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BENKELMAN BEAM TEST

OBJECTIVES:

1) To determine the rebound deflection of a pavement under a standard wheel and load and tyre pressure, with or without deflection i.e. evaluation of structural capacity of existing pavement and estimation of overlay if required.

EQUIPMENTS AND ACCESSORIES REQUIRED

1. Benkelman Beam
   - Consists of slender beam of length 3.66m
   - Pivoted at 2.44m from probe.
   - Distance from pivot to dial gauge = 1.22m
   - Distance from pivot to front leg = 25cm
   - Distance from pivot to rear leg = 1.66m.

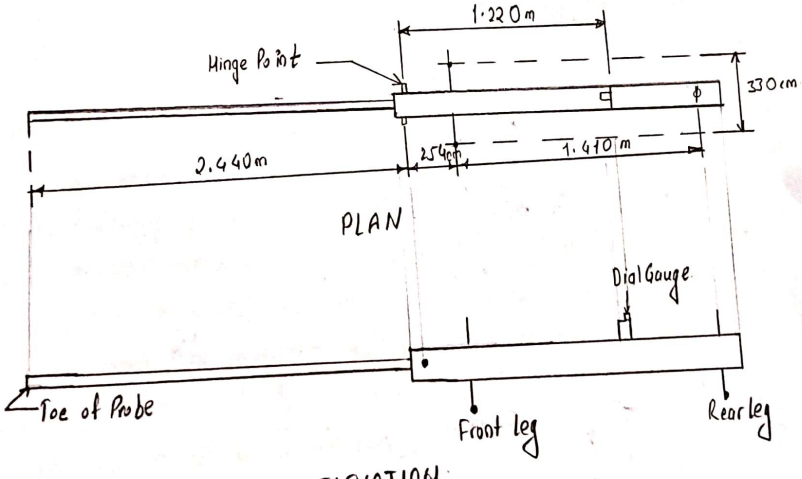


Fig: Diagram showing Critical Dimension of Benkelman Beam.

2. Loaded Truck
- Weight of truck: 12t
- Real axle load 8170 kg (dual tyre) (8.2 ± 0.15 kg)
- Spacing between tyres 30-40mm
- Inflation pressure 5.6 kg/sq.cm. Contact area : 0.048 ± 0.002 m^2 [IRC 81: 1997]
- 10.00x20, 12 ply with tubes and rib treads

3. Accessories:-
- Tyre pressure measuring gauge
- Thermometer (0-100°C) with 1° division (IRC 81: 1997)
- Measuring tape etc. (IRC 81: 1997)
- Mandreal suitable for making a 100mm deep hole in the pavement for inserting thermometer. ϕ_{hole} = 13mm
- A can containing either glycerol or oil for filling thermometer hole (TNT 7/1 June 1977)

THEORY

Benkelman beam test is an experiment conducted to measure the deflection of the highway pavement due to the loads exerted by vehicles moving on it. This experiment evaluates the structural capacity of existing pavement and helps in the estimation and design of overlay for strengthening of weak pavement. The pavement needs to be evaluated because pavement deteriorates functionally and structurally with time due to traffic loading and different climate condition. It is also necessary to evaluate the condition of existing pavement in terms of function and structural strength to carry out the projected future traffic, else is reinforced by providing additional pavement layer.

The performance of flexible pavement is based on the elastic deformation of pavement under wheel load which again is based on subgrade soil type and its moisture content compaction, thickness, quality of pavement courses, drainage condition etc.

The test covers the determination of the rebound deflection of a pavement under standard wheel load and tyre pressure. Rebound deflection refers to the bouncing back of the structure to the original shape on removal of load.

To measure deflection, a survey is carried out to determine the pavement condition according to IRC 81:1997. (in According to the provisions made there:

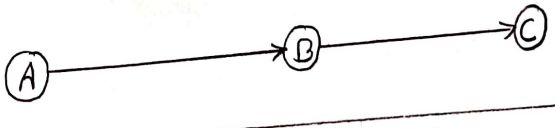
i) Deflection is measured at every 1km stretch of road selecting 10 points (at least) at 50m interval.

ii) Location of point is done as:

Lane Width (m)	Distance from lane Edge (cm)
Less than 3.5	60
More than 3.5	90

PROCEDURE: [According to IRC81:1997]

1. The points ~~there~~ selected and marked.
2. The dual wheels of the truck were centered above the mark.
3. The probe of the Benkelman beam was placed between the dual tyres at the marked position.
4. Dial gauge was set at 1cm.
5. Initial reading (S) was recorded when the rate of deformation was less than or equal to 0.025 mm/min.
6. Truck was slowly driven (at speed 8-10m/s approx) at a distance of 2.7m and stopped.
7. Intermediate reading (1) was recorded.
8. Truck was driven forward to a further distance of 9m and final reading was recorded.
9. Pavement temp^r was recorded at least once in each hour.
10. Tyre pressure was checked at 2-3 hrs interval during a day.



CALCULATIONS:

The initial, intermediate and final readings taken are S, I and F respectively, then,

Differential Readings are given as:

$R_1 = S - I$ —①

$R_2 = S - F$ —②

If the values obtained from eqⁿ ① & ② are less than 0.025mm, the true rebound deflection at tempᵉ 'T' is:

$$X_T = 2(S-F) - ③$$

If the values obtained from eqⁿ ① & ② are greater than 0.025mm, the true rebound deflection at tempᵉ 'T' is:

$$X_T = 2(S-F) + 5.8(I-F) - ④$$

Effects of Temperature:

→ Standard temperature : 35°C.

→ Correction is applied when minimum thickness of the pavement is 40mm.

→ No correction for
- Thin bituminous surfacing.
- Severe cracking in pavement
- Stripped bituminous layer
- Cold and high altitude regions where daily tempᵉ < 20°C.

→ Correction is +ve when tempᵉ is below standard temp and vice versa.

→ Correction factor is 0.01 mm °C⁻¹ variation from standard temperature.

ANALYSIS OF DATA:

Overlay design for a given section is based on the statistical analysis of all measurements in the section, but not on individual deflection.

The statistical parameter is given as:

1. Mean Deflection:

$$\bar{x} = \frac{\Sigma x}{n}$$

2. Standard Deviation: $\sigma = \frac{\sqrt{\Sigma (x-\bar{x})^2}}{n-1}$

3. Characteristic Deflection:

$D_c = M + 2S$

For National Highways and State Highways (In Nep. India)

For National Highways and feeder Roads (In Nepal)

$D_c = M + S$

for other roads.

Concept of overlay

Overlay surface is added over undulated surface and cracked surface based on the graph attached.

Undulated Surface

Cracked Surface.

Overlay Surface.

Existing Surface

COMMENTS, CONCLUSION AND RECOMMENDATION:

The Benkelman beam test is very important tool for the analysis of the highway pavement deflection. We have used the Indian Code for the calculation of deflection based on this test. ~~So,~~

In the laboratory, the apparatus was demonstrated properly with detailed explanations and procedures but the actual field task was missing might be due to technical problems. The practical knowledge demands field work and site tests rather than explanatory demonstration.

CALIFORNIA BEARING TEST (CBR)

THEORY:

CBR test is a method for evaluating the stability of soil subgrade and other flexible pavement materials for the design of pavement thickness. CBR value is defined as the ratio of force per unit area required to penetrate a soil mass with circular plunger of 50mm diameter at the rate of 1.25mm/min to that required for corresponding penetration of standard materials. Standard load is that load which has been obtained from test on crushed stone whose CBR value is taken to be 100 percent. The ratio is usually determined for penetration of 2.5mm and 5.0mm. The result of the test cannot be related accurately with fundamental properties of the material but are useful in the design of flexible pavement.

APPARATUS REQUIRED:

1. A mould 15cm internal dia and 175mm height with a base plate 10mm thick and collar 50mm in height.
2. A loading frame that can move vertically at the rate of 1.25mm/min with the cylindrical plunger of 50mm diameter and at least 100mm long.
3. Dial gauge for measuring the expansion on soaking and the penetration values.
4. A metal spacer disc of 148mm dia and 47.7mm height.
5. One annular metal weight and slotted weights each of 2.5kg and 147mm in diameter with a central hole 53mm in diameter.
6. Miscellaneous apparatus like mixing bowl, straight edge, scales, soaking tank, filter paper, calibrated measuring jar etc.

PROCEDURE:

1. Preparation of specimen:

Preparation of undisturbed sample:

Fitted to the mould, the steel cutting edge of 150mm internal dia. The mould was pushed into the ground gently as possible till the mould was full of soil. The soil was removed from sides and bottom. The excessive soil from the top and

bottom was trimmed off.

2. Preparation of remoulded specimen:

Remoulded specimens were prepared such that the dry density obtained from proctor compaction tests the water content of remoulded samples was either the optimum water content or the field capacity as the case may be. The remoulded samples were either compacted statistically or dynamically.

a) Statistically compacted specimen.

i) The amount of soil required such that it fills the mould (excluding collar) at desired ~~capacity~~ density after compaction was calculated.

ii) The amount of water to be added to give desired water content was calculated.

iii) The water was mixed thoroughly with soil.

iv) The extension collar to the mould was fixed and clamped to the base.

v) The mould was fixed with soil gently pressing it with hands. So, it was not split out of the mould.

vi) A course filter paper was placed over the levelled soil surface and the spacer disc was inserted.

vii) The assembly was placed on the pedestal of compression machine and compacted.

b) Dynamically compacted Specimen

i) The material was sieved through 20mm IS sieve.

ii) About 4.5 kg or more of representative sample for fine grained soils and about 5.5 kg of granular soil were taken in a mixing pan.

iii) Water was added to the soil in the quantity such that the moisture content of the specimen was either equal to field moisture or o.m.c. as desired.

iv) The soil and water were mixed together uniformly.

v) The mould was clamped along with the extension collar to base plate, course filter paper was placed on top of the spacer disc.

vi) Soil water mix was poured in the mould in such a qtt that after compaction, about 1/5th of mould was filled. 56 blows were given with the rammer weighing 2.6 kg dropped through 310mm in 3 layers or 4.89 kg dropped through 450mm in 5 layers.

vii) The top layer of compacted soil surface was scratched, more soil was added and compacted in the same manner.

viii) The extension collar was removed and excess soil was trimmed off by a straight...

ix) The base plate, spacer disc and filter paper were removed and weight of mould & compacted specimen were noted down. A coarse filter paper was placed on perforated base plate.

x) The mould containing the compacted soil was inverted and clamped to the base plate.

3 Testing

a) The mould containing the specimen with base plate was placed in position on the testing machine

b) The annular weight of 2.5kg was placed on the top surface of soil.

c) The penetration plunger was brought in contact with soil surface and a load of 4kg was applied so that full contact between soil and plunger was established. This should be taken as zero load.

d) The remainder surcharge weight was placed so that total surcharge wt. was = 5kg.

e) The reading of dial gauges was set to zero

f) The load was applied so that penetration rate was 1.25mm/min. The load of penetration values: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0, 12.5mm were recorded. The maximum load has to be recorded if it would have occured at less than 12.5mm.

g) About 20 to 50g of soil was collected to determine the water content.

4. Computation of test results:-

a) The load penetration curve with load as ordinate and penetration as abscissa, correction could be applied when the initial ~~position~~ portion of the curve is concave upwards by shifting the origin to the point of intersection of the tangent at greatest slope with abscissa.

b) From the curve, the load value corresponding to the penetration value was determined at which CBR was desired.

$$CBR = \frac{\text{Load sustained by speciment at 2.500, 5.00mm penetration}}{\text{load sustained by standard aggregate at corresponding penetration.}} \times 100\%$$

Penetration	Standard load (kg)	Unit Standard load (kg/m²)
2.5	1370	70
5.0	2055	105

CALCULATION OF SAMPLE CBR:

For the calculation of CBR, the following data were used:-

Penetration (mm)	Load (kg)
0	0
0.5	5.0
1.0	16.2
1.5	28.1
2.0	40
2.5	48.5
3.0	56.5
4.0	67.5
5.0	75.2
7.5	89
10.0	99.5
12.5	106.5

After plotting these values in graph,

Load for 2.5mm penetration = 51.5 kg

$$\therefore CBR = \frac{51.51}{1370} \times 100\% = 3.76\%$$

Load for 5mm penetration = 76 kg

$$\therefore CBR = \frac{76}{2055} \times 100\% = 3.7\%$$

Here, $CBR_{2.5} > CBR_5$. OK //

CONCLUSION:

CBR is usually calculated for 2.5mm penetration. If the CBR value of 5.0mm penetration was more than that for 2.5mm, the test would have to be repeated. If the CBR values give same result, the value for 5mm penetration is adopted. The avg. CBR value of 3 test specimens is reported to the first decimal place as the CBR value of material.

CBR method would be used in pavement design using its relation as:

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

t = Pavement thickness, cm
P = wheel load, kg
CBR = value in %
p = tire pressure kg/cm
A = Area of contact

Level:

Roll No.:

Subject: . . . . . Date:

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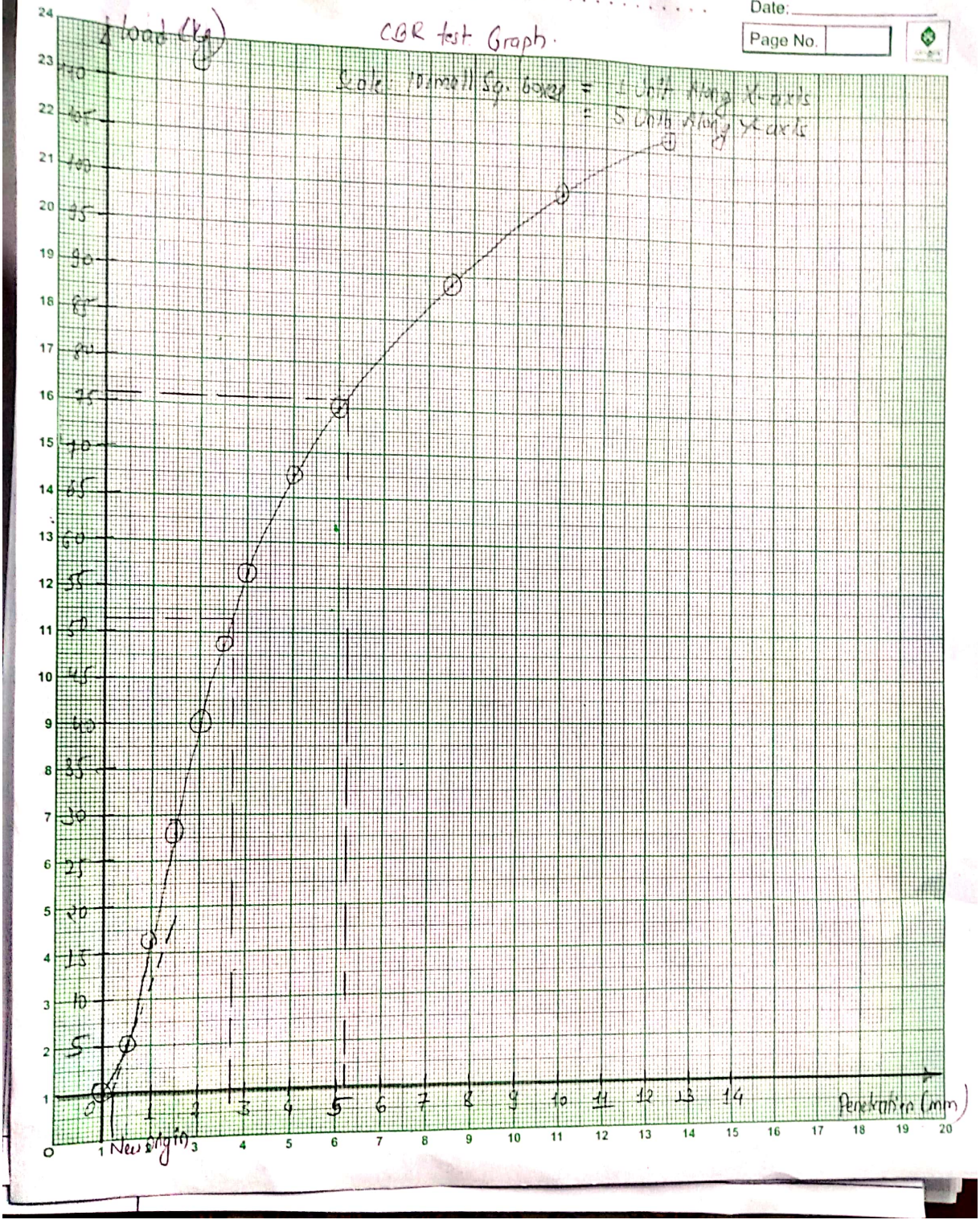


SKID RESISTANCE TEST OF HIGHWAYS USING BRITISH PENDULUM TEST. 1

OBJECTIVES:

To measure the surface ~~friction~~ frictional properties using the British Pendulum skid Resistance tester.

APPARATUS REQUIRED:

i) British Pendulum Tester
ii) Slider
iii) Accessories

Test Specimen:

1. Field: Field test surface shall be free of loose particles and flushed with clean water
2. Laboratory: Laboratory test panels shall be clean and free of loose particles and shall be held rigidly so as not to be moved by the force of pendulum. Flat laboratory test panels shall be have a test surface of at least 3.5 to 6 inches.

THEORY:

The friction or 'skid resistance' between vehicle tyre and pavement surface is one of the factors determing the operating system speed and the minimum distance required for stopping the vehicle. 'Skid' occurs when the wheels slide without revolving or rotating or when the wheels partially revolve i.e. when the path travelled along the road surface is more than the circumferential movements of the wheels due to their rotation.

Skid resistance changes over time. Typically, it increases in the first two years following construction as the roadway is worn away by traffic and rough aggregate surfaces becomes exposed. Then, it decreases over the remaining pavement life as aggregates become more polished. British pendulum procedure includes applying water to swing area, executing one swing without recording, resetting and executing four more times and recording followed by calculation of average value.

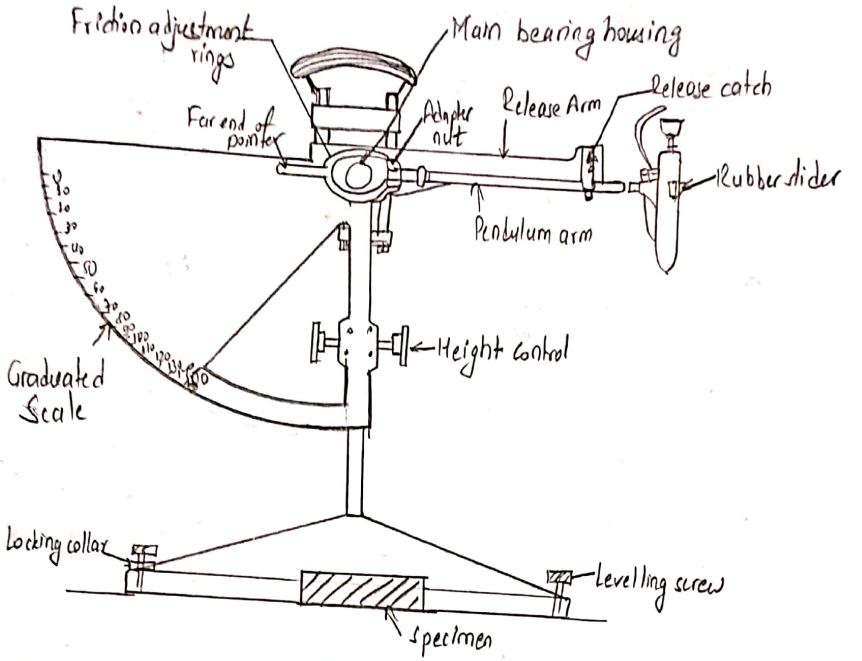


Fig: The British Pendulum Tester

The head of pendulum is locked firmly, the fitting handle is raised and spacer is removed.

Test:

i) Sufficient water was applied to cover the test area thoroughly. One swing was executed but the reading was not recorded. The pendulum was caught during the early position of its return swing.

ii) While returning the pendulum to its starting position, the slider was raised to avoid contact between the slider and the test surface.

iii) Without delay, four swings were made, rewetting the test area each time and recording the result.

OBSERVATIONS:

Temp^{n} of the test surface =
Type = Laboratory test specimen
Age =
Condition = Average
Tested by = Roll No.: 072 BCE 025 to 072 BCE 032
Texture = Fine

Run Number	Initial Reading	Final Reading	British Portable Number BPN
1.			
2.			
3.			
4.			

Average British Portable Number

As the stiffness of rubber slider will vary with temperature, a correction has to be made if the temperature isn't 20°C. Suggested minimum value of skid resistances (measured with pendulum tester) are:

S.No.	Type of site	Min skid resistance (surface wet)
A.	Difficult sites such as: 1. Roundabouts 2. Bends with radius less than 120m on unrestricted roads. 3. Gradients 1 in 20 or steeper of lengths greater than 100m. 4. Approaches to traffic lights on unrestricted roads.	65
B.	Heavy traffic roads ~~with~~ in urban areas (carrying more than 2000 vehicles/day)	55
C.	All other sites	45

The full scale tire friction test is also called locked wheel tester. This method uses a locked wheel skidding along the tested surface to measure friction resistance.

PROCEDUEE:

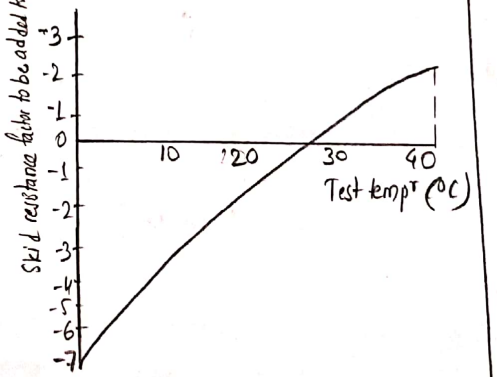
Preparation of Apparatus:

1. Levelling: Levelling the instrument accurately is done by turning the levelling screws until the bubble is centered in the spirit level.
2. Zero Adjustment:- The pendulum is released, the pointer reading is noted. If reading $\neq 0$, the locking ring is loosened and the friction ring is rotated on the friction bearing slightly and locked again.
3. Length Adjustment: With pendulum hanging free, the spacer is placed under adjusting screw of lifting handle. The pendulum is lowered so edge of slider just touches the surface.

DISCUSSION AND CONCLUSION:

The test was performed on laboratory surface rather than the acheal pavement surface and the average value of British Portable Number after temperature correction was found to be

This suggests that the type of surface used in laboratory could be used as in



TRAFFIC VOLUME STUDY AT UN-PARK AND THAPATHALI INTERSECTIONS BY 072BCE AB

THEORY:

One of the most important measurements of traffic on a road system is volume of traffic using the road at a given time interval. It is termed as flow and is expressed in vehicles per hour or vehicles per day. If the traffic is composed of several vehicles, an equivalent passenger car unit (pcu) is introduced by using certain equivalency factors.

When the flow characteristics are known, one can determine whether a particular section of road is handling traffic much above, below or just equal to its capacity. Both lower and higher traffic are harmful, so traffic count helps to evaluate the need to improve the traffic transport facilities and tools.

Number of vehicles passing a particular section of the road per unit time at a specified time is called traffic volume. Sometimes, traffic volume is modified to accommodate the number of pedestrians as well as the number of vehicles especially during peak hours. Traffic volume study is carried out to decide the relative priority of expansion or improvement, to evaluate existing facilities and plans and to make improvements if needed, to assist in structural design of the pavements, to plan regulatory measures on the road, to design intersection, side walks, traffic lights etc.

To get the true picture of traffic volume characteristics, hourly variation along with daily and seasonal variation patterns should be known. The count should be carefully planned and taken at busy locations. The most significant variation is at peak hour. The peak hour observed during mornings and evenings of weekdays, which is usually 8 to 10 percentage of total daily flow of 2 to 3 times the hourly volume. During the design of highway, we adopt maximum 30th hourly volume. To find the traffic volume, the vehicles are counted which are of following types:

1. Short term Counts:- To determine peak-hour traffic flow for use in measuring saturation flow at signalized intersection and the intersection.
   - Counts during peak hours (morning & evening).

2. Full day Count:- To determine hourly fluctuation of flow during non-holidays.
   - Used in intersection counts, as part of transportation survey in cordon line count.

3. Full Week Count:- To determine hourly and daily fluctuation of flow, also used as only means of traffic census on non-urban highways.

4. Continuous Count:- Carried out for continuous monitoring of traffic in urban and non urban locations
   - gives daily, weekly, seasonal and yearly fluctuation ~~and~~
   - to find g annual growth rate of traffic.

While designing a highway, if we only use the data of hourly rate of flow, there migh be an occurance of breakdown as more vehicles than design vehicles have higher chances to move. So, HCM (1997) suggests using 15 minutes for most operational and design analysis. The relationship is given by:

$$\text{Peak hour factor} = \frac{\text{hourly volume}}{\text{max}^m \text{ flow rate}}$$

The max^m flow rate can be between 1 to 0.25. If entire hourly traffic occurs in those 15 minutes, maximum rate of flow is 0.25.

Methods of Traffic Counts

i) Manual Counts
ii) Manual Machine counter
iii) Automatic devices
iv) Moving observer method
v) Photographic Method.

Manual Method

The data is manually noted down in a given format. The format should include : direction, classification of vehicles based on size or speed, time of observations. Sometimes, it can be modified to accommodate the pedestrian volume as well. The number of personnel needed to record the depends upon the number of lanes in the highway on which the work is to be carried out. Manual method is mostly used during peak hours.

The equipments and tools used are watch, pencils, erasers, sharpners, blank field data sheet and a clipboard.

Merits:
→ Classified count of vehicles with directional breakdown
→ No need of costly equipments.
→ Automatic data check.
→ Easy analysis of data
→ Suitable for short and non-continuous count
→ Simultaneous count of pedestrian
→ Easy recording during unusual condition.

Demerits:
→ Not feasible for continuous counts
→ Costly and requires large manpower.

The manual method was applied for traffic volume survey.
The data can be presented as flow map of intersection.
If we apply ~~Poisson~~ Poisson's Distribution to the data, then the probability of arrival of x vehicles in any time interval 't' seconds is given by: $P(x) = (\lambda t)^x e^{-\lambda t} / x!$

If 'V' is the no. of vehicles per hour, the value of λ is simply $\frac{V}{3600}$ but it should be noted that λ and t should be in same unit.

OBSERVATIONS:

Location 1: UN-Park ~~near~~ Bagmati Bridge Site

Observers: 072/BCE/025 to 072/BCE/046

~~Last~~ Location 2: Thapathali Chowk Intersection

Observers: 072/BCE/001 to 072/BCE/022.

Data of Location 2: Thapathali Intersection

Time	Route	No. of vehicles
09:45 to 10:045 am	1-2 Tripureshwor to Maitighar	36 Bus, 44 micros, 10 three wheelers, 222 cars/jeep/vans, 73 taxies, 7 utility vehicles, 43 cycles, 15 light trucks, 1474-2 wheles = 1924
09:45 to 10:45 am	1-4 Tripureshwor to Norvic Hospital	39 car/Jeep/Van, 40 taxis, 232 two wheelers, 3 Utility vehicles, 17 cycles = 331.
09:45 to 10:45 am	1-5 Tripureshwor to Kupondole	22 buses, 8 hiaces, 22 tempo, 9 sajha bus, 201 C/J/V, 45 taxis, 740 two wheelers, 5 Utility vehicles, 18 cycles, 7 light trucks = 1082.
09:45 to 10:45 am	3-4 Maitighar to Norvic	2 micros, 36 C/J/V, 26 taxis, 103-2 wheeles, 1 utility vehicles, 7 cycles = 175
09:45 to 10:45 am	3-5 Maitighar to Kupondole	54 buses, 90 micros, 61 tempos, 422 C/J/V, 128 taxis, 1345-2 wheeles, 25 Utility vehicles, 44 cycles, 5 light trucks = 2154
09:45 to 10:45 am	3-7 Maitighar to Tripureshwor	12 buses, 10 micros, 8 tempos, 899-2 wheelers, 7 Utility vehicles, 7 cycles, 11 light trucks, 135 car/Jeep/Van = 1159
09:45 to 10:45 am	4-5 Norvic to Kupondole	88 C/J/V, 47 taxis, 295-2 wheeles, 2 utility vehicles, 21 cycles = 453
09:45 to 10:45 am	6-2 Kupondole to Maitighar	36 buses, 50 micros, 20 tempos, 493 C/J/V, 98 taxis, 1663-2 wheeles, 8 Utility vehicles, 16 cycles = 2423
09:45 to 10:45 am	6-4 Kupondole to Norvic	2 micros, 110 C/J/V, 27 taxis, 275 two wheeles, 14 cycles = 428
09:45 to 10:45 am	6-7 Kupondole to Tripureshwor	14 buses, 8 micros, 23 tempos, 9 Sajha buses, 379 C/J/V, 124 taxis, 2149-2 wheeles, 6 Utility vehicles, 43 cycles = 2755

Data for location 1: UN Park Intersection:

Time	Route	No. of vehicles
10:00 to 11:00 am	1-2 (specified in map)	5 two wheelers, 5 cycles, 1 light truck, 2 taxis = 12
10:00 to 11:00 am	1-3	1 C/J/V, 10 two wheelers, 4 cycles, 2 light trucks = 17
10:00 to 11:00 am	1-5	6 C/J/V, 2 taxis, 23 two wheelers, = 31
10:00 to 11:00 am	1-4	5 C/J/V, 6 taxis, 25 two wheelers, 4 cycles, 1 light truck = 41
10:00 to 11:00 am	2-3	1 C/J/V, 25 two wheelers, 3 cycles = 29.
10:00 to 11:00 am	2-1	1 two wheelers, 3 cycles = 4
10:00 to 11:00 am	2-4	12 C/J/V, 9 taxis, 66 two wheelers, 1 cycle, 1 light truck = 89
10:00 to 11:00 am	2-5	40 C/J/V, 9 taxis, 210 two wheelers, 4 Utility vehicles, 3 cycles, 1 light truck = 267
10:00 to 11:00 am	3-2	4 taxis, ~~2333~~ 27 two wheelers = ~~33~~ 31
10:00 to 11:00 am	3-1	1 cycle only
10:00 to 11:00 am	3-5	26 C/J/V, 5 taxis, 188 two wheelers, 7 cycles, 2 Utility vehicles = 228
10:00 to 11:00 am	3-4	11 C/J/V, 9 two wheelers, 1 Utility vehicle = 21
10:00 to 11:00 am	4 to 1	2 C/J/V, 3 taxis, 25 two wheelers, 1 cycle = 31.

Time	Route	No. of Vehicles.
10:00 to 11:00 am	4-2	39 C/J/V, 10 taxis, 224 two wheelers, 8 utility vehicles, 1 cycle = 282.
10:00 to 11:00 am	4-3	4 C/J/V, 5 two wheelers = 9
10:00 to 11:00 am	4-5	288 C/J/V, 54 taxis, 1305 two wheelers, 45 utility vehicles, 22 cycles, 5 light trucks = 1719
10:00 to 11:00 am	5-1	5 C/J/V, 21 two wheelers, 2 cycles, = 28
10:00 to 11:00 am	5-3	37 C/J/V, 12 taxis, 207 two wheelers, 5 Utility vehicles, 11 cycles = 272
10:00 to 11:00 am	5-4	2 micros, 194 C/J/V, 62 taxis, 562 two wheelers, 55 utility vehicles, 3 cycles, 5 light trucks = 883
10:00 to 11:00 am	5-6	16 C/J/V, ~~69 taxis~~ 85 two wheelers, 11 Utility vehicles, 6 cycles, 4 light trucks = 123
10:00 to 11:00 am	5-7	369 C/J/V, 69 taxis, 1797 two wheelers, 3 Utility vehicles, 4 light trucks = 2242
10:00 to 11:00 am	6-7	10 C/J/V, 105 two wheelers, 105 Utility vehicles, 10 cycles, 1 light trucks = 127
10:00 to 11:00 am	6-5	83 C/J/V, 2 taxis, 114 two wheelers, 9 cycles, 3 light trucks = 151
10:00 to 11:00 am	7-6	17 C/J/LV, 1 taxis, 86 two wheelers, 11 cycles = 115
10:00 to 11:00 am		29 micros, 403 C/J/V, 98 taxis, 1320 two wheelers, 39 cycles, 10 light trucks, 25 Utility vehicles = 1924

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PRESENTATION:

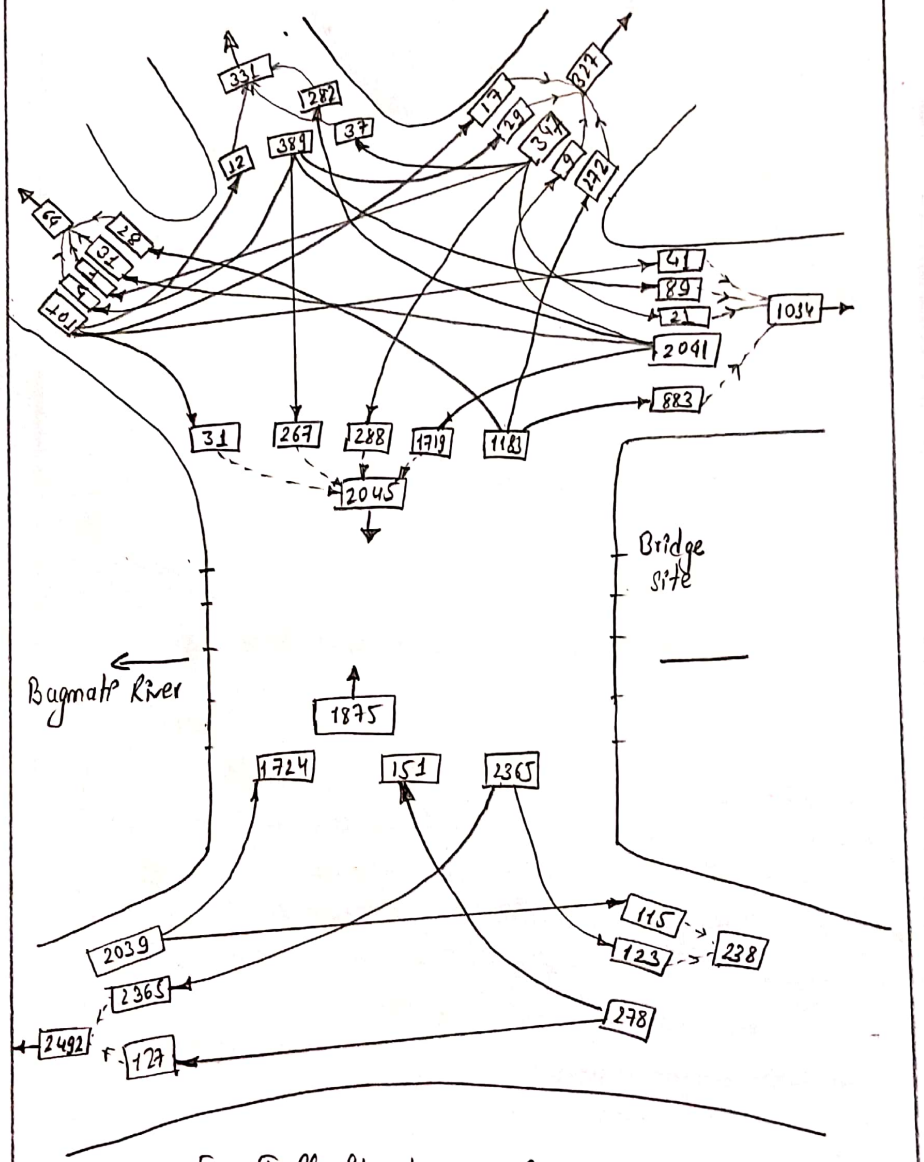

Fig: Traffic flow diagram of UN Park.

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Presentation:

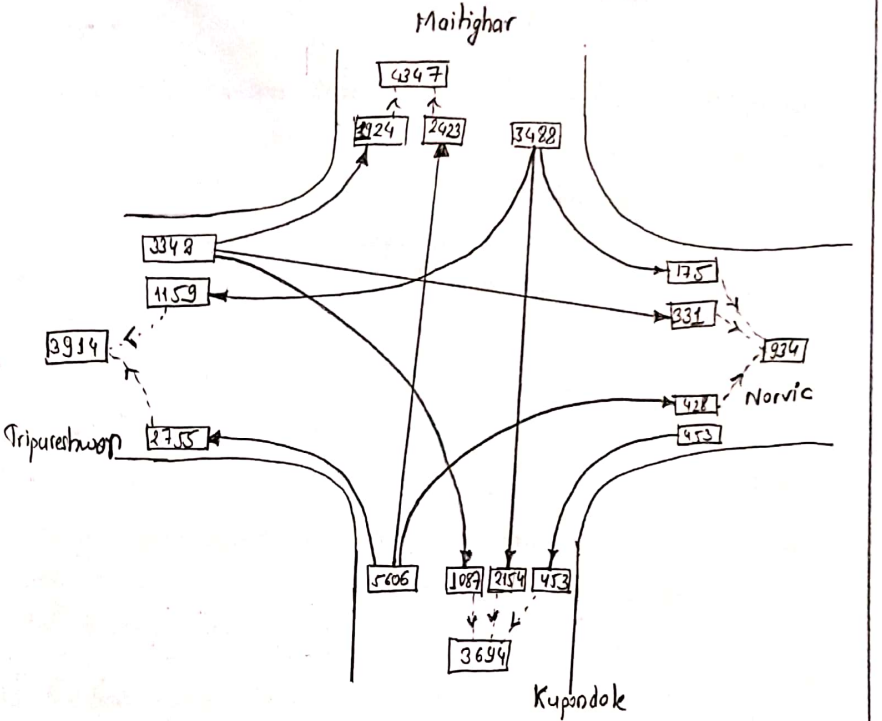


Fig: Traffic flow Map of Thapathali Intersection.

CONCLUSION:

From the traffic volume count conducted at Thapathali and UN Park, the hourly traffic volume was established and it was found that traffic inflow was approximately equal to traffic outflow at the junction branch. Slight difference was obtained due to difference in timing of the watches used by different students in the field, stopping of vehicles, slow movements of vehicles, mistakes in observations due to lack of experience and so on. To obtain errorless data, trainings should be given to surveyors and manual method must be supported by other modern methodologies.

SPOT SPEED STUDY AT UN PARK AND THAPATHALI

THEORY:

Speed is one of the most important traffic characteristics and its measurement is a frequent necessity in traffic studies. Speed is the rate of movement of traffic. The speed of vehicles moving on road may vary depending on factors like geography, traffic, time, environment etc. The study of speed are carried out to determine speed trends to plan traffic and to study crashes. The various types of speed are :

a) Spot Speed: It is the instantaneous speed of the vehicle as it passes a specific point on the highway. It is estimated from ~~time~~ measurement of time required to travel a short distance (say 30m). The spot speed depends on factors like condition of road, composition and volume of traffic, environmental influences, human behaviour (of pedestrian, drivers) and characteristics of vehicles.

b) Average Speed: It is the average of spot speeds of all the vehicles passing a specified point on the highway. It is further classified as:

i) Time mean speed: Average of several spot speeds observed at particular location i.e. arithmetic speed is time mean speed. It represents the speed distribution of vehicles at a point on the road. It is given as:

$$v_t = \frac{\sum v_i}{n}, \text{ where } n \text{ - no. of vehicles}$$

$$\sigma_t^2 = \frac{\sum (v_i - v_t)^2}{n-1}$$

ii) Spacemean speed: It is the average speed of vehicles over a certain length of road at a given time. Space mean speed is the average of the speed measurements at an instant of time over a space. It is the harmonic mean of all speeds.

i.e $SMS = \frac{nL}{\sum_{i=1}^{n} t_i}$ where, L = length of road in meters
n = number of observed vehicles
t_i = Travel time of observed vehicles in sec

Time mean speed (v_t) is given as,

$v_t = v_s + \frac{\sigma_{v_s}^2}{v_s}$ (v_s: space mean speed)

c) Travel Time: It is the reciprocal of speed and this is a simple measure of how well road network is operating.

d) Running speed: It is the average speed maintained by a vehicle over a given course while the vehicle is in motion. It is given as,

$$\text{Running speed} = \frac{\text{Length of course}}{\text{running time}} = \frac{\text{length of course}}{\text{Journey time} - \text{Delay}}$$

e) Journey Speed: It is known as overall travel speed. It is the effective speed of vehicle between two points of observation inclusive of delays. It is given as:

$$\text{Journey Speed} = \frac{\text{Length}}{\text{Journey time (including delay)}}$$

There are ~~two~~ several methods of study of speeds, out of which we performed these methods:

1. Spot Speed Study
2. Speed and delay studies.

Spot Speed Study:

The spot speed is affected by factors like physical features of the roads (sight distance, radius of curve, gradient, pavement width, intersection etc.), drivers personal reason etc. Spot Speed Study is useful for studying speed trends, traffic capacity, to plan traffic control and regulation measures, to redesign existing highway, geometric design, crash study etc.

Since all the vehicles donot move with the same speed on the road, the amount of speed dispersion from the average speed affects both capacity and safety. For free flow of vehicles speed distribution follows a normal distribution curve. The

quality of flow of vehicles in a stream depends upon the speed dispersion. They can be analysed by several methods such as 85th percentile - 15th percentile speed, standard deviation of speeds as the coefficient of variation inspect.

For the geometrical design of roads, the realistic estimate of speeds at which vehicles travel can be determined from the speed studies. The speed study enables safe speed limits to be established and speed zoning to be determined, it also enables design of traffic signal, determination of location and size of traffic signs. Spot speed data are also needed to analyse the cause of accidents and to identify existing relation between speed and accidents.

Spot speed study data can be presented in 3 forms:

i) Average speed of vehicles
ii) Cumulative speed distribution curve
iii) Modal average.

i) Average speed of vehicles:

From the spot speed data, frequency distribution curve is plotted with speed of the vehicles on X-axis and percentage of vehicles in that group on Y-axis. The curve so plotted has a definite peak known as modal speed of the vehicles in specified section of the road and the curve is called speed distribution curve.

ii) Cumulative Speed distribution Curve:

In this method, spot speed data is presented in the form of curve known as cumulative speed distribution curve.

In this curve, speed of vehicles or upper limits of each speed groups are taken on X-axis and cumulative percent of vehicles travelling at or below the different speed groups on the Y-axis.

85th percentile speed is found from this curve. 85th percentile speed is adopted as the safe speed limit at a specified point on highway. The rest 15% are taken as reckless drivers. If an expressway is to be constructed, the 15th percentile speed is adopted to define the maximum speed on the highway. Vehicles travelling below this speed are considered dangerous as they obstruct the smooth flow of traffic.

iii) Modal Average:-

It is the average at which maximum percentage at the vehicles using the particular road section will be of adopting.

Arithmetic Mean and Standard Deviation:

Arithmetic mean is given as:

$$\bar{V} = \Sigma v_i / n$$

$\bar{V}$: Avg. spot speed, kmph
v_i = i^{th} Spot speed
n = No. of observations

The variation is a better measure and is given as:

$$CI = \frac{R}{(1+3.322 \log n)}$$

CI: Class interval
R: range between the largest and the smallest speed
n : no. of observations

Standard deviation is given as:

$$S = \sqrt{\frac{\Sigma (v_i - \bar{v})^2}{N-1}}$$

Methods of Speed Measurement:

The various methods of spot speed measurement are as follows:-

(i) Enascope
(ii) Pneumatic tube or pressure contact strips
(iii) Inductive loop detector
iv) Radar speed meter
v) Sonic detector
vi) Time laps camera

Presentation: Tabular presentation of data is done. The followings are determined:-

i) Class Interval (CI) = $\frac{R}{1+3.322 \log n}$

ii) Graphical analysis using histogram and cumulative frequency curves.
iii) Modal speed
iv) Median speed
v) 98^{th}, 85^{th}, 15^{th} percentile speed.
vi) Arithmetic mean or average spot

Application of normal distribution to analysis of spot speed data:-

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-1/2\left(\frac{x-\mu}{\sigma}\right)^2}$$

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-z^2/2}$$

OBSERVATIONS:

Location no: 2/1

Location : Near UN Park Bagmati Bridge, Thapathali Chowk

Observation group : B/A

Observers : 072/BCE/047 and 072/BCE/048
072/BCE/023 and 072/BCE/024

The observations were taken ~~normally~~ manually with stop watches.

ROUTE : THAPATHALI TO TRIPURESHWOR.

Speed Group		Middle Speed	No. of vehicles (f)	Vehicles in group (%)	Cumulative vehicles (%) Cumulative frequency (%)
Lower	Upper				
0	1	0.5	0	0	0
1	2	1.5	4	3.7	3.7
2	3	2.5	6	5.56	9.26
3	4	3.5	19	17.59	26.85
4	5	4.5	35	32.41	59.26
5	6	5.5	23	21.30	80.56
6	7	6.5	11	10.19	90.75
7	8	7.5	7	6.48	97.23
8	9	8.5	1	0.93	98.16
9	10	9.5	2	1.85	100.0
	Total		108		

ROUTE: TRIPURESHWOR TO THAPATHALI

Speed Groups		Middle Speed	No. of Vehicles (f)	Vehicles in group (f%)	Cumulative vehicles (%) Cumulative frequency (%)
Lower	Higher				
0	1	0.5	0	0	0
1	2	1.5	2	1.75	1.75
2	3	2.5	18	15.79	17.54
3	4	3.5	23	20.18	37.72
4	5	4.5	25	21.93	59.65
5	6	5.5	12	10.53	70.18
6	7	6.5	18	15.79	85.97
7	8	7.5	3	2.63	88.6
8	9	8.5	8	7.02	95.62
9	10	9.5	3	2.63	98.25
10	11	10.5	2	1.75	100.0

Total : 114

ROUTE: Baneshwor to UN Park

No. of vehicles (f)	Speed Group		Middle Speed	Vehicle in group (%)	Cumulative vehicle (%) Cumulative frequency (%)
	Lower	Upper			
0	0	5	2.5	0	0
12	5	10	7.5	24	24
9+16	10	15	12.5	50	74
10	15	20	17.5	20	94
3	20	25	22.5	6	100

ROUTE : UN PARK TO BANESHWOR

No. of vehicles	Speed Group		Middle Speed	Vehicle in group (%)	Cumulative vehicles (%) Cumulative frequency (%)
	Lower	Upper			
0	0	5	2.5	0	0
11	5	10	7.5	22	22
37	10	15	12.5	74	96
1	15	20	17.5	2	98
1	20	25	22.5	2	100

Total - 50

RESULTS:-

After plotting the graph of speed vs the cumulative percentage of vehicles in the graph for:

i) ROUTE: BANESHWOR TO UN PARK

Upper Speed limit (Space Safe speed) = 85th Percentile Speed
= 14.9 m/s = 53.64 kmph.

Lower Speed for regulation = 15th Percentile Speed
= 6.2 m/s = 22.32 kmph

Speed to check geometric design = 98th percentile speed
= 19.3 m/s = 69.48 kmph

Median Speed = 50th Percentile Speed = 9.2 m/s = 33.12 kmph.

(ii) ROUTE: UNPARK TO BANESHWOR

Upper Speed limit (Safe speed) = 85th Percentile Speed
= 10.2 m/s
= 36.72 km/hr

Lower Speed for regulation = 15th Percentile Speed
= 6.6 m/s
= ~~23.04 km~~ 23.76 km/hr.

Speed check for geometric design = 98th percentile speed
= 20.6 m/s
= 74.16 kmph.

Median Speed = 50th Percentile speed = ~~10.2 m/s~~ = 8.2 m/s = 29.52 kmph.

So, Upper speed limit (Safe speed) (we take lower value of 2 lanes) = 36.72 km/hr.
Lower Speed regulation (higher value) = 23.76 km/hr.
Geometric design speed = 74.6 kmph.

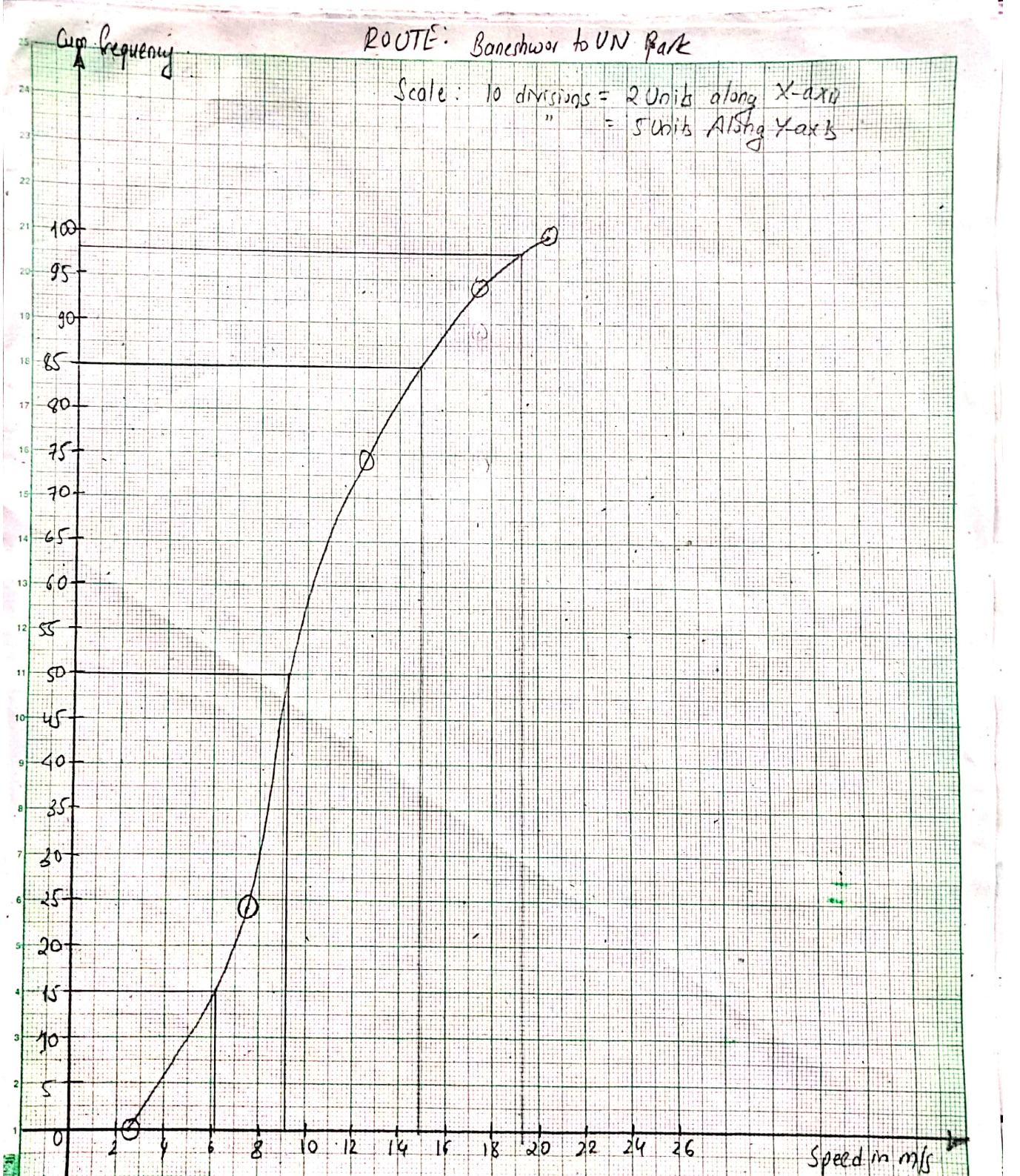
(iii) ROUTE: TRIPURESHWOR TO THAPATHALI

Upper Speed limit = ~~5.45 m/s = 19.62 kmph~~ 6.4 m/s = 23.04 kmph
Lower Speed for regulation = 2.5 m/s = 9 kmph
Speed Check for geometric Design = 9.52 m/s = 34.272 kmph
Median Speed = 4.1 m/s = 14.76 kmph.

(iv) ROUTE: THAPATHALI TO TRIPURESHWOR

Upper Speed limit: 5.45 m/s = 19.62 kmph
Lower Speed for regulation = 2.9 m/s = 10.44 kmph.
Speed Check for geometric Design = 7.85 m/s = 28.26 kmph
Median Speed = 4.2 m/s = 15.12 kmph.

So, Upper Speed limit (We take lower values of the two lanes) = 19.62 kmph
Lower Speed limit (" " higher " " " " ") = 10.44 kmph
Geometric design speed (" " " " " " ") = 34.272 kmph.



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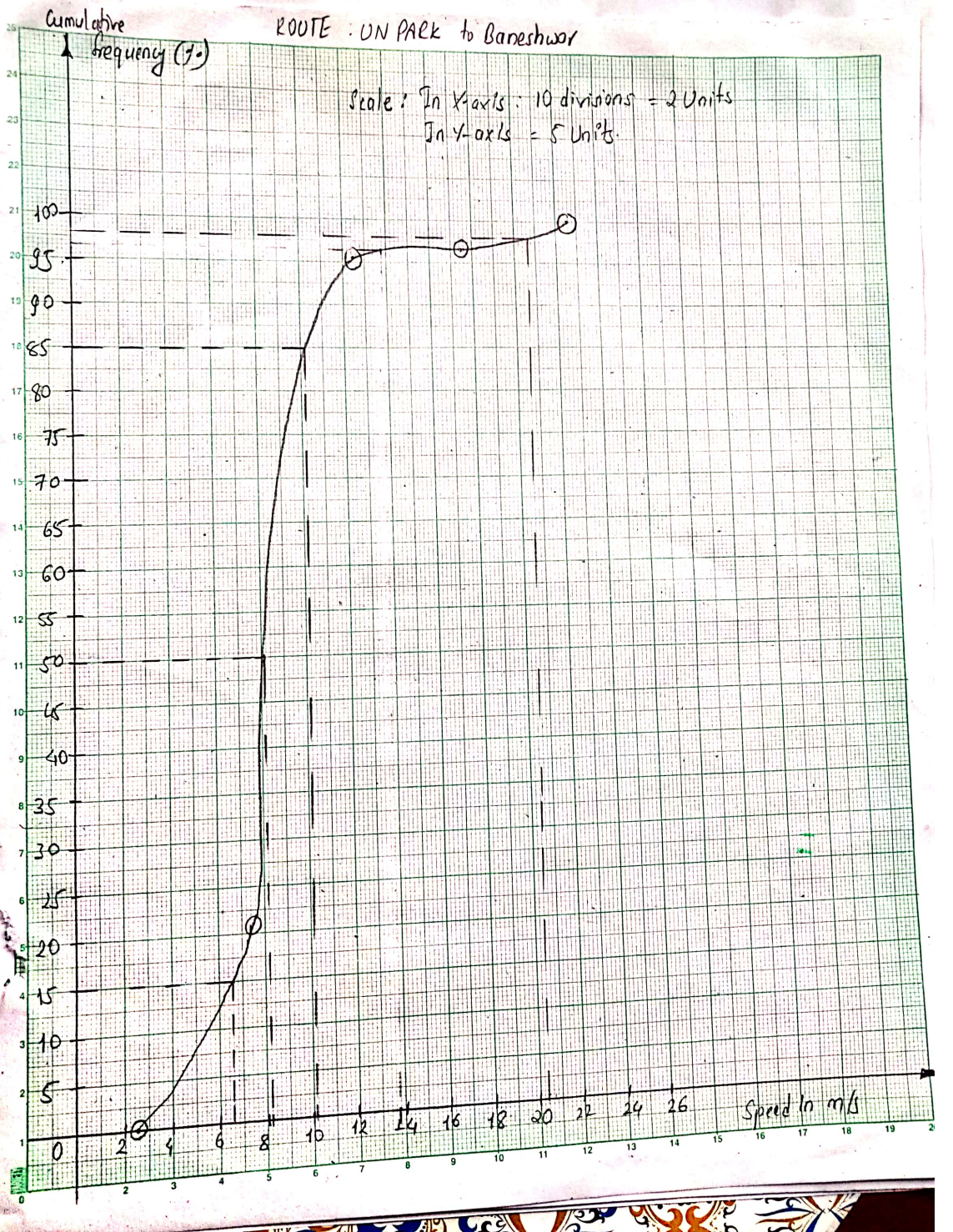

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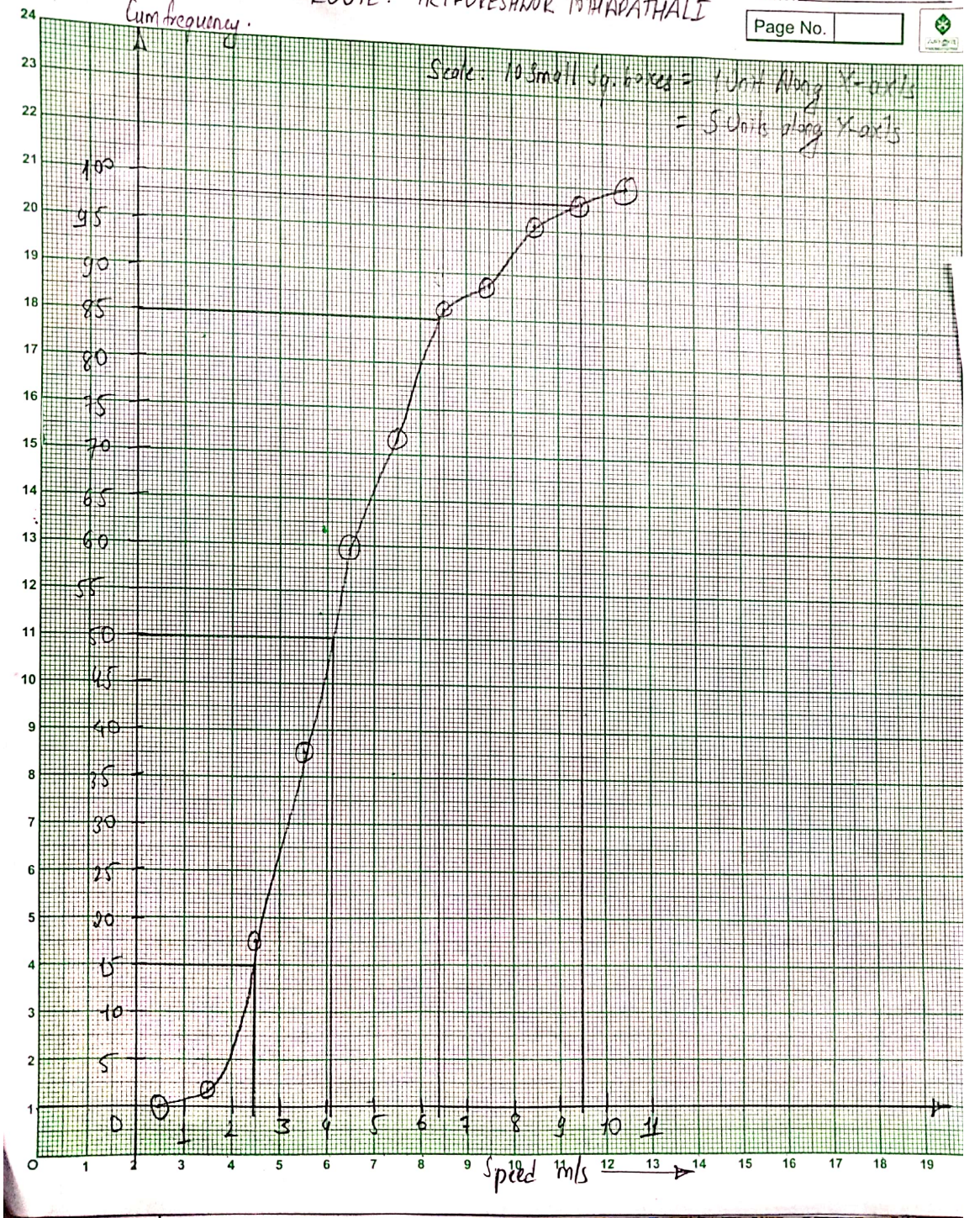

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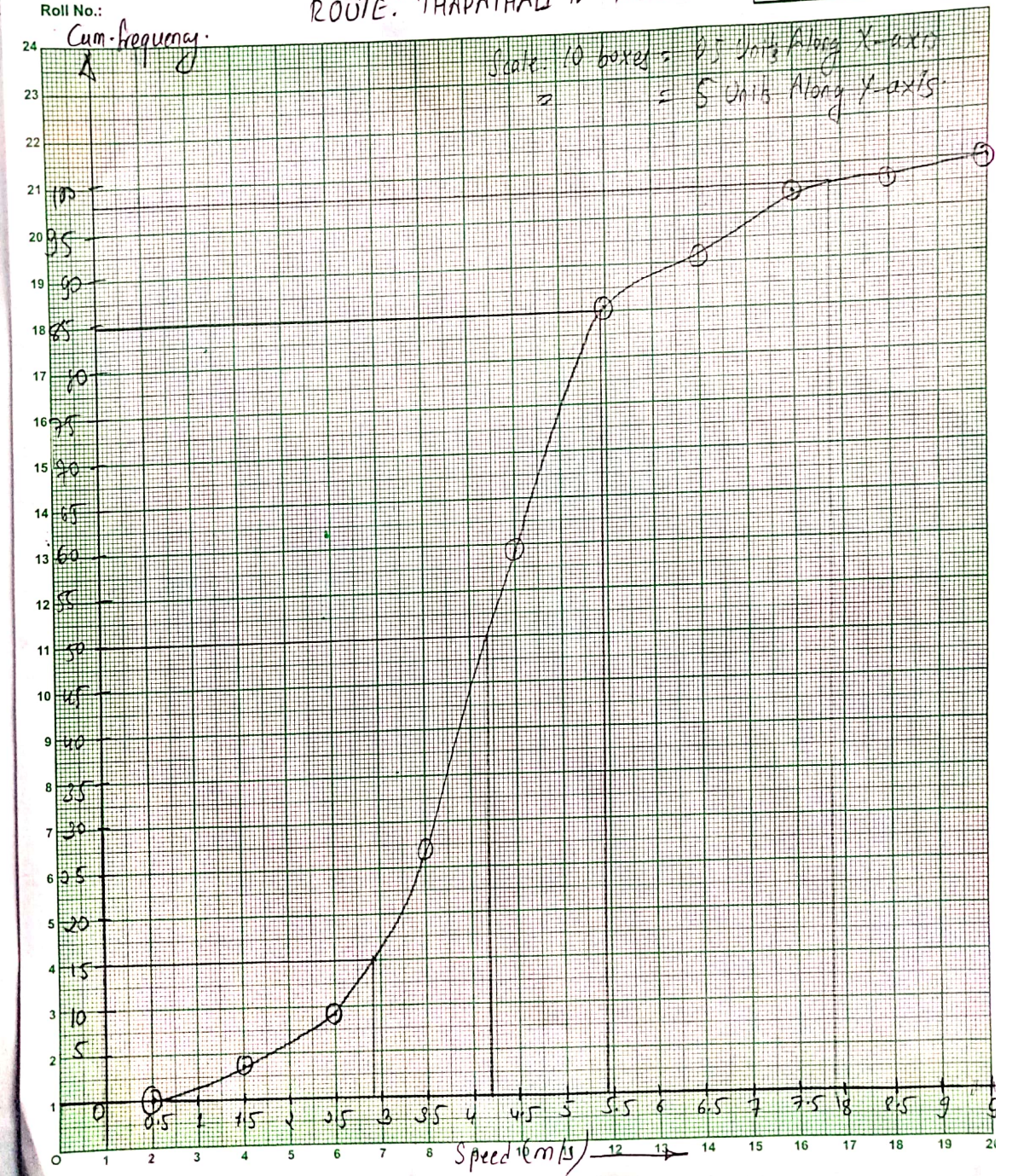

DISCUSSION AND CONCLUSION:

The spot study was conducted at two places : UN Park, Lalitpur and Thapathali, Kathmandu, done on both lanes of the highway. As seen from the result, the spot speed data for both lanes were different so are the parameters like safe speed, design speed etc. The difference is obtained due to various factors as discussed in theory. So, the lower value of the safe upper ~~limit~~ speed was taken amongst the two lanes of same highway and the higher value of geometric design speed and lowest permissible speed were taken for safety purpose.

The data obtained for safe speed, design speed were lower compared to the standards of road. This is because of the limitations in our study as the study was conducted during the busiest hours of the day. The traffic was more slower. To find more convincing value, the range and scope of study should be extended, so that more accurate equipments and methods could be used.

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