velocity বেশি হয়

- basic limiting value (multiplying factor)

- capacity কে multiplying factor দ্বারা গুণ করতে হবে।

Table-7.3

Lane width	Capacity	
	two lane	multi lane

Table-7.4

Shoulder width → lane width (11) one lane total (22) ft two lane

Shoulder width 4 ft and multiplying factor হবে 92

Example: সব multiplying factor কে পরে capacity র সাথে multiply করতে।

1. Roadway pattern: 2 lane 2way
2. Lane width : 11 ft
3. Shoulder width : (2-4 ft) এর মাঝে হলে interpolate করতে।
4. Operating speed → কে করতে হবে।

⇒ capacity of two lane two way road
= 2000 veh/hr

Actual roadway capacity = 2000 × 0.68 × 0.88 × 0.92 veh/hour
= 1101 passenger veh/hour in both direction

Table-7.5 → PCU unit

- 15 min পরপর গাড়ি count করতে হবে।
- এভাবে 15 min-2 side থেকে কত গাড়ি pass

In 15 min

20 busses × 3 = 60 pcu/15 min

= 240 pcu/hour in one direction

= 480 pcu/hour in both direction

Speed বের করতে হবে।

$V = \frac{S}{t}$ → ধরে নিব

এলাকা গাড়ি কতক্ষণ ধরে ঐ distance pass হচ্ছে তা count করবো।

$$\text{Operating speed} = \frac{\text{PCU in 1 hour} \times \text{Speed}}{\text{Total number of PCU in 1 hour}}$$

- সবগুলো Rickshaw যাবে সবগুলোর speed avg বের করতে হবে।
- 15 min পর পর section-এ গিয়ে 1 hour data নিতে।
- just data calculation ~~& Discussion~~

Munim Sir

10.09.24

Lecture-12:

Example: The standard axle weights for a standing-room-only loaded Metro articulated bus (60-ft. Flyer) are →

Axle	Empty	Full
Steering	13000 lb	17000 lb
Middle	15000 lb	20000 lb
Rear	9000 lb	14000 lb

Using the 4th power approximation, determine the total equivalent damage caused by this bus in terms of ESAL's when it is empty. How about when it is full?

Soln: When empty:

$$\text{Total ESAL's} = \left(\frac{13}{18}\right)^4 + \left(\frac{15}{18}\right)^4 + \left(\frac{9}{18}\right)^4 = 0.817$$

When full:

$$\text{Total ESAL's} = \left(\frac{17}{18}\right)^4 + \left(\frac{20}{18}\right)^4 + \left(\frac{14}{18}\right)^4 = 2.686$$

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Vehicle speed :

- গাড়ি slow অবস্থায় move করলে damage বেশি হয়।
- 2km/hr A veh চললে যে damage হবে তা 24km/hr এর damage এর 40 গুণ।

Environment :

① Temp → imp for rigid pavement

② Precipitations → imp for flexible pavement

- no of repetation → কতবার move হচ্ছে গাড়ি

Car	Bus/Truck
2000 repetations	1 repetation
সারাদিনে 2000 টা গাড়ি move করছে	সারাদিনে 1টা truck move করছে

Lecture-13 : 17.09.24

Traffic analysis :

$$ESAL = (ADT)_0 (T)(T_f)(G)(D)(L)(365)(Y)$$

- ESAL → for a single/design lane এর traffic
- $(ADT)_0$ → 1st design period এর ADT
- T → % of truck → কত % truck আছে
- $(ADT)_0$ → ১ম design period এর traffic কত পরিমাণ আছে
- T_f → Truck factor
- G → Growth factor
- D → Directional Distribution → কোন দিকে কেমন গাড়ি যাচ্ছে → কত % গাড়ি যাবে।
- L → lane distribution factor → একদিকে একটা lane থাকলে 100% গাড়ি move করবে
- 365 → ADT এর
- Y → design period

Truck factor (T_f) → এখন থাকবে ques-এ

Growth factor (G_f) → 3 methods

→ কোনটিতে ques-এ বলা না থাকলে যেটি use করবে

(i) Avg traffic at the start and end of the design period —

$$G = \frac{1}{2}\left[1 + (1+r)^Y\right]$$ → always max Value নিবে

r → increasing traffic per year (in decimal) → 5% হলে $r = 0.05$

Y = design period

(ii)

Ex- 6.11 : For an annual growth rate 3.5% and a design period of 30 years, compute the growth factors by eqn 6.31, 6.32, 6.33

Soln :

$r = 0.035 = 3.5\%$

$Y = 30$ years

eqn, 6.31 → $G = 0.5\left[1 + (1+0.035)^{30}\right] = 1.90$

eqn, 6.32 → $G = (1+0.035)^{0.5\times30} = 1.68$

eqn, 6.33 → $G = \left[(1+0.035)^{30} - 1\right] / (0.035\times30)$
$= 1.72$

To determine the annual growth rate, following factors are considered :

1. Attracted or diverted traffic due to the improvement of existing pavement.
2. Normal traffic growth rate due to the increased number

নতুন রাস্তা না হলে যে traffic টা আসতোনা

3. Generated traffic due to motor vehicles trips that would not have been made if the new facility had not been constructed

4. Development traffic due to changes in land use as a result of the new facility

→ তার জন্য G বের করে যেটা max আসে নিবো

table use করতে হবেনা, Value দিলেই দিবে

$T_f = 0.38$

Ex 6.12 : A two-lane major rural highway (যানে এর দিয়ে একটা lane এ 2টা গাড়ি যাবে) has an AADT of 4000 during the 1st year of traffic, 25% trucks, 4% annual growth rate and 50% on the design lane. If the distribution

AADT (Annual Average Daily Traffic) use করা হয়েছে four G

(ADT)

$T = 0.25$

r_c

(যেহেতু two way তে এ একদিকে 50% আরেকদিকেও 50% এটা directional distribution

third lane

যদি 4 lane two way হয় তারপরেও D = 0.5 হবে।

- যেহেতু two lane মানে একদিকে যাওয়ার একটাই lane. একদিকে 50% গেলে আরেকদিকেও 50% যাবে। এটা directional distribution (D) = 0.5 যদি কোনো কিছু বলা না দেয়া থাকে তারলে D = 0.5 ধরা হয়।

- যেহেতু একদিকে যাওয়ার জন্য একটাই lane আছে তাই একদিকের lane-এ 100% গাড়ি যাবে। তাই L = 1 হবে। একদিকে যাওয়ার জন্য একাধিক lane থাকলে L change হয়।

- two lane highway → each direction has only one lane.

- 4 lane highway → each direction has two lane → D = 0.5 হবে
  L = 80% – 100% এর মধ্যে হবে

- 16 lane highway → each direction has 8 lane
  → each direction-এ 4 এর বেশি লেনের হলে L → 4 এর জন্য যেটা দেওয়া use করবো।

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- One way traffic → D=1

Lecture-14: pdf পড়ে বুঝি 24.09.24

2 set → 1 compulsory

- last 4টি lesson → pavement এর → 10,11,12,13 → Lecture → 1set

for compulsory

L-12-13: EALF, ESAL → v.v.I^o → def^n, eq^n, Math

Lec-9-13 → Lec-12-13 → pavement design factors

v.v.I^o → temp, precipitation, failure criteria এগুলো হবে

- Traffic analysis → Math (ESAL, Growth factor) 6.11

L-10:

- Types of pavement,
- Conventional, flexible, rigid pavement এর ছবি drawing করতে হবে।

interconnect কোথায় হয়?

- full depth asphalt কী?

Lec-11:

- subbase course, base course কোন লাগাবে।
- Rigid pavement কখন কোথায় লাগাবে + ৫টি ছবি, philosophy টা কী?
- Difference → design principal, temp, economy, openness to traffic

=বাকি Lecture মিলে 1টি কোশ্চেন → math আসবে 30% →

- theory quer → যে গুলো Mid, CT তে আসছে বা বাদ

Lec-12:

- traffic engg. কেন essential? → 5/6টি কারণ
- Causes of congestion → মুখস্থ লাগবে
- Traffic engg tools → physical, regulatory v.v.I^o ছবি লাগবে
- Internal factors

L-3 :

v.v.Imp — Volume, flow rate → difference

- 15 min-এ flow rate কেন নেয়া হয়?
  - peak 15 min
  - highest 15 min কে hour-এ convert করতে

- Capacity, LOS → নামমাত্র জানা

v.v.Imp → ADT, AADT, PHV → কোথায় কোথায় এগুলো লাগে।

- Types of flow → service, contra, tidal, induced

v.v.Imp — Why 30th highest hour? — ছবি দিয়ে explain করতে

~~[illegible]~~

Lec → 4, 5 :

v.v.Imp — ~~Headway~~ — ২টা

- types of speed

v.v.Imp — ~~Graphical~~ problem — ২টা graph আঁকতে হবে → Normal graph

v.v.Imp

- Minimum data required → Math

L-6 :

- What is design veh; static, dynamic, kinematic characteristics
- ~~AASHTO~~ guidline for design veh.
- Veh characteristics → affects গুলো → length, height, Gantry
- Kinematic ও → Importance গুরুত্ব ২টা
  - motion নিয়ে criteria, highspeed → behaviour

L-7 :

- ~~General~~ requirement of traffic control device → 6-7টা
- types of traffic sign → কয়টা নাম
- Special mendatory sign কী?
  - (i) Yield (ii) Stop
- placement criteria → sign dimension
- VMS
- shown arrow

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Lec → 8,9 :

- Intergreen period, effective green time, all red period is given ?

- main ans লিখতে হবে খুব, extra লেখা যাবেনা.

Name → খুব নাম লিখবে
State
indicate

এগুলো আবার explain করতে হবেনা

The factors are given below → X
না লেখাই ভালো

factors → এগুলো লিখবে
:
:

Discuss
explain
Enumare
ছবি দিয়ে explain করা better

- mark অনুযায়ী ans করবে

Exam

Lecture-12.13 : (Math)

Standard axle → 80KN (18 kip)
single axle with dual wheel → 4ft wheel-2 load পড়ে 2টা, each will get 20KN

$$ESAL = \sum_{i=1}^{m} f_i n_i$$

; f_i = the EALF of each axle load group
n = no of passes of each axle load group
m = no of axle load group

4th powere rule for EALF →

$$EALF = \left(\frac{L_x}{18}\right)^4$$ → for single axle
L_x = load in kip on a single axle

$$EALF = \left(\frac{L_x}{L_s}\right)^4$$ → for tandem or tridem axle
L_s = load in kip on standard axles having same no axles as L_x
L_x = load in kip on tandem or tridem axle

Example-6.9:

for single axles,

1. $EALF = \left(\frac{L_x}{18}\right)^4$; $L_x = 5000\ lb = 5\ kip$
$= \left(\frac{5}{18}\right)^4 = 0.005$

2. $EALF = \left(\frac{L_x}{18}\right)^4 = \left(\frac{50}{18}\right)^4 = 59.54$; $L_x = 50000\ lb$

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for tandem axles,

Standarad, $L_S = 32$ kip

1. $EALF = \left(\frac{L_x}{L_S}\right)^4$; $L_x = 15000\ lb = 15\ kip$

$= \left(\frac{15}{32}\right)^4 = 0.048$

2. $EALF = \left(\frac{L_x}{L_S}\right)^4$; $L_x = 60000\ lb = 60\ kip$

$= \left(\frac{60}{32}\right)^4 = 39.06$

To obtain equivalent factor between 15 kip, 60 kip tandem axle and 18 kip single axle,

$EALF = 0.048 \times 0.857 = 0.041$

$EALF = 39.06 \times 0.857 = 33.47$

Example:

When empty →

$ESAL = \left(\frac{13}{18}\right)^4 + \left(\frac{15}{18}\right)^4 + \left(\frac{9}{18}\right)^4 = 0.817$

When full →

$ESAL = \left(\frac{17}{18}\right)^4 + \left(\frac{20}{18}\right)^4 + \left(\frac{14}{18}\right)^4 = 2.686$

Traffic analysis:

To design a highway pavement,

$$ESAL = (ADT)_0 \times T \times T_f \times G \times D \times L \times 365 \times Y$$

ADT_0 → 1st year traffic design ADT → quer-a দিতে

T → % of Truck → "

T_f → Truck factor → "

G → Growth factor → বইয়ে থেকে

D → Directional distribution factor → clue দিবে

L → Lane distribution " → clue দিবে

Y → design period → quer-a দিবে

Growth factor, 3 formula; Y = design period.

① Avg traffic, $G = \frac{1}{2}\left[1 + (1+r)^Y\right]$ r = growth rate

→ always max value দিবে।

② PCA, $G = (1+r)^{0.5Y}$

③ AASHTO, $G = \frac{(1+r)^Y - 1}{r \times Y}$

Total Growth factor = $G \times Y = \frac{(1+r)^Y - 1}{r}$

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6.11 :

$r = 3.5\% = 0.035$

$Y = 30$ years

(i) $G_1 = \frac{1}{2} \times [1 + (1+r)^Y] = \frac{1}{2} [1 + (1+0.035)^{30}]$

$= 1.90$

(ii) $G_1 = (1+r)^{0.5Y} = (1+0.035)^{0.5 \times 30}$

$= 1.68$

(iii) $G_1 = \frac{(1+r)^Y - 1}{r \times Y} = \frac{(1+0.035)^{30} - 1}{0.035 \times 30}$

$= 1.72$

6.12 :

We know,

$ESAL = (ADT)_0 \times T \times T_f \times G \times D \times L \times 365 \times Y$ ⟵ (1)

Given,

$(ADT)_0 = 4000$; $Y = 20$ years

$T = 25\% = 0.25$; $r = 4\% = 0.04$

$T_f = 0.38$

$D = 0.5$ (two way)

$L = 1$ (একদিকের জন্য একটি lane)

for growth factor, (i) $G_1 = \frac{1}{2} \times [1 + (1+r)^Y]$

(ii) $G_1 = (1+r)^{0.5Y}$

$= (1+0.04)^{0.5 \times 20}$

$= 1.5$

$\therefore$ Growth-factor, $G_1 = 1.6$

$= \frac{1}{2} \times [1 + (1+0.04)^{20}]$

$= 1.6$

(iii) $G_1 = \frac{(1+r)^Y - 1}{r \times Y}$

$= \frac{(1+0.04)^{20} - 1}{0.04 \times 20}$

$= 1.5$

from (1),

$ESAL = 4000 \times 0.25 \times 0.38 \times 1.6 \times 0.5 \times 1 \times 365 \times 20$

$= 2219200$

~~66.~~ ~~D=0.5~~ Previous year,

$(ADT)_0 = 20000$

$T = 40\% = 0.4$

$T_f = 0.38$

$D = 50\% = 0.5$

$L = 100\% = 1$

$Y = 20$ year

$r = 4\%$

$\therefore G_1 = \frac{1}{2} \times (1 + (1+0.04)^{20}) = 1.6$

$EASL = (ADT)_0 \times T \times T_f \times G \times D \times L \times 365 \times Y$

$= 20000 \times 0.4 \times 0.38 \times 1.6 \times 0.5 \times 1 \times 365 \times 20$

$= 17753600$

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