## 7.3 TRAFFIC SURVEY AND FORECAST

### 7.3.1 Approach

1) Traffic Forecast Procedure

Based on the results of the analysis of regional characteristics, traffic survey and projection of agricultural development, forecast of future traffic volumes was made for the proposed routes. The forecasted traffic was given by type of vehicle in the first, 7th and 15th years after the opening of the proposed routes, both in with and without project cases.

The flow of the traffic forecast is illustrated in Figure 7.3.1.

Method employed for the forecasting was either "Growth Rate Method" or "Assignment Method" depending on the characteristics of proposed routes.

The Assignment Method was applied only to the proposed route IM-1, 7, 25, 28, 30 and 33 where a considerable diverted traffic and/or much induced traffic is expected after improvement of the roads, while the Growth Rate Method is applied to the remaining routes.

The traffic forecast was made according to the following steps:

a) Growth Rate Method

- Estimation of traffic volume (ADT) by vehicle type for base year (1982) based on the traffic count survey.

- Estimation of traffic volume of the passenger and the freight movement for 1982 converting estimated ADT to them according to the occupancy rate and average load obtained from the O/D survey.

- Estimation of future growth of the passenger movement based on future growth rate of population and GRP, and elasticities of transportation demand.

- Estimation of future growth of the freight movements in correlation with the passenger movement for non-agricultural freight movement, and in application of the growth rates of agricultural production for agricultural freight movement.

- Forecast of future ADT converting the estimated volumes of future passenger and freight movement using future occupancy rate and average load by vehicle type and traffic composition.

b) Assignment Method

- Traffic zoning and measurement of road link conditions.

- Estimation of volumes of passenger and freight movement by origin-destination pair for 1982 based on the present population and agricultural production in the traffic zone and O/D survey results.

- Forecast of future ADT by vehicle type based on the assigned traffic movement for 1982 by applying the same growth rates, occupancy rate, average load and traffic composition as mentioned in the above a).

2) Type of Traffic and Vehicle

a) Type of Traffic

For the purpose of estimation of road users' benefits, traffic was classified into four types of traffic, i.e., normal, diverted, induced and developed traffic.

Normal Traffic is defined as the traffic which takes place on the existing road, arising from the natural increase of population and economic activities independent of the road improvement.

Diverted Traffic is defined as the traffic which may change its routes due to the improvement or new construction of road.

Induced Traffic is defined as the extra traffic which is newly generated as a result of improvement of transport condition such as decrease of traveling time and cost. In the estimation of induced traffic, only population with natural growth would be considered as a source of traffic, in other words, population increase by migration would be disregarded.

Developed Traffic is defined as the traffic which occurs in excess of natural growth of population and economic activities due to the agricultural development attributable to the road development.

b) Type of Vehicle

According to the result of traffic surveys in the study area, the present traffic can be classified into ten types of vehicles in views of trip purpose, shape of vehicle and public/private use. They are motorcycle, passenger car, pickup (passenger use), light bus, medium bus and heavy bus for passenger traffic and pickup (truck use), 4-wheel truck, 6-wheel truck and 10-wheel truck for freight traffic.

Since no significant change is predicted, the future traffic was also forecasted with these ten types of vehicles.

Representative type of vehicles and characteristics of each class were recognized as below:

Motorcycle (M/C) - Two-wheel vehicle such as Suzuki A 100 and Honda Dt 100. The engine capacity of the representative type is 100 cc.

Passenger Car (P/C) - Vehicles such as Toyota Corolla, Corona with 1,300 cc petrol engine.

Pickup for passenger use (P/P) - Vehicle type is the same as so-called "pickup truck" such as Toyota Hilux and Datsun 1600 but they are mainly used for passenger trip. The engine capacity of representative type is about 1,600 cc.

Light Bus (L/B) - Such vehicles represented by Isuzu Faster and Toyota Hilux whose engine capacity ranges 1,600 cc to 2,000 cc. They provide longitudinal bench seats and canopy of canvas. The seat capacity is about 10.

Medium Bus (M/B) - Representative type is Toyota Dina with diesel engine of about 4,500 cc in capacity. It provides longitudinal bench seats and canopy of canvas. The seat capacity is about 16.

Heavy Bus (H/B) - Representative type is Hino Bx 321. The seat capacity is about 38.

Pickup for Truck Use (P/T) - The representative type is the same as pickup for passenger use but they are used mainly for freight transport. The loading capacity is about 1 ton.

4-Wheel Truck (4/T) - Truck such as Isuzu 250 diesel. The loading capacity is about 4 tons.

6-Wheel Truck (6/T) - Double axle truck such as Isuzu 250 diesel and Isuzu 85 HP. The loading capacity is about 6 tons.

10-Wheel Truck (10/T) - Triple axle truck such as Isuzu 120. The loading capacity is about 13 tons.

### 7.3.2 Traffic Survey

#### 1) O/D Survey and Traffic Counts

Roadside interviews to drivers and bus passengers (O/D survey), and automatic traffic counts and classified manual counts were conducted at 42 survey points in total.

Number of the survey points and survey times by each survey were as follows:

Number of Survey Points and Survey Times

| Survey | Survey Point | Survey Time |
|---|---|---|
| Road Side Interview | 7 | 6.00 a.m. - 4.00 p.m. |
| Traffic Counts | 42 | 6.00 a.m. - 6.00 p.m. (manual)<br>more than 24 hours (automatic) |
| Bus Passenger Interview | 7 | |

Their locations are shown in Appendix 7.1.

a) Roadside Interview to Driver

The roadside interviews aimed mainly to derive the O/D patterns between traffic zones in each project area. In addition, other information useful for the traffic forecast was also collected.

The main survey items are as follows:

- Origin and destination of vehicle trip
- Kind of commodities loaded and average load of freight vehicle
- Average number of passengers in passenger vehicle
- Vehicle type
- Occupancy rate of vehicle

b) Interview to Bus Passengers

To obtain O/D pattern of passenger movement, interview survey to bus passengers was carried out. This survey was conducted by interview to bus passengers on the representative bus routes around the proposed route.

c) Traffic Counts

Manual traffic counts by vehicle type and automatic counts were conducted at each site of roadside interview. The data were used for the estimation of an expansion factor to be employed in obtaining average daily traffic volume.

2) Home Interview Survey

The home interview survey aimed mainly to obtain the supporting data for the estimation of income elasticity coefficient which should be the basis of projection of future growth rate of passenger transportation demands.

The survey was conducted along each proposed routes. Number of samples collected was about 30 by each route and 1,000 in total.

The main survey items are as follows:

- Household income
- Household expenditure for transportation
- Number of person trip by vehicle type

At the same time, information necessary for assessment of social impact as described in 7.8 was also collected.

### 7.3.3 Traffic Forecasting

Comparing the Growth Rate Method and the Assignment Method mentioned in 7.3.1, methodologies and procedures to estimate passenger and freight movement in base year are quite different, but procedures to project future traffic based on estimated base year movement are almost same.

1) Passenger and Freight Movement in Base Year

a) Growth Rate Method

Passenger and freight movement were estimated converting ADT by vehicle type using average occupancy and load obtained from O/D Survey. Adjustment of seasonal fluctuation was made analyzing through year traffic count data of DOH. Seasonal fluctuation parameter was as follows.

ADT = Counted Traffic Number/0.95

The average occupancy and load by vehicle type obtained in the O/D Survey are shown below.

Average Occupancy

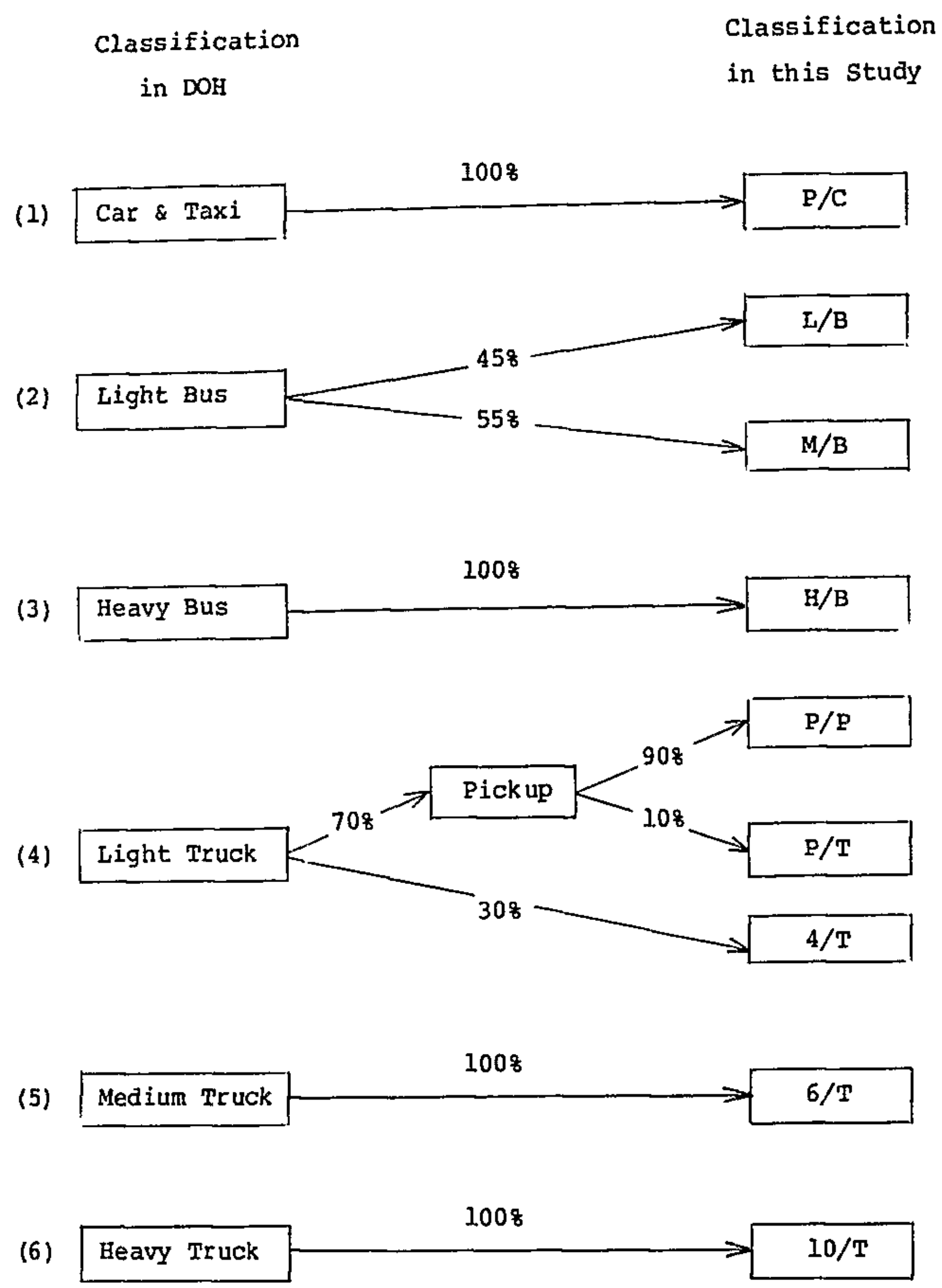
| Vehicle Type | | Occupancy (person/vehicle) |
|---|---|---|
| Passenger Car | (P/C) | 3.0 |
| Pickup Truck, Passenger Use | (P/P) | 3.8 |
| Light Bus | (L/B) | 14.5 |
| Medium Bus | (M/B) | 20.6 |
| Heavy Bus | (H/B) | 38.7 |

Average Load

| Vehicle Type | | Average Load of Loaded Truck (ton/vehicle) | Loaded Trucks Ratio (%) | Ave. Loading (ton/vehicle) |
|---|---|---|---|---|
| Pickup Truck, Freight Use | (P/T) | 1.19 | 50 | 0.60 |
| 4-Wheel Truck | (4/T) | 1.34 | 55 | 0.74 |
| 6-Wheel Truck | (6/T) | 3.74 | 58 | 2.17 |
| 10-Wheel Truck | (10/T) | 13.05 | 66 | 8.61 |

Classification of vehicle type by DOH is different from that of this Study. Where traffic count data of DOH were used, therefore, the classification in DOH was converted by the following propotions referring to the results of the O/D survey.

<u>Conversion of Vehicle Type</u>




Base traffic volumes adjusted through the procedure mentioned above are shown in Route Report.

b) Assignment Method

i) Zoning

The area of influence of each proposed routes subject to the Assignment Method was divided into several traffic zones. Traffic zonings as indicated in Route Report were made taking into consideration the road networks, constraints of physical features such as rivers and mountains, and Tambon boundaries. Population and agricultural products by traffic zone were estimated basing on Tambon statistics or prorating total production in the area of influence. The zone node was set at the place being most predominant in terms of socio-economic activities within a zone.

ii) Road Link

The related existing roads and the proposed routes were divided into several road links which were assumed to be uniform throughout the link in its characteristics such as surface condition and traffic volume. Assuming the opening year of the project at 1987, the related roads which are committed to be improved or constructed by 1987 under the Government programs were regarded as improved ones in both cases of with and without project. Dummy nodes were placed at the intersections of the road link and other roads in addition to the zone node. The specific road characteristics, i.e., distance, surface condition, average traveling speed, improvement plan under the Government program were surveyed through the field reconnaissance, road inventory survey and data available in the DOH. For the sake of simplification, the road links were classified into one of the 11 road grades considering surface condition, alignment and traveling speed as shown below:

Road Grade

| Grade | Surface Condition | Alignment | Traveling Speed (km/h) |
|---|---|---|---|
| 1 | AC | Good | 85 |
| 2 | AC | Fair | 75 |
| 3 | AC | Bad | 65 |
| 4 | DBST | Good | 78 |
| 5 | DBST | Fair | 68 |
| 6 | DBST | Bad | 58 |
| 7 | SA | Good | 58 |
| 8 | SA | Fair | 48 |
| 9 | SA | Bad | 38 |
| 10 | Earth | Fair | 21 |
| 11 | Earth | Bad | 16 |

Note: AC = Asphaltic Concrete
DBST = Double Bituminous Surface Treatment
SA = Soil Aggregate Surfacing

iii) Estimation of Passenger Transportation Demand

In accordance with the traffic zoning, transportation demands of passenger by origin and destination pair was estimated in the base year (1982).

A mathematical model of gravity type, of which variables are population size in traffic zone and traveling time between zones was developed for the estimation of passenger traffic demands. The model formula is as follows:

$$V_{ij} = Q_i \cdot k \cdot \frac{Q_j^a}{t_{ij}^b}$$

where, $V_{ij}$ : Transportation demands of passenger between zone i and zone j (trip/day)

$Q_i$ : population size in origin zone i

$Q_j$ : population size in destination zone j

$t_{ij}$ : traveling time between zone i and zone j

a, b, k : model parameter

The model parameters, a, b and k, were determined by a least square method. The regression analysis was made on the correlation of the data on number of trips by O/D pair obtained from the results of roadside interview survey, present population size of corresponding traffic zones and actual traveling time between the zones under existing road network condition. In general, O/D Survey by roadside interview can not catch all of the transportation demands to be generated in a zone, because some of traffic may move on the other routes without passing the O/D stations. Furthermore, a pattern of traffic observed through O/D survey is characterized depending on the specific functions and conditions of the road on which the survey station is located. Therefore, the data of actual transportation demand of passenger were carefully checked to obtain the reasonable input data for the estimation of model parameters. Then 35 data were selected among the results of O/D Survey. The estimated parameters together with the correlation coefficient between the actual transportation demands and that estimated by the model are shown below:

Estimated Model Parameters

| Parameter | | | Correlation Coefficient |
|---|---|---|---|
| a | b | k | |
| 0.470 | 1.194 | 167.9 | 0.96 |

In case of the estimation of passenger transportation demands in base year at 1982, projected population by traffic zone and traveling time between zones which is calculated by searching minimum pass for O/D pair concerned based on the road link data, were given as the inputs for the calculation.

iv) Passenger Transportation Demand by Type

For the sake of VOC benefit calculation, the estimation was made for the transportation demands of passenger corresponding to each type of traffic, normal and induced, applying the model formula denoted above.

Calculation formula of the transportation demand for passenger by traffic type are as follows:

Calculation Formula of Transportation Demand by Type

(Passenger Traffic)

| Type | Description | Calculation Formulae 1/ |
|---|---|---|
| Normal | Corresponds to the population with natural growth | $V_{ij}^{(N)} = \bar{Q}_i \cdot k \cdot \frac{\bar{Q}_j^a}{\bar{t}_{ij}^b}$ |
| Induced | Corresponds to the difference in the traveling time between with and without project | $V_{ij}^{(I)} = \bar{Q}_i \cdot k \cdot \frac{\bar{Q}_j^a}{t_{ij}^b} - \bar{Q}_i \cdot k \cdot \frac{\bar{Q}_j^a}{\bar{t}_{ij}^b}$ |

1/: $V_{ij}^{(N)}$ : Normal transportation demand between zone i and zone j

$V_{ij}^{(I)}$ : Induced transportation demand between zone i and zone j

$V_{ij}^{(DV)}$ : Developed transportation demand between zone i and zone j

$\bar{Q}_i$ : Population in zone i of without project

$Q_i$ : Population in zone i of with project

$\bar{t}_{ij}$ : Minimum traveling time between zone i and zone j of without project

$t_{ij}$ : Minimum traveling time between zone i and zone j of with project

a, b, k : Model parameter

v) Link Assignment of Passenger

Assignment of the transportation demands by type to road links was carried out searching the most probable route by O/D pair under the all or nothing method taking minimum traveling time as a sole yardstick.

In order to clarify the traffic types of normal, diverted and induced, four cases of combination of transportation demands and road network were set up for link assignment as shown below:

Case of Link Assignment

| Case | Transportation Demand | Road 2/ Network in | Type of Traffic on Road Link |
|---|---|---|---|
| 1 | $V_{ij}^{(N)}$ | $\bar{W}$ | Normal |
| 2 | $V_{ij}^{(N)}$ | W | Normal + Diverted |
| 3 | $V_{ij}^{(I)}$ | W | Induced |
| 4 1/ | $V_{ij}^{(I)}$ | $\bar{W}$ | - |

1/ : Hypothetical case for use of benefit calculation

2/ : $\bar{W}$ : without project case

W : with project case

vi) Estimation of Freight Movement

- Non-agricultural Freight Traffic:

The freight traffic except agricultural freight was estimated on the basis of the relationship between passenger movement and tonnage of general freight on a road link. A model of exponential type was assumed to the relationship as shown in the following formula:

$$Z_i = a \cdot Y_i^b$$

Where, $Z_i$ : tonnage of non-agricultural freight carried on road link i

$Y_i$ : passenger movement on road link i

a,b: model parameter

The actual data of $Y_i$ and $Zi$, which were obtained from the roadside interview survey, were used for the estimation of the parameters. Parameters were estimated as shown below:

Estimated Parameters

| a | b | Corr. Coefficient |
|---|---|---|
| 0.00576 | 1.288 | 0.98 |

The transportation demands of non-agricultural freight by traffic type, i.e. normal and induced traffic, were also estimated basing on the above equation applying corresponding figures of passenger transportation demand by type.

- Agricultural Freight Movement

The transportation demand of agricultural freight was estimated, based on the agricultural production volume forecasted in Section 7.6, applying the following equations:

$$F_{Ti} = F_{Ni} \cdot (F_{AA}/F_{NA})$$

where, $F_{Ti}$ = Total freight movement by link
$F_{Ni}$ = Non-agricultural freight movement by link
$F_{AA}$ = Average agricultural freight movement by route
$F_{NA}$ = Average non-agricultural freight movement calculated based on $F_{Ni}$

The ratios of $F_{AA}/F_{NA}$ are shown in Route Report.

2) Estimation of Future Passenger and Freight Movement

Future passenger and freight movement were estimated multiplying their estimated movements in base year by growth rates established as mentioned below.

a) Growth of Passenger Movement

The growth rate of passenger movement were calculated by the following equation:

$$G = GC \cdot EC + GT \cdot ET + GP \cdot EP$$

where, G : Growth rate of passenger movement
GC : Growth rate of per capita GRP
GT : Growth rate of transportation price increase
GP : Growth rate of population
EC : Income elasticity of person trip
ET : Transportation price elasticity of person trip
EP : Population elasticity of person trip

In the estimation of the growth rate of passenger movement the following rates were employed:

| Item | 1982-1987 | 1987-1993 | 1993-2001 |
|---|---|---|---|
| Per Capita GRP (% p.a.) | 4.2 | 4.5 | 4.7 |
| Transportation Price Increase (% p.a.) | 4.5 | 4.5 | 4.5 |
| Population | as estimated by Amphoe in Text | | |

Income elasticity of person trip was estimated to be 1.218 based on the result of Home Interview Survey.

Transportation price elasticity was quoted to be -0.24 from previous study. And population elasticity was assumed to be 1.0.

The growth rate of passenger movement calculated by each proposed route is shown in Route Report.

b) Growth Rate of Freight Movement

Growth of freight movement was estimated separating for non-agricultural freight and agricultural freight.

Non-agricultural movement by proposed route was obtained by the formula mentioned in 1) b) - vi) of 7.3.3.

The growth of agricultural freight was based on the growth of agricultural production described in 7.6.

The growth rates of freight movement by proposed route are shown in Route Report.

3) Induced and Developed Traffic

a) Induced Traffic

In the case of Assignment Method, the induced traffic were estimated as described in Section 1) b) - iv) in 7.3.3.

For the cases of Growth Rate Method, induced traffic was estimated multiplying normal traffic of passenger and freight by the ratio of induced traffic. The induced traffic ratio used in this Study is 15 %, which is commonly used in the study of DOH.

b) Developed Traffic

Developed traffic was estimated multiplying the normal plus induced traffic to the ratio of developed traffic.

The ratio of developed traffic was calculated by the following formula.

$$R_D = (A_W - A_{\overline{W}}) / A_{\overline{W}}$$

where, $R_D$ : Ratio of developed traffic

$A_W$ : Cultivated area in case of with project

$A_{\overline{W}}$ : Cultivated area in case of without project

The ratio of developed movement by proposed route is shown in Route Report.

4) Estimation of Traffic Volume by Vehicle Type

The forecasted traffic movements were transformed into traffic volume by vehicle type applying estimated traffic composition described below and the occupancy rates and average loads previously obtained from the field survey results.

Present traffic composition was adopted, as a traffic composition in base year. Present traffic composition was obtained through analysis of data of the roadside interview survey, manual traffic counts and traffic records by DOH. In case no existing composition is available, such as the case of routes of which traffic volume was forecasted applying assignment method, the adopted traffic composition was those of the road of which surface condition was similar to and located near the proposed routes.

Traffic composition in 2001 was estimated on the following conditions;

Traffic Composition in 2001

| Kinds of Movements | | | Without Project | With Project |
|---|---|---|---|---|
| Passenger | Private | Total | 41% 1/<br>PE 2/ | (In case of PE 41%)<br>(In case of PE 41%) |
| | | By Vehicle Type | Present Proportion | Proportion on Paved Road |
| | Public | Total | 59% 1/<br>100-PE | (In case of PE 41%)<br>(In case of PE 41%) |
| | | By Vehicle Type | Present Proportion | Proportion on Paved Road |
| Freight | | | Present Composition | Composition on Paved Road |

1/; From the result of Home Interview Survey

2/; PE is present private traffic percentage out of passenger traffic.

The present traffic composition on the existing paved highways is summarized as follows:

Traffic Composition on Paved Highway

| | | | | | |
|---|---|---|---|---|---|
| Passenger Traffic | P/C<br>15.8 | P/P<br>48.5 | L/B<br>13.2 | M/B<br>15.6 | H/B<br>6.9 |
| Freight Traffic | P/T<br>16.7 | 4/T<br>15.8 | 6/T<br>34.9 | 10/T<br>32.6 | |

Traffic composition in 1987 and 1993 were estimated interpolating those of base year and 2001.

For use in calculation of VOC savings, volume of motorcycle traffic was estimated applying a model developed analysing manual traffic count data. A model applied is as follows:

$$M/C = (3.817 - 0.490 \cdot \log_e ADT + 0.167 \cdot (L/B + M/B)/ADT) \cdot ADT$$

(r = 0.83)

Where,
- M/C : Motorcycle traffic (Vehicle/day)
- L/B : Light bus traffic (Vehicle/day)
- M/B : Medium bus traffic (Vehicle/day)
- ADT : Average daily traffic (Vehicle/day)

The method of estimation of motorcycle traffic volume by traffic type is as follows:

Normal

$$M/C^{(N)} = ADT^{(N)}.a - b.\log ADT^{(N)} + c . \frac{(L/B^{(N)} + M/B^{(N)})}{ADT^{(N)}}$$

Induced

$$M/C^{(I)} = M/C^{(N+I)} - M/C^{(N)}$$

$$= ADT^{(N+I)}.a - b.\log ADT^{(N+I)} + c.\frac{(L/B^{(N+I)} + M/B^{(N+I)})}{ADT^{(N+I)}}$$

$$- ADT^{(N)}.a - b.\log ADT^{(N)} + c.\frac{(L/B^{(N)} + M/B^{(N)})}{ADT^{(N)}}$$

Developed

$$M/C^{(DV)} = M/C^{(T)} - M/C^{(N+I)}$$

$$= ADT^{(T)}.a - b.\log ADT^{(T)} + c.\frac{(L/B^{(T)} + M/B^{(T)})}{ADT^{(T)}}$$

$$- ADT^{(N+I)}.a - b.\log ADT^{(N+I)} + c.\frac{(L/B^{(N+I)} + M/B^{(N+I)})}{ADT^{(N+I)}}$$

Where, T : Total traffic

N : normal traffic (including diverted traffic)

I : induced traffic

DV : developed traffic

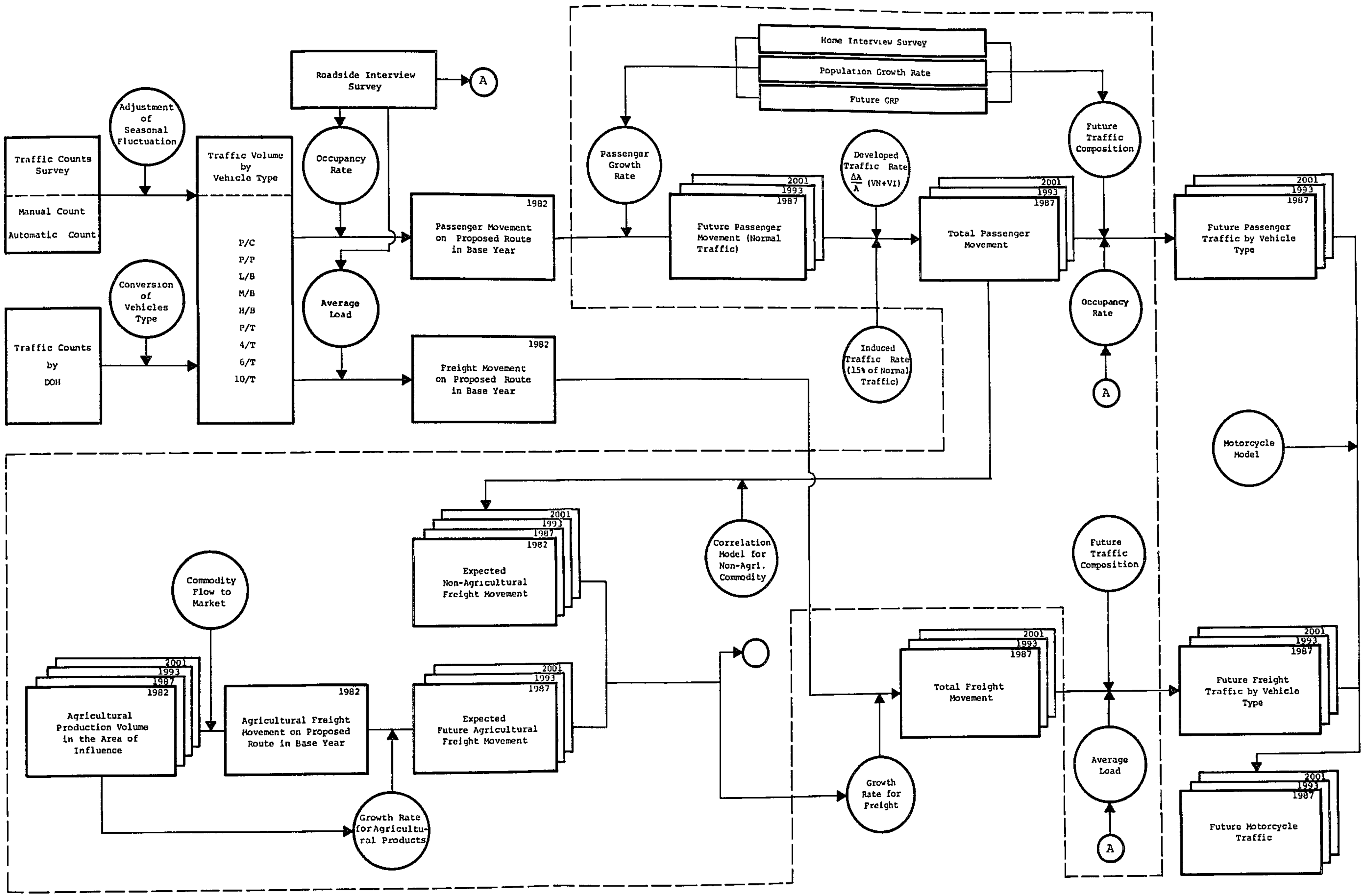
a,b,c,: Parameters

5) Forcasted ADT

Summary of the forcasted ADTs on each proposed routes in 1987, 1993 and 2001 are shown in table 7.3.1 and the details are given in Route Report.

# Figure 7.3.1 PROCESS OF TRAFFIC FORECASTING (I)

## (I) GROWTH RATE METHOD



# PROCESS OF TRAFFIC FORECASTING (2)

## (2) ASSIGNMENT METHOD

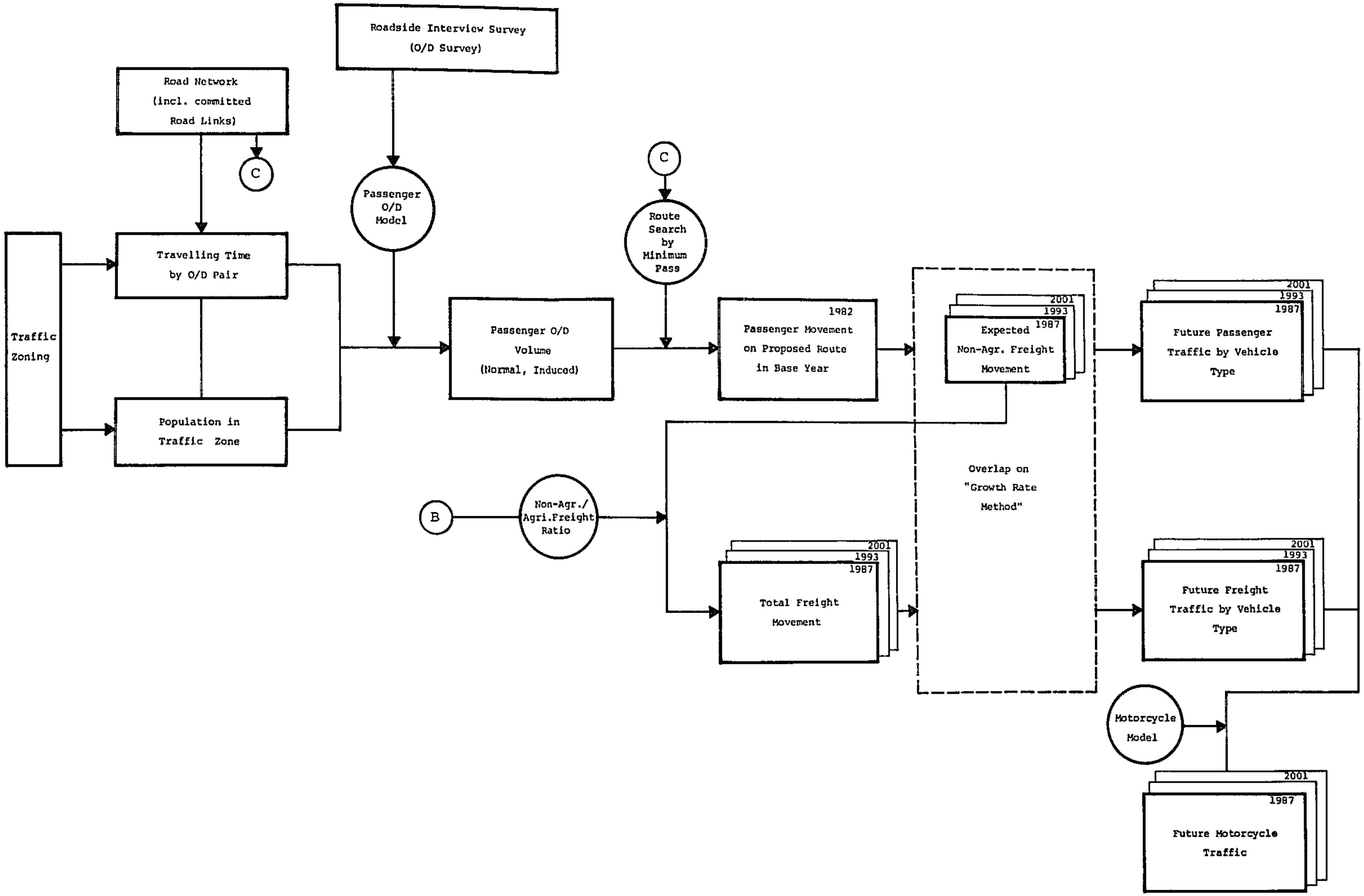


Table 7.3.1 FORECASTED ANNUAL DAILY TRAFFIC

(UNIT:VEHICLE/DAY)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | 185 | 239 | 335 |
| IM - 2 | B. WAEO | K.A. NA PHO | 243 | 333 | 499 |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 141 | 177 | 250 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 134 | 173 | 250 |
| IM - 5 | A. NAM PHONG | (J.R.209) | 455 | 622 | 957 |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | 136 | 174 | 254 |
| IM - 7 | B. KHOK LAT | B. THA YOM | 192 | 251 | 373 |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | 385 | 502 | 720 |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | 290 | 356 | 487 |
| IM - 10 | A. PHEN | (J.R.212) | 190 | 228 | 307 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | 95 | 118 | 167 |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | 359 | 466 | 670 |
| IM - 13 | B. CHUAM | A. NA WHA | 96 | 123 | 175 |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | 128 | 160 | 222 |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | 133 | 171 | 248 |
| IM - 16 | (J.R.212) | A. WHAN YAI | 86 | 105 | 142 |
| IM - 17 | A. KUCHINARAI | B. NA KHU | 167 | 211 | 298 |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | 149 | 188 | 262 |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | 387 | 486 | 674 |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | 136 | 170 | 236 |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | 447 | 623 | 997 |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | 121 | 169 | 267 |
| IM - 23 | B. DON CHIK | B. NON RIANG | 217 | 325 | 564 |
| IM - 24 | B. NA SUANG | B. NA YIA | 259 | 367 | 588 |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 202 | 270 | 407 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | 225 | 305 | 461 |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | 351 | 501 | 793 |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | 890 | 1,255 | 1,950 |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | 274 | 398 | 616 |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | 456 | 626 | 970 |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | 252 | 321 | 451 |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | 73 | 86 | 130 |
| IM - 33 | (J.R.2) | A. CHOKCHAI | 928 | 1,221 | 1,677 |

## 7.4 ENGINEERING STUDY AND COST ESTIMATES

### 7.4.1 Inventory Survey and Field Reconnaissance

1) Inventory Survey

To collect information necessary for the road design, the inventory survey for the identified 33 routes was carried out with an accuracy of pre-feasibility study level. The total length of routes surveyed was about 1,200 km.

The major items surveyed were the road length and width, general condition of alignment, surface type, embankment height/cutting depth, location and condition of bridges, terrain, land use and name of villages along the routes, and the past records of flood.

The results of inventory survey are shown in Route Report by each proposed route.

2) Field Reconnaissance

For the section which should be constructed newly, careful reconnaissances were performed for the engineering design. Prior to the reconnaissance, desk studies for the design were carried out based on the 1/50,000 scale topographic maps.

The main check points in the reconnaissance were:

i) required embankment height
ii) required cutting depth
iii) required drainage structures
iv) river condition and location and required length of bridges
v) difficulties of the acquisition of right-of-way

The reconnaissances were carried out about 75.0 km in total length for the whole section of IM-33 and partial sections of IM-1, IM-3, IM-26, IM-28 and IM-30.

### 7.4.2 Design Standard

Considering roles and functions of the proposed route, most of the routes were classified as provincial road defined in highway classification of DOH, except for 4 routes, IM-22, IM-28, IM-30 and IM-33, which may be classified to be national highway.

Due to the reasons that most of the routes are classified into provincial highway and for the purpose to evaluate at equal level, all proposed routes were designed based on the DOH Standard for provincial road.

DOH has the minimum design standards for provincial road under the name of F Standard. The F Standard is subdivided into seven road classes from FD to F6 according to the projected ADT as shown in Table 7.4.1.

Projected average ADTs at 7th year after opening of the proposed routes scatter between 87 and 1255 as given in 7.3.3. Based on this result, F3, F4 or F5 Standard must be adopted individually to each of routes corresponding to each of projected ADT.

For the first step of the economic evaluation, F4 class of Standard was applied to all proposed routes.

In case that the economic evaluation based on the design by F4 Standard would find some routes not economical, design under F5 Standard was applied to such routes for further evaluation.

### 7.4.3 Preliminary Design

1) Geometric Design

Alignment

The alignments of the proposed routes were designed utilizing the existing alignments as much as possible in order to minimize the construction cost. The improvement of alignment was considered in the section of only poor existing alignment.

New cnstruction sections were planned for about 75.0 km in total length as shown below.

Length of New Construction Section

| Proposed Route | Total | Length (km) Improvement Section | New Construction Section | Remark |
|---|---|---|---|---|
| IM-1 | 48.0 | 46.0 | 2.0 | To avoid flood section |
| IM-3 | 30.6 | 27.6 | 3.0 | Short cut |
| IM-26 | 39.5 | 35.5 | 4.0 | New alignment of DOH plan |
| IM-28 | 42.0 | 34.3 | 7.7 | Short cut |
| IM-30 | 51.0 | 44.5 | 6.5 | New alignment of DOH plan |
| IM-33 | 51.5 | - | 51.5 | |
| Total | 262.6 | 187.9 | 74.7 | |

Route alignments by proposed route are shown in Route Report, Volume 3.

Typical Cross Section

Typical cross sections of embankment type and cut type of F4 and F5 Standard are shown in Figure 7.4.1.

The major components of cross section such as the road width, the surface type, the cross slope are specified in the DOH's Standard and they were used unchanged in this Study. The other components such as the embankment and cut slopes and minimum depth of the side ditch were determined through the studies of the typical cross sections of the DOH's highway projects implemented recently.

2) Earthwork

Required minimum heights of embankment were determined mainly in consideration of the influence of surface water on the road structures. The minimum heights of embankment employed in this study are shown below.

Minimum Embankment Height

| Description | Minimum Height (m) |
|---|---|
| Ordinary Sections | 1.0 |
| Approach of Bridge in Flat Area | 2.0 |
| Flood Section | 0.7 (above flood level) |

Side borrow method is the most common and economical method for embankment construction in Thailand. This method was, therefore, applied to whole sections of the proposed roads and construction costs were estimated under this method.

Cutting was designed to improve poor exisitng vertical alignment in mountainous sections of only the two proposed routes, IM-6 and IM-22. Judging from observations during the inventory survey, only common soil is cut in IM-22, but considerable amount of hard rock has to be excavated in IM-6.

3) Pavement

According to the DOH Standard, the type of pavement for the road class of F4 Standard is low cost pavement, that is single bituminous surface treatment (SBST) and double bituminous surface treatment (DBST), consisting of soil aggregate subbase on a layer of selected material, crushed stone base and bituminous surface. In this Study, DBST is applied to whole proposed routes.

Thickness of pavement of DBST was determined referring to the DOH's typical pavement structures as follows:

F4 Standard

| | | |
|---|---|---|
| - DBST | | 2.5 cm |
| - Crushed stone base | CBR = 80% | 15 cm |
| - Soil aggregate subbase | CBR = 20% | 15 cm |
| - Selected material | CBR = 6% | 20 cm |

For F5 class road, soil aggregate surfacing is applied. The thickness was designed in accordance with the DOH typical pavement structure as follows:

F5 Standard

| | | |
|---|---|---|
| - Soil aggregqte surface | CBR = 20% | 15 cm |
| - Selected material | CBR = 6% | 20 cm |

Typical pavement structure for F4 and F5 are shown in Figure 7.4.1.

For the proposed routes designed with F5 Standard, the sections in built-up area and the sections connecting other paved roads were planned to be paved by DBST.

The overlay to be carried out at 8th year after opening was planned by 4 cm thickness of asphaltic concrete for DBST sections in both cases of F4 and F5 Standard.

4) Drainage

To maintain roads in all-weather condition, perfection of drainage facilities is an indispensable factor. The inventory survey revealed that the existing facilities of cross drainage on existing roads concerned are insufficient in number and capacity. Substantial improvement of drainage facilities was required for all proposed routes.

Pipe Culvert

Pipe culvert of 100 cm diameter in minimum was applied considering easy maintainance.

Average interval of pipe culvert was determined corresponding to land use along the proposed route, as follows:

Standard Interval of Pipe Culvert

| Land Use | Standard Interval (m) |
|---|---|
| Paddy Area | 200 |
| Others | 500 |

For the existing pipe culverts, their extension was proposed so as to match additional width of the existing road.

Box Cluvert

A size of 2.4 m x 2.4 m double cell type concrete culvert box was applied referring to the typical structures employed by DOH.

Required locations were determined based on the inventory surveys and reconnaissances.

5) Bridge

The bridges on the existing roads are mostly wooden bridges, but in some section, permanent concrete bridges are also located.

Among the concrete bridges, a few bridges recently constructed satisfy design loading and carriageway width required in F4 Standard, but others are made up with one lane and are judged from visual inspection to have insufficient bearing capacity. On the other hand, all wooden bridges are out of F4 standard in both bearing capacity and carriageway width. It was planned, therefore, to replace the existing concrete bridges insufficient for F4 Standard and all existing wooden bridges with normal concrete bridges or concrete box culverts.

Besides the replacement of the existing bridges, new concrete bridges were planned at the river crossing sites where no bridges exist and also in new construction section.

Length and location of bridges were determined using the data obtained in the inventory surveys and the reconnissances.

Types of the bridge were selected in accordance with the DOH's Standard bridge structures, taking the scale of rivers into account, as shown in the followings:

Types of Bridge Structures

| Description | Types of Super-structure |
|---|---|
| Short Span Bridge | RC - Slab |
| Long Span Bridge | PC - Girder |

Among the proposed roads, only one bridge about 120 m in length crossing over the Lam Chi river on proposed Route IM-28 was designed as a long span bridge and all other bridges as a short span bridge.

### 7.4.4 Construction Quantity and Cost

#### 1) Construction Quantity

Construction quantities on major work items were calculated on the basis of the engineering studies performed in the previous sections. The major construction works consist of the following 16 items:

- Clearing and grubbing
- Excavation - Soil
- Excavation - Hard rock
- Embankment (Side borrow method)
- Selected material
- Soil aggregate subbase
- Crushed stone base
- Soil aggregate shoulder
- Prime coat and DBST

- Asphalt Concrete (for Overlay)
- Pipe culvert
- Box culvert
- Long span bridge
- Short span bridge
- Land acquisition in highly developed land
- Land acquisition in less developed land

The areas of land acquisition attributable to the widening of existing road and to new construction road were calculated, classifying into developed land and less developed land, on the basis of data obtained during field surveys.

For the proposed routes which utilize DOH roads, land acquisition was not considered following usual practice for construction of DOH rural roads. Required width of right-of-way for other roads was planned to be 30 meters.

The calculated quantities of each proposed route are presented in Route Report.

2) Construction Cost

The unit rates as of 1982 to be used in this study were developed from the DOH's cost data and the latest bid prices on projects similar to the roads proposed in the Study.

The unit rates for the major items are shown in Table 7.4.2.

The construction costs of major work items were calculated by applying these unit rates to the estimated construction quantities. The costs of minor items such as side ditches, slope protection, guard rails, traffic signs etc., were estimated at 7 percent of total cost of major work items. The direct construction cost was obtained totaling these costs.

The total construction costs were calculated by adding the following cost items to the direct construction cost.

| | | |
|---|---|---|
| Physical contingency | : | 15 % of direct construction costs |
| Engineering and Administration | : | 10 % of direct construction costs |

The land acquisition costs were also calculated classifying the land of highly developed and less developed.

Economic construction cost to be used in the economic evaluation was calculated by deducting the tax component of each work item from the financial construction cost. The percentages of tax component included in the unit rate are shown in Table 7.4.2. They were determined referring to the previous studies on the similar type of construction in Thailand, under the assumption that the construction would be performed by local contractors.

The financial and economic costs by each proposed route are summarized in Table 7.4.3 and their detail are shown in Route Report.

Construction period by each proposed route was estimated based on the project scale.

The construction period including the detail design and the land aquisition and the ratio of yearly disbursement of construction cost were estimated as follows:

Construction Period and Cost Disbursement Ratio (%)

| Construction Cost ($10^3$B) | Construction Period (year) | Disbursement Ratio (%) 1st Year | 2nd Year | 3rd Year |
|---|---|---|---|---|
| less than 13,000 | 2 | 20 | 80 | |
| 15,000 - 60,000 | 2 | 40 | 60 | |
| more than 60,000 | 3 | 20 | 50 | 30 |

When the construction period was estimated, rainy period of about five months was taken into account, considering the work efficiency in that period.

# Table 7.4.1 MINIMUM DESIGN STANDARD FOR PROVINCIAL ROADS

1. Access control: When designated under the Highway Law.
2. Highway crossing: Grade separation only after proven viable by economic feasibility calculations.
3. Railroad crossing: Grade separation only after proven viable by economic feasibility calculations.
4. Bridge width (1): 8 m. for $F_1$ & $F_2$, 7 m. for $F_3$ to $F_6$
5. Vertical clearance = 4.50 m
6. Design bridge loading = HS 20
7. Pavement design shall be based on the accumulated number of equivalent axle load predicted during the first 7-year after construction.
8. Follow AASHO recommendation for any design details not separately specified.

| Class | (5) | $F_D$ | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|---|---|
| Average Daily Traffic | (5) | Above 8,000 | 4,000-8,000 | 2,000-4,000 | 1,000-2,000 | 300-1,000 | ← Below 300 | → |
| Design Speed k.p.h. | (2) | | | | | | | |
| Flat and moderately rolling | | ← | ← | 70 - 90 | → | 60-80 | ← 60 | → |
| Rolling and hilly | | ← | ← | 55 - 70 | → | 45-60 | ← 45 | → |
| Mountainous | | ← | ← | 40 - 55 | → | 30-45 | ← 30 | → |
| Maximum Gradient | (3) | | | | | | | |
| Flat and moderately rolling | | ← | ← | 6 | → | 8 | ← 12 | → |
| Rolling and hilly | | ← | ← | 8 | → | 10 | ← 12 | → |
| Mountainous | | ← | ← | 10 | → | 10 | ← 12 | → |
| Suggested Surface Type | | ← High | → | ← Intermediate | → | Low | ← Soil Aggregate | → |
| Width of Carriageway m. | | Divided 2 @7.00 | 7.00 | 6.50 | 6.00 | 5.50 | 9.00 | 6.00 |
| Width of Shoulder m. | | 2.50 | 2.50 | 2.25 | 2.00 | 1.75 | Travelled way | Travelled way |
| Right of Way m. | (4) | ← | ← | 40 - 60 | → | → | ← 20 - 40 | → |

## Explanatory Notes

(1) Any $F_D$, $F_1$ or $F_2$ road that planned to be raised to National Highway system in the future, bridges less than 15 m. long shall be to the full roadbed width.

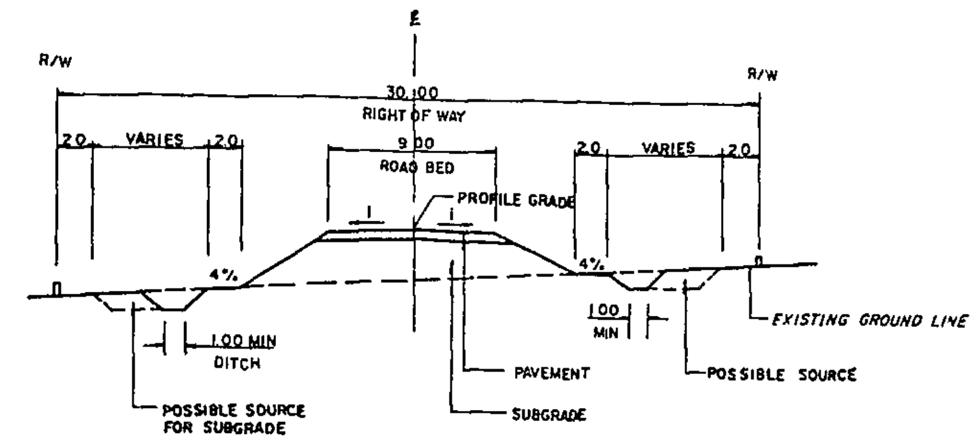
(2) Design speed may be relaxed in exceptional circumstances on account of right of way difficulties or mountainous terrain.

(3) Refer to the AASHO Policy on Geometric Design of Rural Highways to relate desirable grade lengths,climbing lanes, etc.

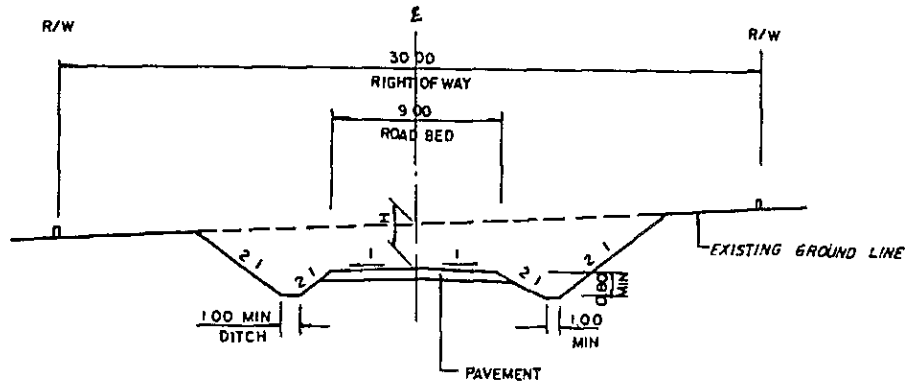
(4) May be reduced in urban or semi-urban conditions at the discretion of the Department provided that a suitable cross section including service roads, where necessary, is obtainable.

(5) Class $F_D$ roads are required on the basis of a 7-year ADT projection or be justified by economic feasibility calculations. Class $F_1$ to $F_3$ roads are required on the basis of a 15-year ADT projection. Class $F_4$ roads have a projected ADT more than 300 in 7 years and less than 1,000 in 15 years. Class $F_5$ roads have a projected ADT less than 300 in 7 years and more than 300 in 15 years. Class $F_6$ roads have a projected ADT less than 300 in 15 years.

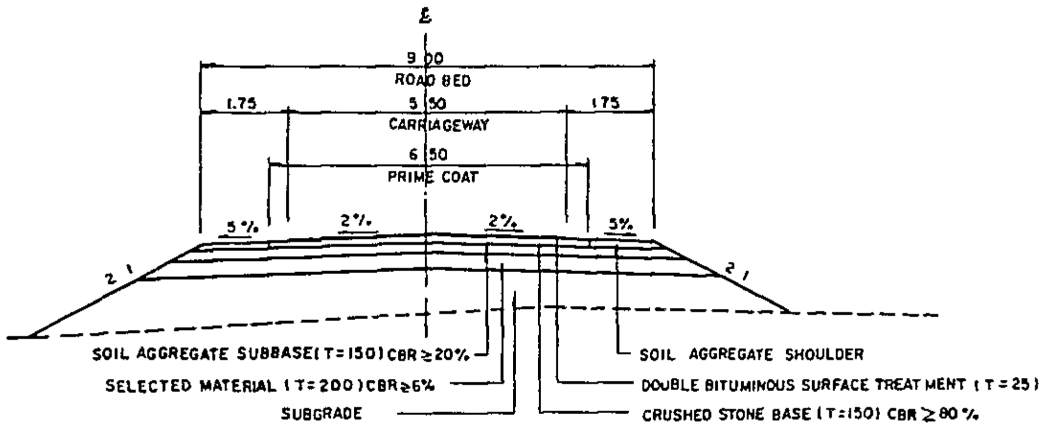
# Figure 7.4.1 TYPICAL CROSS SECTION AND TYPICAL PAVEMENT STRUCTURE



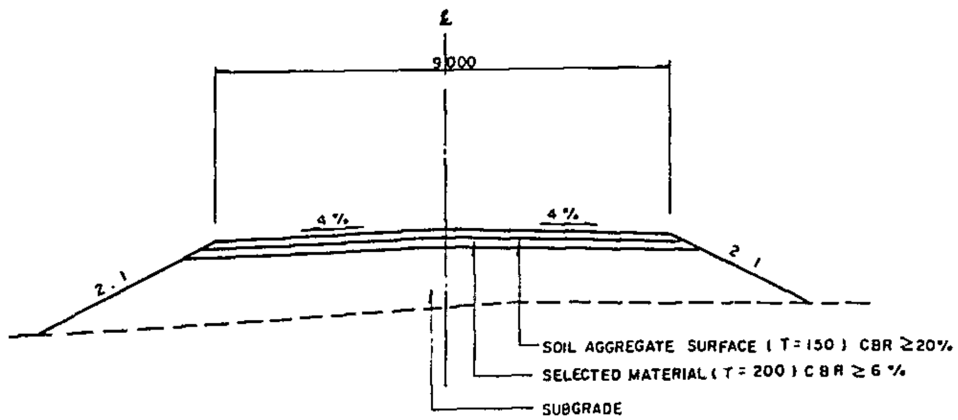

FILL SECTION




CUT SECTION




DOUBLE BITUMINOUS SURFACE TREATMENT (DBST) ROAD (Class F4)




SOIL AGGREGATE SURFACED ROAD (Class F5)

Table 7.4.2 UNIT RATES FOR MAJOR WORK ITEMS
(Improvement and New Construction)

| Work Item | Unit of Quantity | Financial Unit Rate ( Ø ) | Tax Component ( % ) | Remarks |
|---|---|---|---|---|
| Clearing and Grubbing | ha | 15,000 | 9 | |
| Excavation - Soil | $m^3$ | 20 | 10 | |
| Excavation - Hard Rock | $m^3$ | 160 | 10 | |
| Embankment | $m^3$ | 45 | 9 | |
| Selected Material | $m^3$ | 80 | 11 | |
| Soil Aggregate Subbase | $m^3$ | 105 | 11 | |
| Crushed Stone Base | $m^3$ | 370 | 8 | |
| Soil Aggregate Shoulder | $m^3$ | 105 | 11 | |
| DBST with Prime Coat | $m^2$ | 55 | 10 | |
| Asphalt Concrete | $m^2$ | 88 | 10 | t = 40 mm, Overlay |
| Tack Cort | $m^2$ | 10 | 10 | Overlay |
| R.C. Pipe Culvert | m | 2,100 | 8 | ø100 with Head walls |
| P.C. Box Culvert | m | 16,000 | 10 | (2.4 x 2.4) with Aprons |
| R.C. Short Span Bridge | m | 40,000 | 11 | Slab Bridge, Span 5∿10 m |
| P.C. Long Span Bridge | m | 80,000 | 11 | P.C. Ginder, Span 30m |
| Land Aquisition - Highly Developed Land | ha | 50,000 | - | |
| Land Aquisition - Less Developed Land | ha | 15,000 | - | |

Table 7.4.3 SUMMARY OF CONSTRUCTION COST

($10^3$ ฿)

| Proposed Route No. | Length (km) | F4 (DBST) Financial Cost 1/ | F4 (DBST) Economic Cost | F4 (DBST) + F5 (Laterite) Financial Cost 1/ | F4 (DBST) + F5 (Laterite) Economic Cost | F5 (Laterite) Financial Cost 1/ | F5 (Laterite) Economic Cost | F4 (DBST) Link>300 in ADT Financial Cost 1/ | F4 (DBST) Link>300 in ADT Economic Cost | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| IM-1 | 48.0 | 91,483 | 82,908 | - | - | 49,380 | 44,611 | | | |
| IM-2 | 9.4 | 16,277 | 14,778 | - | - | 8,809 | 7,985 | | | |
| IM-3 | 30.6 | 57,753 | 52,366 | 49,995 | 45,174 | 32,127 | 29,060 | 28,848 | 26,000 | Length of link>300 in ADT = 14.0 km |
| IM-4 | 35.3 | 60,602 | 56,439 | 46,489 | 42,012 | 33,707 | 30,383 | 30,939 | 27,999 | Length of link>300 in ADT = 17.0 km |
| IM-5 | 29.1 | 61,472 | 55,565 | - | - | - | - | | | |
| IM-6 | 20.3 | 52,407 | 47,423 | - | - | 36,034 | 32,480 | | | |
| IM-7 | 24.0 | 45,951 | 41,689 | - | - | 24,199 | 21,903 | | | |
| IM-8 | 16.7 | 27,361 | 24,778 | - | - | - | - | | | |
| IM-9 | 33.4 | 72,564 | 65,760 | - | - | 45,218 | 40,887 | | | |
| IM-10 | 48.1 | 87,680 | 79,533 | 69,147 | 62,674 | 53,516 | 48,457 | 45,614 | 41,344 | Length of link>300 in ADT = 26.0 km |
| IM-11 | 8.3 | 18,823 | 17,001 | - | - | 12,398 | 11,157 | | | |
| IM-12 | 18.1 | 35,903 | 32,590 | - | - | - | - | | | |
| IM-13 | 19.8 | 37,519 | 33,915 | - | - | 24,489 | 22,065 | | | |
| IM-14 | 12.0 | 27,687 | 25,135 | - | - | 18,518 | 16,796 | | | |
| IM-15 | 40.1 | 75,443 | 68,442 | - | - | 45,160 | 40,896 | | | |
| IM-16 | 9.1 | 15,224 | 13,835 | - | - | 7,555 | 6,862 | | | |
| IM-17 | 30.4 | 66,060 | 59,650 | - | - | 40,628 | 36,519 | | | |
| IM-18 | 50.7 | 98,245 | 89,203 | - | - | 59,599 | 54,020 | | | |
| IM-19 | 46.0 | 95,310 | 86,000 | - | - | - | - | | | |
| IM-20 | 17.2 | 32,869 | 29,666 | - | - | 22,284 | 20,038 | | | |
| IM-21 | 65.3 | 112,410 | 101,589 | - | - | - | - | | | |
| IM-22 | 122.4 | 217,108 | 196,082 | 153,492 | 138,215 | 116,559 | 106,625 | | | |
| IM-23 | 44.8 | 74,174 | 67,049 | - | - | 38,544 | 34,785 | | | |
| IM-24 | 14.5 | 25,653 | 23,184 | - | - | 13,387 | 12,027 | | | |
| IM-25 | 38.2 | 68,025 | 61,658 | 58,473 | 52,896 | 36,655 | 33,126 | 39,928 | 36,224 | Length of link>300 in ADT = 23.0 km |
| IM-26 | 39.5 | 74,327 | 67,347 | - | - | - | - | | | |
| IM-27 | 31.1 | 51,994 | 47,048 | - | - | 31,110 | 28,051 | | | |
| IM-28 | 42.0 | 96,110 | 86,938 | - | - | - | - | | | |
| IM-29 | 48.0 | 95,474 | 86,323 | - | - | - | - | | | |
| IM-30 | 51.0 | 96,372 | 87,320 | - | - | - | - | | | |
| IM-31 | 59.7 | 93,083 | 84,259 | - | - | - | - | | | |
| IM-32 | 29.0 | 49,461 | 44,938 | - | - | 29,097 | 26,415 | | | |
| IM-33 | 51.5 | 108,627 | 99,100 | - | - | - | - | | | |
| Total | 1183.6 | 2,239,451 | 2,029,511 | 377,596 | 340,971 | 778,973 | 705,148 | 145,329 | 131,567 | |

Note: 1/ excluding price contengency

## 7.5 ESTIMATION OF VOC SAVING BENEFIT

### 7.5.1 Approach

The method of calculation of vehicle operating cost (VOC) in this Study was based on the method provided in the report, "Standardization of Vehicle Operating Costs for Thailand, 1977" (hereinafter referred to as SVOCT). First, VOC on level tangent paved road at benchmark speed is calculated based on the latest cost data. Then it is varied due to road surface condition, and average traveling speed, and finally it is transformed to the actual cost of each subject road link corresponding to the actual running frictions on the link such as curves, grades and narrow bridges. The method of conversion from costs on level tangent roads to costs on actual road links was basically followed those of SVOCT but simplified setting typical types of topographic characteristics. Road users' benefits were measured by savings of VOC, valued in economic prices, in case of with project.

### 7.5.2 Representative Vehicles

Analysis of the findings of the O/D Survey revealed a set of representative vehicle types prevailing in the study area. They are classified into motor cycle (M/C), passenger car (P/C), light bus (L/B), medium bus (M/B), heavy bus (H/B), pickup truck (P/T), 4-wheel truck (4/T), 6-wheel truck (6/T), and 10-wheel truck (10/T).

Basic characteristics of the representative vehicles selected are given in the following table:

Characteristics of Representative Vehicles

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Typical Model | Suzuki A100 | Toyota Corolla (40%) Toyota Corona (60%) | Toyota Hilux (40%) Isuzu Faster (60%) | Hino KM | Hino BX321 | Toyota Hilux (40%) Datsun (60%) | Isuzu 250 Diesel | Isuzu 85HP | Isuzu 120 |
| No. of Axle | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| No. of Tyre | 2 | 4 | 4 | 4 | 6 | 4 | 4 | 6 | 10 |
| Engine Capacity (CC) | 100 | 1,300<br>1,600 | 1,600<br>2,000 | 4,500 | 6,400 | 1,600<br>1,600 | 2,775 | 2,775 | 5,800 |
| New Vehicle Price ($10^3$Baht) | 23 | 243<br>292 | 142<br>126 | 303 | 600 | 124<br>149.5 | 219 | 262 | 575 |
| Economic[1/] Cost ($10^3$Baht) | 18.1 | 141.1<br>108.3 | 119.0<br>104.2 | 254.5 | 491.2 | 103.1<br>125.9 | 178.3 | 214.9 | 466.2 |

1/: Economic cost of each vehicle was calculated net of tyre and tube costs.

### 7.5.3 Vehicle Operating Costs under Ideal Condition

#### 1) Components of Vehicle Operating Costs

Usually, road users' costs include mainly vehicle operating costs (VOC) and occupants time cost. In this study, however, occupants time cost was excluded because of its insignificance in rural areas, although crew cost which depends on time was included in VOC. Vehicle operating costs in this study consist of the following components:

i) Fuel cost
ii) Oil cost

iii) Tyre and tube cost
iv) Repair and maintenance cost
v) Depreciation and interest cost
vi) Overhead cost
vii) Crew cost

2) Ideal Condition

Basic costs of each component of VOC are calculated in an ideal condition, i.e. running constantly at benchmark speed or lifetime speed on level tangent paved road of good surface condition and without traffic frictions. The fuel cost, oil cost and repair and maintenance cost were calculated at the benchmark speeds, which is 80 km per hour for passenger car and 72 km per hour for the other vehicles. While, tyre and tube cost, depreciation and interest cost, overhead cost and crew cost were calculated at the average lifetime speed which was taken at 56 km per hour.

3) Basic Data of Cost Components

a) Fuel Cost

The unit cost of fuel was obtained from interviews to the fuel distributing companies and related organizations.

The selling price of premium gasoline, regular gasoline and diesel were calculated, by averaging the pump prices in 16 points in the Northeastern Region, at 13.823, 11.773 and 7.765 Baht per liter, respectively.

The taxes and oil fund included in these prices are 6.8718, 5.3271 and 0.9927 Baht per liter, respectively. Subsidy is granted only for diesel at 0.1732 Baht per liter.

Thus, the economic unit costs of fuel calculated are 6.9512, 6.4459 and 6.9455 Baht per liter, respectively for premium, regular gasoline and diesel.

Type of fuel used by each vehicle class and fuel consumption rates were obtained from field survey and interviews to manufacturing companies.

The fuel cost by vehicle type, together with relevant data, is shown below:

Fuel Costs

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Fuel type | Regular | Premium (60%) Regular (30%) Diesel (10%) | Premium (20%) Regular (40%) Diesel (40%) | Diesel | Diesel | Premium (85%) Diesel (15%) | Diesel | Diesel | Diesel |
| Fuel consumption (km/liter) | 30.0 | 13.5 | 11.0 | 6.0 | 5.3 | 11.0 | 9.5 | 9.0 | 4.0 |
| Fuel cost (Baht/km) | 0.2149 | 0.5036 | 0.6134 | 1.1577 | 1.3106 | 0.6318 | 0.7312 | 0.7718 | 1.7365 |

b) Oil Cost

Though a wide variety of oils are used in Thailand, the commonly used oils can be classified into two groups, namely standard type as SHELL X-100 or ESSO EXTRA and high-class type as SHELL SUPER PLUS or ESSO UNIFLO. An average price of them in Northeastern Region, 34.66 Baht per liter, was used in this study as the selling price of oils.

The custom duty and business tax of oils were estimated at 4.283 Baht per liter. Hence the economic cost of oils is estimated at 30.377 Baht per liter.

The oil costs by vehicle class, together with the consumption rates are shown below:

Oil Costs

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Consumption (km/liter) | 750 | 1,000 | 920 | 770 | 450 | 920 | 770 | 450 | 450 |
| Oil cost (Baht/km) | 0.041 | 0.030 | 0.033 | 0.040 | 0.068 | 0.033 | 0.040 | 0.068 | 0.068 |

c) Tyre and Tube Cost

The data on unit price of new tyre and its discount structure were obtained from interviews to the major tyre manufacturing companies and local distributors. Tyres are sold at about 20% discounted prices for motor cycle and about 30% discounted prices for other vehicles against the list prices, and tubes are sold at about 25% discounted prices for all vehicles. The selling price of retread tyre is around 40% of that of new tyre. The tax components included in selling price are 7.7% for the business tax and 2.0% for the import duty on materials.

The tyre and tube cost by vehicle type, together with the relevant data is shown below:

Tyre and Tube Cost

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Tyre size | 2.75x18 4 ply | 165SR13 - | 6.0x14 6 ply | 7.0x15 8 ply | 9.0x20 14 ply | 6.0x14 6 ply | 7.5x15 10 ply | 7.5x15 12 ply | 9.0x20 14 ply |
| Selling Price of New T&T (Baht) | 185 | 780 | 918 | 1,382 | 3,573 | 918 | 1,722 | 1,722 | 3,573 |
| New Tyre and tube cost less tax (Baht) | 167 | 704 | 829 | 1,248 | 3,226 | 829 | 1,555 | 1,555 | 3,226 |
| Average life of new tyre ($10^3$ km) | 30 | 45 | 35 | 40 | 50 | 35 | 40 | 45 | 50 |
| Selling price of retread tyre (Baht) | - | - | 370 | 500 | 1,400 | 370 | 690 | 690 | 1,400 |
| Retread tyre cost less tax (Baht) | - | - | 334 | 452 | 1,264 | 334 | 623 | 623 | 1,264 |
| Average life of retread tyre ($10^3$ km) | - | - | 28 | 32 | 40 | 28 | 32 | 36 | 40 |
| Nos. of retread | - | - | 0.5 | 0.5 | 1.0 | 0.5 | 0.5 | 1.0 | 1.0 |
| Tyre and tube cost (Baht/km) | 0.011 | 0.063 | 0.081 | 0.105 | 0.299 | 0.081 | 0.133 | 0.161 | 0.499 |

d) Repair and Maintenance Cost

The figures for hours of labor used in this study are basically same as given in SVOCT, with minor adjustment. The percentages of parts costs were reviewed and adjusted referring to the Jan De Weille's "Quantification of Road User Savings".

The labor wage rate was taken from the average rate in the Northeastern Region, i.e. 58 Baht per hour.

The calculated repair and maintenance costs are given below:

Repair and Maintenance Costs

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Labor Cost (hour/1,000 km) | 1.30 | 1.65 | 1.90 | 1.90 | 9.40 | 1.90 | 1.90 | 7.64 | 9.40 |
| Parts Cost (% of economic cost of vehicle/1,000 km) | 0.10 | 0.11 | 0.21 | 0.21 | 0.12 | 0.12 | 0.21 | 0.21 | 0.07 |
| Repair and Maintenance Cost (Baht/km) | 0.094 | 0.237 | 0.348 | 0.645 | 1.135 | 0.245 | 0.485 | 0.894 | 0.872 |

e) Depreciation and Interest Cost

Depreciation and interest cost of respective vehicle was calculated using the following equation:

$$D = (P - L)\ CRF + L \cdot i$$

where,
- D = Depreciation and interest cost
- P = Economic value of vehicle
- L = Salvage value of vehicle
- CRF = Capital recovery factor
- i = Annual rate of interest, 12 percent

The depreciation and interest cost by vehicle type is shown below:

Depreciation and Interest Cost

| | M/C | P/C | L/B | M/B | H/B | P/T | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|---|
| Economic Value of Vehicle ($10^3$ Baht) | 18.1 | 128.0 | 113.0 | 254.5 | 491.2 | 116.7 | 178.3 | 214.9 | 466.2 |
| Salvage Value of Vehicle ($10^3$ Baht) | - | 20.0 | 10.0 | 10.0 | 50.0 | 15.0 | 10.0 | 45.0 | 50.0 |
| Service Life (years) | 6 | 10 | 7 | 7 | 9 | 10 | 8 | 10 | 10 |
| CRF | 0.2432 | 0.1770 | 0.2191 | 0.2191 | 0.1877 | 0.1770 | 0.2013 | 0.1770 | 0.1770 |
| Annual Travel ($10^3$ km) | 10 | 20 | 40 | 40 | 70 | 25 | 35 | 40 | 50 |
| Depreciation and Interest Cost (Baht/km) | 0.440 | 1.076 | 0.594 | 1.369 | 1.269 | 0.792 | 1.002 | 0.887 | 1.593 |

f) Overhead Cost

The overhead cost was counted for commercial vehicles: medium bus, heavy bus, 6-wheel truck and 10-wheel truck. It was estimated that overhead costs at average lifetime speed of 56 km per hour were 7% of economic cost of vehicle for heavy bus, 4% for 10-wheel truck and 2.5% for medium bus and 6-wheel truck.

The overhead costs by vehicle type are shown below:

Overhead Cost

| | M/B | H/B | 6/T | 10/T |
|---|---|---|---|---|
| Overhead Cost ($10^3$ Baht/Year) | 6.4 | 34.4 | 5.4 | 18.7 |
| Annual Travel ($10^3$ km) | 40 | 70 | 40 | 50 |
| Overhead Cost (Baht/km) | 0.159 | 0.491 | 0.134 | 0.373 |

g) Crew Costs

Crew costs were estimated basing on the actual wages to be paid to crews of commercial vehicles. As light buses and 4 wheel trucks are usually owner operated, their crew costs were counted at half of wages for employed drivers.

Wage rates were estimated referring to the information obtained from ETO1/ and other agencies.

The crew costs by vehicle type are shown below:

Crew Costs

| | L/B | M/B | H/B | 4/T | 6/T | 10/T |
|---|---|---|---|---|---|---|
| Number of Crew: | | | | | | |
| - Driver | 1 | 1 | 1 | 1 | 1 | 1 |
| - Asst. Driver | - | - | - | - | - | 1 |
| - Conductor | - | 1 | 2 | - | - | - |
| - Labor | - | - | - | - | - | 1 |
| Crew costs at lifetime speed (Baht/km) | 0.660 | 1.800 | 1.509 | 0.754 | 1.320 | 1.944 |

4) VOC at Benchmark Speed (Basic Cost)

Calculated vehicle operating costs at benchmark speed on level tangent road, asphalt concrete paved and good conditioned, are summarized in the following table:

1/: ETO, Express Transport Organization

Basic Cost of VOC

(at Benchmark Speed on Level Tangent Paved Road)

| Vehicle Type | Bench-Mark Speed (km/hr) | Fuel Cost | Oil Cost | 1/ Tyre & Tube Cost | Repair & Maintenance Cost | Depreciation & Interest Cost 1/ | Overhead Cost 1/ | Crew Cost 1/ | Total |
|---|---|---|---|---|---|---|---|---|---|
| M/C | 72 | 0.215 | 0.041 | 0.014 | 0.094 | 0.440 | - | - | 0.804 |
| P/C | 80 | 0.504 | 0.030 | 0.090 | 0.237 | 1.076 | - | - | 1.937 |
| L/B | 72 | 0.613 | 0.033 | 0.104 | 0.347 | 0.478 | - | 0.512 | 2.087 |
| M/B | 72 | 1.148 | 0.040 | 0.135 | 0.645 | 1.141 | 0.123 | 1.395 | 4.637 |
| H/B | 72 | 1.311 | 0.068 | 0.386 | 1.135 | 1.057 | 0.380 | 1.169 | 5.506 |
| P/T | 72 | 0.632 | 0.033 | 0.104 | 0.245 | 0.645 | - | - | 1.659 |
| 4/T | 72 | 0.731 | 0.040 | 0.172 | 0.485 | 0.80 | - | 0.584 | 2.820 |
| 6/T | 72 | 0.772 | 0.068 | 0.208 | 0.894 | 0.739 | 0.105 | 1.023 | 3.809 |
| 10/T | 72 | 1.737 | 0.068 | 0.644 | 0.872 | 1.327 | 0.289 | 1.507 | 6.444 |

1/ : Converted from the costs at lifetime speed of 56 km/hr to the costs at benchmark speed.

### 7.5.4 Vehicle Operating Costs on Actual Road Links

#### 1) Factors Affecting Cost Variation

The actual VOCs on each road link concerned are to be estimated transforming the basic costs calculated in the foregoing section into the actual costs corresponding to the actual conditions of each road link. Major factors affecting VOC may include: traveling speed, surface type, grades, curves, speed change caused by traffic restriction.

As the basic costs estimated in the foregoing section 7.5.3 - (4) are those at benchmark speed on level tangent paved road, it is required first to obtain VOC on each road class by surface type at average traveling speed on level tangent road. Then, they are to be varied into actual VOC with additional costs affected by road geometry such as grades and curves and speed change due to bridges.

2) Cost Variation by Surface Type

The VOC at benchmark speed on level tangent paved road were converted to VOC at average traveling speeds on level tangent road of four road classes, i.e. paved, laterite (good), laterite (poor) and earth.

Judging from the field observation in the project area, average traveling speeds on level tangent roads, were determined as follows:

Average Traveling Speed by Road Class
(on level Tangent Road)

| Vehicle Type | Average Traveling | | | |
|---|---|---|---|---|
| | Road 1 (Paved) | Road 2 (Laterite Good) | Road 3 (Laterite Poor) | Road 4 (Earth) |
| M/C | 64 | 48 | 40 | 32 |
| P/C | 80 | 56 | 40 | 32 |
| L/B | 72 | 48 | 40 | 32 |
| M/B | 72 | 48 | 40 | 32 |
| H/B | 72 | 48 | 40 | 32 |
| P/T | 72 | 48 | 40 | 32 |
| 4/T | 72 | 48 | 40 | 32 |
| 6/T | 64 | 48 | 40 | 32 |
| 10/T | 64 | 48 | 40 | 32 |

The conversion indices for variation due to speed and road surface were quoted from the T.P. O'Sullivan's "Road User Cost in Thailand; Technical Report No. 36" (hereinafter referred to as RUCT) and also referred to SVOCT.

For fuel cost, oil cost, tyre cost and repair and maintenance cost, the conversion factors in RUCT were employed, and for depreciation and interest cost, overhead cost and crew cost, those in SVOCT were employed.

Thus converted VOC on level tangent road by four road classes are summarized in Table 7.5.1 to 7.5.4.

3) Additional Costs due to Road Geometry and Speed Change Cycle

a) Gradients and Curves

Adjustment coefficients for additional costs due to gradients and curves were prepared for each case of typical types of topography, based on the coefficients given in SVOCT. The typical types of topography and road geometry were decided, giving typical composition of gradients and curves per 1 km. Using the coefficients in SVOCT, adjustment coefficients in terms of percentages of level tangent costs were developed for each topographic type and road class by vehicle type, as shown in Table 7.5.5. Each link of the proposed routes was classified into one of the typical topographic types, as shown in Route Report, and its additional costs of VOC was calculated applying suitable coefficients accordingly.

b) Speed Change Cycle

Generally, VOC will be affected by deceleration and acceleration due to traffic frictions such as narrow bridges, passing villages, cross roads, and other bottlenecks. Considering the significance of effects to VOC, this study paid attention only to the speed change cycle due to wooden bridges and narrow concrete bridges. It is assumed that deceleration will be made down to 0 km/hr in case of wooden bridges and to 16 km/hr in case of narrow concrete bridges. Based on the coefficients in SVOCT, additional cost per bridge are prepared for each road class and vehicle type as shown in Table 7.5.5.

### 7.5.5 Vehicle Operating Cost Savings

The savings were obtained from the difference of total VOC in the related road network in case of with project and that of without project case. They were calculated by vehicle type and by traffic type and then summed up.

Whole savings were counted for normal traffic of both passenger and freight, while one half of savings were counted for induced traffic as in the usual manner. Savings for developed traffic were not counted here, because the benefits corresponding to developed traffic were considered to be included in the benefits of agricultural development discussed in the following section.

Vehicle operating cost savings in four cases of the economic evaluation are summarized in Tables 7.5.6 to 7.5.9.

Table 7.5.1
Table 7.5.2

Table 7.5.1 VEHICLE OPERATING COSTS ON LEVEL TANGENT ROAD
(Paved Road)

| Vehicle Type | Speed (Km/hr) | Fuel | Oil | Tyre & Tube | Repair & Maint. | Deprec.& Interest | Overhead | Crew | Total |
|---|---|---|---|---|---|---|---|---|---|
| M/C | 64 | 0.204 | 0.041 | 0.012 | 0.087 | 0.440 | - | - | 0.784 |
| P/C | 80 | 0.504 | 0.030 | 0.090 | 0.237 | 1.076 | - | - | 1.937 |
| L/B | 72 | 0.613 | 0.033 | 0.104 | 0.347 | 0.478 | - | 0.512 | 2.087 |
| M/B | 72 | 1.158 | 0.040 | 0.135 | 0.645 | 1.141 | 0.123 | 1.395 | 4.637 |
| H/B | 72 | 1.311 | 0.068 | 0.386 | 1.135 | 1.057 | 0.380 | 1.169 | 5.506 |
| P/T | 72 | 0.632 | 0.033 | 0.104 | 0.245 | 0.645 | - | - | 1.659 |
| 4/T | 72 | 0.731 | 0.040 | 0.172 | 0.485 | 0.808 | - | 0.584 | 2.820 |
| 6/T | 64 | 0.711 | 0.068 | 0.182 | 0.803 | 0.828 | 0.118 | 1.155 | 3.865 |
| 10/T | 64 | 1.598 | 0.068 | 0.564 | 0.783 | 1.486 | 0.328 | 1.705 | 6.532 |

Table 7.5.2 VEHICLE OPERATING COSTS ON LEVEL TANGENT ROAD
(Laterite Road - Good)

| Vehicle Type | Speed (Km/hr) | Fuel | Oil | Tyre & Tube | Repair & Maint. | Deprec.& Interest | Overhead | Crew | Total |
|---|---|---|---|---|---|---|---|---|---|
| M/C | 48 | 0.224 | 0.052 | 0.015 | 0.095 | 0.497 | - | - | 0.883 |
| P/C | 56 | 0.499 | 0.038 | 0.096 | 0.243 | 1.216 | - | - | 2.092 |
| L/B | 48 | 0.584 | 0.042 | 0.112 | 0.371 | 0.774 | - | 0.769 | 2.652 |
| M/B | 48 | 1.103 | 0.050 | 0.146 | 0.689 | 1.951 | 0.185 | 2.094 | 6.218 |
| H/B | 48 | 1.535 | 0.085 | 0.418 | 1.206 | 1.807 | 0.570 | 1.754 | 7.375 |
| P/T | 48 | 0.602 | 0.047 | 0.114 | 0.291 | 1.103 | - | - | 2.157 |
| 4/T | 48 | 0.696 | 0.050 | 0.186 | 0.518 | 1.310 | - | 0.876 | 3.636 |
| 6/T | 48 | 0.903 | 0.085 | 0.224 | 0.950 | 1.264 | 0.158 | 1.534 | 5.118 |
| 10/T | 48 | 2.032 | 0.086 | 0.696 | 0.927 | 2.269 | 0.434 | 2.262 | 8.706 |

Table 7.5.3 VEHICLE OPERATING COSTS ON LEVEL TANGENT ROAD
(Laterite Road - Poor)

| Vehicle Type | Speed (Km/hr) | Fuel | Oil | Tyre & Tube | Repair & Maint. | Deprec.& Interest | Overhead | Crew | Total |
|---|---|---|---|---|---|---|---|---|---|
| M/C | 48 | 0.266 | 0.062 | 0.018 | 0.113 | 0.591 | - | - | 1.050 |
| P/C | 56 | 0.599 | 0.046 | 0.120 | 0.292 | 1.463 | - | - | 2.519 |
| L/B | 48 | 0.770 | 0.055 | 0.148 | 0.489 | 1.021 | - | 1.014 | 3.497 |
| M/B | 48 | 1.487 | 0.067 | 0.197 | 0.929 | 2.631 | 0.249 | 2.823 | 8.384 |
| H/B | 48 | 2.103 | 0.116 | 0.573 | 1.652 | 2.476 | 0.781 | 2.403 | 10.104 |
| P/T | 48 | 0.797 | 0.057 | 0.153 | 0.336 | 1.355 | - | - | 2.697 |
| 4/T | 48 | 0.928 | 0.067 | 0.248 | 0.691 | 1.747 | - | 1.168 | 4.849 |
| 6/T | 48 | 1.089 | 0.103 | 0.270 | 1.151 | 1.537 | 0.191 | 1.850 | 6.190 |
| 10/T | 48 | 2.774 | 0.117 | 0.950 | 1.266 | 3.098 | 0.593 | 3.088 | 11.886 |

Table 7.5.4 VEHICLE OPERATING COSTS ON LEVEL TANGENT ROAD
(Earth Road)

| Vehicle Type | Speed (Km/hr) | Fuel | Oil | Tyre & Tube | Repair & Maint. | Deprec.& Interest | Overhead | Crew | Total |
|---|---|---|---|---|---|---|---|---|---|
| M/C | 32 | 0.281 | 0.061 | 0.019 | 0.139 | 0.634 | - | - | 1.134 |
| P/C | 32 | 0.618 | 0.045 | 0.107 | 0.337 | 1.550 | - | - | 2.657 |
| L/B | 32 | 0.704 | 0.058 | 0.143 | 0.530 | 1.333 | - | 1.152 | 3.920 |
| M/B | 32 | 1.330 | 0.070 | 0.187 | 0.984 | 3.479 | 0.278 | 3.139 | 9.467 |
| H/B | 32 | 2.195 | 0.119 | 0.533 | 1.914 | 3.223 | 0.854 | 2.630 | 11.468 |
| P/T | 32 | 0.704 | 0.058 | 0.143 | 0.351 | 1.711 | - | - | 2.967 |
| 4/T | 32 | 0.840 | 0.070 | 0.238 | 0.739 | 2.255 | - | 1.313 | 5.455 |
| 6/T | 32 | 1.293 | 0.119 | 0.287 | 1.508 | 2.255 | 0.237 | 2.301 | 8.000 |
| 10/T | 32 | 2.908 | 0.119 | 0.890 | 1.471 | 4.046 | 0.651 | 3.391 | 13.476 |

# Table 7.5.5 ADDITIONAL COST FOR CURVE, GRADIENTS AND SPEED CHANGE

| Topographic Features | Road Class | M/C Curve | M/C Gra. | M/C Total | P/C Curve | P/C Gra. | P/C Total | L/B P/T Curve | L/B P/T Gra. | L/B P/T Total | M/B 4/T Curve | M/B 4/T Gra. | M/B 4/T Total | H/B Curve | H/B Gra. | H/B Total | 6/T Curve | 6/T Gra. | 6/T Total | 10/T Curve | 10/T Gra. | 10/T Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CURVE AND GRADIENTS | | ( % of Level Tangent Cost / km) | | | | | | | | | | | | | | | | | | | | |
| Flat | Road 1 | 1.38 | - | 1.38 | 2.41 | - | 2.41 | 1.83 | - | 2.41 | 2.07 | - | 2.07 | 2.34 | - | 2.34 | 1.52 | - | 1.52 | 3.05 | - | 3.05 |
| | Road 2A | 0.87 | - | 0.87 | 1.06 | - | 1.06 | 0.87 | - | 0.87 | 0.99 | - | 0.89 | 1.23 | - | 1.23 | 1.23 | - | 1.23 | 2.34 | - | 2.34 |
| | Road 2B | 1.59 | - | 1.59 | 2.09 | - | 2.09 | 1.59 | - | 1.59 | 1.68 | - | 1.68 | 2.19 | - | 2.19 | 2.19 | - | 2.19 | 4.18 | - | 4.18 |
| | Road 3 | 1.29 | - | 1.29 | 1.29 | - | 1.29 | 1.29 | - | 1.29 | 1.38 | - | 1.38 | 1.79 | - | 1.79 | 1.79 | - | 1.79 | 3.37 | - | 3.37 |
| | Road 4 | 1.06 | - | 1.06 | 1.06 | - | 1.06 | 1.06 | - | 1.06 | 1.14 | - | 1.14 | 1.53 | - | 1.53 | 1.53 | - | 1.53 | 2.28 | - | 2.82 |
| Rolling | Road 1 | 1.38 | 0.69 | 2.07 | 2.41 | 0.34 | 2.75 | 1.83 | 0.53 | 2.36 | 2.07 | 1.06 | 3.13 | 2.34 | 4.56 | 6.90 | 1.52 | 2.97 | 4.49 | 3.05 | 10.57 | 13.62 |
| | Road 2A | 0.87 | 0.92 | 1.79 | 1.06 | 0.84 | 1.90 | 0.89 | 0.92 | 1.79 | 0.99 | 0.97 | 1.96 | 1.23 | 0.62 | 1.85 | 1.23 | 0.62 | 1.85 | 2.34 | 7.58 | 10.82 |
| | Road 2B | 1.59 | 0.92 | 2.51 | 2.09 | 0.84 | 2.93 | 1.59 | 0.92 | 2.51 | 1.68 | 0.97 | 2.65 | 2.19 | 0.62 | 2.81 | 2.19 | 0.62 | 2.81 | 4.18 | 7.58 | 11.76 |
| | Road 3 | 1.29 | 0.76 | 2.05 | 1.29 | 0.76 | 2.05 | 1.29 | 0.76 | 2.05 | 1.38 | 0.91 | 2.29 | 1.63 | 0.08 | 1.71 | 1.63 | 0.08 | 1.71 | 3.37 | 6.44 | 9.81 |
| Mountanious | Road 1 | 16.92 | 4.83 | 21.76 | 29.64 | 3.58 | 33.22 | 22.46 | 4.22 | 26.68 | 25.08 | 6.48 | 31.56 | 29.94 | 36.85 | 66.79 | 20.47 | 28.08 | 48.55 | 40.12 | 61.56 | 101.68 |
| | Road 2A | 9.77 | 5.34 | 15.11 | 13.02 | 5.14 | 18.16 | 9.77 | 5.34 | 15.11 | 10.81 | 6.29 | 17.20 | 13.61 | 13.66 | 27.29 | 13.61 | 13.66 | 27.29 | 25.90 | 45.33 | 71.23 |
| | Road 2B | 26.47 | 7.40 | 33.87 | 36.66 | 7.20 | 43.86 | 26.47 | 7.40 | 33.87 | 26.78 | 8.55 | 35.33 | 35.74 | 18.51 | 54.25 | 35.74 | 18.51 | 54.25 | 45.10 | 52.44 | 97.54 |
| | Road 3 | 19.31 | 7.51 | 26.82 | 19.31 | 7.51 | 26.82 | 19.31 | 7.51 | 26.82 | 20.21 | 8.31 | 28.52 | 26.11 | 12.82 | 38.93 | 26.11 | 128.2 | 38.93 | 48.96 | 43.91 | 92.87 |

SPEED CHANGE CYCLE (% of Level Tangent Cost/Bridge)

| Road | Initial speed | M/C | P/C | L/B P/T | M/B 4/T | H/B | 6/T | 10/T |
|---|---|---|---|---|---|---|---|---|
| Road 2B | I.S.-0 km/h 1/ | 42.90 | 56.34 | 42.90 | 44.19 | 58.39 | 58.39 | 175.81 |
| | I.S.-16 km/h | 31.99 | 45.25 | 31.99 | 32.96 | 43.52 | 43.52 | 136.52 |
| Road 3 | I.S.-0 km/h | 31.25 | 31.25 | 31.25 | 32.04 | 43.63 | 43.63 | 128.71 |
| | I.S.-16 km/h | 20.75 | 20.75 | 20.75 | 21.55 | 29.12 | 29.12 | 90.06 |
| Road 4 | I.S.-0 km/h | 21.53 | 21.53 | 21.53 | 21.80 | 30.52 | 30.52 | 87.69 |

1/: I.S. = Initial Speed

Road 1 : Paved Road

Road 2A : Laterite Road with good surface condition and alignment

Road 2B : Laterite Road with good surface condition but poor alignment

Road 3 : Laterite Road with poor surface condition and alignment

Road 4 : Earth Road

Table 7.5.6 VEHICLE OPERATING COST SAVINGS

(Paved)

(UNIT:1000 BAHT)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | 7,115 | 9,622 | 14,919 |
| IM - 2 | B. WAEO | K.A. NA PHO | 1,074 | 1,692 | 3,002 |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 3,065 | 4,449 | 7,015 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 2,662 | 4,012 | 6,679 |
| IM - 5 | A. NAM PHONG | (J.R.209) | 10,487 | 16,188 | 28,131 |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | 2,353 | 3,462 | 5,623 |
| IM - 7 | B. KHOK LAT | B. THA YOM | 2,989 | 5,204 | 10,014 |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | 4,429 | 6,139 | 9,467 |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | 6,393 | 8,782 | 13,198 |
| IM - 10 | A. PHEN | (J.R.212) | 5,921 | 8,434 | 12,204 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | 812 | 1,162 | 1,824 |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | 3,879 | 5,583 | 9,102 |
| IM - 13 | B. CHUAM | A. NA WHA | 2,134 | 2,891 | 4,336 |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | 1,122 | 1,676 | 2,825 |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | 3,815 | 5,407 | 8,443 |
| IM - 16 | (J.R.212) | A. WHAN YAI | 472 | 669 | 1,030 |
| IM - 17 | A. KUCHINARAI | B. NA KHU | 4,928 | 6,747 | 10,171 |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | 4,693 | 6,458 | 9,515 |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | 14,873 | 21,203 | 33,806 |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | 2,188 | 3,127 | 4,926 |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | 14,077 | 20,246 | 32,072 |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | 11,981 | 17,339 | 27,897 |
| IM - 23 | B. DON CHIK | B. NON RIANG | 5,328 | 7,832 | 12,681 |
| IM - 24 | B. NA SUANG | B. NA YIA | 2,122 | 3,238 | 5,678 |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 3,974 | 5,698 | 9,331 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | 8,108 | 10,600 | 15,232 |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | 4,359 | 5,971 | 9,175 |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | 27,478 | 42,867 | 77,119 |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | 7,979 | 11,687 | 19,254 |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | 10,877 | 17,416 | 32,098 |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | 12,075 | 17,467 | 28,069 |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | 2,210 | 2,672 | 3,185 |
| IM - 33 | (J.R.2) | A. CHOKCHAI | 25,839 | 35,627 | 55,556 |

Table 7.5.7 VEHICLE OPERATING COST SAVINGS

(Combined Paved and Laterite)

(UNIT:1000 BAHT)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | - | - | - |
| IM - 2 | B. WAEO | K.A. NA PHO | - | - | - |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 2,701 | 4,005 | 6,424 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 2,466 | 3,754 | 6,303 |
| IM - 5 | A. NAM PHONG | (J.R.209) | - | - | - |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | - | - | - |
| IM - 7 | B. KHOK LAT | B. THA YOM | - | - | - |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | - | - | - |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | - | - | - |
| IM - 10 | A. PHEN | (J.R.212) | 5,468 | 7,860 | 11,388 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | - | - | - |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | - | - | - |
| IM - 13 | B. CHUAM | A. NA WHA | - | - | - |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | - | - | - |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | - | - | - |
| IM - 16 | (J.R.212) | A. WHAN YAI | - | - | - |
| IM - 17 | A. KUCHINARAI | B. NA KHU | - | - | - |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | - | - | - |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | - | - | - |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | - | - | - |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | - | - | - |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | 10,815 | 15,783 | 25,549 |
| IM - 23 | B. DON CHIK | B. NON RIANG | - | - | - |
| IM - 24 | B. NA SUANG | B. NA YIA | - | - | - |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 3,553 | 5,112 | 8,404 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | - | - | - |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | - | - | - |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | - | - | - |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | - | - | - |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | - | - | - |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | - | - | - |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | - | - | - |
| IM - 33 | (J.R.2) | A. CHOKCHAI | - | - | - |

# Table 7.5.8 VEHICLE OPERATING COST SAVINGS

(Laterite)

(UNIT: 1000 BAHT)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | 4,526 | 6,541 | 10,965 |
| IM - 2 | B. WAEO | K.A. NA PHO | 399 | 821 | 1,754 |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 1,636 | 2,667 | 4,561 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 1,023 | 1,973 | 3,883 |
| IM - 5 | A. NAM PHONG | (J.R.209) | - | - | - |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | 1,738 | 2,670 | 4,470 |
| IM - 7 | B. KHOK LAT | B. THA YOM | 1,484 | 3,323 | 7,394 |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | - | - | - |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | 3,666 | 5,245 | 8,008 |
| IM - 10 | A. PHEN | (J.R.212) | 3,013 | 5,177 | 8,137 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | 618 | 918 | 1,474 |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | - | - | - |
| IM - 13 | B. CHUAM | A. NA WHA | 1,452 | 2,027 | 3,128 |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | 724 | 1,120 | 1,935 |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | 2,367 | 3,552 | 5,786 |
| IM - 16 | (J.R.212) | A. WHAN YAI | 296 | 437 | 682 |
| IM - 17 | A. KUCHINARAI | B. NA KHU | 3,400 | 4,782 | 7,335 |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | 2,576 | 3,904 | 5,996 |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | - | - | - |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | 1,556 | 2,307 | 3,719 |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | - | - | - |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | 7,725 | 11,415 | 18,489 |
| IM - 23 | B. DON CHIK | B. NON RIANG | 1,817 | 2,939 | 4,901 |
| IM - 24 | B. NA SUANG | B. NA YIA | 744 | 1,321 | 2,681 |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 1,999 | 2,978 | 5,064 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | - | - | - |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | 610 | 776 | 1,052 |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | - | - | - |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | - | - | - |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | - | - | - |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | - | - | - |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | 1,658 | 2,071 | 2,400 |
| IM - 33 | (J.R.2) | A. CHOKCHAI | - | - | - |

Table 7.5.9 VEHICLE OPERATING COST SAVINGS

(Splitted Paved Link)

(UNIT:1000 BAHT)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | - | - | - |
| IM - 2 | B. WAEO | K.A. NA PHO | - | - | - |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 1,421 | 2,133 | 3,413 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 2,206 | 3,416 | 5,819 |
| IM - 5 | A. NAM PHONG | (J.R.209) | - | - | - |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | - | - | - |
| IM - 7 | B. KHOK LAT | B. THA YOM | - | - | - |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | - | - | - |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | - | - | - |
| IM - 10 | A. PHEN | (J.R.212) | 4,708 | 6,760 | 9,713 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | - | - | - |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | - | - | - |
| IM - 13 | B. CHUAM | A. NA WHA | - | - | - |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | - | - | - |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | - | - | - |
| IM - 16 | (J.R.212) | A. WHAN YAI | - | - | - |
| IM - 17 | A. KUCHINARAI | B. NA KHU | - | - | - |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | - | - | - |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | - | - | - |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | - | - | - |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | - | - | - |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | - | - | - |
| IM - 23 | B. DON CHIK | B. NON RIANG | - | - | - |
| IM - 24 | B. NA SUANG | B. NA YIA | - | - | - |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 2,630 | 3,773 | 6,190 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | - | - | - |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | - | - | - |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | - | - | - |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | - | - | - |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | - | - | - |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | - | - | - |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | - | - | - |
| IM - 33 | (J.R.2) | A. CHOKCHAI | - | - | - |

## 7.6 ESTIMATION OF AGRICULTURAL DEVELOPMENT BENEFIT

### 7.6.1 Approach

In view of the remarkably predominant share of agricultural sector in the study area, development benefits attributable to the road development are represented by the increment of net added value of agricultural production within the area of influence of the proposed routes.

Gross value of production in the area of influence in case of with project is expected to be higher than the without project case, due to the following major factors:

- increase of production volume due to the rapid expansion of planted area accelerated by road development.
- increase of production volume due to the improvement of crop yield owing to the accelerated promotion of agricultural extension and guidance services.
- increase of farmgate prices due to the improvement of transportation and marketing conditions.
- diversification of cropping pattern into the commercial oriented.

Development benefits were estimated by the following formula:

$$P(\bar{w})_i^t = (1 + \alpha_i)^t \, PA_i \, . \, (1 + \beta_i)^t \, Y_i$$

$$P(w)_i^t = (1 + \gamma_i)^t \, PA_i \, . \, (1 + \sigma_i)^t \, Y_i$$

$$NPV(\bar{w})_i^t = P(\bar{w})_i^t \, . \, FP(\bar{w})_i - (i + \delta_i)^t \, PA_i \, . \, PC(\bar{w})_i - LPC \, . \, NL(\bar{w})^t$$

$$NPV(w)_i^t = P(w)_i^t \cdot FP(w)_i - (1 + \gamma_i)^t PA_i \cdot PC(w)_i$$

$$- LPC \cdot NL(w)^t$$

$$DB^t = \sum_i NPV(w)_i^t - \sum_i NPV(\bar{w})_i^t$$

where,

| | | |
|---|---|---|
| $P_i^t$ | : | Production of i crop at year t |
| $PA_i$ | : | Planted Area at base year of i crop |
| $\alpha_i$ | : | Growth rate of planted area of i crop (without) |
| $\beta_i$ | : | Growth rate of yield of i crop (without) |
| $Y_i$ | : | Yield of i crop |
| $\gamma_i$ | : | Growth rate of planted area of i crop (with) |
| $\delta_i$ | : | Growth rate of yield of i crop (with) |
| $NPV_i^t$ | : | Net Crop Production Value of i crop at year t |
| $FP_i$ | : | Farmgate Price of i crop |
| $PC_i$ | : | Production Cost of i crop |
| LPC | : | Land Preparation Cost for newly opened land |
| $DB^t$ | : | Development Benefit at year t |
| $NL^t$ | : | New Land opened at year t |
| $(\bar{w})$ | : | Without project case |
| (w) | : | With project case |

7.6.2 Area of Influence

An underlying premise in delineation of the area of influence is that the intensive influence of improved roads extends over ranges of about 5 km either side of the roads. The actual area of influence is, however, to be defined taking into account topographic features such as rivers, mountains, existing roads and other transport modes. It is plausible that the area of influence may not extend beyond big rivers and mountains. A portion of the area of influence of proposed road which is duplicated with that of existing roads is to be shared mutually by the proposed road and the existing roads concerned. It is considered that the area thus defined is a spacial range where the influence of a proposed road may extend to its socio-economic activities such as agricultural development. The area of influence for each proposed road is shown in land use and capability map in Route Report.

### 7.6.3 Planted Area and Land Capability

Land use and land capability in the area of influence of each proposed route were analysed basing on the following materials, together with the field survey findings:

- Land Use Map by Changwat, 1:100,000, 1978-79, Department of Land Development

- Land Capability Map of Thailand, 1:100,000, (1978), 1:1,250,000 (1980), Department of Land Development

- Soil Salinity Map, 1:500,000, Department of Land Development

From the above maps superimposed on the respective proposed routes, cultivated area and unused cultivable area were measured for each area of influence of proposed routes, as shown in Route Report.

Growth rates of planted area in case of without project were estimated based on the past trend of Amphoe data and the growth of population by Amphoe. On the other hand, for the case of with project, higher growth rates were estimated considering that expansion of planted area will be faster stimulated by the improvement of accessibility. The growth rates were adjusted taking into account unused cultivable area available.

Estimated planted areas in the future without project and with project are shown separately in Route Report.

Crop planting share in each area of influence was determined referring to the Amphoe level data of cropping pattern obtained from Changwat Offices.

### 7.6.4 Crop Yield

Yield in each area of influence in base year was determined based on the analysis of the Amphoe level data collected in the field survey. For estimation of future growth of yields for without project case, general tendency of Amphoe and Changwat level data and components of production costs at agro-zone level were analysed. The estimated future crop yields are shown in Route Report, separately by proposed route.

It is expected that the road development will bring about the increase of crop yields. Improvement of bargaining power of farmer due to the better accessibility will be an incentive for farmers to improve productivity. Social and economic mobility, including easy access for agricultural extension officers, enhanced by the road development will also provide various impacts to contribute indirectly to the improvement of farmers' agricultural practices to produce higher yields. More direct effects will be brought about by the availability of less expensive agricultural inputs as a result of improvement of transport conditions.

Viewing the above-mentioned and taking into consideration relationship between production costs and yields, future targets of crop yields at Amphoe level was forecasted and the consequent future growth rates of yields by area of influence in case of with project were estimated as shown separately in Route Report.

### 7.6.5 Farmgate Prices

Farmgate prices in case of without project are set basically with reference to statistical data of farmgate price in 1981 prepared by Ministry of Agriculture.

Considering that financial prices may not reflect economic value to the national economy, financial farmgate prices were converted to economic prices using conversion factors which were derived from components of taxes and other transfer items. They are 1.3 for paddy, 1.03 for maize, beans, cotton, ground nuts, cassava and kenaf and 1.08 for sugar cane.

Farmgate prices in with project case were estimated in consideration of the price effects of road development. Improved roads will bring about higher farmgate prices to farmers due to improvement of farmer's bargaining power, reduction of transportation costs and savings of marketing/handling costs and also avoidance of deterioration of crop quality. Sampling survey of farmgate prices indicates the general tendency that prices of major crops in areas with good accessibility are higher by around 5% than those of isolated areas. This implies that the currently isolated area can benefit from increase of at least 2.5% above average prices upon improvement of roads. For major crops such as paddy, maize, cassava and kenaf, farmgate prices in with project case were set 2.5% higher than the case of without project.

Thus estimated farmgate prices to be applied for each area of influence in the cases of with project and without project are shown separately in Route Report.

### 7.6.6 <u>Production Costs and Land Preparation Costs</u>

Production costs for major crops in case of without project were elaborated from data of the production costs by agro-zone prepared by Ministry of Agriculture. As the original data are given by zone, it was required to assign production costs to each areas of influence after necessary adjustment taking into account the current yields of the Amphoe related.

For with project case, production costs were estimated analyzing each cost component so as to correspond to the forecasted target yields. In relation with the raising up of yields, increase of fertilizer costs and agro-chemicals and increase of labor cost were considered correspondingly.

The estimated production costs for each area of influence are shown separately in Route Report.

Land preparation costs for opening new cultivation area were estimated at a minimum requirement level, for felling down of forests or bushes and initial plowing, 950 Baht per rai. Further investment costs such as costs for irrigation system and soil improvement were not included in this evaluation, since a part of yield increase to be due to such investment was excluded from the consideration of development benefits directly attributable to the projects.

### 7.6.7 Increment of Net Production Value

Using the input data estimated as in the foregoing section, net crop production values both in cases of with and without project were calculated. As a consequent, development benefits of each project route were obtained from the differences between the above two net production values at three points, 1987, 1993 and 2001, as shown in the following Table 7.6.1.

## Table 7.6.1 AGRICULTURAL DEVELOPMENT BENEFIT

(UNIT:1000 BAHT)

| PROPOSED ROUTE | ORIGIN | DESTINATION | 1987 | 1993 | 2001 |
|---|---|---|---|---|---|
| IM - 1 | A. KHONG | (J.R.2180) | 1,708 | 3,826 | 6,080 |
| IM - 2 | B. WAEO | K.A. NA PHO | 19 | 645 | 1,579 |
| IM - 3 | (J.R.2301) | A. NA CHUAK | 980 | 2,162 | 3,650 |
| IM - 4 | A. CHONNABOT | B. KUT RU | 299 | 2,433 | 5,373 |
| IM - 5 | A. NAM PHONG | (J.R.209) | 331 | 1,348 | 2,733 |
| IM - 6 | B. SOK CHAN | UBOLRATANA DAM | 92 | 320 | 622 |
| IM - 7 | B. KHOK LAT | B. THA YOM | 47 | 330 | 684 |
| IM - 8 | B. HUAI KOENG | A. KUMPHAWAPI | 129 | 949 | 2,030 |
| IM - 9 | A. NONG HAN | A. KUMPHAWAPI | 1,250 | 3,069 | 4,962 |
| IM - 10 | A. PHEN | (J.R.212) | 638 | 2,579 | 4,775 |
| IM - 11 | B. THUNG YAI | K.A. THUNG FON | 41 | 497 | 1,146 |
| IM - 12 | A. SAWANG DAEN DIN | A. SONG DAO | 64 | 530 | 1,030 |
| IM - 13 | B. CHUAM | A. NA WHA | 61 | 1,159 | 2,665 |
| IM - 14 | (J.R.223) | K.A. TAO NGAI | 86 | 311 | 615 |
| IM - 15 | A. RENU NAKHON | B. KU RU KHU | 732 | 1,526 | 2,613 |
| IM - 16 | (J.R.212) | A. WHAN YAI | 20 | 446 | 984 |
| IM - 17 | A. KUCHINARAI | B. NA KHU | 516 | 1,555 | 2,877 |
| IM - 18 | C. KALASIN | B. KHOK NONG BUA | 262 | 6,159 | 11,305 |
| IM - 19 | A. SELAPHUM | B. KHAM PHON SUNG | 907 | 2,723 | 5,162 |
| IM - 20 | B. NA HAI | A. KUT KHAO PUN | 188 | 979 | 2,057 |
| IM - 21 | A. TRAKAN PHUT PHON | A. KHEMARAT | 1,044 | 3,730 | 7,210 |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN | 403 | 1,439 | 2,798 |
| IM - 23 | B. DON CHIK | B. NON RIANG | 2,616 | 4,105 | 6,483 |
| IM - 24 | B. NA SUANG | B. NA YIA | 230 | 550 | 987 |
| IM - 25 | A. MAHA CHANA CHAI | A. YANG CHUM NOI | 1,904 | 3,389 | 5,494 |
| IM - 26 | B. NON DANG | A. RATTANA BURI | 287 | 2,733 | 5,192 |
| IM - 27 | B. NONG KHAO | A. CHOM PHRA | 872 | 2,371 | 4,491 |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) | 310 | 2,410 | 5,352 |
| IM - 29 | A. PRAKHON CHAI | A. KRASANG | 1,311 | 4,656 | 8,688 |
| IM - 30 | A. HUAI THALAENG | B. KA SANG | 1,616 | 3,271 | 5,282 |
| IM - 31 | A. LAMPLAI MAT | B. NONG KI | 1,950 | 3,963 | 6,328 |
| IM - 32 | B. YOK KHAM | A. SOENG SANG | 1,153 | 1,852 | 2,647 |
| IM - 33 | (J.R.2) | A. CHOKCHAI | 92 | 2,134 | 5,003 |

## 7.7 ESTIMATION OF ROAD MAINTENANCE COST SAVINGS

The annual routine maintenance costs by road class were estimated using the conventional type of equations. Though little information was available of the correlation between road maintenance costs and level of traffic volume by surface type, the following equations were elaborated from the analysis of DOH maintenance budget and equipment revolving fund for 1982 together with reference to the previous maintenance studies.1/

Annual Routine Maintenance Cost

| Surface Type | Annual Maintenance Cost (฿/km) (Economic Cost) |
|---|---|
| Earth | 12,000 + 75 AADT |
| Laterite (Good) | 21,000 + 30 AADT |
| Laterite (Poor) | 16,000 + 55 AADT |
| SBST | 27,000 + 11 AADT |
| Asphaltic Concrete | 30,000 + 4 AADT |

The road maintenance benefits are considered to be the difference of maintenance costs in the network related to each proposed route between with project case and without project case. The road maintenance cost savings estimated are shown separately in Route Report.

1/; "Study of Highway Maintenance and Equipment Needs" KAMPSAX, March, 1976.

## 7.8 ECONOMIC EVALUATION

### 7.8.1 Approach

For the purpose of assessment of priority order of the proposed routes from viewpoint of national economy, the economic evaluation was worked out in terms of internal rate of return (IRR), in the following steps:

Case 1: All routes are evaluated on condition that whole sections are constructed under the F4 Standard (DBST)

Case 2: Among the routes judged not feasible in the Case 1, routes which contain any links with higher ADT than 300 in 7th year are evaluated on condition that the F4 Standard is applied for such high ADT links and the F5 Standard for the remaining low ADT links.

Case 3: Of the routes in the Case 2, the links of higher ADT than 300 are splitted out and evaluated under F4 Standard (DBST).

Case 4: Routes which are judged not feasible in the Case 1, Case 2 and Case 3 are evaluated on condition that all links are constructed under the F5 Standard.

In the evaluation, the following conditions were assumed:

- Year of opening to traffic is the beginning of 1987, which is also the base point of calculation of present worth.

- Overlay costs are counted at 8th year after opening.

- Residual values are counted at the 15th year after opening, summing up 50% of direct construction cost including physical contingency and 100% of land acquisition cost.

- All benefits are counted for 15 years after opening.

- All costs and benefits are estimated at economic value, net of transfer items, in 1982 constant price.

- Costs are expensed at beginning of year and benefits accrue at year end.

- An opportunity cost of capital is deemed at about 12%, which is employed as a cut-off rate of IRR.

### 7.8.2 Evaluation and Ranking

In line with the approach mentioned above, IRRs were calculated for each case. The result is summarized in Table 7.8.1 and the process of screening is illustrated in Figure 7.8.1. A priority order of the proposed routes ranked by IRR in Case 1 and 3 is shown in Table 7.8.2. Details of costs and benefits of each proposed route are shown separately in Route Report.

Table 7.8.1 SUMMARY OF EVALUATION
(Routes for Improvement and New Construction)

| Proposed Route | Origin | Destination | Length (km) | ADT (1993) | Const. Cost1/ (Mill. Baht) DBST 2/ (F4) | Const. Cost1/ (Mill. Baht) S.A. 3/ (F5) | IRR DBST 4/ | IRR DBST+S.A. 5/ | IRR S.A. 6/ | O.O.Y 4/ DBST FYB=12% |
|---|---|---|---|---|---|---|---|---|---|---|
| IM - 1 | A. KHONG (J.R. 2150,2160) | (J.R. 2180) | 48.0 | 239 | 91.5 | 49.4 | 9.6 | - | 15.7 | 1989 |
| IM - 2 | B. WAEO (J.R. 202) | K.A. NA PHO | 9.4 | 333 | 16.3 | 8.8 | 10.2 | - | 12.7 | 1991 |
| IM - 3 | (J.R. 2301) | A. NA CHUAK (J.R. 219) | 30.6 | 175 | 57.8 | 32.1 | 7.4 | - | 11.6 | 1993 |
| Sect. 1 | (J.R. 2301) | A. PUAI NOI | 24.0 | 315 | 28.8 | - | 9.2 | 9.0 | | |
| Sect. 2 | A. PUAI NOI | A. NA CHUAK | 16.6 | 81 | - | 21.1 | - | | | |
| IM - 4 | A. CHONNABOT (J.R. 2057) | B. KUT RU (J.R. 2065) | 35.3 | 173 | 60.6 | 33.7 | 6.2 | - | 9.8 | 1994 |
| Sect. 1 | A. CHONNABOT | A. WANG YAI | 17.0 | 305 | 30.9 | - | 10.3 | 9.2 | | |
| Sect. 2 | A. WANG YAI | B. KUT RU | 18.3 | 50 | - | 15.6 | | | | |
| IM - 5 | A. NAM PHONG | (J.R. 209) | 29.1 | 622 | 61.5 | - | 20.0 | - | - | 1987 |
| IM - 6 | B. SOK CHAN (J.R. 2146) | UBOLRATANA DAM (J.R. 2109) | 20.3 | 174 | 62.4 | 36.0 | 4.0 | - | 6.2 | 1999 |
| IM - 7 | B. KHOK LAT (J.R. 2313) | B. THA YOM (J.R. 2316) | 24.0 | 251 | 46.0 | 24.2 | 8.1 | - | 11.6 | 1993 |
| IM - 8 | B. HUAI KOENG (J.R. 2) | A. KUMPHAWAPI (J.R. 2023) | 16.7 | 502 | 27.4 | - | 18.1 | - | - | 1987 |
| IM - 9 | A. NONG HAN (J.R. 22) | A. KUMPHAWAPI (J.R. 2023) | 33.4 | 356 | 72.6 | 45.2 | 11.1 | - | | 1988 |
| IM - 10 | A. PHEN (J.R. 2022) | (J.R. 212) | 48.1 | 228 | 87.7 | 53.5 | 7.7 | | | 1992 |
| Sect. 1 | A. PHEN | K.A. SONG KHOM | 26.0 | 311 | 45.6 | - | 12.4 | 10.1 | | |
| Sect. 2 | K.A. SONG KHOM | (J.R. 212) | 22.1 | 129 | - | 23.5 | | | 6.4 | |
| IM - 11 | B. THUNG YAI (J.R. 2096) | K.A. THUNG FON | 8.3 | 118 | 18.8 | 12.4 | 5.1 | - | 8.8 | 1996 |
| IM - 12 | A. SAWANG DAEN DIN (J.R. 22) | A. SONG DAO | 18.1 | 466 | 35.9 | - | 12.5 | - | - | 1987 |
| IM - 13 | B. CHUAM (J.R. 2094) | A. NA WHA | 19.8 | 123 | 37.5 | 24.5 | 6.6 | - | 9.4 | 1994 |
| IM - 14 | (J.R. 223) | K.A. TAO NGAI | 12.0 | 160 | 27.7 | 18.5 | 3.7 | - | 5.8 | 1999 |
| IM - 15 | A. RENU NAKHON (J.R. 2031) | B. KU RU KHU (J.R. 22) | 40.1 | 171 | 75.4 | 45.2 | 5.1 | - | 8.9 | 1996 |
| IM - 16 | (J.R. 212) | A. WHAN YAI | 9.1 | 105 | 15.2 | 7.6 | 3.0 | - | 8.6 | 1999 |
| IM - 17 | A. KUCHINARAI | B. NA KHU | 30.4 | 211 | 66.1 | 40.6 | 8.7 | - | 12.2 | 1991 |

Note:
1/ Financial Cost excluding price contingency
2/ Double Bituminous Surface Treatment
3/ Soil Aggregate Surfaced
4/ Case 1 and Case 3
5/ Case 2
6/ Case 4
7/ Optimum Opening Year, the year when first year benefit exceeds 12% of total investment

SUMMARY OF EVALUATION (2)
(Routes for Improvement and New Construction)

| Proposed Route | Origin | Destination | Length (km) | ADT (1993) | Const. Cost 1/ (Mill. Baht) DBST 2/ (F4) | S.A. 3/ (F5) | IRR DBST 4/ | DBST+S.A. 5/ | S.A. 6/ | O.O.Y 7/ DBST FYB=12% |
|---|---|---|---|---|---|---|---|---|---|---|
| IM - 18 | C. KALASIN | B. KHOK NONG BUA (J.R. 2116) | 50.7 | 188 | 98.2 | 59.6 | 7.5 | - | 11.6 | 1992 |
| IM - 19 | A. SELAPHUM (J.R. 23) | B. KHAM PHON SUNG (J.R. 2136) | 46.0 | 486 | 95.3 | - | 17.1 | - | - | 1987 |
| IM - 20 | B. NA HAI (J.R. 2049) | A. KUT KHAO PUN | 17.2 | 170 | 32.9 | 22.3 | 8.4 | - | 11.0 | 1992 |
| IM - 21 | A. TRAKAN PHUT PHON (J.R. 2049) | A. KHEMARAT (J.R. 202) | 65.3 | 623 | 112.4 | - | 14.3 | - | - | 1987 |
| IM - 22 | A. KHEMARAT | B. HUA SAPHAN (J.R. 217) | 122.4 | 169 | 217.1 | 116.6 | 4.5 | 7.6 | 8.1 | 1997 |
| IM - 23 | B. DON CHIK (J.R. 217) | B. NON RIANG (J.R. 2182) | 44.8 | 325 | 74.2 | 38.5 | 10.7 | - | 13.9 | 1988 |
| IM - 24 | B. NA SUANG (J.R. 24) | B. NA YIA | 14.5 | 367 | 25.7 | 13.4 | 10.6 | - | 11.4 | 1989 |
| IM - 25 | A. MAHA CHANA CHAI (J.R. 2083) | A. YANG CHUM NOI (J.R. 2168) | 38.2 | 270 | 68.0 | 36.7 | 8.6 | - | | 1991 |
| Sect. 1 | A. MAHA CHANA CHAI | A. KHO WANG | 23.0 | 313 | 39.9 | - | 11.6 | 10.5 | | |
| Sect. 2 | A. KHO WANG | (J.R. 2168) | 15.2 | 190 | - | 18.5 | | | | |
| IM - 26 | B. NON DANG (J.R. 2080,2083,2084) | A. RATTANA BURI | 39.5 | 305 | 74.3 | - | 11.8 | - | - | 1987 |
| IM - 27 | B. NONG KHAO (J.R. 2079) | A. CHOM PHRA (J.R. 214) | 31.1 | 501 | 52.0 | 24.5 | 11.3 | - | | 1988 |
| IM - 28 | C. BURI RAM | LAMCHI (RIVER) (J.R. 2078) | 42.0 | 1255 | 96.1 | - | 27.0 | - | - | 1987 |
| IM - 29 | A. PRAKHON CHAI (J.R. 24) | A. KRASANG | 48.0 | 398 | 95.5 | - | 11.5 | - | - | 1987 |
| IM - 30 | A. HUAI THALAENG | B. KA SANG (J.R. 218) | 51.0 | 626 | 96.4 | - | 14.6 | - | - | 1987 |
| IM - 31 | A. LAMPLAI MAT (J.R. 2073) | B. NONG KI (J.R. 24) | 59.7 | 321 | 93.1 | - | 15.1 | - | - | 1987 |
| IM - 32 | B. YOK KHAM (J.R. 2309) | A. SOENG SANG (J.R. 2119) | 29.0 | 86 | 49.5 | 29.1 | 4.5 | - | 9.8 | 1999 |
| IM - 33 | (J.R. 2) | A. CHOKCHAI | 51.5 | 1221 | 108.6 | - | 21.6 | - | - | 1987 |

Note:
1/ Financial Cost excluding price contingency
2/ Double Bituminous Surface Treatment
3/ Soil Aggregate Surfaced
4/ Case 1 and Case 3
5/ Case 2
6/ Case 4
7/ Optimum Opening Year, the year when first year benefit exceeds 12% of total investment

Figuer 7.8.1 SCREENING IN ECONOMIC EVALUATION

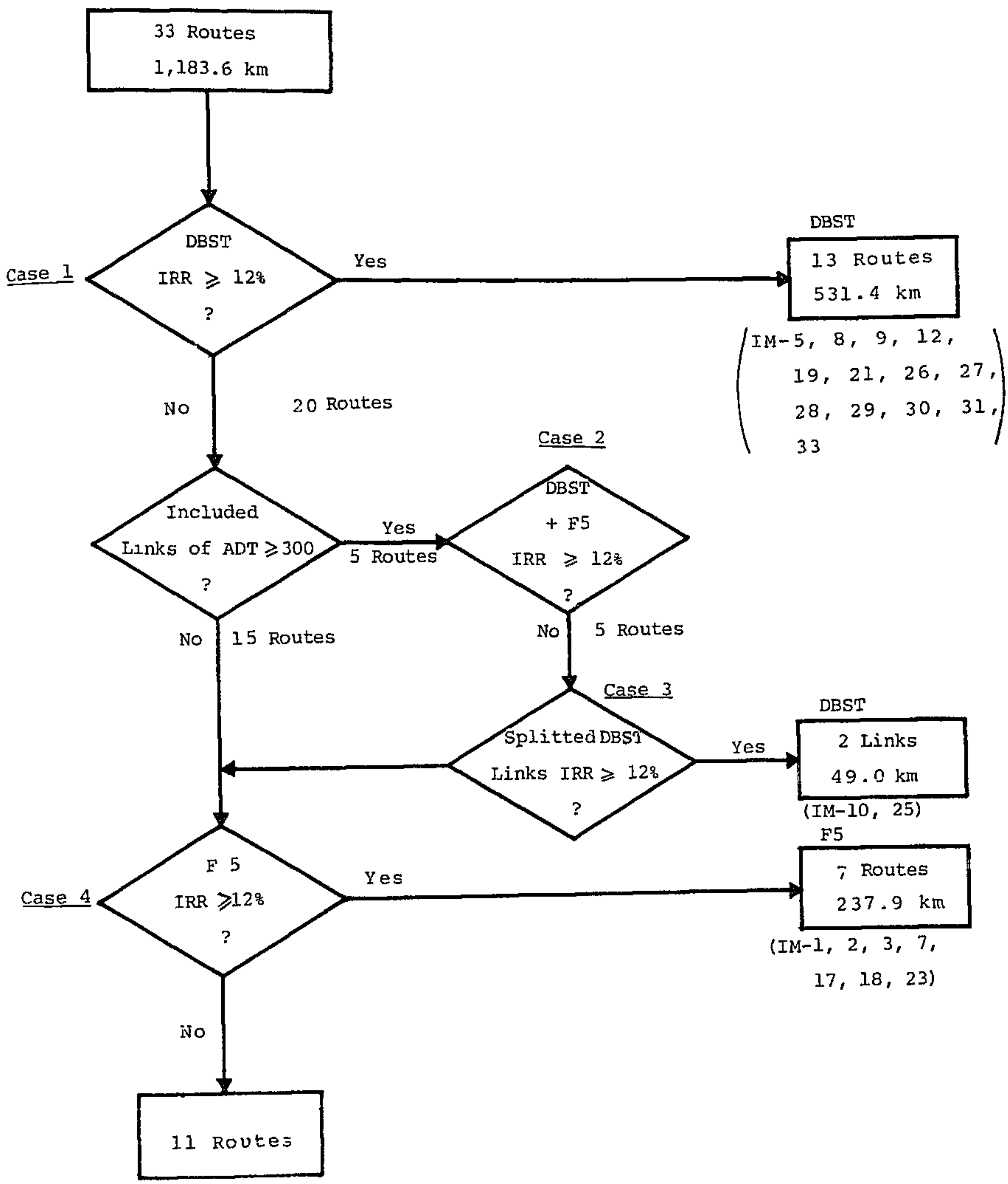


Table 7.8.2

Table 7.8.2 RANKIG BY IRR
(Case 1&3: F4 Class - DBST)

| Rank | Proposed Route | Origin | Destination | Length (km) | IRR (%) |
|---|---|---|---|---|---|
| 1 | IM-28 | C.Buri Ram | Lam Chi River | 42.0 | 27.0 |
| 2 | IM-33 | J.R 2 | A.Chokchai | 51.5 | 21.6 |
| 3 | IM-5 | A.Nam Phong | J.R 209 | 29.1 | 20.0 |
| 4 | IM-8 | B.Huai Koeng | A.Kumphawapi | 16.7 | 18.1 |
| 5 | IM-19 | A.Selaphum | B.Kham Phon Sung | 46.0 | 17.1 |
| 6 | IM-31 | A.Lamplai Mat | B.Nong Ki | 59.7 | 15.1 |
| 7 | IM-30 | A.Huai Thalaeng | B.Ka Sang | 51.0 | 14.6 |
| 8 | IM-21 | A.T. Phut Phon | A.Khemarat | 65.3 | 14.3 |
| 9 | IM-12 | A.S. Daen Din | A.Song Dao | 18.1 | 12.5 |
| 10 | IM-26 | B.Non Dang | A.Rattana Buri | 39.5 | 11.8 |
| 11 | IM-29 | A.Prakhon Chai | A.Krasang | 48.0 | 11.5 |
| 12 | IM-27 | B.Nong Khao | A.Chom Phra | 31.1 | 11.3 |
| 13 | IM-9 | A.Nong Han | A.Kumphawapi | 33.4 | 11.1 |
| 14 | IM-23 | B.Don Chik | B.Non Riang | 44.8 | 10.7 |
| 15 | IM-24 | B.Na Suang | B.Na Yia | 14.5 | 10.6 |
| 16 | IM-2 | B.Waeo | K.A. Na Pho | 9.4 | 10.2 |
| 17 | IM-1 | A.Khong | J.R 2180 | 48.0 | 9.6 |
| 18 | IM-17 | A.Kuchinarai | B.Na Khu | 30.4 | 8.7 |
| 19 | IM-25 | A.M. Chana Chai | A.Y. Chum Noi | 38.2 (23.0)* | 8.6 (12.6)* |
| 20 | IM-20 | B.Na Hai | A.Kut Khao Pun | 17.2 | 8.4 |
| 21 | IM-7 | B.Kok Lat | B.Tha Yom | 24.0 | 8.1 |
| 22 | IM-10 | A.Phen | J.R 212 | 48.1 (26.6)* | 7.7 (12.4)* |
| 23 | IM-18 | C.Kalasin | B.K. Nong Bua | 50.7 | 7.5 |
| 24 | IM-3 | J.R 2301 | A.Na Chuak | 30.6 (24.0)* | 7.4 (9.2)* |
| 25 | IM-13 | B.Chuam | A.Na Wha | 19.8 | 6.6 |
| 26 | IM-4 | A.Chonnabot | B.Kut Ru | 35.3 (17.0)* | 6.2 (10.3)* |
| 27 | IM-11 | B.Thung Yai | K.A. Theng Fon | 8.3 | 5.1 |
| 28 | IM-15 | A.R. Nakhon | B.Ku Ru Khu | 40.1 | 5.1 |
| 29 | IM-32 | B.Yok Kham | A.Soeng Sang | 29.0 | 4.5 |
| 30 | IM-22 | A.Khemarat | B.Hua Saphan | 122.4 | 4.5 |
| 31 | IM-6 | B.Sok Chan | Ubolratana | 20.3 | 4.0 |
| 32 | IM-14 | J.R 223 | K.A. Tao Ngai | 12.0 | 3.7 |
| 33 | IM-16 | J.R 212 | A.Whan Yai | 9.1 | 3.0 |

Note: * show the cases of splitted sections of high ADT.

## 7.9 ASSESSMENT OF SOCIAL IMPACTS

### 7.9.1 Approach

Decentralization of social services and enhanced development of backward rural areas are the important items of the national objectives of the Kingdom. In line with this policies, the future road development pays more attention to the accelerated rural road development as well as the completeness of trunk road networks. In this connection, it became more vital to assess the significance of road development not only from the economic viewpoint but also from the social viewpoint. Importance should be placed on how the road development contributes to the people's convenience to have better social services and also to the alleviation of income disparity from the standard level.

In this study, an attempt was made, although it is still imperfect, to assess the social impacts of the proposed routes on their influence areas. In the selection of criteria and indicators to quantify social impacts, careful examination was performed in view of not only their relevance but data availability. A set of criteria and indicators finally selected are as shown in Table 7.9.1 which composed of the following four major criteria:

- Alleviation of Isolation
- Impact on Health Services
- Impact on Educational Services
- Alleviation of Income Disparity

Each criterion has one to three sub-criteria as seen in Table 7.9.1.

### 7.9.2 Survey

Primary data required for quantification of the selected indicators were collected also in the Home Interview Survey conducted for traffic forecasting. Data were collected and compiled by proposed route on the following items: location of hospitals and medical centers, location of secondary schools, number of students, number of teachers, teachers' academic career, student enrollment ratio, expenditure for education, expenditure for medical services, etc. Compiled data were carefully examined their significance and some of them were selected out to use for quantification of the indicators.

### 7.9.3 Quantification of Indicators

#### 1) Alleviation of Isolation

##### a) Improvement of Access to Amphoe

Savings of average traveling time for the people in the area of influence to the Amphoe center are measured, on a per capita basis, as follows:

$$Ti = (Li/Si(\bar{w}) - Li/S(w)) / Pi$$

where,

- $Ti$ = per capita time savings of Route i
- $Li$ = average traveling distance to Amphoe of Route i
- $Si(\bar{w})$ = average running speed of pickup in case of without project, Route i
- $S(w)$ = average running speed of pickup in case of with project (72 kph)
- $Pi$ = population of area of influence of Route i

##### b) Improvement of Access to Artery Highway

Savings of average traveling time from the Amphoe center to the nearest artery highway are measured on a per capita basis as in a same manner as in the above a). In measuring distance from Amphoe to artery highway, the length of the existing paved road connecting the proposed route with the artery highway was not counted as it is common both in the with project case and in the without project case.

c) Alleviation of Impassability

Duration of impassability of road a year by disasters such as erosion by flood was measured on a per capita basis as follows:

$$Ii = \frac{Wi}{52} / Pi$$

where,
- $Ii$ = degree of impassability of road a year, per capita
- $Wi$ = number of weeks impassable a year
- $52$ = weeks a year
- $Pi$ = population in influence area of Route i

2) Impacts on Health

a) Improvement of Access to Hospital

Per capita savings of average traveling time for the people in the area of influence to access Amphoe level hospitals having doctor were quantified on a per capita basis as follows:

$$T'i = (L'i/Si(\bar{W}) - L'i/S(W)) / Pi$$

where,
- $T'i$ = per capita time savings
- $L'i$ = average traveling distance to hospital
- $Si(\bar{W})$ = average running speed of pickup in case of without project, Route i
- $S(W)$ = average running speed of pickup in case of with project (72 kph)

b) Improvement of Access to Medical Facilities

As same in manner as the above a), per capita time savings to medical facilities, including health centers and sanitary centers, were quantified.

3) Impacts on Education

a) Improvement of Access to Secondary School

Savings of traveling time to secondary school per student were quantified as in a similar manner as in the above (2)-a). Rates of secondary school student per population were obtained by route from the Home Interview Survey.

b) Improvement of Teacher Intensity

Qualitative and quantitative level of intensity of teachers were measured by route as follows:

$$E = \frac{\text{Number of University Graduate Teachers}}{\text{Number of Students}} + \frac{\text{Total Number of Teachers}}{\text{Number of Students}}$$

And, the degree of improvement of teacher intensity was quantified by:

$$E(P) \,/\, Ei(\bar{W})$$

where,

$E(P)$ = average of Indicator E in case of areas with paved road

$Ei(\bar{W})$ = indicator E of Route i in case of without project

Indicator E(P) was calculated at 68.4 based on the data collected nearby paved roads in the Home Interview Survey.

4) Alleviation of Disparity

a) Alleviation of Income Disparity

A level of income disparity was measured by the following indicator:

$$Di = \frac{\text{Per Capita Average Crop Production Value in the Northeast}}{\text{Per Capita Crop Production Value in Route i}}$$

And, the degree of alleviation of income disparity was quantified by:

$$Di(\bar{W}) - Di(W)$$

Where, $Di(\bar{W})$ = indicator Di in case of without project
$Di(W)$ = indicator Di in case of with project

The average per capita crop production value of the Northeastern Region was estimated at 3,040 Baht in 1993, based on the projected per capita GRP and the share of crop production in GRP.

### 7.9.4 Scoring

The quantified indicators were transformed into scores as in the following manner:

(i) For each sub-criterion, calculate average value, Xj, of indicator values of the all proposed routes, and

(ii) Calculate an index measure of respective indicator value for each proposed route, Xij, by sub-criterion according to the following and assume it to be a score of each proposed route in respect of the sub-criterion:

$$Sij = \frac{Xij}{Xj}$$

Where,
Sij = Score of route i in sub-criterion j
Xij = indicator value of Route i in sub-criterion j
Xj = average value of all indicators in sub-criterion j

Table 7.9.2 shows calculated scores of each proposed route by criterion and details of quantified indicators and scores are given separately by route in Route Report.