Chapter VI

TRAFFIC

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TRAFFIC

6-1 OUTLINE OF TRAFFIC FORECAST PROCEDURE

6-1-1 General

The usual traffic forecast method, which predicts the traffic growth trends and applies them to the existing traffic, was not used in this study. There was no past traffic count data on the road network in the Project Area, available for the estimation of present traffic and traffic growth trends. Though some traffic counts were made during the survey period on the existing road in the Project Area, the results show only the traffic volume of one day in rainy season. In rainy season, as some road sections, especially those in east-west direction crossing the Pasak River, become impassable as described in Chapter III, the movement pattern is far different from that in dry season. In addition, there are much variations in transportation demands between harvesting and non-harvesting seasons. Therefore, it is difficult to estimate the present ADT from the traffic count data.

Traffic forecast was made based mainly on the forecasted agricultural production in the Project Area for freight traffic, and on the forecasted population and trip rates obtained by home interview survey for passenger traffic. The traffic count data was used only to determine the present and future traffic composition and to check the traffic forecast model used in this study.

Traffic was forecasted separately for freight traffic and passenger traffic, and then combined. The transport demands of freight were estimated based on the forecasted agricultural development. The tonnage of agricultural production, calculated assuming road link as the origin, was subdivided into 3 groups according to the destination: 1) Lam Narai and southward (Bangkok or Tha Rua in case of maize), ii) Towns along Route 21 and iii) within Project Area. On the other hand, transportation demands of passenger were estimated based on the trip rates for origin and destination pairs, obtained through home interview survey, by multiplying the forecasted population at the origin to them. The probable routes were searched taking minimum freight charge and minimum passenger fare as a sole yardstick, by all or nothing method, on the assumption that the Project road will be improved to F5 standard of DOH. Then, the freight flow and passenger flow were determined for all origin and destination pairs of traffic. The traffic volume on each road link thus assigned was then converted into ADT based on the future traffic composition.

The work flow for freight traffic forecast and that for passenger traffic forecast are illustrated in Figure 6-1 and 6-2, respectively.

6-1-2 Type of Traffic

Traffic forecast on the subject roads was undertaken dividing into the following three types of traffic.

a) Normal traffic
b) Developed traffic
c) Induced traffic

Normal traffic is defined as the traffic which will take place on the existing road, arising from the natural increase in population and economic activities independent of the improvement. After the improvement or new construction of road in the Project Area, normal traffic volume may increase or decrease on some road links comparing with do-nothing case, as some trips may change their route or destination. Though these increase or decrease can be considered as the diverted traffic, they were included in the normal traffic in this study, as they are only the transfer within

the road network in the Project Area. In the context of this study, there will be no diverted traffic from other competitive route or mode. Even if the north-south road connecting Phetchabun and Chai Badan is constructed in the Project Area, no traffic would be diverted from the National Highway Route 21, as the road standard of Route 21 is far higher than those which would be applied to the subject road. And, there is no competition between road transportation and water transportation of the Pasak River, as the Pasak is only navigable by very small boat.

Developed traffic is defined as the traffic which occurs on account of the agricultural development in excess of natural growth, and population increase by migration for it.

Induced traffic is defined as the extra traffic which is newly induced as a result of decrease of vehicle operating cost and travel time and increase of comfort, and which previously did not exist at all. In this study, induced traffic was estimated only for passenger traffic.

6-2 TRAFFIC SURVEY

6-2-1 Traffic Count

Classified traffic counts were made in the Project Area at 11 stations, 12 hour manual counts at 4 stations on 5th August and 8 hour manual counts at 7 stations on 8th September. In addition to the classified manual counts, automatic countings were carried out for 48 hours including the time of manual count, at 2 stations, one on Link 3 and the other on Link 16, in order to obtain a full picture of daily traffic distributions. The location of these counting stations is shown with the results of traffic count in Figure 6-3.

The present traffic was classified into 6 types of vehicle, i.e., passenger car, light bus and heavy bus for passenger traffic and light truck, medium truck and heavy truck for freight traffic. Standard type of vehicle and characteristics of each class are described below:

a) Passenger Car (P/C)

Standard models are Datsun 160J, Toyota Corona, and Mazda 808, with a 1,600 cc petrol engine.

b) Light Bus (L/B)

Light bus is a simple adoption of 4 wheel light truck such as Datsun 1500 and Mazda 1600 with longitudinal bench seats and canopy of canvas. Seat capacity is 10 in average.

c) Heavy Bus (H/B)

Heavy bus has wide range from modified 6 wheel medium truck such as Toyota Dyna and Isuzu Elf with long bench seats to large tour bus such as Isuzu BD61 and Hino BF320. Seat capacity ranges from 20 to 40.

d) Light Truck (L/T)

Light truck is 4 wheel truck such as Datsun 1500 and Mazda 1600, with loading capacity of 2 tons.

e) Medium Truck (M/T)

Medium truck is 6 wheel double axle truck such as Toyota Dyna and Hino KR 320 with loading capacity up to 6 tons.

f) Heavy Truck (H/T)

Heavy truck is 10 wheel triple axle truck such as Isuzu TWD80 HJ and Hino KT920, with loading capacity up to 13 tons.

The results of classified traffic count suggest that the present traffic on the subject road is an order of 300 vehicles per day at the heaviest.

6-2-2 Roadside Interview

Roadside interview to drivers was conducted at 3 stations on Link 3, 13 and 37, from 1st to 3rd August 1978, in order to obtain information on occupancy rates of passenger cars and buses and loading condition of trucks. The average occupancy and average load through a year was estimated as shown below.

Occupancy Rate

	(persons)
Pessenger car	4
Light bus	9
Heavy bus	20

Average Load

	(ton)
Light truck	0.9
Medium truck	2.4
Heavy truck	7.2

6-2-3 Home Interview Survey

Home interview survey was carried out in 19 villages in the Project Area to obtain the rates of vehicle trip per population per year. Number of sample households was 193 excluding invalid answers, and number of inhabitants was 858. The survey was designed to obtain information on number of vehicle trip during a year by origin and destination pair, route, fare, vehicle type and trip purpose.

Table 4A-1 and 4A-2 of Appendix 4 show the person trip rates for each origin and destination pair, divided into the following two categories of trip, grouped by trip purpose:

a) Trips without Fixed Destination

Trips with purpose such as shopping, agricultural production transport, etc. which may change destination to more convenient one after the road is improved.

b) Trips with Fixed Destination

Trips with purpose such as business, school, visiting friend, etc. which may not change destination after the road is improved.

6-2-4 Road Classification

The actual travelling speed on the existing road was surveyed in the course of road inventory survey. Based on the results, all road links in the Project Area were classified into nine grades, as shown in Table 6-1.

The actual road conditions in rainy and dry seasons were taken into consideration in calculating the average travelling speed. For example, in case of the road link crossing the Pasak River, which becomes difficult to pass in rainy season, the travelling speed in rainy season was calculated by averaging the speed of vehicle on muddy road, speed of small wooden boat and waiting time for transfer over the link length.

While, the transportation costs of freight and passenger were investigated by the interview to drivers at bus terminals and transport businesses, and they were related to the road grades.

The link resistance of each link was expressed in the transportation cost, as shown in Table 4A-3 of Appendix 4, and used to search the probable route of freight and passenger traffic. Time cost is included in the transportation cost of passengers. Unit time value of passengers is quoted from the report "Study of Highway Maintenance and Equipment Needs, 1976" by Kampsax, but averaged as 4.3 Bahts per passenger per hour.

In addition, the travelling speeds on level tangent road were decided on different types of road surface as shown below. They were adopted as the benchmark speeds to calculate road users' benefit.

Travel Speed on Level Tangent Road

(km/hr)

Surface Condition	Vehicle Type					
	P/C	L/B	H/B	L/T	M/T	H/T
Asphalt concrete	88	88	88	88	80	80
Bituminous surface treatment	80	80	80	80	72	72
Soil aggregate, good	56	56	56	56	48	48
Soil aggregate, fair	48	48	48	48	40	40
Earth, fair	32	32	32	32	24	24
Earth, bad	16	16	16	16	10	10

6-3 TRAFFIC COMPOSITION

The present traffic on the road network in the Project Area comprises passenger cars and buses for passenger traffic and trucks for freight traffic. According to the traffic count data, light buses form 70 to 80 percent of passenger stream. Passenger cars form about 12 percent, and heavy buses about 9 percent. In the freight stream, light trucks occupy 70 to 80 percent, with 2 axle medium trucks of about 20 percent and 3 axle heavy trucks of less than 8 percent following.

Over the evaluation period of 20 years, it is predicted that light trucks and light buses will continue to occupy the largest portion in freight and passenger movement, respectively, and that the share of heavy buses will increase considerably upon completion of the all-weather road by further introduction of scheduled operation. The share of 3 axle heavy trucks will also increase at the expense of 2 axle trucks, but the extent of this change will be slow and small. There will be little chance that other types of vehicle appear in the Project Area.

Taking the present and future traffic composition into consideration, six types of vehicle same as stated in 6-2-1 were taken in the study. The following table sets out the future traffic composition in the Project Area.

Traffic Composition

Freight Traffic

Year	L/T	M/T	H/T (%)
1983	70	20	10
1989	65	22	13
1997	65	22	13

Passenger Traffic

Year	P/C	L/B	H/B (%)
1983	12	67	21
1989	12	67	21
1997	12	67	21

6-4 FORECAST OF FREIGHT TRAFFIC

6-4-1 Agricultural Production

The agricultural land development in the Project Area was forecasted by crop for both cases of with and without project, as described in Chapter V. The whole agricultural land was divided into small areas connecting with each road link, as shown in Tables 4A-4 to 4A-7 of Appendix 4. The production volume of crops along each road link was calculated by multiplying unit yields, also mentioned in Chapter V, to these areas.

The following tables show the rates of shipment by season and the rates of distribution by destination, which were determined taking cropping calendar and consumption in and around the Project Area into account.

Rates of Shipment

(%)

Kind of Crop	Rainy Season	Dry Season
Maize	100	0
Paddy	0	100
Beans	30	70
Others	30	70

Distribution by Destination

(%)

Kind of Crop	Southward of Lam Narai	Towns along Route 21	Consumed in the Project Area
Maize	98	0	2
Paddy	70	3	27
Beans	90	3	7
Others	50	3	47

Based on the aboves, the tonnage of agricultural products by link by destination was estimated as shown in Tables 4A-8 to 4A-14 of Appendix 4.

Besides the transportation of agricultural products, there are other transportation demands of goods such as forest products, livestocks, daily consumables, agricultural inputs like fertilizers and agro-chemicals, etc. They were estimated, however, to be negligible in traffic forecast, since their quantities in terms of ADT are not significant, and moreover some inflow goods are transported by the inbound trip of the same trucks for collection of agricultural products from the outside area.

6-4-2 Freight Traffic

Between road link, as the origin of transportation of agricultural products, and destination, the most probable route was searched, separately for rainy season and dry season, taking minimum freight charge as a sole yardstick, by all or nothing method. For the traffic which

has its destination on the Route 21, the nearest node on Route 21 was selected. The freight tonnage on each road link assigned based on the above was converted into ADT using future traffic composition and loading.

Freight traffic was estimated dividing into normal traffic and developed traffic by the following criteria:

Normal traffic	:	corresponds to the agricultural production without project
Developed traffic	:	corresponds to the agricultural production in excess of that without project

6-5 FORECAST OF PASSENGER TRAFFIC

6-5-1 Population Projection

In order to project the population at link nodes, the population by Tambon in the Project Area, shown in Table 3-1, was rearranged to that by link node. Population projection was then formulated for each link node, with reference to the past trends and projected agricultural land development.

A natural growth rate of 1.8 percent per annum was used through 1983, thereafter diminishing to 1.6 percent per annum to the end of the study period. Population increase in excess of natural growth due to the accelerated agricultural land development by road improvement was estimated for with project case based on the difference in agricultural land area between with and without project. It is estimated that all labors required for new land development, about 150 labors per square kilometer of maize and paddy farm, will be purchased by migration from the outside area.

The projected population at each node is shown in Table 4A-15 of Appendix 4.

6-5-2 Passenger Traffic

By multiplying the population at origin node to the person trip rates shown in Table 4A-1 and 4A-2 of Appendix 4, the transportation demand of passenger was estimated by origin and destination pair, dividing into normal traffic and developed traffic by the following criteria:

Normal traffic	:	corresponds to the population with natural growth
Developed traffic	:	corresponds to the migrated population

The most probable route was searched by origin and destination pair, taking minimum passenger fare as a sole yardstick, by all or nothing method. As the nearest node on Route 21 was selected for the trip having unfixed destination on Route 21, some trips changed their destination from without project case.

In addition to the normal and developed traffic, the increase in transportation demand induced by road improvement was estimated using trip inducing rate of each origin and destination pair, derived based on the difference in the total resistance between with and without project.

Based on the roadside interview and home interview survey, person trip rate was related to the passenger fare incurred, by the following equation:

$$T = a \cdot F^b$$

where, T : Trip rate

F : Passenger fare

a = 0.2135, b = -0.2898 :
Coefficient determined by regression analysis

Using the above, the trip inducing rate was defined by origin and destination pair, as follows:

$$TIR = \frac{aF^b - a\bar{F}^b}{a\bar{F}^b}$$

where, TIR : Trip inducing rate

F : Total resistance from origin to destination with project, expressed in passenger fare

$\bar{F}$: Total resistance from origin to destination without project, expressed in passenger fare

The induced traffic was calculated by multiplying the trip inducing rate to the total of normal and developed traffic.

The passengers on each road link thus assigned were converted into ADT using future traffic composition and occupancy.

6-6 FORECASTED TRAFFIC

Using the traffic forecast model of this study, the traffic in 1978 was calculated and compared with the traffic count data, as shown in Table 6-2. The total traffic volume estimated is generally larger than that of traffic count data. In the traffic mix, estimated passenger traffic is generally larger than traffic count, while estimated freight traffic is smaller. Based on the local information, it was considered that as the time of traffic count was in harvesting season of maize, local people made less trip than annual average, while freight traffic to transport maize was large. Though the seasonal fluctuations in traffic volume and movement pattern are still vague, it was judged that there was little difference in the order of traffic volume between estimation and actual traffic, and that the model of the study was effective.

The projected ADT of Route Alternative-I, -II and -III are shown in Table 6-3, 6-4 and 6-5, and ADT in 1989 of them are illustrated in Figure 6-4, 6-5 and 6-6, respectively.

6-7 ESTIMATION OF ROAD USERS' BENEFIT

6-7-1 General

The direct benefits that accrue to road users from road improvement were quantified by measuring the savings in road users' costs, composed of vehicle operating costs and time costs.

As some traffic changes its route and/or destination after the improvement of road, the savings were measured with the difference in total road users' costs from trip origin to destination between with and without project. They were calculated by origin and destination pair of traffic for freight and passenger, and then summed up.

For normal traffic of both freight and passenger, whole savings were counted, while for developed and induced traffic of passenger one half of savings were counted. Savings for developed traffic of freight were not counted, because this benefit is considered to be included in the benefit of agricultural development discussed in Chapter V.

The work flow for the estimation of road users' benefit is shown in Figure 6-7.

6-7-2 Road Users' Costs

Unit road users' costs were based on the report "Standardization of Vehicle Operating Costs for Thailand", in which vehicle operating costs and time costs on level tangent road are calculated for 10 classes of vehicle at 10 speed levels by surface type, using March 1977 price.

Adjustments were made to the vehicle operating costs, as the prices of fuel have risen from the time of the above report. From March 1977, the price of regular petrol has risen 36 percent from 3.55 to 4.82 Bahts per liter, and that of diesel fuel has risen 9 percent from 2.53 to 2.77 Bahts per liter. The adjusted vehicle operating costs are shown in Table 4A-16 of Appendix 4. The time costs of the above report were used without any change.

The changes of road users' cost on level tangent road due to grades, curves and speed changes at intersections or narrow bridges included in the actual road, were made using the method shown in the report "Investment Alternative Study for Corridors 4 and 5", in which the changes in road users' costs are expressed by the ratios of the costs on level tangent road. The figures in the report were quoted for additional curve costs, additional uphill grade costs, deduction for downhill grade costs, additional speed change cycle costs and additional speed change cycle time.

6-7-3 Road Users' Benefit

Road users' benefits of Route Alternative-I, -II and -III were estimated for 1983, 1989 and 1997, as shown below.

Road Users' Benefit

(1,000 Baht)

Year	Route Alternative		
	I	II	III
1983	48,807	26,187	49,479
1989	56,527	30,094	54,369
1997	63,777	33,710	60,771

Table 6-1 ROAD GRADE

Grade	Surface Condition	Travelling Speed (Km/h)	Transportation Cost per Kilometer	
			Passenger (B/person)	Freight (B/bag)
1	Asphalt concrete, good	over 85	0.10	0.04
2	Asphalt concrete, fair	75-84	0.10	0.04
3	Bituminous surface treatment	65-74	0.16	0.26
4	Soil aggregate, good	50-64	0.16	0.30
5	Soil aggregate, fair	40-49	0.22	0.35
6	Earth, good	30-39	0.22	0.46
7	Earth, fair	15-29	0.40	0.46
8	Earth, bad	5-14	0.40	0.69
9	Earth, bad	0-4	0.40	1.38

Table 6-2 TRAFFIC IN 1978

Node No.	Estimation							Traffic Count /1						
	P/C	L/B	H/B	L/T	M/T	H/T	Total	P/C	L/B	H/B	L/T	M/T	H/T	Total
3	33	218	22	24	8	5	310	33	108	6	54	12	10	223
6	26	171	17	12	4	2	232	3	54	25	25	6	6	119
11	30	170	20	16	5	3	244	22	71	29	55	32	10	219
16	26	165	17	46	16	9	279	12	120	2	115	18	13	280
18	36	237	24	12	4	2	315	2	87	-	78	18	4	189
22	17	113	11	5	2	1	149	2	46	-	66	7	4	125
37	8	53	-	6	2	1	70	10	68	-	33	28	-	139
39	10	57	-	3	1	1	72	9	52	-	47	13	-	121
41	22	128	40	43	15	9	257	9	104	-	70	26	28	237

Remarks: /1 Converted into daily traffic volume

Table 6-3 TRAFFIC PROJECTION (ROUTE ALTERNATIVE-I)

(vehicles per day)

ROAD LINK NO.	TYPE OF TRAFFIC	1983							1989							1997						
		P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL
3	Normal	29	171	53	28	9	5	295	32	189	59	41	14	8	343	36	214	66	59	20	11	406
	Developed+Induced	3	16	5	0	0	0	24	10	56	18	10	3	2	99	10	56	18	10	3	2	99
	Total	32	187	58	28	9	5	319	42	245	77	51	17	10	442	46	270	84	69	23	13	505
6	Normal	24	140	43	8	3	2	220	27	155	48	14	5	2	251	30	176	55	20	7	4	292
	Developed+Induced	2	14	5	0	0	0	21	7	40	13	3	1	1	65	7	40	13	3	1	1	65
	Total	26	154	48	8	3	2	241	34	195	61	17	6	3	316	37	216	68	23	8	5	357
11	Normal	24	139	44	33	11	6	257	29	171	54	45	15	8	322	32	191	60	61	20	11	375
	Developed+Induced	0	1	0	0	0	0	1	1	4	1	7	3	2	18	1	4	1	7	3	2	18
	Total	24	140	44	33	11	6	258	30	175	55	52	18	10	340	33	195	61	68	23	13	393
16	Normal	56	330	103	66	22	13	590	67	393	123	80	27	16	706	76	443	138	98	33	19	807
	Developed+Induced	7	36	11	0	0	0	54	12	68	21	12	4	2	119	12	70	22	12	4	2	122
	Total	63	366	114	66	22	13	644	79	461	144	92	31	18	825	88	513	160	110	37	21	929
18	Normal	37	213	67	25	9	5	356	45	264	82	34	12	7	444	50	295	92	44	16	9	506
	Developed+Induced	2	13	4	0	0	0	19	6	31	10	7	2	1	57	6	33	10	7	2	1	59
	Total	39	226	71	25	9	5	375	51	295	92	41	14	8	501	56	328	102	51	18	10	565
22	Normal	17	99	32	11	4	2	165	19	111	35	14	5	2	186	21	126	40	19	6	3	215
	Developed+Induced	3	15	4	0	0	0	22	5	26	8	3	1	1	44	5	28	9	3	1	1	47
	Total	20	114	36	11	4	2	187	24	137	43	17	6	3	230	26	154	49	22	7	4	262
23	Normal	17	98	31	10	3	2	161	20	110	34	11	4	2	181	21	127	39	11	4	2	204
	Developed+Induced	2	13	4	0	0	0	19	3	19	6	1	0	0	29	5	20	6	1	0	0	32
	Total	19	111	35	10	3	2	180	23	129	40	12	4	2	210	26	147	45	12	4	2	236
25	Normal	25	143	45	19	7	4	243	28	163	51	21	7	5	275	32	184	58	24	7	5	310
	Developed+Induced	1	9	3	0	0	0	13	2	13	4	2	1	0	22	2	15	4	2	1	0	24
	Total	26	152	48	19	7	4	256	30	176	55	23	8	5	297	34	199	62	26	8	5	334
27	Normal	34	195	61	43	15	8	356	38	224	70	47	16	9	404	43	255	79	50	17	9	453
	Developed+Induced	1	6	2	0	0	0	9	2	9	3	2	1	1	18	2	9	3	2	1	1	18
	Total	35	201	63	43	15	8	365	40	233	73	49	17	10	422	45	264	82	52	18	10	471
30	Normal	5	26	8	0	0	0	39	5	29	10	0	0	0	44	6	33	11	0	0	0	50
	Developed+Induced	0	3	1	3	1	1	9	1	4	1	3	1	1	11	1	5	1	3	1	1	12
	Total	5	29	9	3	1	1	48	6	33	11	3	1	1	55	7	38	12	3	1	1	62
33	Normal	2	10	4	12	4	2	34	2	12	4	13	4	3	38	2	14	4	13	4	3	40
	Developed+Induced	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1
	Total	2	11	4	12	4	2	35	2	13	4	13	4	3	39	2	15	4	13	4	3	41
35	Normal	2	10	3	3	1	1	20	2	10	4	4	1	1	22	2	12	4	4	1	1	24
	Developed+Induced	0	1	0	0	0	0	1	0	2	0	0	0	0	2	0	2	0	0	0	0	2
	Total	2	11	3	3	1	1	21	2	12	4	4	1	1	24	2	14	4	4	1	1	26
37	Normal	7	38	12	16	5	3	81	7	42	14	16	6	3	88	8	49	15	16	6	3	97
	Developed+Induced	1	4	1	0	0	0	6	1	5	1	0	0	0	7	1	5	2	0	0	0	8
	Total	8	42	13	16	5	3	87	8	47	15	16	6	3	95	9	54	17	16	6	3	105
40	Normal	45	264	83	71	25	14	502	48	276	86	74	25	15	524	54	315	99	76	26	15	585
	Developed+Induced	1	1	0	0	0	0	2	3	18	6	2	1	0	30	3	19	6	2	1	0	31
	Total	46	265	83	71	25	14	504	51	294	92	76	26	15	554	57	334	105	78	27	15	616

Remarks: P/C: Passenger Car, L/B: Light Bus, H/B: Heavy Bus, L/T: Light Truck, M/T: Medium Truck, H/T: Heavy Truck

Table 6-4 TRAFFIC PROJECTION (ROUTE ALTERNATIVE-II)

(vehicles per day)

ROAD LINK NO.	TYPE OF TRAFFIC	1983							1989							1997						
		P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL
3	Normal	31	181	57	43	15	8	335	35	201	63	64	22	13	398	38	221	69	93	32	18	471
	Developed+Induced	1	7	2	10	3	2	25	20	118	37	73	25	14	287	20	119	37	76	26	15	293
	Total	32	188	59	53	18	10	360	55	319	100	137	47	27	685	58	340	106	169	58	33	764
7	Normal	4	19	6	0	0	0	29	4	19	6	0	0	0	29	4	19	6	0	0	0	29
	Developed+Induced	0	2	1	16	5	3	27	13	76	23	61	21	12	207	13	76	23	78	27	15	232
	Total	4	21	7	16	5	3	56	17	95	30	61	21	12	236	17	95	29	78	27	15	261
12	Normal	3	19	5	0	0	0	27	4	24	7	0	0	0	35	4	25	7	0	0	0	36
	Developed+Induced	0	2	1	6	2	1	12	5	30	10	19	7	4	75	5	30	10	24	8	5	82
	Total	3	21	6	6	2	1	39	9	54	17	19	7	4	110	9	55	17	24	8	5	118
17	Normal	15	86	27	0	0	0	128	19	107	33	0	0	0	159	21	118	37	0	0	0	176
	Developed+Induced	1	4	1	10	4	2	22	4	25	8	18	6	4	65	4	25	8	21	7	4	69
	Total	16	90	28	10	4	2	150	23	132	41	18	6	4	224	25	143	45	21	7	4	245
19	Normal	17	95	29	0	0	0	141	18	109	35	0	0	0	162	21	123	38	0	0	0	182
	Developed+Induced	1	2	1	3	1	1	9	2	9	3	7	2	1	24	2	9	3	8	3	2	27
	Total	18	97	30	3	1	1	150	20	118	38	7	2	1	186	23	132	41	8	3	2	209
23	Normal	17	104	32	23	7	5	188	22	127	40	27	10	5	231	25	142	45	33	11	6	262
	Developed+Induced	1	2	1	1	1	0	6	1	7	2	9	3	2	24	1	7	2	9	3	2	24
	Total	18	106	33	24	8	5	194	23	134	42	36	13	7	255	26	149	47	42	14	8	286
25	Normal	12	63	19	32	11	6	143	12	73	22	38	13	7	165	14	81	26	44	15	8	188
	Developed+Induced	1	5	2	0	0	0	8	2	9	3	8	3	2	27	2	10	3	8	3	2	28
	Total	13	68	21	32	11	6	151	14	82	25	46	16	9	192	16	91	29	52	18	10	216
28	Normal	7	37	12	0	0	0	56	7	45	14	0	0	0	66	8	49	16	0	0	0	73
	Developed+Induced	0	2	1	11	4	2	20	1	4	1	13	4	2	25	1	4	1	13	5	3	27
	Total	7	39	13	11	4	2	76	8	49	15	13	4	2	91	9	53	17	13	5	3	100
35	Normal	6	32	10	4	1	1	54	7	38	11	4	1	1	62	8	42	13	4	1	1	69
	Developed+Induced	0	1	0	0	0	0	1	0	2	1	0	0	0	3	0	2	1	0	0	0	3
	Total	6	33	10	4	1	1	55	7	40	12	4	1	1	65	8	44	14	4	1	1	72
37	Normal	12	69	22	16	6	3	128	14	80	25	17	6	3	145	16	91	28	18	6	3	162
	Developed+Induced	1	4	1	0	0	0	6	1	6	2	0	0	0	9	1	6	2	0	0	0	9
	Total	13	73	23	16	6	3	134	15	86	27	17	6	3	154	17	97	30	18	6	3	171
40	Normal	47	170	84	72	25	14	412	52	302	94	75	25	15	563	58	342	107	77	26	16	626
	Developed+Induced	3	16	5	0	0	0	24	3	19	6	2	1	0	31	4	21	6	2	1	0	34
	Total	50	286	89	72	25	14	536	55	321	100	77	26	15	594	62	363	113	79	27	16	660

Remarks: P/C: Passenger Car, L/B: Light Bus, H/B: Heavy Bus, L/T: Light Truck, M/T: Medium Truck, H/T: Heavy Truck

Table 6-5 TRAFFIC PROJECTION (ROUTE ALTERNATIVE-III)

(vehicles per day)

ROAD LINK NO.	TYPE OF TRAFFIC	1983							1989							1997						
		P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL	P/C	L/B	H/B	L/T	M/T	H/T	TOTAL
8	Normal	39	228	71	73	25	14	450	47	271	85	97	34	19	553	52	304	95	130	45	26	652
	Developed+Induced	3	16	5	3	1	1	29	5	28	9	16	5	3	66	5	30	9	16	5	3	68
	Total	42	244	76	76	26	15	479	52	299	94	113	39	22	619	57	334	104	146	50	29	720
10	Normal	5	26	9	0	0	0	40	7	44	13	0	0	0	64	8	47	14	0	0	0	69
	Developed+Induced	0	2	0	5	2	1	10	1	6	2	13	5	3	30	1	6	2	20	7	4	40
	Total	5	28	9	5	2	1	50	8	50	15	13	5	3	94	9	53	16	20	7	4	109
15	Normal	47	273	85	30	10	6	451	55	318	100	35	12	7	527	59	338	106	42	15	8	568
	Developed+Induced	2	9	3	0	0	0	14	2	15	4	4	1	1	27	2	15	4	4	1	1	27
	Total	49	282	88	30	10	6	465	57	333	104	39	13	8	554	61	353	110	46	16	9	595
20	Normal	64	371	116	60	21	12	644	75	440	137	75	26	14	767	85	493	154	93	32	18	875
	Developed+Induced	1	6	2	1	0	0	10	2	11	4	8	3	2	30	2	12	4	8	3	2	31
	Total	65	377	118	61	21	12	654	77	451	141	83	29	16	797	87	505	158	101	35	20	906
18	Normal	49	287	90	21	7	4	458	57	335	104	25	8	5	534	65	374	118	30	10	6	603
	Developed+Induced	2	13	4	0	0	0	19	4	23	7	2	1	0	37	4	25	7	2	1	0	39
	Total	51	300	94	21	7	4	477	61	358	111	27	9	5	571	69	399	125	32	11	6	642
29	Normal	30	174	55	83	29	16	387	34	200	62	89	31	17	433	38	226	70	95	33	18	480
	Developed+Induced	0	2	0	0	0	0	2	1	2	1	4	1	1	10	1	2	1	4	1	1	10
	Total	30	176	55	83	29	16	389	35	202	63	93	32	18	443	39	228	71	99	34	19	490
27	Normal	31	183	57	48	16	9	344	36	209	65	52	18	10	390	41	234	74	57	20	11	437
	Developed+Induced	1	4	1	0	0	0	6	1	6	2	3	1	1	14	1	7	2	3	1	1	15
	Total	32	187	58	48	16	9	350	37	215	67	55	19	11	404	42	241	76	60	21	12	452
36	Normal	2	10	3	36	12	7	70	2	11	4	37	13	7	74	2	12	4	38	13	8	77
	Developed+Induced	0	0	0	0	0	0	0	0	1	0	1	0	0	2	0	1	0	1	0	0	2
	Total	2	10	3	36	12	7	70	2	12	4	38	13	7	76	2	13	4	39	13	8	79
40	Normal	43	248	78	53	19	11	452	47	276	86	56	19	11	485	54	313	98	57	19	12	553
	Developed+Induced	2	13	4	1	0	0	20	3	14	5	2	1	0	25	3	17	5	2	1	0	28
	Total	45	261	82	54	19	11	472	50	290	91	58	20	11	520	57	330	103	59	20	12	581

Remarks: P/C: Passenger Car, L/B: Light Bus, H/B: Heavy Bus, L/T: Light Truck, M/T: Medium Truck, H/T: Heavy Truck

Figure 6-1 WORK FLOW OF FREIGHT TRAFFIC FORECAST

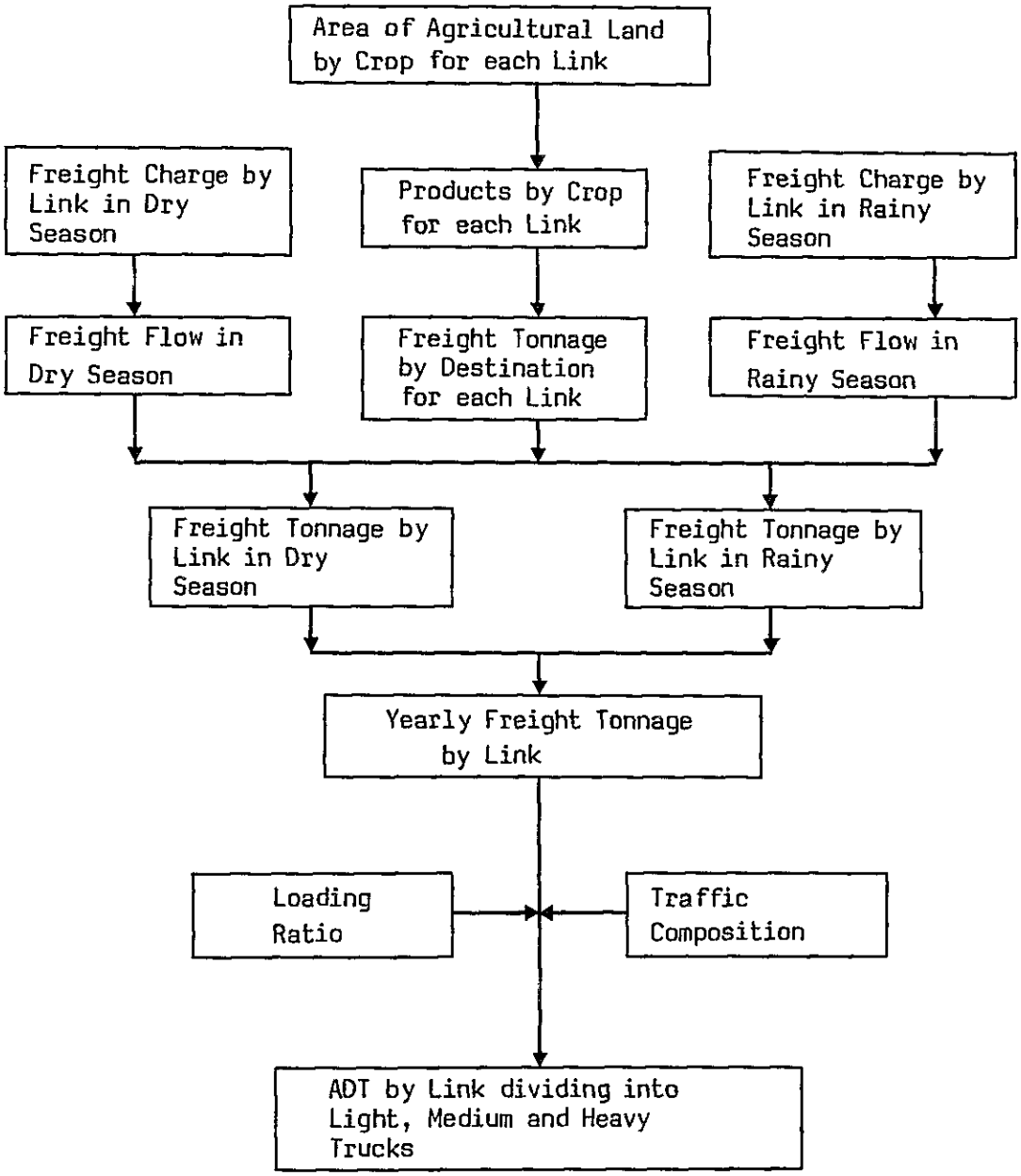


FIGURE 6-2

Figure 6-2 WORK FLOW OF PASSENGER TRAFFIC FORECAST

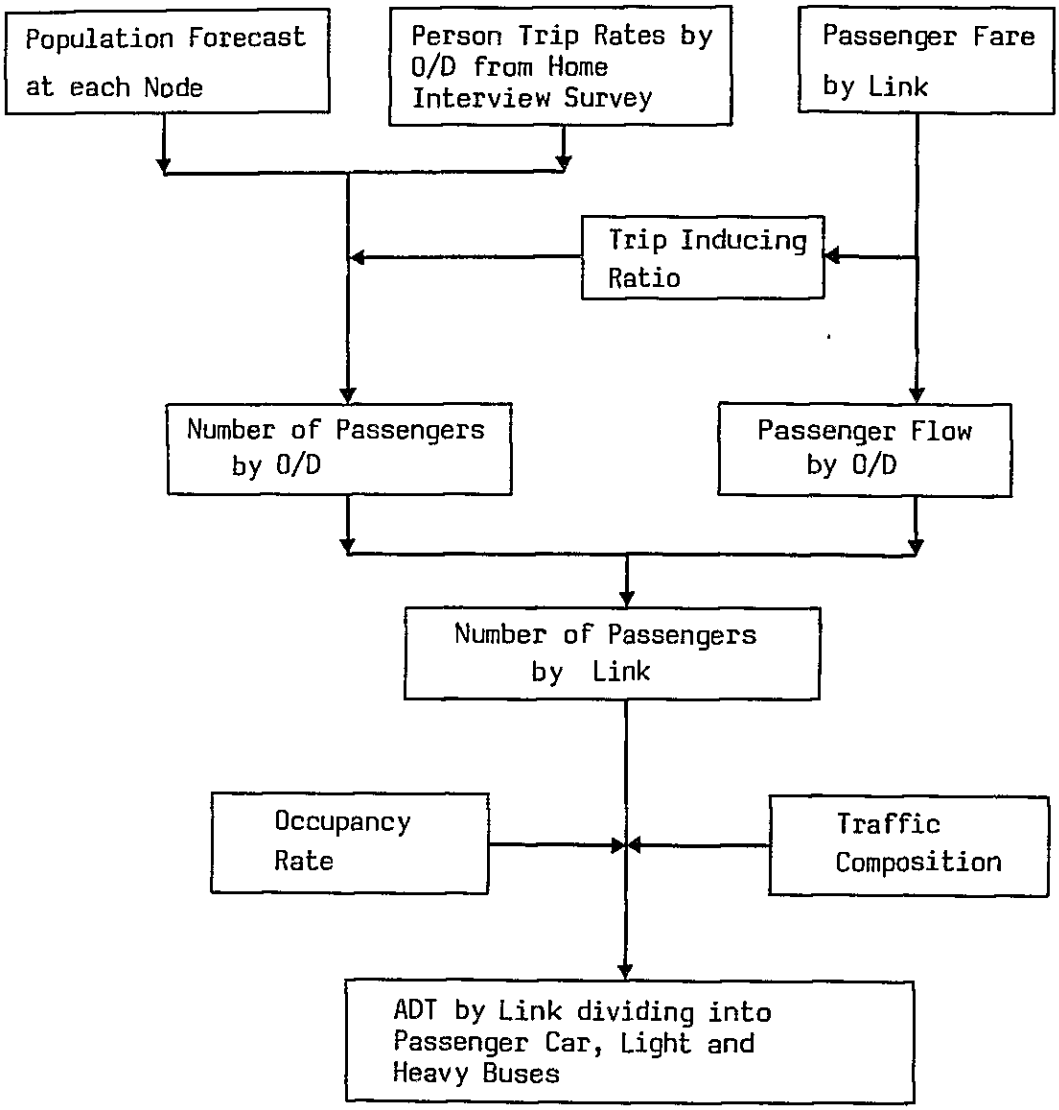
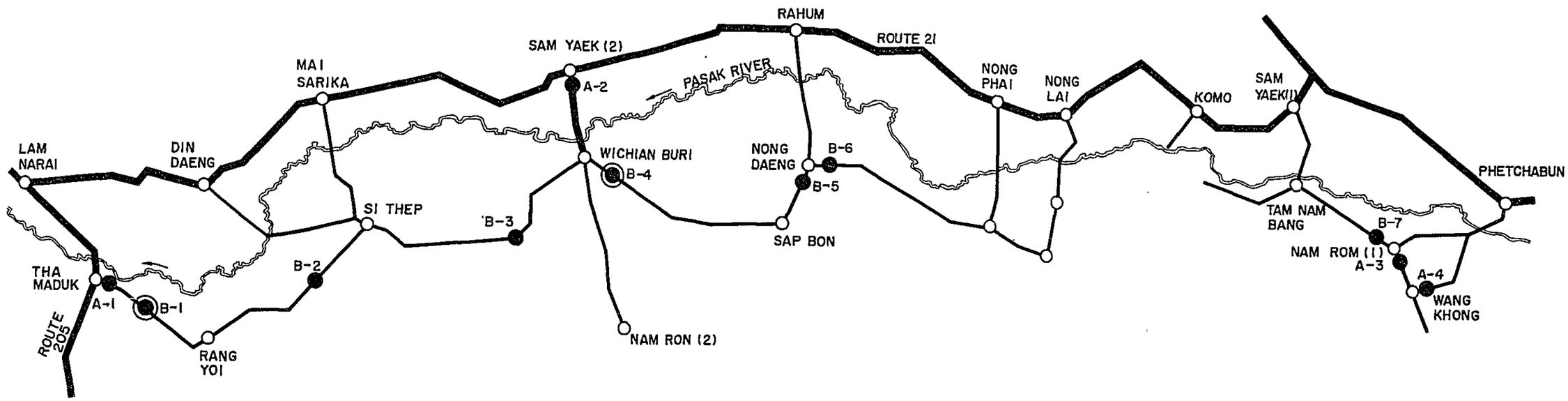


Figure 6-3 TRAFFIC COUNTS



LEGEND

● : Manual Count

◉ : Manual and Automatic Counts

A) 12 hours count on 5th August 1978

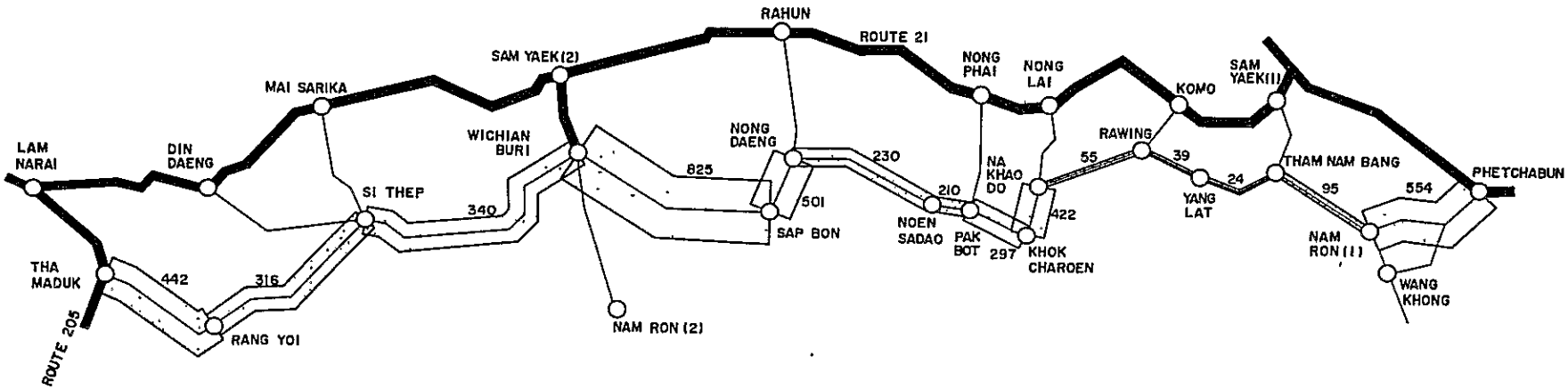
STA. NO.	LINK NO.	VEHICLE TYPE						TOTAL
		P/C	L/B	H/B	L/T	M/T	H/T	
A-1	3	2	40	9	63	17	7	147
A-2	13	142	92	69	356	62	22	743
A-3	39	7	40	-	36	10	-	93
A-4	41	7	80	-	54	20	21	182

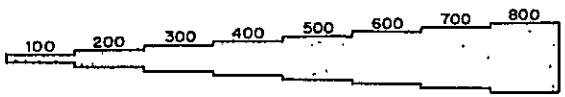
Remarks:
P/C: Passenger Car, L/B: Light Bus,
H/B: Heavy Bus, L/T: Light Truck,
M/T: Medium Truck, H/T: Heavy Truck

B) 8 hours count on 8th September 1978

STA. NO.	LINK NO.	VEHICLE TYPE						8 HOURS TOTAL	24 HOURS TOTAL
		P/C	L/B	H/B	L/T	M/T	H/T		
B-1	3	24	78	4	39	9	7	161	223
B-2	6	2	39	18	18	4	4	85	
B-3	11	16	51	21	40	23	7	158	
B-4	16	7	73	1	70	11	8	170	280
B-5	18	1	62	-	56	13	3	135	
B-6	22	1	33	-	47	5	3	89	
B-7	37	7	48	-	24	20	-	99	

Figure 6-4 ADT IN 1989 (Route Alternative-I)

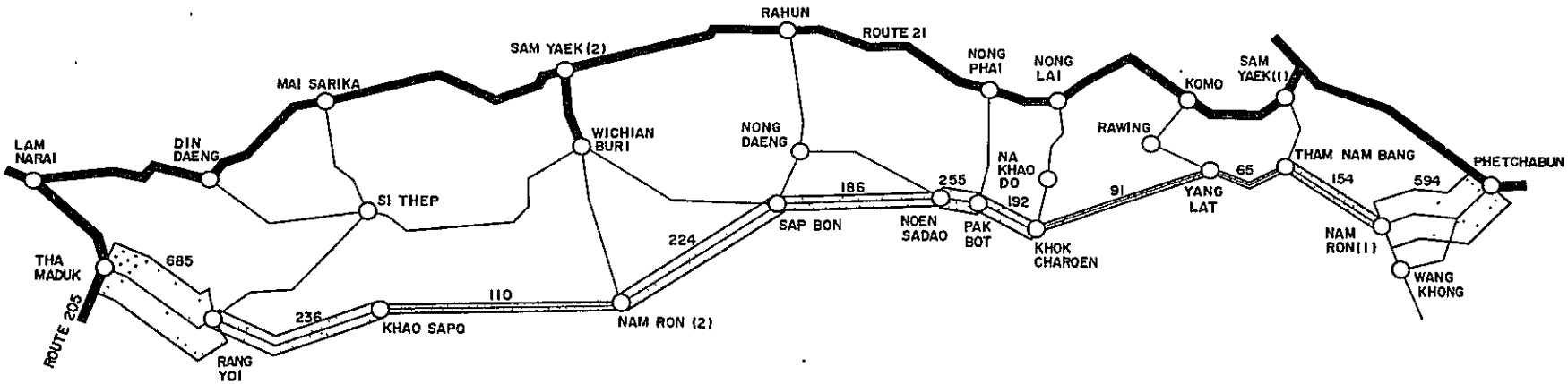


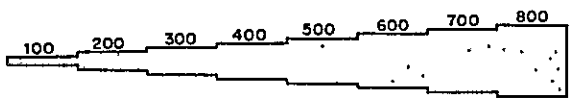


TRAFFIC SCALE

SECTION	VEHICLE TYPE						TOTAL
	P/C	L/B	H/B	L/T	M/T	H/T	
THA MADUK - RANG YOI	42	245	77	51	17	10	442
RANG YOI - SI THEP	34	195	61	17	6	3	316
SI THEP - WICHIAN BURI	30	175	55	52	18	10	340
WICHIAN BURI - SAP BON	79	461	144	92	31	18	825
SAP BON - NONG DAENG	51	295	92	41	14	8	501
NONG DAENG - NOEN SADAO	24	137	43	17	6	3	230
NOEN SADAO - PAK BOT	23	129	40	12	4	2	210
PAK BOT - KHOK CHAROEN	30	176	55	23	8	5	297
KHOK CHAROEN - NA KHAO DO	40	233	73	49	17	10	422
NA KHAO DO - RAWING	6	33	11	3	1	1	55
RAWING - YANG LAT	2	13	4	13	4	3	39
YANG LAT - THAM NAM BANG	2	12	4	4	1	1	24
THAM NAM BANG - NAM RON (1)	8	47	15	16	6	3	95
NAM RON (1) - PHETCHABUN	51	294	92	76	26	15	554

Figure 6-5 ADT IN 1989 (Route Alternative-II)

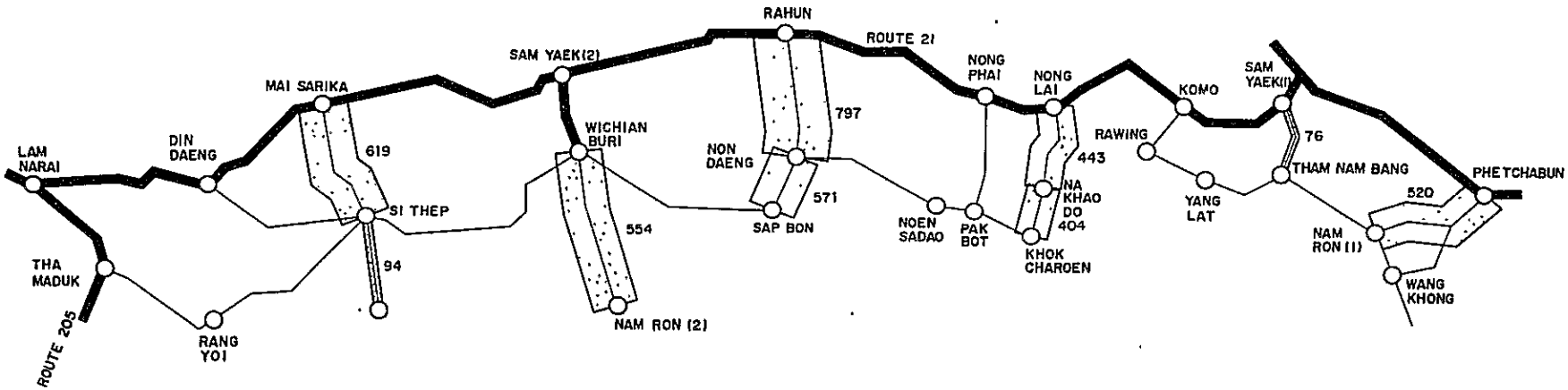


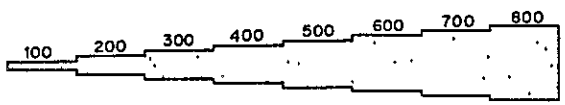


TRAFFIC SCALE

SECTION	VEHICLE TYPE						TOTAL
	P/C	L/B	H/B	L/T	M/T	H/T	
THA MADUK - RANG YOI	55	319	100	137	47	27	685
RANG YOI - KHAO SAPHO	17	95	30	61	21	12	236
KHAO SAPHO - NAM RON (2)	9	54	17	19	7	4	110
NAM RON (2) - SAP BON	23	132	41	18	6	4	224
SAP BON - NOEN SADAO	20	118	38	7	2	1	186
NOEN SADAO - PAK BOT	23	134	42	36	13	7	255
PAK BOT - KHOK CHAROEN	14	82	25	46	16	9	192
KHOK CHAROEN - YANG LAT	8	49	15	13	4	2	91
YANG LAT - THAM NAM BANG	7	40	12	4	1	1	65
THAM NAM BANG - NAM RON (1)	15	86	27	17	6	3	154
NAM RON (1) - PHETCHABUN	55	321	100	77	26	15	594

Figure 6-6 ADT IN 1989 (Route Alternative-III)



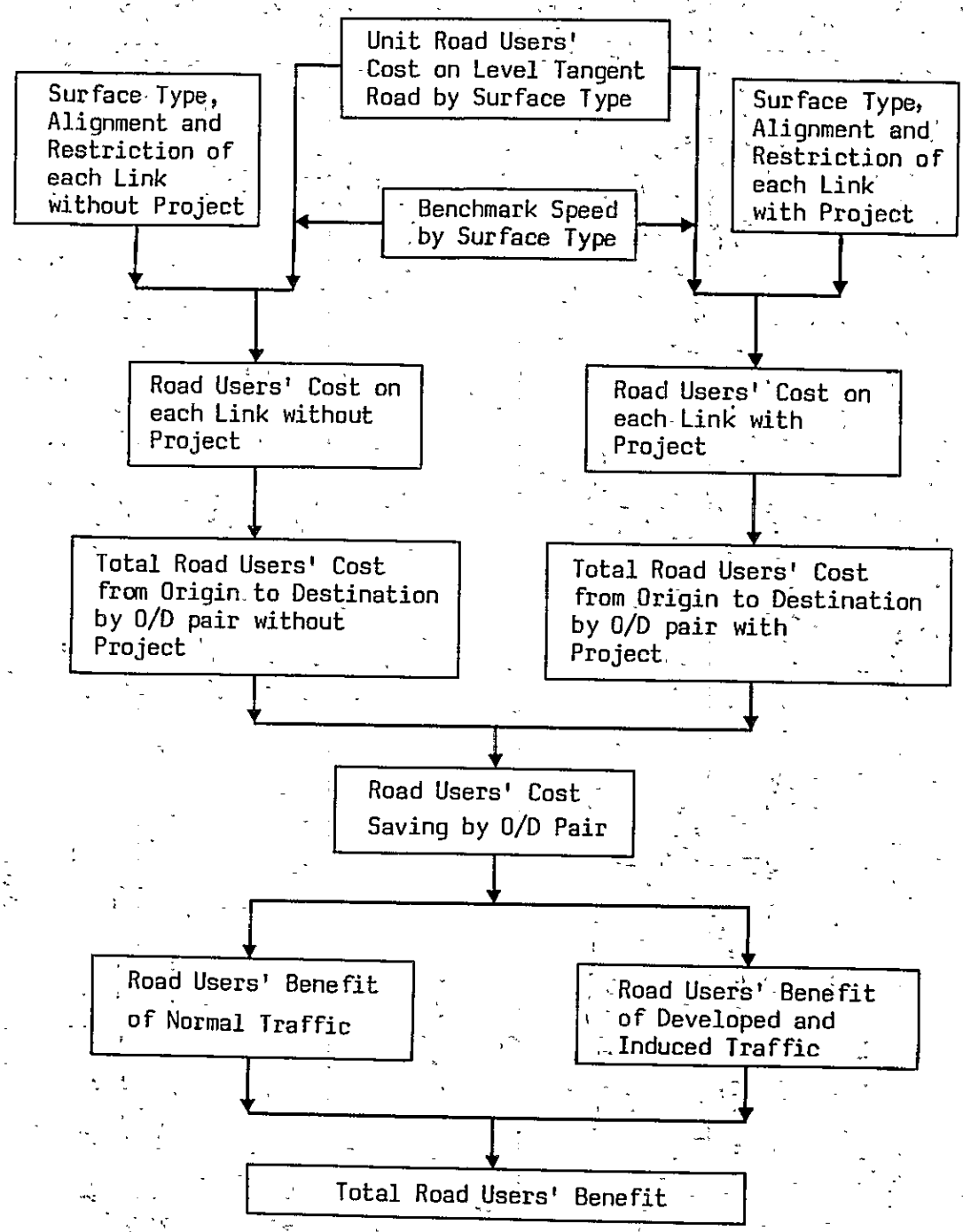


TRAFFIC SCALE

SECTION	VEHICLE TYPE						TOTAL
	P/C	L/B	H/B	L/T	M/T	H/T	
MAI SARIKA - SI THEP	52	299	94	113	39	22	619
SI THEP - KHAO SAPHO	8	50	15	13	5	3	94
WICHIAN BURI - NAM RON (2)	57	333	104	39	13	8	554
RAHUN - NONG DAENG	77	451	141	83	29	16	797
NONG DAENG - SAP BON	61	358	111	27	9	5	571
NONG LAI - NA KHAO DO	35	202	63	93	32	18	443
NA KHAO DO - KHOK CHAROEN	37	215	67	55	19	11	404
SAM YAEK(1) - THAM NAM BANG	2	12	4	38	13	7	76
PHETCHABUN - NAM RON (1)	50	290	91	58	20	11	520

FIGURE 6-7

Figure 6-7 WORK FLOW OF ROAD USERS' BENEFIT ESTIMATE



Chapter VII

PRELIMINARY ENGINEERING

Chapter VII

PRELIMINARY ENGINEERING

In this Chapter, preliminary design is made and construction costs are estimated for three route alternatives formulated in Chapter IV for their comparison. The work components of the engineering studies involve field surveys, selection of design standard to be applied, geometric and structual design, pavement design, quantity calculation and cost estimates.

7-1 FIELD SURVEYS

Different approaches were taken for the existing road links and the new road links.

7-1-1 Inventory Survey for Existing Road Links

An inventory survey was carried out for all the existing road links included in three route alternatives, and the sites where improvements appeared necessary were identified.

The inventory included such items as distance, horizontal and vertical alignment, cross sectional dimensions, road surface condition, flood condition, topography and land use along the road, drainage structures and bridges. The method and purpose of the inventory survey are described in Table 7-1. The results of the inventory survey are summarized in Table 7-2, of which details are shown in Tables 5A-1 to 5A-14 of Appendix 5.

The findings are briefly described below.

a) Almost all road links are constructed by side borrow method and surfaced with soil aggregate (or laterite) with the formation width varying from 6 to 9 meters.

b) The soil aggregate surface is susceptible to wet condition and rutted heavily in rainy days. This makes difficult the smooth travelling as vehicles have to run selecting better part of road. On the other hand, dust is blown up in fine days.

c) Horizontal alignment is generally good, although steep grade more than 8 percent exists in some sections. The alignment of bridge approach is also poor, some because it climbs in a short distance to bridge formation level which is generally higher than that of adjacent roads.

d) Most bridges made of wood are in poor conditions and submerged in flood season.

e) Drainage structures are short in number and capacity, and some of them are clogged up due to the lack of maintenance.

f) There are many road sections which are submerged in rainy season, especially in east-west road links. In rainy season, due to the shortage in drainage capacity of bridge openings and culverts, the water of the Pasak River and its tributaries is dammed up spreading over the upstream side of the road. When the water exceeds the reserving capacity of the upstream side, it runs downstream over the road in the lower sections. Raising up of road formation together with proper provision of bridges for relief open and drainage structures is necessary to improve the existing road to the all-weather road.

7-1-2 Reconnaissance for New Road Links

Reconnaissance was made along the new road links. Prior to the reconnaissance, the routes were examined in the office study based on the topographic maps (scale 1/50,000) and the aerial photographs (scale 1/15,000) obtained from the Royal Thai Survey Department. The major check points were i) deep cut and high embankment, ii) bridge location, iii) necessity of access road for construction, iv) difficulty of right of way acquisition.

In the course of the field reconnaissance, the aboves were checked and other information for preliminary design on the necessity of drainage structures, soil characteristics along the route, applicability of side borrow method for construction, etc. was collected.

The routes of new road links were finally determined after the necessary modifications based on the above reconnaissance.

7-2 DESIGN STANDARD

DOH has separate design standards for Primary Highways, Secondary Highways and Provincial Roads. For the proposed road, as this is classified into the Provincial Road, the Standard for Provincial Roads is to be applied. The Standards of Provincial Roads are subdivided into seven road classes from FD to F6, according to the projected ADT, as shown in Table 7-3.

Based on the traffic forecast made for every road link of three route alternatives, the estimated ADT in the 7th year after opening ranges from 24 to 825. This means that the Road Class F4 or F5 (hereinafter referred to as F4 or F5 Standard) is used for this study. As summarized below, the major difference between two standards is surface type.

Summary of F4 and F5 Standards

	F4	F5
ADT in 7th year	more than 300	below 300
Design Speed (km/h)		
Flat and moderately rolling	60-80	60
Rolling and hilly	45-60	45
Mountainous	30-45	30
Surface Type	low cost pavement	soil aggregate
Width of Carriage Way (m)	5.50	9.00
Width of Shoulder (m)	1.75	-
Maximum Gradient (%)		
Flat and moderately rolling	8	12
Rolling and hilly	10	12
Mountainous	10	12
Right of Way (m)	20-40	20-40

According to the traffic forecast made in Chapter VI, the standard to be applied was determined by road link as shown below, based on the DOH's classification.

Standard to be Applied

Route Alternative-I		Route Alternative-II		Route Alternative-III	
Link No.	Standard	Link No.	Standard	Link No.	Standard
3	F4	3	F4	8	F4
6	F4	7	F5	10	F5
11	F4	12	F5	15	F4
16	F4	17	F5	18	F4
18	F4	19	F5	20	F4
22	F5	23	F5	27	F4
23	F5	25	F5	29	F4
25	F5	28	F5	36	F5
27	F4	35	F5	40	F4
30	F5	37	F5		
33	F5	40	F4		
35	F5				
37	F5				
40	F4				
F4 :	96.3 km (61%)	F4 :	23.5 km (17%)	F4 :	71.5 km (65%)
F5 :	61.1 km (39%)	F5 :	115.8 km (83%)	F5 :	38.8 km (35%)
Total	157.4 km	Total	139.3 km	Total	110.3 km

7-3 PRELIMINARY DESIGN

7-3-1 Geometric Design

The following geometric design criteria were adopted for the improvement of the existing road, and existing road alignments were checked based on the data obtained in the inventory survey.

Geometric Design Criteria

Description	F4 Standard	F5 Standard
Standard design speed (km/h)	80	60
Min. radius of curvature (m)	280	150
Max. gradient (%)	4	8
Min. horizontal curve length (m)	140	100
Min. vertical curve length (m)	70	50
Min. sight distance (m)	110	75
Min. radius of vertical curve (m)		
Crest	3,000	1,400
Sag	2,000	1,000

The following lengths are to be improved due to the existing poor alignment.

Improvement of Alignment

Road Link No.	Location (km) /1	Length (km)	Remarks
- Vertical -			
3	11.2 - 12.0	0.8	Alternate ups and downs
6	0.0 - 7.7	7.7	"
20	6.2 - 10.2	4.0	"
35	0.0 - 8.5	6.0	Steep grade and alternate ups and downs
37	0.0 - 11.7	9.6	"
- Horizontal -			
11	17.7	0.2	Small radius of curvature
29	5.0	0.5	"
37	0.3	0.3	"
37	9.2	0.2	"
40	8.8	0.2	"

Note: /1 Distance from the beginning point of each road link

For the submerged sections, the formation levels were determined as to get more than 50 centimeters above the highest water level experienced in the past, the information of which was collected by road inventory survey. The sections where the raising up of the formation becomes necessary are listed in Table 7-4. The highest raising up, which is 1.5 meters from the existing road formation, occurs in Road Link No. 8, 36 and 40.

For the new road links, as F5 Standard was applied for all of them, minimum radius of curvature of 150 meters and maximum grade of 8 percents were adopted for the design.

7-3-2 Earthwork

The existing road links will be widened for the almost whole length as the existing width is generally less than 9 meters which is required in accordance with F4 or F5 standard. The widening will be made on one side, considering that the existing traffic will be kept even in construction period.

The side borrow method, which is the most common and cheapest road construction method in Thailand, will be applied generally for both improvement sections and new road sections.

The soil in the Project Area is composed mainly of silty clay of alluvial deposit in flat terrain and of silty or sandy loam in rolling terrain. Such types of soil are not so excellent material for embankment, as the strength decreases rapidly when moisture content becomes high or over compacted. However, they are assessed to be still utilizable when proper construction method is taken, judging from the condition of the existing roads constructed with these soils.

Side borrow method is not suitable for the raising up of submerged sections, because the road side soil is the deposit of soft clay or organic clay of high moisture content. Therefore, the embankment material will be procured from the suitable borrow pits.

Cutting will be required in the new road links. In Road Link No. 12, 17, 19 and 28, five meters cutting is anticipated at the deepest. Rock excavation is anticipated to occur only in the new road links, but its quantity is small. The rock is classified into soft rock and rippable.

7-3-3 Pavement Design

Soil aggregate surfacing is applied to the road links of F5 Standard. In accordance with the DOH's standard for the typical pavement structures of soil aggregate surfacing, the pavement design was made with the following thickness:

Selected material	CBR	≧ 6%	20 cm
Soil aggregate	CBR	≧ 15%	20 cm

Single bituminous surface treatment (hereinafter referred to as SBST) with crushed stone base course will be applied to the road links of F4 Standard. Design was made with the thickness shown below:

Selected material	CBR	≧	6	20 cm
Soil aggregate subbase	CBR	≧	20	20 cm
Crushed stone base	CBR	≧	80	15 cm
SBST				1.7 cm

7-3-4 Bridge Design

There are 8 concrete bridges and 41 timber bridges in the existing road links.

All concrete bridges, which are RC slab type, PC slab type or PC girder type, have enough width and clearance over the highest water level. And they seem, from visual examination, to have enough strength to the design bridge loading HS20. Therefore, no replacement was planned for the existing concrete bridges.

Most of the existing timber bridges are of one lane and comprised of longitudinal timber beam with lateral wooden slab. They are sound under the existing light traffic, however, they have not enough strength to the bridge design loading HS20. Some of timber bridges are just logs spanned over the channels and become submerged or fall in flood season. Moreover, the approach embankment juts to the river flow to shorten the bridge length. This not only obstructs the smooth river flow but causes scoring of abutments which results in the falling of bridges. Therefore, all timber bridges will be replaced to complete the all-weather road network.

There are some streams crossing the road which has no bridge over them. These portions can be passed in dry season when water is very scarce, but become impassable in rainy season. For such portions, new bridge construction was planned.

The following two types of concrete bridge were applied in the design:

RC slab bridge as short span bridge
PC girder bridge as long span bridge

The long span bridge was planned over the deep rivers, where the construction of substructure was supposed rather difficult. All bridges over the Pasak River and its main tributaries were planned with long span bridges. Where the river is relatively shallow, short span bridge was planned.

The bridge formation was set as to keep the clearance of 1.5 meters above the high water level. The bridge length was determined after check calculation of run-off and flow capacity of bridge opening. The method for these calculations is described in 7-3-6. Jutting of approach embankment into the river flow was avoided. The standard designs of DOH were used and appropriate size was selected for each bridge among them.

The number of bridges to be constructed as the replacement of timber bridges and those to be newly constructed was counted at totally 60, of which locations and dimensions are shown in Table 7-5.

7-3-5 Drainage Design

Drainage is one of the most important factors to keep all-weather condition of road. The existing road has no crossfall to drain surface water smoothly. Crossfall of 4 percent will be provided for soil aggregate surface road and 2 percent for SBST road. The number and capacity of cross drainage structures is also insufficient in the existing road links. Locations of required cross drainage were identified for existing road links by inventory survey and for new road links by field reconnaissance.

Concrete box culverts and pipe culverts were planned as cross drainage. The existing culverts in good condition will be utilized with required extension. The size of box culvert was determined based on run-off calculation and flow capacity calculation using Manning's formula. The minimum diameter of pipe culvert was set at 80 centimeters for easy maintenance. The standard designs of DOH were also used for culvert design with selecting adjustable size.

7-3-6 Countermeasures for Overflow

As described in 7-1-1, there are many sections which suffer overflows of the water of the Pasak River and its tributaries. The water runs over the road in flood season. The countermeasures for such overflow are, therefore, the most important factor for the construction of the all-weather road in the Project Area.

No river improvement scheme have been contemplated for the Pasak River itself so far. Though the National Energy Administration has a plan of dam construction in the upper reaches of the Pasak, the effect on flood control in the Project Area is doubtful. Therefore, the countermeasures for overflow have to be taken by road construction itself.

Provision of bridges for relief open was examined together with the raising up of road formation described in 7-3-1. The length of bridges to be required for relief open was determined in the following procedures:

a) Calculation of peak discharge

b) Calculation of flow capacity of existing bridge opening

c) Determination of additional opening and bridge length for relief open

1) Peak Discharge

The peak discharges of the Pasak River and its tributaries were calculated using the following formulae:

$$Q_m = \frac{f \times r \times A}{3.6} \quad \text{.....} \quad (1)$$

$$r = \frac{R24}{24} \left(\frac{30}{t + 6}\right) \quad \text{.....} \quad (2)$$

$$t = \frac{L}{V} \quad \text{.....} \quad (3)$$

$$V = 72\left(\frac{H}{L}\right)^{0.6} \quad \text{.....} \quad (4)$$

where, Qm = Peak discharge (m^3/sec)

f = Coefficient of run-off, 0.5 was taken

r = Average rainfall intensity from the beginning of rainfall to the arrival of flood to the subject site (mm/hr)

A = Catchment area (km^2)

t = Time of concentration (hr)

R24 = Daily rainfall (mm), 153.9 mm was taken

H = Difference in elevation between at the farthest source of river and at the subject site (km)

L = Distance along the river from the farthest source of river to the subject site (km)

V = Mean velocity of the flood water (km/hr)

There are many rainfall observation stations in the Pasak River basin. However, the available records are mostly monthly or annual rainfall. Daily rainfall of 153.9 millimeters used in the analysis is the only record available this time, which was recorded at the Phetchabun station on 8th September 1951, the heaviest daily rainfall during 1951-1965 period (Source: Climatological data, Meteorological Department).

The results of the peak discharge calculation are shown in Table 7-6.

2) Flow Capacity of the Bridge Opening

The flow capacities of the existing opening were estimated. As to the bridges for which the replacement is proposed in 7-3-4, the proposed dimensions were used in the estimation.

The formula used is shown below:

$$Q = 0.75\ b \cdot hz\ \sqrt{2g \cdot hs} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (5)$$

where, Q = Flow capacity (m^3/sec)

b = Bridge length (m)

hz = Water level on downstream side (m)

hs = Difference in water level between up and downstream sides of bridge (m), assumed at 0.5 m.

g = Acceleration of gravity (9.8 m/sec^2)

The results are shown in Table 7-7.

3) Length of Bridges for Relief Open

The discharge to be relieved by the additional bridges was calculated by subtracting the flow capacity of the existing bridges from the peak discharge. The length of bridges required to drain this discharge was then calculated using the equation (5).

The results are shown also in Table 7-7, and the locations and length of these bridges for relief open are listed in Table 7-5.

7-4 PRELIMINARY COST ESTIMATE

7-4-1 Construction Quantities

Construction quantities together with land acquisition were calculated based on the information obtained in the inventory survey and field reconnaissance, and the preliminary design made in the preceding section. They are calculated dividing into the following work items:

a) Clearing & grubbing
b) Soil excavation
c) Rock excavation
d) Embankment
e) Selected fill
f) Subbase & shoulder (Laterite surfacing in case that F5 Standard is applied)
g) Base
h) SBST
i) Pipe culvert
j) Box culvert
k) Long span bridge
l) Short span bridge

Quantities by road link are shown in Table 6A-1 of Appendix 6, and those by route alternative in Table 7-9.

7-4-2 Construction Cost

The 1978 unit rates were developed based on the current bid data provided by DOH. The unit rate of each work item is shown in Table 7-8. The percentage of tax component and the percentage of foreign currency portion included in the rate were decided referring to the previous studies/1 on the similar type of construction in Thailand, and also shown in Table 7-8.

The direct construction costs of three route alternatives were estimated applying the unit rates to the calculated quantities and adding the cost for minor items. The total construction costs were calculated adding the following items to them.

Physical contingency	:	15% of direct construction cost
Engineering and administration	:	8% of direct construction cost
Land acquisition	:	based on the estimated quantities

The economic construction cost was also estimated deducting all tax components from the financial cost.

The total construction costs of three route alternatives are given below, and the details are shown in Table 7-9.

/1 "Report on Investment Alternatives in Highways in the Corridors between Muak Lek and Ban Chai Badan, Ban Chai Badan and Dan Khun Thot", Vallentine, Laurie and Davies, August 1975.

Total Construction Cost

(million Baht)

Description	Route Alternative		
	I	II	III
FINANCIAL COST			
Direct Const. Cost	226.1	206.7	247.0
Physical Contingency	33.9	31.0	37.0
Engineering & Administration	18.1	16.5	19.8
Land Acquisition	1.3	10.5	3.9
Total	279.4	264.7	307.7
ECONOMIC COST			
Direct Const. Cost	205.0	186.4	223.3
Physical Cintingency	30.7	27.9	33.5
Engineering & Administration	16.4	14.9	17.9
Land Acquisition	1.3	10.5	3.9
Total	253.4	239.7	278.6

Table 7-1 MAJOR ITEMS OF INVENTORY SURVEY

ITEM	METHOD OF SURVEY	PURPOSE
Distance	Distance meter of Land Rover	To determine road link length and location of structures site
Alignment	Observation and survey using hand level	To determine sections to be improved
Cross section	Tape measurement	To judge the necessity of widening
Road surface	Observation	To judge the necessity of raising up the formation and of additional drainage structures
Flood condition	Observation and hearing	To determine the location and the height of raising up the formation and to judge the necessity of bridges for relief open
Topography	Observation	To determine the locations of additional drainage structures
Drainage structures	Tape measurement and Observation	To determine the length of extension and to evaluate capacity and structural soundness
Bridge	Tape measurement	To evaluate the capacity of opening, clearance and structural soundness

Table 7-2 SUMMARY OF ROAD INVENTORY

ROAD LINK NO.	LINK LENGTH	POOR ALIGNMENT SECTIONS	NARROW WIDTH SECTIONS		CULVERTS		BRIDGES				OVERFLOW SECTIONS		SURFACE TYPE	
							TIMBER		CONCRETE					
	(km)	(km)	WIDTH (m)	LENGTH (km)	PIPE (each)	BOX/1 (each)	(each)	(m)	(each)	(m)	HEIGHT OF OVERFLOW (m)	LENGTH (km)	SOIL AGGREGATE (km)	LOW COST PAVEMENT (km)
3	12.5	0.8	7.4	12.5	25	10	-		2	77.0	0.5	2.9	12.5	-
6	18.0	7.7	6.0	18.0	35	16	-		1	22.5	-	-	18.0	-
8	13.2	-	6.8	13.2	9	-	2	*/2	-	-	0-1.0	5.0	11.6	1.6
11	24.0	0.2	6.6	24.0	44	-	2	31.0	-	-	0-0.5	7.4	21.2	2.8
15	15.7	-	8.5	15.7	6	-	1	24.3	-	-	0-0.1	7.0	15.4	0.3
16	21.0	-	7.6	17.0	9	-	4	93.4	-	-	0-0.5	6.2	19.7	1.3
18	5.3	-	8.0	3.0	1	-	1	15.0	-	-	-	-	5.3	-
20	12.8	4.0	6.8	10.0	11	-	4	63.8	1	75.0	0.5	5.6	12.8	-
22	14.0	-	8.0	14.0	18	-	6	86.3	-	-	0-0.5	2.0	14.0	-
23	4.4	-	8.0	4.4	5	-	3	58.1	-	-	0-0.1	0.1	4.4	-
25	6.0	-	8.0	3.0	9	-	3	65.7	-	-	-	-	6.0	-
27	4.5	-	8.7	4.5	2	-	4	62.9	-	-	-	-	4.5	-
29	9.0	0.5	7.5	3.0	1	-	3	80.8	1	50.0	0.5	2.6	9.0	-
35	8.5	6.0	6.0	8.5	19/3	-	1	21.5	-	-	-	-	8.5	-
36	8.0	-	5.0	4.8	7	-	2	46.1	1	50.0	1.0	4.0	4.6	3.4
37	11.7	9.6	6.5	11.7	37	-	-	-	-	-	-	-	11.7	-
40	11.0	0.2	6.5	10.6	2	-	5	83.1	2	132.0	0.5-1.0	9.0	10.6	0.4

Notes: /1 Numbers indicate total row of all box culverts.
/2 Unknown (Submerged)
/3 Estimation

TABLE 7.1 MAJOR ITEMS OF INVENTORY SURVEY

Table 7-3 MINIMUM DESIGN STANDARDS 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 Highway 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.

Remark

In special cases, the Department may reduce the carriageway width to 3.5, 4, 4.5 or 5 m. on various roadbed widths, i.e. 5 m. on 7 m. roadbed width. Such the case the class of the road will be defined as class F_4 (5/7). If the geometric standard of the road section in the said case below than F_4 then the road class will be defined as F (4) (5/7).

For laterite road the travelled way width may be reduced from 9 m. to 7 m. and the standard will be defined as class F_5 (0/7).

Table 7-4 RAISING UP OF FORMATION

Road Link No.	Location (km)	Raising Up Height (m)	Length (km)
3	0.2 - 1.9	1.0	1.7
	2.6 - 3.8	1.0	1.2 (2.9)
8	2.0 - 6.0	1.5	4.0
	8.4 - 8.9	0.5	0.5
	11.9 - 12.4	0.5	0.5 (5.0)
11	3.0 - 3.5	0.5	0.5
	3.8 - 4.6	0.7	0.8
	6.5 - 7.0	0.5	0.5
	14.0 - 18.5	1.0	4.3
	19.0 - 20.0	0.5	1.0
	23.2 - 23.5	0.5	0.3 (7.4)
15	1.5 - 2.5	0.5	1.0
	5.0 - 9.0	0.5	4.0
	11.4 - 12.4	0.5	1.0
	13.6 - 14.6	0.5	1.0 (7.0)
16	2.8 - 4.6	0.5	1.8
	4.9 - 5.9	1.0	1.0
	8.9 - 10.7	0.5	1.8
	19.4 - 21.0	0.5	1.6 (6.2)
20	2.2 - 6.2	1.0	4.0
	6.6 - 7.0	1.0	0.4
	7.4 - 7.5	1.0	0.1
	7.8 - 7.9	1.0	0.1
	9.0 - 10.0	1.0	1.0 (5.6)
22	10.6 - 12.6	1.0	2.0 (2.0)
23	4.3 - 4.4	0.5	0.1 (0.1)
29	3.0 - 5.6	1.0	2.6 (2.6)
36	3.2 - 7.2	1.5	4.0 (4.0)
40	1.4 - 8.1	1.5	6.7
	8.3 - 10.6	1.0	2.3 (9.0)

Notes: 1) Location means distance from the beginning point of each road link.
2) Figure in parentheses shows the total length in each link.

TABLE 7-5
1 of 3

Table 7-5 LIST OF BRIDGES

Link No.	Location /1	Existing Bridge Type /2	Existing Bridge Width & Length (m)	Proposed Bridge Type /3	Proposed Bridge Length (m)	Remarks
3	12.4	C	7.0x36.0	-	-	
"	12.5	C	7.0x41.0	-	-	
6	15.2	C	7.0x22.5	-	-	
8	4.2	T	*	C-L	50	Unknown (Submerged)
"	4.5	-	-	C-S	105	Relief Open
"	5.3	-	*	C-L	40	No Bridge
"	5.8	T	*	C-S	20	Unknown (Submerged)
10	2.5	-	-	C-S	20	
"	4.0	-	-	C-S	20	
11	3.2	-	-	C-S	115	Relief Open
"	14.6	T	5.6x15.5	C-S	20	
"	15.5	-	-	C-S	110	Relief Open
"	17.9	T	4.2x15.5	C-S	20	
15	11.3	T	4.2x24.3	C-S	25	
16	9.0	T	4.0x63.7	C-S	65	
"	9.3	T	4.6x6.9	C-S	10	
"	16.0	T	4.2x11.3	C-S	14	
"	19.6	T	4.2x11.5	C-S	14	
17	0.2	-	-	C-S	20	
"	10.2	-	-	C-S	30	
"	16.6	T	4.2x11.5	C-S	14	Common to bridge at 19.6 km of Link 16
18	2.4	T	4.2x15.0	C-S	14	
20	3.2	T	4.3x18.3	C-S	20	
"	3.5	T	4.4x25.0	C-S	25	
"	3.7	T	4.4x15.5	C-S	15	
"	4.0	-	-	C-S	105	Relief Open
"	4.9	C	7.0x75.0	-	-	Pasak River
"	6.7	T	4.2x5.0	*	-	To be replaced with Box Culvert
22	0.8	T	4.2x14.9	C-S	15	
"	1.1	T	4.2x11.2	C-S	15	
"	1.4	T	4.2x22.5	C-S	25	

Table 7-5 LIST OF BRIDGES (cont'd)

Link No.	Location /1	Existing Bridge Type /2	Existing Bridge Width & Length (m)	Proposed Bridge Type /3	Proposed Bridge Length (m)	Remarks
22	5.9	T	4.3x11.5	C-S	15	
"	9.7	T	2.7x2.5*	C-S	15	Logs spanned
"	10.1	T	4.2x11.2	C-S	40	Relief Open
"	11.1	T	2.7x4.5*	C-S	10	Logs Spanned
"	11.9	T	4.2x15.0	C-S	15	
23	0.6	T	4.4x15.4	C-S	15	
"	2.9	T	4.2x18.4	C-S	20	
"	3.5	T	4.5x24.3	C-S	25	
25	0.4	T	4.5x23.7	C-S	25	
"	2.0	T	4.4x23.6	C-S	25	
"	2.2	T	4.4x18.4	C-S	20	
27	0.3	T	4.2x15.2	C-S	15	
"	0.7	T	4.3x18.2	C-S	20	
"	1.3	T	4.3x15.0	C-S	15	
"	1.7	T	4.0x14.5	C-S	15	
28	0.6	-	-	C-S	30	
29	4.3	T	4.1x30.3	C-L	40	
"	5.1	-	-	C-S	105	Relief Open
"	5.8	C	7.0x50.0	-	-	Pasak River
"	6.5	T	4.2x32.5	C-L	50	Broken
"	8.0	T	4.1x18.0	C-S	20	
35	4.8	T	3.5x21.5	C-S	21	
36	3.1	C	7.0x50.0	-	-	
"	3.8	T	3.7x38.4	C-L	40	
"	4.0	T	3.6x7.7	C-S	10	
"	6.0	-	-	C-S	135	Relief Open
"	6.7	-	*	C-L	70	No Bridge
40	0.6	T	2.6x18.5	C-S	20	
"	1.2	T	4.0x27.8	C-S	30	
"	1.9	T	3.5x12.0	C-S	15	
"	2.1	T	3.3x14.5	C-S	15	
"	2.9	T	3.6x10.3	C-S	15	

Table 7-5 LIST OF BRIDGES (cont'd)

Link No.	Location /1	Existing Bridge Type /2	Existing Bridge Width & Length (m)	Proposed Bridge Type /3	Proposed Bridge Length (m)	Remarks
40	8.2	C	7.0x90.0	-	-	Pasak River
"	9.6	-	-	C-S	150	Relief Open
"	10.7	C	8.0x42.0	-	-	
15*	4.0	-	-	C-S	20	
18*	2.0	-	-	C-S	20	
27*	0.6	-	-	C-S	20	
36*	3.5	-	-	C-S	20	
40*	1.0	-	-	C-S	20	

Remarks: /1 Location means distance (km) from the beginning point of each road link

/2 C : Concrete Bridge

T : Timber Bridge

/3 C-L : Long Span Concrete Bridge

C-S : Short Span Concrete Bridge

Table 7-6 PEAK DISCHARGE OF THE PASAK AND ITS TRIBUTARIES

Road Link No.	Section	H (km)	L (km)	H/L	$(H/L)^{0.6}$	V (km/hr)	Tr (hr)	r (mm)	A (km^2)	Q (m^3/sec)
(THE PASAK)										
40	Phetchabun-Nam Ron (1)	0.19	147	0.0013	0.019	1.37	107.3	1.67	3890	900
36	Sam Yack (1) - Yang Sam Ton	0.195	164	0.0012	0.018	1.30	126.2	1.47	4660	950
29	Nong Lai - Khok Charoen	0.210	188	0.0011	0.017	1.22	154.1	1.22	5660	960
20	Rahun-Nong Daeng	0.23	217	0.0011	0.017	1.22	180.0	1.02	6820	970
13	Sam Yaek (2) - Wichian Buri	0.24	237	0.0010	0.016	1.15	206.1	0.90	7840	980
8	Mai Sarika-Si Thep	0.25	258	0.0010	0.016	1.15	224.3	0.83	8690	1000
(TRIBUTARIES OF THE PASAK)										
11	Si Thep-Wichian Buri (4 km from Si Thep)	0.08	15	0.0053	0.043	3.11	4.3	17.80	65	160
11	Si Thep-Wichian Buri (17 km from Si Thep)	0.035	20	0.0018	0.022	1.50	12.5	10.30	312	450
16	Wichian Buri-Sap Bon (5 km from Wichian Buri)	0.01	7	0.0014	0.019	1.40	5.0	17.48	14	34
22	Nong Daeng-Pak Bot (10 km from Nong Daeng)	0.3	5	0.0060	0.046	2.34	1.5	25.60	36	130

TABLE 7-7

1 of 2

Table 7-7 ADDITIONAL BRIDGES FOR RELIEF OPEN

Road Link No.	Total Discharge	Existing Bridge			Additional Bridge		
		Length/2	Depth/3 of Water	Flow Capacity	Length	Depth/3 of Water	Flow Capacity
	(m^3/sec)	(m)	(m)	(m^3/sec)	(m)	(m)	(m^3/sec)
(THE PASAK)							
40	900	45	2.0	43.5			
		45	2.0	43.5			
		90*	4.5	594			
		total		681	150	1.0	219
36	950	70	4.5	462	135	2.5	488
29	960	40	2.5	144			
		50*	4.5	330			
		50	2.5	180			
		total		654	105	2.0	306
20	970	70*	4.5	495			
		20	2.0	58			
		25	2.0	73			
		15	2.0	43			
		total		669	105	2.0	301
13	980	40*	2.5	144			
		32*	2.5	115			
		160*	4.5	1,056			
		40*	2.0	116			
		50*	2.0	145			
		total		1,576	No additional bridge		
8	1,000	50	4.5	330			
		40	4.5	264			
		20	2.0	72			
		total		666	115	2.0	334

Table 7-7 ADDITIONAL BRIDGES FOR RELIEF OPEN (Cont'd)

Road Link No.	Total Discharge (m^3/sec)	Existing Bridge Length /2 (m)	Existing Bridge Depth of Water /3 (m)	Existing Bridge Flow Capacity (m^3/sec)	Additional Bridge Length (m)	Additional Bridge Depth of Water /3 (m)	Additional Bridge Flow Capacity (m^3/sec)
(TRIBUTARIES OF THE PASAK)							
11-1	160 (STA. 4.0) /1	20	2.0	54	115	1.0	106
11-2	450 (STA. 17.0) /1	20	2.5	72			
		20	2.5	72			
		total		144	110	2.0	306
16	34	-	-	-	2 box culverts are enough		
22	130	15	2.0	44			
		10	1.0	29			
		total		73	40	1.0	58

Notes: /1 STA. means the distance (km) from the beginning point of link.

/2 The bridges with "*" mark is concrete bridges not to be replaced. The lengths of the other bridges are those after replacement.

/3 Depth of water in downstream side.

TABLE 7-8

Table 7-8 UNIT RATES FOR CONSTRUCTION

Item	Unit of Quantity	Financial Unit Rates (Baht)	Tax Component (%)	Foreign Currency Portion (%)
Clearing & grubbing	ha	7,000	9.1	42
Soil excavation	m^3	30	9.9	46
Rock excavation	m^3	70	13.7	51
Embankment	m^3	55	9.6	41
Selected fill	m^3	70	9.6	41
Subbase/1 & shoulder	m^3	130	10.8	47
Base	m^3	300	6.7	51
SBST	m^2	35	5.5	55
Asphalt concrete	ton	650	5.5	55
Pipe culvert	m	1,400	8.2	34
Box culvert	m	9,200	10.8	38
Long span bridge	m	50,000	11.3	46
Short span bridge	m	33,000	11.3	46
Land acquisition	ha	32,000	-	-

Remarks: /1 To be understood as laterite surfacing in case that F5 Standard is applied.

Table 7-9 TOTAL CONSTRUCTION COST

DESCRIPTION	UNIT OF Q'TY	FINANCIAL UNIT RATE (Baht)	TAX (%)	ROUTE ALTERNATIVE-I			ROUTE ALTERNATIVE-II			ROUTE ALTERNATIVE-III		
				Q'TY	FINANCIAL COST (1,000 Bahts)	ECONOMIC COST (1,000 Bahts)	Q'TY	FINANCIAL COST (1,000 Bahts)	ECONOMIC COST (1,000 Bahts)	Q'TY	FINANCIAL COST (1,000 Bahts)	ECONOMIC COST (1,000 Bahts)
DIRECT CONSTRUCTION COST												
Clearing & Grubbing	ha	7,000	9.1	12	84	76	274	1,918	1,743	98	686	624
Soil Excavation	m^3	30	9.9	834,400	25,032	22,554	780,100	23,403	21,086	1,008,100	30,243	27,249
Rock Excavation	m^3	70	13.7	13,800	966	834	45,000	3,150	2,718	19,800	1,386	1,196
Embankment	m^3	55	9.6	1,137,100	62,541	56,537	1,461,500	80,383	72,666	1,233,100	67,821	61,310
Selected Fill	m^3	70	9.6	142,000	9,940	8,986	229,700	16,079	14,535	151,100	10,577	9,562
Subbase & Shoulder /1	m^3	130	10.8	221,700	28,821	25,708	240,220	31,226	27,854	197,700	25,701	22,925
Base	m^3	300	6.7	85,200	25,560	23,847	21,700	6,510	6,074	75,100	22,530	21,020
Prime & SBST	m^2	35	5.5	539,000	18,865	17,827	137,500	4,813	4,548	479,300	16,776	15,853
Pipe Culvert	m	1,400	8.2	2,115	2,961	2,718	3,020	4,228	3,881	1,745	2,443	2,243
Box Culvert	m	9,200	10.8	195	1,794	1,600	505	4,646	4,144	200	1,840	1,641
Long Span Bridge	m	50,000	11.3	65	3,250	2,883	-	-	-	290	14,500	12,862
Short Span Bridge	m	33,000	11.3	895	29,535	26,198	455	15,015	13,318	1,035	34,155	30,295
Sub total					209,349	189,768		191,371	172,567		228,658	206,780
Minor Items (8% of the above)					16,748	15,181		15,310	13,805		18,293	16,542
Total					226,097	204,949		206,681	186,372		246,951	223,322
PHYSICAL CONTINGENCY /2					33,915	30,742		31,002	27,956		37,043	33,498
ENGINEERING AND ADMINISTRATION /3					18,088	16,396		16,534	14,910		19,756	17,866
SUB TOTAL					278,100	252,087		254,217	229,238		303,750	274,686
LAND ACQUISITION	ha	32,000		40	1,280	1,280	327	10,464	10,464	123	3,936	3,936
TOTAL				40	279,380	253,367	327	264,681	239,702	123	307,686	278,622

Remarks: /1 To be understood as laterite surfacing in case that F5 Standard is applied.
/2 15% of direct construction cost
/3 8% of direct construction cost