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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS & HIGHWAYS

# Feasibility Study of the Road Improvement Project on the Pan-Philippine Highway (Philippines-Japan Friendship Highway)

## FINAL REPORT

## GUIDE FOR ROAD FUNCTION IMPROVEMENT PLANNING

(VOLUME V)

SEPTEMBER, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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## PREFACE

From the time the initial improvements were undertaken up to present, the Pan-Philippine Highway (Philippines-Japan Friendship Highway) has played the very vital role in the country's economic development. At present, the Highway suffers many deficiencies including low quality of services in major urban sections as well as sections nearest to Metro Manila which if not corrected, will impede the momentum of the socio-economic development currently being pursued for the country.

Medium-Term Philippine Development Plan (1987-1992) specifically points out the strategy that priority shall be given to the maintenance of existing and soon-to-be completed infrastructure to prolong their useful lives, reduce costs to the users, and postpone huge investments for their major rehabilitation on replacement. Rehabilitation and restoration, as well as improvement and upgrading of existing facilities shall take the precedence over replacement and new construction as low-cost measures to provide acceptable levels of infrastructure services.

In line with the stress on development policies, the Government of the Philippines thru the Department of Public Works and Highways (DPWH) has decided to pursue the Feasibility Study of the Road Improvement Project on the Pan-Philippine Highway (Philippines-Japan Friendship Highway) (The Feasibility Study) with a technical assistance from the Government of Japan.

In response to the request of the Government of the Philippines, the Government of Japan has decided to conduct the Feasibility Study thru the Japan International Cooperation Agency (JICA), which is the official agency responsible for the implementation of technical cooperation programs.

This Guide was drawn up compiling the road and traffic survey results and study outputs on road function improvements through undertaking the Feasibility Study. Since the Feasibility Study was confined to the Sta. Rita-Aritao Section (about 200 kms.) and the Calamba-Calauag Section (about 180 kms.) of the Pan-Philippine Highway, therefore, this Guide may have some deficiencies in application to other sections, particularly on the following:

i) The Guide was prepared based purely on road and traffic characteristics on the Study Section of the Feasibility Study.

ii) The Guide mainly deals with a) level of service analysis and b) introduction of concept of improvement level. Other road planning and design aspects were not included.

iii) Construction costs may not necessarily be warranted to be applicable in any job site in the country.

However, the Guide intends to invite active discussions on road function improvement among those who are engaged in the field of road planning. Therefore, the Guide is sincerely desired to be positively utilized, whenever applicable, and to be further developed to a more comprehensive guide.

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# INTRODUCTION

CHAPTER 1

INTRODUCTION

## 1.1 The Feasibility Study

The objectives of the Feasibility Study were;

- To identify and establish the needed improvement works to upgrade the functional efficiency of the Study Sections.
- To prioritize the road segments for which improvement works are required.
- To conduct the feasibility study of typical improvement work proposed within the prioritized segments.

The Study Section was;

- Sta. Rita - Aritao Section (approximately 200 kilometers)
- Calamba - Calauag Section (approximately 180 kilometers)

The Final Report of the Feasibility Study composes of;

Volume I; Executive Summary
Volume II; Main Text
Volume III; Appendix
Volume IV; Drawings
Volume V; Guide for Design of Road Function Improvement
Volume VI; Guide for Design of Pavement Rehabilitation

This report is Volume V of the Final Report. Whenever necessary, other volumes are desired to be referred.

## 1.2 Subjects Mainly Discussed in the Guide

Three (3) subjects, i.e. traffic characteristics on the Pan-Philippine Highway, level of service analysis and improvement level, are mainly discussed in the Guide.

### Traffic Characteristics on the Pan-Philippine Highway

Various traffic characteristics which will be useful for level of service analysis are compiled based on traffic data obtained by the Feasibility Study. These could be utilized in the absence of detailed traffic data along the Study Section in the future.

### Level of Service Analysis

New edition of "Highway Capacity Manual" published by Transportation Research Board, National Research Council, Washington, D.C. 1985 (hereinafter referred to as "HCM, 1985") was basically followed. Efforts were focused on modifications/adjustments of factors adopted in HCM, 1985 so that it can be applicable to road and traffic conditions in this country. Modifications/adjustments of factors were made based on limited data obtained by the Feasibility Study, therefore, more suitable factors may be developed when more data are compiled.

### Improvement Level

Improvement level was developed by the Feasibility Study based on analysis of road users' opinions and from viewpoints of road planning. Recommended improvement level is intended for major trunk roads, therefore, it could be relaxed for minor roads.

## 1.3 Definitions and Concepts

### Level of Service

Definitions of levels of service based on HCM, 1985 are as follows:

. The concept of levels of service is defined as a qualitative measure describing operational conditions within a traffic stream, and their perceptions by road users. Six levels of service are defined with level-of-service A representing the best operating conditions and level-of-service F the worst.

Level-of-service A

- Free flow
- Freedom to select desired speeds and to maneuver is extremely high
- General level of comfort and convenience is extremely high

Level-of-service B

- Stable flow
- Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver
- Level of comfort and convenience is somewhat less than A

Level-of-service C

- Stable flow
- Selection of speed is affected by the presence of others, and maneuvering requires substantial vigilance.
- General level of comfort and convenience declines noticeably.

Level-of-service D

- High density, approaching unstable flow but in the range of stable flow
- Speed and freedom to maneuver are severely restricted
- Road users experience a generally poor level of comfort and convenience
- Small increases in traffic flow will generally cause operational problems

Level-of-service E

- Unstable flow
- Operational conditions at or near capacity level
- All speeds are reduced to a low, but relatively uniform value
- Freedom to maneuver is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accomodate such maneuvers
- Comfort and convenience levels are extremely poor and driver or pedestrian frustration is generally high

Level-of-service F

- Forced on breakdown flow
- Operations are characterized by stop-and-go waves
- Arrival flow exceeds discharge flow which causes the queue to form

## Improvement Level

Improvement level is defined as:

"the minimum allowable of traffic operational conditions to be maintained by major trunk roads in order to fully fulfill their roles and functions as integral parts of major trunk road network system. When a certain section approaches to the minimum allowable level, improvement or remedial measures of the said section shall be implemented, thus improvement level specifies optimum timimg for implementation of improvement."

A level of traffic operational conditions is measured by a "level of service."

# CHAPTER 2

# TRAFFIC CHARACTERISTICS ON THE PAN-PHILIPPINE HIGHWAY

# CHAPTER 2
# TRAFFIC CHARACTERISTICS ON THE PAN-PHILIPPINE HIGHWAY

## 2.1 Volume Characteristics

### 2.1.1 Traffic Volume

Daily Traffic Volume

The heaviest traffic volume in the rural section observed on the Study Section was 12,085 vehicle per day on the Calamba-Sto. Tomas section. In general, traffic volume becomes lighter as the section is located farther from Metro Manila. At 100-km point from Manila. traffic volumes were 5,987 and 4,150 vehicle per day in the North and the South Study Sections, respectively. At 200-km point from Manila, traffic becomes quite light at 2,365 and 1,860 vehicle per hour in the North and the South Study Section, respectively. (See Table 2.1-1).

The heaviest traffic volume in the urban section was observed at Cabanatuan, and was 23,931 vehicle per day, of which 60% (or 14,220 vehicles) were tricycles. Quite heavy volume of tricycles was observed on almost all urban sections in the North Study Section ranging from 5,000 to 14,000 tricycles per day, whereas tricycle traffic on urban sections in the South Study Section was light, ranging from 900 to 3,700 tricycles per day. (See Table 2.1-1).

Peak Hour Traffic Volume

In the rural sections, the heaviest hourly traffic volume was 811 vehicle per hour observed on the Calamba-Sto. Tomas Section, followed by 727 vehicle per hour on Sta. Rita-Plaridel Section, both are located at the exit of the Expressway.

The heaviest hourly traffic volume in urban sections was 2,086 vehicle per hour at Cabanatuan, followed by 1,448 vehicle per hour at Plaridel. Hourly traffic volume on urban sections in the South Study Section is still light, ranging from 714 to 435 vehicle per hour.

TABLE 2.1-1 TRAFFIC VOLUME ON THE PAN-PHILIPPINE HIGHWAY

Unit: Vehicle Per Day

| K m | North Study Section (Sta. Rita-Aritao) Section | Car | Jeepney | Bus | Truck | Tricycle | Total | South Study Section (Calamba-Calauag) Section | Car | Jeepney | Bus | Truck | Tricycle | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Vehicle Type | | | | | | | Vehicle Type | | | | | |
| 39 (52) | Exit of Expressway | 5,248 (49%) | 1,954 (18%) | 825 (8%) | 2,248 (21%) | 475 (4%) | 10,750 (100%) | Exit of Expressway (Km 52) | 7,945 (66%) | 1,092 (9%) | 1,164 (10%) | 1,828 (15%) | 56 (-) | 12,085 (100%) |
| 100 | Gapan -Sta. Rosa | 2,770 (46%) | 1,089 (18%) | 587 (10%) | 1,342 (23%) | 199 (3%) | 5,987 (100%) | Tiaong-Candelaria 1/ | 2,000 (48%) | 700 (17%) | 500 (12%) | 950 (23%) | - (-) | 4,150 (100%) |
| 150 | Muñoz -San Jose | 983 (26%) | 1,141 (30%) | 268 (7%) | 1,015 (26%) | 410 (11%) | 3,817 (100%) | Pagbilao -Atimonan | 757 (37%) | 152 (8%) | 445 (22%) | 675 (33%) | 1 (-) | 2,030 (100%) |
| 200 | San Jose -Sta. Fe | 600 (25%) | 751 (32%) | 208 (9%) | 806 (34%) | - (0%) | 2,365 (100%) | Gumaca -Lopez | 574 (31%) | 395 (21%) | 236 (13%) | 642 (35%) | 13 (-) | 1,860 (100%) |
| Urban Section | Plaridel (Km 42) | 5,911 (31%) | 4,499 (24%) | 804 (4%) | 2,097 (11%) | 5,590 (30%) | 18,901 (100%) | San Pablo (Km 81) | 3,711 (52%) | 436 (6%) | 682 (10%) | 1,337 (19%) | 930 (13%) | 7,096 (100%) |
| | Gapan (Km 92) | 3,761 (22%) | 1,209 (7%) | 635 (4%) | 1,763 (11%) | 9,350 (56%) | 16,718 (100%) | Candelaria (Km 108) | 2,613 (28%) | 1,128 (12%) | 622 (7%) | 1,229 (13%) | 3,680 (40%) | 9,272 (100%) |
| | Cabanatuan (Km 117) | 3,886 (16%) | 3,469 (14%) | 742 (3%) | 1,614 (7%) | 14,220 (60%) | 23,931 (100%) | Sariaya (Km 121) | 2,540 (33%) | 1,600 (20%) | 489 (6%) | 1,004 (13%) | 2,160 (28%) | 7,793 (100%) |

NOTE: 1/ Estimated only

TABLE 2.1-2 PEAK HOUR TRAFFIC VOLUME (1986)

| Km | North Study Section | | | South Study Section | | |
|---|---|---|---|---|---|---|
| | Section | Peak Hour | Traffic Volume | Section | Peak Hour | Traffic Volume |
| 39 (52) | Exit of Expressway (Km 39) | 9:00 - 10:00 | 727 | Exit of Expressway (Km 52) | 14:00 - 15:00 | 811 |
| 100 | Gapan-Sta. Rosa | 9:00 - 10:00 | 435 | Tiaong-Candelaria | - | - |
| 150 | Muñoz-San Jose | 8:00 - 9:00 | 216 | Pagbilao-Atimonan | 9:00 - 10:00 | 119 |
| 200 | San Jose-Sta. Fe | 9:00 - 10:00 | 149 | Gumaca-Lopez | 13:00 - 14:00 | 118 |
| Urban | Plaridel (Km 42) | 9:00 - 10:00 | 1.448 | San Pablo (km 81) | 17:00 - 18:00 | 435 |
| | Gapan (Km 92) | 7:00 - 8:00 | 1.406 | Candelaria (Km 108) | 10:00 - 11:00 | 714 |
| | Cabanatuan (Km 117) | 7:00 - 8:00 | 2.086 | Sariaya (Km 121) | 10:00 - 11:00 | 598 |

Expansion Factors

In many cases, traffic count surveys are conducted only for 12 hours from 6:00 A.M. to 6:00 P.M. In order to estimate daily traffic volume based on the 12-hour traffic count results, expansion factors are utilized. Expansion factors for the following two (2) cases were developed based on the 24-hour traffic count survey results:

$$\text{Expansion Factor (1)} = \frac{\text{24-hour Traffic Volume}}{\text{12-Hour Traffic Volume (6:00 A..M. - 6:00 P.M.)}}$$

$$\text{Expansion Factor (2)} = \frac{\text{24-hour Traffic Volume}}{\text{16-hour Traffic Volume (6:00 A.M. - 10:00 P.M.)}}$$

Expansion Factors are summarized in Table 2.1-3. In general, trucks have high expansion factors. Many trucks are travelling during night time.

TABLE 2.1-3 EXPANSION FACTORS

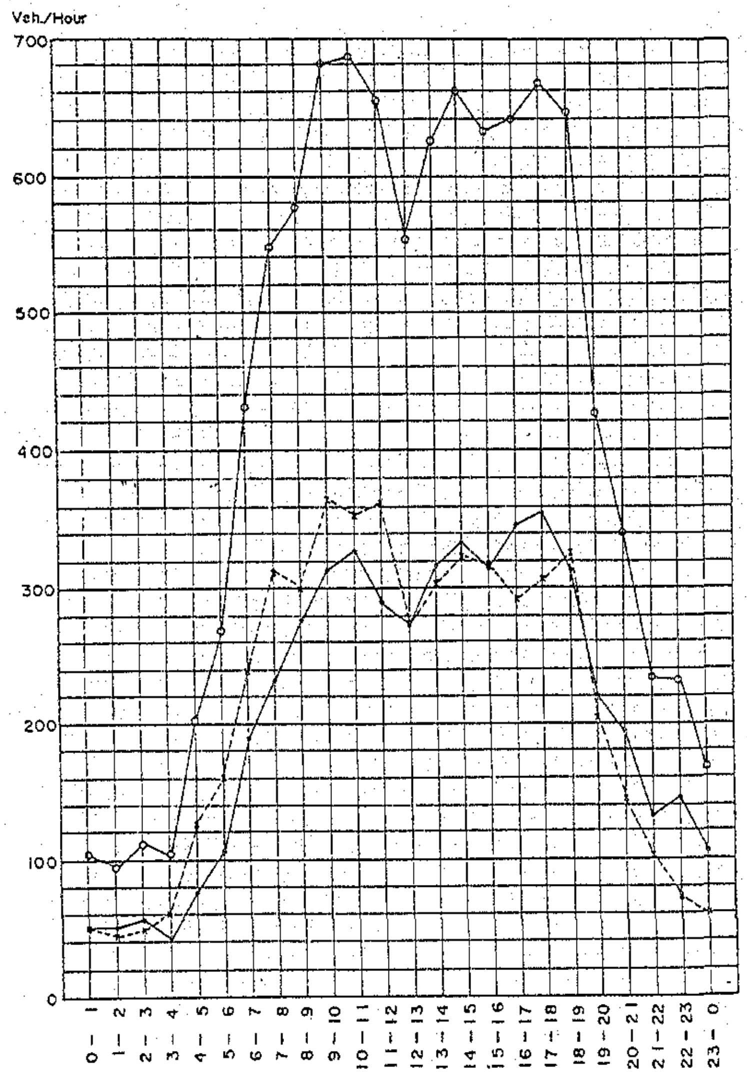
| Section | Expansion Factor (1) (24-Hour/12-Hour) | | | | | | Expansion Factor (2) (24-Hour/16-Hour) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Car | Jeepney | Bus | Truck | Tricycle | Total | Car | Jeepney | Bus | Truck | Tricycle | Total |
| North Study Section | | | | | | | | | | | | |
| Km. 40: Sta. Rita-Plaridel | 1.36 | 1.34 | 1.34 | 1.59 | 1.32 | 1.39 | 1.10 | 1.12 | 1.15 | 1.28 | 1.06 | 1.14 |
| Km. 85: San Miguel-Gapan | 1.33 | 3.13 | 1.38 | 1.78 | 1.19 | 1.50 | 1.10 | 1.53 | 1.16 | 1.37 | 1.07 | 1.20 |
| Km. 100: Gapan-Sta. Rosa | 1.29 | 1.26 | 1.34 | 1.54 | 1.30 | 1.34 | 1.10 | 1.07 | 1.17 | 1.27 | 1.09 | 1.13 |
| Km. 125: Cabanatuan-Talavera | 1.33 | 1.21 | 1.61 | 1.89 | 1.40 | 1.40 | 1.15 | 1.08 | 1.37 | 1.44 | 1.16 | 1.19 |
| South Study Section | | | | | | | | | | | | |
| Km. 60: Calamba-Sto. Tomas | 1.37 | 1.22 | 1.29 | 1.64 | 1.40 | 1.38 | 1.13 | 1.06 | 1.10 | 1.29 | 1.19 | 1.14 |
| Km. 61: Sto. Tomas-Alaminos | 1.69 | 1.20 | 1.49 | 1.92 | 1.12 | 1.56 | 1.33 | 1.09 | 1.29 | 1.45 | 1.05 | 1.27 |
| Km. 122: Sariaya-Lucena | 1.35 | 1.26 | 1.60 | 1.60 | 1.05 | 1.36 | 1.13 | 1.10 | 1.25 | 1.30 | 1.02 | 1.16 |

### 2.1.2 Hourly Variation

Generally, hourly traffic volume variation on the Pan-Philippine Highway is small during day time from 7:00 A.M. to 5:00 P.M., except lunch period from 12:00 noon to 1:00 P.M. Traffic volumes are more or less evenly distributed, therefore, there is no predominant peak hour.

Figure 2.1-1 shows hourly traffic variations on the North Study Section. Direction 1 is the direction from Manila to Cagayan, and Direction 2 to opposite direction on the Sta. Rita-Plaridel Section, hourly traffic volume of both directions ranges from 550 to 690 vehicle per hour from 7:00 A.M. to 5:00 P.M. Each direction has also small fluctuation of traffic volume throughout the day time. The Gapan-Sta. Rosa Section has almost similar tendency of hourly traffic variation.

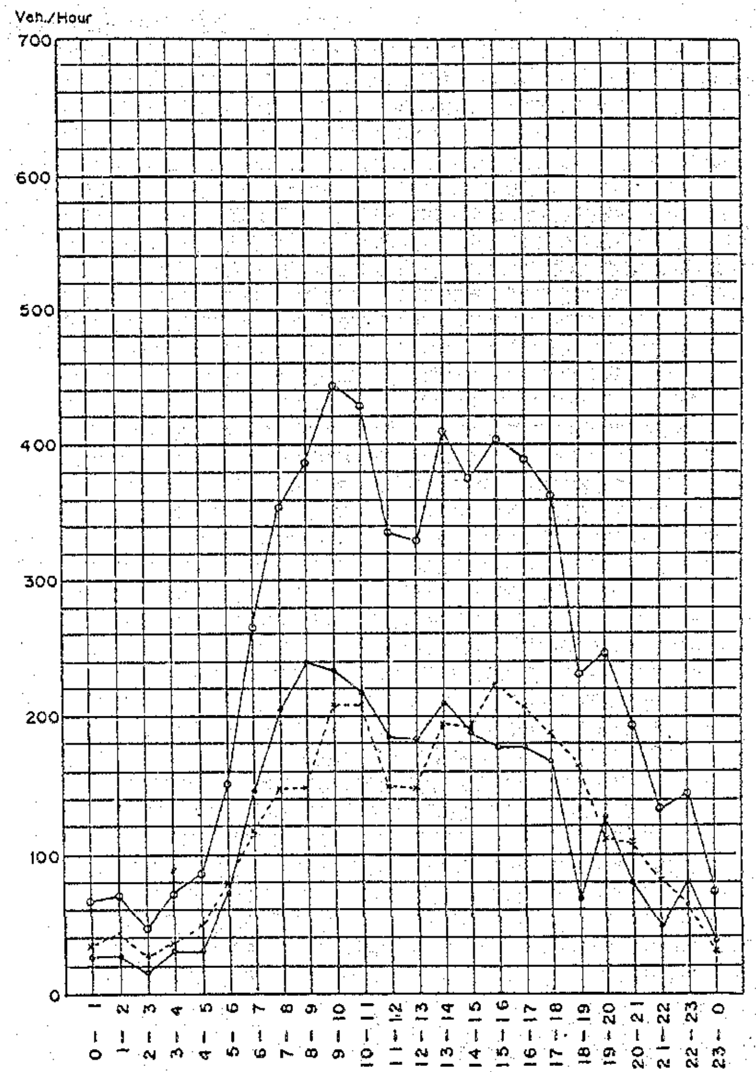
Figure 2.1-2 shows hourly traffic variations on the South Study Section. Direction 1 is from Manila to Bicol and Direction 2 from Bicol to Manila. Hourly traffic volume on the Calamba-Sto. Tomas Section ranges from 520 to 680 vehicles per hour between 7:00 A.M. to 5:00 P.M. Direction 1 has smaller variation than Direction 2. The former ranges from 190 to 330 vehicle per hour, whereas the latter from 210 to 330 vehicle per hour. Hourly traffic variation on the Sariaya-Lucena Section is quite small, differences in hourly traffic volume is about 80 vehicles per hour for both directions and about 60 vehicles per hour for each direction between 7:00 A.M. to 5:00 P.M.




SURVEY STA. N-01 Sta. Rita - Plaridel

- DIRECTION 1
- DIRECTION 2
- BOTH DIRECTION

(Excluding Tricycles and Others)

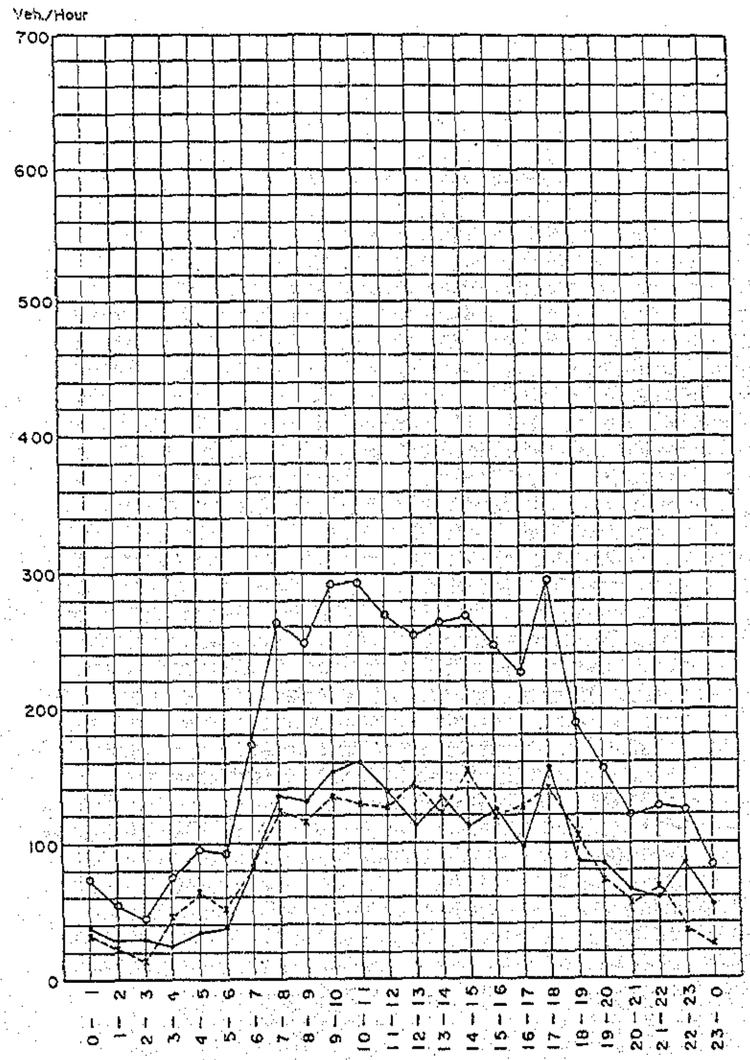



SURVEY STA. N-23 Gapan - Sta. Rosa

- DIRECTION 1
- DIRECTION 2
- BOTH DIRECTION

(Excluding Tricycles and Others)

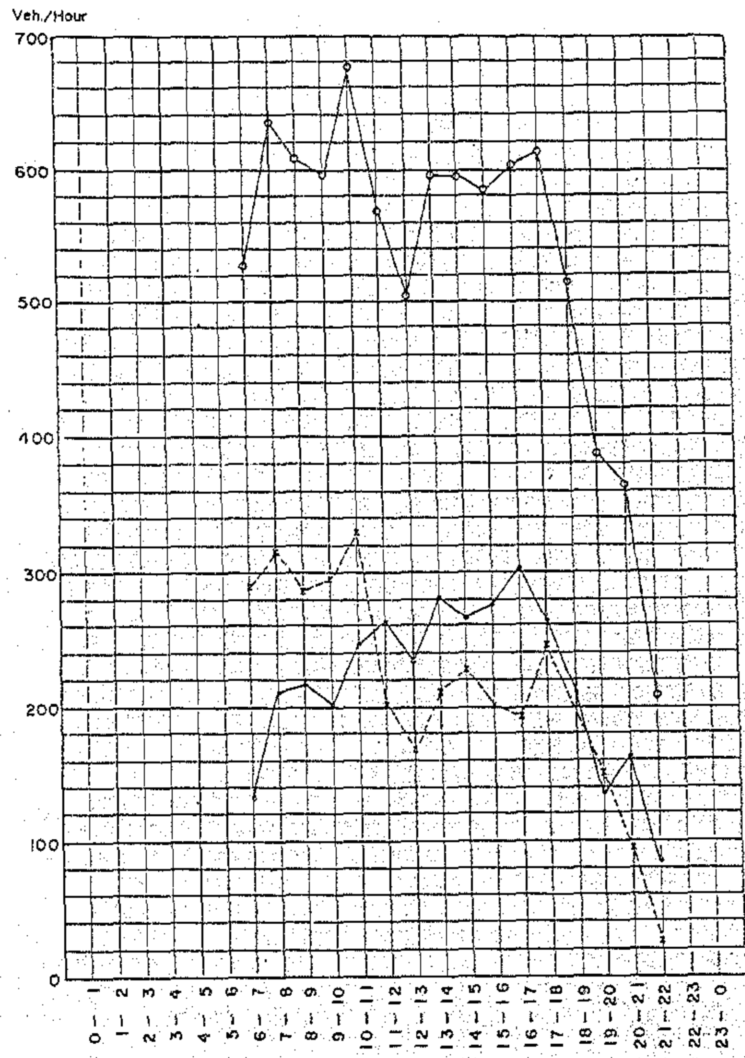
FIGURE 2.1-1 HOURLY TRAFFIC VARIATIONS (NORTH STUDY SECTION)




SURVEY STA. S-11 Sariaya – Lucena

• DIRECTION 1
x DIRECTION 2
o BOTH DIRECTION

(Excluding Tricycles and Others)




SURVEY STA. S-01 Calamba – Sto. Tomas

• DIRECTION 1
x DIRECTION 2
o BOTH DIRECTION

(Excluding Tricycles and Others)

FIGURE 2.1-2 HOURLY TRAFFIC VARIATIONS (SOUTH STUDY SECTION)

### 2.1.3 Peak Hour Ratios

Peak hour ratio is defined as a ratio (expressed in percent) of peak hour traffic volume to daily traffic volume. As stated in 2.1.2, there is no predominant peak hour, therefore, the Study Section has relatively low peak hour ratio. Relation between daily traffic volume and peak hour ratio is shown in Figure 2.1-3. There is no clear relation between daily traffic volume and peak hour ratio. Rather, peak hour ratio is related to location of a section. Urban sections have slightly higher peak hour ratios than rural Sections. The North Study Section has slightly higher peak hour ratios than the South Study Section. Peak-hour ratio ranges are summarized below.

TABLE 2.1-4 PEAK-HOUR RATIO

| Section Type | Peak Hour Ratio | |
|---|---|---|
| | North Study Section | South Study Section |
| Rural | 5.5% - 8.2% | 5.2% - 7.3% |
| Urban | 6.9% - 8.7% | 6.6% - 8.3% |

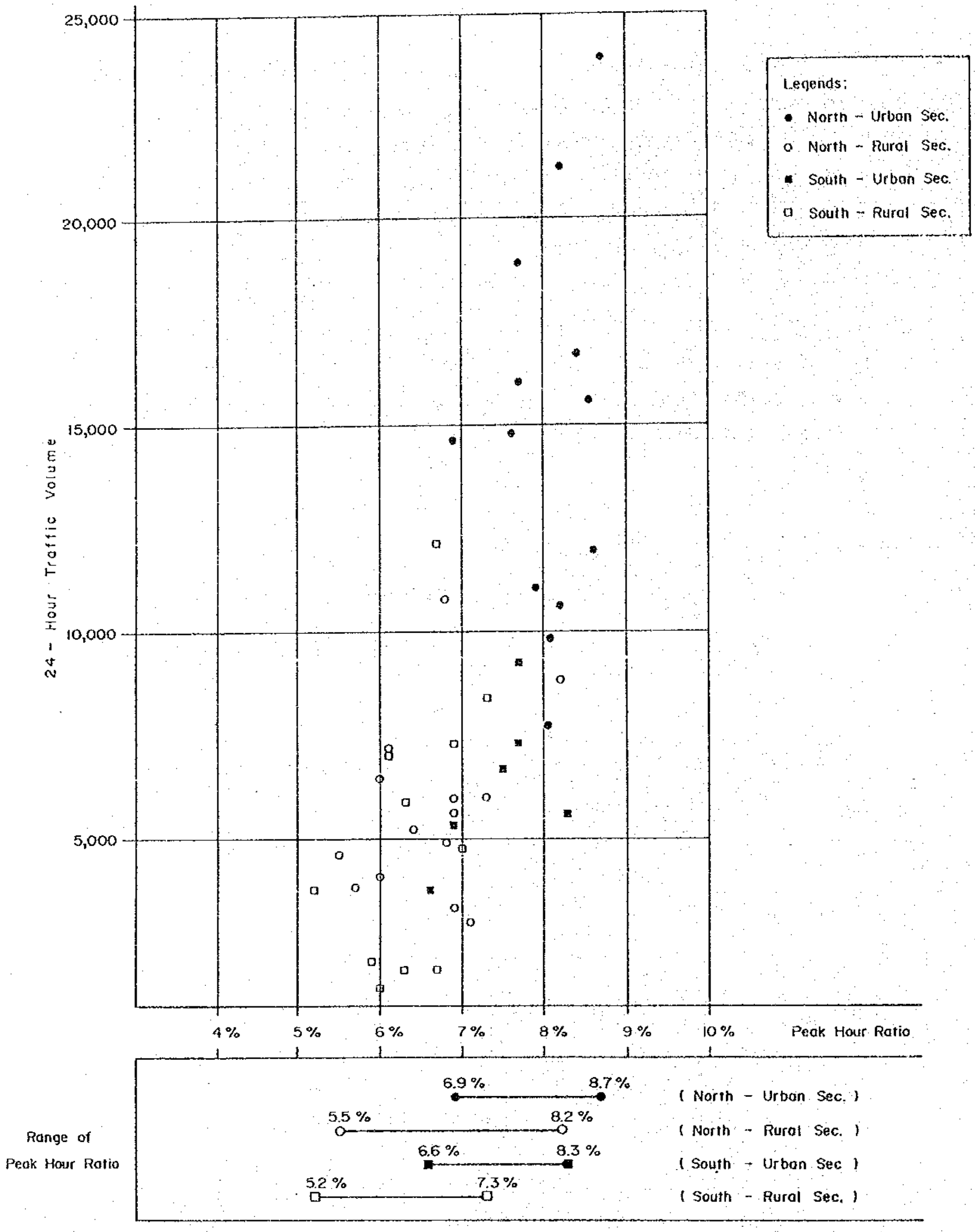



FIGURE 2.1-3 PRESENT PEAK HOUR RATIO

### 2.1.4 Directional Distribution

Directional distribution characteristics at peak hours are summarized in Table 2.1-5.

TABLE 2.1-5 DIRECTIONAL DISTRIBUTION CHARACTERISTICS

| Section Type | Percent Traffic in Peak Direction | |
|---|---|---|
| | North Study Section | South Study Section |
| Rural | 50% - 60% | 50% - 62% |
| Urban | 52% - 57% | 50% - 59% |

Directional variation in traffic volume is small. There is no predominant peak direction and both directions have almost the same traffic volume. This tendency is true for both rural and urban sections.

### 2.1.5 Peak-Hour Factor

Peak-hour factor (PHF) is defined as follows:

$$\text{PHF} = \frac{\text{Hourly Volume}}{4 \times (\text{Peak 15-Minute Volume})}$$

During the traffic count survey, traffic-volume for every 15-minute period was recorded, the PHFs were computed. Figure 2.1-4 shows PHFs in relation to hourly traffic volume on the Pan-Philippine Highway, and summarized as shown in Table 2.1-6.

TABLE 2.1-6 PEAK HOUR FACTOR

| Hourly Traffic Volume | Ranges of PHFs | Recommended PHFs | Remarks (HCM, 1985[1/]) |
|---|---|---|---|
| 100 | 0.69 - 0.87 | 0.78 | 0.83 |
| 200 | 0.73 - 0.89 | 0.82 | 0.87 |
| 300 | 0.77 - 0.91 | 0.85 | 0.90 |
| 400 | 0.81 - 0.93 | 0.87 | 0.91 |
| 500 | 0.83 - 0.94 | 0.89 | 0.91 |
| 600 | 0.85 - 0.95 | 0.90 | 0.92 |
| 700 | 0.86 - 0.95 | 0.91 | 0.92 |
| 800 | 0.87 - 0.95 | 0.91 | 0.93 |
| 900 | 0.88 - 0.95 | 0.92 | 0.93 |
| 1,000 | 0.88 - 0.95 | 0.92 | 0.93 |
| 1,100 | - | 0.93 | 0.94 |
| 1,200 | - | 0.93 | 0.94 |
| 1,300 | - | 0.94 | 0.94 |
| 1,400 | - | 0.94 | 0.94 |
| 1,500 | - | 0.95 | 0.95 |

NOTE: [1/] Based solely on the assumption of random flow and may be somewhat higher than those obtained from field studies.

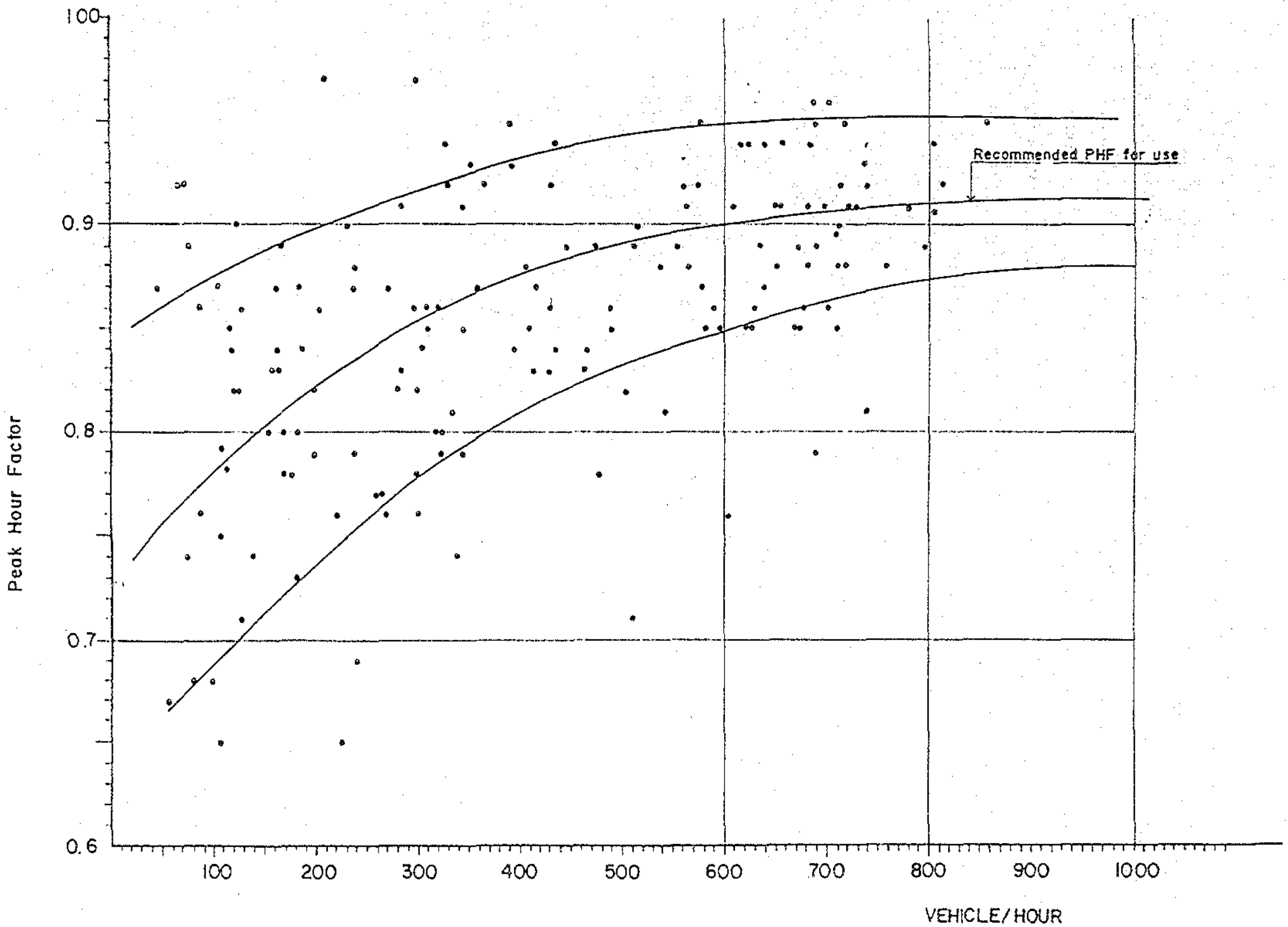



Figure 2.1-4 Peak Hour Factor on Pan-Philippine Highway

### 2.1.6 Traffic Composition

Figure 2.1-5 shows composition of vehicle type for daily traffic volume. In the North Study Section,cars have high share between Sta. Rita and Cabanatuan up to about 120 kms. from Manila, then its share drops to low. Jeepneys have high share between Cabanatuan and Aritao, its share between Sta. Rita and Cabanatuan is low. Buses maintain almost same share throughout the North Study Section. Truck share fluctuates depending on sections, however, generally maintains high share.

In the South Study Section, cars have quite high share, especially sections near Metro Manila. Jeepneys and buses shares become high on the sections south of Lucena. Trucks have generally low share in this Section.

Traffic composition in peak hour, which is required for level of service analysis, is shown in Table 2.1-7. In urban sections in the North Study Section, tricycles' share is quite high.

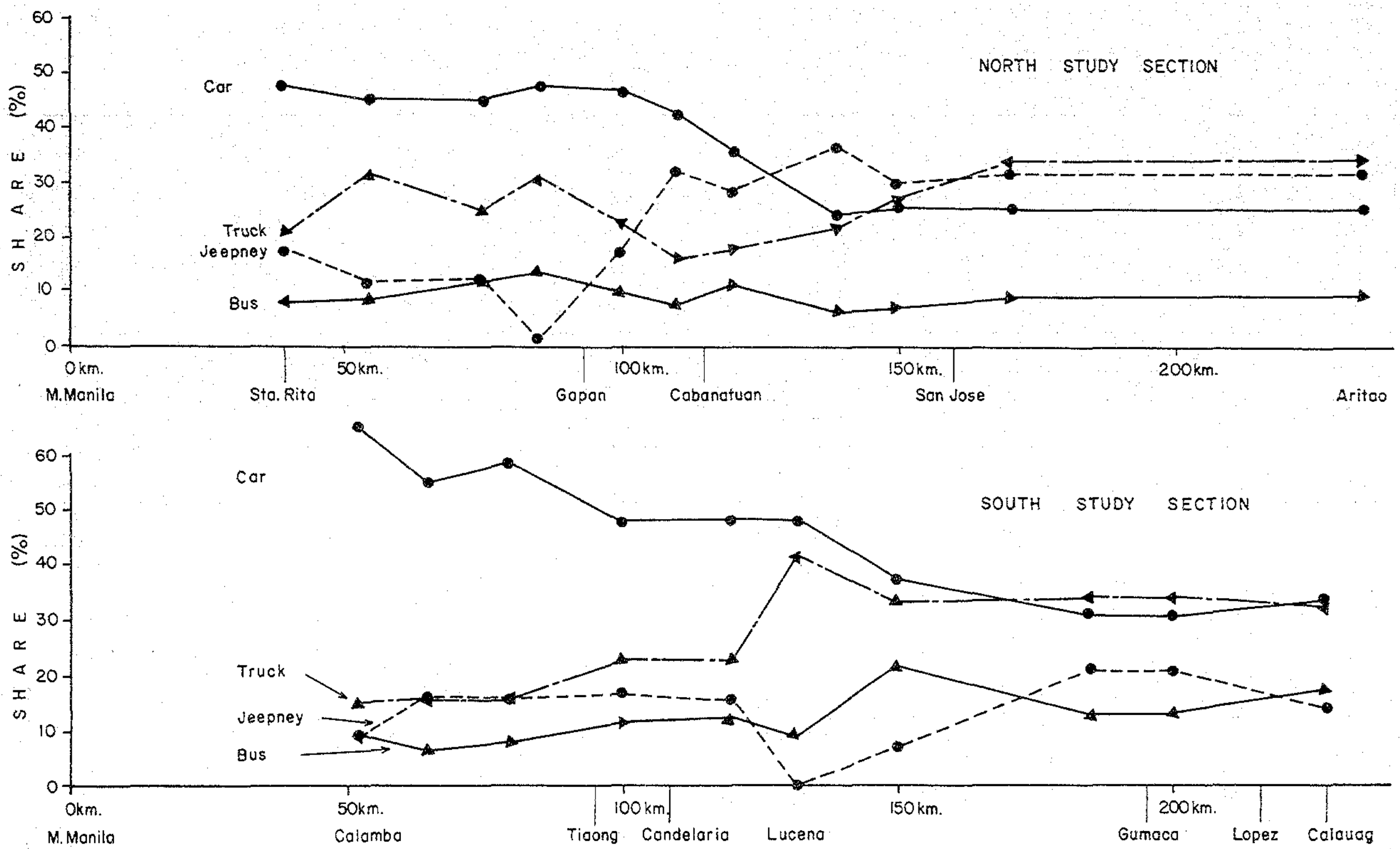



FIGURE 2.1-5 COMPOSITION OF VEHICLE TYPE

TABLE 2.1-7 TRAFFIC COMPOSITION IN PEAK HOUR

North Study Section

Unit: Percent

| | Rural Section | | | | | | | | Urban Section | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sta. Rita-Plaridel (Km 39-41) | San Ildefonso -San Miguel (Km 67-73) | Bulacan-Nueva Ecija Boundary (Km 82-87) | Gapan-Sta. Rosa (Km 95-106) | Sta. Rosa-Cabanatuan (Km 108-111) | Cabanatuan-Talavera (Km 120-127) | Muñoz-San Jose (Km 147-157) | San Jose-Sta. Fe (Km 161-235) | Plaridel (Km 42) | Gapan (Km 93) | Cabanatuan (Km 117) | San Jose (Km160) |
| Car | 51 | 38 | 44 | 57 | 42 | 44 | 24 | 28 | 31 | 15 | 13 | 12 |
| Jeepney | 16 | 31 | 10 | 21 | 35 | 34 | 25 | 28 | 21 | 7 | 18 | 6 |
| Bus | 9 | 10 | 11 | 8 | 5 | 7 | 6 | 10 | 4 | 2 | 3 | 1 |
| Truck | 18 | 21 | 35 | 14 | 18 | 15 | 45 | 34 | 8 | 8 | 6 | 5 |
| Tricycle | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 68 | 60 | 76 |

South Study Section

| | Rural Section | | | | | | | | Urban Section | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calamba-Sto. Tomas (Km 52-60) | Sto. Tomas-San Pablo (Km 65-80) | San Pablo -Tiaong (Km 90-94) | Tiaong-Candelaria (Km 96-107) | Candelaria -Sariaya (Km 109-120) | Sariaya-Lucena (Km 121-125) | Pagbilao-Atimonan (Km 142-176) | Gumaca-Lopez (Km 198-215) | Tiaong (Km 95) | Candelaria (Km 108) | Sariaya (Km 120) | Gumaca (Km197) |
| Car | 70 | 60 | 54 | 54 | 55 | 55 | 44 | 42 | 34 | 29 | 26 | 8 |
| Jeepney | 5 | 19 | 18 | 18 | 17 | 17 | 17 | 27 | 23 | 11 | 20 | 5 |
| Bus | 8 | 8 | 8 | 8 | 8 | 8 | 17 | 12 | 5 | 5 | 5 | 2 |
| Truck | 16 | 13 | 20 | 20 | 20 | 20 | 22 | 19 | 6 | 13 | 11 | 11 |
| Tricycle | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 41 | 38 | 74 |

## 2.2 Speed Characteristics

### 2.2.1 Travel Speed

Rural Section

Travel speeds in rural sections are, in general, high over 60 kms. per hour, except the following four (4) sections:

- Sta. Rita-Plaridel Sections ----- travel speed ranges 40 to 45 kms. per hour due to heavy volume of traffic.
- Dalton Pass Section ----- travel speed is about 40 kms. per hour due to sharp grades and successive sharp horizontal curves.
- Calamba-Sto. Tomas Section ------ travel speed ranges from 35 to 40 kms per hour due to heavy volume of traffic.
- Pagbilao-Atimonan Section (km. 158 to km. 175) ------ travel speed is about 40 kms per hour due mainly to very bad pavement surface condition.

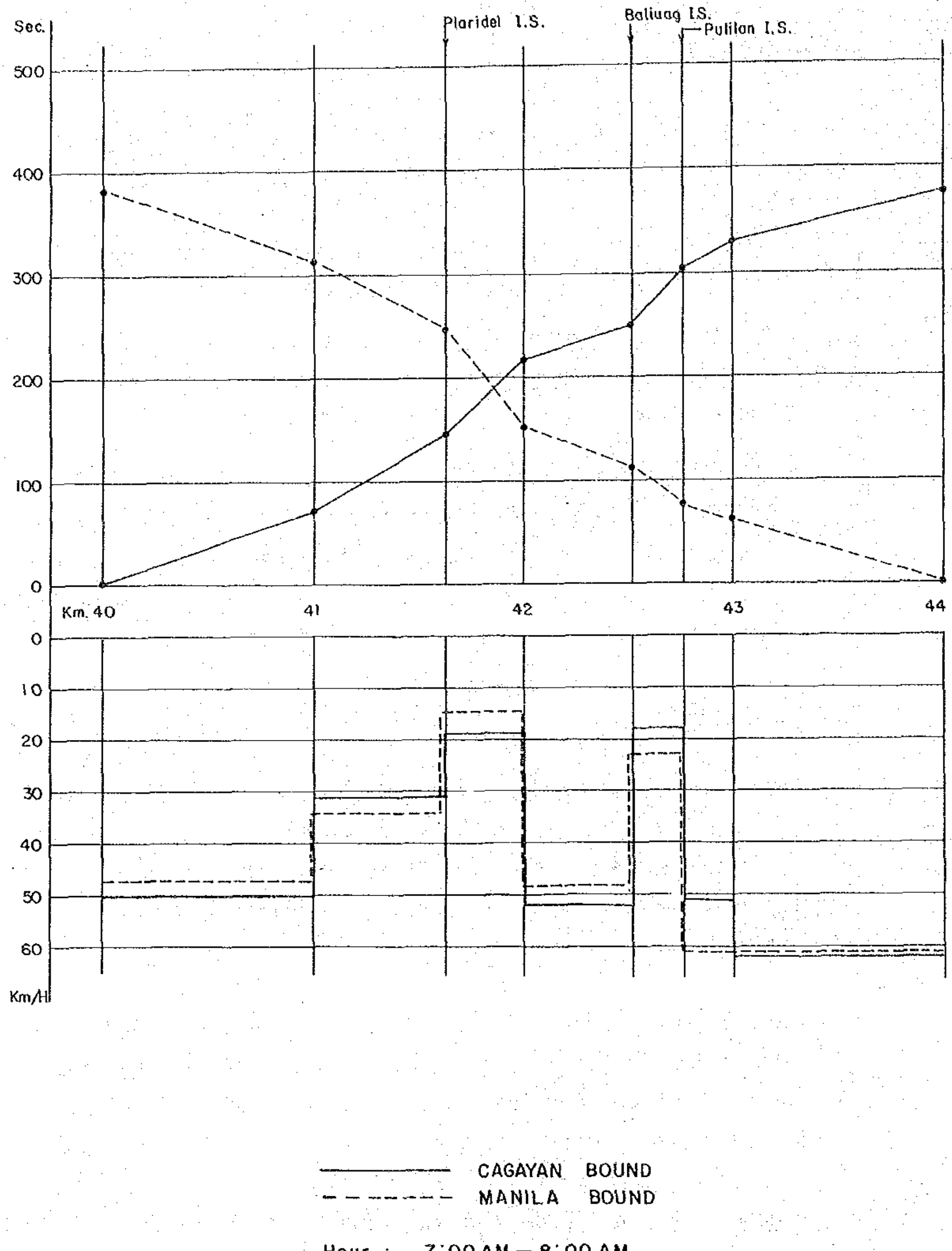
Urban Section

Travel speeds are drastically reduced to low speeds in major urban sections due mainly to heavy volume of traffic, high composition of slow moving vehicles like tricycle, frequent stops of public utility vehicles and on-street parkings. Travel speeds in the following major urban sections are:

| | |
|---|---|
| Plaridel Urban Section .............. | 20-30 kms. per hour |
| Gapan Urban Section ................. | 35-40 kms. per hour |
| Cabanatuan Urban Section ............ | 25-35 kms. per hour |
| San Jose Urban Section .............. | 30-40 kms. per hour |

Figures 2.2-1 and 2 show travel time survey results on Plaridel and Cabanatuan Urban Sections, respectively.

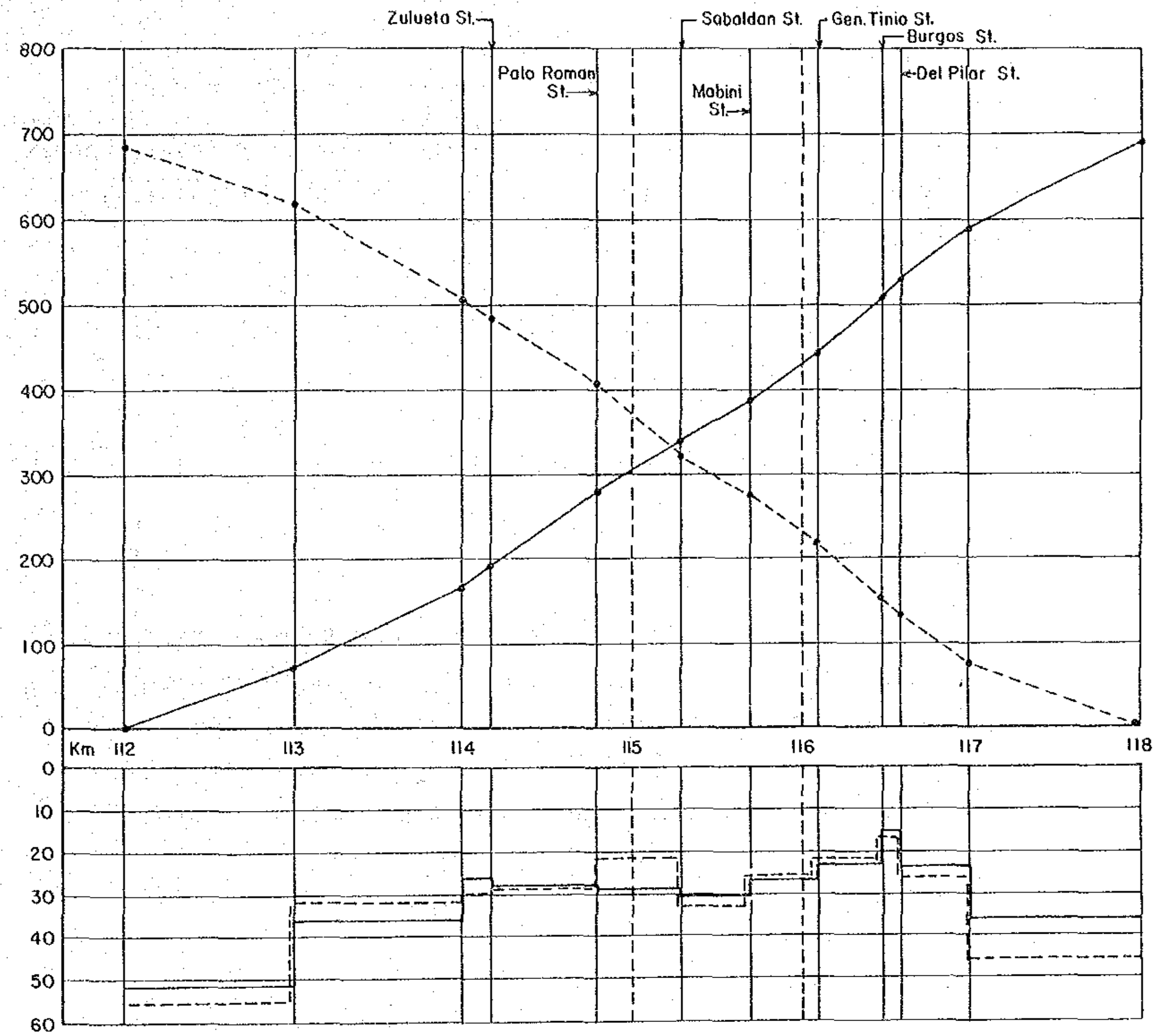
In other urban sections, travel speed of about 40 kms. per hour is maintained.




CAGAYAN BOUND
MANILA BOUND

Hour : 7:00 AM – 8:00 AM
Average of 4 Runs

FIGURE 2.2-1 TRAVEL SPEED : PLARIDEL




CAGAYAN BOUND
MANILA BOUND

Hour 7:00 AM - 8:00 AM
Average of 2 Runs

FIGURE 2.2-2 TRAVEL SPEED: CABANATUAN

### 2.2.2 Travel Speed and Volume/Capacity Ratio

Relation between travel speeds and volume/capacity ratios was developed based on travel time survey results and road/traffic survey results.

Rural Section

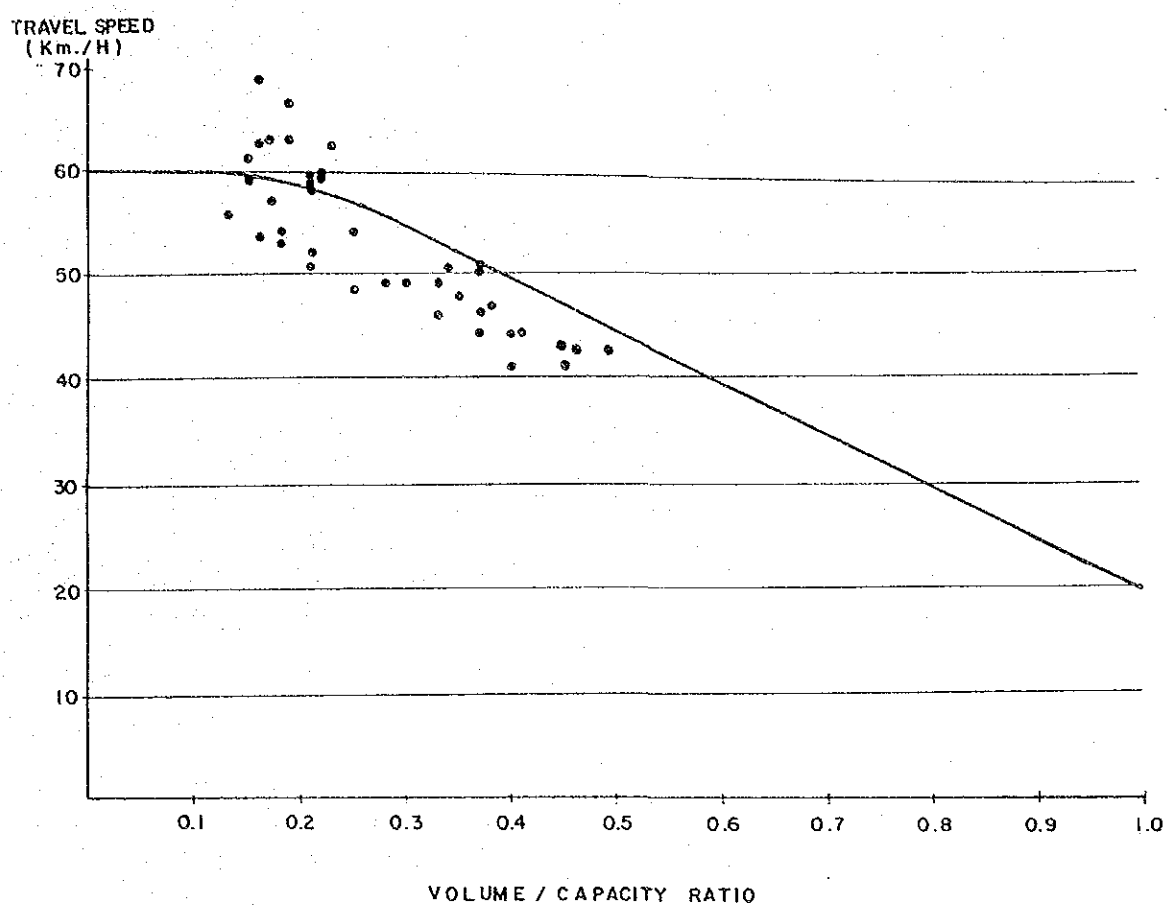
Figure 2.2-3 shows the interrelation curve between travel speeds and volume/capacity ratios for rural sections. Road conditions assumed are as follows:

| | | |
|---|---|---|
| Number of lanes and lane width | : | 2-lane x 3.35 m = 6.7 m |
| Shoulder width | : | 2 m |
| Terrain | : | flat |
| Roadside friction | : | light |

Urban Section

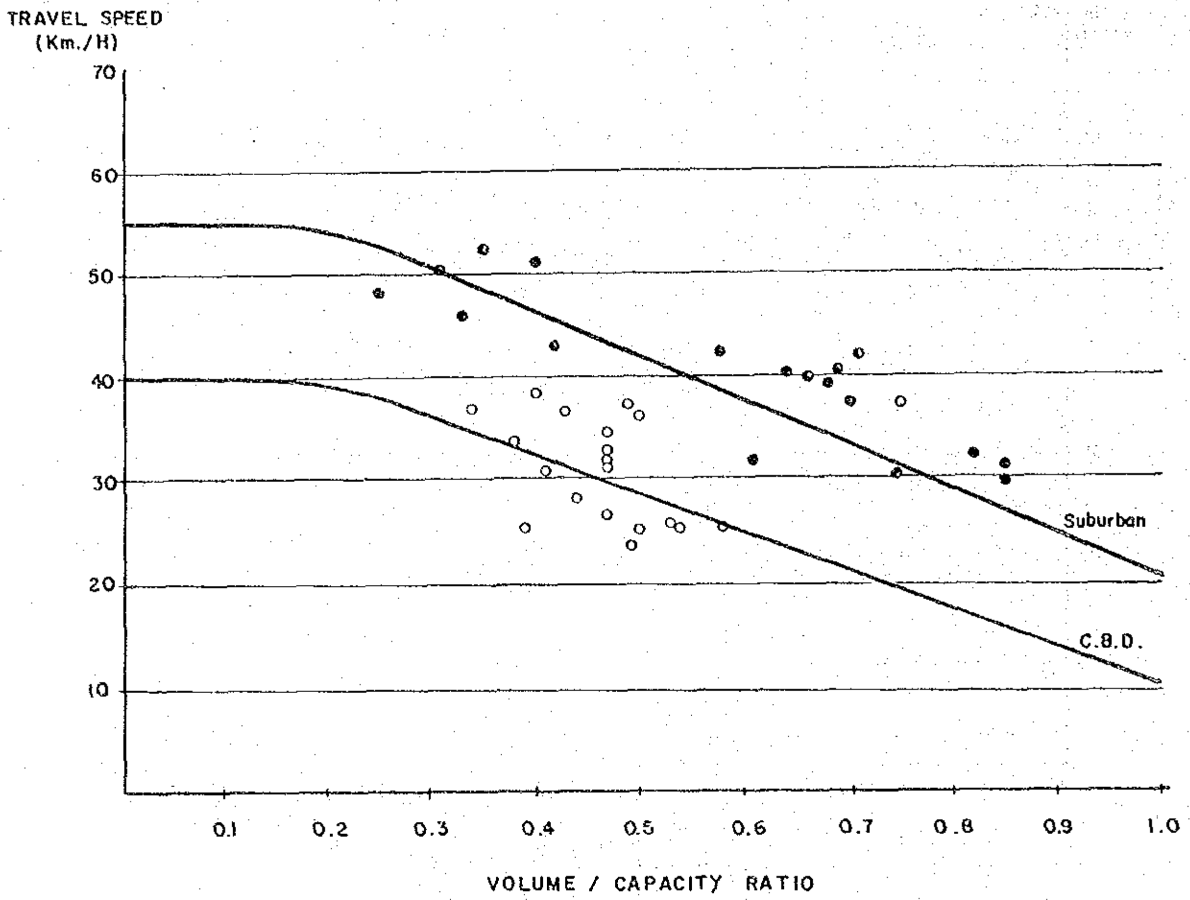
Figure 2.2-4 shows the interrelation curve between travel speeds and volume/capacity ratios for urban sections. Road conditions assumed are as follows:

| | | |
|---|---|---|
| Number of lanes and lane width | : | 2-lane x 3.35 m = 6.7 m |
| Shoulder width | : | 2 m |
| Terrain | : | flat |
| Roadside friction (CBD) | : | Heavy |
| Roadside friction (suburban) | : | Medium |




| | | |
|---|---|---|
| Number of Lane | : | 2 |
| Lane width | : | 3.35 meters |
| Shoulder width | : | 2.0 meters |
| Terrain | : | Flat |
| Roadside friction. | | Light |

FIGURE 2.2.-3 TRAVEL SPEED VS VOLUME/CAPACITY RATIO (RURAL SECTION)




| | | |
|---|---|---|
| Number of Lane | : | 2 |
| Lane Width | : | 3.35 meters |
| Shoulder Width | : | 2.0 meters |
| Terrain | : | Flat |
| Roadside Friction | | |
| C B D | : | Heavy |
| Suburban | : | Medium |

FIGURE 2.2-4 TRAVEL SPEEDS VS VOLUME/CAPACITY RATIO (URBAN SECTION)

## 2.3 Headway Characteristics

Traffic flows at urban sections and at the uncontrolled urban intersections were video-taped, then headways were measured. Based on this survey, the headway characteristics as shown in Tables 2.3-1 and 2 were developed (Refer to Appendix 2-1). To be noted are as follows:

- Traffic flow was not necessarily saturated flow.
- Effects of roadside friction were included.
- Number of samples were not necessarily enough.

Table 2.3-1 Headway at Urban Section

| Type of Vehicle | | No. of | Mean Value of |
|---|---|---|---|
| Preceding Veh. | Following Veh. | Samples | Headway (Sec.) |
| Car | Car | 100 | 2.00 |
| Car | Tricycle | 192 | 2.06 |
| Tricycle | Car | 224 | 1.94 |
| Tricycle | Tricycle | 885 | 1.49 |
| Car | Jeepney | 52 | 3.10 |
| Jeepney | Car | 53 | 2.20 |
| Jeepney | Jeepney | 25 | 2.90 |

Table 2.3-2 Headways at Uncontrolled Urban Intersection

| Type of Vehicle | | No. of | Mean Value of |
|---|---|---|---|
| Preceding Veh. | Following Veh. | Samples | Headway (Sec.) |
| Car | Car | 153 | 2.18 |
| Car | Tricycle | 261 | 1.74 |
| Tricycle | Car | 371 | 1.36 |
| Tricycle | Tricycle | 2,269 | 1.32 |
| Car | Jeepney | 59 | 2.30 |
| Jeepney | Car | 69 | 2.30 |
| Jeepney | Jeepney | 52 | 2.30 |

## 2.4 Passenger Car Equivalent Factor (PCEF)

### 2.4.1 Two-lane Highway

Passenger car equivalent factors (PCEF) for the 2-lane highway were recommended as shown in Table 2.4-1, based on discussions below:

TABLE 2.4-1 Recommended PCEF for 2-lane Highway

| Vehicle Type | PCEF |
|---|---|
| Car | 1.0 |
| Jeepney | 1.5 1/ |
| Tricycle | 1.0 |
| Truck | 2.0 - 2.2 2/ (depending on level of service) |
| Bus | 1.6 - 2.0 2/ (depending on level of service) |

1/ Highway Planning Mannual

2/ HCM, 1985

Jeepneys and tricycles are unique vehicle and observed only in the Philippines, HCM, 1985 which is developed based on USA data base, is judge applicable with modification of passenger car equivalent factors (PCEF) of these vehicle types. The Highway Planning Manual recommends PCEF of 1.5 for jeepneys and 2.5 for tricycles in flat terrain with no roadside friction. Tricycles are given high PCEF due mainly to their slow moving and frequent-stopping operations. However, contrary to these movements having an adverse effect on road capacity, the following movements which eventually have an effect to increase road capacity, are observed in the Study Section:

- double driving on one lane of one direction
- utilizing of shoulder for stopping (loading/unloading) and sometimes even for driving

To find appropriate PCEFs,two analysis were conducted:

- Headway analysis by utilizing video tape recording
- Comparison of v/c ratios for various PCEFs with road user's opinions on traffic congestion degree

Flows of vehicle in several urban sections were recorded in video tapes and headways were computed. Results are shown in Table 2.4-2 (refer to Appendix 2-1).

TABLE 2.4-2 PCEF Based on Headway

| Type of Vehicle | | Mean Value of Headway (sec.) | Ratio to Headway of Car | PCEF Based on Headway |
|---|---|---|---|---|
| Preceding | Following | | | |
| Car | Car | 2.00 | 1.00 | 1.0 |
| Car | Jeepney | 3.10 | 1.55 | Jeepney = 1.5 |
| Jeepney | Car | 2.20 | 1.10 | |
| Jeepney | Jeepney | 2.90 | 1.45 | |
| Car | Tricycle | 2.06 | 1.03 | Tricycle = 1.0 |
| Tricycle | Car | 1.94 | 0.97 | |
| Tricycle | Tricycle | 1.49 | 0.75 | |

<u>Jeepney</u>

PCEF of a jeepney in the urban section based on headway characteristics is found to be 1.5 which is the same value recommended by the Highway Planning Manual for flat terrain with no roadside friction. PCEFs for a jeepney recommended by the Highway Planning Manual are adopted by this Study.

Tricycle

PCEF for a tricycle in the urban section based on headway characteristics is found to be 1.0 which is much lower than the one recommended by the Highway Planning Manual which is 2.5 for flat terrain with no roadside friction. It is the fact that about 23,900 vehicles are accomodated by the Cabanatuan Urban Section, of which more than one half or about 14,200 are tricycles.

The changes of v/c ratios against various PCEFs for a tricycle were plotted as shown in Figure 2.4-1 and compared with opinions of road users and the Study Team regarding congestion degree.

It was found that PCEF of 1.0 for tricycle is a best fit and reflecting a tricycle's movment characteristics. This factor of 1.0 should be understood as a nominal value, and if there is no double driving and /or frequent utilization of shoulder space is not possible, PCEF for a tricycle could be higher than this as recommended by the Highway Planning Manual.

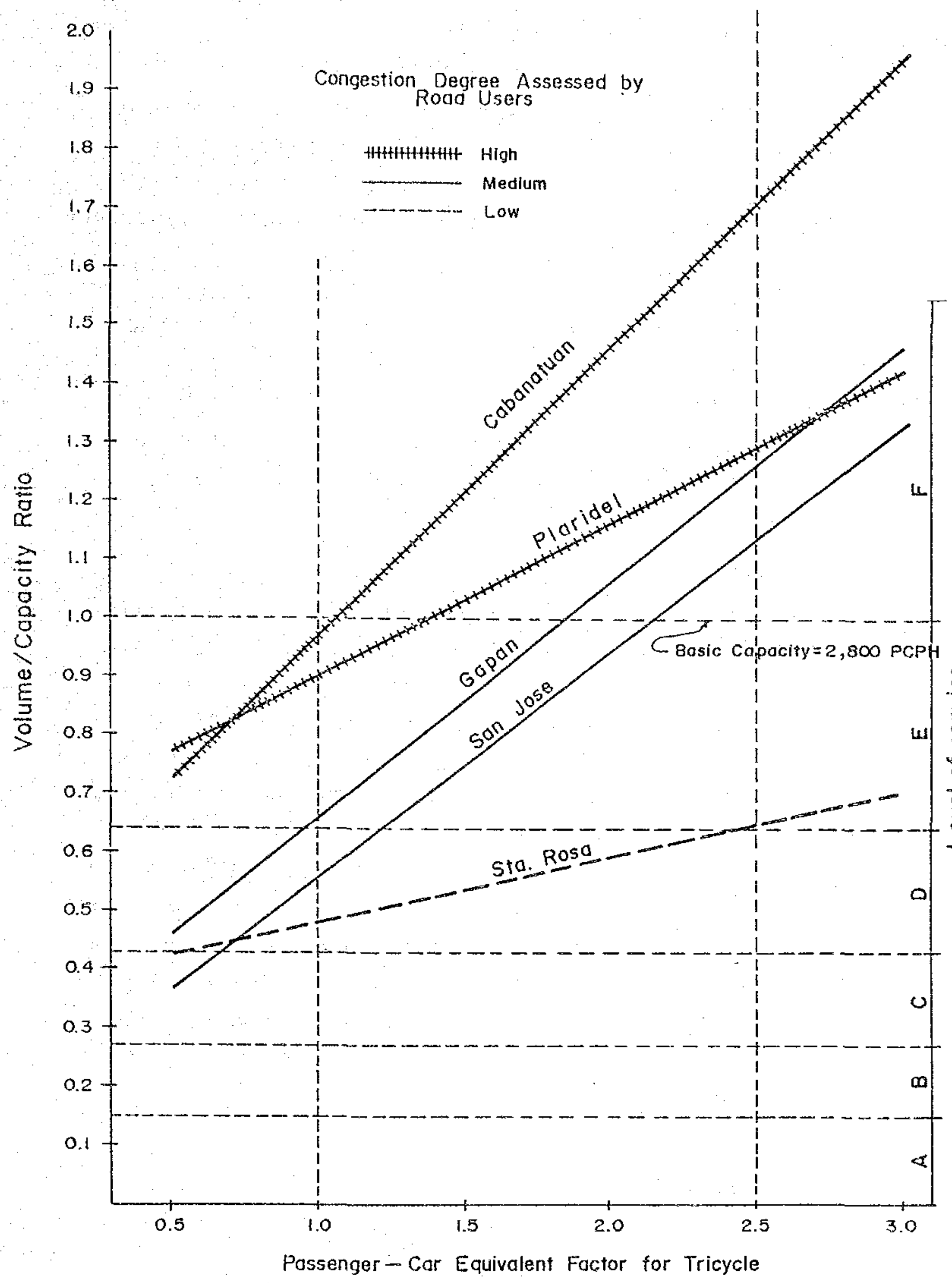



*Figure 2.4-1 Volume/Capacity Ratio by the change of* Passenger-Car Equivalent Factor for Tricycle (Two-lane Highway)

### 2.4.2 Uncontrolled Urban Intersection

PCEFs for the uncontrolled urban intersection were recommended as shown in Table 2.4-3, based on discussion below.

TABLE 2.4-3 Recommended PCEF for Uncontrolled Urban Intersection

| Vehicle Type | PCEF |
|---|---|
| Car | 1.0 |
| Jeepney | 1.0 |
| Tricycle | 0.6 |
| Heavy Vehicle | 1.5 1/ |

Note: 1/ HCM, 1985

PCEF for heavy vehicles is based on HCM, 1985. The movement of jeepney at an uncontrolled intersection is considered to be basically the same as that of 2-lane highway except for stopping for loading/unloading effect of which is, however, adjusted separately. Headway analysis also suggested PCEF of 1.0 for a jeepney at an uncontrolled intersection (See Table 2.4-4).

Tricycles are flowing quite flexibly, fully utilizing gaps in a major traffic stream at an intersection. Similar analyses made for PCEF of a 2-lane highway were conducted. Table 2.4-4 shows headway characteristics of tricycles and Figure 2.4-2 shows v/c ratios against various PCEFs for a tricycle. PCEF of 0.6 was adopted for a tricycle in the uncontrolled urban intersection.

TABLE 2.4-4 PCEFs Based on Headway Uncontrolled Urban Intersection

| Type of Vehicle | | Mean Value of Headway (sec.) | Ratio to Headway Time of Car | PCEF Based on Headway |
|---|---|---|---|---|
| Preceding | Following | | | |
| Car | Car | 2.18 | 1.00 | 1.0 |
| Car | Jeepney | 2.30 | 1.06 | Jeepney = 1.0 |
| Jeepney | Car | 2.30 | 1.06 | |
| Jeepney | Jeepney | 2.30 | 1.06 | |
| Car | Tricycle | 1.74 | 0.80 | Tricycle = 0.6 |
| Tricycle | Car | 1.36 | 0.62 | |
| Tricycle | Tricycle | 1.32 | 0.61 | |

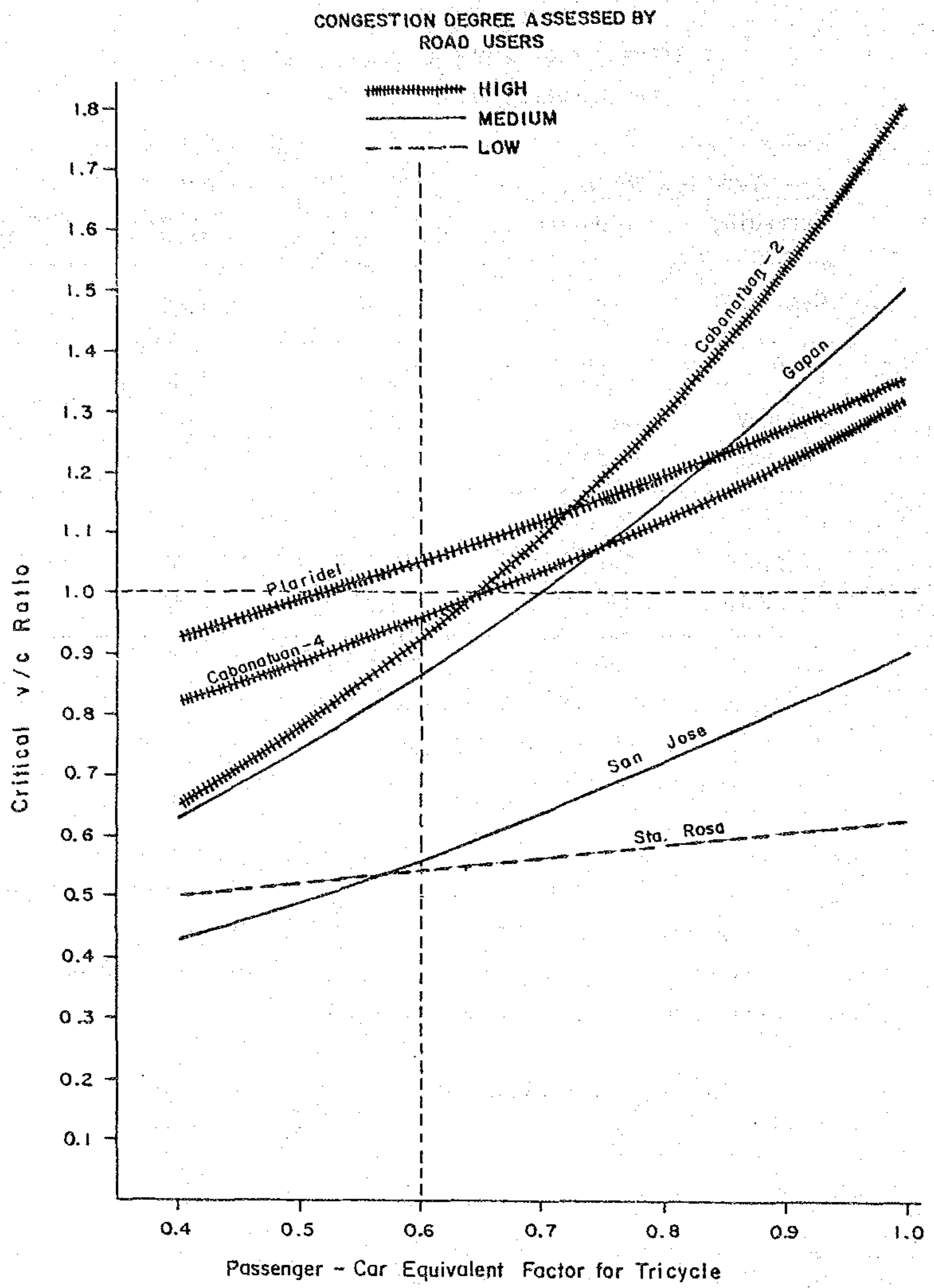



Figure 2.4-2 Critical v/c Ratio by the Change of Passenger-Car Equivalent Factor for Tricycle (Intersection)

### 2.4.3 Signalized Intersection

As there is no signalized intersection in the Study Section, the study on PCEFs for signalized intersection could not be carried out. However, when an intersection is signalized, traffic stream will become more orderly that that of uncontrolled intersections, because double driving of tricycles and tricycle's flexible utilization of gap as in the case of uncontrolled intersection will be minimized. Therefore, it is expected that PCEF for tricycle at the signalized intersection will be bigger than that of the uncontrolled intersection. PCEF for tricycles was recommended to be 1.0.

TABLE 2.4-5 Recommended PCEFs for Signalized Intersection

| Vehicle Type | PCEF |
|---|---|
| Car | 1.0 |
| Jeepney | 1.0 |
| Tricycle | 1.0 |
| Heavy Vehicle | 1.5 1/ |

Note: 1/ HCM, 1985

# CHAPTER 3

# LEVEL OF SERVICE ANALYSIS

CHAPTER 3

# LEVEL OF SERVICE ANALYSIS

## 3.1 General

Level of service analysis methods established by HCM, 1985 are introduced in this Chapter with modifications/adjustments which were made in consideration of road and traffic conditions of the Study Section.

Methods for the following facilities are discussed:

- Two-lane Highway
- Multi-lane Highway
- Signalized Intersection
- Uncontrolled Intersection

## 3.2 Two-Lane Highway

Measures of effectiveness for level of service definition for 2-lane highways are:

. Percent time delay (%) ...... the average percent of time that all vehicles are delayed while travelling in platoons due to inability to pass.
. Average travel speed (km/h)
. Ratio of the demand flow rate to the capacity of the facility

General terrain segment and specific grade segment are analyzed in separate procedures. The general terrain methodology estimates average traffic operational measures along a section of highway based on average terrain, geometric and traffic conditions. This procedure is usually applied to highway sections of at least 3 kms. in length. The procedure for specific guide is usually applied to extended specific grade segment, usually with grade of not less than 3% and longer than 400 meters in length.

3.2.1 General Terrain Segment

The level of service is determined by comparing the actual flow rate with service flow rate which is obtained by the following equation:

$$SF_i = 2{,}800 \times (v/c)_i \times f_d \times f_w \times f_{hv}$$

where:

$SF_i$ = total service flow rate in both directions for prevailing roadway and traffic conditions, for level of service i, in vph;

$(v/c)_i$ = ratio of flow rate to ideal capacity for level of service i, obtained from Table 3.2-1.

$f_d$ = adjustment factor for directional distribution of traffic, obtained from Table 3.2-2

$f_w$ = adjustment factor for narrow lanes and restricted shoulder width, obtained from Table 3.2-3

$f_{hv}$ = adjustment factor for the presence of heavy vehicles, jeepneys and tricycles in the traffic stream, computed as :

$f_{hv}$ = 1/(Pcar + PJny Ejny + Pmcy Emcy + Pmtr Emtr + Ptrk Etrk + Pbus Ebus)

where:

Pcar, Pjny, Pmcy, Pmtr, Ptrk and Pbus
= proportion of cars, jeepneys, motorcycles, motortricycles, trucks and buses respectively in the traffic stream, expressed as a decimal;

Ejny, Emcy, Emtr, Etrk and Ebus
= passenger-car equivalent for jeepneys, motorcycles, motortricycles, trucks and buses respectively, obtained from Tables 3.2-4 and 5.

Tables and work sheet for level of service analysis for general terrain segment are attached in Appendix 3-1.

3.2.2 Specific Grade Segment

The service flow rate for any given average upgrade speed is given by the following relationship:

$$SF_1 = 2{,}800 \times (v/c)_1 \times f_d \times f_w \times f_g \times f_{HV}$$

where:

$SF_1$ = service flow rate for level-of-service i, or speed i, total vph for both directions, for prevailing roadway and traffic conditions.

$(v/c)_1$ = v/c ratio for level-of-service i or speed i, obtained from Table 3.2-6;

$f_d$ = adjustment factor for directional distribution, obtained from Table 3.2-7;

$f_w$ = adjustment factor for narrow lanes and restricted shoulder width, obtained from Table 3.2-3;

$f_g$ = adjustment factor for the operational effects of grades on passenger cars, computed as described below; and

$f_{HV}$ = adjustment factor for the presence of heavy vehicles in the upgrade traffic stream, computed as described subsequently.

Adjustment for passenger cars on grades

$$f_g = 1/[1 + (P_p I_p)]$$

where:

$f_g$ = adjustment factor for the operation of passenger cars on grades;

$P_p$ = proportion of passenger cars in the upgrade traffic stream, expressed as a decimal;

$I_p$ = impedence factor for passenger cars, computed as:

$$I_p = 0.02\ (E - E_o)$$

$E$ = base passenger-car equivalent for a given percent grade, length of grade, and speed, selected from Table 8-9; and

$E_o$ = base passenger-car equivalent for 0 percent grade and a given speed, selected from Table 3.2-8.

Adjustment for heavy vehicles in the traffic stream.

$$f_{HV} = 1/[1 + P_{HV}\ (E_{HV} - 1)]$$

where:

$f_{HV}$ = adjustment factor for the presence of heavy vehicles in the upgrade traffic stream;

$P_{HV}$ = total proportion of heavy vehicles (trucks + jeepney + buses) in the upgrade traffic stream;

$E_{HV}$ = passenger-car equivalent for specific mix of heavy vehicles present in the upgrade traffic stream, computed as:

$$E_{HV} = 1 + (0.25 + P_{r/HV})\ (E - 1)$$

$P_{t/HV}$ = proportion of trucks among heavy vehicles, i.e., the proportion of trucks in the traffic stream divided by the total proportion of heavy vehicles in the traffic stream; and

$E$ = base passenger-car equivalent for a given percent grade, length of grade, and speed, selected from Table 3.2-8.

Tables and work sheets for level of service analysis for specific grade segment are attached in Appendix 3-2.

## 3.3 Multi-Lane Highway

Density (passenger cars per km per lane) is used as a measure of effectiveness for level of service definition for multi-lane highways.

Table 3.3-1 gives the values of maximum service flow rate and v/c ratio for multilane highways. These values represent maximum flow rates that can be accommodated under ideal conditions. Equations (1) through (3) are used to compute service flow rate under prevailing roadway and traffic conditions.

$$SF_i = MSF_i \times N \times f_w \times f_{hv} \times f_e \times f_p \qquad (1)$$

$$MSF_i = c_j \times (v/c)_i \qquad (2)$$

$$SF_i = c_j \times (v/c)_i \times N \times f_w \times f_{hv} \times f_e \times f_p \qquad (3)$$

Where:

$SF_i$ = service flow rate; the maximum flow rate that can be accommodated by the multilane highway segment under study, in one direction, under prevailing roadway and traffic conditions, while meeting the performance criteria of LOS i, in vph;

$MSF_i$ = maximum service flow rate; the maximum rate of flow which can be accommodated by the multilane highway segment under study, per lane, under ideal conditions, while meeting the performance criteria of LOS i, in pcphpl;

$c_j$ = capacity per lane for a multilane highway with design speed j; 2,000 pcphpl for j = 112 kmph or 96 kmph, 1,900 pcphpl for j = 80 kmph; $c_j$ may be obtained from Table 3.3-1 as the maximum service flow rate for LOS E;

N = number of lanes in one direction

$(v/c)_i$ = maximum volume-to-capacity ratio allowable while maintaining the performance characteristics of LOS i (Table 3.3-1);

$f_w$ = adjustment factor for lane width and/or lateral clearance restrictions (Table 3.3-2);

$f_{hv}$ = adjustment factor for the presence of heavy vehicles in the traffic stream;

$$f_{hv} = 1/(Pcar + Pjny\ Ejny + Pmcy\ Emcy + Ptrk\ Etrk + Pbus\ E\ bus)$$

Where:

Pcar, Pjny, Pmcy, Ptrk and Pbus

= proportion of cars, jeepneys, motorcycles, trucks and buses, respectively, in the traffic stream, expressed as a decimal;

Ejny, Emcy, Etrk and E bus

= passenger-car equivalent for jeepneys, motorcycles, trucks and buses, respectively (Table 3.3-3)

$f_E$ = adjustment factor for the development environment and type of multilane highway; (Table 3.3-4) and

$f_p$ = adjustment factor for driver population (Table 3.3-5)

Tables and work sheets for level of service analysis for multi-lane highways are attached in Appendix 3-3.

## 3.4 Signalized Intersection

### 3.4.1 Level of Service for Signalized Intersection

Level of service for signalized intersections is defined in terms of stopped delay. Level of service criteria are given in Table 3.4-1.

TABLE 3.4-1 Level of Service Criteria For Signalized Intersection

| Level of Service | Stopped Delay Per Vehicle (Sec.) |
|---|---|
| A | < 5.0 |
| B | 5.1 to 15.0 |
| C | 15.1 to 25.0 |
| D | 25.1 to 40.0 |
| E | 40.1 to 60.0 |
| F | > 60.0 |

### 3.4.2 Methodology

The analysis of signalized intersection is divided into five distinct modules, as follows:

1) Input module - This analysis module focuses on the definition of all required information on which subsequent computations are based. It includes all necessary data on intersection geometry, traffic volumes and conditions, and signalization. It is used to provide a convenient summmary for the remainder of the analysis.

2) Volume asjustment module - Demand volumes are generally stated in terms of vehicles per hour for a peak hour. The volume adjustment module converts these to flow rates for a peak 15-min. analysis period, and accounts for the effects of lane distribution. The definition of lane groups for analysis also takes place in this module.

3) Saturation flow rate module - This module is used to compute the saturation flow rate for each of the lane groups established for analysis. It is based on the adjustment of an "ideal" saturation flow rate to reflect a variety of prevailing conditions.

4) Capacity analysis module - In this module, volumes and saturation flow rates are manipulated to compute the capacity and v/c ratios for each lane group and the critical v/c ratio for the intersection.

5) Level-of-service module - Delay is estimated for each lane group established for analysis. Delay measures are aggregated for approaches and for the intersection as a whole, and levels of service are determined.

Saturation Flow Rate

The saturation flow rate is the flow in vehicles per hour which could be accommodated by the lane group assuming that the green phase was always available to the approach- i.e., that the green ratio, g/C, was 1.00. Computations begin with the selection of an "ideal" saturation flow rate, usually 1,800 passenger cars per hour of green time per lane (pcphgpl), and adjustment of this value for a variety of prevailing conditions that are not ideal.

$$s = s_o N f_w f_{HV} f_g f_p f_{bb} f_a f_{RT} f_{LT}$$

where:

- $s$ = saturation flow rate for the subject lane group, expressed as a total for all lanes in the lane group under prevailing conditions, in vphg;
- $s_o$ = ideal saturation flow rate per lane, usually 1,800 pcphgpl;
- $N$ = number of lanes in the lane group.
- $f_w$ = adjustment factor for lane width; 3.65 m lanes are standard; given in Table 3.4- ;
- $f_{HV}$ = adjustment factor for heavy vehicles in the traffic stream, given in Table 3.4- ;
- $f_g$ = adjustment factor for approach grade, given in Table 3.4- ;
- $f_p$ = adjustment factor for the existence of a parking lane adjacent to the lane group and the parking activity in that lane, given in Table 3.4- ;

$f_{bb}$ = adjustment factor for the blocking effect of local buses stopping within the intersection area, given in Table 3.4- ;

$f_a$ = adjustment factor for area type, given in Table 3.4- ;

$f_{RT}$ = adjustment factor for right turns in the lane group, given in Table 3.4- ; and

$f_{LT}$ = adjustment factor for left turns in the lane group, given in Table 3.4- or computed as described in following sections.

Capacity

The Capacity of each lane group is computed from Eq. (2):

$$c_1 = s_1 \times (g/C)_1$$

If the signal timing is not known, a timing plan will have to be estimated or assumed to make these computations.

where:

$c_i$ = capacity of lane group or approach i, in vph;

$s_i$ = saturation flow rate for lane group or approach i, in vphg; and

$(g/C)_i$ = green ratio for lane group or approach i.

The v/c ratio for aeach lane group is computed directly, by dividing the adjusted flows by the capacities computed above, as in Eq. (3):

$$X_i = v_i / c_i$$

The final capacity parameter of interest is the critical v/c ratio, $X_{CD}$ for the intersection. It is computed from Eq. (4), as follows:

$$X_c = \sum_i (v/S)_{ci} \times [C/(C - L)]$$

where:

$X_c$ = critical v/c ratio for the intersection;

$\sum_i (v/S)_{ci}$ = the summation of flow ratios for all critical lane groups or approaches, i;

C = cycle length, in sec; and

L = total lost time per cycle; computed as the sum of "start-up" and change interval lost

Level-of-service determination

Delay assuming randon arrivals- The delay for each lane group is found using the following relationship.

$$d = 0.38C \frac{[1 - g/C]^2}{[1 - (g/C)(X)]} + 173 X^2 \left[(X - 1) + \sqrt{(X - 1)^2 + (16 X/c)}\right] \quad (5)$$

where:

d = average stopped delay vehicle for the lane group, in sec/veh;

C = cycle length, in sec;

g/C = green ratio for the lane group; the ratio of effective green time to cycle length;

X = v/c ratio for the låne group; and

c = capacity of the lane group.

Tables and work sheets are attached in Appendix 3-4.

## 3.5 Uncontrolled Intersection

No method for level of service analysis of uncontrolled intersections is discussed either in HCM, 1985 nor in Highway Planning Manual. Based on studies as presented in Appendix 3-5, a method which gives an approximation to evaluate level of service, was proposed in the Feasibility Study. The method proposed was based on specific traffic and intersection geometric conditions, therefore, it would not be applicable to other intersecitions. It is desired that further studies will be conducted to establish more suitable method for uncontrolled intersections.

The method adopted by the Feasibility Study was as follows:

- An uncontrolled intesection is assumed as if it were a signalized intersection.
- The method for a signalized intersection is adjusted/ amended as follows:
  - Ideal saturation flow rate is reduced to 1,600 pcphgpl.
  - Two-phase signal with signal split prorated on the basis of the flow ratio in the critical flow of each phase is assumed.
  - Right-turn traffic is disregraded in the analysis because the field observation shows that right-turn is made mostly using shoulder and this movement is considered to have little effect on intersection capacity.
  - The passenger-car equivalent factors are as follows:

| | | |
|---|---|---|
| Heavy vehicle | : | 1.5 |
| Jeepney | : | 1.0 |
| Tricycle | : | 0.6 |

# CHAPTER 4
# IMPROVEMENT LEVEL FOR ROAD FUNCTION

# CHAPTER 4
# IMPROVEMENT LEVEL FOR ROAD FUNCTION

## 4.1 General

As defined in Chapter 1, improvement level is the minimum allowable level of traffic operational conditions to be maintained by major trunk roads. For establishing improvement level, one of the important factors is that to what extent majority of road users can be tolerable to traffic congestions. Another factor is that from viewpoint of highway planning, which level of service major trunk roads should maintain in order to fully attain targeted efficiency of overall trunk road network system. The last factor is that whether proposed improvement level could be economically justified from viewpoint of national economy. Above three (3) factors were studied in the Feasibility Study and introduced in this Chapter.

## 4.2 Road Users' Requirement

Two (2) kinds of surveys were conducted to obtain road users' tolerable limit to traffic congestion and opinions on improvement needs. One was the interview survey, in which car, bus and truck drivers were interviewed to identify five (5) most congested sections along the Study Section and to assess degree of congestion and needs of improvement of each section which they identified. The other survey was conducted by traffic and highway engineers. While they were travelling along the Study Section, they were required to assess degree of congestion, needs of improvement and type of improvement needed, without having been given any information on traffic volumes prior to their travel.

Results of two surveys and levels of service of corresponding sections are correlated and presented in Figures 4.2-1 and 2.

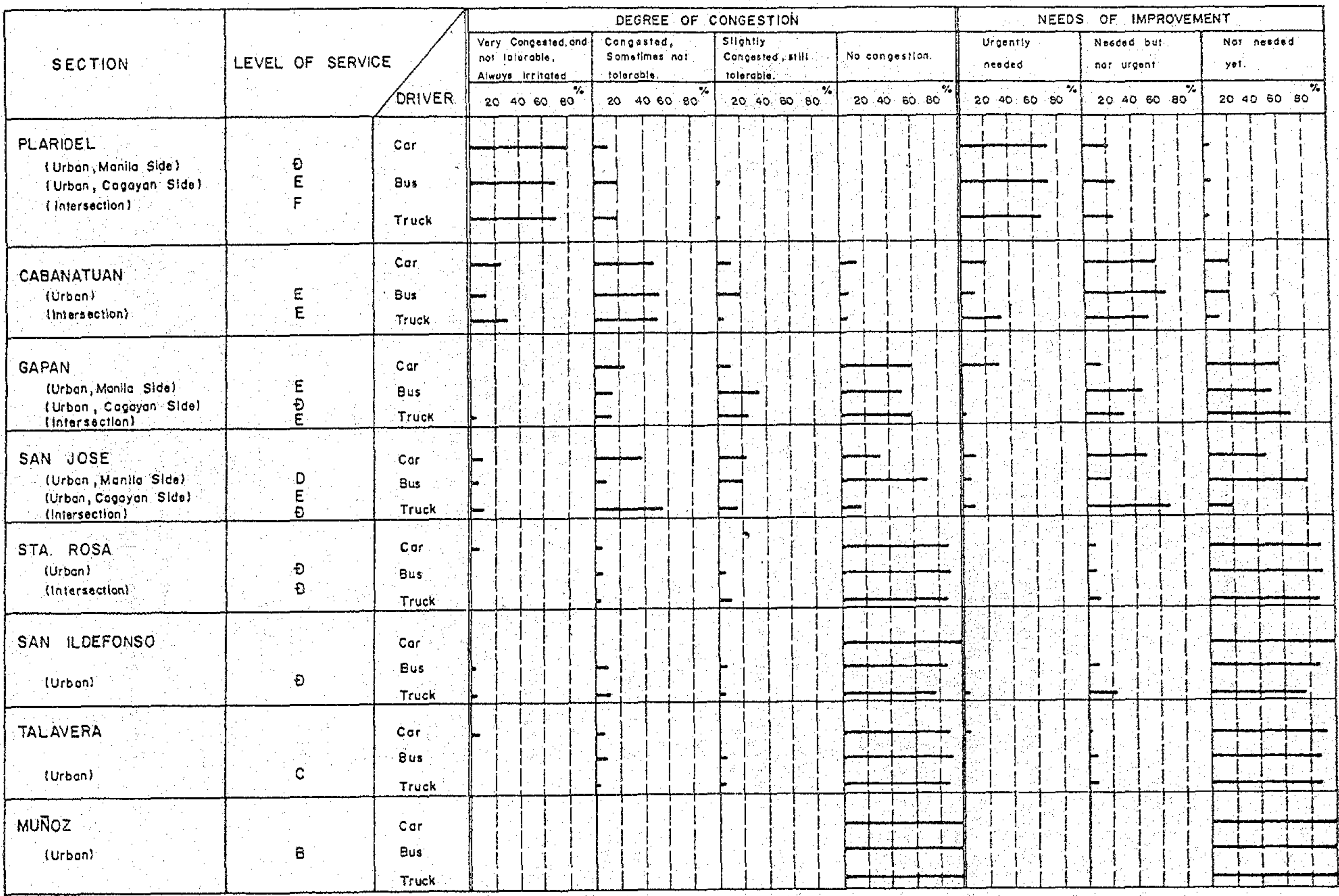


FIGURE 4.2-1 DRIVERS' OPINION ON IMPROVEMENT NEEDS AND LEVEL OF SERVICE

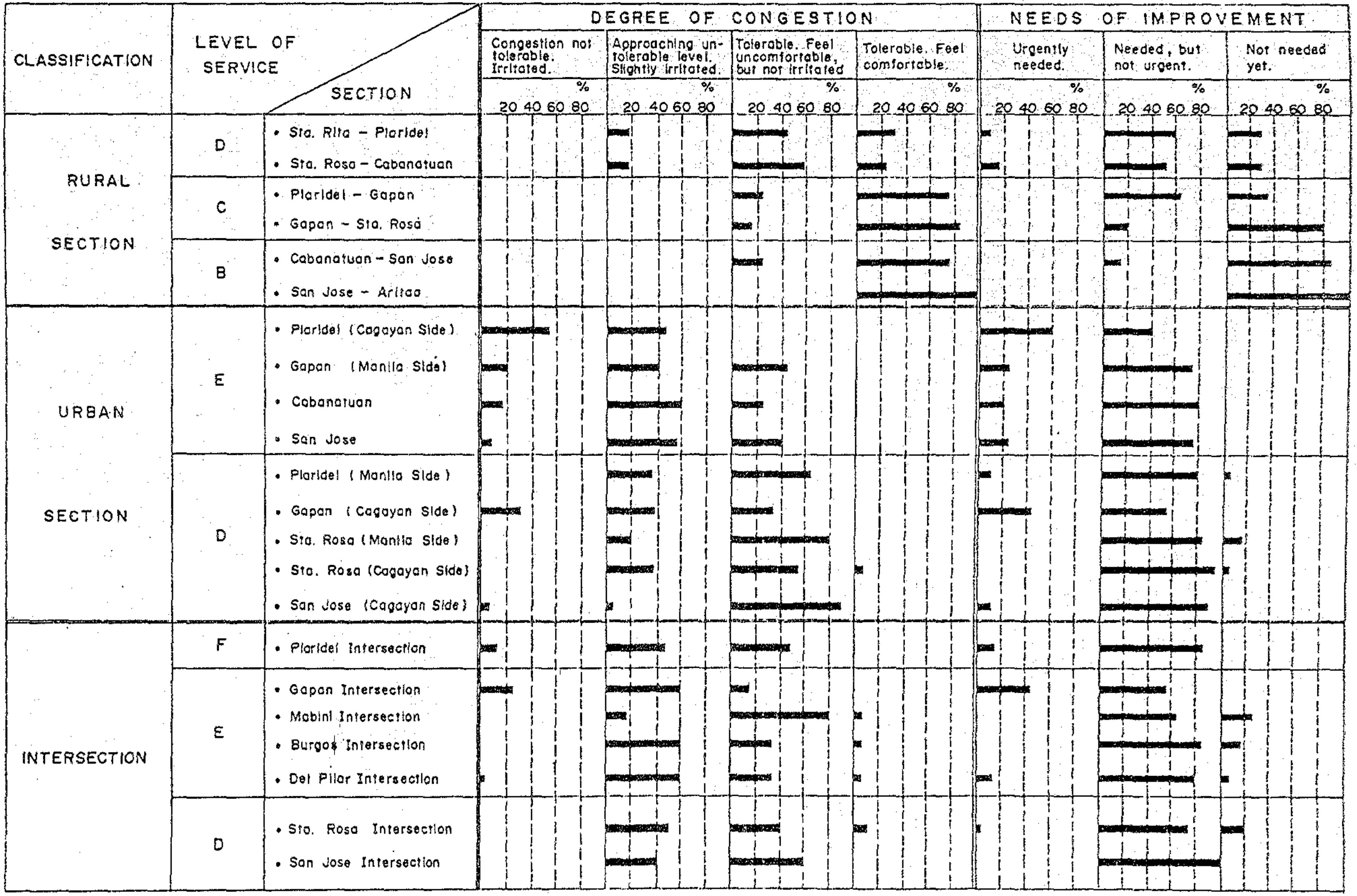



FIGURE 4.2-2 ENGINEERS' OCULAR ASSESSMENT ON IMPROVEMENT NEEDS AND LEVEL OF SERVICE

When degree of congestion reaches to a level that "congestion is approaching to untolerable condition", it could be interpreted that the condition is unacceptable to road users and they desire improvement. Percent of drivers and engineers stating unacceptable is summarized in Table 4.2-1.

TABLE 4.2-1 LEVEL OF SERVICE AND % OF UNACCEPTABLE

| Level of Service | | Percent of Drivers/Engineers Stating Unacceptable: Rural Section | Urban Section | Intersection |
|---|---|---|---|---|
| F | | __ 1/ | __ 1/ | 60% |
| E | (mostly middle stage of E) | __ 1/ | 70-80% | 60% |
| D | Latter stage of D (Approaching to E) | 20% | 20-40% | 40% |
| | early and middle stage of D | | 10-30% | |
| C and B | | 0% | 0-5% | - |

NOTE: At present, no section in the Study Section falls in this level of service.

When a level of service of an urban section or an intersection becomes the middle stage of E, more than 50% or road users feel unacceptable. Therefore, the middle stage of LOS E of urban sections and intersection seems to be a critical level for establishing improvement levels required by road users.

Whereas, the middle stage of LOS D, is presently the lowest level of the rural sections, the lowest acceptable level of service required by road users for rural sections could not be identified by the surveys. However, road users generally require higher level of service in rural sections than in urban sections, therefore, the early stage of level of service E would be a critical level for rural sections.

Improvement levels of required by road users are estimated as shown below:

| S e c t i o n | Improvement Level Required by Road Users |
|---|---|
| Rural Section | early stage of LOS E |
| Urban Section | middle stage of LOS E |
| Intersection | middle stage of LOS E |

## 4.3 Desirable Improvement Level From Viewpoint of Highway Planning

Improvement levels required by road users would be the lowest allowable levels. From the viewpoint of highway planning, highways should be planned to provide higher quality of service as much as possible to provide faster, safer and more comfortable means of transport in due consideration of roles and function of each highway, if such plans are economically and financially feasible.

Among various functions, traffic function is principal one for roads. Traffic function consists of two incompatible functions: mobility and land access. For mobility, consistent high speeds and infrequent passing delays are desirable and low speeds undesirable.

Major trunk roads are, in general, serving for long-distance trips, mobility should be given high priority. Land access should be, as much as possible, restricted to minimum. Therefore, travel speeds of a reasonable level should be maintained all the time on major trunk roads.

Relationship between travel speeds and levels of services on the Study Section were developed as shown in Table 4.3-1.

TABLE 4.3-1 TRAVEL SPEED AND LEVEL OF SERVICE ON THE PAN-PHILIPPINE HIGHWAY

| Level of Service | Travel Speed (Kms per hour) | |
|---|---|---|
| | Rural Section | Urban Section |
| A | 60 < | 40 < |
| B | 56 - 60 | 37 - 40 |
| C | 48 - 56 | 31 - 37 |
| D | 38 - 48 | 23 - 31 |
| E | 20 - 38 | 10 - 23 |
| F | 20 > | 10 > |

In rural sections, travel speeds at a level of service D will become 48 to 38 kms per hour. Major trunk roads mostly passes through rural areas, therefore, rural sections should be planned to provide high quality of service, which will produce overall efficiency of mobility. Travel speed of more than 40 kms. per hour in rural sections would be an appropriate target. From the viewpoint of highway planning, it would be appropriate that the improvement level for rural sections be set at the latter stage of level of Service D (approaching E).

In urban sections, travel speeds are lower by about 10 to 15 kms per hour than rural sections. Urban sections usually extend only for a short stretch, therefore, even a lower quality of service is planned in urban sections, overall efficiency of mobility will not be affected considerably. It would be acceptable that improvement level for urban sections be set at the early stage of level of service E.

Desirable improvement levels proposed from the viewpoint of highway are summarized in Table 4.3-2.

TABLE 4.3-2 DESIRABLE IMPROVEMENT LEVEL FROM VIEWPOINT OF HIGHWAY PLANNING

| Section | Desirable Improvement Level |
|---|---|
| Rural Section | the latter stage of level of service D (approaching E) |
| Urban Section | the early stage of level of service E |
| Intersection | the early stage of level of service E |

## 4.4 Recommended Improvement Level

Two (2) improvement alternatives: Alternative A which is based on road users' requirement and Alternative B which is based on highway planning viewpoint, were subjected economic evaluation. Results of cost benefit analyses are shown below.

| Type of Section | Type of Improvement | Section | Improvement Level of Alternative | Opening Year | IRR (%) |
|---|---|---|---|---|---|
| Rural | Widening to a 4-lane | Sta. Rita-Plaridel | A | 1995 | 45.8 |
| | | | B | 1990 | 35.9 |
| | Widening to a 4-lane | Calamba-Sto. Tomas | A | 1995 | 48.9 |
| | | | B | 1990 | 39.8 |
| Urban | Construction of a bypass | Plaridel | A | 1995 | 16.4 |
| | | | B | 1991 | 13.2 |
| | Construction of an Alternative route | Cabanatuan | B | 1990 | 35.6 |
| | Paving of Shoulders/ Sidewalks | Gapan | B | 1990 | 23.9 |
| | | Cabanatuan | B | 1990 | 36.4 |
| | | San Jose | B | 1990 | 15.0 |

Economic evaluation shows that "Improvement Level Alternative B" which requires higher level of service than Alternative A was economically justified, except in the case of Plaridel Bypass which requires high construction cost due to required long bridge over Angat River.

Recommended improvement levels are shown in Table 4.4-1.

TABLE 4.4-1 RECOMMENDED IMPROVEMENT LEVEL

| Section Type | Recommended Improvement Level | Type of Improvement Measures |
|---|---|---|
| Rural Section | Latter Stage of LOS D | . Widening to a 4-lane road |
| Urban Section | Early Stage of LOS E | . Bypass 1/<br>. Paving of shoulders and construction of sidewalks |
| Intersection | Early Stage of LOS E | . Signalization |

NOTE: 1/ In case that a project requires bigger investment than usual projects due to construction of a long bridge or such, improvement level at the middle stage of LOS E is recommended.

# CHAPTER 5

# PROBLEM AND POSSIBLE SOLUTION

# CHAPTER 5

# PROBLEM AND POSSIBLE SOLUTION

## 5.1 Identification of Problem Sections

Problem sections will be identified by comparing level of service of a section with improvement level. Future problem sections will also be predicted by comparing future level of service with improvement level.

Figure 5.1-1 shows general relation between level of service and daily traffic volume on the Pan-Philippine Highway. From this Figure and improvement level, critical daily traffic volume which requires improvement, is roughly estimated as follows:

| Section Type | Road Condition | Critical Daily Traffic Volume Which Requires Improvement (veh. per day) |
|---|---|---|
| Rural | . 2 x 3.35 m-lane<br>. shoulder width of 2.0 m<br>. flat terrain<br>. light roadside friction<br>. peak hour ratio 6 to 7% | 13,000 to 15,000 |
| Urban | . 2 x 3.35 m-lane<br>. shoulder width of 2.0 m<br>. flat terrain<br>. medium to heavy roadside friction<br>. peak hour ratio 8 to 8.5% | 15,000 to 16,000 |
| Urban | . 2 x 3.35 m-lane<br>. shoulder width of 1.0 m<br>. flat terrain<br>. medium roadside friction<br>. peak hour ratio 7 to 8% | 12,000 to 14,000 |

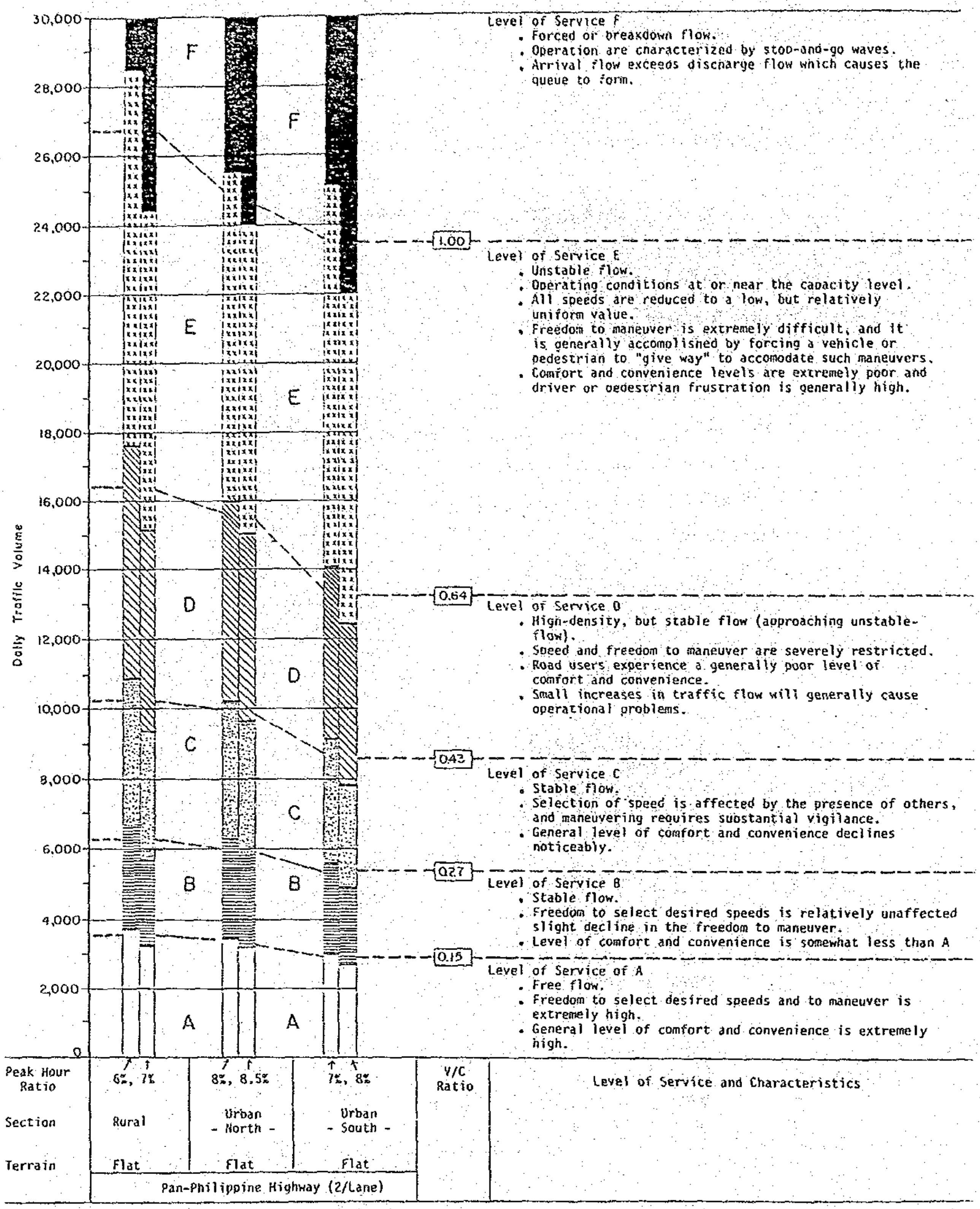



FIGURE 5.1-1 LEVEL OF SERVICE VS. DAILY TRAFFIC VOLUME

## 5.2 General Problems on the Pan-Philippine Highway

Rural sections still maintain high level of service except two (2) sections nearest to Metro Manila, of which levels of service are deteriorated lower than improvement level due mainly to heavy volume of traffic.

More traffic problems were observed on urban sections in major cities/municipalities. Urban sections can be classified into three (3) types (See Figure 5.2-1):

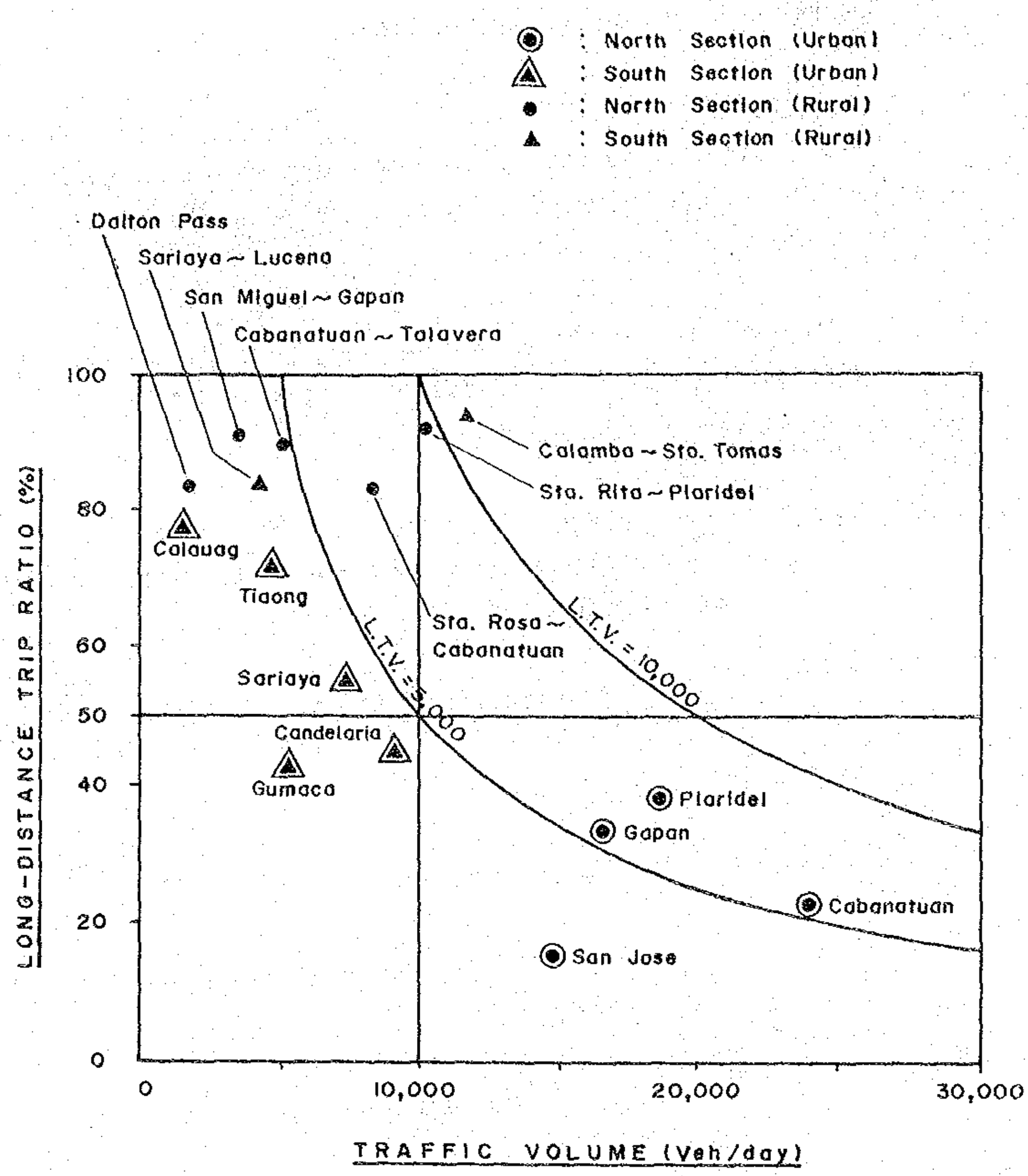
Type 1 ------ Sections are loaded two (2) incompatibel functions, i.e., mobility and land access, at the same degree of importance.

- Daily traffic volume exceeds 15,000 vehicle per day
- Long-distance trip traffic exceeds 5,000 vehicle per day
- High share of local traffic (60 to 80% of total traffic).

Plaridel, Gapan and Cabanatuan Urban Sections are classified in this category.

Type 2 ------ Sections have more than 10,000 vehicles per day, however, most of which are local traffic. Long-distance trip traffic is still less than 5,000 vehicle per day. San Jose Urban Section is included in this type.

Type 3 ------ Sections have traffic of less than 10,000 vehicle per day and still maintain higher level of service than improvement level. All urban sections in the South Study Section are included in this type.




Notes: Long-distance Trip Ratio = $\frac{\text{Long-distance Trip Traffic Volume}}{\text{Total Traffic Volume}}$

L.T.V. : Long-distance Trip Traffic Volume (Veh/day)

Figure 5.2-1 LONG-DISTANCE TRIP RATIO ON THE PAN-PHILIPPINE HIGHWAY

To be noted is that most major urban sections in the North Study Section are classified as Types 1 or 2, whereas urban sections in the South Study Section are classified as Type 3. Major difference in traffic conditions between the North and the South Study Sections is volume of tricycle traffic. Quite heavy tricycle traffic is observed on urban sections in the North Study Section, in extreme case exceeding 10,000 tricycles per day and accounting for more than 60% of total traffic, therefore, how to accomodate or control tricycles on the major trunk roads is an important issue in the North Study Section.

Table 5.2-1 shows problems observed on the Pan-Philippine Highway. These problems will be similarly experienced on other major trunk roads.

Table 5.2-1 PROBLEMS OBSERVED ON THE PAN PHILIPPINE HIGHWAY

| Section Classification | | Identified Problem Section | Problems | Possible Improvement Measures |
|---|---|---|---|---|
| Rural Section | North | a) Sta. Rita-Plaridel Sect. (Km 39-Km 41; L=2 kms) | . ADT ................ 10,750<br>. LOS ................ latter stage of D<br>. Travel Speed ....... 40-45 kph. | . Widening to 3-lanes<br>. Widening to 4-lanes<br>. Construction of an alternative route |
| | South | b) Calamba-Sto. Tomas Sect. (Km. 52-Km. 61; L=10 kms) | . ADT ................ 12,085<br>. LOS ................ latter stage of D<br>. Travel Speed ....... 35-40 kph. | |
| | North | c) Dalton Pass Section (Km 201-Km 216; L=15 km) | . Sharp curves and steep grade | . Improvement of alignment<br>. Construction of new route |
| Urban Section | North Section | Type 1<br>a) Plaridel Urban Section (Km 41-Km 42 + 500, L = 1.5 kms) | . ADT ................ 14,681-18,901<br>. LOS ................ latter stage of D Middle of Stage of E<br>. Travel Speed ....... 20-30 kph<br>. Long-distance trip.. 40%<br>. Local trip ........ 60%<br>. Heavy roadside friction due to public market and loading/unloading of PUV passengers<br>. On-street parking of private/public vehicles especially near the public market<br>. Jeepney/tricycle terminals near the intersection<br>. U-turn of jeepneys assigned to Plaridel-Monumento/Meycauayan route<br>. Irregular and slow movement of tricycles (tricycle traffic 3,070-5,590)<br>. Frequent crossings of pedestrians at any place of the section | . Improvement of existing section with traffic management<br>- paving of shoulders and sidewalks<br>- selection of proper location of PUV loading/unloading zones and terminals<br>- regulation and/or re-routing of tricycle/jeepney route<br>- on-street parking ban<br>- re-development of public market area<br>. Construction of a bypass |
| | | Type 1<br>b) Gapan Urban Section (Km 92-Km 95, L = 3 km) | . ADT ................ 16,718-11,896<br>. LOS ................ Middle Stage of E-latter Stage of D<br>. Travel Speed ....... 35-40 kph<br>. Long-distance trip.. 34%<br>. Local trip ........ 66%<br>. High share of tricycles of which movement is irregular and slow (tricycle traffic 9,350-5,755)<br>. Heavy roadside friction due to loading/unloading of PUV passengers<br>. Bus stops and jeepney/tricycle terminals near intersection<br>. Frequent crossing of pedestrians at any place of the section | . Improvement of existing section with traffic management<br>- paving of shoulders and sidewalks<br>- regulation of tricycle routes<br>- selection of proper location of bus stops and jeepney/tricycle loading/unloading zones<br>. Construction of bypass |
| | | Type 1<br>c) Cabanatuan Urban Section (Km 111-Km 118, L = 7 kms) | . ADT................ 21,311 - 15,610 - 23,931<br>. LOS ................ latter Stage of E and D<br>. Travel Speed ....... 25 - 35 kph<br>. Long-distance trip . 20%<br>. Local Trip.......... 80%<br>. Heavy roadside friction due to many intersecting roads and loading/unloading of PUV passengers<br>. Concentration of PUV routes to certain roads going to city center<br>. High share of tricycles of which movement is irregular and slow (tricycle traffic 10,290-9,340-14,220)<br>. Frequent crossings of pedestrians at any place of the section<br>. Urban road network is insufficient and is not coincide with urban expansion trend, resulting in concentration of traffic on the Pan-Philippine Highway | . Improvement of existing section with traffic management<br>- paving of shoulders and sidewalks<br>- re-routing of PUV routes<br>- selection of proper location of bus stops and jeepney/tricycle loading/unloading zones<br>. Construction of a bypass or an alternative route parallel to the Pan-Philippine Highway |

Table 5.2 -1 (Cont'd)

| Section Classification | | Identified Problem Section | Problems | Possible Improvement Measures |
|---|---|---|---|---|
| Urban Section | North Section | Type 2<br>d) San Jose Urban Section<br>(Km 157-Km 161,<br>L = 4 kms) | . ADT ................ 14,851 - 16,012<br>. LOS ................ latter stage of D and early stage of E<br>. Travel Speed ....... 30-40 kph<br>. Long-distance trip . 18%<br>. Local trip ......... 82%<br>. No overtakings due to center median island<br>. High share of tricycles of which movement is irregular and slow (tricycle traffic: 9,480 - 16,012)<br>. Heavy roadside frictions due to loading/unloading of PUV passengers<br>. Frequent crossings of pedestrians at any place of the section | . Improvement of existing section with traffic management<br>- removal of center median island or widening to allow overtakings<br>- paving of shoulders and sidewalks<br>- selection of proper location of bus stops and jeepney/tricycle loading/unloading zones |
| | | Type 3<br>e) Urban section of<br>- San Ildefonso<br>(Km 65+700-Km 66+700,<br>L = 1.0 km)<br>- Sta. Rosa<br>(Km 106+800-Km 107+900<br>L = 1.1 kms)<br>- Talavera<br>(Km 130-Km 131,<br>L = 1.0 km) | . In terms of levels of service, no problem yet<br>. Sections have either gravel shoulder or severely deteriorated AC pavement shoulders<br>. Sections have either no sidewalks nor deteriorated sidewalks<br>. Loading/unloading of PUV passengers disturbing flow of traffic<br>. Pedestrians walking on a roadway are one of potential causes of traffic accidents | . Improvement of existing section<br>- paving of shoulders and sidewalks |
| | South Section | - Alaminos<br>(Km 73+200-Km 74+400,<br>L = 1.2 kms)<br>- Tiaong<br>(Km 94+600-Km 95+800,<br>L = 1.2 kms)<br>- Candelaria<br>(Km 107-Km 108,<br>L = 1.0 km)<br>- Sariaya<br>(Km 120-Km 121,<br>L = 1.0 km)<br>- Pagbilao<br>(Km 140-Km 141+500,<br>L = 1.5 kms)<br>- Gumaca<br>(Km 196-Km 197+500,<br>L = 1.5 kms)<br>- Lopez<br>(Km 216-Km 217,<br>L = 1.0 kms) | | |
| Intersection | North Section | a) Plaridel Intersection<br>(Km 41+700)<br>b) Gapan Intersection<br>(Km 93+900)<br>c) Cabanatuan Intersection<br>(Junction with Mabini St.<br>Km 115+700)<br>d) Cabanatuan Intersection IV<br>(Junction with<br>Del Pilar St.,<br>Km 116+600)<br>e) San Jose Intersection<br>(Km 159+400) | . Level of Service<br>a) ............................F<br>b) ............................E<br>c) ............................E<br>d) ............................E<br>e) ............................E<br>. Loading/Unloading of PUV passengers within the intersection area<br>. Pedestrians are potential causes of traffic accidents | . Signalization<br>. Channelization<br>. Pedestrian crossings |
| | | f) Baliuag Bypass Intersection<br>(Km 54 + 400) | . In terms of level of service, no problem, yet<br>. Priority is not given to traffic on the Pan-Philippine Highway<br>. Improper guide signs | . Improvement of geometrics |
| | South Section | g) Sto. Tomas Intersection I<br>(Km. 60)<br>h) Sto. Tomas Intersection II<br>(Km 61) | | |

## 5.3 Possible Solutions

### 1) Rural Sections

When level of service of a section approaches to improvement level, improvement shall be planned. Possible solutions are:

- Widening to a 3-lane road
- Widening to a 4-lane road
- Construction of an alternative route

Although a 3-lane road could be an intermediate solution to a 4-lane expansion, due to traffic operational problems and traffic safety consideration, widening to a 3-lane road is not recommendable.

Widening to a 4-lane road should be considered first. Key to this solution is whether new right-of-way to accommodate a 4-lane road can be acquired or not. Existing right-of-way width usually ranges from 15 to 19 meters along the Pan-Philippine Highway. Minimum 20 meters and preferably more than 25 meters right-of-way is required to accommodate 4-lane road. When acquisition of new right-of-way is practically possible, widening to a 4-lane road should be positively considered.

Construction of an alternative route will be considered under following conditions:

- Widening of an existing section is practically impossible due to righto-of-way problems, topographic conditions, etc.

- From viewpoint of medium or long term highway development plan, new route is more advantageous.

2) Urban Section, Type 1

In this type of urban sections, split of two (2) incompatible functions, i.e.. mobility and land access, should be positively considered. Split of functions will be done by construction of a bypass.

. Land access (local traffic) ----- Existing Section
. Mobility (long-distance trip traffic) -----
a bypass

For planning a bypass, OD patterns should be obtained. Plaridel and Cabanatuan Urban Sections have the following differences in OD pattern:

Plaridel ...... most of long-distance trip traffic is through traffic, therefore, it is expected that most of long-distance traffic will be diverted to a bypass.

Cabanatuan ..... most of long-distance trips have their origins/destinations at Cabanatuan, therefore, through traffic is relatively light. In this case, construction of an alternative route which have good accesses to major traffic generating/attracting centers of the city will be more effective to relieve traffic burden of the existing section.

To be also considered is economic aspect. Proposed Plaridel bypass has to cross Angat River and overpass the Plaridel-Bustos Road, thus 335-meter bridge is required in 4.2 km bypass route. High construction cost suggested defered implementation.

3) Urban Section, Type 2

For this type of uban sections, efforts should be concentrated on maximum and effective utilization of existing right-of-way and traffic management with strict enforcement of traffic rules and regulations. Paved shoulders of 2.5 to 3.0 meters with sidewalks should be provided. Shoulders can be utilized for tricycles' travel way and loading/unloading of passengers and cargos, thus 2-lane will be fully available for long and medium-distance trip traffic.

4) Urban Section, Type 3

This type of urban sections has less traffic problems, but usually its cross section is still rural type, i.e. gravel shoulders with no sidewalks. Paving of shoulders and construction of sidewalks are proposed improvement to secure traffic safety and to improve urban environment.

5) Intersection

Most intersections on the major trunk roads are still uncontrolled intersections (not signalized nor right-of-way is not assigned to any traffic movement). In general, the vicinity of urban intersections are heavily built-up, therefore, widening beyond existing road right-of-way is not practical solution. Improvement measures should be planned within the existing road right-of-way. To attain maximum utilization of the existing roadway space as well as to attain orderly stream of traffic and traffic safety, signalization of an intersection will be the most practical improvement measures.

# CHAPTER 6

# EVALUATION OF IMPROVEMENT MEASURES

# CHAPTER 6

# EVALUATION OF IMPROVEMENT MEASURES

## 6.1 Quantifiable Benefits

Various benefits will be derived from improvement measures. Figure 6.1-1 shows impacts of improvement measures and quantifiable benefits. "Highway Planning Mannual" prepared by the MPWH will be referenced for benefit estimates.

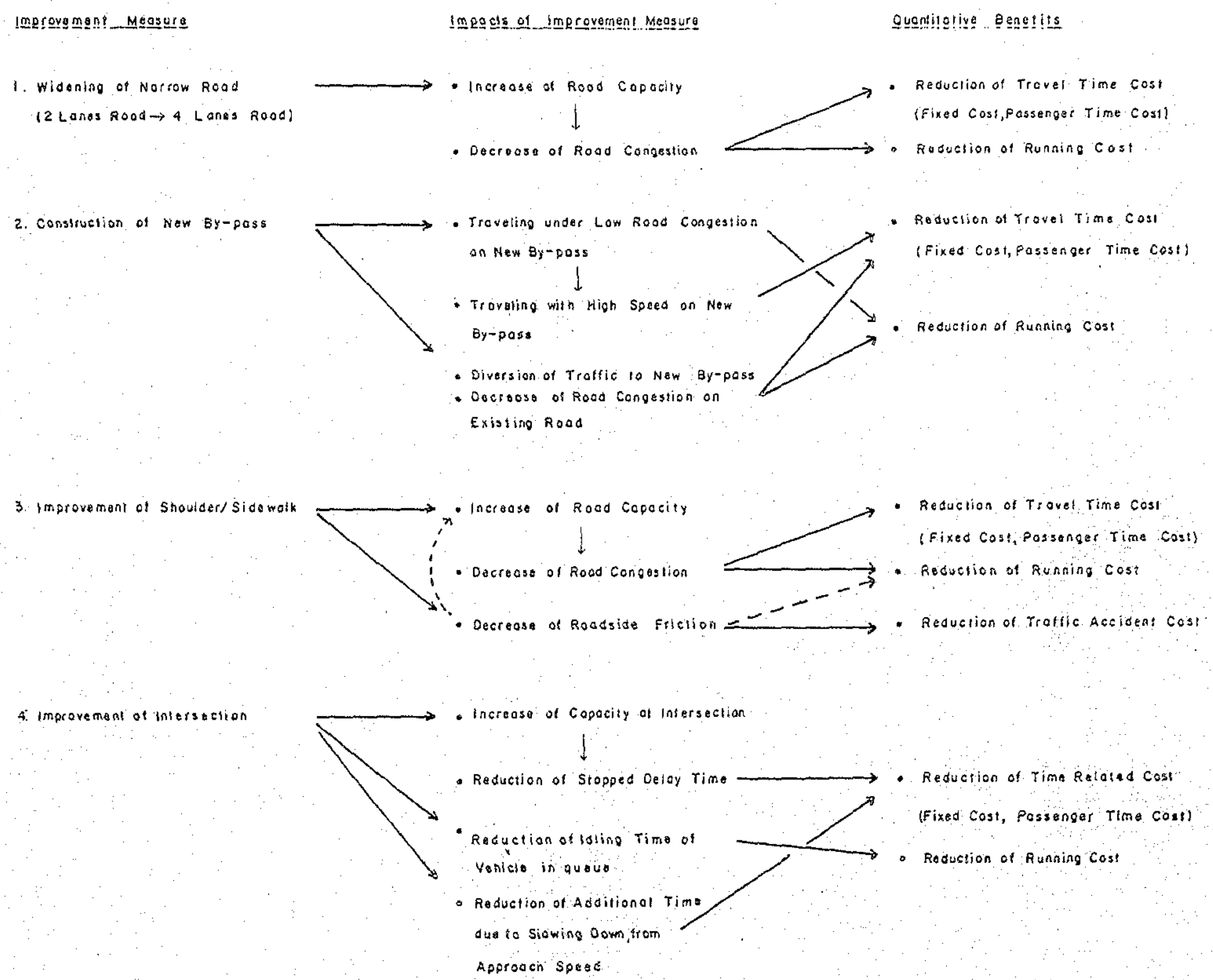



FIGURE 6.1-1 IMPACTS AND QUANTIFIABLE BENEFITS

## 6.2 Economic Feasibility of Improvement Measures

Based on cost benefit analysis undertaken for various improvement measures in the Feasibility Study, two (2) Figures were prepared. Figure 6.2-1 shows relationship between internal rate of returns (IRRs) and opening year traffic volume by type of improvement work. Figure 6.2-2 shows relationship between IRRs and v/c ratios by type of improvement work. These two (2) Figures were prepared with small specific traffic/road/topographic conditions, utilization of these figures are limited. However, two (2) figures roughly suggest the following:

Widening to a 4-lane road

- When traffic volume on a 2-lane section reaches to 10,000 veh. per day or more, widening to a 4-lane road would be economically feasible.
- When level of service of a 2-lane section becomes LOS D, (or v/c ratio becomes more than 0.45), widening to a 4-lane road would economically feasible.

Construction of a bypass

- When traffic volume on a existing 2-lane urban section reaches to about 15,000 veh. per day or more, construction of a bypass would economically viable.
- When level of service of a 2-lane urban section becomes middle stage of LOS E (or v/c ratio becomes 0.7 or more), construction of a bypass would economically justified.

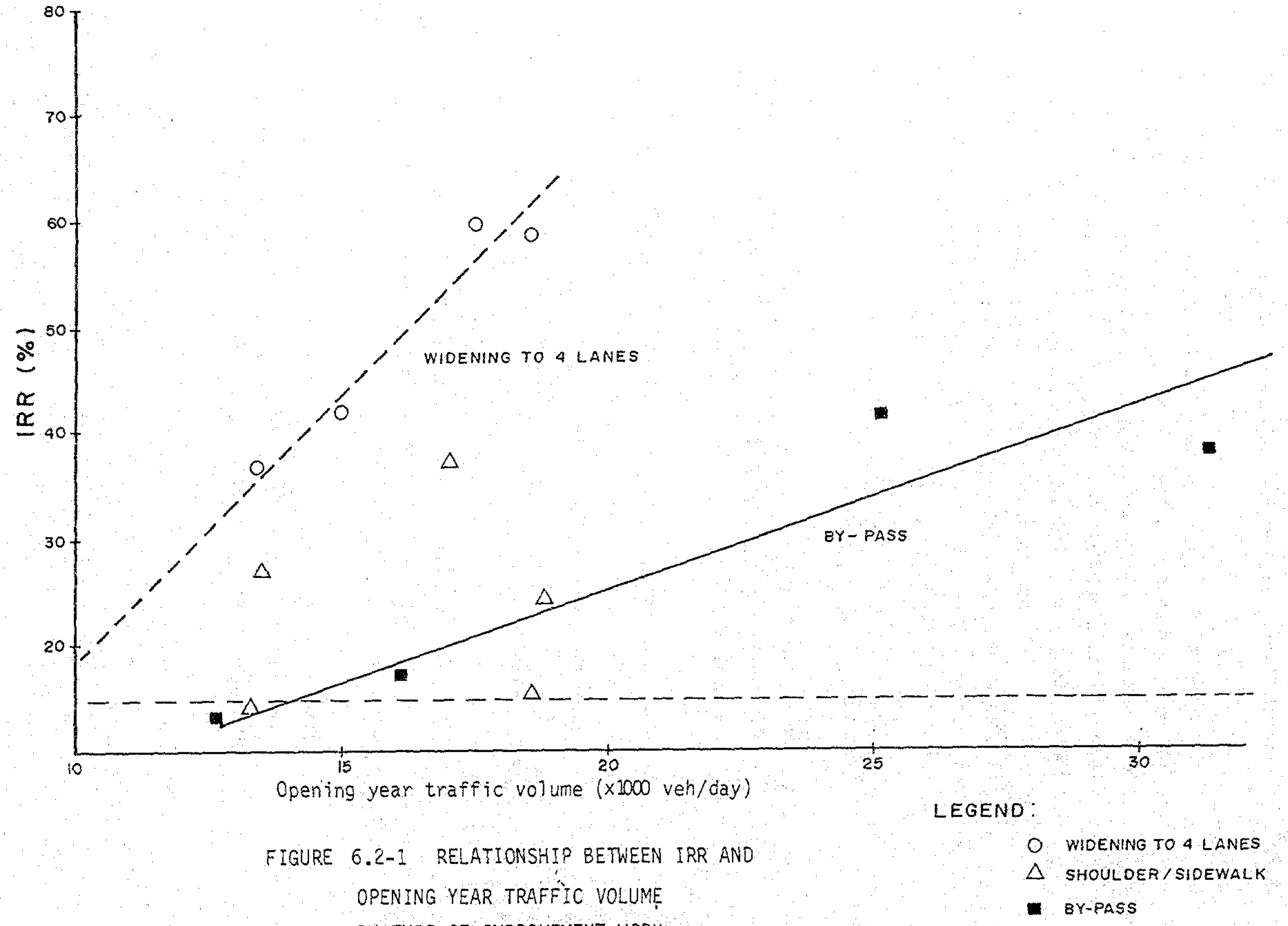



FIGURE 6.2-1 RELATIONSHIP BETWEEN IRR AND OPENING YEAR TRAFFIC VOLUME BY TYPE OF IMPROVEMENT WORK

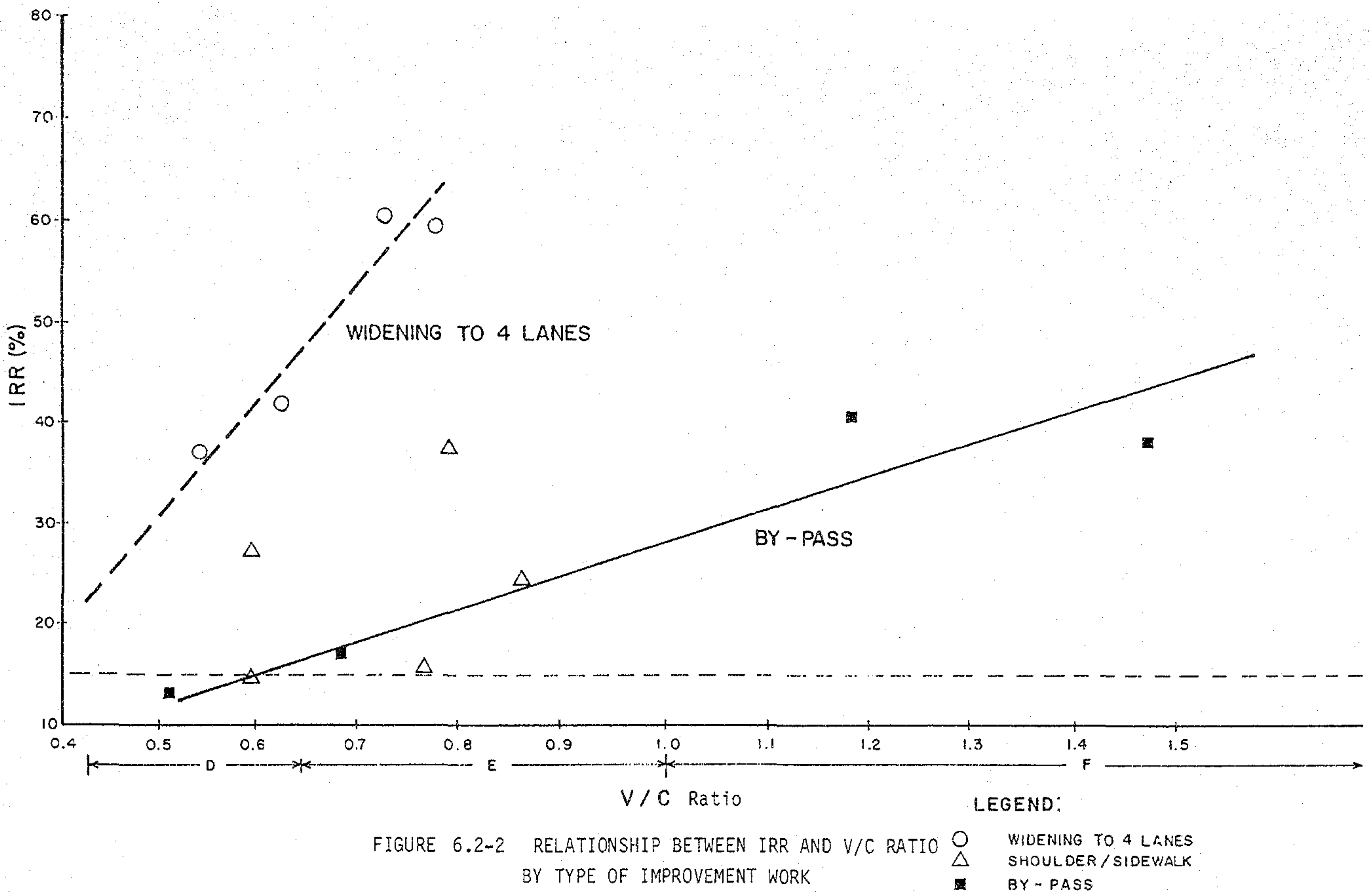



FIGURE 6.2-2 RELATIONSHIP BETWEEN IRR AND V/C RATIO BY TYPE OF IMPROVEMENT WORK

# APPENDIX

# APPENDIX 2-1
## HEADWAY CHARACTERISTICS AND PASSENGER CAR EQUIVALENT FACTORS ON THE PAN-PHILIPPINE HIGHWAY

## HEADWAY CHARACTERISTICS AND PASSENGER CAR EQUIVALENT FACTORS ON THE PAN-PHILIPPINE HIGHWAY

### 1. Study Flow

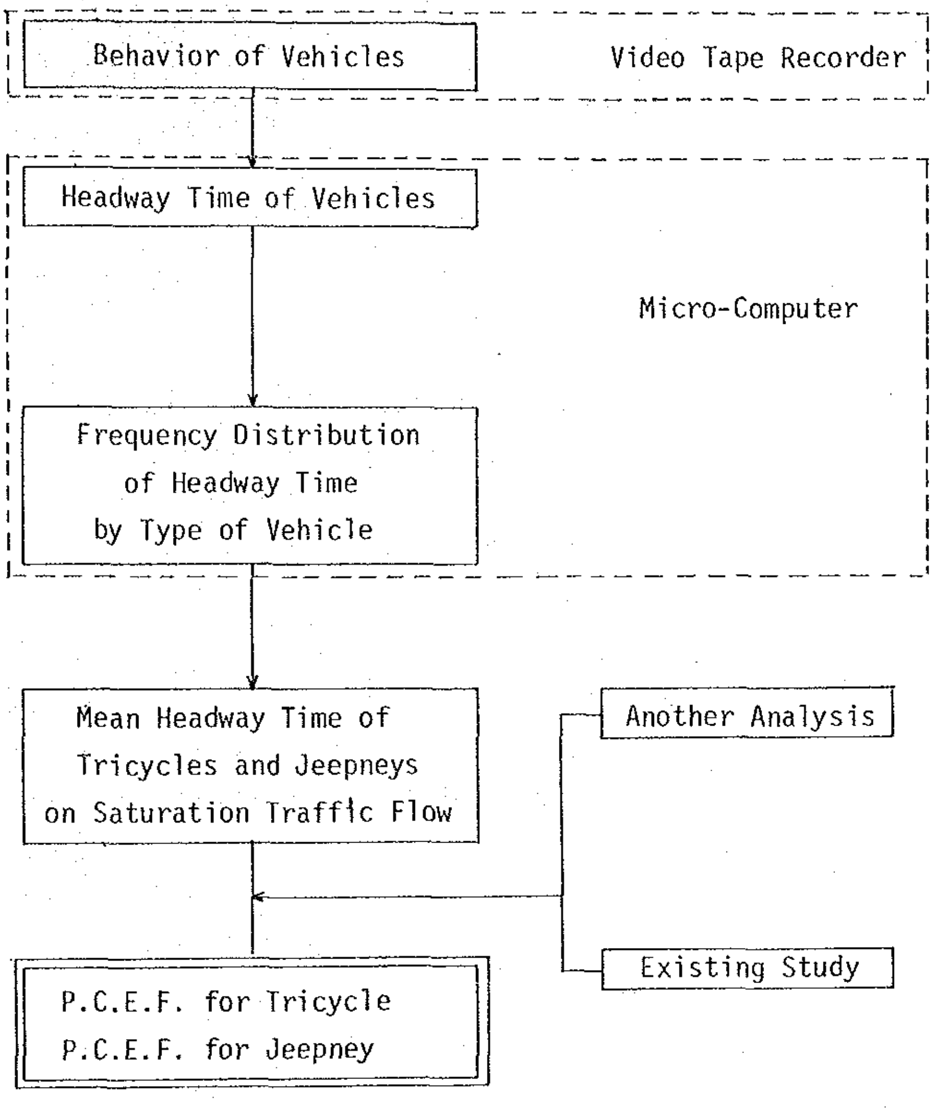



FIGURE 1

### 2. Recording of Vehicle Behavior

In order to estimate the P.C.E.F. of tricycles and jeepneys at intersections and urban sections, behavior of vehicles at the station listed in Table 1 were observed and recorded on the video tapes.

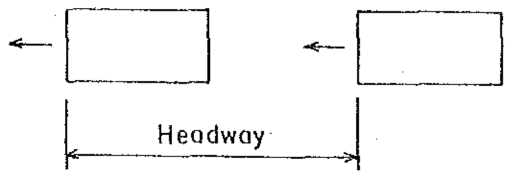
TABLE 1 RECORDING STATION

| | Location | Leg/Bound | Time |
|---|---|---|---|
| Intersection | Plaridel | Cagayan Leg | 7:00 - 8:00 |
| | Plaridel | Manila Leg | 8:11 - 9:15 |
| | Plaridel | Malolos Leg | 10:30 - 11:30 |
| | Gapan | San Fernando Leg | 6:45 - 7:45 |
| | Gapan | Cagayan Leg | 7:57 - 9:15 |
| | Gapan | Gen. Tiño Leg | 9:15 - 10:00 |
| | Sta. Rosa | Manila Leg | 8:07 - 9:10 |
| | Cab. Mabini | Manila Leg | 9:30 - 10:35 |
| | Cab. Mabini | Subdivision Leg | 13:00 - 14:00 |
| | Cab. Del Pilar | Cagayan Leg | 6:54 - 8:00 |
| | Cab. Del Pilar | Palayan Leg | 8:10 - 9:10 |
| | Cab. Del Pilar | Manila Leg | 10:58 - 12:00 |
| | Cab. Del Pilar | City Center Leg | 16:00 - 17:00 |
| | San Jose | Manila Leg | 10:25 - 11:25 |
| | San Jose | Rizal Leg | 12:58 - 14:00 |
| 2-Lane Highway (Urban Section) | Plaridel | | 9:18 - 10:25 |
| | Gapan | | 10:15 - 11:15 |
| | Sta. Rosa | | 7:00 - 8:00 |
| | Cabanatuan | Manila Leg | 6:58 - 8:00 |
| | Cabanatuan | Cagayan Leg | 8:08 - 9:10 |
| | San Jose | Manila Leg | 8:00 - 9:00 |
| | San Jose | Cagayan Leg | 9:05 - 10:05 |

3. Headway Time of Vehicle

Headway and headway time are indicated as below.

° Headway: distance between head of the vehicle and head of the preceding vehicle




° Headway Time: S2 - S1

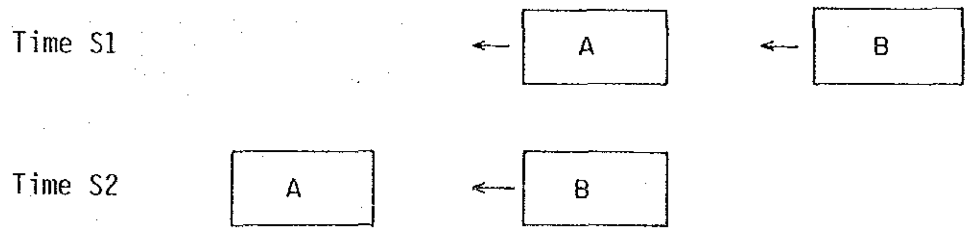



FIGURE 2

The headway time is depend on road/traffic condition and vehicle type. On saturation traffic follow, ratio of the headway times of tricycle/jeepney to those of car may be regard as P.C.E.F. of tricycle/jeepney.

4. Distribution of Headway Time

In the saturation traffic flow, headway time of vehicles are assumed to be distributed as below.

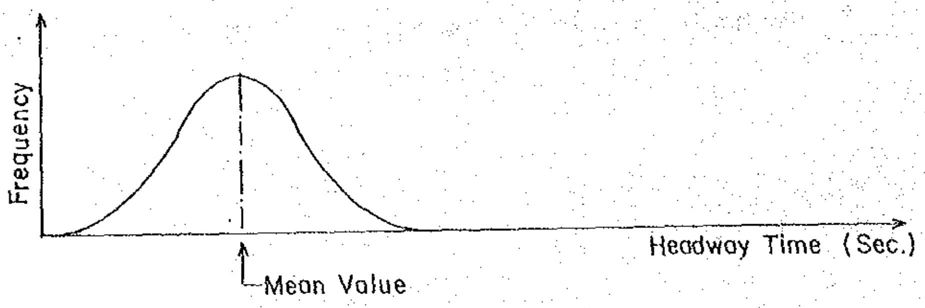



FIGURE 3

In the traffic flow which is not saturated, those are also assumed to be distributed as below.

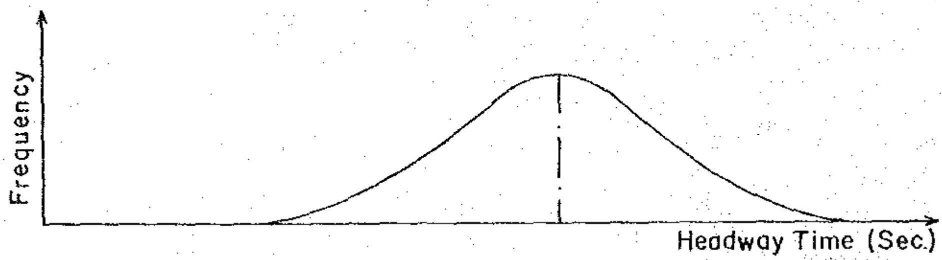



FIGURE 4

Since actual traffic flows observed in this study are not always saturated even on most congested section, actual frequency distribution of headway time shall be as below.

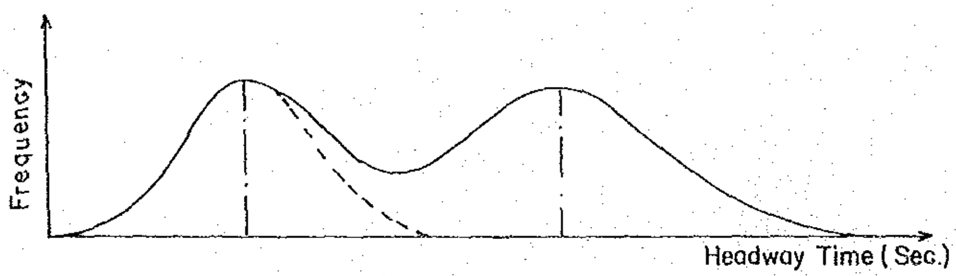



FIGURE 5

Based on the above assumption, distribution curves are regressed from observed data. The distribution curves are provided by the following combinations of vehicle types.

| Preceding Vehicle | Following Vehicle |
|---|---|
| 1. Car | Car |
| 2. Car | Tricycle |
| 3. Tricycle | Car |
| 4. Tricycle | Tricycle |
| 5. Car | Jeepney |
| 6. Jeepney | Car |
| 7. Jeepney | Jeepney |

Figure 6 to 12 show the distribution curves for intersection, and Figure 13 to 19 show those for two-lane Highway.

TABLE 2 HEADWAY TIME OF THE VEHICLES ON SATURATION FLOW

| | Type of Vehicle Preceding | Type of Vehicle Following | Number of Samples | Mean Value of Headway Time | Ratio to Headway Time of Car | P.C.E.F. |
|---|---|---|---|---|---|---|
| Intersection | Car | Car | 153 | 2.18 sec. | 1.00 | 1.0 |
| | Car | Tricycle | 261 | 1.74 | 0.80 | 0.6 |
| | Tricycle | Car | 371 | 1.36 | 0.62 | |
| | Tricycle | Tricycle | 2,269 | 1.32 | 0.61 | |
| | Car | Jeepney | 59 | 2.3 | 1.06 | 1.0 |
| | Jeepney | Car | 69 | 2.3 | 1.06 | |
| | Jeepney | Jeepney | 52 | 2.3 | 1.06 | |
| Two-Lane Highway | Car | Car | 100 | 2.00 | 1.00 | 1.0 |
| | Car | Tricycle | 192 | 2.06 | 1.03 | 1.0 |
| | Tricycle | Car | 224 | 1.94 | 0.97 | |
| | Tricycle | Tricycle | 885 | 1.49 | 0.75 | |
| | Car | Jeepney | 52 | 3.1 | 1.55 | 1.5 |
| | Jeepney | Car | 53 | 2.2 | 1.10 | |
| | Jeepney | Jeepney | 25 | 2.9 | 1.45 | |

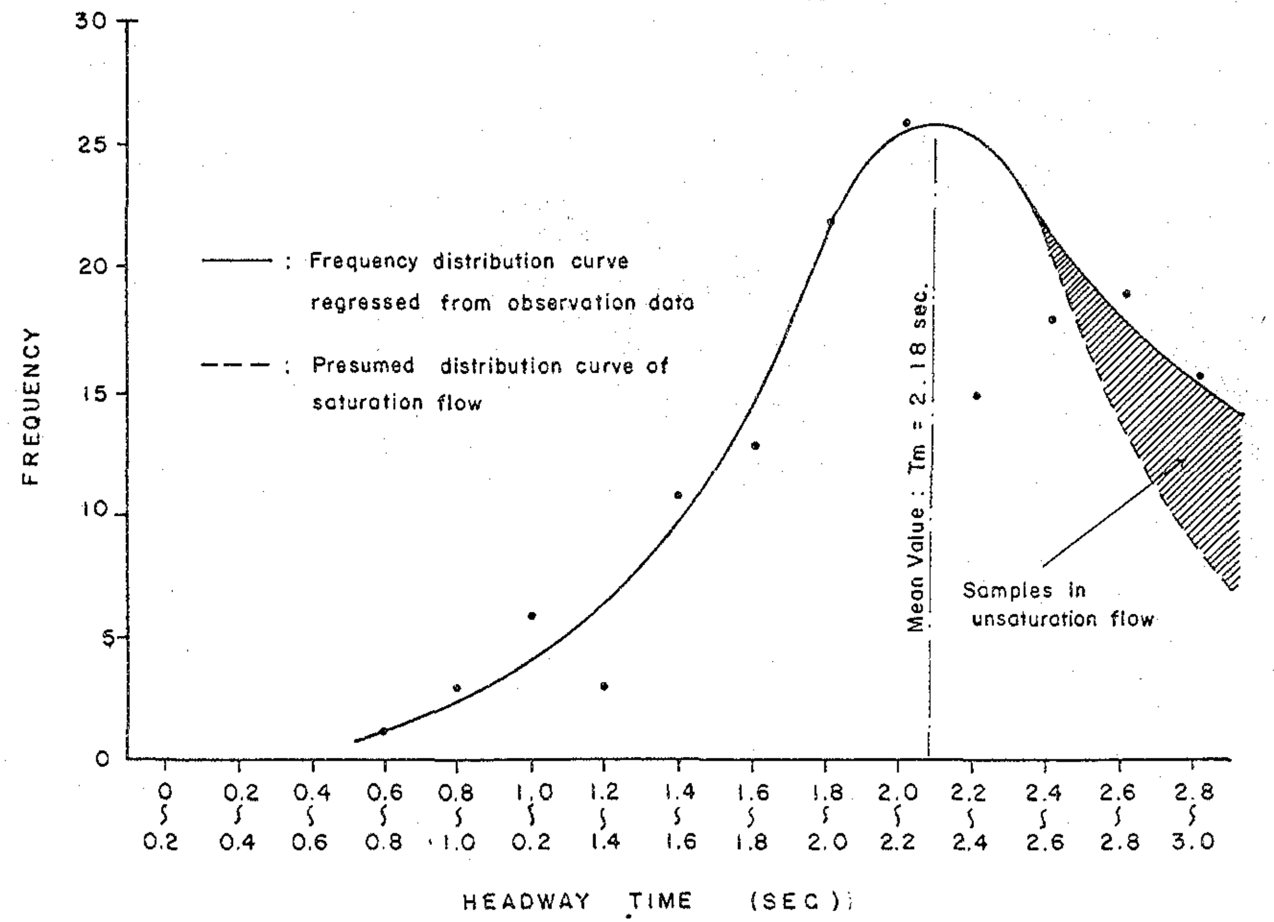



Figure 6 HEADWAY TIME AT INTERSECTION (CAR - CAR)

SOY'87

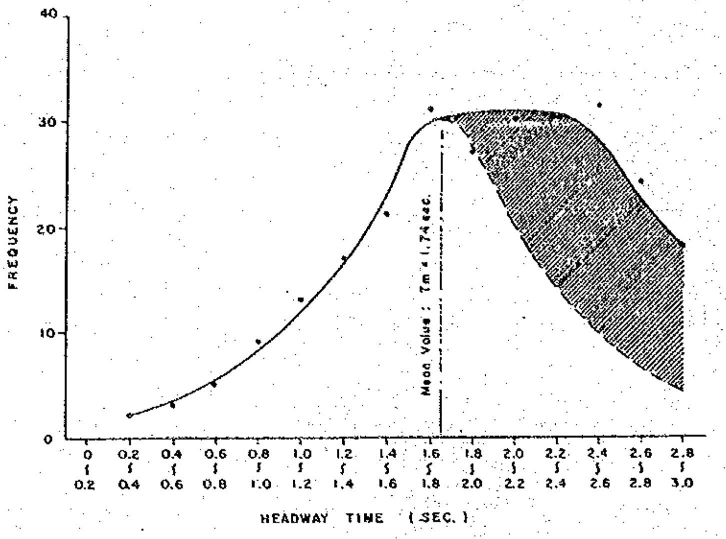



Figure 7 HEADWAY TIME AT INTERSECTION
(CAR – TRICYCLE)

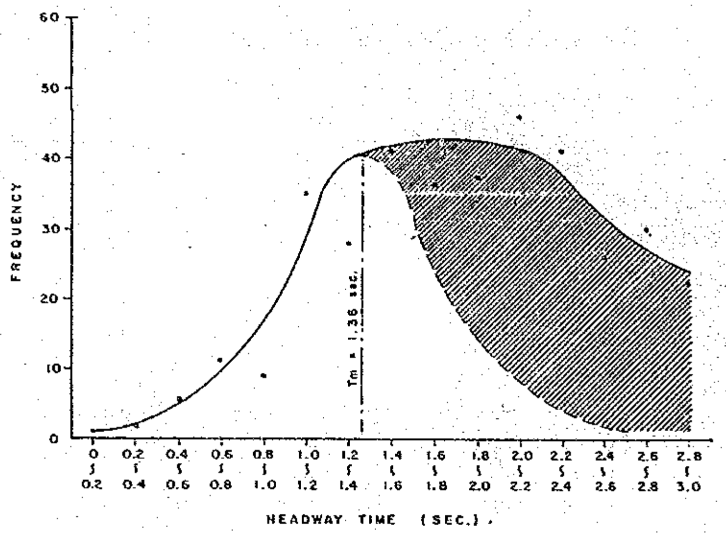



Figure 8 HEADWAY TIME AT INTERSECTION
(TRICYCLE – CAR)

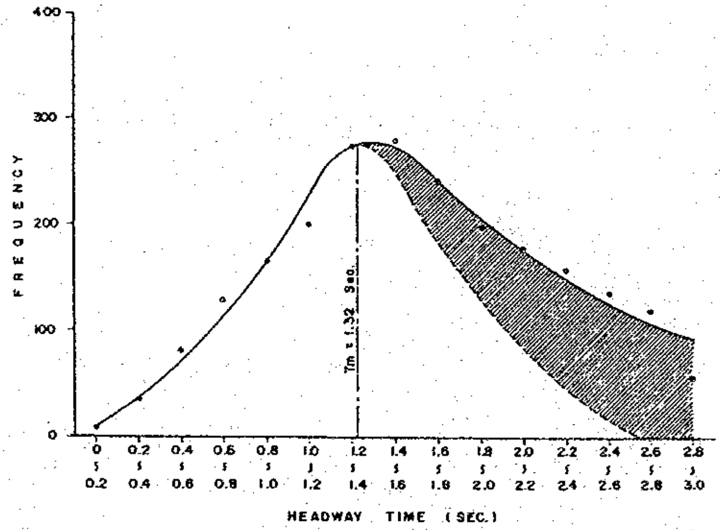



Figure 9 HEADWAY TIME AT INTERSECTION
(TRICYCLE – TRICYCLE)

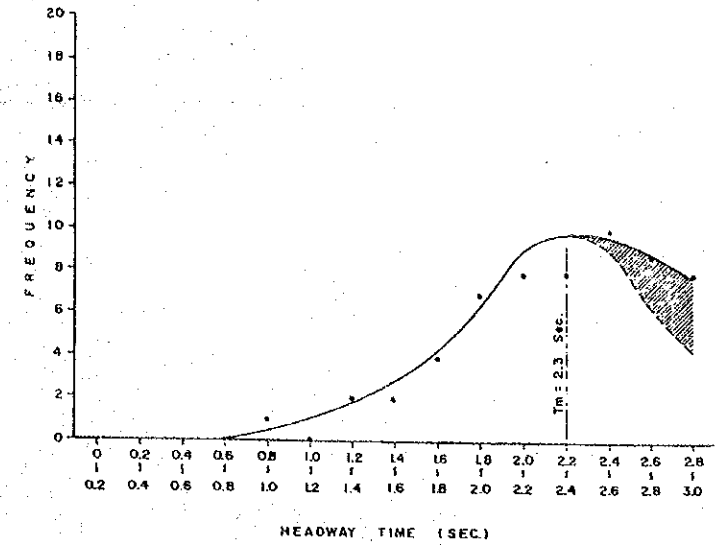



Figure 10 HEADWAY TIME AT INTERSECTION
(CAR-JEEPNEY)

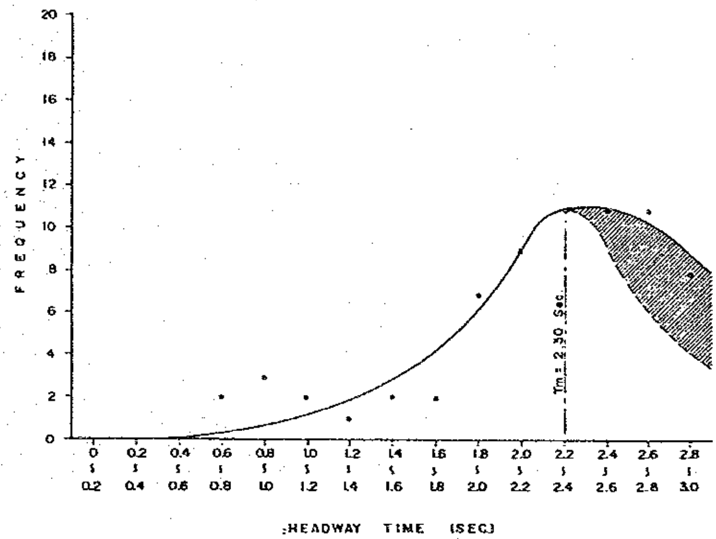



Figure 11 HEADWAY TIME AT INTERSECTION
(JEEPNEY-CAR)

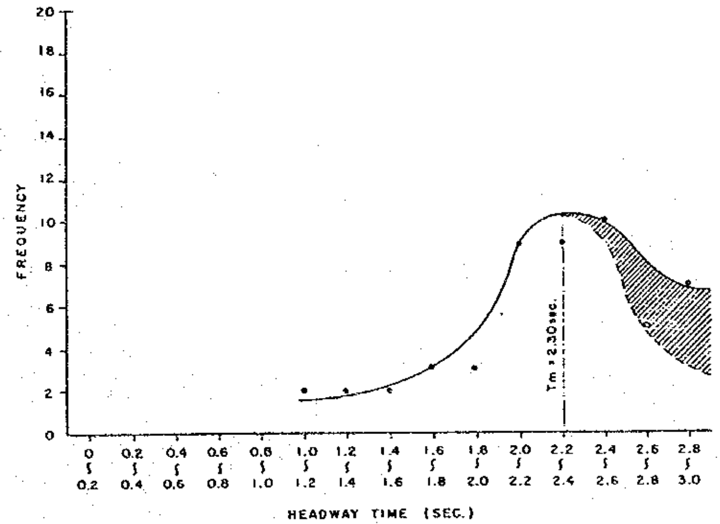



Figure 12 HEADWAY TIME AT INTERSECTION
(JEEPNEY - JEEPNEY)

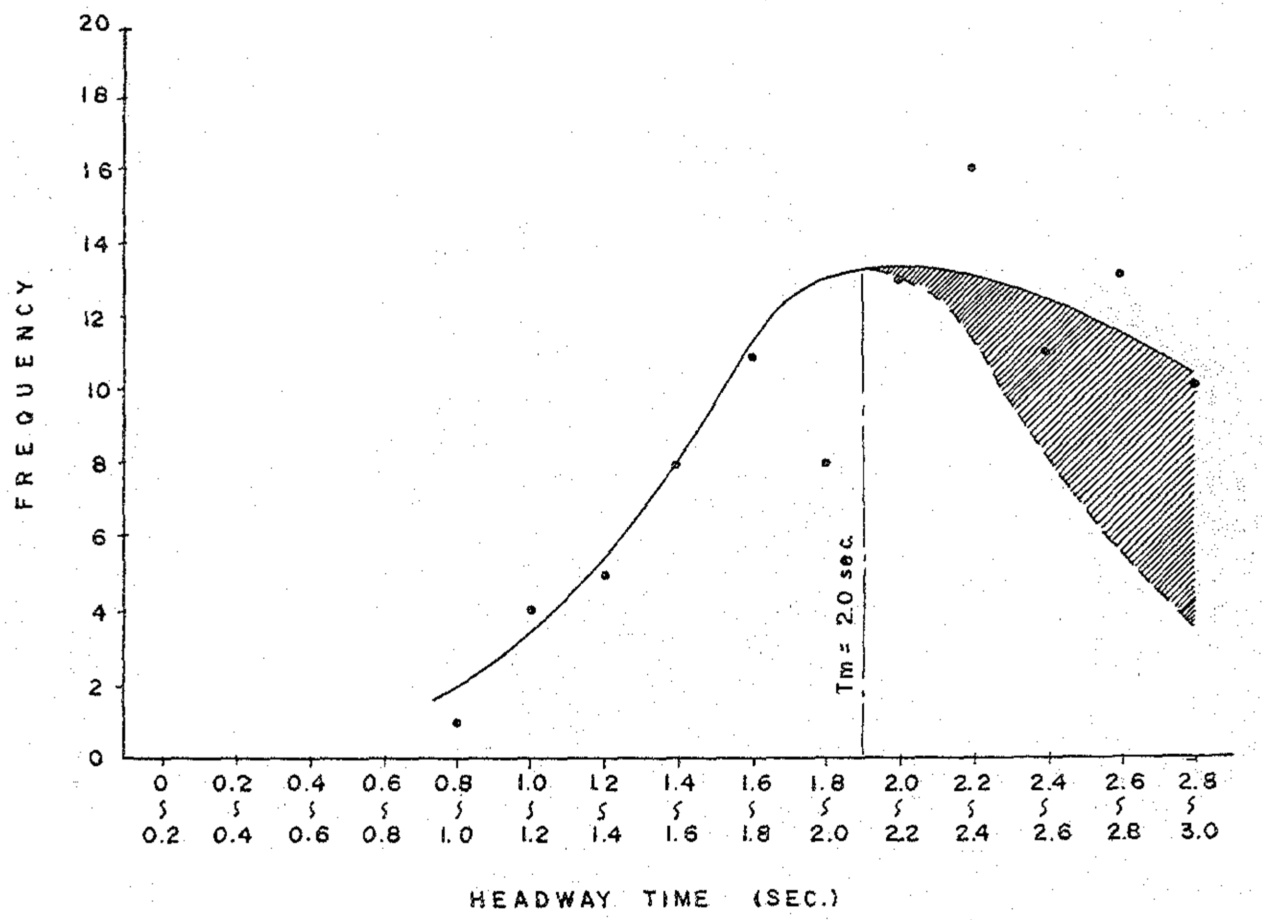



Figure 13 HEADWAY TIME ON TWO-LANE HIGHWAY

(CAR - CAR)

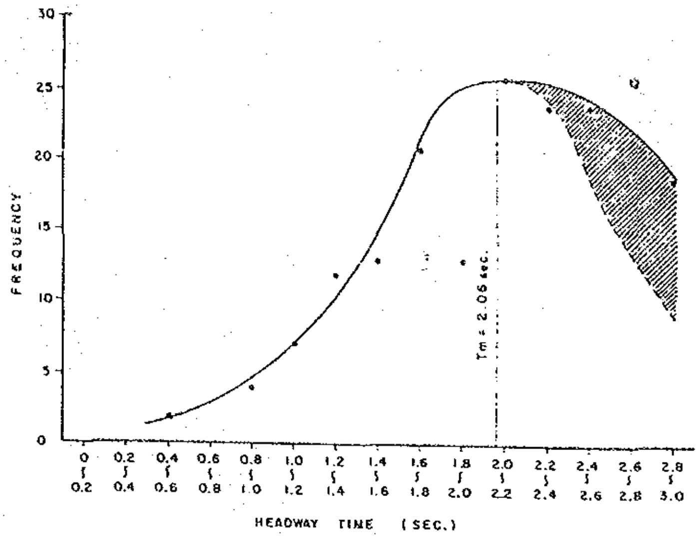



Figure 14 HEADWAY TIME ON TWO-LANE HIGHWAY
(CAR-TRICYCLE)

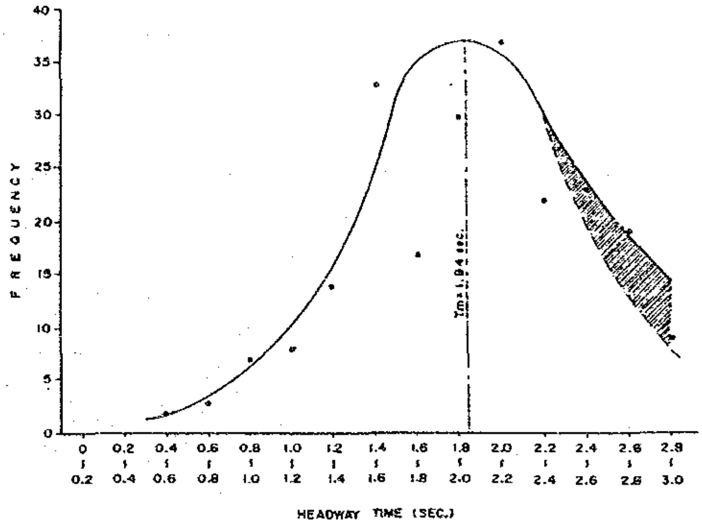



Figure 15 HEADWAY TIME ON TWO-LANE HIGHWAY
(TRICYCLE-CAR)

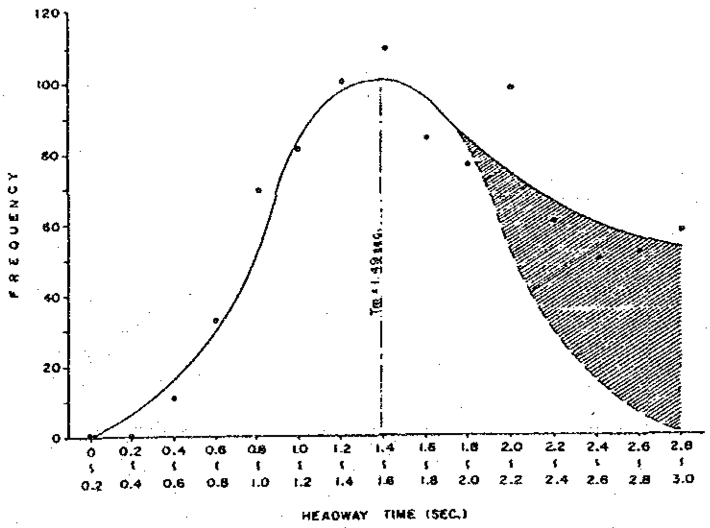



Figure 16 HEADWAY TIME ON TWO-LANE HIGHWAY
(TRICYCLE-TRICYCLE)

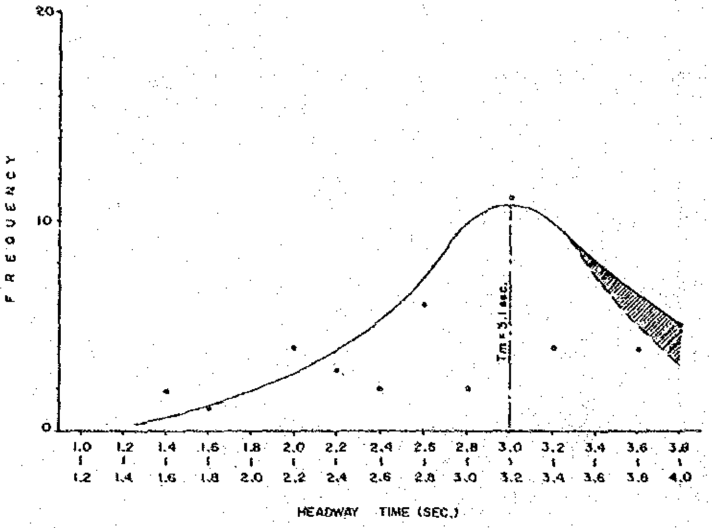



Figure 17 HEADWAY TIME ON TWO-LANE HIGHWAY
(CAR-JEEPNEY)

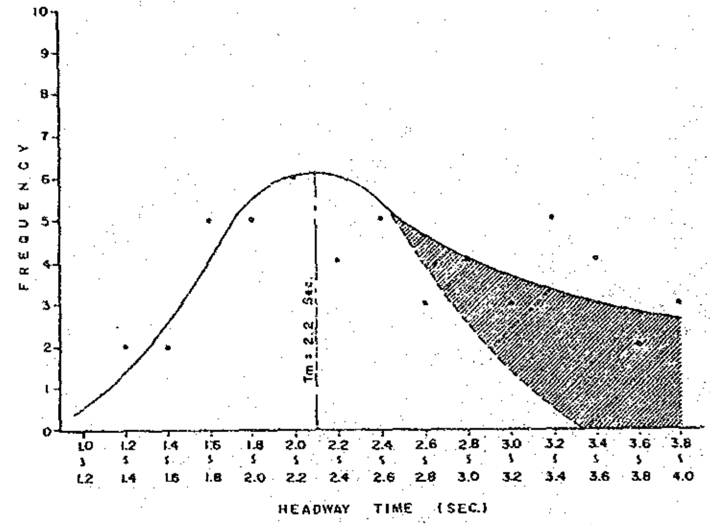



Figure 18 HEADWAY TIME ON TWO-LANE HIGHWAY
(JEEPNEY-CAR)

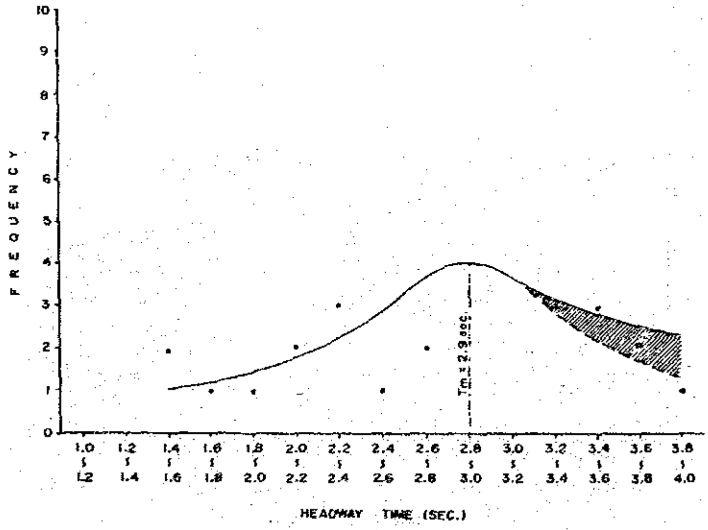



Figure 19 HEADWAY TIME ON TWO-LANE HIGHWAY
(JEEPNEY - JEEPNEY)

# APPENDIX 3-1
# WORK SHEET AND TABLES FOR
# LEVEL OF SERVICE ANALYSIS
# - TWO-LANE HIGHWAY: GENERAL TERRAIN SEGMENT -

# WORKSHEET FOR GENERAL TERRAIN SEGMENTS

Site Identification: ____________ Date: ________ Time: ________

Name: ____________ Checked by: ____________

## I. GEOMETRIC DATA

NORTH

Shoulder ______ m.

______ m.

Shoulder ______ m.

Roadside Environment: Rural, Residential, Commercial

Design Speed: ________ kph

% No Passing: ________ %

Terrain (L.R.M.): ________

Segment Length: ________ km

## II. TRAFFIC DATA

Total Volume, Both Dir. ____________ vph

Flow Rate = Volume ÷ PHF

______ = ______ ÷ ___

Directional Distribution: ____________

Traffic Composition: Car ____ %, Jny ____ %, Mcy ____ %

Mtr ____ %, Trk ____ %, Bus ____ %

PHF: ________

## III. LEVEL OF SERVICE ANALYSIS

$$SF_i = 2.800 \times (v/c)_i \times f_d \times f_w \times f_{HV}$$

$$f_{HV} = 1 / (P_{car} + P_{jny} E_{jny} + P_{mcy} E_{mcy} + P_{mtr} E_{mtr} + P_{trk} E_{trk} + P_{bus} E_{bus})$$

| LOS | SF | = 2.800 × | (v/c) × Table 3.2-1 | $f_d$ × Table 3.2-2 | $f_w$ × Table 3.2-3 | $f_{HV}$ | $P_{car}$ | $P_{jny}$ | $E_{jny}$ | $P_{mcy}$ | $E_{mcy}$ | $P_{mtr}$ | $E_{mtr}$ | $P_{trk}$ | $E_{trk}$ | $P_{bus}$ | $E_{bus}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 2.800 | | | | | | | | | | | | | | | |
| B | | 2.800 | | | | | | | | | | | | | | | |
| C | | 2.800 | | | | | | | | | | | | | | | |
| D | | 2.800 | | | | | | | | | | | | | | | |
| E | | 2.800 | | | | | | | | | | | | | | | |

## IV. COMMENTS

Flow Rate ____________ vph LOS = ________

Table 3.2-1 LEVEL-OF-SERVICE CRITERIA FOR GENERAL TWO-LANE HIGHWAY SEGMENTS

| | | v/c RATIO[a] | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LEVEL TERRAIN | | | | | | | ROLLING TERRAIN | | | | | | | MOUNTAINOUS TERRAIN | | | | | |
| | PERCENT TIME DELAY | AVG[b] SPEED | PERCENT NO PASSING ZONES | | | | | | AVG[b] SPEED | PERCENT NO PASSING ZONES | | | | | | AVG[b] SPEED | PERCENT NO PASSING ZONES | | | | |
| LOS | | | 0 | 20 | 40 | 60 | 80 | 100 | | 0 | 20 | 40 | 60 | 80 | 100 | | 0 | 20 | 40 | 60 | 80 | 100 |
| A | ≤ 30 | ≥ 93 | 0.15 | 0.12 | 0.09 | 0.07 | 0.05 | 0.04 | ≥ 92 | 0.15 | 0.10 | 0.07 | 0.05 | 0.04 | 0.03 | ≥ 90 | 0.14 | 0.09 | 0.07 | 0.04 | 0.02 | 0.01 |
| B | ≤ 45 | ≥ 88 | 0.27 | 0.24 | 0.21 | 0.19 | 0.17 | 0.16 | ≥ 87 | 0.26 | 0.23 | 0.19 | 0.17 | 0.15 | 0.13 | ≥ 87 | 0.25 | 0.20 | 0.16 | 0.13 | 0.12 | 0.10 |
| C | ≤ 60 | ≥ 84 | 0.43 | 0.39 | 0.36 | 0.34 | 0.33 | 0.32 | ≥ 82 | 0.42 | 0.39 | 0.35 | 0.32 | 0.30 | 0.28 | ≥ 79 | 0.39 | 0.33 | 0.28 | 0.23 | 0.20 | 0.16 |
| D | ≤ 75 | ≥ 80 | 0.64 | 0.62 | 0.60 | 0.59 | 0.58 | 0.57 | ≥ 79 | 0.62 | 0.57 | 0.52 | 0.48 | 0.46 | 0.43 | ≥ 72 | 0.58 | 0.50 | 0.45 | 0.40 | 0.37 | 0.33 |
| E | > 75 | ≥ 72 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | ≥ 64 | 0.97 | 0.94 | 0.92 | 0.91 | 0.90 | 0.90 | ≥ 56 | 0.91 | 0.87 | 0.84 | 0.82 | 0.80 | 0.78 |
| F | 100 | < 72 | — | — | — | — | — | — | < 64 | — | — | — | — | — | — | < 56 | — | — | — | — | — | — |

[a] Ratio of flow rate to an ideal capacity of 2,800 pcph in both directions.
[b] Average travel speed of all vehicles (in mph) for highways with design speed ≥ 96kph; for highways with lower design speeds, reduce speed by 6 kph for each 16 kph reduction in design speed below 96kph; assumes that speed is not restricted to lower values by regulation.

Table 3.2-2 ADJUSTMENT FACTORS FOR DIRECTIONAL DISTRIBUTION ON GENERAL TERRAIN SEGMENTS

| Directional Distribution | 100/0 | 90/10 | 80/20 | 70/30 | 60/40 | 50/50 |
|---|---|---|---|---|---|---|
| Adjustment Factor, $f_d$ | 0.71 | 0.75 | 0.83 | 0.89 | 0.94 | 1.00 |

Table 3.2-3 ADJUSTMENT FACTORS FOR THE COMBINED EFFECT OF NARROW LANES AND RESTRICTED SHOULDER WIDTH, $f_w$

| USABLE[a] SHOULDER WIDTH (FT) | 3.65m LANES | | 3.35m LANES | | 3.05m LANES | | 2.75m LANES | |
|---|---|---|---|---|---|---|---|---|
| | LOS A–D | LOS[b] E | LOS A–D | LOS[b] E | LOS A–D | LOS[b] E | LOS A–D | LOS[b] E |
| ≥ 1.8 | 1.00 | 1.00 | 0.93 | 0.94 | 0.84 | 0.87 | 0.70 | 0.76 |
| 1.2 | 0.92 | 0.97 | 0.85 | 0.92 | 0.77 | 0.85 | 0.65 | 0.74 |
| 0.6 | 0.81 | 0.93 | 0.75 | 0.88 | 0.68 | 0.81 | 0.57 | 0.70 |
| 0 | 0.70 | 0.88 | 0.65 | 0.82 | 0.58 | 0.75 | 0.49 | 0.66 |

[a] Where shoulder width is different on each side of the roadway, use the average shoulder width.
[b] Factor applies for all speeds less than 72 kph

Table 3.2-4 AVERAGE PASSENGER-CAR EQUIVALENTS FOR TRUCKS, RV'S, AND BUSES ON TWO-LANE HIGHWAYS OVER GENERAL TERRAIN SEGMENTS

| VEHICLE TYPE | LEVEL OF SERVICE | TYPE OF TERRAIN | | |
|---|---|---|---|---|
| | | LEVEL | ROLLING | MOUNTAINOUS |
| Trucks, $E_T$ | A | 2.0 | 4.0 | 7.0 |
| | B and C | 2.2 | 5.0 | 10.0 |
| | D and E | 2.0 | 5.0 | 12.0 |
| RV's $E_R$ | A | 2.2 | 3.2 | 5.0 |
| | B and C | 2.5 | 3.9 | 5.2 |
| | D and E | 1.6 | 3.3 | 5.2 |
| Buses, $E_B$ | A | 1.8 | 3.0 | 5.7 |
| | B and C | 2.0 | 3.4 | 6.0 |
| | D and E | 1.6 | 2.9 | 6.5 |

SOURCE: Ref. 6

TABLE 3.2-5 AVERAGE PASSENGER CAR EQUIVALENT FOR JEEPNEYS, MOTORCYCLES AND MOTORTRICYCLES

| Vehicle Type | Level of Service | Roadside Environment | Terrain Level |
|---|---|---|---|
| Jeeoney, Ejny | all | Rural | 1.5 |
| | | Residential | 1.5 |
| | | Commercial | 1.5 |
| Motorcycle, Emcy | all | Rural | 0.5 |
| | | Residential | 0.5 |
| | | Commercial | 0.5 |
| Motorcycle, Emtr | all | Rural | 1.0 |
| | | Residential | 1.0 |
| | | Commercial | 1.0 |

APPENDIX 3-2

WORK SHEETS AND TABLES FOR

LEVEL OF SERVICE ANALYSIS

- TWO-LANE HIGHWAY: SPECIFIC GRADE SEGMENT -

# WORKSHEET FOR SPECIFIC GRADES

Page 1

Site Identification:______________ Date:__________ Time:__________

Name:______________ Checked by:______________

## I. GEOMETRIC DATA

NORTH

Shoulder ______m.

______m.

Shoulder ______m.

Design Speed:__________kph.
Grade:________%,________km.
% No Passing Zones:__________

## II. TRAFFIC DATA

Total Volume, Both Dir.______________vph
Flow Rate = Volume ÷ PHF
________ = ______ ÷ _____

Directional Distribution:______________
Traffic Composition:______ %Truck, ______% Bus & Jny.
PHF:______________

## III. SOLVING FOR ADJUSTMENT FACTORS $f_g$ AND $f_{HV}$

$f_g = 1 / [1 + P_p I_p]$
$I_p = 0.02 (E - E_o)$

$f_{HV} = 1 / [1 + P_{HV} (E_{HV} - 1)]$
$E_{HV} = 1 + (0.25 + P_{T/HV}) (E - 1)$

| Speed (Kph) | $P_p$ | $I_p$ | E Table 3.2 - 8 | $E_o$ Table 3.2 - 8 | $f_g$ | $P_{HV}$ (including Jeepney) | $E_{HV}$ | $P_{T/HV}$ ($P_T/P_{HV}$) | E Table 3.2 - 8 | $f_{HV}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 88 | | | | | | | | | | |
| 84 | | | | | | | | | | |
| 80 | | | | | | | | | | |
| 72 | | | | | | | | | | |
| 64 | | | | | | | | | | |
| 48 | | | | | | | | | | |

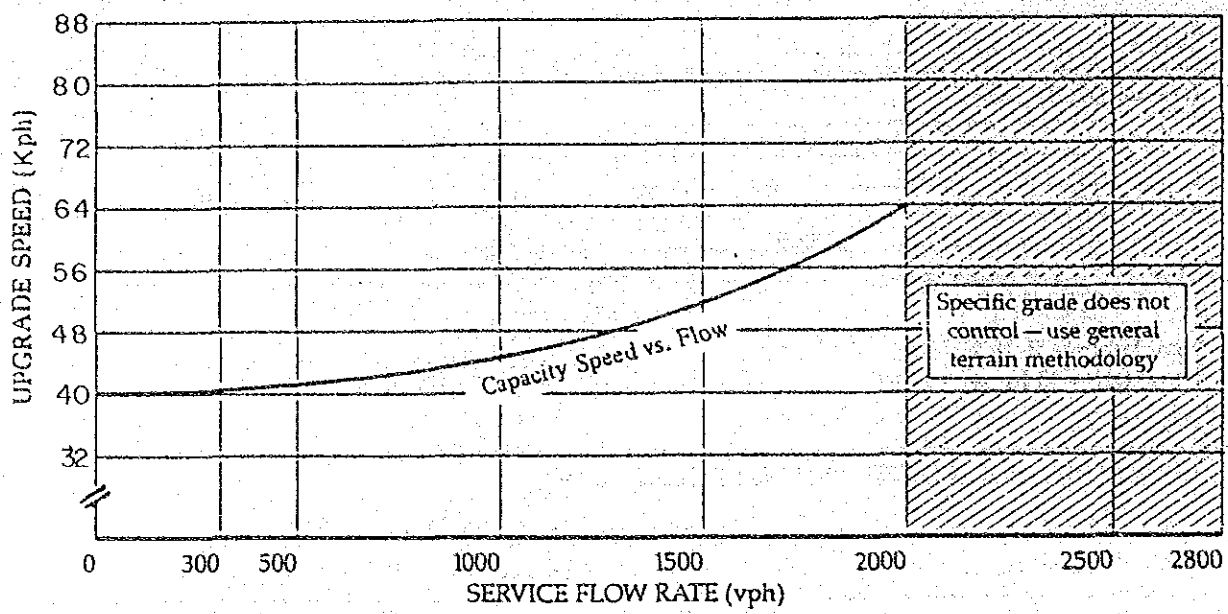
## IV. SOLVING FOR SERVICE FLOW RATE

| Speed (mph) | SF | 2,800 | × v/c | × $f_d$ | × $f_w$ | × $f_g$ | × $f_{HV}$ |
|---|---|---|---|---|---|---|---|
| | | | Table 3.2-6 | Table 3.2-7 | Table 3.2-3 | | |
| 88 (LOS A) | | 2,800 | | | | | |
| 84 | | 2,800 | | | | | |
| 80 (LOS B) | | 2,800 | | | | | |
| 72 (LOS C) | | 2,800 | | | | | |
| 64 (LOS D) | | 2,800 | | | | | |
| 48 | | 2,800 | | | | | |

## WORKSHEET FOR SPECIFIC GRADES

Page 2

### V. PLOT SF vs Speed




Intersection of Capacity Speed vs Flow curve with Service Flow Rate vs Speed curve defines Capacity, $SF_E$, and Speed at Capacity, $S_c$

### VI. LEVEL OF SERVICE ANALYSIS

| LOS | SF (from Worksheet) | Actual Flow Rate | Comments: |
|---|---|---|---|
| A | | | |
| B | | | |
| C | | | |
| D | | Level of Service | |
| E | | | |

Table 3.2-6 VALUES OF $v/c$ RATIO[a] VS. SPEED, PERCENT GRADE, AND PERCENT NO PASSING ZONES FOR SPECIFIC GRADES

| PERCENT GRADE | AVERAGE UPGRADE SPEED (KPH) | PERCENT NO PASSING ZONES | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 20 | 40 | 60 | 80 | 100 |
| 3 | 88 | 0.27 | 0.23 | 0.19 | 0.17 | 0.14 | 0.12 |
| | 84 | 0.42 | 0.38 | 0.33 | 0.31 | 0.29 | 0.27 |
| | 80 | 0.64 | 0.59 | 0.55 | 0.52 | 0.49 | 0.47 |
| | 72 | 1.00 | 0.95 | 0.91 | 0.88 | 0.86 | 0.84 |
| | 68 | 1.00 | 0.98 | 0.97 | 0.96 | 0.95 | 0.94 |
| | 64 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 4 | 88 | 0.25 | 0.21 | 0.18 | 0.16 | 0.13 | 0.11 |
| | 84 | 0.40 | 0.36 | 0.31 | 0.29 | 0.27 | 0.25 |
| | 80 | 0.61 | 0.56 | 0.52 | 0.49 | 0.47 | 0.45 |
| | 72 | 0.97 | 0.92 | 0.88 | 0.85 | 0.83 | 0.81 |
| | 68 | 0.99 | 0.96 | 0.95 | 0.94 | 0.93 | 0.92 |
| | 64 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 5 | 88 | 0.21 | 0.17 | 0.14 | 0.12 | 0.10 | 0.08 |
| | 84 | 0.36 | 0.31 | 0.27 | 0.24 | 0.22 | 0.20 |
| | 80 | 0.57 | 0.49 | 0.45 | 0.41 | 0.39 | 0.37 |
| | 72 | 0.93 | 0.84 | 0.79 | 0.75 | 0.72 | 0.70 |
| | 68 | 0.97 | 0.90 | 0.87 | 0.85 | 0.83 | 0.82 |
| | 64 | 0.98 | 0.96 | 0.95 | 0.94 | 0.93 | 0.92 |
| | 56 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 6 | 88 | 0.12 | 0.10 | 0.08 | 0.06 | 0.05 | 0.04 |
| | 84 | 0.27 | 0.22 | 0.18 | 0.16 | 0.14 | 0.13 |
| | 80 | 0.48 | 0.40 | 0.35 | 0.31 | 0.28 | 0.26 |
| | 72 | 0.89 | 0.76 | 0.68 | 0.63 | 0.59 | 0.55 |
| | 68 | 0.93 | 0.84 | 0.78 | 0.74 | 0.70 | 0.67 |
| | 64 | 0.97 | 0.91 | 0.87 | 0.83 | 0.81 | 0.78 |
| | 56 | 1.00 | 0.96 | 0.95 | 0.93 | 0.91 | 0.90 |
| | 48 | 1.00 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 |
| 7 | 88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 84 | 0.13 | 0.10 | 0.08 | 0.07 | 0.05 | 0.04 |
| | 80 | 0.34 | 0.27 | 0.22 | 0.18 | 0.15 | 0.12 |
| | 72 | 0.77 | 0.65 | 0.55 | 0.46 | 0.40 | 0.35 |
| | 68 | 0.86 | 0.75 | 0.67 | 0.60 | 0.54 | 0.48 |
| | 64 | 0.93 | 0.82 | 0.75 | 0.69 | 0.64 | 0.59 |
| | 56 | 1.00 | 0.91 | 0.87 | 0.82 | 0.79 | 0.76 |
| | 48 | 1.00 | 0.95 | 0.92 | 0.90 | 0.88 | 0.86 |

[a] Ratio of flow rate to ideal capacity of 2,800 pcph, assuming passenger-car operation is unaffected by grade.
NOTE: Interpolate for intermediate values of "Percent No Passing Zone"; round "Percent Grade" to the next higher integer value.

Table 3.2-7 ADJUSTMENT FACTOR FOR DIRECTIONAL DISTRIBUTION ON SPECIFIC GRADES, $f_d$

| PERCENT OF TRAFFIC ON UPGRADE | ADJUSTMENT FACTOR |
|---|---|
| 100 | 0.58 |
| 90 | 0.64 |
| 80 | 0.70 |
| 70 | 0.78 |
| 60 | 0.87 |
| 50 | 1.00 |
| 40 | 1.20 |
| 30 | 1.50 |

Table 3.2-8 PASSENGER-CAR EQUIVALENTS FOR SPECIFIC GRADES ON TWO-LANE RURAL HIGHWAYS, $E$ AND $E_o$

| GRADE (%) | LENGTH OF GRADE (MI) | AVERAGE UPGRADE SPEED (KPH) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 88 | 84 | 80 | 72 | 64 | 48 |
| 0 | All | 2.1 | 1.8 | 1.6 | 1.4 | 1.3 | 1.3 |
| 3 | 0.4 | 2.9 | 2.3 | 2.0 | 1.7 | 1.6 | 1.5 |
| | 0.8 | 3.7 | 2.9 | 2.4 | 2.0 | 1.8 | 1.7 |
| | 1.2 | 4.8 | 3.6 | 2.9 | 2.3 | 2.0 | 1.9 |
| | 1.6 | 6.5 | 4.6 | 3.5 | 2.6 | 2.3 | 2.1 |
| | 2.4 | 11.2 | 6.6 | 5.1 | 3.4 | 2.9 | 2.5 |
| | 3.2 | 19.8 | 9.3 | 6.7 | 4.6 | 3.7 | 2.9 |
| | 4.8 | 71.0 | 21.0 | 10.8 | 7.3 | 5.6 | 3.8 |
| | 6.4 | [a] | 48.0 | 20.5 | 11.3 | 7.7 | 4.9 |
| 4 | 0.4 | 3.2 | 2.5 | 2.2 | 1.8 | 1.7 | 1.6 |
| | 0.8 | 4.4 | 3.4 | 2.8 | 2.2 | 2.0 | 1.9 |
| | 1.2 | 6.3 | 4.4 | 3.5 | 2.7 | 2.3 | 2.1 |
| | 1.6 | 9.6 | 6.3 | 4.5 | 3.2 | 2.7 | 2.4 |
| | 2.4 | 19.5 | 10.3 | 7.4 | 4.7 | 3.8 | 3.1 |
| | 3.2 | 43.0 | 16.1 | 10.8 | 6.9 | 5.3 | 3.8 |
| | 4.8 | [a] | 48.0 | 20.0 | 12.5 | 9.0 | 5.5 |
| | 6.4 | [a] | [a] | 51.0 | 22.8 | 13.8 | 7.4 |
| 5 | 0.4 | 3.6 | 2.8 | 2.3 | 2.0 | 1.8 | 1.7 |
| | 0.8 | 5.4 | 3.9 | 3.2 | 2.5 | 2.2 | 2.0 |
| | 1.2 | 8.3 | 5.7 | 4.3 | 3.1 | 2.7 | 2.4 |
| | 1.6 | 14.1 | 8.4 | 5.9 | 4.0 | 3.3 | 2.8 |
| | 2.4 | 34.0 | 16.0 | 10.8 | 6.3 | 4.9 | 3.8 |
| | 3.2 | 91.0 | 28.3 | 17.4 | 10.2 | 7.5 | 4.8 |
| | 4.8 | [a] | [a] | 37.0 | 22.0 | 14.6 | 7.8 |
| | 6.4 | [a] | [a] | [a] | 55.0 | 25.0 | 11.5 |
| 6 | 0.4 | 4.0 | 3.1 | 2.5 | 2.1 | 1.9 | 1.8 |
| | 0.8 | 6.5 | 4.8 | 3.7 | 2.8 | 2.4 | 2.2 |
| | 1.2 | 11.0 | 7.2 | 5.2 | 3.7 | 3.1 | 2.7 |
| | 1.6 | 20.4 | 11.7 | 7.8 | 4.9 | 4.0 | 3.3 |
| | 2.4 | 60.0 | 25.2 | 16.0 | 8.5 | 6.4 | 4.7 |
| | 3.2 | [a] | 50.0 | 28.2 | 15.3 | 10.7 | 6.3 |
| | 4.8 | [a] | [a] | 70.0 | 38.0 | 23.9 | 11.3 |
| | 6.4 | [a] | [a] | [a] | 90.0 | 45.0 | 18.1 |
| 7 | 0.4 | 4.5 | 3.4 | 2.7 | 2.2 | 2.0 | 1.9 |
| | 0.8 | 7.9 | 5.7 | 4.2 | 3.2 | 2.7 | 2.4 |
| | 1.2 | 14.5 | 9.1 | 6.3 | 4.3 | 3.6 | 3.0 |
| | 1.6 | 31.4 | 16.0 | 10.0 | 6.1 | 4.8 | 3.8 |
| | 2.4 | [a] | 39.5 | 23.5 | 11.5 | 8.4 | 5.8 |
| | 3.2 | [a] | 88.0 | 46.0 | 22.8 | 15.4 | 8.2 |
| | 4.8 | [a] | [a] | [a] | 66.0 | 38.5 | 16.1 |
| | 6.4 | [a] | [a] | [a] | [a] | [a] | 28.0 |

[a] Speed not attainable on grade specified.
NOTE: Round "Percent Grade" to next higher integer value.