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THE KINGDOM OF THAILAND
MINISTRY OF INTERIOR
DEPARTMENT OF TOWN AND COUNTRY PLANNING

CITY PLANNING MANUAL

VOLUME V TRANSPORT PLANNING

THE STUDY ON APPLIED TECHNOLOGY FOR MAKING CITY PLAN

JANUARY 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

This manual was prepared under the "Study on Applied Technology for Making City Plan" at the Department of Town and Country Planning, Thai Government. The Study, financed by Japan International Cooperation Agency (JICA), Japanese Government, was conducted between December 1987 to February 1989.

This Manual is the fifth volume of the City Planning Manual totalling nine volumes as listed below:

- Volume 1 - Integrated City Planning
- Volume 2 - Mapping
- Volume 3 - Socio-Economic Analysis
- Volume 4 - Land Use Planning
- Volume 5 - Transport Planning
- Volume 6 - Urban Facilities Planning
- Volume 7 - Land Readjustment
- Volume 8 - District Planning
- Volume 9 - DBMS Development Manual

This Transport Planning Manual was prepared under the following organizations.

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- *Risucholn PANICHYOTAI* Engineer 6, Engineering Division, DTCP	Assistant Author who provided materials for Sections 7.1 and 7.2.3

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VOLUME V

TRANSPORT PLANNING MANUAL

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PART 1:

Introduction

1.1 Use of This Manual

This Manual aims at providing procedural guidelines and technical references to the transport sector planning in the preparation of the statutory General Plan.[1] The planning activities defined within this Manual closely correlate to the duties and responsibilities of the Engineering Division of the Department of Town and Country Planning (DTCP), Ministry of Interior, Royal Thai Government, and their Provincial Town Planning Offices, as well as local authorities. A General Plan, covers the area within the General Planning boundary, which encompasses the concerned municipality(ies) and its (their) surrounding areas. The planning horizon of a General Plan is usually 20 years. The transport plan in a General Plan, therefore, concerns the provision of major transport network that serves as basic communication channels to the urban land use activities, and guides the city development into a preferable direction. The scope of transport planning covered within the Manual is set by considering the planning activities undertaken for the formulation and preparation of General Plans.

This Manual is one of the volumes that cover all the sectors involved in the preparation of a General Plan : The most relevant volumes to this Manual are, Socio-Economic Analysis (Volume III) Land Use Planning (Volume IV) as well as DBMS Development Manual (Volume VII). Other materials, such as working papers and related study reports, are referred to within this Manual.

The Manual tries to incorporate as many practical examples and guiding standards as possible. A case study in Chiang Mai[2] was used to illustrate the Manual in some sections. Experiences in other countries have also been cited because of the shortage of such applications and relevant figures in Thailand as well as the limitation of time made available for the preparation of this Manual. These adopted planning guidelines, however, should be replaced in the future with more appropriate ones that can be worked out in the continuing studies in DTCP and other related authorities. The method of establishing such guidelines are provided within this Manual.

Fortunately, modern transport planning techniques are well documented, and their coverage is comprehensive[3]. Therefore, this Manual does not

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[1] Town Planning Act (1975), Thai Government Gazette Vol. 92, Part 33.

[2] JICA (1988), Transport Planning in Chiang Mai, Working Paper, Applied Technology in City Planning, Japan International Cooperation Agency, and DTCP, MOI.

[3] For example : Hutchingson, B.G. (1974), Principles of Urban Transport Systems Planning, New York : McGraw-Hill Book Company. JICA (1984) Comprehensive Urban Transportation Planning, Japan International Cooperation Agency.

try to reproduce all of the theories and critical arguments contained in those materials, but it puts emphasis on the practical side of their application in realistic planning contexts, although, a minimum amount of theoretical background is provided to assist the reader in attaining a deeper insight into modern transport planning techniques.

During the compilation of this Manual, special attention was paid to the simplification of the quantitative approach. Due to the resource availability, all of the cities concerned by DTCP may not be planned by the full scale modelling method. A variety of simplification methods have been proposed for medium to small cities. One of them is the O-D matrix estimation technique by using road side traffic volume counts; and another is the use of coarser traffic zones and strategic transport network; more detailed explanations are presented in PART 6 of this Manual. The simplified approaches shown in this Manual have been selected so that they present sufficient practicality. Guidelines for the adoption of these alternative approaches are also given, but the final decisions are left for planners, who can practice the most appropriate method depending on the characteristics of the city and specific planning situations as well as the resource made available for the preparation of the plan.

1.2 Institutional Background to Transport Planning in Thai Cities

This section describes the characteristics of transport planning as statutory planning (General Plan), and the authorities relating to the planning and administration of transport systems in municipalities and their surrounding area. The information provided in this Section will serve as background knowledge to the formulation and implementation of transport plans covered in this Manual.

Transport Planning as Statutory Planning

A transport plan enacted as a part of a General Plan is used to secure urban land area for transport facilities, mainly the road network, i.e. to secure public right-of-way (e.g. 60~80 m wide in rural areas). The major function of the plan, therefore, is the restriction and guidance of urban development. Once the plan is enacted, the local authority can prohibit any development to take place within the area specified as public road network. The plan is usually reviewed once every five years.

The specification of road network plan, in general, is made in three categories:

a. Cross-section redesign without changing total width of the roadway;

b. Widening or realignment of the existing right-of-way; and

c. Construction of new links.

Each improvement project is identified by a unique numbering system and the detailed description of the improvement works and their location is enacted and enforced as a ministerial regulation. The project location is also shown on the map scaled at 1:10,000 - 1:30,000.

Local governments are supposed to elaborate on the exact location of these right-of-ways, assisted by the DTCP, on the actual site and on a more detailed map. The local authorities also work out the priority of the projects with the assistance of DTCP, and in most cases, finance them by their own budget.

Relevant Authorities Responsible for Planning and Administration of Urban Transport Systems in Thailand

There is a total of 7 authorities, other than the DTCP, directly responsible for planning and administration of urban roads[1]. The DTCP coordinates these authorities to produced General Plan. The seven authorities are:

a. Department of Highways (DOH), Ministry of Communication;
b. Public Works Department (PWD), Ministry of Interior;
c. Changwat Governments;
d. Municipal (Tesaban) Governments;
e. District (Sukhaphiban) Administrations;
f. Expressway and Rapid Transit Authority of Thailand (ETA);
g. Department of Land Transport (DLT).

Department of Highways (DOH). is responsible for the construction and maintenance of the national and major provincial highways of the country.

Public Works Department (PWD). constructs and maintains bridges and some part of approach roads.

Changwat Governments. are responsible for the construction and maintenance of rural highways outside the municipal and sanitary areas.

Municipal Governments. are responsible for the construction and maintenance of municipal roads.

District Administration. is responsible for district roads.

Express-way and Rapid Transit Authority (ETA). is an autonomous public organization which is responsible for the planning, research, construction, maintenance and operation of the toll expressways and the mass transit system.

Department of Land Transport (DLT). is responsible for planning and construction of truck terminals and inter-city coach terminals. The organization also administers all types of vehicle registration.

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[1] For Bangkok Metropolitan Area, STTR working paper lists a total of 37 official agencies with responsibility for some aspect of planning, evaluating, approving, and operating and maintaining urban transport. See Appendix 1.

Other related authorities are as follows:

Royal Irrigation Department. construction and maintenance of irrigation bank roadways which sometimes becomes a part of urban transport network.

Police Department. enforces the traffic laws and regulations, and keeps road traffic accident records.

National Economic & Social Development Board (NESDB). prepares overall policy and strategy for infrastructure projects including those of the transport sector of the metropolitan region.

Bangkok Metropolitan Transit Authority (BMTA). State Enterprise operating bus services in Greater Bangkok.

State Railway of Thailand (SRT). State Enterprise responsible for planning, implementing and operating the national railway.

Harbour Department (HD). Planning and regulation of inland waterways and coastal transport, including ferry services.

Office of the Committee for the Management of Road Traffic (OCMRT). Conducting traffic analyses, preparing traffic policies, designing traffic management schemes for major cities in Thailand.

1.3 Definition and Scope of Transport Planning as Dealth with in This Manual

The transport plan dealth with in this Manual, consists of the following components:

Main area of concern:

a. major road network;
- Rural highways
- Urban highways
- primary distributors
- district distributors
- local distributors
- access roads[1]

Related transport facilities:

b. public transport network;
- Railway network
- Bus routes

c. transport terminals;
- Airports
- Railway stations
- Bus/coach terminals
- Truck terminals
- Docks and seaports

[1] This classification is the functional classification used in a General Plan prepared by DTCP, see Sec. 7.2.2 for the definition.

These transport facilities collectively provide physical communication channels between urban land use activities. The term 'transport' in urban transport planning, usually refers to these transport infrastructures.

Physical movement of people and goods is performed by passenger cars, buses, trucks and trains; walking and cycling are also important means of transport. These moving units on the transport channels form 'traffic' which puts demand on transport systems. In this context, transport system is the supply side of component in the well-discussed demand-and-supply concept. Higher capacity of transport system clearly increases the transport supply but it is costly to provide. Lower capacity, on the other hand, induces traffic congestion that may be described as a social cost to the urban community.

Transport problems arise when transport capacity exceeds the transport demand. This implies that one of the major aims of a transport plan is the supply of sufficient capacity to accommodate transport demand, so that smooth traffic flow on the transport network is secured, and to provide accessibility and mobility to people and goods in urban areas. Supply of transport facilities, however, involves substantial amounts of public expenditure. Thus, the efficiency of network management is also an important element of planning. Traffic also incurs "external diseconomies" such as air pollution due to exhaust gases, and noise and vibration pollution, as well as traffic accidents. For these reasons transport plans should be evaluated in order to minimize these adverse impacts on the urban environment.

As it has been mentioned in the previous section, the planning horizon in the General Plan is usually 20 years, therefore the above listed transport components are strategic components of urban transport systems. They provide a basic structure to the urban area and guide its development. At a local scale of transport planning, more detailed aspects of transport improvements, such as intersection improvements, parking planning, traffic safety improvements, become important. These items are not covered here, but the transport planner should be aware of these complementary measures of transport planning to attain an overall efficiency of urban transport systems.

PART 2:

Transport Planning Process

TRANSPORT PLANNING PROCESS

2.1 Transport Planning Process - Generalized Procedure

Transport planning process, in general, consists of the following five steps; which roughly describes the structure of the Manual.

1. Data collection (PART 3);
2. Analysis (PART 4);
3. Forecast (PART 5 and 6);
4. Plan design (PART 7); and
5. Plan evaluation (PART 8).

At the data collection stage, necessary data for planning, for example, socio-economic indices, topographic data, existing condition of transport systems and land use, among many others, are collected through field survey. Certain data are collected from local authorities and other governmental organizations. The collected data are then used to analyze the existing situation of the city, and the problems which need to be dealt with in the course of plan designing are identified. The planning strategies (policies) are formulated based on the results of these analyses.

Planning is future-oriented. Target population and expected levels of activities are provided as a framework for the transport systems planning. The future transport demands are forecasted by using this framework. The methods of transport demand forecast should preferably be based on quantitative approaches but simplified methods may be applied in certain cases.

At the plan design stage, the transport planner considers a variety of factors to prescribe transport system so that the transport problems identified at the earlier stage may be overcome and the expected future transport demand may be accommodated. Coordination with the land use planners is particularly important at this stage in order to balance transport supply and demand, and to provide the transport system to guide the urban development in a preferable direction.

The plan design is conducted in parallel with plan evaluation. A set of evaluation indices are determined and the adequacy of the alternative plans are tested against these indices. The best plan is, then, put forward as a draft General Plan for the transport system.

The transport planning process in the formulation of a comprehensive land use/transport plan is shown in Figure 2-1. Appendix 2-1 shows the detailed steps of transport planning tasks in the preparation of a General Plan as a statutory planning process.

2.2 Coordination with Related Sectors

As can be seen in the previous diagram (Fig. 2-1), the transport planning sector requires close coordination with other Sectors particularly with the mapping sector, socio-economic research sector and

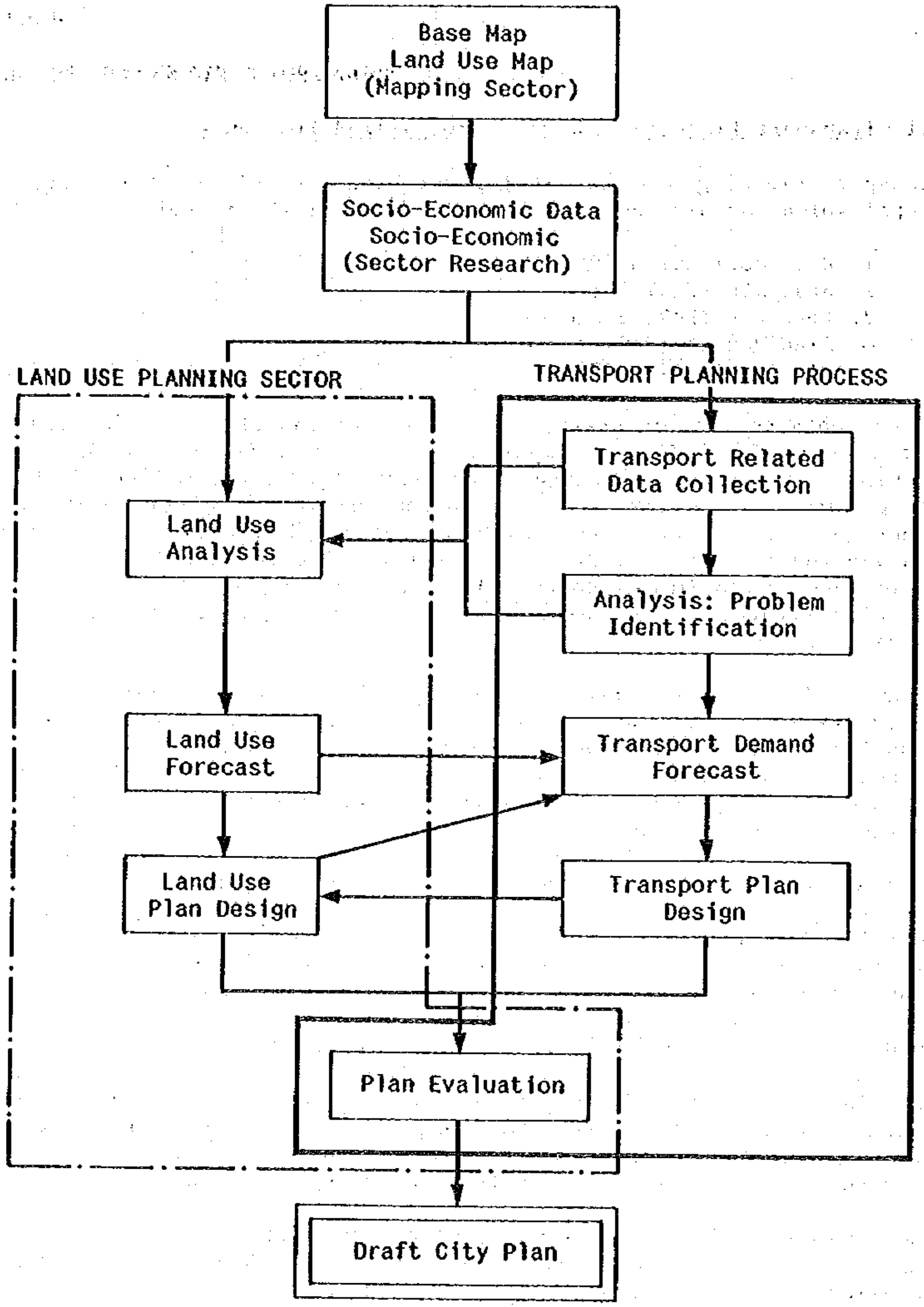

Fig. 2-1 Transport Planning Process in the Formulation of General Plan

land-use planning sector. The involvement with these Divisions will be made clear in a detailed explanation of planning activities in the later parts of this Manual, but the general relationships may be summarized as follows:

Mapping Sector

Preparation of a transport plan requires the following maps for the field surveys and plan formulation purposes.

- Base map (1:10,000 ~ 1:30,000)
- Existing land-use map (1:10,000)
- Existing building use map (1:4,000)

Socio-Economic Research Sector

Transport planning requires a great deal of data in the areas of socio-economic and transport, of which transport related data are collected by the transport planning sector (see Part 3 of this Manual) but the socio-economic sector provides socio-economic data. Main items of required socio-economic data are listed as follows:

- Area wide population and employment (existing, future);
- Zonal distribution of population and employment (existing, future); and
- Other socio-economic indices by zone (existing and future).

The transport related data collection has to be coordinated with the socio-economic sector for maximum integration of the information collected by both sectors. The most important point to be noted here is the specification of survey zones and traffic zones. The detailed explanation of the zoning system is explained in Section 3.4.2 of this Manual.

Land Use Planning Sector

Transport systems essentially cater for land use activities, but the transport plan can influence the way land use is actually developed. In other words, they interact with each other. Then, it is imperative that these two systems are planned together at the same level, and this demands the transport planner to closely coordinate with the land use planner. The information required from the land use planning sector can be listed as follows:

- Existing land use plan;
- Future land use plan;
- Existing and future land use activity levels (quantitative); and
- Land use constraints showing the area where certain transport systems may not be developed. (e.g. military bases).

Transport planning sector, in turn, feeds back the planned transport system to the land use planning level to check the consistency between the two systems.

PART 3:

Transport and Traffic Surveys

TRANSPORT AND TRAFFIC SURVEYS

3.1 Design of Field Survey

Transport planning process requires a variety of data. Such data are necessary to analyze existing performance of transport systems, and to forecast future transport demand. Good quality information is a most important ingredient of rational transport planning.

Some of the data necessary for transport planning are collected by socio-economic surveys (see Vol. III: Socio-Economic Research Manual), others are obtained from the relevant authorities (Table 3-9). Most of the vital information, however, is directly collected through carefully designed field surveys. The preparation is as important as actual data collection for the quality of information and the efficiency of data collection. Table 3-9 shows the list of data required for transport planning, and their sources.

In most cases, all of the listed items in the table are necessary, but in certain cases, the field survey can be scaled down to collect the most basic information required for particular planning situations.

There are a variety of planning situations. The factors shown below, which depicts the characteristics of cities, changes from one city to another[1], and influence the way transport plans are formulated.

- Population size (large or small)
  Rate of urban growth

- Modal share (roles of private and public transport)

- Characteristics of highway network (complex or simple)

- Future transport strategy
  (private car, bus service, railway system)

- Type of transport problems (Traffic congestion, public transport inefficiency etc.)

The field survey, therefore, should be designed to give maximum efficiency within the constraints of the survey period, manpower and budget. For an illustrative purpose, three types of city are chosen, they are: type A, B and C cities. Typical characteristics of those cities are assumed as in Table 3-2.

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[1] For the same city, the planning situation also changes along the time scale. This is why cyclic revision is required in planning.

Table 3-1 List of Data Required for Transport Planning, and Their Sources

Category	Data Item	Sources
Maps	Base Map (1:10,000-1:30,000)	Mapping Div., DTCP
Socio-Economic Data	Area Wide Population and Other Socio-Economic Indices	Research & Analysis Div., DTCP
	Elaboration of Above Indices by Traffic Zones	" "
Land Use Pattern	Existing Land Use Patterns	Mapping Div., DTCP
	Future Land Use Plans	Comprehensive Planning Div., DTCP
	Existing and Future Land-Use Activity Levels (Quantitative) by Traffic Zones	" (Supplementary analysis may be required for quantification)
	Land Use Constraints showing the Area Where Certain Transport Systems may not be Developed	Comprehensive Planning Div., DTCP (Supplementary analysis may be required)
Transport Systems	Road Inventory Cross-Section Levelling Surface Type	Primary Survey DOH Local Government
	Public Transport Bus/Truck Terminal	Department of Land Transport
	Cycle Path	Local Government
	Traffic Regulation	Police Department
Traffic Data	Traffic Volume and Composition	Primary Survey
	Travel Time, Traffic Speed	"
	Occupancy Rates	"
	Traffic Congestion	Police Department
Traffic Movement	Person Trip Survey	Primary Survey
	Car Owner O-D Survey	"
	Cordon O-D Survey	"
	Number Plate Survey	"
Related Data	Accident Statistics	Police Department
	Car-Ownership	Department of Land Transport
	Existing Transport Project	Local Government DOH PWD BMTA

Table 3-2 Three Types of City and Their Characteristics Concerning Transport Related Data Collection

Characteristics	City Type A	City Type B	City Type C
Future Population	less than 10,000	10,000 ~200,000	300,000 or more
Urban growth	slow	medium	fast
Dominant trans- mode	private car	private car + buses	private car + buses truck system)
Highway network	relatively simple (less than three)	relatively complicated	Complicated
Type of transport problems	No significant problem except in urban center	Peak hour congestion	Traffic Congestion is scattered over city center and the perimeter Delay of buses is a serious problem.

Transport strategies for those type of cities are made clear in later parts of the annual, but the guideline for survey items can be summarized in Table 3-3.

Table 3-3 Guideline for Survey Items for Different City Types

Survey Item	City Type (1) Type A (Small)	Type B (Medium)	Type C (Large)
Transport Systems:			
Road Inventory	**	**	**
Bus Route and Schedule	*	**	**
Bus/Coach Terminal	**	**	**
Parking Facility	*	**	**
Traffic Data:			
Traffic Volume	**	**	**
Traffic Composition	**	**	**
Traffic Speed	**	**	**
Traffic Movement:			

Person Trip Survey	-	*	**
Car Owner O-D Survey	*	**	-
Cordon O-D Survey	-	**	**
Number Plate Survey	**	-	-
Related Data:			
Traffic Congestion	**	**	**
Accident Statistics	**	**	**
Car Ownership	**	**	**
Existing Project	**	**	**

(Legend : ** essential; * preferable; - not necessary)
(1) See Table 3-2 for the definitions

3.2 Transport System Survey

Road Inventory

Road inventories are also carried out by other governmental agencies such as DOH, Municipal and Amphoe (District) authorities and contacts should be made with these organization at the early stage of the field survey. When these agencies do not provide sufficient information, additional measurements have to be made to find out: road administration; the width of right of way; vehicle lanes; sidewalks; types of road surface; and other related information.

Other related information can include:

- location type and condition of bridges;
- maintenance record; and
- history of flood.

The collected data should preferably be stored in a systematic manner in the form of a database, and periodically updated so that the planner and the road administrator can have access to the latest information of their concerned systems.[1]

Public Transport System

The forms and usage of public transport systems in the area are investigated by contacting railway stations, provincial land transport department, municipal authority or airport authority. Amount of passengers carried by these modes are obtained for past 5 to 10 years. The changing roles of these forms of transport and their importance to the planning area can be identified. Bus routes and the frequency of services may also be investigated. The extent and location of bus/coach terminals and dock and harbours are significant at the strategy formulation stage of transport planning. (See Figure 3-1 and 3-2 for example survey sheet)

[1] See JICA (1986), Study on Road Improvement, Rehabilitation and Traffic Safety in Bangkok, Vol. V for an example of an elaborated road inventory system using micro-computer.

Fig. 3-1 Public Transport System Survey Form

1. Is there any bus/coach terminal?............................

   If yes, state the location and area............................

   Area......................km^2

   If no, where is the area used for bus/coach parking?.........

   ....

   ....

2. Bus/coach routes, state the routes and no. of daily operation

   ....

   ....

3. No. of registered vehicles under this office supervision

   - Bus/coach..............veh., (Big scale...............veh.
     medium scale..................veh.)
   - Private truck...............................veh.
   - Private small scale truck...................veh.
   - Private bus.................................veh.

4. Attach timetable of buses and coaches.

Fig. 3-2 Bus/Coach Time Schedule Survey Form

Section No.	Route No.	Name of Route	Operation			No. of Vehicles	Distance Km.	Fare	Remarks
			Outward Journey	Return Journey	Total Trips/Day				

Cycle Paths and Pedestrian Routes

Cycle and pedestrian paths planning is important for certain cities where the routes with higher bicycle and pedestrian traffic are identified to provide information for the planning. Related land use such as school zones and residential areas as well as market places is identified for later analysis.

3.3 Traffic Studies

3.3.1 Traffic Volume and Composition

Traffic volume surveys provide the most essential information to transport planning, and should be conducted for every city. The traffic volume information reveals the utilization of existing road network and gives their relative importance and functions. It also indicates the sections of traffic concentration and the degree of congestions by comparing the degree of utilization with their respective capacities.

Traffic volume is expressed in the number of traffic units passing a given point for a given time period. Unit is usually expressed in the number of vehicles, but for a more detailed study, vehicle types are identified. Vehicle types used in those studies are, for example, passenger car, motorcycle, bus, light or heavy trucks and trailers. Number of pedestrians and bicycles may be a counting unit of traffic volume for special planning situations.

Different type of vehicles have different dimensions and speed characteristics, and one heavy truck contribute to the traffic congestion differently from one motorcycle. Traffic on every road section possesses different compositions therefore comparison of traffic volume requires unified measurement. Passenger car unit (PCU)[1] is used for converting them into a single unit.

Time Span for Expressing Traffic Volume

Time span is another essential element in expressing traffic volume. 'Hourly' traffic as well as 'Daily' traffic are the most common length of time. Besides these two types, 'Annual' traffic or short interval (eg. 15 min.) are also used in certain cases. Major applications of these four types of time span are described as follows:

Annual Traffic in vehicles per year is used for:

- Estimating expected highway user revenue;
- Computing accident rates; and
- Indicating trends in volume change.

Average Daily Traffic (ADT) or Average Annual Daily Traffic (AADT) in vehicles per day is most common, and used for:

- Establishing the function and importance of road sections;
- Planning for major or arterial highway systems;
- Locating areas where new facilities or improvements to existing facilities are needed; and
- Project programming.

[1] See Sec. 5.2.1 of this manual for detailed explanation.

Hourly Traffic in vehicles per hour is used for:

- Determining length and magnitude of peak periods;
- Evaluating capacity deficiencies;
- Establishing traffic control measures - volume is usually among the warrants for the:
  . installation of signs, signals, and markings;
  . designation of through streets, one-way streets, unbalanced flow, and traffic routing; and
  . prohibition of parking, stopping, and turning.
- Geometric design or redesign of streets and intersections.

Short Term Counts (Covering 5, 6, 10 or 15 min. intervals) are usually expanded into hourly flow rates. Such counts are primarily used to analyze:

a. Maximum flow rates;
b. Flow variations within peak hours;
c. Capacity limitations or traffic flow; and
d. Characteristics of peak hour volumes.

Type of Traffic Counts

Traffic counting methods can be categorized into four types:

1. *Road Side Vehicular Traffic Counts* (Total volume without regard to direction) are used in developing daily volumes, preparing traffic flow maps, determining trends, etc. Traffic volume are usually classified into two directions.

2. *Turning Movement or Intersection Counts* are used in designing channelization, planning turn prohibitions, calculating capacity, analyzing high accident intersections, evaluating congestion, etc.

3. *Traffic Composition Counts* (volumes of the various types or classes of vehicles in the traffic stream) are used in establishing structural and geometric design criteria, computing expected highway revenue, capacity (effect of commercial vehicles), determining correction factors for machine counts, etc.

4. *Pedestrian Counts* are used in evaluating sidewalk and crosswalk needs, justifying pedestrian signals, timing traffic signals, etc.

Counting Techniques

Traffic volume data can be collected by automatic or manual counting methods. An automatic counter provides continuous measurement but the number of vehicle types observed and its accuracy of vehicle classification has certain limitations. Manual count, on the other hand, can distinguish vehicle types much more accurately, but the prolonged measurement is costly. There is also a limitation on the extent of traffic volume which this method can handle. There follows a detailed explanation of the characteristics of these two methods.

Automatic Counters. are used to obtain continuous counts. They consist of an electronically operated system usually actuated by air impulses from pneumatic cables stretched across the vehicle lanes. Since each axle crossing the cable gives a pulse, these counters are designed to add one count for each two pulses for the most simple cases. With this system, however, if a significant number of multi-axle trucks are present, an error is introduced. A correction factor may be obtained from a sample manual-classification count.

Some of the later models, however, can classify vehicle types based on the speed and axle length measured by pneumatic cable and loop detector (Figure 3-3, 3-4). This machine has internal memory so that the recorded data can be directly transferred to computer for analysis and tabulation.[1] the accuracy of vehicle classification is said to be 90%, but this type of equipment can also measure speeds at the same time and substantial savings can be made in volume/speed survey if they are to be conducted purely by manual measurement.

The results of the traffic counter experiment suggested that it identified the vehicle class correctly over 90% cases. The difficulty arose when vehicle speeds were lower than 10 km/h; under this condition, motor-cycle was identified as passenger car and vice versa, though the former type of mistake was more frequent. The tube detector was sometimes insensitive to motor-cycles because of their light weight, this can be overcome, however, by increasing the tube pressure. For this reason, and possibly for some other reasons, PCU conversion of the machine count compared with the manual count showed that it over-estimates about 5 to 8%. This error, however, appeared to be acceptable for the present purpose. Furthermore, if the error is consistent in every measurement, there is a possibility to correct the results systematically with a fair level of accuracy, but this has to be proved by further experiments.

The classification counter could allow the following improvements to traffic data collection in DTCP:

1) Automatic classification count gives substantial manpower saving. Previously, classification has been possible only by the manual counting method.[1]

2) Continuous classification count becomes possible, which provides more informaiton in the change of vehicle compositions and PCU converted traffic volume over time.

3) Classified traffic-volume counts and the average traffic speed measurements can be performed simultaneously that enable the analyst to establish Q-V relations that are vital for the improvement of network simulation and also to establish existing congestion levels; i.e. calculation of V/C ratios.

[1] For detailed handling method, refer to 'Trafficomp 241 classification Recorder Operating Manual'

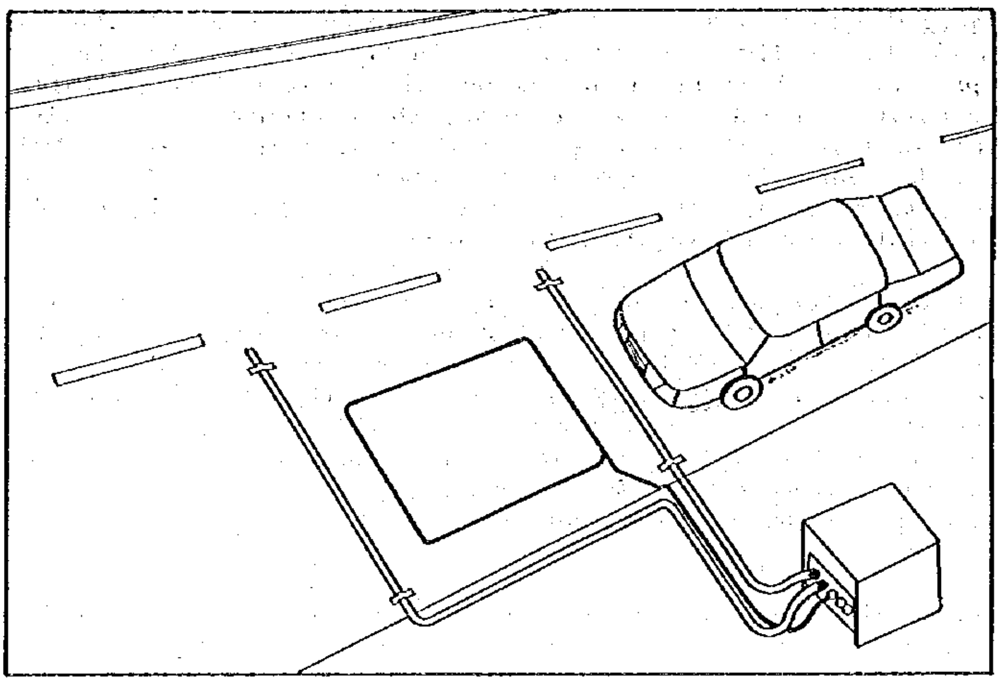
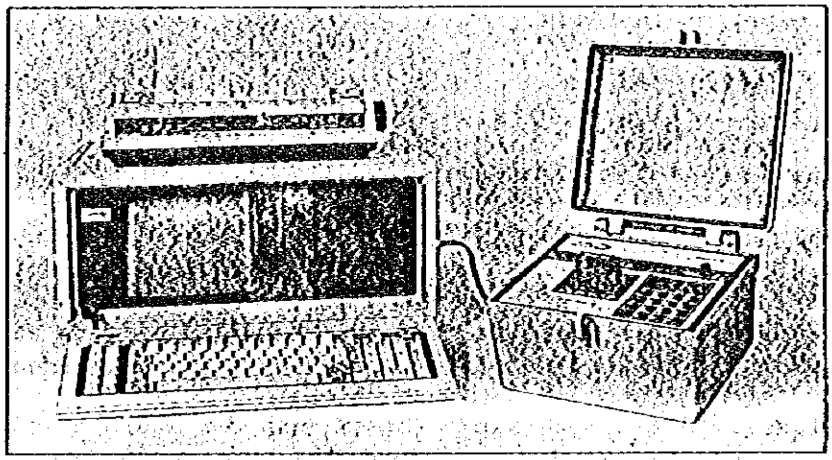


Fig. 3-3 The Installation of Tube and Loop Detection



Data is easily transferred for further processing by direct hook-up to a computer or polling via telephone line.

Fig. 3-4 Traffic counter with Vehicle-Classification Capability

Manual Counts. are necessary in certain studies since the desired data cannot be obtained by mechanical counters for light volumes, tally marks on a form are adequate. Manually operated tally counters are available for heavier volumes. As many of these counters as are needed can be mounted in banks on a counting board. Manual counts are used in:

- Turning movement counts;
- Classification counts;
- Pedestrian counts; and
- Other counts when supplement to mechanical counter is required.

When and How Long Should the Traffic Volume Count be Conducted

The time and length that a specific location should be counted is also dependent upon the data desired and the application in which the data are to be used.

Some of the more commonly used intervals are:

- Weekend Counts: covering the period from 6 p.m., Friday to 6 a.m., Monday.

- 24-hour Counts: normally covering any 24-hour period between noon Monday and noon Friday. (Traffic on Monday mornings and Friday afternoons usually vary from the normal patterns). If a specific day count (i.e., Sunday or Wednesday) is desired, the count should be from midnight to midnight.

- 16-hour Counts: usually from 6 a.m. to 10 p.m. This period contains most of the daily flow including evening traffic.

- 12-hour Counts: usually from 7 a.m. to 7 p.m. to cover most daytime traffic movements, especially in commercial or business areas. Such counts made in shopping centers or districts where stores are open at night, are usually extended until after 9 p.m.

- Peak-period Counts: which vary depending on size of city area, proximity to major generators (such as the CBD or industrial areas), and the type of facility (gateway, radial arterial, etc.). Commonly used periods are 6 or 7 to 9 a.m. and 3 or 4 to 6 p.m.

Special condition should be avoided unless the purpose of the count is to obtain data concerning these unusual conditions. Examples of such conditions include:

- Special events (holidays, parade, sports, exhibitions, sales, etc.);
- Abnormal weather conditions;
- Temporary closure of streets affecting the volume pattern; and
- Bus or train workers.

Adjustment factors may be applied to the data to remove seasonal or other variations to provide a realistic estimate of the average volume condition. These factors may be obtained by means of permanent count stations or by establishing systematic counting programme.

For actual traffic-volume survey by DTCP, the following process has been adopted:

Automatic Count is carried out on a 24 hour basis for a period of one week. Automatic counters are installed on major roadway sections. The observation points should also be chosen to cover typical frontage land uses such as business establishments and residential districts. For each traffic zone, at least one observation point should be specified for later analysis.

Manual count is used by assigning 1-2 persons to each selected observation point to enumerate traffic volume with type of vehicle classification. Survey is conducted between 7:00 to 10:00 a.m. & from 3:00 to 6:00 p.m. to cover morning and evening peak hours. On principal or main arteries traffic counts are made as long as the available time. The form used for manual traffic count is shown in Figure 3-5. Hand tally and push-botton manual counters are mainly used for counting. The manual counting sites are chosen in conjunction with automatic counting sites. Major counting sites need to be observed by both methods.

The measurement of vehicle turning movement is conducted if any improvement is to be recommended on intersections. (Figure 3-6) Four to eight observers are required at each intersection.

3.3.2 Travel Time and Speed Survey

Purpose of Travel Time and Speed Survey

Travel speed can be defined in two ways: one is the spot speed and the other average speed over a specified road section. The spot speed can be measured by installing a radar speed meter or cable/loop detectors. Average speed over a specific section can be obtained by measuring travel time of that section and dividing it by the section length.

Travel time survey determines the amount of time required to traverse a specific route or section of a street or highway. The data obtained provide travel time and mean travel-speed information. They are used in the following purposes:

- Congestion can be evaluated by means of speed and delay studies. Facts are provided on the amount, location, and causes of delay, which are useful in remedial measure selection. The delay data also indicate locations where other studies are needed to determine the proper remedies. Congestion indices can be based upon travel-time information.

- Traffic assignment to new facilities is based upon relative travel times in addition to other factors.

- Economic studies such as benefit-cost analyses utilize travel-time data. Such data may also be useful in estimating gasoline consumption.

- Trend studies use travel-time data to evaluate the level of service as it changes with the passage of time.

Fig. 3-5 Classification Manual Traffic country Form

Division of Engineering

DTCP : Ministry of Interior

Station No. ....Road Name......................... Direction of Travelling..............Changwat..............

dd/mm/yy ../../.. Time	Bicycle	Tricycle	Motorcycle	Motor tricycle / Little cab	Private car / Taxi / Jeep / Van	Mini bus / Medium bus	Bus/Coach	Pickup car / Truck	6-wheel / 10-wheel / Trailer	Total

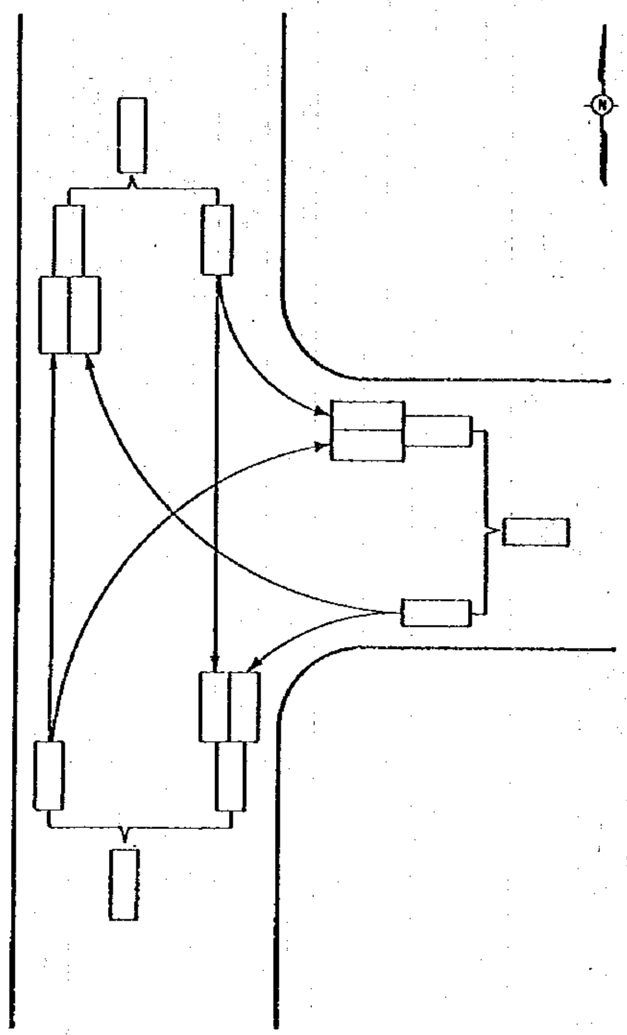
Fig. 3-6 Turning Movement Survey summary Sheet (Three Leg Case)
Engineering Division
Department of Town and Country Planning

Name of city...

Name of intersection...

Day....................Date...

Interval of time...



Measuring Method for Travel Time

The measurement of travel time along a specific route can most efficiently be observed by the 'moving observer method'. This method employs one observation vehicle with one or two observers and stop watches. The driver is instructed to travel in line with the traffic stream and the observers record the time of passing the control points (such as intersections). The test vehicle is driven along the specified route in accordance with the following operating conditions.

- Floating-car technique: driver floats with the traffic by overtaking as many vehicles as the number of vehicles that overtake the test car.

- Average-car technique: vehicle is driven according to the driver's judgment of the average speed of the traffic-stream.

The average-car technique is simpler and gives reasonable base for observing traffic performance.

An observer can use two stop watches. The first watch records the time at various control points along the route. The second watch measures the length of individual stop-time and delays. The time, location, and cause of these delays are recorded either on forms developed for this purpose by the second observer, or by voice recording equipment. (See Figure 3-7)

Other type of special recording devices have been developed to eliminate the necessity of using two people to make the observations, such as,

- Speed-and-delay timer or travel-time meter;
- Recording speedometer; and
- Traffic chronograph.

The result of the travel time measurement can be used to draw time-space diagram that can illustrate running speed of each section and bottle necks. (Figure 3-8)

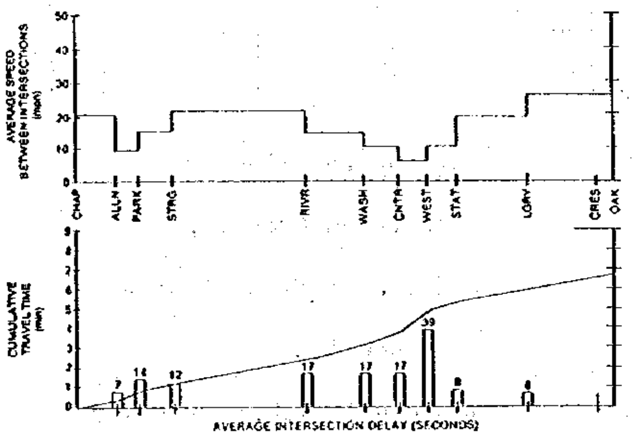


Fig. 3-8 An Example Travel Time and Speed Diagram Along Major Street
(Source: Institute of Transportation Engineers, 1976)

Fig. 3-7 Travel Times and Delays Study Form

Date................ Day.............. Page No. ....

Start............... Milage...................

Finish.............. Milage.........Distance..........kms.

Control Point	Time of Passing	Distance (Km.)	Delay (Sec)	Reason of Delay*	Travel Time	Running Time

* Reason for Delay

1. Waiting for Signals
2. Pedestrian Crossing
3. Vehicle in front Stopped
4. Intersection
5. Vehicle in front Crossing
6. Vehicle in front Turning
7. Others

Traffic Queue Survey at Intersections

The extent of traffic congestion at intersections can be best described by the 'length' of traffic queues. A traffic queue is defined as a group of cars which is forced to stand still because the number of cars heading for the intersection exceeds the capacity of the approach to that intersection.

The length of the queue can be observed by marking the kerb to indicate the distance from the stopline and overlooking the traffic from a nearby building. If a convenient place cannot be found, two to three ground observers can fulfill the task. The longest queues within specified time intervals during morning and evening peak hours should be recorded for major intersections.

3.4 O-D Surveys

The O-D (Origin and Destination) survey is conducted to observe the movement of people, vehicles and commodities. The survey collects the data on the location of departure and destination along with the purpose of trip, the mode of transport and the trip duration. The O-D survey also collects the attributes of households and individuals, so that it provides basic data on travel behaviours. Once the mechanism of travel behaviours is made clear, it gives more rational means of future demand forecast compared with, for example, simple trend analysis.

3.4.1 Type of O-D Surveys

There are three types of O-D surveys depending on the survey subjects and study purposes: person trip survey, vehicle O-D survey and commodity flow survey.

Person Trip Survey

This type of survey is aimed at obtaining the data concerning the travel behaviours of residents in the planning area for all types of transport mode. Figure 3-9 shows an example of home-to-work trip behaviour.

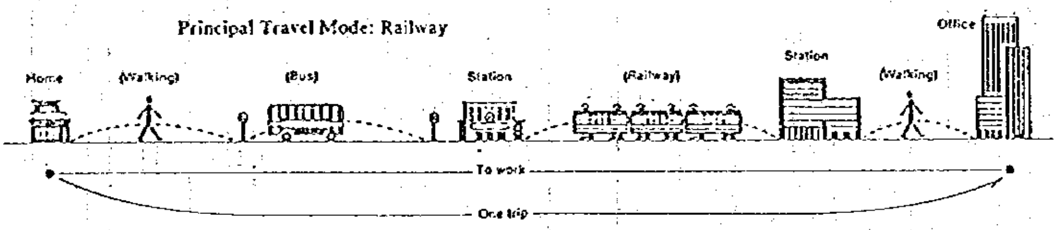


Fig. 3-9 Example of Home-to-Work Trip Behavior
(Source: JICA)

In the diagram, a traveller leaves his home and gets to the bus stop on foot, and then rides the bus to the railway station. The traveller takes a train ride to the railway station nearest to his office and descends there to walk to his office. The survey also finds out the traveller's attributes such as, age, occupation, sex, income level etc. Sample Questionnaire is shown in Figure 3-10.

Fig. 3-10 Person Trip Questionnaire

Person Trip O-D Survey / Home Interview Survey	General Plan of....................	Zone No.	Household Address..................	Interviewer	Supervisor

Sheet No.	Survey Date	Date of Trips	Personal Information	Place of Work or School	Age	Sex	Total Number of Trips
Serial No. for each person trip	DD:MM:YYY	Date of Trips on working day	○ 1 Government Official ○ 2 Manager, Professional of Office Worker ○ 3 Shop Owner ○ 4 Service & Sales Worker ○ 5 Factory, Construction Worker or Labour ○ 6 Agricultural Worker ○ 7 Student ○ 8 Housewife ○ 9 Self-Employed ○ 10 Unemployed ○ 11 Others	Address (If not clear state the name of nearby wellknown place)	○ 1 5-10 ○ 2 10-20 ○ 3 20-30 ○ 4 30-40 ○ 5 40-60 ○ 6 60 and over	○ 1 Male ○ 2 Female	Total No. of Trips made in a day
□□□□	□□:□□:□□	□□	□□	Zone □□□	□	□	□

Period	Origin			Destination			Time	Trip Purpose	Travel Mode						Occupancy	
									Mode		1st Mode	2nd Mode	3rd Mode	4th Mode		
○ 1 6:00- 9:00 ○ 2 9:00-15:00 ○ 3 15:00-18:00 ○ 4 18:00- 6:00	Facility ○ 1 Residence ○ 2 Workplace ○ 3 School ○ 4 Shop, Department Store ○ 5 Market ○ 6 Restaurant ○ 7 Others	Address (If not clear state the name of nearby wellknown place)	Departure Time	Facility ○ 1 Residence ○ 2 Workplace ○ 3 School ○ 4 Shop, Department Store ○ 5 Market ○ 6 Restaurant ○ 7 Others	Address (If not clear state the name of nearby wellknown place)	Arrival Time	Time spent for this trip hr. : min.	○ 1 to home ○ 2 to workplace ○ 3 to school ○ 4 sales delivery ○ 5 shopping ○ 6 social entertainment ○ 7 to eat out ○ 8 others	How many mode did you use ?	○ 1 Motorcycle ○ 2 Passenger Car ○ 3 Bus ○ 4 Mini Bus ○ 5 Taxi ○ 6 Tuk Tuk, Samlor ○ 7 Pick Up ○ 8 Light Truck ○ 9 Heavy Truck ○ 10 Walking ○ 11 Bicycle ○ 12 Others	Mode	Time Spent: hr : min		Place of Mode Change	Did you drive ? ○ 1 Yes ○ 2 No	If yes, how many passengers including you ?
1st Trip □	□	Zone □□□		□	Zone □□□		□:□□	□	□		□□□□□	□□□□□	□□□□□	□□□□□	□	□□
2nd Trip □	□	Zone □□□		□	Zone □□□		□:□□	□	□		□□□□□	□□□□□	□□□□□	□□□□□	□	□□
3rd Trip □	□	Zone □□□		□	Zone □□□		□:□□	□	□		□□□□□	□□□□□	□□□□□	□□□□□	□	□□
4th Trip □	□	Zone □□□		□	Zone □□□		□:□□	□	□		□□□□□	□□□□□	□□□□□	□□□□□	□	□□
5th Trip □	□	Zone □□□		□	Zone □□□		□:□□	□	□		□□□□□	□□□□□	□□□□□	□□□□□	□	□□

Vehicle O-D Survey

Vehicle O-D survey is conducted to observe movements of vehicles in the same manner as the Person Trip Survey. There are three types of survey method to observe vehicular movement: i.e. Car Owner O-D Survey, Cordon O-D Survey and Number Plate Survey.

Car Owner O-D Survey. is useful for those cities where vehicular traffic will remain as the dominant mode of traffic in the future. Practically, the survey is conducted in a similar manner as the person trip survey, that is by interviews, but the interviewees are limited only to vehicle owners and only vehicular trips are recorded.[1] In this way, a limited budget may be utilized more efficiently so as to collect specific data in more detail.

Cordon O-D Survey. is a supplementary study for a person trip survey which collects information regarding the travel patterns within the planning boundary. The trips that have at least one end outside the planning boundary, are also important to attain a complete picture of traffic movements. Cordon O-D survey can produce this type of information, and be carried out by road side interviews (Figure 3-11). Every major entry point to the planning area should be chosen as a survey station. Basic questions regarding origin and destination of trips, purposes, number of passengers and freight contents, etc., are asked to the drivers by stopping vehicles with the help of the traffic police.

Number Plate Survey. is conducted for relatively small cities to find out the proportion of traffic volume with one end in the planning area, and both ends outside the area (i.e. through traffic). The survey stations are set to cover both entry and exit points of the planning area on a major road network. The data are analyzed by computer matching technique by taking time lag into consideration. (Figure 3-12)

Screen-Line Survey. Theoretically, vehicle O-D patterns derived from the Person Trip Survey and Car O-D Survey should represent actual traffic movements on city streets, and the actual number of traffic passing through any 'cut' of the transport network should be equal to the total volume of traffic on desire-lines that are segregated by this 'screen-line'. Screen-line survey is conducted to secure the validity of O-D matrix, by observing the traffic volumes on a group of convenient check points, often along a major river, that effectively form a 'screen-line' or a 'cut'. The results of this type of traffic volume survey are used to adjust the relevant O-D matrices.

Commodity Flow Survey

The commodity flow survey aims at observing the flow pattern of commodities, which provides supplementary information to the movement of people and vehicles. In an urban transport planning context, the result of this survey is often translated into truck movements to increase the accuracy of the demand forecast of this vehicle type;

---

[1] Taxi interviews and bus interviews are also carried out to cover all kinds of vehicle movement.

Fig. 3-11 Cordon O-D Survey Questionnaire

Survey Sheet No. ☐☐☐

Classification No.	Survey Point No.	Direction	Time	Vehicle Type	Ownership	Remarks
Serial No. for inbound and outbound	Check with survey point map	○ 1 inbound ○ 2 outbound	Hour eg.(10:15 → 10) (13:30 → 13)	○ 1 Motorcycle ○ 2 Passenger Car ○ 3 Bus ○ 4 Mini Bus ○ 5 Taxi ○ 6 Tuk Tuk, Samlor ○ 7 Pick Up ○ 8 Light Truck ○ 9 Heavy Truck ○ 12 Others	○ 1 Private Car ○ 2 Company Car	
☐☐☐☐	☐☐	☐	☐☐	☐☐	☐	

Origin	Destination	Trip Purpose	No. of Passenger	Type of Cargo	Capacity	Volume
Address <If not clear state the name of nearby wellknown place>	Address <If not clear state the name of nearby wellknown place>	○ 1 to home ○ 2 to workplace ○ 3 to school ○ 4 sales delivery ○ 5 shopping ○ 6 social entertainment ○ 7 to eat out ○ 8 others	No. of Passengers including Driver	○ 1 Empty ○ 2 Agricultural Commodity ○ 3 Marine Products ○ 4 Timber, Sawn Timber ○ 5 Finished Products ○ 6 Others	Permission Capacity in ton	○ 1 Full ○ 2 3/4 ○ 3 Half ○ 4 1/4
☐☐☐	☐☐☐	☐	☐☐☐	☐	☐☐	☐

Fig. 3-12 Licence Plate Survey Field Sheet
Engineering Division
Department of Town and Country Planning

Occupancy Survey

General Plan of ....

Location..................

Observer......................

Direction.................

Date..........................

Supervisor..............

☐ ☐ ☐	7:00 7:15 10:30 10:45 16:00 16:15	7:15 7:30						8:45 9:00 12:15 12:30 17:45 18:00
Motorcycle								
Total passengers								
No. of Motorcycles								
Average Pass.								
Passenger Car								
Total Pass.								
No. of Cars								
Aver. Pass.								

therefore, the number of truck trips are used as survey subject rather than freight tons for a comprehensive survey. The survey is usually conducted by two separate methods. The first one is concerned with the attributes of firms: such as the number of employees, number of trucks, type of industry. The second is a survey on freight dispatching with its destination, quantity, frequency and the mode of transport.

3.4.2 Application Strategy of O-D Surveys

The types of O-D survey are determined by considering the characteristics of the study area and its transport planning objectives. The application guidelines of each type of O-D survey is described in the previous section, but they are summarized in Table 3-4.

Table 3-4 Guidelines for Application of O-D Surveys to Different Planning Situation

Type of Survey	Application Guideline
Person Trip Survey	Relatively larger area with population of more than 150,000~200,000, where planning for public transport as well as private vehicles is becoming important elements of transport planning.
Car Owner O-D Survey	Cities where vehicular transport will remain as the dominant mode of traffic at present and in the future.
Cordon O-D Survey	Supplementary survey to person trip survey and car owner survey. It captures the movement of vehicles in-bound and outbound of the study zones, and gives invaluable information to the planning of transport network leading to nearby cities within a regional setting.
Screen-Line Survey	To secure the validity of O-D surveys. If the traffic assignment is to be conducted by using the O-D survey results, the adjustment to the O-D matrix is made using the results of this survey.
Number Plate Survey	Suited for relatively small cities with small number of trunk roads. This method can find out only the entry and exit points of a specified cordon line, and its resolution is limited, but useful for identifying the amount of through traffic and their major movements.

Commodity Flow Survey	As an additional set of data to that collected by the person trip survey. It is particularly recommended to conduct this survey when the study area involves major commodity flow terminals such as truck terminal, factory or large scale market place. On other occasions this survey can be scaled down to collect the movement of trucks.

Zoning Method

Although transport planning concerns the movement of people and vehicles over the entire space of the study area, it is impossible to trace all the individual trips in a continuous space. For the convenience of analysis, the zoning method is widely applied in the quantitative transport demand analysis. It is a system of dividing the study area into smaller blocks (sub-zones), the origin and destination is aggregated into these sub-zone centers. The socio-economic characteristics such as population, employment and car-ownership are correlated to the travel demand of each zone.

The most convenient way of subdividing the study area is the use of lower level administrative boundaries such as 'Tambon', because socio-economic indices are usually tabulated by these administrative units. In Thai cities, however, not all of the planning area can be subdivided conveniently by this method. Lower level administrative units do not exist in certain municipalities. This can be overcome by considering existing land use and topographic condition, or natural delineations such as a river. Use of a major road or a railway is not recommended because the gravity centre of travel demand may not conveniently be related to transport network in the later analysis.

The number of zones should be determined in relation to associating network analysis. For a strategic purpose, coarser zones and network representation[1] is used, and for short term planning, finer zones and detailed network is usually applied. The finer the zones and network, the more costly the analysis becomes. The finer zoning does not necessarily mean the higher accuracy though it may give higher resolution of demand distribution, but the important point is to balance the purpose of planning and the degree of resolution required.

The actual process of zoning proceeds as follows:

1. Draw circle with different diameter around the city center where the density of the urban activities is at its highest.

2. Determine the directions of nearby centers that exist outside the study area.

3. Subdivide the rings produced by the circles drawn in 1 above along the directions determined by 2. Use zone boundary principle explained above.

[1] See Sec. 5.2.2 of this manual on network representation.

The above process usually ensures similar levels of trip demand from each zone, and this becomes an important factor to attain statistical reliability of the zone-based O-D matrix manipulation.

Sampling Design

O-D surveys are normally performed by applying certain sampling method. The sampling is designed to economize the survey effort while attaining the best representation of the whole population, and the statistical significance. There are two major aspects in sampling design : determination of sampling rate and sampling method.

Sampling for person trip survey. Required sampling rate differs depending on the resolution of O-D matrix. When the O-D matrix is stratified into several types of transport modes the element of O-D matrix tends to have a smaller number compared with non-stratified O-D matrix. The sampling rate of the former case should be higher in order to get a similar level of statistical reliability. Various calculation methods are available for sample rate determination but the usual sampling rates used in Japan, are shown in Table 3-5 according to the population size of the cities.

Table 3-5 Population Size and Sampling Rate - Japanese Example

Population('000)	Sampling Rate	
	Minimum	Average
Less than 50	10%	20%
50~150	5	12.5
150~300	3	10
300~500	2	6.5
500~1000	1.5	5
1000 and over	1	4

[1]

Sampling subjects of person trip survey are usually the families residing within the study area. The members of the household - five years old or over, are interviewed to elicit detailed information of travel behaviour. Additional sampling may be necessary for specific transport users, if the planning concerns the detailed analysis of particular transport mode. University dormitory and other significant establishments that hold resident population, should also be covered by the sampling. An important point to note is that the sampling covers all categories of city residents.

[1] JITE (1984) Traffic Engineering Handbook (in Japanese), Japan Institute of Traffic Engineers, P 295

The choice of sampling subjects is made by applying one of the following systems : random sampling; numbering method; or stratified sampling. In random sampling, the resident registration can be used to determine a prespecified member of survey households. The choice is made arbitrarily, or by using random numbers. Arbitrarily choice of households on the survey site could bias the result since the easily accessible houses from main roads are more likely to be chosen, but the application of a certain rule such as the choice of houses that are roughly separated from each others can prevent such bigs; this method is often used in the U.S.A. Numbering Method applies a serial number to houses on the map or resident registration and chooses samples of equal interval, say 10 (for 10%), 20 (for 5%) etc. Stratified Sampling requires clustering of population such as by age-cohort or transport modes, and applies random sampling method for each of the clusters.

The important point in the sampling system is that roughly the same number of samples are obtained from every zone. For this reason, sampling rate of each zone could change, but if the traffic zones are subdivided in such a way that the population sizes are nearly equal, then, the zonal sampling rate should remain almost the same and this is the most preferable situation from a statistical point of view.

Sampling for vehicle O-D survey. Sampling system of Vehicle Owner O-D Survey is almost the same as that of person trip survey except that the survey subjects are limited to motor vehicle owners. Registration of motor vehicles kept by Department of Land Transport may be used for this purpose.

The subject of the Cordon O-D Survey is normally the drivers of private vehicles and trucks, who have to be stopped by enough to be interviewed. Stations selected are at natural passes in the topography, bridges, tunnels, ferries, and other funneling points of traffic flow. Traffic is filtered through the questionnaire lane by pre-warning signs and the presence of police officers in uniform. On heavy thoroughfares a multilane arrangement is necessary to avoid accumulation of traffic during peak periods: one lane is used for interviewing, and excess traffic is bypassed in the extra lane. Total-volume count is taken by hourly or half-hourly periods to determine the percentage of interviewed sample for each period of the study and to permit proper expansion factors to be applied to the collected sample. (See Figure 3-11 for example survey sheet used for this survey)

In the License-Plate survey, observers are simultaneously stationed at selected points of entry and exit to form a complete cordon around the study area. By employing synchronized timing method, license-plate numbers are recorded in a time series as vehicles enter or leave the cordoned area. Each sheet of recorded data is keyed to a location, direction, and time period of movement. The collected data are analyzed by tracing each license-plate number through the complete record from point-and- time of entry to point-and-time of exit. These points are taken as the origin and destination of movement. Sampling is performed by selecting particular number of ending such as even or odd number for 50% sampling, 0 and 5 for 20% sampling. (Figure 3-12 for an example survey sheet)

Sampling for commodity flow survey: Preferably, all firms in the survey area has to be surveyed to collect freight distribution data. The analysis is concerned with truck movement only, then, vehicle owner survey method is to be applied.

Preparation and Conduct of Field Survey (O-D Surveys in General)

The field survey requires a number of interviewers who visit households and business establishment to distribute, and recover questionnaires and interview the respondents. Therefore, it is important that sufficient number of questionnaire forms are ready printed and the survey is performed without delay.

In the field survey, survey workers visit the respondents and elucidate the necessary information listed on the questionnaire. Therefore, it is necessary for the survey worker to familialize himself with the contents of the questionnaire and the purpose of survey. Pilot surveys can be conducted by each survey worker during the training period. The problems found in these pilot surveys should be resolved prior to the full scale survey.

Person Trip Survey should cover an average weekday for 24 hrs. All of the interviews should cover preferably same-day activities for all the respondents -- cordon O-D survey also should be synchronized, but if this is not possible, the survey period can be extended to 9 to 10 days, provided that an unusual traffic pattern would not take place during that period.

Besides performing the visit and interview at the same time, the use of 'leave-and-collect' method can be employed to economize the survey cost. The former method, however, is the most reliable method, because the interviewers fill in the questionnaire and misunderstanding by respondents can be eliminated. Mailing method of distributing and collecting the questionnaire is another method, but this is not reliable and difficult to ask complicated questions, though the cost of survey is substantially lower compared with interview methods.

3.5 Other Related Information

Traffic Congestion

Road sections with traffic congestion can be identified by traffic speed observation explained in Section 3.3., but the Traffic Police or municipal authority may also keep this kind of information. Both traffic speed observation and the views of local authority should be taken into account to provide better understanding on the congested sections and their causes. Identify also the extent of congestion by indicating the maximum lengths of traffic queues and the frequencies to note whether the congestion is caused by commuter traffic or seasonal traffic; such as holiday and agricultural activities.

Accident Statistics

Accident records are obtained from police stations located within the planning boundary, and the hazardous road sections are identified for possible improvements. (Figure 3-13)

Fig. 3-13 Accident Record Survey Sheet
Changwat ____________

dd/mm/yy Time	Place of Accident	Number of Casualties		Estimated cost of damage	Type of Accident				Cause of Accident				Remarks
		fatality	injury		1	2	3	4	1	2	3	4	
													<u>Type of Accident</u> 1 motor car & motor car 2 motor car & pedestrain 3 motor car alone 4 others <u>Cause of Accident</u> 1 driver's fault 2 pedestrain's fault 3 vehicle's fault 4 others Source............... ....

Road deficiencies, such as holes, slippery surface, inadequate alignment, grade, sight distance, shoulders, or control devices, contribute to accidents where motorists do not make proper allowance to adjust to these design deficiencies, or are not properly warned of their existence. Numerous studies have shown that accident rates drop substantially when an inadequate highway section is converted to a multi lane highway. Access control, elimination of grade crossings, and separation of opposing traffic streams are three methods of reducing accident hazards. On a small scale, accident rates can be reduced after study of individual locations to detect design deficiencies.

The hazardous location can be identified simply by mapping the accident record and selecting the location where multiple accidents occurred in past few years. These accident patterns should be studied and reflected on highway network planning.

Passenger Occupancy Survey

Occupancy rate (number of passengers or each vehicle) is an essential figure to convert person trips to vehicle trips. Survey sheet shown in Figure 3-14 may be used to collect this type of data.

Fig. 3-14 Occupancy Rate Survey Field Sheet

Road...................... ( ) inbound ( ) outbound

Province..................

Date...................... Surveyor name..................

Time								

PART 4:

Analysis of Existing System

PART 4

ANALYSIS OF EXISTING SYSTEMS

The data collected by field surveys contain valuable information regarding the understanding of the existing condition of transport systems and the identification of planning strategies. This part of the manual attempts to show the method of analyzing the raw data to extract meaningful information that is then used for the successive transport planning process.

The analysis of the existing system proceeds in the following steps:

1) Compilation and analysis of basic data;
2) Identification of existing problems and constraints; and
3) Formulation of planning strategy.

The first item is performed by the transport analyst by the use of a computer and other data processing techniques and procedures. The second and third items are qualitative assessment of all the information obtained through the process.

Existing problems and constraints regarding topographic conditions and land availabilities etc. are elucidated, and the goals and objectives of the planning are formulated.

4.1 Compilation and Analysis of Basic Data

Tabulations and drawings are made by analysing data collected in the field survey. The major tasks involve the following items:

- Compilation of transport systems data;
- Compilation of traffic data; and
- Analysis of O-D pattern.

4.1.1 Compilation of Transport Systems Data

Road inventry data are summarized as cross-section diagrams and table. The widths of the right-of-way and pavement type can also be shown on the map format. (e.g. Figures 4-1 - 4-3)

Public transport data are summarized to show frequency of services, trends of patronage over past several years, bus routes and locations of transport terminals (Bus/coach terminals, railway stations and airports) are drawn on the map.

If cycle paths already exists, their locations and physical dimensions (length, width) are plotted on the map. The related land use such as school zones, residential areas and parks may be located on the same map.

4.1.2 Traffic Data Analyses

Data from automatic traffic counter provides most of the basic information for transport planning such as:

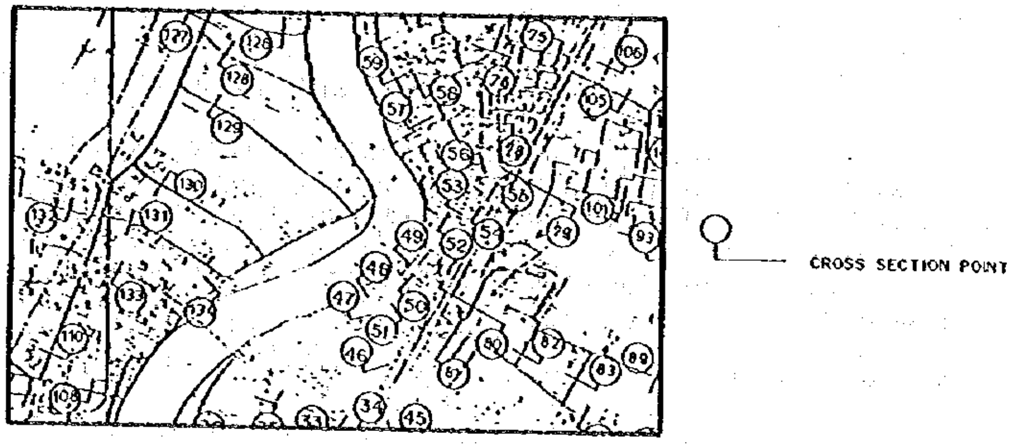


Fig. 4-1 Cross Section Point of Road (Example)

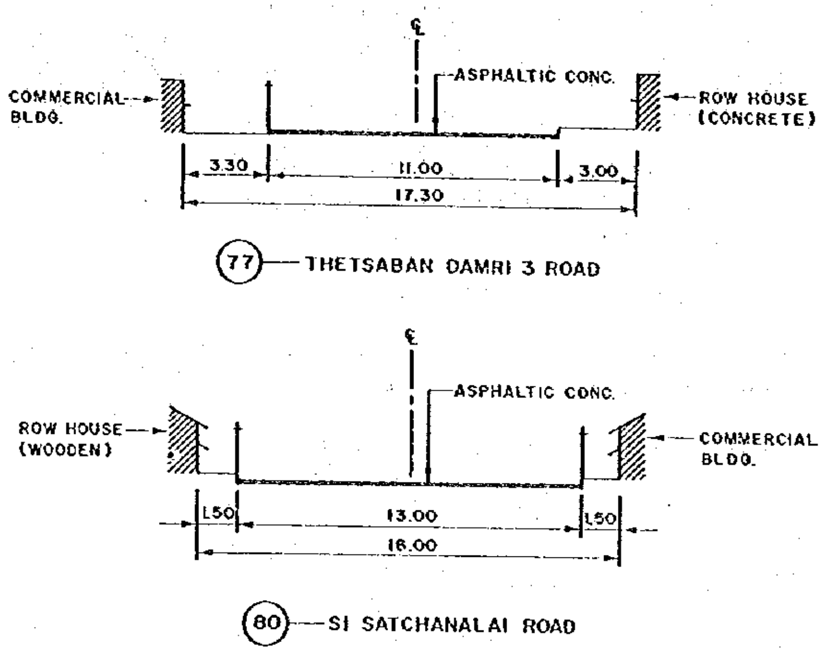


Fig. 4-2 Road Cross Section at Various Section Point (Example)

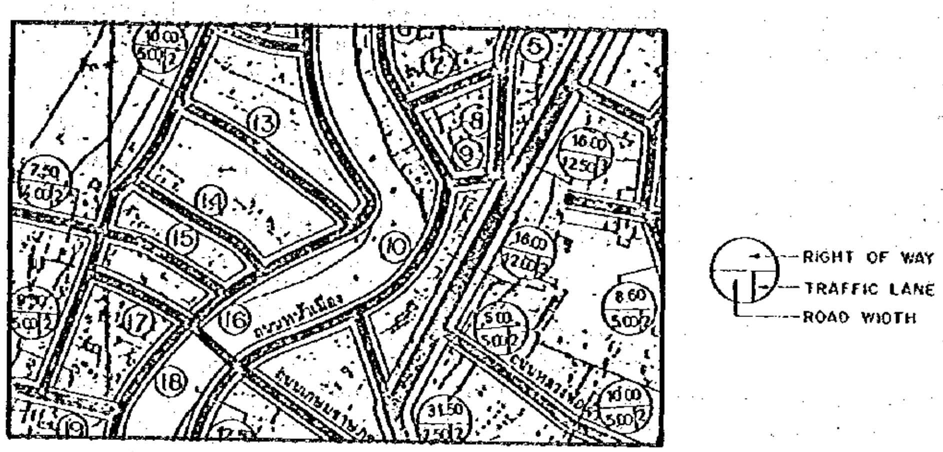


Fig. 4-3 Right-of-Way, Road with A Traffic Lane (Example)

- Traffic volume on major road sections;
- Volume to capacity (V/C) ratio;
- Traffic speed;
- Function of road sections; and
- Over all traffic problem.

Traffic Volume and Composition

The output from automatic counter can be processed efficiently by using a computer. If the recording medium is the printouts on paper, the data is manually input to the computer. In the case of magnetic type with a computer interface, the raw data are directly transferred to the computer for analysis.

Manual count distinguishes nine types of vehicles. The results are tabulated to show traffic composition of each survey station (e.g. Table 4-1, Fig. 4-4). Automatic counts provide hourly fluctuations of traffic volume throughout the day. (e.g. Table 4-2, Fig. 4-5)

The result of the road side traffic counts can be summarized in a traffic volume map, which shows either peak hourly traffic volume or daily traffic volume on major highway sections. A sample of this type of map is shown in Fig. 4-6.

Volume to Capacity (V/C) Ratio

Practical capacity of road sections can be worked out by referring to Sec. 7.2 of this manual. The capacity varies from one road section to another depending on the geometry and the frontage land use. The comparison of the observed traffic volume with this practical capacity will provide the service level of each section. The level of service and the corresponding degree of traffic situation are shown in Table 4-2.

Table 4-2 Volume to Capacity Ratio - A Measure of Service Level

Level of Service Category	The V/C Ratio*
A	0.2 or less
B	0.2~0.4
C	0.4~0.6
D	0.8 and over

The V/C ratio can be shown on the map by expressing, for example, different categories by different colour. The bottle-neck sections of the existing highway network are clearly shown on this map.

* 0.2 is V/C ratio for A & B
0.4 is V/C ratio for B & C
0.7 is not included

Table 4-1 Example of Traffic Composition Summary Table

JAN-MAY 1987
TIME 16.00-17.00

STATION	BICYCLE	TRICYCLE	MOT.CYCLE	M.CAR	CAR	M.BUS	BUS	M.TRUCK	TRUCK	TOTAL (VEH)	TOTAL (PCU)
35	28 1.74X	26 1.62X	843 52.46X	40 2.49X	222 13.81X	202 12.57X	4 0.25X	240 14.93X	2 0.12X	1607 100.00X	1238
36	40 1.59X	24 0.95X	1522 60.35X	52 2.06X	308 12.21X	301 11.93X	29 1.15X	239 9.48X	7 0.28X	2522 100.00X	1880
37	45 1.48X	37 1.22X	1633 53.73X	137 4.51X	362 11.91X	302 9.94X	23 0.76X	478 15.73X	22 0.72X	3039 100.00X	2354
38	46 1.28X	28 0.78X	1597 44.36X	99 2.75X	448 12.44X	407 11.31X	40 1.11X	916 25.44X	19 0.53X	.00 100.00X	2980
39	22 1.05X	28 1.33X	967 46.09X	58 2.76X	117 5.58X	441 21.02X	37 1.76X	410 19.54X	18 0.86X	2098 100.00X	1802
40	20 1.08X	5 0.27X	1034 55.98X	53 2.87X	234 12.67X	211 11.42X	1 0.05X	281 15.21X	8 0.43X	1847 100.00X	1391

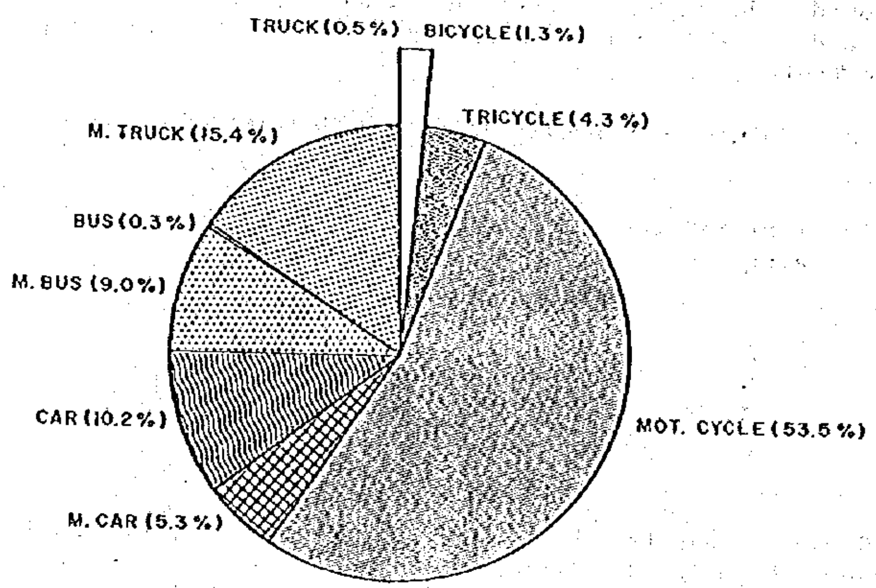
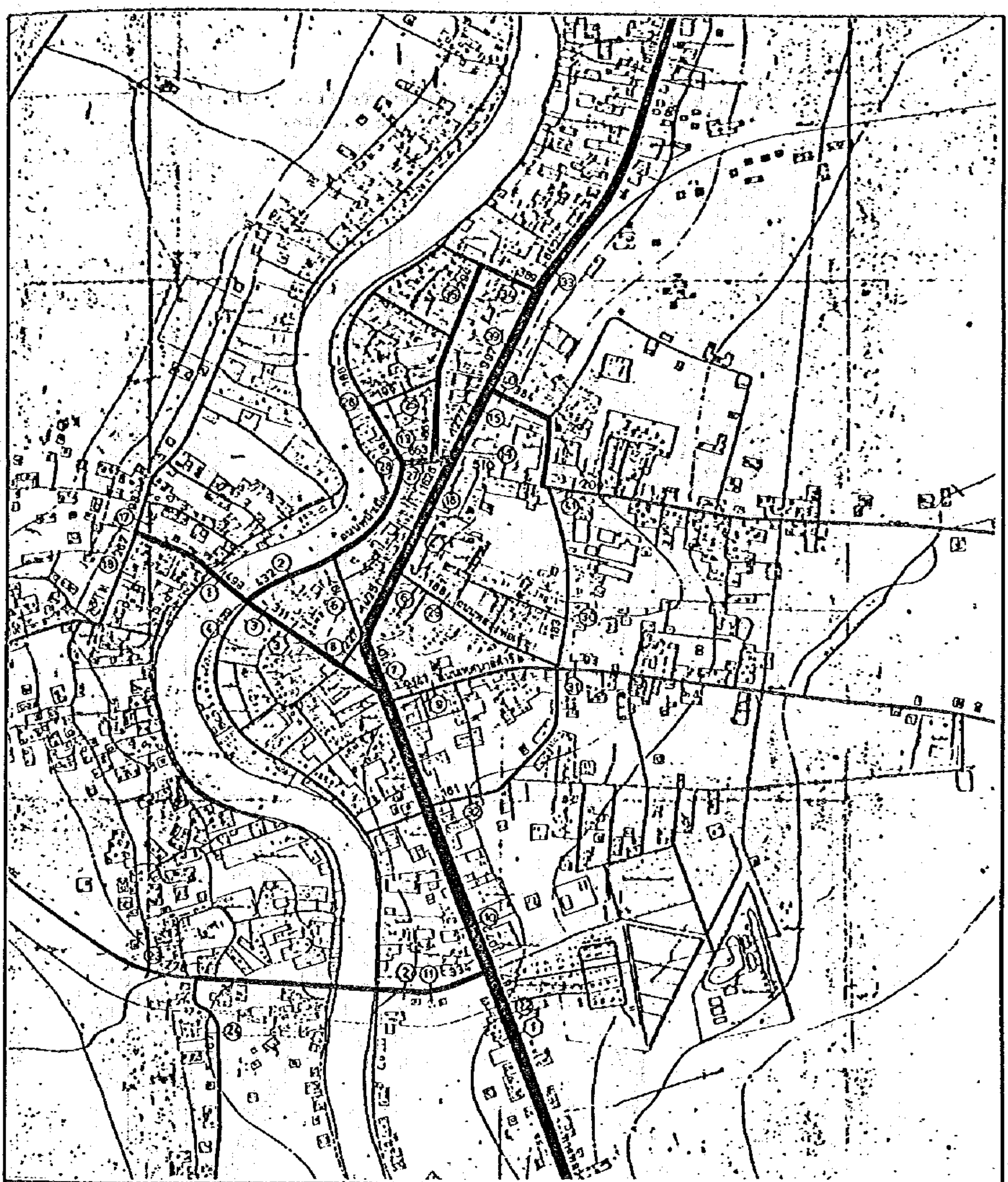


Fig. 4-4 Traffic Composition Diagram Section 17



LEGEND

100 – 300 VEH.

301 – 600 VEH.

601 – 900 VEH.

≥ 901 VEH.

MANUAL COUNT POINT

AUTOMATIC COUNT POINT

Fig. 4-5 Peak-Hour Traffic Volume and Location of Traffic Count Points

Table 4-3 Hourly Fluctuation of Traffic Volume Collected by Automatic Counter

CITY : SAWANKALOK-SUKHOTHAI
STATION NO : 1
LOCATION : CHAROOVITEETONG RD.
DIRECTION : TWO WAYS

TIME	SAT	SUN	MON	TUE	WED	THU	FRI
00.00-01.00	78	36	32	34	35	32	26
01.00-02.00	60	33	36	40	35	21	25
02.00-03.00	47	36	27	38	33	44	32
03.00-04.00	55	55	33	52	40	48	40
04.00-05.00	46	67	58	54	56	69	79
05.00-06.00	90	78	80	87	91	76	83
06.00-07.00	176	147	201	200	213	162	193
07.00-08.00	367	324	679	646	673	643	656
08.00-09.00	408	361	533	474	465	435	469
09.00-10.00	501	415	453	468	391	437	386
10.00-11.00	491	441	423	394	335	368	377
11.00-12.00	367	333	392	362	361	354	359
12.00-13.00	387	369	382	356	334	351	399
13.00-14.00	381	301	321	389	355	336	371
14.00-15.00	338	301	263	361	366	336	392
15.00-16.00	318	282	536	555	497	440	564
16.00-17.00	346	401	587	545	518	488	559
17.00-18.00	446	489	451	510	500	409	351
18.00-19.00	302	291	284	318	317	271	285
19.00-20.00	203	201	171	220	208	155	157
20.00-21.00	122	151	114	135	134	118	123
21.00-22.00	92	83	80	60	77	60	97
22.00-23.00	59	62	79	66	71	56	53
23.00-24.00	59	41	66	48	64	38	51
TOTAL	5739	5298	6291	6412	6170	5748	6127

ENGINEERING DIVISION
DEPARTMENT OF TOWN AND COUNTRY PLANNING

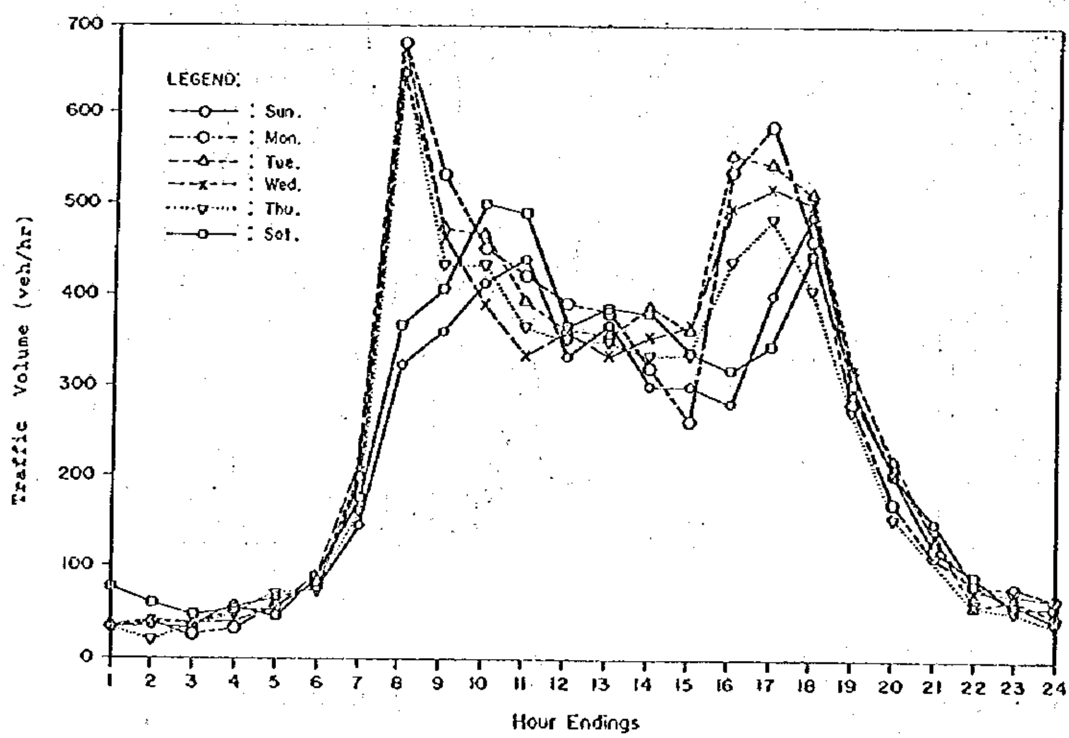


Fig. 4-6 Hourly Fluctuation of Traffic Volume Station I (Route No. 101)

Traffic Speed

Traffic speed data is also tabulated and presented on a map. The sections with an average speed of less than, say, 10 km/hr needs attention as congested sections. Another map should be prepared showing the location and, if it is possible, the degree of traffic congestion measured in length of traffic queues or duration of traffic congestions in peak hours.

Functions of Road

Function of road network is prescribed at the plan formulation stage, but the reality of the way each road section is used could be different from what is prescribed, and it is important to know the actual functioning when road network improvements are to be worked out. The collected data on traffic volume and traffic composition are utilized to infer the actual state of functions.

The indices used for this purpose are the day/night volume ratio, the heavy truck rate and rate of holiday traffic.

Day/night volume ratio. is the ratio of day time (7:00 ~ 19:00) volume (T12) to 24 hour traffic volume (T24); i.e.

$$R = \frac{T24}{T12}$$

where,
R = Day/Night volume ratio
T24 = 24 hour traffic volume
T12 = Daytime (7:00~19:00) traffic volume

This ratio becomes larger for higher level roads such as national highways and provincial highways, and smaller for local distributors or access roads.

Heavy Truck Rate. Heavy truck traffic is usually generated in major industrial areas, and it has longer trip lengths. The truck traffic is restricted in certain urban areas but channeled into major routes. The higher level trunk roads, therefore, have a higher rate of heavy trucks.

Rate of Holiday Traffic. If daily traffic volume is available for a whole week, a comparison is made between weekend (holiday) traffic volume and week day traffic volume. Special consideration should be made to the improvement of road sections where the rate of holiday traffic is relatively higher compared with the rest of the road sections. These sections are important for the local tourism industry, therefore, they should not be neglected because of the peak hour traffic of average weekdays is small.

Summarizing Overall Traffic Problems

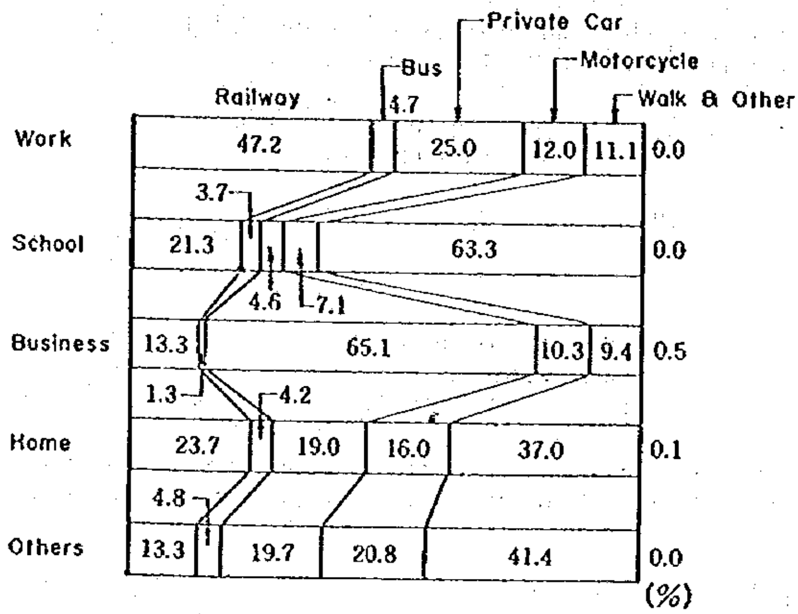
The results of traffic data analysis are summarized on a traffic problem map of the study area. On this map, the sections with lower traffic speed, congestions and accidents are shown together. The area where pedestrians or street vendors conflicts with vehicular traffic in the street are also shown on the same map.

4.1.3 Analysis of Travel Behaviours and Existing O-D Pattern

The major source of this phase of the analysis is the data obtained from various O-D surveys explained in PART 3 (TRANSPORT AND TRAFFIC SURVEYS). The information obtained through a person trip survey contains a rich source of information for the analysis of travel behaviour. The major items of the analysis are: modal split; trip rates; and O-D pattern.

Modal Split

Person trip information allows us to understand how different transport modes are used for travel within the study area. The proportions of the number of trips by each mode are calculated for different trip purposes. (Figure 4-7) The results will show the role of each transport mode within the study area.



(Source : Metropolitan Tokyo Person Trip Study, 1978)

Figure 4-7 Tabulation of Modal Split by Trip Purposes (The results shows the role of each transport mode in the study area)

If, time series data is available, the changing roles of transport modes are illustrated, then, the planning strategy for the future may become clearer. Fig. 4-8 shows the change of public transport passengers in Sydney.

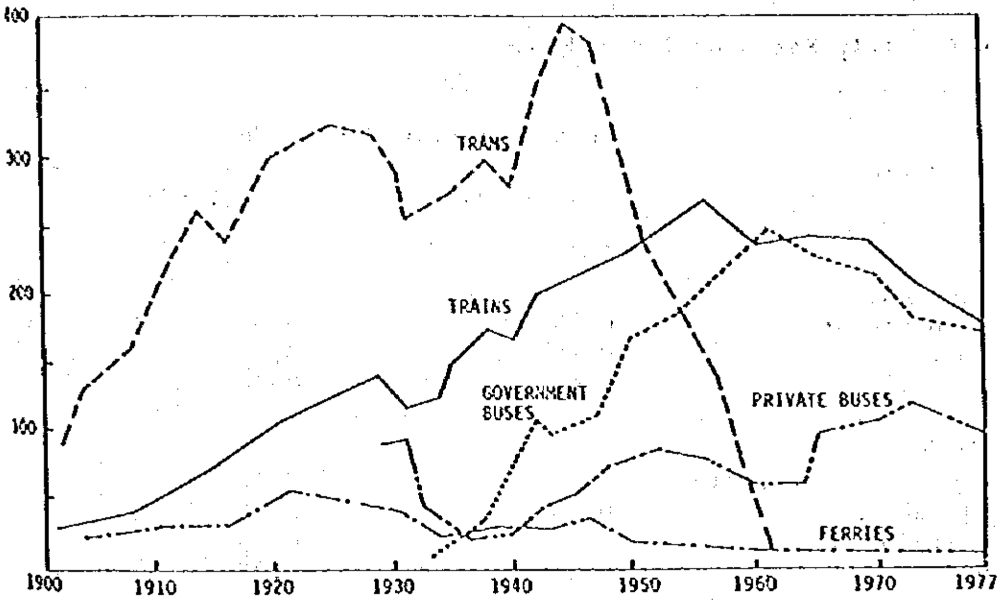


Figure 4-8 Change of Public Transport Passengers in Sydney, 1900-77 [1]

Alternatively, if sufficient data is available, modal shares of different cities are compared to give characteristics of transport systems of the concerned study area.

Trip Rate

Average number of trips one person (or household) makes in a day is tabulated for different trip purposes. The results and the accumulated information give basic data for travel demand forecasting (See PART 5 for detail). Table 4-4 shows the trip rate data from BTS[2] and SES[3].

O-D Patterns

Based on the O-D surveys (See PART 3), spatial distribution patterns of transport demand are analyzed through the construction of origin and destination (O-D) matrix using the method elaborated in PART 5 of this manual. An O-D matrix should be graphically presented to enable visual assessment of traffic demand. (e.g. Figure 4-9).

O-D matrix may be stratified by different trip purposes or by different modes of travel. The vehicular O-D matrix is used for traffic assignment in network design process.

For the area where a number plate survey is conducted, the movement of externally originated traffic in relation to the study area is analyzed by drawing a diagram, as for example shown in Figure 4-10.

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[1] Spearritt, P. (1978), Sydney Since the Twenties, Sydney: Hale and Iremonger, P. 153.
[2] Bangkok Transport Study, (1975)
[3] Second Stage Expressway Study (1982), ETA, JICA.

Table 4-4 Trip Rates by BTS and SES

Trip Categories	Number of trips/person/day	
	BTS (1972)	SES (1982)
<u>Trip Purposes</u>:		
To Work, Business	0.35	0.37
To School	0.19	0.24
Others	0.61	0.72
<u>Travel Modes</u>:		
Private Car & Motor Cycle	0.34	0.37
Taxi, Rickshaws	0.16	0.11
Bus and Train	0.61	0.80
Other Mode	0.04	0.05
Total	1.15	1.33

4.2 Identification of Existing Problems and Constraints

Based on the analyses of data collected by the field survey, existing problems are identified. The process of problem identification is important because it sets the direction for improvements. The problems should be identified in the following categories.

Area-Wide Transport Problems

Transport problems which relate to the planning area as a whole, and localized transport problems characteristic of particular sub-areas, are summarized and their causes noted.

Problems by Route

Traffic problems and transport system problems by route and section are identified. The type of problems are, for example, narrow sections, unconnected links, unpaved sections, traffic conflicts with slow vehicles etc. The descriptions of problems have to be related to specific road sections by attaching to them 'kilo-post mark' or name of the local areas that the road sections pass through.

Once the problems are made clear, the direction of the improvements can be worked out in conjunction with expected future development projects in the area. The planning strategy formulated at this stage is a preliminary one, since the land use specification and future transport-demand levels are not available at this stage.

Land Use Constraints

Road space and other transport systems is a part of the land use in urban area, and the transport network cannot be constructed without considering the relation of transport land use to other types of urban

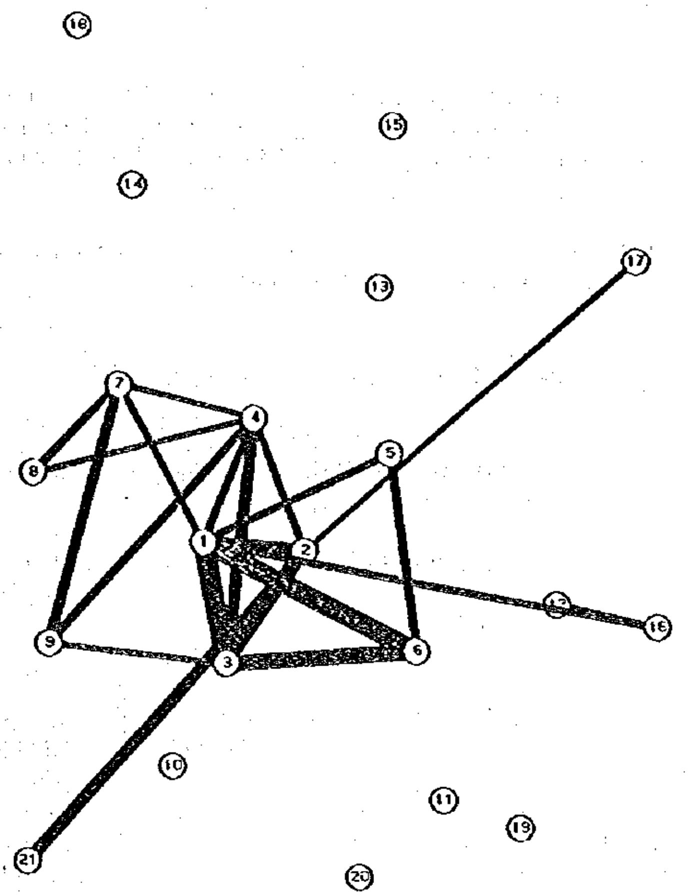

Fig. 4-9 Sample Diagram Showing Spatial Distribution of Transport Demand by Using O-D Survey Result (The Diagram is Draw by Computer Using x-y Plotter at DTCP)

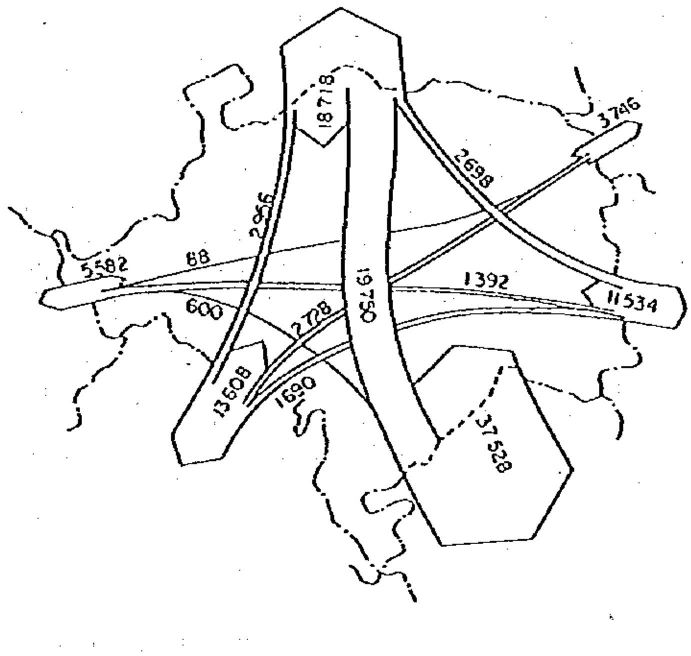

Fig. 4-10 Example Drawing of Macro-Traffic Movement that can be Produced by Using Number-Plate Survey Data