محاضرات مادة هندسة المرور

المرحلة الثالثة / فرع هندسة الطرق والجسور

Traffic Engineering

Third Class / Highways and Bridges

Traffic engineering

① Introduction to traffic engineering

1.1 Defining traffic engineering

1.2 Driver characteristics

1.3 Vehicle characteristics

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6.2 Intersection characteristics

⑦ Traffic signal design

⑧ parking

References

1- "Traffic Engineering, an Introduction", G.R. Wells

2- "Traffic Engineering Theory & practice" by Louis, J. Pignataro, 1973

3- "Traffic and Highway design" by Nicholas, J. Garber and Lester, A. Hoel

4- "Highway Engineering" Vol. 1 by O'Flaherty, C.A.

5- "Highway Engineering" by Clarkson, H. Oglesby

Definition of traffic engineering

: is that part of engineering which deals with traffic planning and design of roads, of frontage (مستقبلية) development and of parking facilities and with the control of traffic to provide safe, convenient and economical movement of vehicles and pedestrians.

phases (اطوار) of traffic engineering

1- The road user مستعمل الطريق < driver / pedestrian
2- The vehicle المركبة
3- Traffic volume حجم المرور
4- speed, travel time, Delay السرعة، الوقت، التأخيرات
5- Origin and destination رحلات المنشأ والمقصد والأغراض للرحلات
6- Traffic capacity سعة المرور
7- Parking مواقف السيارات
8- Accidents (as a measure of failure) الحوادث
9- public transit النقل العام

* هندسة المرور: هو ذلك الجزء من الهندسة الذي يتعامل مع تخطيط المرور وتصميم الطرق اخذاً بالاعتبار التقديرات المستقبلية ويتعامل ايضاً مع خدمات مواقف السيارات وتنظيم المرور والسيطرة عليه لتوفير حركة آمنة ومناسبة واقتصادية للمركبات والمشاة.

Chapter (1)

Characteristics of the Driver, the pedestrian, the vehicle, and the road

The four main components of the highway mode of transportation are ~~the~~

- The driver
- The pedestrian
- The Vehicle
- The road

★ Driver characteristics

1- The human Response process

- Visual reception : The receipt of stimuli by the eye is the most important source of information for both the driver & pedestrian.

the principal characteristics of the eye are

a- Visual acuity حده البصر

والقابليه على تمييز التفاصيل الدقيقه للاشياء

b- peripheral vision

قابليه الاشخاص لرؤيه الاشياء الخارجه عن مخروط الرؤيه الواضحه

c- Color Vision

القابليه لتمييز الالوان عن بعضها

وهذه غير ضروريه جدا فيمكن تمييز الاسود والابيض او الاسود والاصفر

d- Glare Vision and recovery

البريق يؤذي العين (بريق اضاءه المركبات)

وفتره زوال تاثيره على العين

e- Depth perception

عمق الادراك الحسي

في تقدير المسافه والسرعه

f- Hearing perception

تكون مرهقه فقط في حاله وجود سيارات التحذير (الاطفائيه، الاسعاف، الشرطه)

* pedestrian characteristics

خصائص المشاة

Same characteristics of diriver, with addition of others which influence the design and location of pedestrian control devices, such as

تؤثر على تصميم وموقع خدمات وتنظيم مرور حركة المشاة

- special pedestrian signals
- safety zones and islands at intersections
- pedestrian underpasses
- elevated walkways
- crosswalks

مميزات المشاة في العبور لها تأثير مباشر في تصميم وسائل السيطرة
مثلاً : ان تصميم طور الـ all-red والذي يسمح لمرور الاشخاص
في التقاطعات خلال المرور الكثيف للسيارات يتطلب معرفة سرعة
المشي للاشخاص والتي قد تختلف حسب العمر والجنس والذكاء
ودرجة التعلم والحالة النفسية

* Perception-and-Reaction process

العملية التي يقوم خلالها السائق او الماشي (الراجل) بتقييم والتفاعل
مع العوارض التي تواجههم، ممكن تقسيمها الى اربع عمليات اساسية:

1- Perception : seeing the stimuli
2- Identification : understanding the stimuli
3- Emotion : what he will do (to stop, blow horn, to pass)
4- Volition or Reaction : To do the decision

PIEV time or Perception-Reaction time ومختصرها

it is used in the : - determination of braking distances
- length of the yellow phase at signalized intersections

PIEV time قد يتغير بين الاشخاص واحياناً للشخص الواحد حسب الظروف مثلاً
يتغير حسب العمر، الظروف الجوية، التعب، تأثير دواء او كحول

PIEV time $\simeq$ 2.5 sec (AASHTO)

مثال صفحة (45)

★ Vehicle characteristics

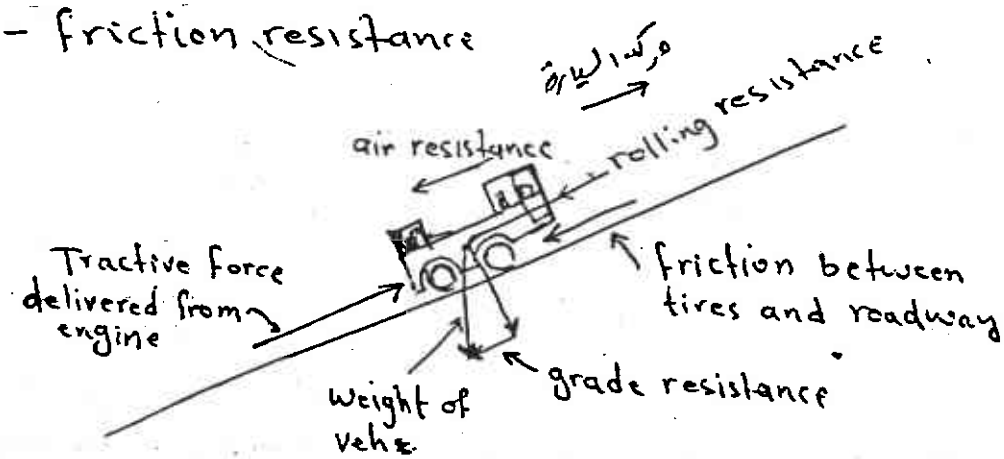
Criteria for the geometric design of highways are partly based on

1- static characteristics
- weight of veh.
- size of the veh.

} as a control of pavement design

2. Kinamatic characteristics
involve the motion of the veh., without considering the forces that cause the motion
- acceleration capability of the veh.
- Braking
- sterring
- lighting
- power
- fuel economy
- operating cost

3. Dynamic characteristics : involve the forces that cause the motion of the vehicle
- air resistance
- grade resistance
- rolling resistance
- Curve resistance
- friction resistance



Desigining a highway involves the selection of a design vehicle,

The vehicle

Cars ranges from compact cars to articulated trucks شاحنات

They differs in their

- max. acceleration (Kinamatic characteristics)
- turning radii (static characteristics)
- weight and size " "
- the ability to climb grades (Dynamic characteristics)

Difinitions

Passenger Cars: All free wheeled, Self propelled vehicles generally designed for the transportation of persons, but limited in seating capacity to not more than nine passengers including

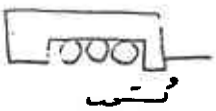
- taxicabs
- limousines
- station wagons

Truks: All free wheeled, self propelled vehicles, design for transportation of persons and having a seating capacity of ten or more passengers.

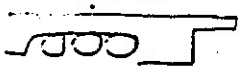
OR

All free wheeled vehicles having dual tyres on one or more axles, or having more than two axles, designed for transportation of freight (بضائع) rather than passengers includes

* Tractor-Truck (تاطره) (سيارة كاملة تدفع نفسها بنفسها)



* Trailers (مقطوره)



* Semitrailers

Road characteristics

these affects

- stopping sight distance — مجال الرؤية للوقوف
- passing " " — " " للتجاوز
- ~~gradient~~
- ~~superelevation~~
- ~~Geometric design of the Road~~

وتشمل

- gradient
- superelevation
- Geometric design of the road

المحاضرة الثانية

Volume studies

Characteristics of traffic flow

Traffic composition: Vehicles of different types have different road space requirements and different effects on the capacity of highway and intersection because of variations in size and performance (اداء).

بسبب الاختلاف بين المركبات من حيث حجمها وادائها وانواعها فان تاثيرها ايضا سيختلف على الطريق والتقاطعات فمثلا وزن وتأثير وحجم مركبة صغيرة (سيارة خاصة) يختلف عن تأثير باص لنقل الركاب او مركبة حمل من حيث السرعة واحتلال حجم اكبر في الطريق وتأثير وزنها على طبقات التبليط

The overall effect on traffic operations by any vehicle can be expressed in terms of the effect of the basic unit - usually a passenger car. So vehicles should be converted to equivalent passenger car unit (PCU) as follow

PCU hwy design manual P2-50

Page 31 wells

Class of veh	Flat	Hilly	Mountainous
private car, Taxi, motorcycle	1	1	1
pick up, bus up to 24 passengers	1.25	1.75	3.00
Truck, bus above 25 passengers	2.00	3.00	6.00
Heavy veh	3.0	5.0	10.0

example: A rural highway has the following traffic composition

passenger car 50%

heavy goods veh = 42%

Buses above 25 passenger = 5%

motor cycles 3%

Find the equivalent passenger car unit if the total number of vehicles passing is 6000

solution

No. of passenger cars $= 6000 * \frac{50}{100} = 3000$

No. of trucks and HGV $= 6000 * \frac{42}{100} = 2520$

No of Buses of 25 pandover $= 6000 * \frac{5}{100} = 300$

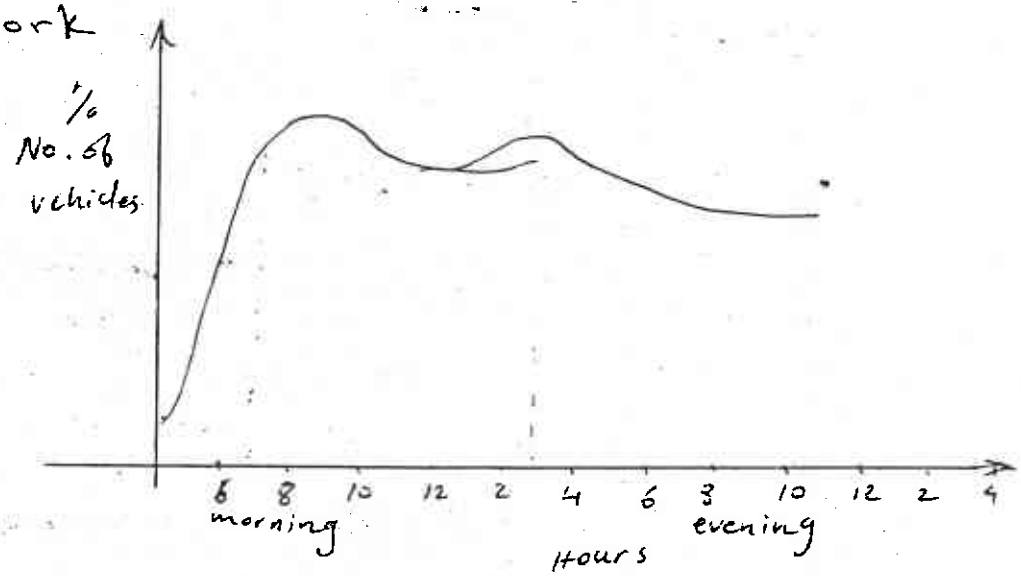
No. of motor cycles $= 6000 * \frac{3}{100} = 180$

Total No. of PCU $= 3000 * 1 + 2520 * 3 + 300 * 2.00 + 180 * 1$
$= 11640$

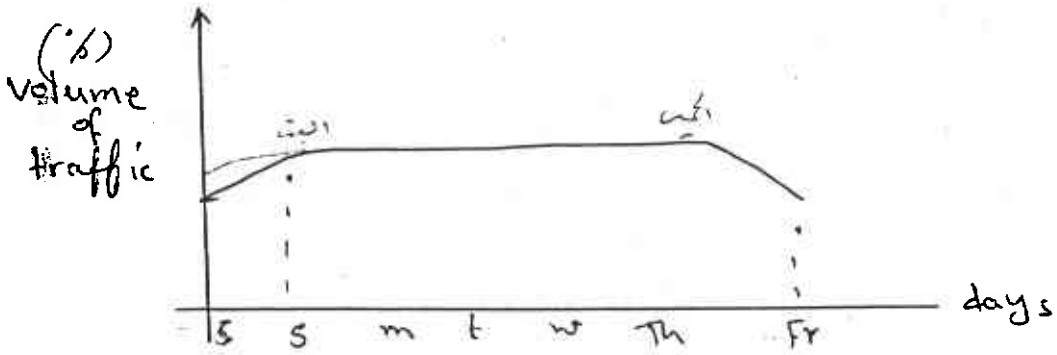
Traffic fluctuation — page 14 wells

:- The flow of traffic is changing throughout the day, the week and the year

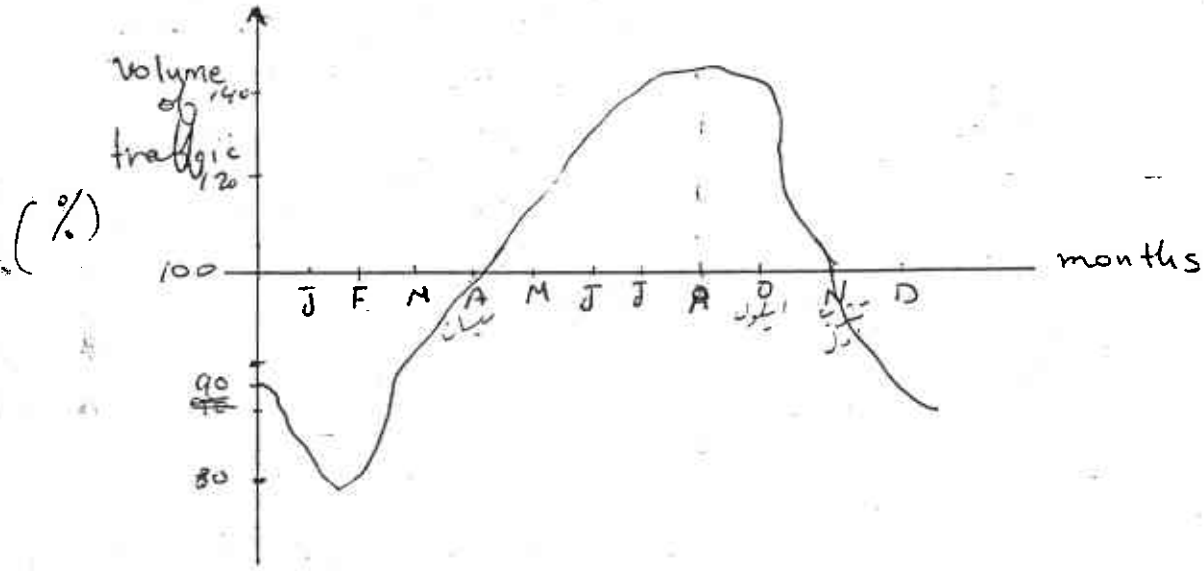
The pattern of hourly traffic through a full day (24 hrs) is indicative of the social pattern of our lives. There is a peak as we go to work in the morning, and another peak in returning from work



within the week the traffic stay constant from saterday to thursday but varies over the weekend



the annual pattern shows considerable fluctuations through the year. Higher flow in summer



Measurment of traffic flow or Traffic Data

Traffic volume: is the number of vehicles passing particular station during agiven interval of time.

Traffic volume can be expressed in terms of annual traffic or daily traffic or hourly traffic.

Average Annual Daily Traffic (AADT) مصطلحات

وهو مقياس عام لتردد المرور في الطرق

It is the total No. of vehicles that pass over a given section of a lane or a roadway during one year divided by 365

$$AADT = \frac{\text{Total traffic of the year}}{365}$$

ان استعمال هذا المقياس في التصميم (geometric design) لا يعتبر صحيحاً حيث انه لا يمثل التغيرات المحسوسة للمرور والتي تظهر خلال اشهر معينة من السنة واسابيع معينة وايام من الاسبوع او ساعات معينة من اليوم. حيث قد يبلغ حجم المرور لبعض الايام في الطرق الريفية Rural ما يجعل ضعف قيمة AADT

AADTs are used in several traffic & transportation analysis for

a- Estimation of hwy. user revenues تقدير المدخولات من مستعملي الطريق

b- Computation of accident rates in terms of accidents per 100 million veh-miles حساب معدل الحوادث لكل مئة مليون (مركبة ميل)

c- Establishment of traffic volume trends تثبيت طبيعة الحجم المروري

d- Evaluation of the economic feasibility of hwy. projects

e- Development of freeway and major arterial street systems التقييم الاقتصادي المناسب لمشاريع الطرق

f- Development of improvement and maintenance programs. تطوير برامج التحسين والصيانة

Vehicle classification (VC): records volume with respect to the type of vehs. eg. passenger cars, two axles trucks, (Vc) is used in

a- Design of geometric characteristics, with particular reference to turning radii requirements, max. grades, lanewidths, --- etc.

b- Capacity analyses, with respect to passenger-car equivalents of trucks

c- Adjustment of traffic counts obtained by machines

d- Structural design of highway pavements, bridges, and so forth

Vehicle Miles of Travel (VMT): is a measure of travel along a section of road. It is the product of traffic (average weekly vol. or ADT) and the length of road way in miles to which the volume is applicable. VMTs used mainly as a base for allocating resources for maintenance and improvement of highways.

VMT = ADT × length of roadway (miles)

Average daily traffic (ADT)

greater than 1 and less the year

$$ADT = \frac{\text{total vol. during a given time period in whole days}}{\text{respective no. of days}}$$

ويجب ان تكون الفترة المأخوذة اكثر من يوم واقل من سنة
وتستعمل لحساب المرور عندما يكون الاختلاف بحجم المرور بين الايام
قليلاً خلال ايام السنة .

It is often used for measuring traffic volumes when traffic volumes vary little from day to day over the course of the year.

وتستعمل او يستفاد من الـ ADT في
a- planning of hwy activities والتخطيط لنشاطات الطرق
b- measurment of current demand حساب الطلب الحالي
c- Evaluation of existing traffic flow تقييم لتدفق المرور الحالي

Design Houre Volume (DHV)

: Is the 30th highest hourly volume of the year (abbreviated 30HV) It is used for design purposes. The DHV is normally expressed as a percentage of ADT (about 15 % ADT)

$$K = \frac{DHV}{ADT} \times 100$$

$K = 10-17\%$ two way

$K = 7-18\%$ one way

هي اعلى حجم مروري لـ ٣٠ ساعة من السنة

Peak Hour Traffic:

: It is the highest number of vehicles per 60 min. and it is required for the design of traffic facilities

وتستعمل في
a- functional classification of hwys.
b- design of geometric characteristics of hwy. eg no. of lanes, intersection signalization or channalization
c- capacity analysis
d- development of programs related to traffic operations ex. oneway st systems
e- development of parking regulations

T_H , T_D : T_H : Percentage of trucks within peak houre

T_D : Percentage of trucks within daily traffic

$T_H = 0.7\, T_D$

Directional Distribution

:- The hourly traffic load in each direction of traffic.

بالرغم من ان حجم المرور يتساوى غالبا في الحرية (ذهابا وايابا) الا انه قد يختلف في ساعات معينة من النهار او في ايام معينة من الاسبوع

It is expressed as a percentage of two directional volume for the particular peak hour and is calculated for both morning and evening peaks

i.e 60/40 during the peak

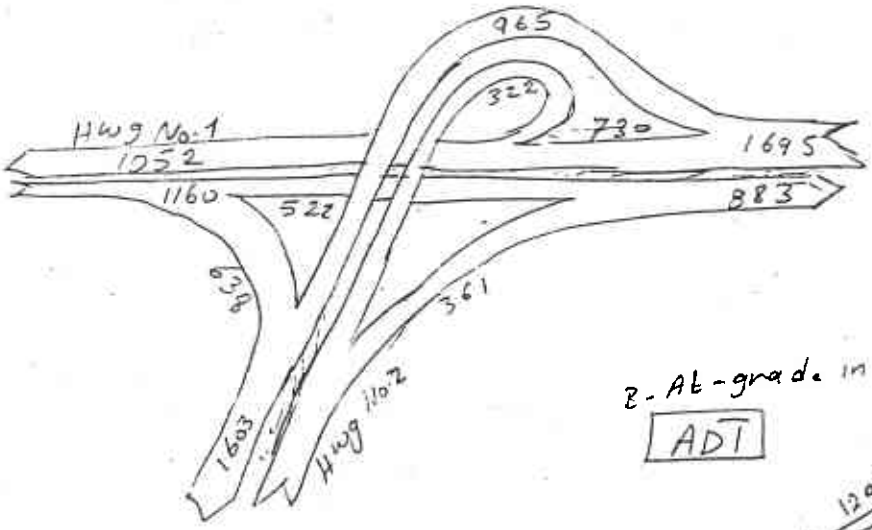
60% ←

40% →

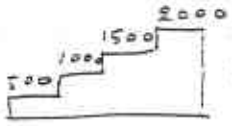
عند تصميم التقاطعات الارضية (grade intersections) او ال (interchanges) من الضروري معرفة تدفق السير في كل فرع خلال فترة الذروة peak بالاضافة الى نسبة المركبات المارة والذاهبة يمينا او يسارا لكل طريق كما في الشكل الاسفل Fig I-32 Hwy design manual

A-grade separated intersection

AM peak



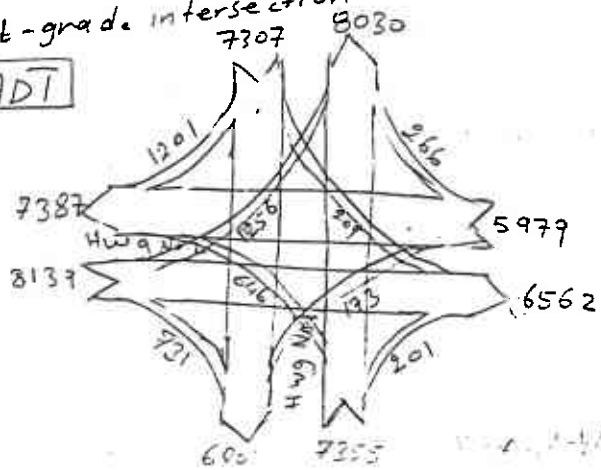
scale



pcu/hr

B- At-grade intersection

ADT



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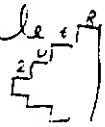


Thousands of Vehs/24 hrs

Deriving representative traffic figures

As we said that the

$$AADT = \frac{\text{Total traffic of the year}}{365}$$

But it is difficult to do so.

Then

The alternative is to use a count at any point in the year, and from this derive an annual average figure if local traffic flow patterns, over at least one or two 12 months periods, are known. such as this one

month	traffic flow as a percentage of annual average month
J	84
F	82
M	94
A	97
M	107
J	107
J	116
A	118
S	107
O	103
N	92
D	90

$$\text{annual av. month} = \frac{\Sigma \text{ of traffic through one year}}{12}$$

$$\% \text{ of annual av month} = \frac{\text{traffic vol. through month}}{\text{traffic of av. month}}$$

Similarly the traffic movement in the 16 hrs from 600 to 2200 have been found to represent just under 93% of the 24 hrs flow, and the daily flows from saturday to thursday to be sensibly constant.

لحساب AADT يكون غير اقتصاديا حساب عدد السيارات لسنة كامله كل يوم وقسمه الرقم على 365 ولهذا ارتؤي حساب المرور شهرين من السنه يبعد بينهما ٦ أشهر مثل كانون الثاني وتموز او آذار وايلول مع الاخذ بنظر الاعتبار التذبذب باليوم الواحد خلال ايام الاسبوع .

اذن من الـ 24 ساعه / سبعه ايام من شهرين لم وتموز نحصل على رقم دقيق لقيمه AADT

AADT=(January 7days flow + July 7days flow) / 14

لكن هل هذه الدقه العاليه ضروريه او مطلوبه خصوصا مع طبيعة المرور المتذبذب وطول فترة الانتظار ٦ أشهر . لهذا فكان الاعتماد على بديل آخر هو العد في اية نقطه من السنه ومن ثم نحسب الـ AADT اذا كان لدينا رسم العلاقة السابقه بين المرور كنسبه من الـ AADT مع اشهر السنه وكلما اخذت هذه النقطه من السنه في فترة الذروه peak من حيث الساعه واليوم والشهر يكون الرقم الناتج اقرب الى الدقيق والصحيح

(17-B)

كذلك فان عدد المركبات ٢٤ ساعه ولمده اسبوع نادراً ما يحصل
فقد وجد ان المرور لمده ١٦ ساعه (من السادسه صباحاً
لغايه العاشره مساءاً) يمثل ٩٢٪ من المرور الكلي في ٢٤ ساعه
والتدفق في يوم السبت لغايه الخميس ثابت تقريبا ولهذا فمن
المنطقي حساب عدد المركبات لمده ١٦ ساعه باليوم الواحد لثلاثه
ايام من الاسبوع هي الخميس ، الجمعه والسبت

example: There was aneed to know the AADT for a rural project where 16 hr flows were counted on thursday, friday & saturday in June as follow

thursday	8000
friday	8000
saturday	10000

Solution:

The seven day - 16 hrs flow = 10000 x 5 + 8000 + 8000
= 66000 veh

The seven day 24 hrs flow = $\frac{66000}{0.93}$ = 70968 vehs.

average June daily traffic = $\frac{70968}{7}$ = 10138

AADT = 10138 x $\frac{100}{107}$ (for average month / for June)
= 9474 ≃ 9500 vehs

The June count could be converted to 16 hrs Augest average flow

7 day June 16 hr flow = 66 000 vehs

Augest flow is 118 % of (AADT flow)

∴ 7 day Augest 16 hr flow = 66000 x $\frac{118}{107}$
= 72785 veh

∴ Average Augest daily traffic = 72785/7 = 10398 veh

Traffic forcast نمو المرور

تصميم طريق جديد او تطوير طريق موجود يجب ان لا يعتمد على المرور الآني (في ذلك الزمن) ولكن على المرور المتوقع ان يستعمل الطريق مستقبلاً وسنة النمو (forcast year) لتصميم المرور يجب ان لا تكون بعيدة جداً عن الوقت الحاضر حتى لا تكون الدقة بالنتائج ضعيفة ولهذا تؤخذ مثلاً من ١٥ الى ٢٠ سنة

Future traffic volumes for the design are normally derived from the current traffic level and the traffic

For important projects traffic forecasts should be based on through-traffic studies considering the analysis of

- Zonal socio-economic variables (e.g. population, jobs, employees, schoolplaces, car ownership)
  تحليل المتغيرات الاجتماعية - الاقتصادية للقطاعات
- mobility الانتقال
- development of transport facilities and modal split. تطور خدمات النقل وتقسيم النقل

future traffic to current traffic. It is a combined factor of (normal traffic growth, generated traffic and developement traffic)

الزيادة او النمو الطبيعي — المرور المتولد — المرور المتطور

$$F = (1+i)^n$$

where F : traffic forcast factor

i : Annual rate of traffic increase

n : Traffic analysis period

also

$$F = \frac{\text{future traffic}}{\text{current traffic}}$$

Components of future traffic مكونات او مركبات المرور المستقبلي

① Current traffic : existing and attracted

وهو حجم المرور
الذي يستعمل طريق جديد او مصلح حديثا ومفتوح
او هو حجم المرور الذي كان يستعمل الطريق سابقا بالاضافة الى
ما سيجذبه من مرور بعد تطويره

Traffic already using the route plus traffic transferring to the new highway from less attractive routes.

② Normal traffic growth (نمو المرور الطبيعي) : is the increase of current traffic due to general increase in number and usage of motor vehicles.

هو مقدار الزيادة في
المرور الحالي نتيجة زيادة عدد واستعمال المركبات

③ Generated traffic : المرور المتولد

وتشمل الرحلات التي استحدثت والتي
لم تكن لولم يتم فتح الطريق وتشمل ثلاثة عناصر

- new trips not previously made by any mode of travel.
- trips that previously were made by public transport
- trips attracted by the new or improved highway.

ويؤخذ هذا المرور بنظر الاعتبار ويحسب حساب حتى
ولو عن طريق التخمين ويتراوح بين 5% - 25%

④ Development traffic : is traffic due to improvements on adjacent land

هو تطور الارض المحيط بالطريق باضافة
ابنية جديدة تستوجب انشاء طرق اضافية
مما سيجذب رحلات اكثر نحو هذا الطريق

- او هو المرور المتولد او المجتذب نتيجة تطور المناطق المحيطة بالطريق

example :- Design data is required for the improvement of two-lane of a two-way highway with central reserve. The current traffic in ~~1999~~ ~~2002~~ 2003 expressed by AADT is 3000 vehicles in both directions. The improved road with a design life of 20 yrs will be opend to traffic in 200~~6~~7 2008. the estimated annual growth rate of traffic is 8%. K value = 12% of ADT

D (Directional distribution) = 55% of total traffic

T_H (peak hour truck percentage) = 18% of hourly volume

Solution

$$F = (1+i)^n \qquad i = 8\%$$

$$n = (2004-1999) + 20 = 25$$
$$(2007-2002) + 20 \text{ year}$$

$$F = (1+0.08)^{25}$$
$$= 6.848$$

∴ future traffic (No. of vehicles at ~~2024~~ ~~2027~~ 2028) = 3000 * 6.848
= 20544 vels. per day

DHV (in the pedominant direction) = ADT * K * D

∴ DHV = 20544 * 0.12 * 0.55 = 1356 (vph)

taking in the account the composition of traffic

% of passenger cars in peak hr. = 100 - 18 = 82%

∴ DHV (in pcu/hr) = 1356 [0.82*1 + 0.18*2]
2024
= 1600 pcu ph

Traffic engineering studies المحاضرة الثالثة

ان توفر طرق النقل السريعة والتي ترتبط بمستوى المعيشة الراقي لها مشاكلها ايضاً ومن هذه المشاكل او السلبيات

The problems related to highway mode of transport are

1- highway related accidents — الحوادث
2- parking facilities — مشكلات مواقف السيارات
3- Congestion — الاختناقات
4- delay — التأخيرات

ولتجاوز هذه السلبيات يجب ان نجمع معلومات صحيحة تشرح مدى توسع هذه المعلومات وتوضح اماكنها وهذه المعلومات تأتي بتنظيم وعمل مسوحات ودراسات هندسية وهناك ثلاث دراسات

هذه الثلاث تعتبر من الدراسات الاساسية

The three categories of traffic studies are (تصنيفات)

1- Inventories: It provides a list or graphic display of existing information. such as street widths, parking spaces, transit routes, traffic regulations and so forth
(قوائم جرد) او رسوم — قوانين المهمة للمرور

بعض هذه المعلومات تتغير مع الزمن مثل انظمة المرور ومواقف السيارات وبعضها ثابت مثل عرض الطريق

2- Administrative studies: They use existing engineering records, available in government agencies and departments.
(وكالات)

هذه الدراسات تشمل نتائج المسوحات ~~الهندسية~~ المأخوذة من مسوحات موقعية او التصوير الجوي

3- Dynamic studies: They involve the collection of data under operational (تشغيل) conditions and include studies of speed (سرعة), traffic volume (الحجم المروري), travel time (زمن الرحلة) and delay (التأخير), Parking (مواقف السيارات), and accidents (الحوادث)

وهذه الدراسات هي التي يقوم بها مهندس المرور وعليه سيتم شرحها بالتفصيل لاحقاً.

طرق قياس التدفق المروري

Methods of measuring the flow of traffic

There are two methods of measuring the flow of vehicle along a road

(A) manual counting العد والحساب اليدوي

(B) Mechanical counting العد والحساب الميكانيكي

(A) Manual counting

1- Simply is to count every veh seen to pass a fixed point on a road. It is done by pen & paper and groups of five H[illegible]

من فوائدها تصنيف المركبات الى PSV , HGV , Cars

Cars : cars, vans, [illegible] side cars and light commercial vehs.

HGV : heavy goods vehicles, i.e over $1\frac{1}{2}$ tonne and having six or more road wheels

PSV سيارات ذات خدمات خاصة : public service vehicles, buses, coaches, trams and trolley buses (الباص الكهربائي)

والاستمارة كما في الشكل صفحة (10) fig 2-1 وما يلي

عدد المرات للشخص الذي يقوم بالعد	Road No. observer		Date: weather	
Time		سيارات خاصة private cars	سيارات تحمل بضائع ثقيلة HGV	مركبات ذات خدمات عامة أي خدمة PSV
from	to			
09:30 or 930	10:00 1000	20	12	13
10:00 1000	10:30 1030			

2- moving observer method والطريقة الثانية هي

وسنشرحها بالتفصيل في موضوع السرعة

و زمن الرحلة

الفوائد — المزايا

Advantages: ① flexibility — بالامكان تغيير الموقع حسب الرغبة

② Simple and quick — سهلة وسريعة ولا تحتاج الى نصب اجهزة او مراقبة معينة

③ permits traffic classification by veh. type — تصنيف المركبات حسب نوعها

④: cheap for short sample counts — رخيصة لفترات قصيرة

المضار

Disadvantages: ① Expensive for long counts or in unsocial hours — مكلفة للفترات الطويلة

② unpopular in inclemental weather — غير محبذة في الظروف الجوية

③: Accuracy depends on quality of observer — الدقة تعتمد على الاشخاص ، معرضة للاخطاء الشخصية

2 TMC/48 electronic manual counter

يستعمل ~~[illegible]~~ للتقاطعات يتم الرسم الى ٤٨ جزء (كل نصف ساعة)

(B) Mechanical counting — الحساب الميكانيكي

الحساب أو الحساب الميكانيكي: mechanical counter — Page / Wells

consists of two elements

- A detector — كاشف
- A counter — عداد

types of detectors — أنواع الكاشف

① - positive contact detector — حيث ان اطارات المركبة تسبب اتصال طرفين معدن لربط دائرة كهربائية . صيانة الحساس صعبة

② - pneumatic detector — نيومايتك

عندما تضغط عجلات المركبة على الانبوب تعطي نبضة Impulse ، صيانة سهلة وهو المستعمل بالعراق

③ - Hydraulic detector:

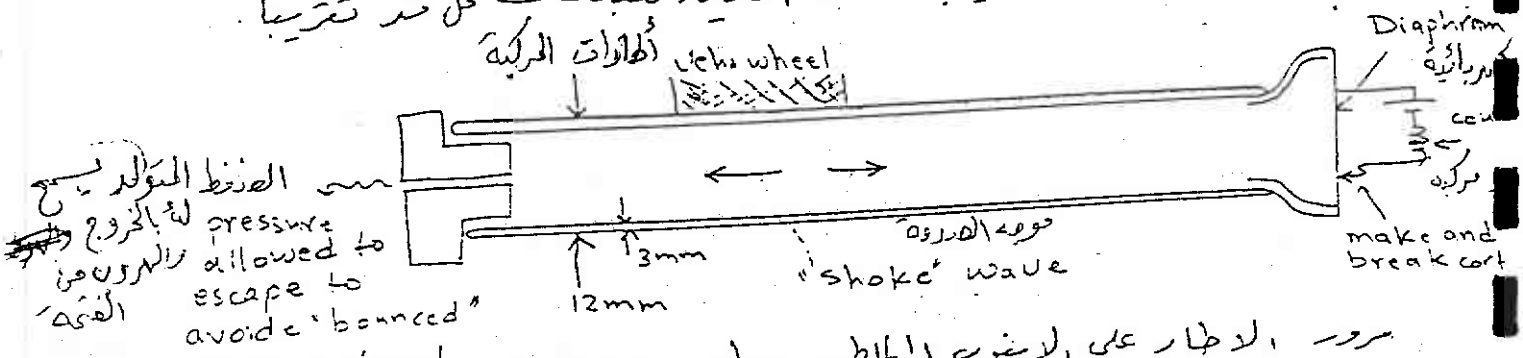
يشبه الـ pneumatic ولكنه يحتوي على سائل وصيانة صعبة ويحتاج لسائل

④ - Magnetic loop detector: يدفن وايرين في سطح الطريق . عندما تعبر سيارة فوقه سيتعكر المجال المغناطيسي وهو جيد جدا كاستخدام وأمثل ولكنه غير مناسب للمرورات العشوائية

5- photo-electric eyes, radar, infra-red or ultrasonic beam

وهنا قد تكون كاميرا او رادار حيث يرسل اشعه ويستردها.
فعند مرور مركبه تقطع سير الاشعه فتسجل، وهو جهاز معقد وصعب الصيانة ويحتاج لشخص ماهر وهو غالي الثمن. ولكنه اكثر دقه

النوع الاكثر استعمالاً وشيوعاً هو ال pneumatic لانه لا يحتاج الى عمال ماهرين ولا يستعمل للموجات المستمره الدائميه
وهو يتكون من انبوب مطاطي سميك مجوف قطره يبلغ (١٢ ملم تقريبا) و (٣ ملم سمك الجدران) ويثبت على الطريق بكلبسات كل متر تقريبا.



مرور الاطار على الانبوب المطاطي يعطي shoke wave تنتقل الى الطرفين احدهما يسير بلا والاخر يدفع diaphram ليرسل دائره كهربائيه. وهنا كل نبضتان two axles يسجل رقم واحد اي مركبه واحده

one car = two axles

ميزة الحساب الميكانيكي او العد الالي للمركبات عندما يكون عددها استمراريه.

Mechanical counting are employed for continuous counts, recording the distribution of traffic, hour of the day, days of the week, months of the year and from year to year. Such counts are important to establish traffic trends. There are several

تسجيل توزيع الحركة اليومية خلال الساعة وخلال ايام الاسبوع وخلال السنة.

مزايا العد او الحساب الالي

Advantages:

١- يمكن اجراؤه في جميع الاوقات والظروف الجويه
٢- مضبوط اذا استعمل في المكان المناسب عند الحفاظ عليه وصيانته
٣- رخيصه للفترات الطويله

المضار

Dis-advantages:

١- غالي عند استعمال الفترات القصيره
٢- يحتاج الى مراقبه وانتباه عالي
٣- لا تستطيع تصنيف المركبات (حتى التي لا ٣ اكسلات لا تستطيع تمييزها)
٤- ادواته غاليه الثمن حيث تتكون من عده اجزاء

انواع حساب الحجم المروري

Types of volume counts

1- Cordon counts — Central Business District (CBD) — مقاطعة ذات مساحة وسط المدينة — حساب منطقة معينة

وتستعمل عندما يراد حساب تراكم المركبات في مساحة معينة كأن تكون CBD وخلال فترة معينة. حيث تخطط الارض او المساحة المدروسة بخطوط وهمية وتدعى انذاك هذه المساحة بال (Cordon area)

وكل شارع يتقاطع مع الحدود الوهمية يعتبر (count station) محطة للعد وفيه يحسب عدد المركبات والاشخاص الداخلين والخارجين من منطقة الدراسة CBD. المعلومات المأخوذة من هذه الطريقة يستفاد منها في التخطيط لخزانات مواقف السيارات، تحديث وتقييم تقنيات تشغيل المرور وعمل خطط طويلة المدى للطرق السريعة والشريانية

The information are used for

1- Planning parking facilities — التخطيط لمواقف السيارات
2- updating and evaluating traffic operational techniques. — تحديث وتقييم التقنيات التشغيلية للمرور
3- making long-range plans for freeway and arterial street systems. — عمل خطط طويلة المدى للطرق السريعة والشريانية

2- Screen line Counts — يتابع الذي قبله

وهنا تقسم منطقة الدراسة الى مقاطع كبيرة باعتماد خطوط وهمية تدعى Screen lines اما طبيعية او يصنعها الانسان مثل مجرى نهر او طريق سريع. يعد المرور في كل نقطة يتقاطع فيها طريق مع الـ Screen line على ان لا يتقاطع هذا الشارع مرتين.

المعلومات المأخوذة من محطات الـ Screen line بفترات منتظمة تخدم في التقاط التغيرات بالاحجام المرورية واتجاهات التدفق المروري نسبة للتغير في استعمالات الارض في منطقة الدراسة (التاثير) ومؤشراته

- facilitates the detection of variations in the traffic vol. and traffic flow direction due to changes in the land-use pattern of the area.

3- Intersection counts

وتجرى لحساب لتصنيف المركبات

حساب الحجوم المرورية في التقاطعات

في حركات التقاطعات الامامية والاستدارات (اليمين واليسار)

data used in determining phase lengths and cycle times for signalized intersections, in the design of Channelization at intersections and in the general design of improvements to intersections

وقت الدورة

جزرة

حساب طول الطور وزمن الدورة للتقاطعات ذات الاشارات الضوئية.

- في تصميم التفرعات بالتقاطعات
- في التصميم العام لتطوير التقاطعات

4- Pedestrian Volume counts.

5- Periodic Volume counts AADT

Traffic Volume data presentation

1- Traffic flow maps
2- intersection summary sheets
3- Time-based distribution Charts لتغيرات اليومية، الشهرية، السنوية ويعطي نسبة من المعدل
4- Summary tables

~~Travel time and Delay studies~~

~~Speed studies~~

4- Pedestrian Volume counts : لتعيين مواقع خطوط العبور

عرضها او تخصيص اشارات ضوئية تناسب العدد

5- Periodic Volume counts

ويجب ان تكون مستمرة وربما

لا ستكون مكلفة فيفضل انواع مختلفة من العد الزمني يتراوح بين 10 دقيقة

الى مستمر والغرض منه لحساب AADT

تكملة المحاضرة الثالثة

Origin - Destination survey (O-D) (7)

هو المكان الذي تبدأ منه الرحلة

Origin : The location of where the trip begins
المكان الذي تنتهي فيه الرحلة

Destination: The location of where the trip ends.

(O-D) study : A measure of the patterns of movement of persons and vehicles within a particular area of interest
أنماط
قياس
قياس لكل من المركبات والاشخاص من منطقة الدراسة

عدة طرق مستخدمة لعملية O.D

Methods of conducting O-D studies

1- Road side interview page (19) مقابل على جانب الطريق
2- postcard survey page (22)
3- Home interview page (26)
4- License renewall or Registration number check لوحة الارقام
5- Telephone
6- Vehicle tag system page 25

check point

الطريقة الاولى : توقف السيارة عند دخولها للمدينة ويسأل السائق عدة اسئلة عن رحلته منها

١- من اين بدأت رحلتك هذا اليوم
٢- الى اين تذهب
٣- ما غرض الرحلة

وفي حالة كون جواب ٢ هو المدينة المسح يسأل ايضا

٤- اي منطقة من المدينة تقصد (تعيين الزمن)
٥- كم ستتوقف من الوقت
٦- بعد انتهاء الزيارة اين ستذهب

يؤخذ نموذج على الاقل ١٠٪ من المركبات

الطريقة الثانية : بعض السائقين الداخلة للمدينة ومعه يرا اسئلة يرد عليها في وقت فراغه ثم يرسلها بالبريد وتكون مصحوبة من الرسوم وهذه الطريقة تكون مقبولة لان الاشخاص الذين يرسلون للموضوع فقط سيردون الاجابة والباقين لا

الطريقة الثالثة : وهي بزيارة البيوت وسؤالهم عن الرحلات التي قاموا بها اليوم السابق ليوم المقابلة

الطريقة الرابعة : احسن طريقة وحيفه معيني الوحيد عبد القادر الكبير الذي تمتاحه وضايقت المساحون في مدخل المدينه ومخرجها مسجلين رقم المركبات الداخله والخارجه واوقاتها

أهم المعلومات التي أستخدمها :-

The information obtained from the O-D as follow

A- Type of vehicle نوع المركبة

B- No. of persons in vehicle Occupancy الاستيعابية وعدد الاشخاص في المركبة

C- Origin and Destination of trip معرفة المنشأ والمقصد

D- purpose of the trip غرض الرحلة

E- parking locations مواقف السيارات

F- Intermediate stops توقفات الوسطية

بيانات مستحصلة (O.D) المهندس المروري ان يحدد المروري

Uses of O-D data استخدامات

The O-D data enable the traffic engineer to determine

① - Travel demand on existing and future transport الطلب على النقل الحالي والمستقبل

② - The adequacy of existing parking, mass transportation مدى كفاية واستيعابية وكذلك مدى كفاية النقل العام

③ - Location of new bridges مواقع الجسور الجديدة

④ - feasibility of by pass route ناحية اقتصادية و باضافة lane مخصصة للاجتياز .

Zones Sectors

في كل الدراسات لل O-D يجب تقسيم المنطقة الى ~~Zones~~ ثم ~~Sectors~~

ويكون التقسيم بحيث ان الزون الواحد يكون له استعمال واحد

مثلا: يكون هناك منطقة سكنية

Industrial او صناعية residential

او تجارية commercial او تكون

محصورة بعوائق طبيعية

كأن تكون محاطة باحد

شوارع سريعة

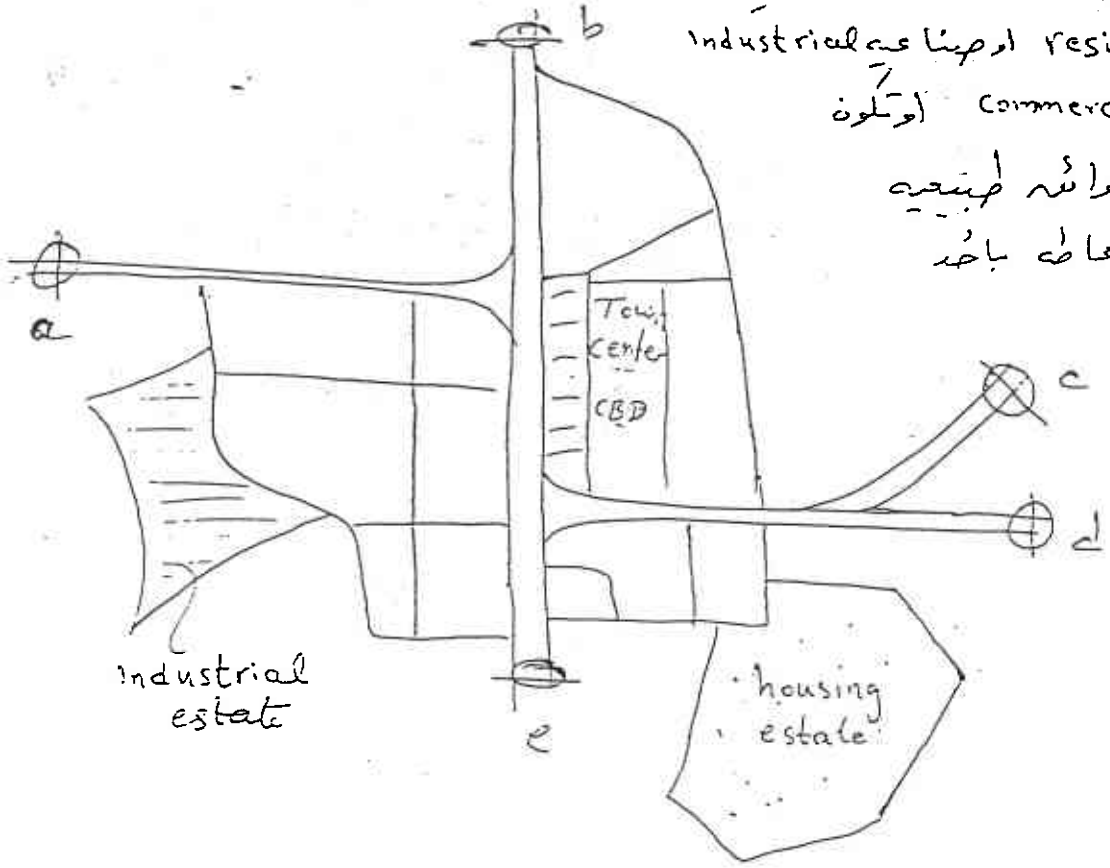
والجهة

الاخرى

بطريقة

مرور

سريع



من متطلبات الطريقة الاولى ان الكادر العامل فيها يكون من

١- مراقب عمل مؤهل يوجه الفريق

٢- مسجلين لعد المركبات يدويا وميكانيكيا وتصنيف المركبات

٣- ستة اشخاص يسألون السائقين يعملون على اوقات متتالية لمدة ١٦ ساعة وكل منهم يجب ان يسأل بين ٥٠ - ١٠٠ سيارة بالساعة

٤- رجلان لتنظيم او توجيه المركبات للدخول الى شارع الاسئلة

٥- رجلا شرطة مرور ليعطيا الشرعية للعمل وحتى يمثل السائقون لهم

Turning movements

من خلال المركبات التي تستدير

It is obtained by a turning movements count (No. of turning vehicles and their classifications) الملاحظ أو الراصد يشاهد المركبات التي تذهب من اليسار الى اليمين.

The observer counts and records vehicles turning left, going straight ahead, and turning right.

يلاحظ ان المركبات التي تستدير يساراً تأثيرها اكثر من تلك التي تسلك يميناً وحيث ان الاستدارات تزيد التاخيرات في التقاطعات (delays) لهذا يجب دراسة الاستدارات وحساب عدد المركبات المستمرة في الطريق وتلك المنحرفة يميناً ويساراً والواصلة فيها ويتم ذلك بمسح الشارع وملئ الاستمارة التالية

Turning movement count

Day: Time: Location:
Date: Name of ~~inter~~ intersection: observer:

left			through straight			right		
Cars	HGV	PSV	Cars	HGV	PSV	Cars	HGV	PSV
卌 卌 卌 卌 卌 II	卌 卌 卌 I	卌 卌 I	卌 卌 卌 卌 卌 卌 卌 III	卌 卌 IIII	III	卌 卌 卌 卌 卌	卌 卌 IIII	IIII

Fig 3.4 كما في صفحة 42

المسح يتم بان يقف شخص واحد مواجهة التقاطع لكل شارع يعد ويسجل المركبات الماشية يميناً وامام ويساراً حسب اصنافها

من معلومات هذه الاستمارة بالامكان تحويل التدفق المروري traffic flow لفترات اقل او اكثر من ساعة الى التدفق بالساعة مع حساب نسبة HGV و PSV ثم ترسم المعلومات على شكل diagram كما في Fig 3.5

اذا اريد الاستفادة من هذه المعلومات لتصميم اشارات ضوئية للتقاطع فيجب ان تحول ارقامنا الى pcu بضرب x معامل (1، 1.75، 2.25) للمركبات الصغيرة، HGV، PSV) على التوالي

و للاغراض الاخرى يجب تمثيل هذه الارقام بالرسوم وحسب مقياس رسم معين وعادة ما تستعمل الوان مختلفة للتمييز بين الاتجاهات كما في fig 3.6 صفحة 44 الكتاب المقرر

وزارة النقل والطرق والجسور

دائرة التخطيط والدراسات / قسم الدراسات

مسح تصنيف مرور

والاستدارات في التقاطع

يوم ------ التاريخ ------ الوقت ------ اسم التقاطع ------ رقم العقدة ------ نقطة سيطرة ------ القائم بالمسح ------

الوقت	صالون	إناص كبير + لوب	إناص صغير + بلك	إناص كبير + لوب	إناص صغير + بلك

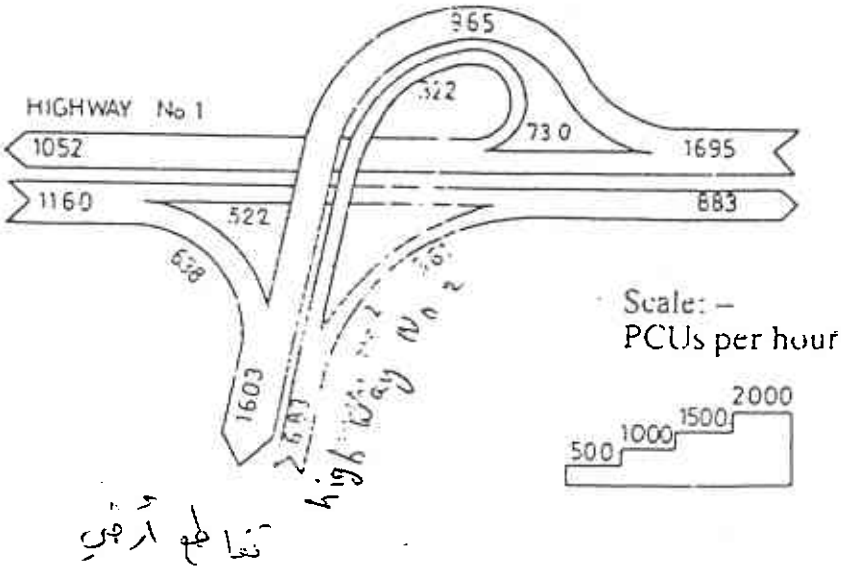
4 TRAFFIC DATA

FIGURE I–32 Typical Intersection Turning Movement Diagrams

A–Grade separated intersection

تقاطع منفصل عن طريق مجسر

AM PEAK

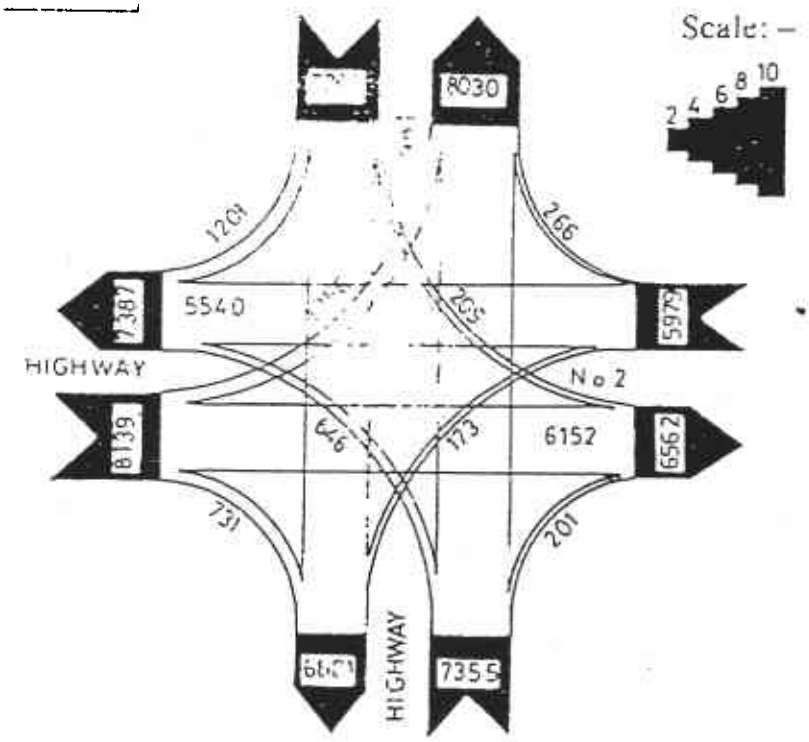


تقاطع أرضي

B– At-grade intersection

ADT

Thousands of vehicles per 24 hours



Speed studies: These studies are conducted mainly for the following purposes.

1- Planning traffic control - establishing speed zones, traffic signals, location of warning, regulatory, and information signs - non passing zones - etc.

2- Determining the speed trends

3- For the accident studies
   a- Relation of accident to speed
   b- Analysis of high accident location
   c- Effectiveness of remedial (علاجية) (measures put in)

4- Used in capacity studies

5- Used for geometric design

Locations and limits of speed study

١- في كل الطرق السريعة الرئيسية major highways

٢- في كل الطرق التي تزداد فيها الحوادث

٣- في كل المواقع التي يفكر في نصب اشارة ضوئية او علامة الوقوف المرورية

٤- في اي موقع آخر لتجميع معلومات للتخطيط لدراسة مستقبلية

ملاحظة: تجرى الدراسة في جو مناسب وجيد

Speed and delay studies

١- دراسة السرعة والتأخيرات توفر حقائق حول كمية وموقع واسباب التأخيرات وتستعمل لعلاج الازدحام في مواقع معينة

٢- تقييم اي خدمة مرورية جديدة مقترحة تتم على اساس زمن الرحلة

٣- الدراسات الاقتصادية تتطلب معرفة زمن الرحلة المستغرق

٤- زمن الرحلة يعطي انطباع عن مدى كفاءة الطريق

٥- دراسات قبل وبعد before and after study تجرى لغرض مدى تأثير التغيرات على السيطرة على المرور مثلا - منع ايقاف المركبات
- وضع اشارات ضوئية
- جعل الطريق باتجاه واحد ... الخ

Speed measurements

Types of speeds are

1- Spot speed : The arithmatic mean of the speeds of all traffic at a specified point

وهي السرعه التي يؤشرها عداد السياره ويحاسب عليها شرطي المرور

2- running speed: a speed over aspecified section of highway

$$\text{running speed} = \frac{\text{Distance}}{\text{running time (excluding delays at intersections)}}$$

3- Travel speed OR Journey speed : The total distance traversed divided by the total time required including all traffic delays.

$$\text{Journey speed} = \frac{\text{Distance}}{\text{total time (including delays)}}$$

measurement of spot speed

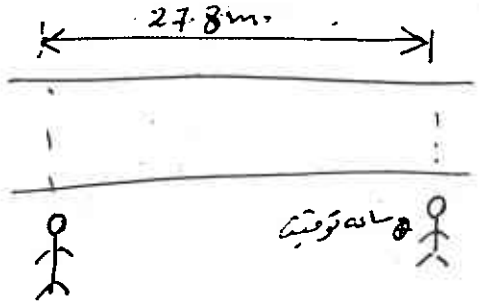
There are five methods of measuring this speed

1) manual method

يقف رجلان بينهما مسافه d على جانب واحد في الطريق احدهما يمسك ساعه توقيت ، وعند مرور مركبه احدهما يؤشر بيده والاخر يشغل الساعه وعند خروج السياره من المسافه d تقفل الساعه ويسجل الوقت t ثم تحسب السرعه $= \frac{d}{t}$ ومن مساوئ هذه الطريقه التأخير الذي يحصل عند التأشير وتشغيل الساعه . كذلك فان السائق يتعمد تبطئة سرعته عند رؤيته هؤلاء الاشخاص .

يجب ان تكون اختيار السيارات عشوائيا ، كأن تكون كل عاشر سياره او السيارات التي يبدأ رقمها بالرقم واحد مثلا

page (35) wells



s = speed = $\frac{100}{t}$

s = spot speed Km/hr

t = time (sec)

$$27.8\,m \times \frac{3600\ sec/hr}{1000\ m/km} = 100\ \frac{sec \cdot km}{hr}$$

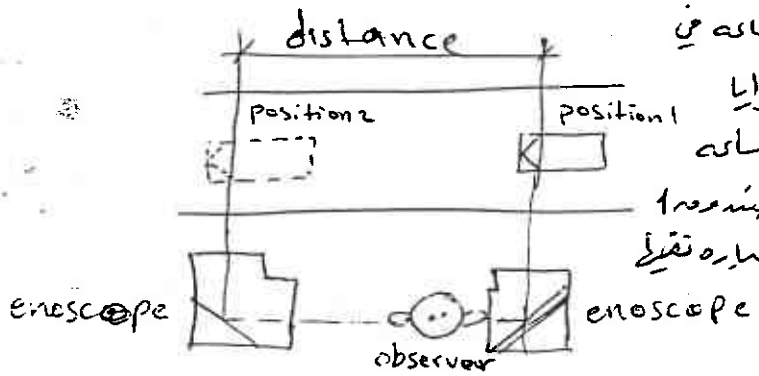
	distance (m)
$S = 90/t$	25
$S = 180/t$	50
$S = 360/t$	100

where t = time (secs)

S = speed (km/hr)

② Enoscope

الطريقة الثانية هي صندوق المرايا
وهنا يقف الراصد ويبدء ساعة في
منتصف المسافة بين صندوقي مرايا
تشبه المسافة بينهما فيفتح الساعة
عند انعكاس صورة السيارة في صندوق 1
ويقفلها عند انعكاس صورة السيارة نفسها
في صندوق 2



③ Using electronics Truvelo and Venner speed meters

حيث ان Venner يستعمل pneumatic tube عدد ٢ غير الطبيعي ومؤقت
ترانزستوري لحساب الوقت المستغرق بين النبضة الاولى في الانبوب
الاول والنبضة الثانية في الانبوب الثاني لنفس السيارة . وهي طريقة
اكثر دقة .
اما ال truvelo يشبه ال Venner ولكنه كله كهربائي

4 Radar speedometer حيث يوضع صندوق اسود جوار الطريق
يبعث شعاعاً فعند ارتطامه بمركبة سوف يرجع ويسجل سرعتها
مباشرة وتكون دقة هذه الاجهزة بحدود ٢-٣ كم/ساعة.

5 photography وهنا يصور الطريق وسرعة المركبات فيه
ثم يعرض في المختبر وبالسرعة المعتادة ومن معرفة المسافة بين
نقطتين وحساب الزمن المستغرق يمكن معرفة السرعة وهذه طريقة
دقيقة حيث لن تلفت انتباه السائق ولا تؤخره ولا تخوفه ولكن
الشرطة لا يستعملوها لانهم لن ينتظروا الفلم ليعاقبوا المخالف

* Sample Size : The larger sample size, the greater the probability that the estimated mean is not significantly different from the true mean.

* Before analyzing spot speed informations statistically, we need to understand some definitions. These are

- average Travel speed
- median speed
- Modal speed
- The ith percentile spot speed
- pace
- standard deviation of speeds

Spot speed studies

Speed characteristics determined from a spot speed study may be used to

1- Establish speed zones
2- Determine whether complaints about speeding are valid
3- Establish passing and no-passing zones
4- Analyze accident data
5- Evaluate the effects of physical improvements
6- Determine the effects of speed enforcement programs and speed control measures.
7- Determine speed trends

* Typically, the duration of spot speed studies are at least 1 hr and sample size is at least 30 vehs.

Some definitions

* Average travel speed: is the arithmatic mean of all observed vehicle speeds (which is the sum of all spot speeds divided by the no. of recorded speeds).

$$\bar{u} = \frac{\sum_{i=1}^{n} f_i u_i}{\sum_{i=1}^{n} f_i} = \frac{\sum_{i=1}^{n} u_i}{N}$$

where

$\bar{u}$ = arithmatic mean
f_i = number of observations in each group
u_i = midvalue for the ith speed group
n = number of observed values

★ **median speed**: is the speed at the middle value in a series of spot speeds that are arranged in ascending (تصاعدي) order (ترتيب). 50% of the speed values will be greater than the median; 50% ~~percent~~ will be less than the median

★ **Modal speed**: is the speed value that occurs most frequently in a sample of spot speeds. هي السرعة التي تتكرر (تظهر) أكثر من جميع السرعات الأخرى ضمن مجموعة وتظهر في الـ frequency histogram المعنى التكراري أو هي السرعة التي تقابل أعلى قيمة تردد أي الأعلى في المنحنى التوزيع الطبيعي

★ **The ith percentile spot speed**: is the spot speed value below which i percent of the vehs. travel; for example, 85% spot speed is the speed below which 85% of the vehs. travel and above which 15% of the vehs. travel

★ **pace**: is the range of speed - usually taken at 10 km/hr intervals - that has the greatest no. of observations. هو المدى (مدى السرعة بحدود ١٠كم/ساعة) التي تسير به أكبر عدد من السيارات

★ **standard deviation of speeds**: is a measure of the spread of the individual speeds. It is estimated as

$$S = \sqrt{\frac{\sum (u_j - \bar{u})^2}{N-1}}$$

where

S: standard deviation OR $S = \sqrt{\frac{\sum f x^2}{\sum f} - \left(\frac{\sum f x}{\sum f}\right)^2}$

$\bar{u}$: arithmatic mean

u_j: jth observation

N: number of observations

For grouped data

$$S = \sqrt{\frac{\sum (f_i u_i^2) - (\sum f_i u_i)^2 / \sum f_i}{\sum f_i - 1}}$$

where

u_i: midvalue of speed class i

f_i: frequency of speed class i

* $$\bar{u} = \frac{\sum_{i=1}^{n} f_i u_i}{\sum_{i=1}^{n} f_i} = \frac{4260}{86} = 49.5 \text{ Km/hr}$$

* The standard deviation

$$S = \sqrt{\frac{\sum_{i=1}^{n} f(u_i - \bar{u})^2}{N-1}}$$

$$= \sqrt{\frac{3632}{86-1}}$$

$$= \mp 6.5 \text{ Km/hr}$$

* The median speed is obtained from the cumulative frequency distribution curve = 49 Km/hr. It is the 50th-percentile speed.

* The pace is obtained from the frequency distribution curve (fig 4-4) as 45 to 55 Km/hr

* The mode or modal speed is obtained from the frequency histogram as 49 Km/hr (fig 4.3). It may be obtained also from the frequency distribution curve shown in fig 4.4 where the speed corresponding to the highest point on the curve is taken as an estimate of the modal speed.

example :

p(173) wells

أخذت 161 قراءه لسرعه سيارات spot speed مثلا

33, 29, 30, 30, 28, 15, 32, 40 - - - - - etc.

المطلوب هو التحليل الاحصائي للمعلومات هذه للحصول منه على معلومات اضافيه ويتم التحليل الاحصائي هذا كالآتي

ترتيب المعلومات على شكل فئات للحصول على المغير التكراري

speed group ①	Midpoint of group (x) ②	No. of speed readings (f) ③	% of speeds in groupes ④ $= \frac{③}{161} \times 100$	cumulative % of total observation Σ④	$(f).(x)$ ②×③
15-17 14.5-17.5	16	2	1	1	32
18-20 >17.5-20.5	19	6	4	5	114
21-23 >20.5-23.5	22	12	8	13	264
24-26 >23.5-26.5	25	20 - 12.4	12	25	500
27-29	28	30	19	44	840
30-32	31	32	20	64	992
33-35	34	28	17	81	952
36-38	37	15	9	90	555
39-41	40	10	6	96	400
42-44	43	6	4	100	258
Totals		161	100		4907

$$\text{Mean} = \frac{4907}{161} = 30.48 = \frac{\Sigma f \cdot x}{\Sigma f}$$

تكملة للجدول بالصفحة السابقة

speed group		fx^2
15 - 17	16	32 × 16 = 512
18 - 20	19	114 × 19 = 2166
21 - 23		5 808
24 - 26		12 500
27 - 29		23520
30 - 32		30 752
33 - 35		32368
36 - 38		20535
39 - 41		16000
42 - 44		11094
		155255

The standard deviation : is a measure of the average deviation of readings from their mean.

$$S = \sqrt{\frac{\Sigma(fx^2)}{\Sigma f} - \left(\frac{\Sigma fx}{\Sigma f}\right)^2} \quad \left(\frac{4907}{161}\right)^2$$

معدل انحراف القراءات عن قيمة المعدل

$$S = \sqrt{\frac{155255}{161} - (30.48)^2}$$

$$= \sqrt{964.32 - 929.03}$$

$$= 5.94 \simeq 6$$

To standardize the spread i.e to express it as a % of the mean value known as the coefficient of variation

where $CV = 100\, S/\bar{x}$

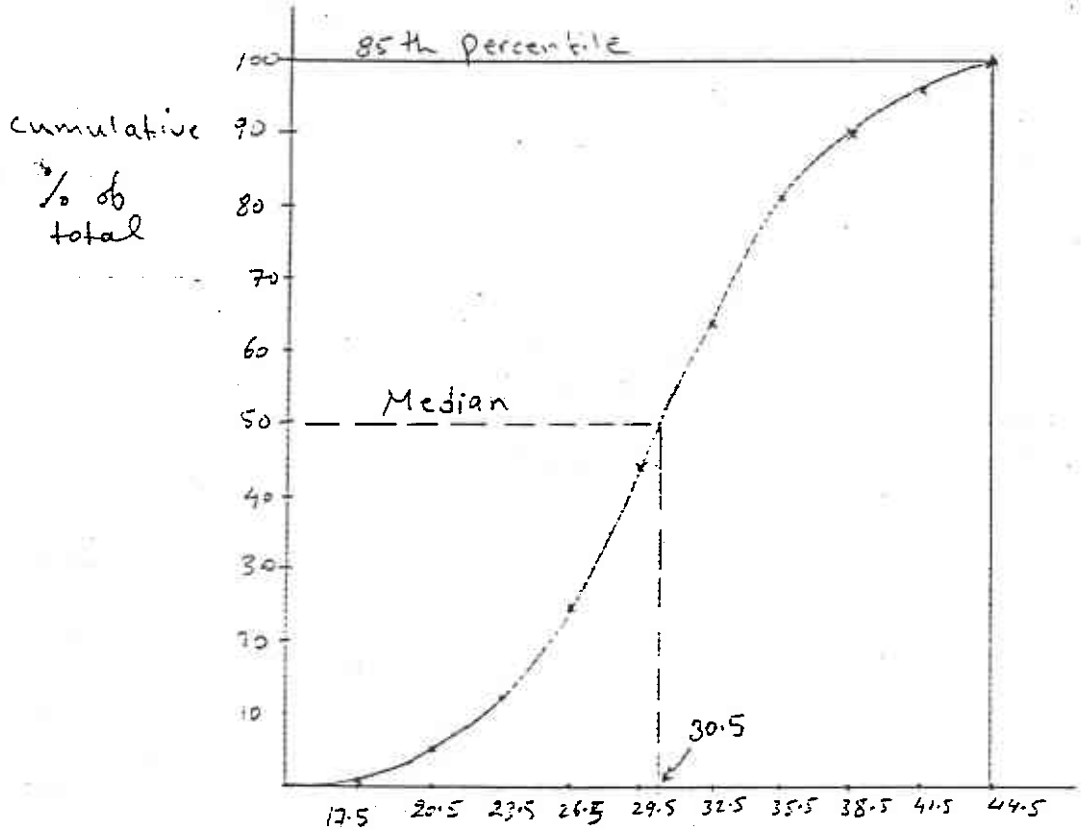
CV : coefficient of variation
S : standard deviation
$\bar{x}$: The mean speed

CV { 6 for 30.48 av. speed = 19 %
6 for 15 = 12 %
6 for 50 = 40 % }

$\therefore CV = 100 \times 5.94 / 30.48 = 19\ \%$

The CV gives a clear impression not only of the spread of the speed readings, but also of the significance of this spread

Fig. 13-2 page 175 wells



Ogive of speed readings

عند رسم المنحنى يثبت الرقم الاعلى في الفئة مثلا في حالتنا رسمت القراءات

17.5 - 1
20.5 - 5
23.5 - 13

Median speed: is the middle or 50% speed from cumulative curve
عدد المركبات التي تسير اكثر منها = عدد المركبات التي تسير اقل منها

85th percentile : It is taken as the design speed mostly. also it is the speed below which 85% of the vehicles are being driven.

15th percentile : Is the minimum speed limit

Arithmatic mean or Average spot speed $= \bar{X} = \frac{\Sigma(xf)}{\Sigma f} = \frac{\Sigma x_i}{n}$

for grouped data

for row data

where $\bar{X}$ = average spot speed
X_i = ith spot speed
n = No. of observation

$$\bar{X} = \frac{\Sigma(\text{Col}\,② \times \text{Col}\,③)}{\Sigma\,\text{Col}\,③}$$ for grouped data

~~Example~~: Determining speed characteristics from a set of speed data

Example: the Table below shows the data collected on a rural highway in Virginia during a speed study. Develop the frequency histogram and the frequency distribution of the data, and determine

1- The arithmatic mean speed
2- The standard deviation
3- The median speed
4- The pace
5- The mode or modal speed

Solution

Frequency distribution table for set of speed data

(1) speed class km/hr	(2) class midvalue u_i	(3) class freq (no. of observation in class f_i	(4) $f_i u_i$	(5) % of observation in class	(6) cumulative % of all observations	(7) $f_i(u_i-\bar{u})^2$
34-35.9	35	2	70	2.3	2.3	420.50
36-37.9	37	3	111	3.5	5.8	468.75
38-39.9	39	2	78	2.3	8.10	220.50
40-41.9	41	5	205	5.8	13.90	361.25
42-43.9	43	3	129	3.5	17.4	126.75
44-45.9	45	11	495	12.8	30.20	222.75
46-47.9	47	4	188	4.7	34.90	25.00
48-49.9	49	18	882	21.0	55.9	9.0
50-51.9	51	7	357	8.1	64.0	15.75
52-53.9	53	8	424	9.3	73.3	98.00
54-55.9	55	11	605	12.8	86.1	332.75
56-57.9	57	5	285	5.8	91.9	281.25
58-59.9	59	2	118	2.3	94.2	180.50
60-61.9	61	2	122	2.3	96.5	264.5
62-63.9	63	2	126	2.3	98.8	364.5
64-65.9	65	1	65	1.2	100	240.25
Totals		86	4260	100		3632.00

IMPRIMERIES CANSON & MONTGOLFIER S.A. FABRIQUE EN FRANCE

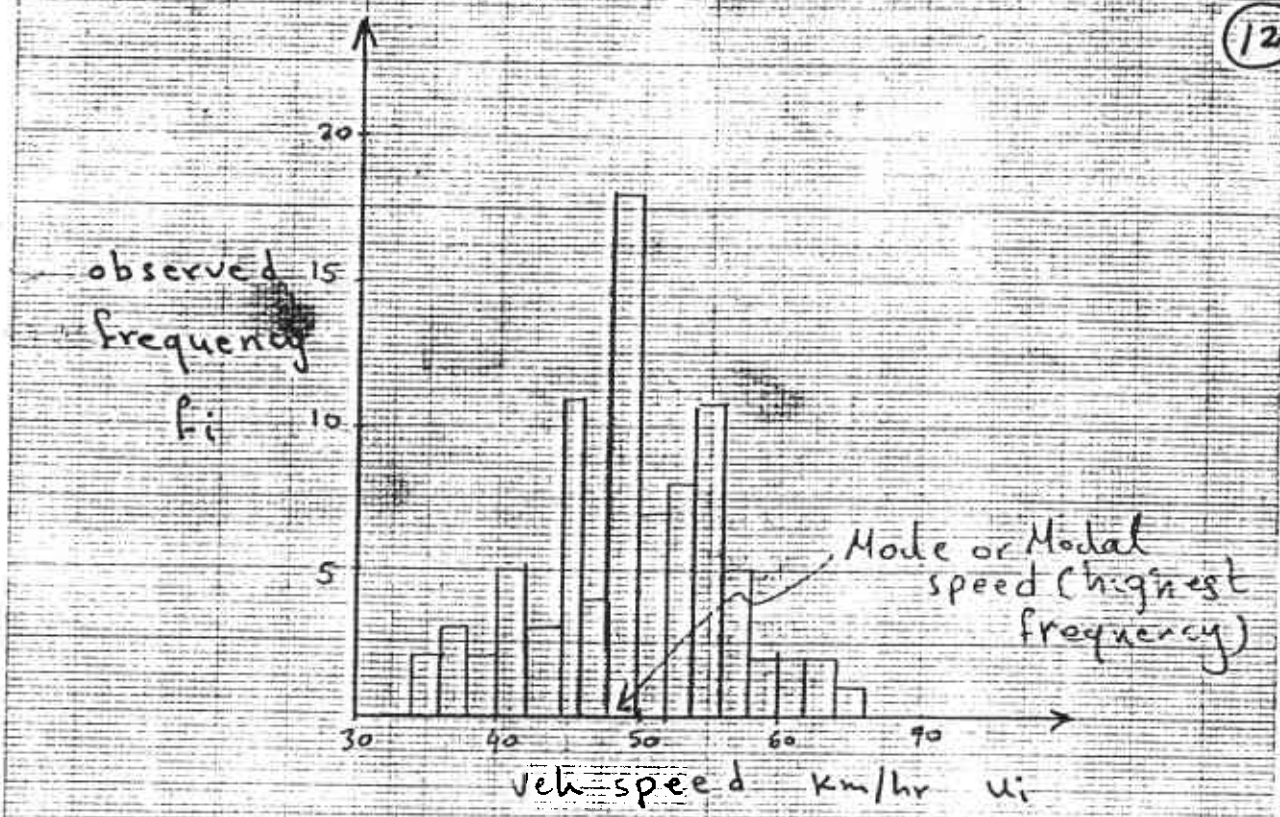


Fig 4.3 Histogram of observed vehicle's speed

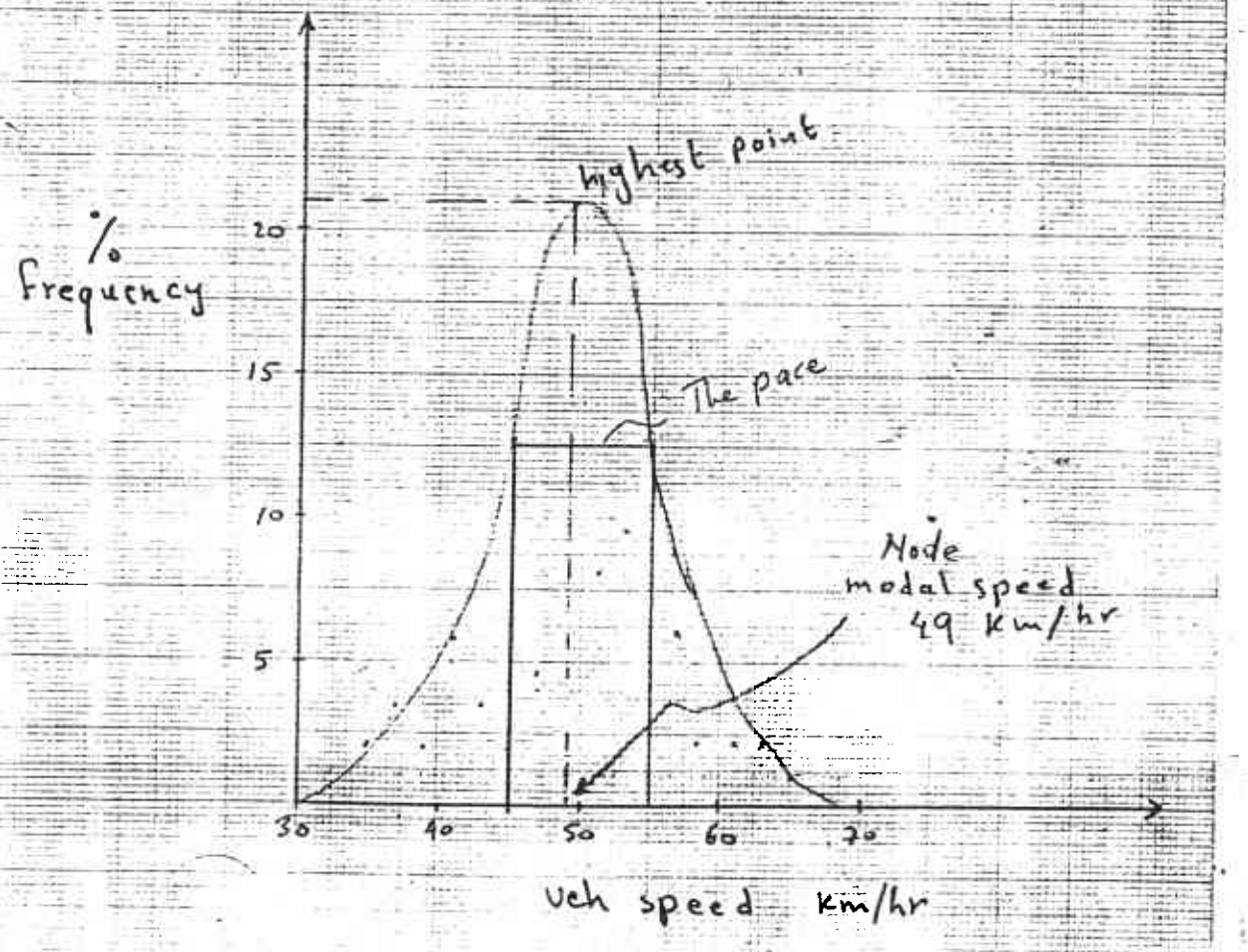


fig 4.4 frequency distribution

American cities have a better distribution of shopping centers, employment, and administrative facilities throughout the city and not centered heavily in the CBD as is the case of Baghdad. Fourthly, parking charges in the CBD of American cities are found to be much higher discouraging non-essential trips to that area.

The number of parking spaces available in the CBD in 1980 was 32400 or 9.6 space per 1000 population, compared to 15.9 parking spaces per 1000 population for the American cities of population more than one million (table 2-7). For that reason, the occupancy of their parking spaces never reached 100% even though their carownership is much higher than ours.

It is worth mentioning also that the on-street parking spaces in the CBD accounted for 66% of total parking spaces while for those of American cities mentioned in table (2-8), was only 14%. It was recommended by BCTS to change the on-street parking spaces to off-street facilities in the area in order to improve the flow of traffic within the central area and minimize accidents caused by parked vehicles.

The surveys showed that percentage of work trips is the highest (33%) followed by shopping and business trips (both of 27%), while for American cities (table 2-9), work trips account for 41% which is also the highest number followed by business trips (30%). The shopping trips account for one thrids business trips (10%). This marked

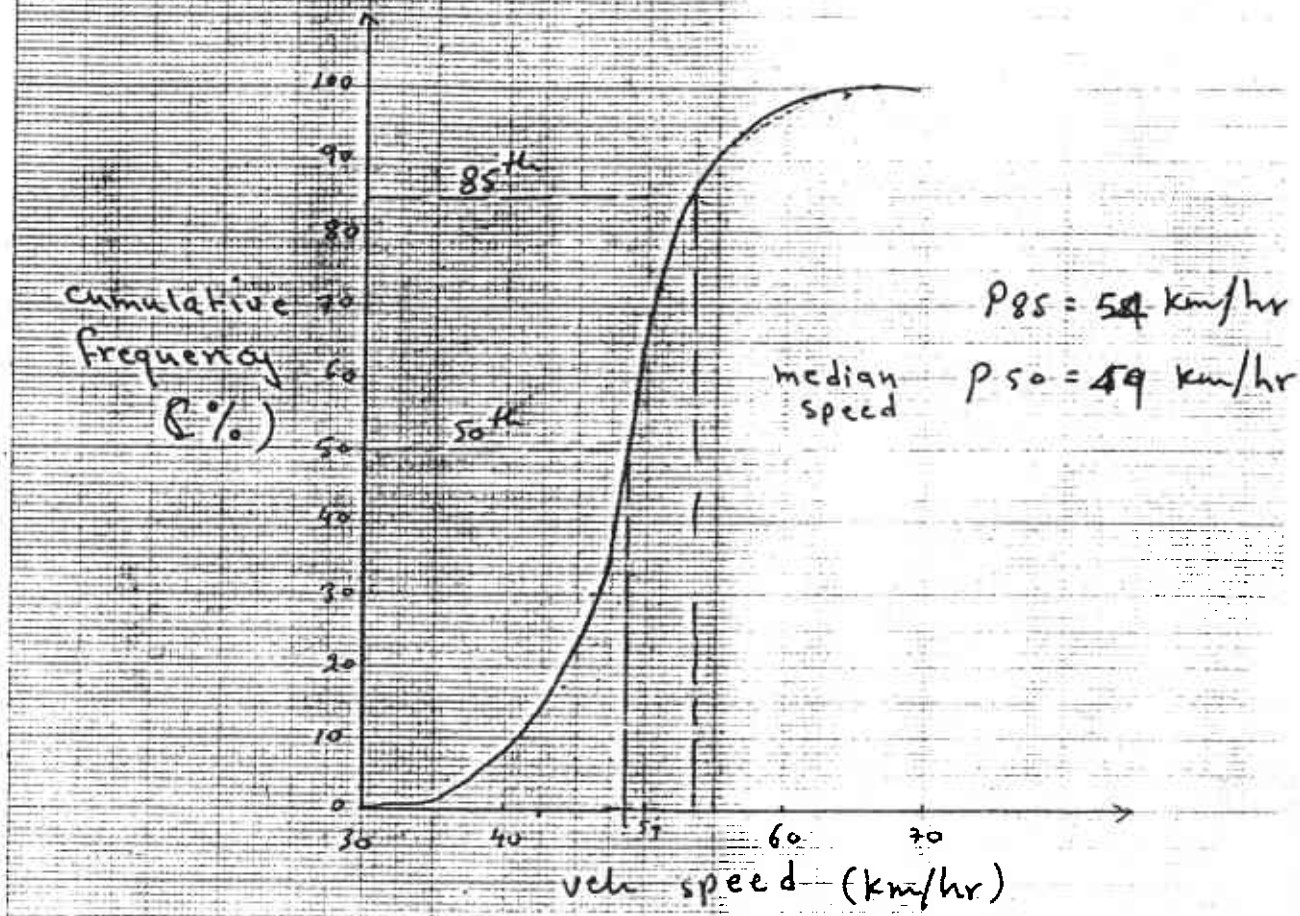


fig 4.5 cumulative distribution curve

Measurment of Running and Journey Speed

running speed : is the average speed maintained over a given route while the vehicle is in motion. It is used for

- for capacity determination
- as a measure of the level of service
- For economic studies

$$\text{running speed} = \frac{\text{المسافة}}{\text{الزمن بدون تأخيرات}}$$

Journey speed : is a direct method of traffic congestion. It is used for

- for highway planning
- for analysis of economic studies

$$\text{Journey speed} = \frac{\text{المسافة}}{\text{الزمن الكلي (مع التأخيرات)}}$$

Methods of measurment : there are three methods

(1) Registration number method

وهنا يؤخذ شارع بطول ٢-٣ كم A ——— B

ويقف شخصان في النقاط A ، B وكل منهم

يسجل رقم المركبة المارة ووقت دخولها او خروجها

ويجب ان يكون الشارع خالي من التقاطعات الرئيسية

او الاشارات الضوئية المرورية لقياس running

ثم تجمع ارقام واوقات دخول سيارات معينة في نقطة A

مع ارقامها واوقات خروجها من B ويحسب الوقت المستغرق

لهذه المركبة في قطع المسافة AB بدون توقفات

وتؤخذ معلومات اكثر من مسح O-D

② Elevated observer method

وهنا يقف راصد في مكان عالي كأن يكون فوق عمارة او يكون في هليكوبتر
ويحسب الوقت اللازم لمركبة يرصدها من الاعلى لقطع مسافة معينة
محسوبة وفي حالة كون الارتفاع قليل فان السرعة المحسوبة ستكون
spot speed .

③ Moving observer method page 38 (wells)

This method is good for يحتاج لثلاث عداديه وسائق سيارة
two way routes only and a minimum of six test runs should made in each direction under same conditions.

Hourly volume for one directional flow is determined by the following الاشتقاق موجود في كتاب Salter الفصل 13

$$q = \frac{(x+y)}{a+w} \quad , \quad t = w - \frac{y}{q}$$

a → against , w → with

where

q = flow of vehicles in one direction

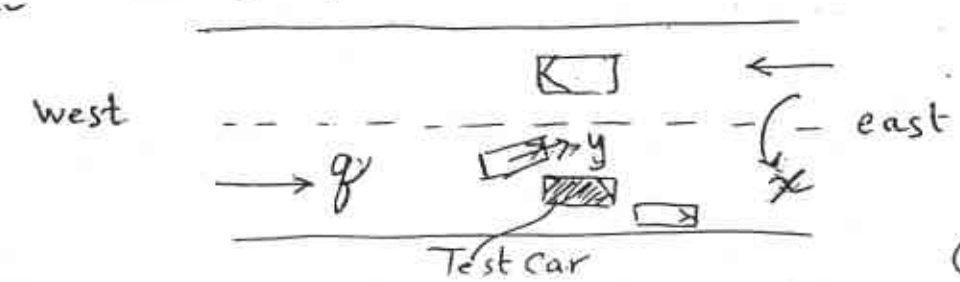
x = average no. of vehicles counted in the q direction when test car was travelling in opposite direction
ويمكن ان يصنف الراصد الكميات الى Cars , PSV , HGV

y = net vehicles overtaking test car when it is travelling in the q direction y = Overtaking test car − Overtaken by the test car
قد يكون موجب او سالب

w = average journey time when test car is travelling in the q direction

a = average journey time when test car is travelling in the opposite direction to q.

t = average journey time for all traffic in direction q



moving observer method نحتاج لثلاث أجهزة وسائقين في طريقة الراصد المتحرك

الأول: يعد السيارات التي تسبق سيارتهم وتلك التي تسبقه سيارتهم والفرق بين الاثنين يسمى y وقد تكون النتيجة موجبة أو سالبة

الثاني: يعد المركبات بالاتجاه المعاكس ويمكن أن يصنفها أيضاً إلى car، psv، HGV

الثالث: يضبط الوقت (البداية والنهاية) ويسجل قيم x، y بالورقة مع الرموز المستخدمة

example:

Six runs were made in each direction along a two way highway between A and B square. Flows were measured both with and against the moving car and the following notes obtained. distance from A to B square = 6.4 km. Calculate the flow and stream speed in each direction

car travelling from A to B square

trip hr:min commences	Ends	min (t)	No. of vehs. overtaking	overtaken (y)		(x) met
16:05	16:16	.11	2	1	1	401
16:34	16:44	.10	3	2	1	360
17:05	17:17	.12	4	1	3	419
17:35	17:44	.9	5	3	2	397
18:05	18:18	.13	2	1	1	406
18:35	18:45	.10	2	3	-1	412
average.		10.83 min 0.1805 hr			1.16	399.17

car travelling from B to A square

					(y)	
16:19	16:31	.12	3	2	1	320
16:50	17:63	.13	7	3	4	319
17:20	17:32	.12	4	2	2	307
17:5	17:59	.09	4	3	1	331
18:2	18:33	.13	5	2	3	317
18:50	19:61	.11	7	1	6	305
		11.7 min 0.195 hr			2.83	316.5

$$q_A = \frac{x+y}{w+a} = \frac{316.5+1.16}{(0.1805+0.195)} = 845.96 \text{ veh/hr}$$

$$\bar{t}_A = t_w - y/q = 0.1805 - \frac{1.16}{845.96} = 0.179 \text{ hr} = 10.74 \text{ min}$$

$$V_A = \frac{D}{t} = \frac{6.4}{0.179} = 35.7 \text{ km/hr}$$

$$q_B = \frac{399.17+2.83}{0.195+0.1805} = 1070.57 \text{ veh/hr}$$

$$\bar{t}_B = 0.195 - \frac{2.83}{1070.57} = 0.192 \text{ hr} = 11.54 \text{ min}$$

$$V_B = \frac{6.4}{0.192} = 33.27 \text{ km/hr}$$

Example: Find the hourly volume and speed for a test section length of 1 km (urban road). data are given below.

North bound trip	time (min)	No. of vehs in opposing direction x	No. of vehs. overtaking test car (السيارات التي تتجاوز السيارة)	No. of vehs overtaken by the test car (السيارات التي تتجاوز)
1	2.65	85	1	0
2	2.7	83	3	2
3	2.35	77	0	2
4	3.00	85	2	0
5	2.42	90	1	1
6	2.54	84	2	1
6 Total	15.66	504	9	6
average	2.61	84	1.5	1

$y_n = 9 - 6 = 3$ $\quad$ av $y = 0.5$

South bound trip	time (min)	x	No. of vehs overtaking test car	No. of vehs overtaken by test car
1	2.33	112	2	0
2	2.30	113	0	2
3	2.71	119	0	0
4	2.16	120	1	1
5	2.54	105	0	2
6	2.48	100	0	1
Total	14.52	669	3	6
average	2.42	111.5	0.5	1

$y_s = 3 - 6 = -3$ $\quad$ av $y = -0.5$

$$q_n = \frac{x + y_n}{a + w} = \frac{(111.5 + 0.5) \times 60}{2.42 + 2.61} = 1336 \text{ veh/hr}$$

$$q_s = \frac{x + y_s}{a + w} = \frac{(84 - 0.5) \times 60}{2.61 + 2.42} = 996 \text{ veh/hr}$$

The average travel time for one directional flow is determined by the following formula

$$t = w - \frac{y}{q}$$

where

t: average Journey time for all traffic in direction q

$$t_n = 2.61 - \frac{0.5}{1336/60} = 2.587 \text{ min}$$
$$= 2' 35''$$

$$t_s = 2.42 - \frac{(-0.5)}{996/60} = 2.45 \text{ min}$$
$$2' 27''$$

في حالة كون المرور منتظم وان السائق لا يتجاوز اي مركبه ولا تتجاوزه اي مركبه فان $t = w$

$$\text{Journey speed } V_n = \frac{1 \times 60}{2.587} = 23.2 \text{ km/hr}$$

$$V_s = 1 \times \frac{60}{2.45} = 24.5 \text{ km/hr}$$

حيث y = عدد السيارات التي تسبق سيارة الاختبار - عدد السيارات التي تتجاوزها سيارة الاختبار

y = No. of vehs overtaking test car - No. of vehs. overtaken by the test car

example(2) Page(39) سؤال الكتاب

Using moving observer method, Seven runs have been made in each direction over a section of road 1.64 km in length with the following readings.

Calculate the flow of traffic and speed in each direction.

eastbound trips

Journey time min-sec	x-count	vehicles overtaking test car	vehicles overtaken by test car
1-50	38	1	4
2-02	42	2	3
2-00	40	1	5
1-56	38	1	4
1-58	38	1	4
1-48	35	1	6
2-13	41	2	2
Total 13-47	272	9	28
Average 1-58 1.97 min	38.8	(9-28) = -19	average y = -2.7

Westbound trips

2-05	27	3	4
2-00	26	2	4
2-10	28	4	4
1-58	25	2	5
2-15	30	4	3
2-07	28	3	3
2-10	31	2	5
Totals 14-45	195	20	28
average 2-06 2.1 min	27.9	(20-28) = -8	Average y = -1.1

$$q_r = \frac{x+y}{a+w} \qquad t = w - y/q$$

للتحويل الى ساعة

$$q_e = \frac{27.9+(-2.7)}{1.97+2.1} * 60 = 371 \text{ veh/hr}$$

$$t_e = 1.97 + \frac{2.7}{371/60} = 2.4 \text{ min} \qquad 2-24$$

$$V_e = \frac{1.64}{2.4/60} = 40.8 \text{ km/hr}$$

$$q_w = \frac{38.8 + (-1.1)}{1.97 + 2.1} \times 60 = \cancel{588}\ 5557 \text{ veh/hr}$$

$$t_w = 2.1 + \frac{-1.1}{588/60} = 2.22 \text{ min} \qquad 2-12$$

$$V_w = \frac{1.64}{2.22/60} = \qquad 44.7 \text{ km/hr}$$

Delays

page(41) wells

There are two types of delays

① Fixed delays: Occurs mostly at roadway intersections like
- Traffic signals
- railway crossing
- roundabouts
- stop signs
- pedestrian crossing

وهو لا يعتمد على حجم المرور او الازدحام حيث يمكن ان تقف سيارة واحدة على الرصيف بدون ان يكون هناك اي مرور بالاتجاهات الاخرى ،
ويدعوها ايضا stopped time delay

② operational delays or running delays: like
- parking & unparking vehs.
- Pedestrians
- crossing & turning vehs at uncontrolled intersections
- congestion caused by heavy traffic

This delay is primarily a reflection of the interacting effects of traffic on the highway or street.

ويدعوها ايضا Congestion time delay

factors affecting delays

1- fixed factors : width, no. of lanes, traffic signals.

2- Traffic factors : congestion, parking + unparking

3- control factors : give way sign, stop sign ..

The fifth chapter, which is the last one discusses the conclusions and recommendations .

Delay Studies - Intersection is the majour delay in the traffic stream. There are several factors affecting intersection delay.

1- physical factors: such as the No. of lanes, width, grades, channelization, bus stop.

2- Traffic factors: such as Volume on each approach, turnning movement, driver approach speeds, parking & pedestrian.

3- Traffic controls: such as timing of signals, stop sign

Example: to find the delay at intersection by using stopped time delay method.

1. count the No. of vehs. stopped in the intersection approach (every 15 secs)
2. Count the vol. during the same time.
3. The results show below

time min. starting	stationary vehs. Total No. of vehs. 00	15	30	45	Approach Volume, stopping	nonstoping
8:00	0	2	7	9	11	7
8:01	4	0	0	3	6	14
8:02	9	16	14	6	18	0
:03	1	4	9	13	17	0
04	5	0	0	2	4	17
subtotal	19	22	30	33	56	38
Total	104				94	

computation

Total delay = 15 * 104 = 1560
total No. of observed vehs. * observation interval

$$\text{Average delay per stopped vehcile} = \frac{\text{Total delay}}{\text{No. of stopping vehs.}}$$

$$= \frac{1560}{56} = 27.8 \text{ secs}$$

$$\text{Average delay per approach veh} = \frac{\text{Total delay}}{\text{approach vol.}}$$

$$= \frac{1560}{94} = 16.8 \text{ secs}$$

$$\text{percent of stopped vehs.} = \frac{\text{No. of stopping vehs}}{\text{approach vol.}}$$

$$= \frac{56}{94} * 100 = 59.5\ \%$$

Average delay 16.8 secs is taken for all approaches and this figure is used for an economic analysis of the junction and the appraisal (يخبر، يقيم) of any proposed improvements to it.

في الطريقة السابقة نحتاج الى شخصين احدهما يعد جميع السيارات لمدة 5 دقائق مقسما المرور الى متوقف stopping وغير متوقف non stopping بينما الآخر يعد كل (15) ثانية الربات المتوقفة على المفترق على مدى الـ 5 دقائق نفس تقسيم النتائج كما في الجدول السابق

where

PHF = peak-hour factor,
V = hourly volume (veh/h), and
V_{15} = volume during the peak 15 min of the peak hour (veh/15 min).

When the PHF is known, it can convert a peak-hour volume to a peak flow rate, as in Equation 7-3:

$$v = \frac{V}{PHF} \tag{7-3}$$

where

v = flow rate for a peak 15-min period (veh/h),
V = peak-hour volume (veh/h), and
PHF = peak-hour factor.

Equation 7-3 does not need to be used to estimate peak flow rates if traffic counts are available; however, the chosen count interval must identify the maximum 15-min flow period. The rate then can be computed directly as 4 times the maximum 15-min count. When flow rates in terms of vehicles are known, a conversion to a flow rate in terms of passenger car equivalents (pce) can be computed using the PHF and the heavy vehicle factor.

SPEED

Although traffic volumes provide a method of quantifying capacity values, speed (or its reciprocal of travel time) is an important measure of the quality of the traffic service provided to the motorist. It is an important measure of effectiveness defining levels of service for many types of facilities, such as rural two-lane highways, urban streets, freeway weaving segments, and others.

Speed parameters

Speed is defined as a rate of motion expressed as distance per unit of time, generally as kilometers per hour (km/h). In characterizing the speed of a traffic stream, a representative value must be used, because a broad distribution of individual speeds is observable in the traffic stream. In this manual, average travel speed is used as the speed measure because it is easily computed from observation of individual vehicles within the traffic stream and is the most statistically relevant measure in relationships with other variables. Average travel speed is computed by dividing the length of the highway, street section, or segment under consideration by the average travel time of the vehicles traversing it. If travel times $t_1, t_2, t_3, \ldots, t_n$ (in hours) are measured for n vehicles traversing a segment of length L, the average travel speed is computed using Equation 7-4.

$$\frac{\text{مجموع المسافات}}{\text{مجموع الازمان}} = \frac{\text{المسافة}}{\text{معدل الازمان}} = S$$

$$S = \frac{nL}{\sum_{i=1}^{n} t_i} = \frac{L}{\frac{1}{n}\sum_{i=1}^{n} t_i} = \frac{L}{t_a} \tag{7-4}$$

where

S = average travel speed (km/h),
L = length of the highway segment (km),
t_i = travel time of the ith vehicle to traverse the section (h),
n = number of travel times observed, and
t_a = $\frac{1}{n}\sum_{i=1}^{n} t_i$ = average travel time over L (h).

The travel times in this computation include stopped delays due to fixed interruptions or traffic congestion. They are total travel times to traverse the defined roadway length.

Several different speed parameters can be applied to a traffic stream. These include the following:

Average running speed—A traffic stream measure based on the observation of vehicle travel times traversing a section of highway of known length. It is the length of the segment divided by the average running time of vehicles to traverse the segment. Running time includes only time that vehicles are in motion.

Average travel speed—A traffic stream measure based on travel time observed on a known length of highway. It is the length of the segment divided by the average travel time of vehicles traversing the segment, including all stopped delay times. It is also a space mean speed.

Space mean speed—A statistical term denoting an average speed based on the average travel time of vehicles to traverse a segment of roadway. It is called a space mean speed because the average travel time weights the average to the time each vehicle spends in the defined roadway segment or space.

Time mean speed—The arithmetic average of speeds of vehicles observed passing a point on a highway; also referred to as the average spot speed. The individual speeds of vehicles passing a point are recorded and averaged arithmetically.

Free-flow speed—The average speed of vehicles on a given facility, measured under low-volume conditions, when drivers tend to drive at their desired speed and are not constrained by control delay.

For most of the procedures using speed as a measure of effectiveness in this manual, average travel speed is the defining parameter. For uninterrupted-flow facilities not operating at level of service (LOS) F, the average travel speed is equal to the average running speed.

Exhibit 7-1 shows a typical relationship between time mean and space mean speeds. Space mean speed is always less than time mean speed, but the difference decreases as the absolute value of speed increases. Based on the statistical analysis of observed data, this relationship is useful because time mean speeds often are easier to measure in the field than space mean speeds.

Average running speed

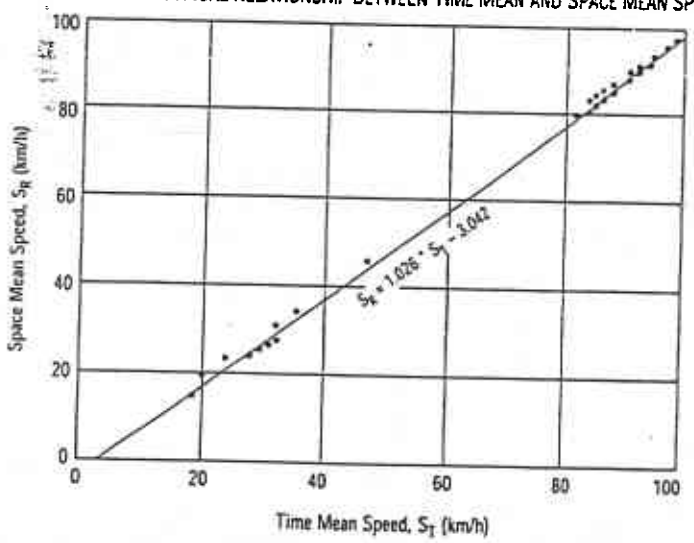
Average travel speed

Space mean speed S.M.S

Time mean speed T.M.S

Free-flow speed FFS

EXHIBIT 7-1. TYPICAL RELATIONSHIP BETWEEN TIME MEAN AND SPACE MEAN SPEED



Source: Drake et al. (1).

It is possible to calculate both time mean and space mean speeds from a sample of individual vehicle speeds. For example, three vehicles are recorded with speeds of 40, 60, and 80 km/h. The time to traverse 1 km is 1.5 min, 1.0 min, and 0.75 min, respectively. The time mean speed is 60 km/h, calculated as (40 + 60 + 80)/3. The space mean speed is 55.4 km/h, calculated as (60)[3 ÷ (1.5 + 1.0 + 0.75)].

Distance = 1 km
speeds 40, 60 & 80 km/hr

$$T.M.S = \frac{40+60+80}{3} = 60 \text{ km/hr}$$

$$S.M.S = \frac{1 \times 3}{\frac{1}{40} + \frac{1}{60} + \frac{1}{80}} = 55.4 \text{ km/hr}$$

For capacity analysis, speeds are best measured by observing travel times over a known length of highway. For uninterrupted-flow facilities operating in the range of stable flow, the length may be as short as 50 to 100 m for ease of observation.

As measures of effectiveness, speed criteria must recognize driver expectations and roadway function. For example, a driver expects a higher speed on a freeway than on an urban street. Lower free-flow speeds are tolerable on a roadway with more severe horizontal and vertical alignment, since drivers are not comfortable driving at high speeds. LOS criteria reflect these expectations.

DENSITY

Density is the number of vehicles (or pedestrians) occupying a given length of a lane or roadway at a particular instant. For the computations in this manual, density is averaged over time and is usually expressed as vehicles per kilometer (veh/km) or passenger cars per kilometer (pc/km).

Direct measurement of density in the field is difficult, requiring a vantage point for photographing, videotaping, or observing significant lengths of highway. Density can be computed, however, from the average travel speed and flow rate, which are measured more easily. Equation 7-5 is used for undersaturated traffic conditions.

Computing density

$$D = \frac{v}{S} \tag{7-5}$$

where

v = flow rate (veh/h),
S = average travel speed (km/h), and
D = density (veh/km).

Example

A highway segment with a rate of flow of 1,000 veh/h and an average travel speed of 50 km/h would have a density of

$$D = \frac{1000\ veh/h}{50\ km/h} = 20\ veh/km$$

Density is a critical parameter for uninterrupted flow facilities because it characterizes the quality of traffic operations. It describes the proximity of vehicles to one another and reflects the freedom to maneuver within the traffic stream.

Roadway occupancy is frequently used as a surrogate for density in control systems because it is easier to measure. Occupancy in space is the proportion of roadway length covered by vehicles, and occupancy in time identifies the proportion of time a roadway cross section is occupied by vehicles.

HEADWAY AND SPACING

Spacing is the distance between successive vehicles in a traffic stream, measured from the same point on each vehicle (e.g., front bumper, rear axle, etc.). Headway is the time between successive vehicles as they pass a point on a lane or roadway, also measured from the same point on each vehicle.

These characteristics are microscopic, since they relate to individual pairs of vehicles within the traffic stream. Within any traffic stream, both the spacing and the headway of individual vehicles are distributed over a range of values, generally related to the speed of the traffic stream and prevailing conditions. In the aggregate, these microscopic parameters relate to the macroscopic flow parameters of density and flow rate.

Spacing is a distance, measured in meters. It can be determined directly by measuring the distance between common points on successive vehicles at a particular instant. This generally requires complex aerial photographic techniques, so that spacing usually derives from other direct measurements. Headway, in contrast, can be easily measured with stopwatch observations as vehicles pass a point on the roadway.

Relationships among density, speed and flow rate, and headway and spacing

The average vehicle spacing in a traffic stream is directly related to the density of the traffic stream, as determined by Equation 7-6.

$$\text{Density (veh/km)} = \frac{1000}{\text{spacing (m/veh)}} \tag{7-6}$$

The relationship between average spacing and average headway in a traffic stream depends on speed, as indicated in Equation 7-7.

$$\text{Headway (s/veh)} = \frac{\text{spacing (m/veh)}}{\text{speed (m/s)}} \tag{7-7}$$

This relationship also holds for individual headways and spacings between pairs of vehicles. The speed is that of the second vehicle in a pair of vehicles. Flow rate is related to the average headway of the traffic stream with Equation 7-8.

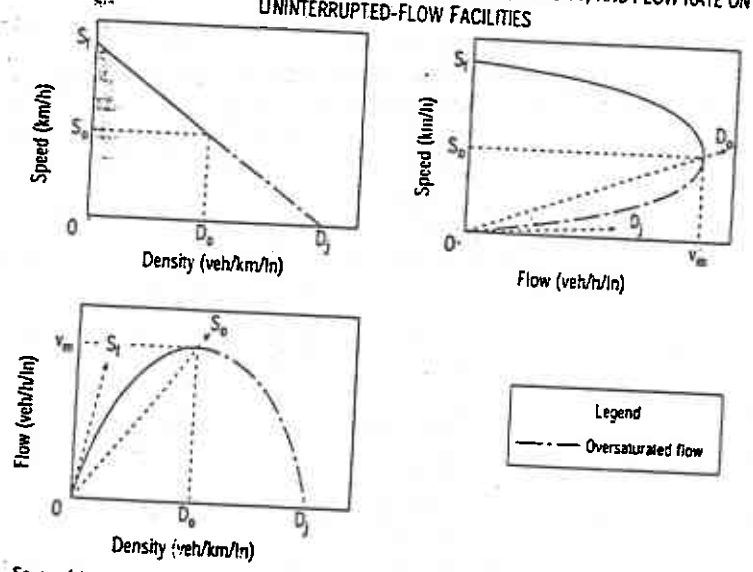
$$\text{Flow rate (veh/h)} = \frac{3600}{\text{headway (s/veh)}} \tag{7-8}$$

RELATIONSHIPS AMONG BASIC PARAMETERS

Equation 7-5 cites the basic relationship among the three parameters, describing an uninterrupted traffic stream. Although the equation v = S * D algebraically allows for a given flow rate to occur in an infinite number of combinations of speed and density, there are additional relationships restricting the variety of flow conditions at a location.

Exhibit 7-2 shows a generalized representation of these relationships, which are the basis for the capacity analysis of uninterrupted-flow facilities. The flow-density function is placed directly below the speed-density relationship because of their common horizontal scales, and the speed-flow function is placed next to the speed-density relationship because of their common vertical scales. Speed is space mean speed.

EXHIBIT 7-2. GENERALIZED RELATIONSHIPS AMONG SPEED, DENSITY, AND FLOW RATE ON UNINTERRUPTED-FLOW FACILITIES



Source: Adapted from May (2).

Illustration of speed-density, flow-density, and speed-flow relationships

V_m: max. flow
S_o: optimum speed or critical speed
D_o: optimum density
D_j: Jam density
S_f: free flow speed

$V_m = D_o * S_o$

The form of these functions depends on the prevailing traffic and roadway conditions on the segment under study and on its length in determining density. Although the diagrams in Exhibit 7-2 show continuous curves, it is unlikely that the full range of the functions would appear at any particular location. Survey data usually show discontinuities, with part of these curves not present (2).

The curves of Exhibit 7-2 illustrate several significant points. First, a zero flow rate occurs under two different conditions. One is when there are no vehicles on the facility—density is zero, and flow rate is zero. Speed is theoretical for this condition and would be selected by the first driver (presumably at a high value). This speed is represented by S_f in the graphs.

The second is when density becomes so high that all vehicles must stop—the speed is zero, and the flow rate is zero, because there is no movement and vehicles cannot pass a point on the roadway. The density at which all movement stops is called jam density, denoted by D_j in the diagrams.

Between these two extreme points, the dynamics of traffic flow produce a maximizing effect. As flow increases from zero, density also increases, since more vehicles are on the roadway. When this happens, speed declines because of the interaction of vehicles. This decline is negligible at low and medium densities and flow rates. As density increases, these generalized curves suggest that speed decreases significantly before capacity is achieved. Capacity is reached when the product of density and speed results in the maximum flow rate. This condition is shown as optimum speed S_o (often called critical speed), optimum density D_o (sometimes referred to as critical density), and maximum flow v_m.

The slope of any ray line drawn from the origin of the speed-flow curve to any point on the curve represents density, based on Equation 7-5. Similarly, a ray line in the flow-density graph represents speed. As examples, Exhibit 7-2 shows the average free-flow speed and speed at capacity, as well as optimum and jam densities. The three diagrams are redundant, since if any one relationship is known, the other two are uniquely defined. The speed-density function is used mostly for theoretical work; the other two are used in this manual to define LOS.

As shown in Exhibit 7-2, any flow rate other than capacity can occur under two different conditions, one with a high speed and low density and the other with high density and low speed. The high-density, low-speed side of the curves represents oversaturated flow. Sudden changes can occur in the state of traffic (i.e., in speed, density, and flow rate). LOS A though E are defined on the low-density, high-speed side of the curves, with the maximum-flow boundary of LOS E placed at capacity; by contrast, LOS F, which describes oversaturated and queue discharge traffic, is represented by the high-density, low-speed part of the functions.

III. INTERRUPTED FLOW

Basic concepts for interrupted-flow facilities: intersection control, saturation flow rate, lost time, and queuing

Interrupted flow is more complex than uninterrupted flow because of the time dimension involved in allocating space to conflicting traffic streams. On an interrupted-flow facility, flow usually is dominated by points of fixed operation, such as traffic signals and stop signs. These controls have different impacts on overall flow.

The operational state of traffic at an interrupted traffic-flow facility is defined by the following measures:

- Volume and flow rate,
- Saturation flow and departure headways,
- Control variables (stop or signal control),
- Gaps available in the conflicting traffic streams, and
- Delay.

The discussion of volume and flow rate in the first part of this chapter also is applicable to interrupted-flow facilities. An important additional point is the screenline at which the traffic volume or flow rate is surveyed. Traditional intersection traffic counts yield only the number of vehicles that have departed the intersection. The maximum flow is

(Traffic and Hwy engineering) Nicolas J. Garber & Lester A. Hoel copy 1998 P 177

Traffic flow theory

Traffic flow theory involves the development of mathmatical relationships among the primary elements of a traffic stream: flow, density and speed. These relationships help the traffic engineer in planning, designing and evaluating the effectiveness of implementing traffic engineering measures on a highway system. تنفيذات، اجراءات

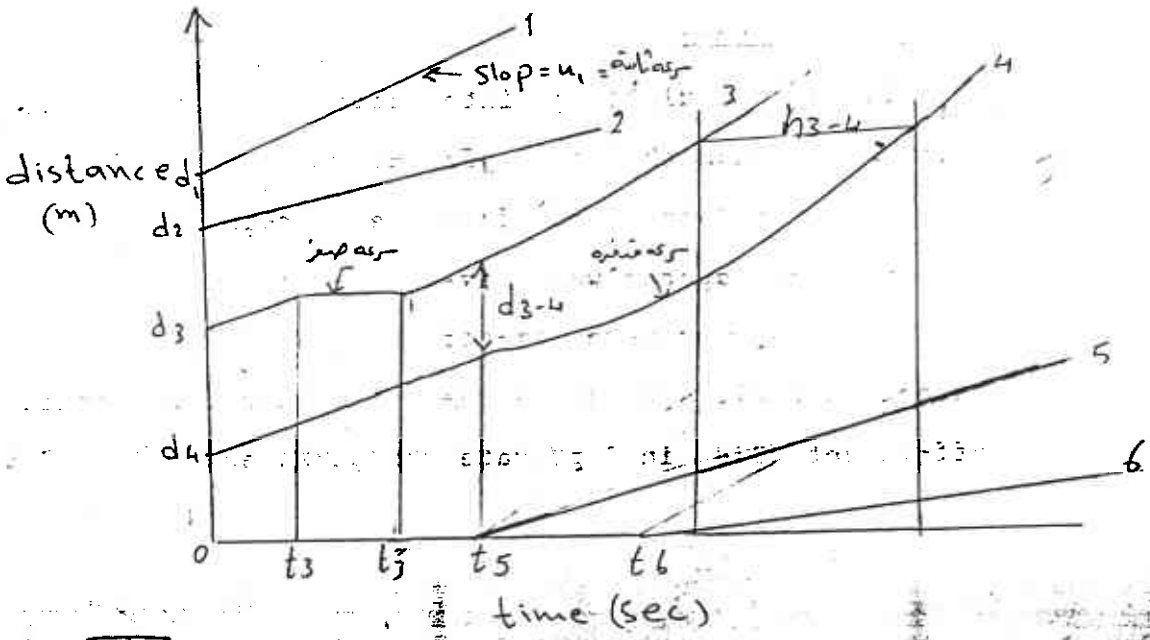
Traffic flow theory is used in

* Design to determine adequate lane lengths for storing left turn vehs. on a separate left turn lanes.
* The average delay at intersections and freeway ramp merging areas
* Simulation, where mathmatical algorithems are used to study the complex relationships, that exist among the elements of a traffic stream or network

Traffic flow elements

قبل الدخول في شرح العلاقة بين عناصر التدفق المروري دعنا نشرح Time-space dia لسهولة شرح هذه العناصر وعلاقتها ببعض

Time space diagram: is a graph that discribes the relationships between the location of vehs. in a traffic stream and the time as the veh. progress along the hwy.



fig(6-1) Time - space diagram for 6 vehs

at time 0, vehs 1, 2, 3 & 4 are at distances d_1, d_2, d_3 & d_4 respectively from a reference point, whereas vehs 5 & 6 cross the refrence point later at times t_5 & t_6 respectively.

CHAPTER FIVE
CONCLUSIONS AND RECOMMONDATIONS

5.1 General

The study was concerned with parking characteristics in a 0.578 km² central part of Baghdad CBD, surrounded by Rashid, Kifah, Amin and Thowra streets. It contains important traffic generators because of its commercial, administrative, and industrial nature.

Four types of surveys were undertaken to collect data. The license plate survey and the driver interview were the most important ones. These surveys were conducted in two public car parks of total capacity 143 spaces and one private car park of capacity 220 spaces.

Number of parking spaces needed in the CBD was calculated by using the study results and compared to other studies.

5.2 Conclusions

It is useful to go into some important particulars observed through the study period.

(1). It was found from the parking inventory that 1035 parking spaces were available in the study area, of which 237 spaces were on-street (166 spaces in the main streets and 71 spaces in the alleyways) · 660 spaces were off-street (338 in 9 private car parks and 322 in 7 public

Flow (q) is the equivalent hourly rate at which vehs. pass a point on a hwy lane during a time period less than 1 hr. It can be determined by

$$q = \frac{n * 3600}{T} \quad (veh/hr)$$

where

n: No. of vehs. passing a point in the roadway in T secs

q: the equivalent hourly flow v/hr

density (k): or concentration and it is the no. of vehs. traveling over a unit length of hwy at an instant of time, and it is expressed by (veh/km) وعادة ميل او كم واحد

Speed (u): is the distance traveled by a veh during a unit time and it is expressed (km/hr) or (m/sec)

ثم نشرح سرع المركبات 2 و 3 من المعنى 1-6

Time mean speed ($\bar{u}_t$): is the arithmatic mean of the speeds of vehs. passing a point on a hwy during an interval of time

$$\bar{u}_t = \frac{1}{n} \sum_{i=1}^{n} u_i = \frac{\text{مجموع السرع}}{\text{عددها}}$$

where:

n: No. of vehs. passing a point on the highway

u_i: Speed of the ith veh.

Space mean speed ($\bar{u}_s$): is the harmonic mean of speeds of vehs. passing a point on a highway during an interval of time

$$\bar{u}_s = \frac{n}{\sum_{i=1}^{n} (1/u_i)} = \frac{nL}{\sum_{i=1}^{n} t_i} = \frac{\text{مجموع المسافات}}{\text{مجموع الازمان}}$$

where:

$\bar{u}_s$: space mean speed (km/hr) or (m/sec)

n: No. of vehs.

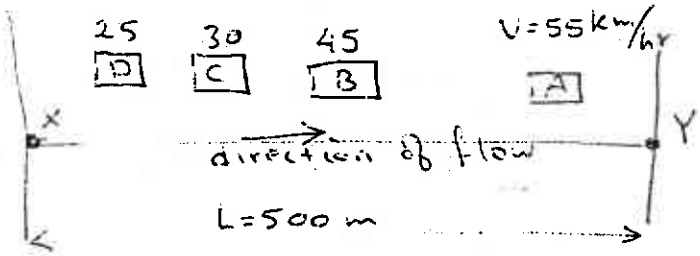
t_i: the time it takes the ith veh. to travel across a section of hwy ([redacted]) sec

u_i: Speed of the ith veh.

L: length of section of hwy ([redacted])

Location B is in sector 2, centering the study area. The car park will replace the parking facility (2-2) and extend to a larger area. This location will require expropriation of a number of old residential and commercial buildings. This location will make the car park serve all the parkers destined the study area.

example: Calculate the flow, density, time mean speed & space mean speed for the four cars A, B, C & D with their positions and speeds obtained by photography as in fig below. The cars pass point X at 12 secs



example. 3 vehs are recorded with speeds of 40, 60 & 80 Km/hr. The time to traverse 1 Km is 1.5 min, 1.0 min, & 0.75 min, respectively, what is the time mean speed & space mean speed

Time mean speed = $\frac{40+60+80}{3} = 60$ Km/hr

Space mean speed = $\frac{1 \times 3 \times 60}{(1.5+1+0.75)} = 55.4$ Km/hr

وهي مجموع مسافات ما تقطعه سيارتان او اكثر على مجموع الازمان التي يستغرقها
هذا العدد من السيارات وتستخدم هذه السرعة في رسم ال
flow-density relationship او وهي السرعة التي تستخدم في رسم

Time headway (h) : الفاصل الزمني بين وصول سيارتان لنفس النقطة is the difference between the time the front of the veh. arrives at a point on the highway and the time the front of the next veh. arrives at that same point. It is usually expressed in (sec)

وهي المسافة h_{3-4} على الرسم time-space diagram
The time headway between vehs. 3 & 4 at d_1 is h_{3-4}

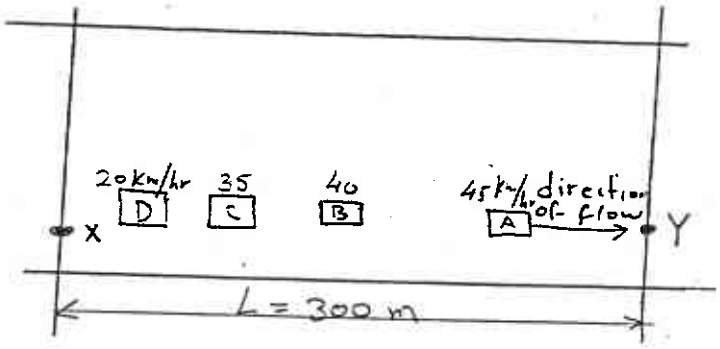
Space headway (d) or (spacing) : الفاصل المكاني بين مقدمتي سيارتين is the distance between the front of a veh. and the front of the following veh. It is usually expressed in (m). The space headway between vehs. 3 & 4 at time t_5 is d_{3-4} see fig (6-1)

example: Fig (6-2) shows vehs. traveling at constant speeds on a two-lane hwy between sections x and y with their positions and speeds obtained at an instant of time by photography. An observer located at point x observes the four vehs. passing point x during a period of T secs. The velocities of the vehs. are measured as 45, 40, 35 and 20 km/hr, respectively. Calculate the flow, the density, the time mean speed and the space mean speed.

Solution

① The flow $q = \frac{n * 3600}{T} = \frac{4 \times 3600}{T} = \frac{14400}{T}$ vph

fig (6-2) Locations and speeds of four vehs. on a two-way hwy at an instant of time.



② density $k = \frac{n}{L} = \frac{4}{300} \times \overset{1000 m/km}{1000} = 133.3$ veh/km

③ Time mean speed $= \bar{u}_t = \frac{1}{n} \sum_{i=1}^{n} u_i$

$= \frac{1}{4}(20 + 35 + 40 + 45)$

$= 35$ km/hr

④ Space mean speed $= \bar{u}_s = \frac{n}{\sum_{i=1}^{n} (1/u_i)} = \frac{Ln}{\sum_{i=1}^{n} t_i}$

where t_i is the time it takes the ith veh. to travel from X to Y at speed u_i, and L(m) is the distance between X and Y

$t_A = \frac{L}{u_i} = \frac{300}{1000 \times 45} \times 3600 = 24$ sec

$t_B = \frac{300}{1000 \times 40} \times 3600 = 27$ sec

$t_C = \frac{300}{1000 \times 35} \times 3600 = 30.85$

$t_D = \frac{300}{1000 \times 20} \times 3600 = 54$

$\therefore \bar{u}_s = \frac{4 \times 300 \times 3600}{1000(24 + 27 + 30.85 + 54)} = 31.8$ km/hr

Flow-Density relationship

Flow = density × space mean speed

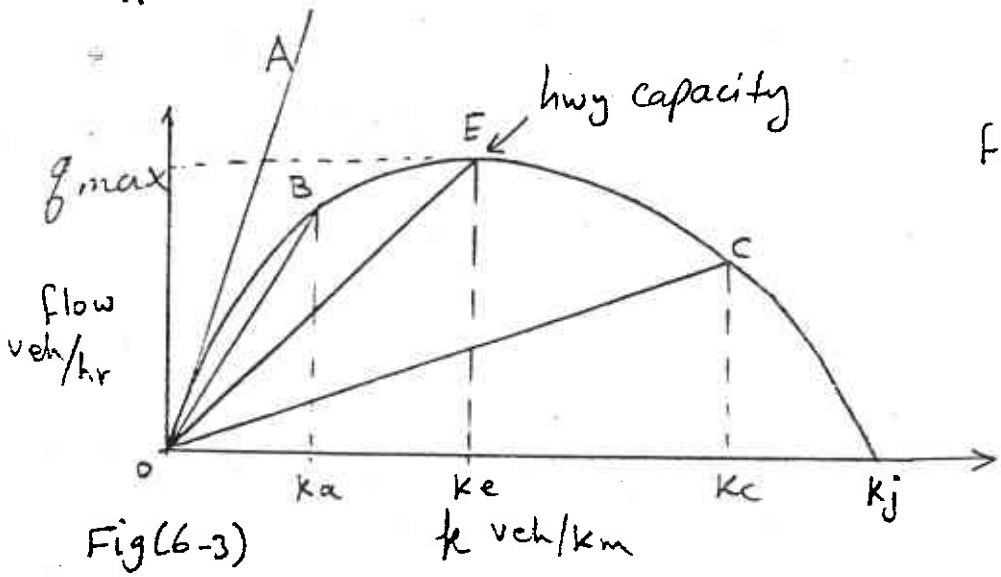
$$q = k\bar{u}_s \qquad \text{- - - - - (6.5)}$$

each of these variables depends on

- characteristics of highway
- " " the vehicle
- " " " driver
- environmental factors such as weather

Fundamental diagram of traffic flow

It means the relationship between the density (veh/km) and the corresponding flow of traffic on a hwy.
~~general~~



Fig(6-3)

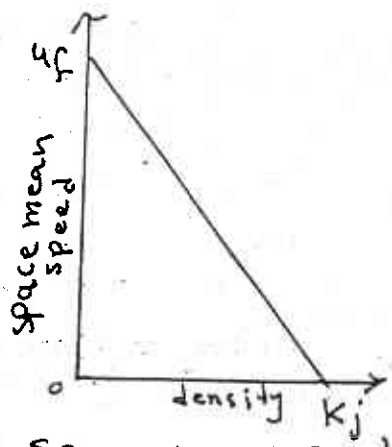
fig(6-3) flow verses density

١- عندما تكون كثافة المرور بالطريق صفراً فان الحجم المروري يكون صفراً ايضاً لان لا يوجد سيارات بالطريق

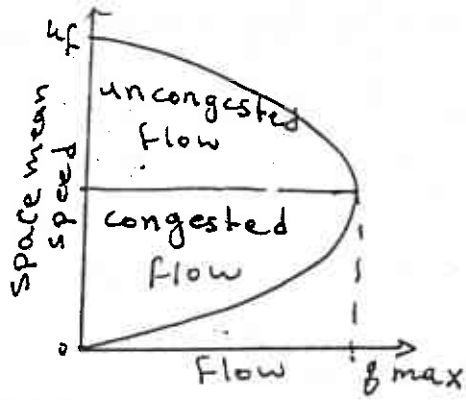
٢- بزيادة الكثافة density يزداد الحجم المروري flow

٣- عندما تصل قيمة الـ density الى اقصى قيمة لها وندعوها kjam وترمز (kj) تصل قيمة الحجم المروري flow الى الصفر لان السيارات ستكون واحدة خلف الاخرى تسد الطريق

٤- بزيادة k يزداد الـ q من قيمة الصفر الى الـ qmax. بعدها تكون الزيادة في k تؤدي الى نقصان q الى ان يصبح قيمة صفراً عندما تساوي k قيمة kj وبهذا فان المنحني سيأخذ الشكل المرسوم (6-3)



(b) Space mean speed verses density



(c) space mean speed verses volume