i Khian Sa - Phra Saeng
ii Khian Sa - Route 4143
iii Northbound extension from Plai Phaya to the above ii.

Basic approach for the latter objective would be upgrading of the existing road together with re-alignment at some necessary points. However, as for the section between Phra Saeng and Surat Thani, special consideration would be necessary. At present, most of the traffic between Surat Thani and Krabi are using Route 4009 because of the shorter distance than via Route 41. The population density along Route 4009 is comparatively higher than the other areas, resulting in a serious conflict between local and long distance traffics. In order to avoid this problem for the future, a possible detouring route will become necessary. The development of Khian Sa - Phra Saeng route is considered reasonable from this aspect, too. Additional route connecting Khian Sa and Route 4143 is indispensable for this purpose. This set of new link will offer Krabi to make easy access to the proposed Khanom Deep Seaport on the east coast of the peninsula, too.

## 4.4 PRELIMINARY ENGINEERING STUDY

### 4.4.1 Route Alignment

The team carried out the field survey along the route connecting Krabi with Surat Thani for the purpose of collecting the information and data necessary for preliminary engineering study. The route commonly traveled from Krabi to Surat Thani consists of Krabi-Route 411 - Route 4 - Route 4035 (Ao Luk) - Route 4009 (Wiang Sa) - Surat Thani, approximate distance amounting to 190 km.

Route 4037 which connects Krabi with Phara Saeng via Khao Phanom is now under improvement to all weather provincial highway. By the completion of this link, the distance between Krabi and Surat Thani is expected to reduced to about 160 km.

New alignment of Krabi - Surat Thani Link is planned by taking account of the following points:

- To make best use of the existing and programmed highways.
- To support the development of Central Lowland by providing easy access to market
- To ensure easy access to Khanom Deep Seaport from Krabi
- To keep the construction cost to the minimum

Fig. 4.1 shows the proposed alignment of Krabi - Surat Thani Link. The total length of the link amounts to 167 km from Krabi municipality to the junction with Route 401. The distance between Krabi and Surat Thani will be reduced to 150 km through this link.

The proposed link is devided into five section.

Section 1 (Krabi - Route 4, 12.2 km)

Route 411 and 4 which are located on flat area have good road conditions. These two highways are to be incorporated into Krabi - Surat Thani Link. The team proposes widening and overlay of the surface as well as the improvement of the junction of Routes 4 and 411.

Section 2 (Route 4 - Route 4035, 56.8 km)

The new road which is now under construction by the Public Works Department (PWD) will form the section between Route 4 and Khao Phanom, and Route 4037 will constitute the section between Khao Panom and Route 4035. Route 4037 is now under improvement by Krabi Highway District, Surat Thani Mechanical Equipment Center and military. This route passes through hilly area. Some sections need horizontal/vertical improvement so as to comply with "S standard". It is also necessary to widen and strengthen the surface.

Section 3 (Route 4035 - Khian Sa, 28.4 km)

New highway construction is proposed for this section in order to promote the development of Central Lowland. The route is aligned from Route 4035 (near Phara Saeng) to Route 4133 (Khian Sa) via a proposed oil palm plantation area. The construction works of this section are considered rather easy and the construction cost will not amount much because most of the terrain belongs to flat area and the existing rural road of 10 km can be fully utilized for this purpose.

Section 4 (Khian Sa - Route 4009, 25.0 km)

Provincial highway which is now under construction by DOH, and rural road can be utilized for the establishment of this section. Widening and strengthening of the surface, however, will become necessary to upgrade these roads to secondary highway standard. It is necessary to construct a new link of about 3 km between Routes 41 and 4009 to detour the urbanized area of Ban Na San.

Section 5 (Route 4009 - Route 401, 44.8 km)

This section will be developed by utilizing some part of Route 4143 and 4010, rural road of 16 km, and constructing a new link of about 8 km. New pavement is required for the rural road which is of laterite surface now. Construction works are easily carried out because of the flat terrain.

### 4.4.2 Principles of Design

Krabi - Surat Thani Link is classified as "Secondary National Highway" by taking account of the roles and functions required for this link. Typical cross section of the link is as shown in Fig. 4.2. Design speed is 80 km/h for flat area and 60 km/h for hilly area. The width of right of way is assumed at 60 meters.

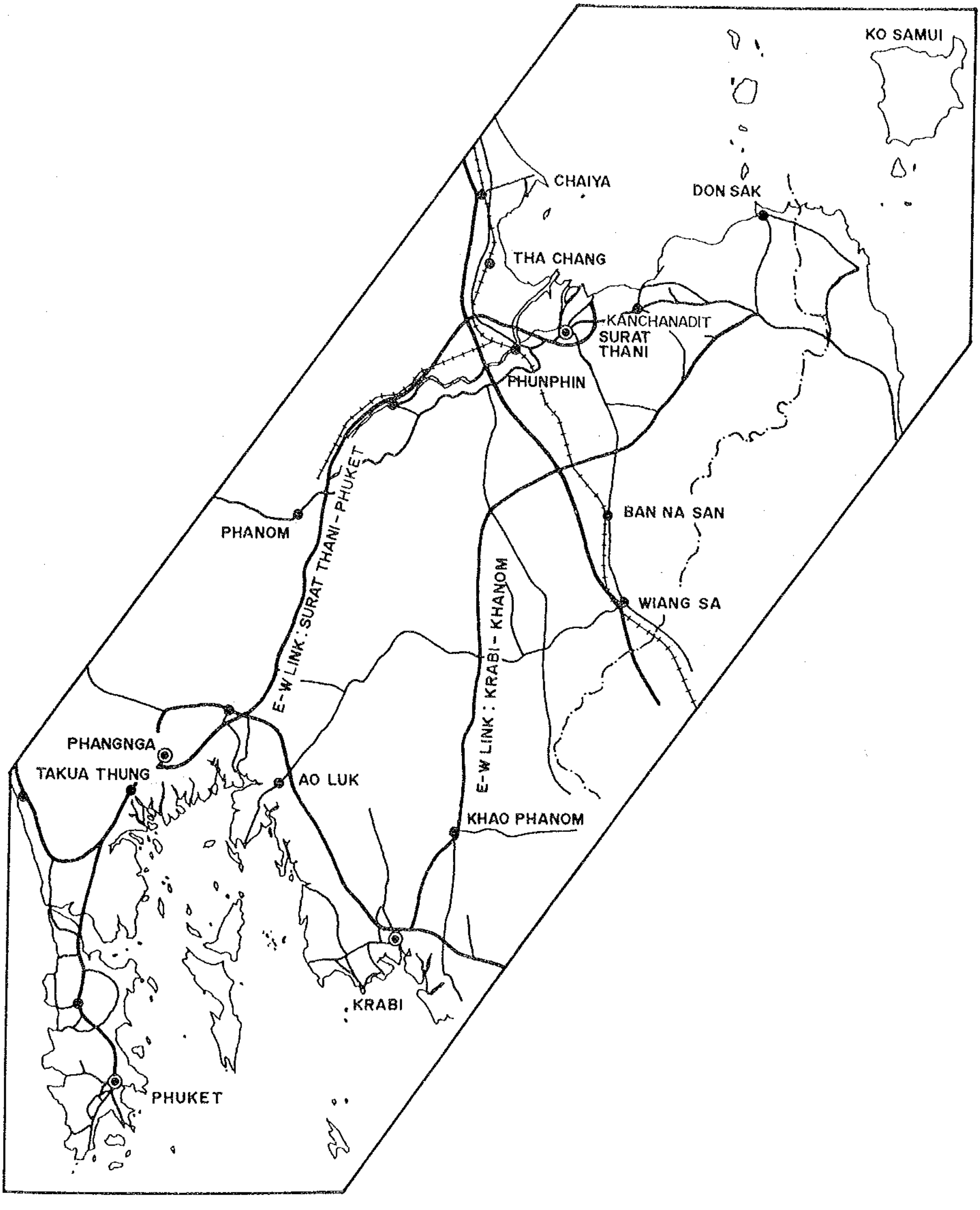


Fig. 4.1 KRABI-SURAT THANI LINK

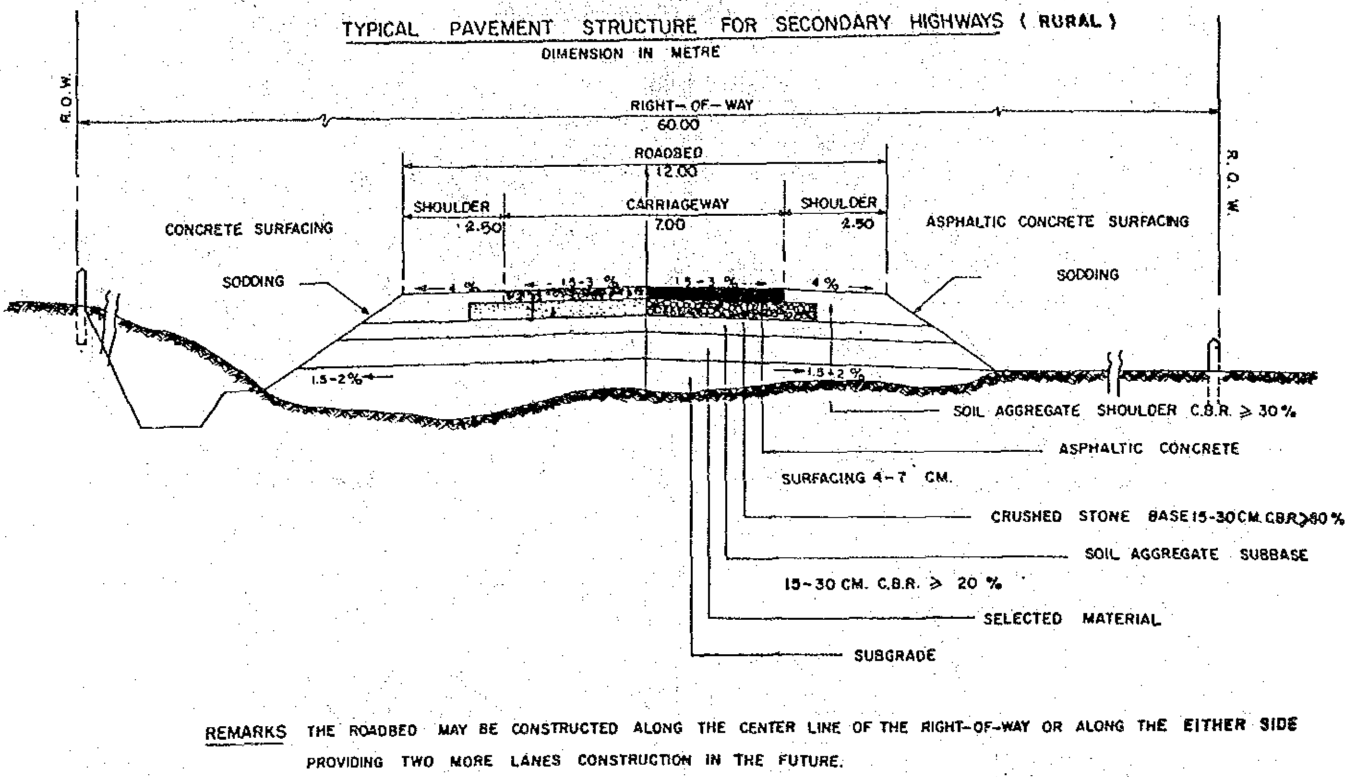


Fig. 4.2 TYPICAL PAVEMENT STRUCTURE FOR SECONDARY HIGHWAYS (RURAL)

4.4.3 Construction Cost

Construction cost of Krabi - Surat Thani Link is estimated at about 700 thousand baht in 1983 price, including 30 thousand baht for engineering service. Table 4.2 shows the estimated construction cost for each section.

Table 4.2 CONSTRUCTION COST OF KRABI-SURAT THANI LINK

| | | Highways | Present condition | Construction words | Cost (1,000 baht) |
|---|---|---|---|---|---|
| Krabi | Section 1 (12.2km) | 411<br>4 | - Flat<br>- Asphalted | - Widening & overlay | 25.5 |
| Route 41 | Section 2 (56.8 km) | 4037 | - Rolling & hilly<br>- To be asphalted | - Widening & strengthen of pavement | 168.7 |
| Route 4035 | Section 3 (28.4km) | | - Rolling & Hillly<br>- Oil palm plantation area | - New construction | 183.0 |
| Khian Sa | Section 4 (25.0km) | | - Rolling & Hilly<br>- To be asphalted | - Widening & overlay<br>- New construction | 79.2 |
| Route 4009 | Section 5 (44.8km) | 4143<br>4010 | - Flat<br>- Laterite | - Pavement<br>- New construction | 209.9 |
| Route 401 | | | | Total | 66.3 |

# 5. EAST-WEST LINK

## 5.1 PRELIMINARY EVALUATION

### 5.1.1 Estimation of Benefit Stream

Transportation demand on East-West Link in 1980 and 2000 was estimated as shown in Table 5.4, vol.2, in the Final Report. Taking account of the longer time horizon of the project, however, transportation demand on East-West Link was estimated for the year 1995, 2005 and 2015. Transportation demand in 1995 was estimated by interpolation based on the transportation demand in 1991 and 2000, in which transportation demand in 1991 was estimated by allocating the increment of transportation demand from 1980 to 2000 in proportion to the growth rates of GDP for cargo and population for passenger of the period of 1980-1991 as against the period of 1980-2000. Transportation demand in 2005 was estimated by extropolation based on the transportation demand in 1991 and 2000, and transportation demand in 2015 was estimated by applying a half of the growth rate over the period of 1991 and 2000.

Vehicle and railway operating costs related to East-West Link were estimated based on the target years of 1995, 2005 and 2015 for the cases of "without project", Alternative 1 (Railway with 2-lane highway)and Alternative 2 (4-lane highway). The procedure for estimating the operating costs are as shown in Fig. 5.1.

1) Cargo Volume and Number of Passengers on East-West Link

Transportation demand in 1995, 2005 and 2015 is estimated as shown in Table 5.1. For the cases of "without project" and Alternative 2, transportation demand on East-West Link will be less than that of Alternative 1. Cement from Thung Song to Phangnga and Phuket will be transported without using East-West Link; to Phangnga via Routes 41, 4035 and 4, and to Phuket via Route 403 and coastal shipping from Kantang to Phuket. Cargoes to be exported to the western situated countries will be transported from the Western Region to Bangkok/Laem Chabang ports instead of being sent to Phuket Deep Seaport. The remaining cargoes will have no choice but to divert from railway to road transport. The number of passengers will be slightly less than that of Alternative 1 because some part of railway passengers will divert to air transport. The expected decrease of passengers for the "without railway" case, however, is not taken into account due to the fact that the diversion of passengers to air transport will have similar effect on both "without project" case and Alternative 2, and that the diversion will produce favourable conditions for Alternative 1 because energy consumption of air transport is nine times as much as that of railway. 1/

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1/ Source: "Study on Energy Policies for the Transportation Sector" by MOC

| | Low | High |
|---|---|---|
| 1) Railway (goe/passenger-km) | 3 | 15 |
| 2) Air ( - ditto - ) | 54 | 135 |
| 3) 2)/1) | 18 | 9 |

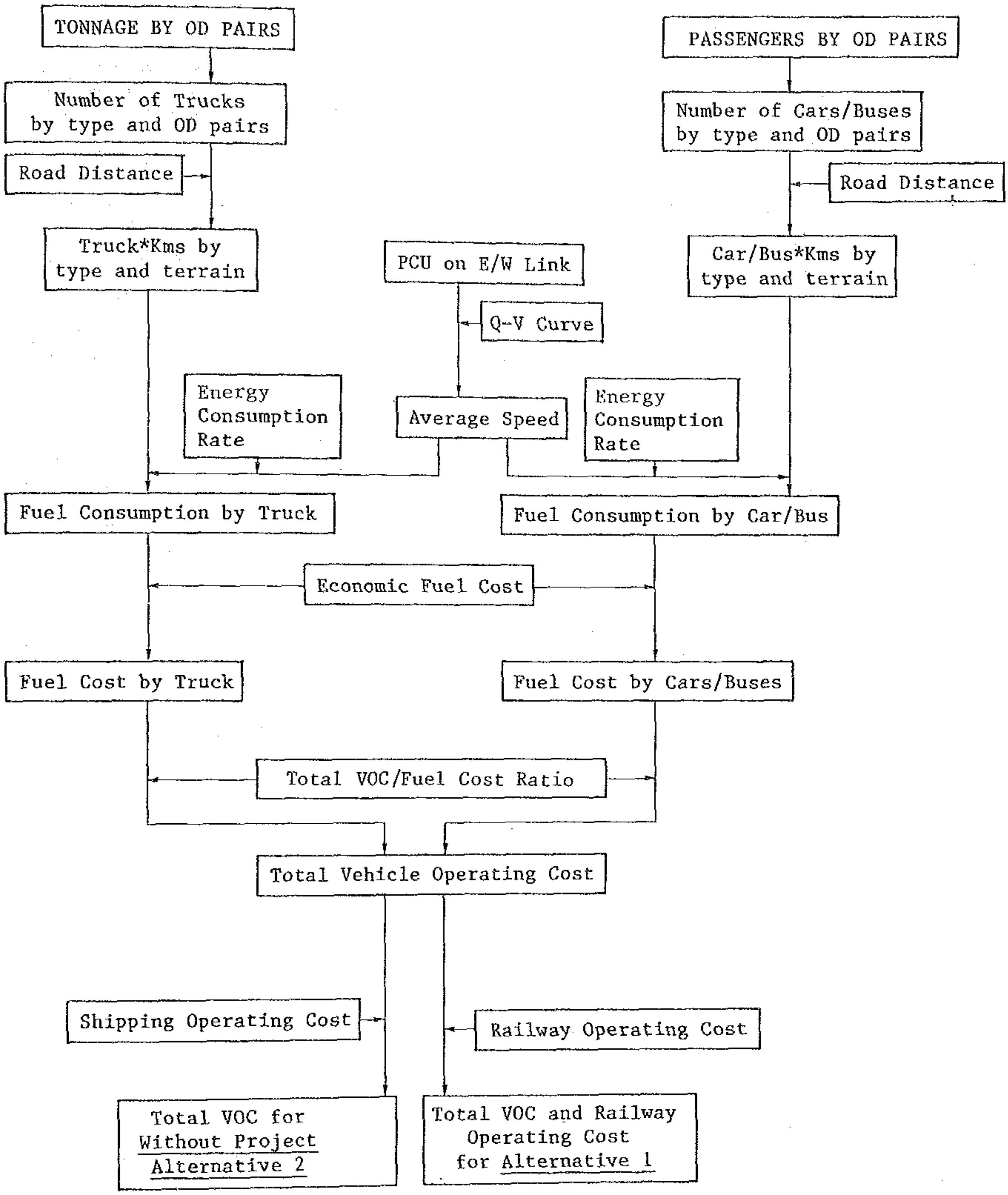


Fig. 5.1 PROCEDURE FOR ESTIMATING VEHICLE OPERATING COST AND RAILWAY COST FOR ALTERNATIVES

Table 5.1 TRANSPORTATION DEMAND ON EAST-WEST LINK

| | 1980 | 1995 | | | 2005 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Road | Road | Rail | Total | Road | Rail | Total | Road | Rail | Total |
| Cargo (1,000 tons/year) | | | | | | | | | | |
| Surat Thani - Phangnga (Intra) | 54.2 | 137.2 | - | 137.2 | 279.0 | - | 279.0 | 398.0 | - | 398.0 |
| - Phangnga (Inter) | 94.9 | 239.2 | - | 239.2 | 490.1 | - | 490.1 | 705.9 | - | 705.9 |
| - Phuket | 6.1 | 278.4 | - | 278.4 | 879.9 | - | 879.9 | 1,564.7 | - | 1,564.7 |
| - Phuket Port | 1.2 | 74.5 | - | 74.5 | 237.3 | - | 237.3 | 423.4 | - | 423.4 |
| Phangnga - Phuket (Intra) | 75.6 | 142.2 | - | 142.2 | 245.6 | - | 245.6 | 322.8 | - | 322.8 |
| - Phuket (Inter) | 420.8 | 510.9 | - | 510.9 | 629.5 | - | 629.5 | 701.2 | - | 701.2 |
| Phuket - Surat Thani Port | 15.4 | 51.4 | - | 51.4 | 117.1 | - | 117.1 | 176.7 | - | 176.7 |
| Subtotal | 668.2 | 1,433.8 | - | 1,433.8 | 2,878.5 | - | 2,878.5 | 4,292.7 | - | 4,292.7 |
| Phangnga - Chumphon | 41.2 | 46.6 | 0.9 | 47.5 | 70.8 | 1.3 | 72.1 | 99.8 | 1.9 | 101.7 |
| - Bangkok/Others | 268.4 | 203.9 | 169.4 | 373.3 | 313.1 | 255.5 | 568.6 | 404.1 | 327.9 | 732.0 |
| Phuket - Chumphon | 17.3 | 32.0 | 5.1 | 37.1 | 61.8 | 9.4 | 71.2 | 87.8 | 13.0 | 100.8 |
| - Bangkok/Others | 294.1 | 176.6 | 202.6 | 379.2 | 230.6 | 263.6 | 494.2 | 264.6 | 301.8 | 566.4 |
| Subtotal | 621.0 | 459.1 | 378.0 | 837.1 | 676.3 | 529.8 | 1,206.1 | 856.3 | 644.6 | 1,500.9 |
| Thung Song - Phangnga | 26.5 | - | 118.1 | 118.1 | - | 234.0 | 234.0 | - | 293.9 | 293.9 |
| - Phuket | 32.5 | - | 158.8 | 158.8 | - | 320.5 | 320.5 | - | 405.0 | 405.0 |
| West Region - Phuket Port | - | - | 422.1 | 422.1 | - | 562.4 | 562.4 | - | 649.2 | 649.2 |
| Subtotal | 59.0 | - | 699.0 | 699.0 | - | 1,116.9 | 1,116.9 | - | 1,348.1 | 1,348.1 |
| Grand Total | 1,348.2 | 1,892.9 | 1,077.0 | 2,969.9 | 3,554.8 | 1,646.7 | 5,201.5 | 5,149.0 | 1,992.7 | 7,141.7 |
| Passenger (1,000 trips/year) | | | | | | | | | | |
| Surat Thani - Phangnga (Intra) | 965.2 | 1,690.2 | - | 1,690.2 | 2,412.7 | - | 2,412.7 | 2,882.6 | - | 2,882.6 |
| - Phangnga (Inter) | 427.1 | 616.3 | 60.8 | 677.1 | 837.1 | 82.5 | 919.6 | 975.5 | 96.2 | 1,071.7 |
| - Phuket | 97.1 | 250.2 | 41.0 | 291.2 | 435.2 | 71.2 | 506.4 | 573.9 | 93.9 | 667.8 |
| Phangnga - Phuket (Intra) | 641.9 | 1,607.5 | - | 1,607.5 | 2,647.0 | - | 2,647.0 | 3,396.7 | - | 3,396.7 |
| - Phuket (Inter) | 665.8 | 1,292.2 | 68.0 | 1,360.2 | 1,974.2 | 103.8 | 2,078.0 | 2,440.1 | 128.3 | 2,568.4 |
| - Phuket (Tourism) | 102.9 | 408.5 | - | 408.5 | 704.9 | - | 704.9 | 926.0 | - | 926.0 |
| Subtotal | 2,900.0 | 5,864.9 | 169.8 | 6,034.7 | 9,011.1 | 257.5 | 9,268.6 | 11,194.8 | 318.4 | 11,513.2 |

(continued)

| | | 1980 | 1995 | | | 2005 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Road | Road | Rail | Total | Road | Rail | Total | Road | Rail | Total |
| Phangnga | - Chumphon | 92.7 | 110.3 | 39.3 | 149.6 | 151.3 | 53.8 | 205.1 | 177.1 | 63.0 | 240.1 |
| | - Bangkok/Others | 154.0 | 57.1 | 218.3 | 275.4 | 82.4 | 314.7 | 397.1 | 98.9 | 377.9 | 476.8 |
| Phuket | - Chumphon | 1.5 | 4.3 | 2.1 | 6.4 | 8.0 | 4.0 | 12.0 | 11.0 | 5.4 | 16.4 |
| | - Bangkok/Others | 166.4 | 111.3 | 496.3 | 607.6 | 203.3 | 906.8 | 1,110.1 | 274.8 | 1,225.6 | 1,500.4 |
| | Subtotal | 414.6 | 283.0 | 756.0 | 1,039.0 | 445.0 | 1,279.3 | 1,724.3 | 561.8 | 1,671.9 | 2,233.7 |
| Grand Total | | 3,314.6 | 6,147.9 | 925.8 | 7,073.7 | 9,456.1 | 1,536.8 | 10,992.9 | 11,756.6 | 1,990.3 | 13,746.9 |

2) Number of Vehicles on East-West Link

The above estimated cargo volume and number of passengers on East-West Link were then converted to number of vehicles, based on the factors shown in Table 5.2.

Table 5.2 FACTORS CONVERTING TO VEHICLES

| | Cargo (Truck) | | | Passenger | | |
|---|---|---|---|---|---|---|
| OD pairs | Light | Medium | Heavy | Car | Light Bus | M/H Bus |
| in Upper South | 35 % | 35 % | 30 % | 25 % | 30 % | 45 % |
| to and from Ports | 10 % | 30 % | 60 % | - | - | - |
| outside Upper South | 10 % | 30 % | 60 % | 10 % | 30 % | 60 % |
| Load Factor | 0.8t | 2.1t | 7.2t | 2.5p | 6.0p | 33.0p |
| PCU | 1 | 2 | 3 | 1 | 1 | 2.5 |

Note: M/H Bus - Medium/Heavy Bus

t - tons, p - persons

Number of vehicles for Alternative 1 differs from those of "without project" case and Alternative 2 while number of vehicles for "without project" case and Alternative 2 are same each other. The estimated vehicle traffics on East-West Road Link are as shown in Table 5.3 and 5.4, for Alternative 1 and for "without project" case and Alternative 2, respectively.

3) Vehicle Travel Distance

Vehicle travel distance related to East-West Road Link was estimated based on the above estimated number of vehicles by type and road distance of each origin and destination pair by terrain. Both vehicle type and terrain affect the energy consumption of vehicles. Table 5.5 shows two cases of road distance between origin and destination pairs, the one based on the prototype East-West Road Link at the end of the Fifth Five Year Plan period and the other based on the developed East-West Road Link proposed by the Team. The distance between Surat Thani and Route 41 is to be reduced from 24.0 km on hilly terrain to 17.9 km on flat terrain. The section between Route 41 and Phanom is to be re-aligned from mountainous to flat terrain, the distance remaining the same. Phuket New Bridge will reduce the distance between Phangnga and the Phuket island from 26.3 km via Sarasin Bridge to 15.2 km. Road distance for cement transportation from Thung Song is 219 km to Phangnga and 101 km to Kantang Port for transshipment to Phuket. Road distance from the Western Region (Ratchaburi) to Laem Chabang Port is 222 km.

Table 5.3 ESTIMATE OF VEHICLE TRAFFIC ON EAST-WEST ROAD LINK

| | Alternative 1 (Road) | 1995 | | | | 2005 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | M | H | PCU | L | M | H | PCU | L | M | H | PCU |
| | Surat Thani | | | | | | | | | | | | |
| | - Phangnga (Intra) | 60.0 | 22.8 | 5.8 | 123.0 | 122.0 | 46.6 | 11.6 | 250.0 | 174.2 | 66.4 | 16.6 | 356.6 |
| | - Phangnga (Inter) | 104.7 | 39.8 | 10.0 | 214.3 | 214.5 | 81.7 | 20.4 | 439.1 | 308.8 | 117.7 | 29.4 | 632.3 |
| | - Phuket | 121.8 | 46.4 | 11.6 | 249.4 | 385.0 | 146.7 | 36.7 | 788.2 | 684.5 | 260.8 | 65.2 | 1,401.7 |
| | - Phuket Port | 9.3 | 10.6 | 6.2 | 49.2 | 29.7 | 33.9 | 19.8 | 156.8 | 52.9 | 60.5 | 35.3 | 279.7 |
| | Phangnga | | | | | | | | | | | | |
| | - Phuket (Intra) | 62.2 | 23.8 | 6.0 | 127.4 | 107.4 | 41.0 | 10.2 | 220.0 | 141.2 | 53.8 | 13.4 | 289.2 |
| | - Phuket (Inter) | 223.5 | 85.2 | 21.3 | 457.7 | 275.4 | 104.9 | 26.2 | 519.0 | 306.8 | 116.9 | 29.3 | 628.1 |
| Trucks (1,000 vehicles/ year) | Phuket | | | | | | | | | | | | |
| | - Surat Thani Port | 6.4 | 7.3 | 4.3 | 34.0 | 14.6 | 16.7 | 9.8 | 77.4 | 22.1 | 25.2 | 14.7 | 116.7 |
| | Sub Total | 587.9 | 235.9 | 65.2 | 1,255.0 | 1,148.6 | 471.5 | 134.7 | 2,450.5 | 1,690.5 | 701.3 | 203.9 | 3,704.3 |
| | Phangnga | | | | | | | | | | | | |
| | - Chumphon | 5.8 | 6.7 | 3.9 | 30.8 | 8.8 | 10.1 | 5.9 | 46.7 | 12.4 | 14.2 | 8.3 | 65.9 |
| | - Bangkok/Others | 25.5 | 29.1 | 17.0 | 134.7 | 39.2 | 44.8 | 26.1 | 206.9 | 50.6 | 57.8 | 33.6 | 267.0 |
| | Phuket | | | | | | | | | | | | |
| | - Chumphon | 4.0 | 4.5 | 2.7 | 21.2 | 7.7 | 8.8 | 5.1 | 40.8 | 11.0 | 12.6 | 7.3 | 58.0 |
| | - Bangkok/Others | 22.1 | 25.3 | 14.8 | 116.6 | 28.8 | 32.9 | 19.2 | 152.4 | 33.1 | 37.8 | 22.0 | 174.8 |
| | Sub Total | 57.4 | 65.6 | 38.4 | 303.3 | 84.5 | 96.6 | 56.3 | 446.8 | 107.1 | 122.4 | 71.2 | 565.7 |
| | Thung Song | | | | | | | | | | | | |
| | - Phangnga | - | - | - | - | - | - | - | - | - | - | - | - |
| | - Phuket | - | - | - | - | - | - | - | - | - | - | - | - |
| | West Region | | | | | | | | | | | | |
| | - Phuket Port | - | - | - | - | - | - | - | - | - | - | - | - |
| | Sub Total | - | - | - | - | - | - | - | - | - | - | - | - |
| | Grand Total | 645.3 | 301.5 | 103.6 | 1,558.3 | 1,233.1 | 568.1 | 191.0 | 2,897.3 | 1,797.6 | 823.7 | 275.1 | 4,270.0 |

Table 5.3 ESTIMATE OF VEHICLE TRAFFIC ON EAST-WEST ROAD LINK (Cont'd)

| Alternative 1 (Road) | | 1995 | | | | 2005 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | M | H | PCU | L | M | H | PCU | L | M | H | PCU |
| | Surat Thani | | | | | | | | | | | | |
| | - Phangnga (Intra) | 169.0 | 84.5 | 23.0 | 311.2 | 241.3 | 120.6 | 32.9 | 444.2 | 288.3 | 144.1 | 39.3 | 530.7 |
| | - Phangnga (Inter) | 61.6 | 30.8 | 8.4 | 113.5 | 83.7 | 41.9 | 11.4 | 154.1 | 97.6 | 48.8 | 13.3 | 179.6 |
| | - Phuket | 25.0 | 12.5 | 3.4 | 46.1 | 43.5 | 21.8 | 5.9 | 80.1 | 57.4 | 28.7 | 7.8 | 105.6 |
| | Phangnga | | | | | | | | | | | | |
| Cars and | - Phuket (Intra) | 160.8 | 80.4 | 21.9 | 295.9 | 264.7 | 132.4 | 36.1 | 487.3 | 339.7 | 169.8 | 46.3 | 625.3 |
| Buses | - Phuket (Inter) | 129.2 | 64.6 | 17.6 | 237.9 | 197.4 | 98.7 | 26.9 | 363.4 | 244.0 | 122.0 | 33.3 | 449.2 |
| (1,000 | - Phuket (Tourism) | 40.9 | 20.4 | 5.6 | 75.2 | 70.5 | 35.2 | 9.6 | 129.8 | 92.6 | 46.3 | 12.6 | 170.5 |
| vehicles/ | Sub Total | 586.5 | 293.2 | 79.9 | 1,079.8 | 901.1 | 450.6 | 122.8 | 1,658.9 | 1,119.6 | 559.7 | 152.6 | 2,060.9 |
| year) | | | | | | | | | | | | | |
| | Phangnga | | | | | | | | | | | | |
| | - Chumphon | 4.4 | 5.5 | 2.0 | 14.9 | 6.1 | 7.6 | 2.8 | 20.5 | 7.1 | 8.9 | 3.2 | 24.0 |
| | - Bangkok/Others | 2.3 | 2.9 | 1.0 | 7.7 | 3.3 | 4.1 | 1.5 | 11.2 | 4.0 | 4.9 | 1.8 | 13.4 |
| | Phuket | | | | | | | | | | | | |
| | - Chumphon | 0.2 | 0.2 | 0.1 | 0.6 | 0.3 | 0.4 | 0.1 | 1.1 | 0.4 | 0.6 | 0.2 | 1.5 |
| | - Bangkok/Others | 4.5 | 5.6 | 2.0 | 15.1 | 8.1 | 10.2 | 3.7 | 27.5 | 11.0 | 13.7 | 5.0 | 37.2 |
| | Sub Total | 11.4 | 14.2 | 5.1 | 38.3 | 17.8 | 22.3 | 8.1 | 60.3 | 22.5 | 28.1 | 10.2 | 76.1 |
| | Grand Total | 597.9 | 307.4 | 85.0 | 1,118.1 | 918.9 | 472.9 | 130.9 | 1,719.2 | 1,142.1 | 587.8 | 162.8 | 2,137.0 |

Note: L-Light, M-Medium, H-Heavy

Table 5.4 ESTIMATE OF VEHICLE TRAFFIC ON EAST-WEST ROAD LINK

| | Without Alternative 2 | 1995 | | | | 2005 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | M | H | PCU | L | M | H | PCU | L | M | H | PCU |
| Trucks (1,000 vehicles/ year) | Surat Thani | | | | | | | | | | | | |
| | - Phangnga (Intra) | 60.0 | 22.8 | 5.8 | 123.0 | 122.0 | 46.6 | 11.6 | 250.0 | 174.2 | 66.4 | 16.6 | 356.6 |
| | - Phangnga (Inter) | 104.7 | 39.8 | 10.0 | 214.3 | 214.5 | 81.7 | 20.4 | 439.1 | 308.8 | 117.7 | 29.4 | 632.3 |
| | - Phuket | 121.8 | 46.4 | 11.6 | 249.4 | 385.0 | 146.7 | 36.7 | 788.2 | 684.5 | 260.8 | 65.2 | 1,401.7 |
| | - Phuket Port | 9.3 | 10.6 | 6.2 | 49.2 | 29.7 | 33.9 | 19.8 | 156.8 | 52.9 | 60.5 | 35.3 | 279.7 |
| | Phangnga | | | | | | | | | | | | |
| | - Phuket (Intra) | 62.2 | 23.8 | 6.0 | 127.4 | 107.4 | 41.0 | 10.2 | 220.0 | 141.2 | 53.8 | 13.4 | 289.2 |
| | - Phuket (Inter) | 223.5 | 85.2 | 21.3 | 457.7 | 275.4 | 104.9 | 26.2 | 519.0 | 306.8 | 116.9 | 29.3 | 628.1 |
| | Phuket | | | | | | | | | | | | |
| | - Surat Thani Port | 6.4 | 7.3 | 4.3 | 34.0 | 14.6 | 16.7 | 9.8 | 77.4 | 22.1 | 25.2 | 14.7 | 116.7 |
| | Sub Total | 587.9 | 235.9 | 65.2 | 1,255.0 | 1,148.6 | 471.5 | 134.7 | 2,450.5 | 1,690.5 | 701.3 | 203.9 | 3,704.3 |
| | Phangnga | | | | | | | | | | | | |
| | - Chumphon | 5.9 | 6.8 | 4.0 | 31.4 | 9.0 | 10.3 | 6.0 | 47.7 | 12.7 | 14.5 | 8.5 | 67.2 |
| | - Bangkok/Others | 46.7 | 53.3 | 31.1 | 246.7 | 71.1 | 81.2 | 47.4 | 375.7 | 91.5 | 104.5 | 61.0 | 483.7 |
| | Phuket | | | | | | | | | | | | |
| | - Chumphon | 4.7 | 5.3 | 3.1 | 24.5 | 8.9 | 10.2 | 6.0 | 47.0 | 12.6 | 14.4 | 8.4 | 66.6 |
| | - Bangkok/Others | 47.4 | 54.2 | 31.6 | 250.5 | 61.8 | 70.6 | 41.2 | 326.5 | 70.8 | 80.9 | 47.3 | 374.2 |
| | Sub Total | 104.7 | 119.6 | 69.8 | 553.1 | 150.8 | 172.3 | 100.6 | 796.9 | 187.6 | 214.3 | 125.2 | 991.7 |
| | Thung Song | | | | | | | | | | | | |
| | - Phangnga | - | - | 16.4 | 49.2 | - | - | 32.5 | 97.5 | - | - | 40.8 | 122.5 |
| | - Phuket | - | - | 22.1 | 66.2 | - | - | 44.5 | 133.5 | - | - | 56.3 | 168.8 |
| | West Region | | | | | | | | | | | | |
| | - Phuket Port | - | - | 58.6 | 175.9 | - | - | 78.1 | 234.3 | - | - | 90.2 | 270.5 |
| | Sub Total | - | - | 97.1 | 291.3 | - | - | 155.1 | 465.3 | - | - | 187.3 | 561.8 |
| | Grand Total | 692.6 | 355.5 | 232.1 | 2,099.4 | 1,299.4 | 643.8 | 390.4 | 3,712.7 | 1,878.1 | 915.6 | 516.4 | 5,257.8 |

Table 5.4 ESTIMATE OF VEHICLE TRAFFIC ON EAST-WEST ROAD LINK (Cont'd)

| Without Alternative 2 | | 1995 | | | | 2005 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | M | H | PCU | L | M | H | PCU | L | M | H | PCU |
| | Surat Thani | | | | | | | | | | | | |
| | - Phangnga (Intra) | 169.0 | 84.5 | 23.0 | 311.2 | 241.3 | 120.6 | 32.9 | 444.2 | 288.3 | 144.1 | 39.3 | 530.7 |
| | - Phangnga (Inter) | 67.7 | 33.9 | 9.2 | 124.6 | 92.0 | 46.0 | 12.5 | 169.3 | 107.2 | 53.6 | 14.6 | 197.3 |
| | - Phuket | 29.1 | 14.6 | 4.0 | 53.6 | 50.6 | 25.3 | 6.9 | 93.2 | 66.8 | 33.4 | 9.1 | 122.9 |
| | Phangnga | | | | | | | | | | | | |
| Cars and | - Phuket (Intra) | 160.8 | 80.4 | 21.9 | 295.9 | 264.7 | 132.4 | 36.1 | 487.3 | 339.7 | 169.3 | 46.3 | 625.3 |
| Buses | - Phuket (Inter) | 136.0 | 68.0 | 18.5 | 250.4 | 207.8 | 103.9 | 28.3 | 382.5 | 256.8 | 128.4 | 35.0 | 472.8 |
| (1,000 | - Phuket (Tourism) | 40.9 | 20.4 | 5.6 | 75.2 | 70.5 | 35.2 | 9.6 | 129.8 | 92.6 | 46.3 | 12.6 | 170.5 |
| vehicles/ | Sub Total | 603.5 | 301.8 | 82.2 | 1,110.9 | 926.9 | 463.4 | 126.3 | 1,706.3 | 1,151.4 | 575.1 | 156.9 | 2,119.5 |
| year) | Phangnga | | | | | | | | | | | | |
| | - Chumphon | 6.0 | 7.5 | 2.7 | 20.3 | 8.2 | 10.3 | 3.7 | 27.8 | 9.6 | 12.0 | 4.4 | 32.5 |
| | - Bangkok/Others | 11.0 | 13.8 | 5.0 | 37.4 | 15.9 | 19.9 | 7.2 | 53.8 | 19.1 | 23.8 | 8.7 | 64.6 |
| | Phuket | | | | | | | | | | | | |
| | - Chumphon | 0.3 | 0.3 | 0.1 | 0.9 | 0.5 | 0.6 | 0.2 | 1.6 | 0.7 | 0.8 | 0.3 | 2.2 |
| | - Bangkok/Others | 24.3 | 30.4 | 11.0 | 82.3 | 44.4 | 55.5 | 20.2 | 150.4 | 60.0 | 75.0 | 27.3 | 203.2 |
| | Sub Total | 41.6 | 52.0 | 18.8 | 140.9 | 69.0 | 86.3 | 31.3 | 233.6 | 89.4 | 111.6 | 40.7 | 302.5 |
| | Grand Total | 645.1 | 353.8 | 101.0 | 1,251.8 | 995.9 | 549.7 | 157.6 | 1,931.9 | 1,240.8 | 686.7 | 197.6 | 2,422.0 |

Note: L-Light, M-Medium, H-Heavy

Table 5.5 ROAD DISTANCE VIA EAST-WEST ROAD LINK

Unit: km

| | | Surat Thani<br>1 | Phangnga<br>2 | Phuket<br>3 | Surat Thani Port<br>4 | Phuket Port<br>5 | Chumphon<br>6 | Bangkok<br>7 |
|---|---|---|---|---|---|---|---|---|
| 1. Surat Thani | Flat | | 138.5 | 216.9 | - | 224.1 | - | - |
| | Hilly | | - | - | - | - | - | - |
| | Mountain | | - | - | - | - | - | - |
| 2. Phangnga | Flat | 77.0 | | 78.4 | 212.5 | 85.6 | 287.6 | 746.6 |
| | Hilly | 24.0 | | - | - | - | - | - |
| | Mountain | 46.9 | | - | - | - | - | - |
| 3. Phuket | Flat | 166.5 | 89.5 | | 290.9 | - | 366.0 | 825.0 |
| | Hilly | 24.0 | - | | - | - | - | - |
| | Mountain | 46.9 | - | | - | - | - | - |
| 4. Surat Thani Port | Flat | - | 151.0 | 240.5 | | 298.1 | - | - |
| | Hilly | - | 24.0 | 24.0 | | - | - | - |
| | Mountain | - | 46.9 | 46.9 | | - | - | - |
| 5. Phuket Port | Flat | 173.7 | 96.7 | - | 247.7 | | 373.2 | 832.2 |
| | Hilly | 24.0 | - | - | 24.0 | | - | - |
| | Mountain | 46.9 | - | - | 46.9 | | - | - |
| 6. Chumphon | Flat | - | 255.0 | 344.5 | - | 351.7 | | - |
| | Hilly | - | - | - | - | - | | - |
| | Mountain | - | 46.9 | 46.9 | - | 46.9 | | - |
| 7. BaNgkok | Flat | - | 714.0 | 803.5 | - | 810.7 | - | |
| | Hilly | - | - | - | - | - | - | |
| | Mountain | - | 46.9 | 46.9 | - | 46.9 | - | |

- Road Distance at the End of the 5th Five-Year Plan Period -

Vehicle travel distance for each alternative was estimated as shown in Table 5.6.

4) Average Travelling Speed on East-West Road Link

Energy consumption rate of vehicles varies in accordance with the travelling speed; the lowest consumption rate will be attained at the velocity of 50 - 70 km/H while the rate will be increased at higher as well as lower velocity. As a step to estimate the travelling speed on East-West Road Link, vehicle traffic on the link was estimated as shown in Table 5.7, by grouping vehicle traffic of every origin and destination pair into the traffics on Surat Thani - Phangnga section and Phangnga - Phuket section. Average daily traffic in terms of passenger car unit (pcu) is estimated at 4,400 in 1995, 8,100 in 2005 and 11,800 in 2015 for Alternative 1 and at 5,200 in 1995, 9,400 in 2005 and 13,300 in 2015 for "without project" case and Alternative 2.

Average daily traffic per highway capacity ratios were calculated based on the assumed highway capacity of 8,000 pcu for 2-lane highway and 32,000 pcu for 4-lane highway. The obtained volume capacity ratios were then applied to Fig. 5.2 to get the average travelling speed on East-West Road Link. Table 5.8 shows the thus estimated average travelling speed of each Alternative.

5) Fuel Consumption by Vehicle Type

Fuel consumption by vehicle type at level tangent was quoted from "Feasibility Study on The Second Stage Expressway System in the Greater Bangkok" by JICA in November, 1983, as shown in Table 5.9. Adjusting factors for hilly and mountainous terrains were referred to the report of "Road Feasibility Study Project" by DOH in October, 1982. Considering that the sections in hilly and mountainous terrains of East-West Road Link contain nearly equal length of uphill and downhill, however, the adjusting factor in this study was defined as the balance of adjusting factors for uphill and downhill specified in the above report. Gradient of 2 percent was applied to hilly terrain, while gradient of 4 percent was applied to mountainous terrain. These are shown in Table 5.10.

Table 5.6 VEHICLE TRAVEL DISTANCE

Unit: 1,000 vehicle km/year

| | | | | 1995 | | | 2005 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | M | H | L | M | H | L | M | H |
| Without | Cargo | E-W | F | 65,376 | 36,022 | 15,966 | 133,537 | 72,405 | 28,900 | 203,684 | 106,907 | 41,412 |
| | | | H | 5,813 | 2,498 | 770 | 15,451 | 6,697 | 2,081 | 25,639 | 11,141 | 3,471 |
| | | | M | 16,268 | 10,492 | 4,780 | 37,267 | 21,165 | 8,784 | 58,902 | 31,821 | 12,654 |
| | | Others | F | 60,676 | 69,316 | 59,282 | 86,185 | 98,450 | 86,427 | 105,825 | 120,887 | 105,282 |
| | Passenger | E-W | F | 31,753 | 20,276 | 6,180 | 50,508 | 32,818 | 10,086 | 63,947 | 41,929 | 12,951 |
| | | | H | 2,323 | 1,164 | 317 | 3,422 | 1,711 | 466 | 4,176 | 2,088 | 568 |
| | | | M | 6,491 | 4,714 | 1,502 | 9,924 | 7,391 | 2,844 | 12,354 | 9,315 | 3,020 |
| | | Others | F | 23,150 | 28,972 | 10,484 | 39,200 | 49,020 | 17,803 | 51,237 | 63,987 | 23,321 |
| Alternative 1 | Cargo | E-W | F | 71,355 | 37,003 | 14,213 | 158,761 | 78,732 | 28,823 | 249,947 | 121,636 | 43,582 |
| | | | H | - | - | - | - | - | - | - | - | - |
| | | | M | - | - | - | - | - | - | - | - | - |
| | | Others | F | 31,435 | 35,926 | 21,009 | 45,324 | 51,797 | 30,195 | 56,305 | 64,321 | 37,411 |
| | Passenger | E-W | F | 29,035 | 15,808 | 4,499 | 44,836 | 24,550 | 6,996 | 55,964 | 30,688 | 7,776 |
| | | | H | - | - | - | - | - | - | - | - | - |
| | | | M | - | - | - | - | - | - | - | - | - |
| | | Others | F | 5,025 | 6,273 | 2,229 | 8,206 | 10,288 | 3,740 | 10,643 | 13,229 | 4.824 |
| Alternative 2 | Cargo | E-W | F | 79,099 | 45,844 | 19,349 | 169,438 | 90,927 | 35,960 | 262,737 | 136,240 | 52,165 |
| | | | H | - | - | - | - | - | - | - | - | - |
| | | | M | - | - | - | - | - | - | - | - | - |
| | | Others | F | 60,676 | 69,316 | 59,282 | 86,185 | 98,450 | 86,427 | 105,825 | 120,887 | 105,282 |
| | Passenger | E-W | F | 36,504 | 23,472 | 7,169 | 57,380 | 37,570 | 11,573 | 72,269 | 47,765 | 14,801 |
| | | | H | - | - | - | - | - | - | - | - | - |
| | | | M | - | - | - | - | - | - | - | - | - |
| | | Others | F | 23,150 | 28,972 | 10,484 | 39,200 | 49,020 | 17,803 | 51,237 | 63,987 | 23,321 |

Note: 1) For Trucks - L: Light Truck, M: Medium Truck, H: Heavy Truck
For Passenger - L: Passenger Car, M: Light Bus, M: Medium/Heavy Bus

2) E-W: East-West Road Link
Others: Highways other than East-West Link

Table 5.7 VEHICLE TRAFFIC ON EAST-WEST ROAD LINK

Unit: 1,000 vehicles/year

| | | 1995 | | | | 2005 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | M | H | PCU | L | M | H | PCU | L | M | H | PCU |
| Alternative 1 | | | | | | | | | | | | | |
| Surat-Phang | Cargo | 359.6 | 192.5 | 76.3 | 973.2 | 850.3 | 422.2 | 154.6 | 2,158.3 | 1,349.6 | 653.0 | 232.4 | 3,352.7 |
| | Passenger | 267.0 | 142.0 | 39.9 | 509.1 | 386.3 | 206.6 | 58.3 | 738.7 | 465.8 | 249.7 | 70.6 | 892.0 |
| | Total | 626.6 | 334.5 | 116.2 | 1,482.3 | 1,236.6 | 628.8 | 212.9 | 2,897.0 | 1,815.4 | 902.7 | 303.0 | 4,244.7 |
| Phang-Phuket | Cargo | 449.3 | 203.1 | 66.9 | 1,055.5 | 848.6 | 384.9 | 127.0 | 1,954.6 | 1,251.6 | 567.6 | 187.2 | 2,948.2 |
| | Passenger | 360.6 | 183.7 | 50.6 | 670.8 | 584.5 | 298.7 | 82.3 | 1,089.2 | 745.1 | 381.1 | 105.2 | 1,389.3 |
| | Total | 809.9 | 386.8 | 117.5 | 1,726.3 | 1,433.1 | 683.6 | 209.3 | 3,043.8 | 1,996.7 | 948.7 | 292.4 | 4,337.5 |
| Average | Cargo | 404.5 | 197.8 | 71.6 | 1,014.4 | 849.5 | 403.6 | 140.8 | 2,056.5 | 1,300.6 | 610.3 | 209.8 | 3,150.5 |
| | Passenger | 313.8 | 162.9 | 45.3 | 589.9 | 485.3 | 252.6 | 70.3 | 913.9 | 605.4 | 315.4 | 87.9 | 1,140.6 |
| | Total | 718.3 | 360.7 | 116.9 | 1,604.3 | 1,334.8 | 656.2 | 211.1 | 2,970.4 | 1,906.0 | 925.7 | 297.7 | 4,291.1 |
| Without & Alternative 2 | | | | | | | | | | | | | |
| Surat-Phang | Cargo | 406.9 | 246.5 | 107.7 | 1,223.0 | 916.6 | 497.9 | 198.9 | 2,508.4 | 1,430.1 | 744.9 | 286.4 | 3,778.7 |
| | Passenger | 307.4 | 185.0 | 55.0 | 630.3 | 452.9 | 278.2 | 83.6 | 940.3 | 551.7 | 342.7 | 103.7 | 1,153.4 |
| | Total | 714.3 | 431.5 | 162.7 | 1,853.3 | 1,369.5 | 776.1 | 282.5 | 3,448.7 | 1,981.8 | 1,087.6 | 390.1 | 4,932.1 |
| Phang-Phuket | Cargo | 475.3 | 232.8 | 84.1 | 1,192.7 | 882.8 | 424.0 | 149.9 | 2,134.9 | 1,290.9 | 612.5 | 213.6 | 3,156.2 |
| | Passenger | 391.4 | 214.1 | 61.1 | 758.3 | 638.5 | 352.9 | 101.3 | 1,244.8 | 816.6 | 453.2 | 130.6 | 1,596.9 |
| | Total | 866.7 | 446.9 | 145.2 | 1,951.0 | 1,521.3 | 776.9 | 251.3 | 3,379.7 | 2,107.5 | 1,065.7 | 344.2 | 4,753.1 |
| Average | Cargo | 441.1 | 239.6 | 95.9 | 1,207.9 | 869.7 | 461.0 | 174.4 | 2,321.7 | 1,360.5 | 678.7 | 250.0 | 3,467.5 |
| | Passenger | 349.4 | 199.6 | 58.1 | 694.3 | 545.7 | 315.5 | 92.5 | 1,092.5 | 684.2 | 398.0 | 117.2 | 1,375.1 |
| | Total | 790.5 | 439.2 | 154.0 | 1,902.2 | 1,445.4 | 776.5 | 266.9 | 3,414.2 | 2,044.7 | 1,076.7 | 367.2 | 4,842.6 |

Note :1) Cargo L : Light Truck, M : Medium Trunk, H : Heavy Trunk
Passenger L : Passenger Car, M : Light Bus,
H : Medium and Heavy Bus
PCU : Passenger Car Unit

2) Surat-Phang : Surat Thani - Phangnga section
Phang-Phuket: Phangnga - Phuket section
Average : Average of both sections

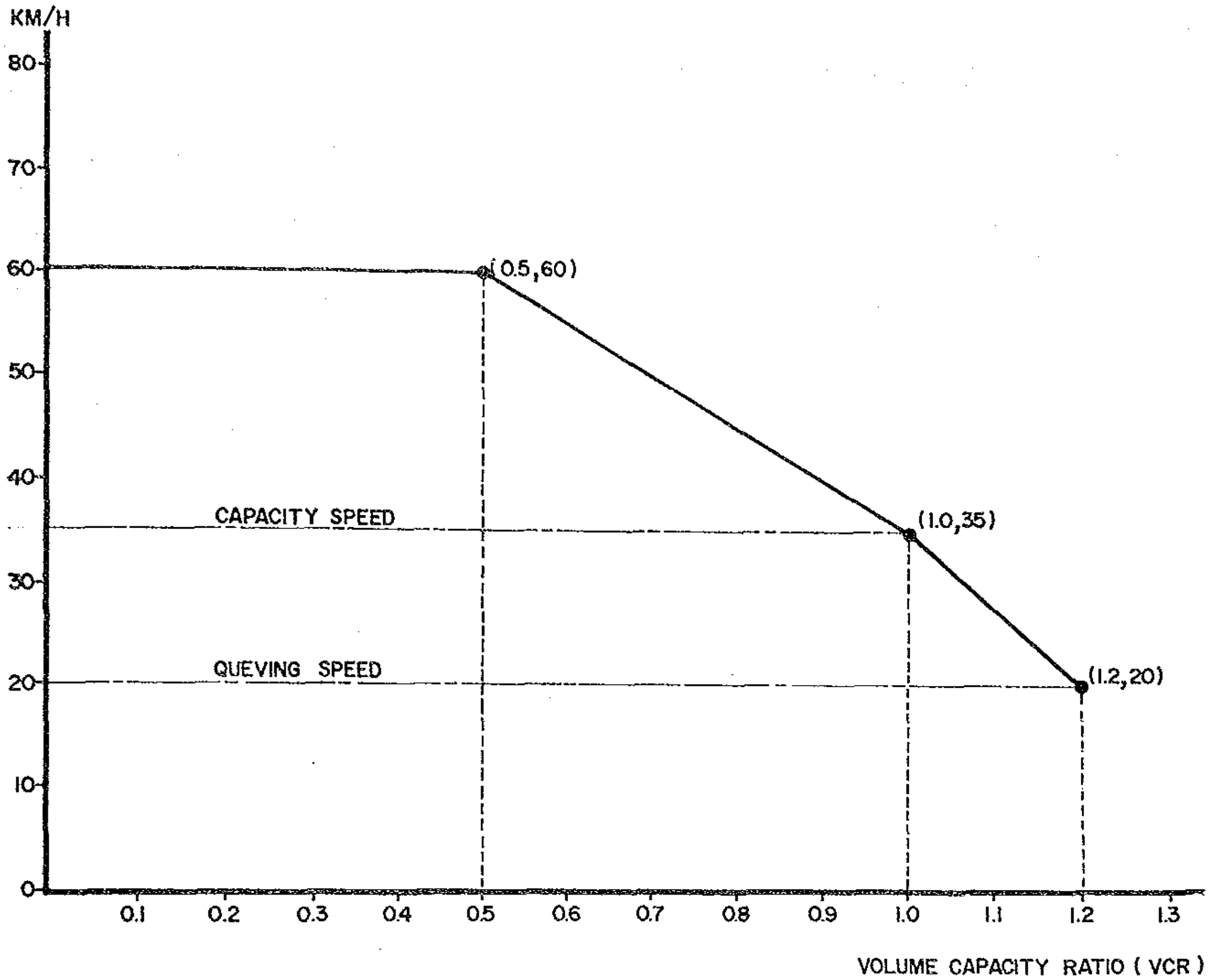


Fig. 5.2 VCR/SPEED RELATIONSHIP

Table 5.8 AVERAGE TRAVELING SPEED ON EAST-WEST ROAD LINK

Unit : km/h

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Without | 53 | 22 | 20 |
| Alternative 1 | 57 | 34 | 20 |
| Alternative 2 | 60 | 60 | 60 |

Table 5.9 FUEL CONSUMPTION RATE BY VEHICLE TYPE
AT LEVEL TANGENT

Unit: liters/1,000 kms

| Speed (km/H) | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|
| Light Truck | 100.1 | 96.2 | 97.5 | 101.4 | 107.9 | 122.2 | 156.0 |
| Medium Truck | 192.3 | 161.3 | 151.5 | 153.8 | 163.9 | 185.2 | 227.3 |
| Heavy Truck | 250.0 | 209.6 | 197.0 | 200.0 | 213.1 | 240.8 | 295.5 |
| Passenger Car | 77.0 | 74.0 | 75.0 | 78.0 | 83.0 | 94.0 | 120.0 |
| Light Bus | 96.0 | 83.8 | 78.2 | 81.8 | 90.0 | 105.9 | 138.5 |
| M/H Bus 1/ | 221.2 | 185.5 | 174.3 | 176.9 | 188.5 | 213.0 | 261.4 |

Note: 1/ Average of Medium and Heavy Trucks

Source: "Feasibility Study on the Second Stage Expressway System in the Greater Bangkok" by JICA in November, 1983.

Table 5.10 ADJUSTING FACTORS FOR FUEL CONSUMPTION RATE BY TERRAIN

Hilly Terrain 2% (Uphill - Downhill)

Unit: % for level tangent

| Speed (km/H) | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|
| Light Truck | 2.4 | 2.4 | 2.3 | 2.2 | 2.0 | 1.5 | 0.9 |
| Medium Truck | 12.9 | 8.6 | 4.3 | 1.3 | 0.0 | 0.0 | 0.0 |
| Heavy Trunk | - | 24.9 | 20.9 | 16.8 | 13.6 | 11.0 | 7.4 |
| Passenger Car | 0.7 | 1.3 | 1.7 | 2.0 | 2.5 | 0.0 | 0.0 |
| Light Bus | 2.4 | 2.4 | 2.3 | 2.2 | 2.0 | 1.5 | 0.9 |
| M/H Bus 1/ | - | 16.8 | 12.6 | 9.1 | 6.8 | 5.5 | 3.7 |

Mountainous Terrian 4% (Uphill - Downhill)

Unit: % for level tangent

| Speed (km/H) | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|
| Light Truck | 8.1 | 8.7 | 9.0 | 8.4 | 7.4 | 7.2 | 6.9 |
| Medium Truck | - | - | 33.0 | 21.1 | 12.9 | 7.6 | 4.1 |
| Heavy Trunk | - | - | 84.3 | 65.9 | 51.5 | 38.8 | 25.6 |
| Passenger Car | 4.9 | 5.9 | 6.7 | 6.4 | 7.7 | 7.5 | 7.5 |
| Light Bus | 8.1 | 8.7 | 9.0 | 8.4 | 7.4 | 7.2 | 6.9 |
| M/H Bus 1/ | - | - | 58.7 | 43.5 | 32.2 | 23.2 | 14.9 |

Source: "Road Feasibility Study Project" by DOH in October 1982

Note: 1/ Adjusting factors for M/H Bus (Medium and Heavy) was assumed to be the average of the factors for Medium and Heavy trucks.

Fuel consumption rates corresponding to the estimated vehicle travelling speed was estimated by interpolation of the fuel consumption rates at the speed given in Table 5.9. The same method was applied to estimate the fuel consumption rates for hilly and mountainous terrain. The estimated results are as shown in Table 5.11.

6) Fuel consumption by Alternatives

Fuel consumption by each alternative was calculated based on both vehicle travel distance shown in Table 5.6 and fuel consumption rates shown in Table 5.11. Fuel consumption rates for highways other than East-West Road Link were assumed at the rate of 50 km/H on level tangent for cargo transportation and the rate of 60 km/H on level tangent for passenger transportation. The estimated fuel consumptions are as shown in Table 5.12. Fuel consumptions were then converted to monetary terms at the economic cost of 7.31 baht per liter for gasoline and 6.05 baht per liter for diesel oil. It was assumed that gasoline is used by light truck, passenger car and light bus, and that diesel oil is used by medium and heavy trucks/buses. The estimated economic fuel costs for each alternative are as shown in Table 5.13.

Table 5.11 FUEL CONSUMPTION RATES

Unit: liters/1,000 kms

| Speed (km/H) | 60 | 57 | 53 | 50 | 34 | 22 | 20 |
|---|---|---|---|---|---|---|---|
| Level Tangent | | | | | | | |
| Light Truck | 97.5 | 98.7 | 100.2 | 101.4 | 116.3 | 148.6 | 156.0 |
| Medium Truck | 151.5 | 152.2 | 153.1 | 153.8 | 176.4 | 218.2 | 227.3 |
| Heavy Truck | 197.0 | 197.9 | 199.1 | 200.0 | 229.3 | 283.6 | 295.5 |
| Passenger Car | 75.0 | 75.9 | 77.1 | 78.0 | 88.0 | 114.3 | 120.0 |
| Light Bus | 78.2 | 79.3 | 80.7 | 81.8 | 99.2 | 131.3 | 138.5 |
| M/H Bus | 174.3 | 175.1 | 176.1 | 176.9 | 205.3 | 250.9 | 261.4 |
| Hilly Terrain | | | | | | | |
| Light Truck | 99.7 | 101.0 | 102.4 | 103.6 | 118.0 | 149.9 | 157.4 |
| Medium Truck | 158.0 | 158.7 | 155.1 | 155.8 | 176.4 | 218.2 | 295.5 |
| Heavy Truck | 238.2 | 239.3 | 232.5 | 233.6 | 254.5 | 304.6 | 317.4 |
| Passenger Car | 76.3 | 77.2 | 78.6 | 79.0 | 88.0 | 114.3 | 120.0 |
| Light Bus | 80.0 | 81.1 | 82.5 | 83.6 | 100.7 | 132.5 | 139.7 |
| M/H Bus | 196.3 | 197.2 | 192.1 | 193.0 | 216.6 | 260.2 | 271.1 |
| Mountainous Terrain | | | | | | | |
| Light Truck | 106.3 | 107.6 | 108.6 | 109.9 | 124.7 | 158.9 | 166.8 |
| Medium Trunk | 201.5 | 202.4 | 185.4 | 186.3 | 189.8 | 227.1 | 236.6 |
| Heavy Truck | 363.1 | 364.7 | 330.3 | 331.8 | 318.3 | 356.2 | 371.1 |
| Passenger Car | 80.0 | 81.0 | 82.0 | 83.0 | 94.6 | 122.9 | 129.0 |
| Light Bus | 85.2 | 86.4 | 87.5 | 88.7 | 106.3 | 140.4 | 148.1 |
| M/H Bus | 276.6 | 277.9 | 252.7 | 253.9 | 252.9 | 288.3 | 300.3 |

Table 5.12 FUEL CONSUMPTION BY ALTERNATIVES

Unit: 1,000 liters/year

| | | | 1995 | | | 2005 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | M | H | L | M | H | L | M | H |
| Without | Cargo | EW 1/ | 8,913 | 7,847 | 4,937 | 28,082 | 22,067 | 11,959 | 45,636 | 35,121 | 18,035 |
| | | Others 2/ | 6,153 | 10,661 | 11,856 | 8,739 | 15,142 | 17,285 | 10,731 | 18,592 | 21,056 |
| | Pass. | EW | 3,163 | 2,272 | 1,529 | 7,384 | 5,574 | 3,472 | 9,769 | 7,479 | 4,446 |
| | | Others | 1,736 | 2,266 | 1,827 | 2,940 | 3,833 | 3,103 | 3,843 | 5,004 | 4,065 |
| Alt. 1 | Cargo | EW | 7,043 | 5,632 | 2,813 | 18,464 | 13,888 | 6,609 | 38,992 | 27,648 | 12,878 |
| | | Others | 3,188 | 5,525 | 4,202 | 4,596 | 7,966 | 6,039 | 5,709 | 9,893 | 7,482 |
| | Pass. | EW | 2,204 | 1,254 | 788 | 3,946 | 2,435 | 1,436 | 6,716 | 4,250 | 2,033 |
| | | Others | 377 | 491 | 389 | 615 | 805 | 652 | 798 | 1,035 | 841 |
| Alt. 2 | Cargo | EW | 7,712 | 6,945 | 3,812 | 16,520 | 13,775 | 7,084 | 25,617 | 20,640 | 10,277 |
| | | Others | 6,153 | 10,661 | 11,856 | 8,739 | 15,142 | 17,285 | 10,731 | 18,592 | 21,056 |
| | Pass. | EW | 2,738 | 1,836 | 1,250 | 4,304 | 2,938 | 2,017 | 5,420 | 3,735 | 2,580 |
| | | Others | 1,736 | 2,266 | 1,827 | 2,940 | 3,833 | 3,103 | 3,843 | 5,004 | 4,065 |

Note : 1/ East-West Road Link
2/ Sections other than East-West Road Link

Table 5.13 ECONOMIC FUEL COST

Unit: million baht/year

| | | | 1995 | | | 2005 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | M | H | L | M | H | L | M | H |
| Without | Cargo | EW | 65.2 | 47.5 | 29.9 | 205.3 | 133.5 | 72.4 | 333.6 | 212.5 | 109.1 |
| | | Others | 45.0 | 64.5 | 71.7 | 63.9 | 91.6 | 104.6 | 78.4 | 112.5 | 127.4 |
| | Pass. | EW | 23.1 | 16.6 | 9.3 | 54.0 | 40.7 | 21.0 | 71.4 | 54.7 | 26.9 |
| | | Others | 12.7 | 16.6 | 11.1 | 21.5 | 28.0 | 18.8 | 28.1 | 36.6 | 24.6 |
| Alt. 1 | Cargo | EW | 51.5 | 34.1 | 17.0 | 135.0 | 84.0 | 40.0 | 285.0 | 167.3 | 77.9 |
| | | Others | 23.3 | 33.4 | 25.4 | 33.6 | 48.2 | 36.5 | 41.7 | 59.9 | 45.3 |
| | Pass. | EW | 16.1 | 9.2 | 4.8 | 28.8 | 17.8 | 8.7 | 49.1 | 31.1 | 12.3 |
| | | Others | 2.8 | 3.6 | 2.4 | 4.5 | 5.9 | 3.9 | 5.8 | 7.6 | 5.1 |
| Alt. 2 | Cargo | EW | 56.4 | 42.0 | 23.1 | 120.8 | 83.3 | 42.9 | 187.3 | 124.9 | 62.2 |
| | | Others | 45.0 | 64.5 | 71.7 | 63.9 | 91.6 | 104.6 | 78.4 | 112.5 | 127.4 |
| | Pass. | EW | 20.0 | 13.4 | 7.6 | 31.5 | 21.5 | 12.2 | 39.6 | 27.3 | 15.6 |
| | | Others | 12.7 | 16.6 | 11.1 | 21.5 | 28.0 | 18.8 | 28.1 | 36.6 | 24.6 |

7) Economic Vehicle Operating Cost

Vehicle operating cost consists of such components as fuel, oil, tire, depreciation, wage, maintenance parts and labour, and overhead. Rates of total vehicle operating cost per fuel cost were calculated by vehicle type and travel speed based on "Feasibility Study on the Second Stage Expressway System in the Greater Bangkok", by JICA in November, 1983 as shown in Table 5.14.

Table 5.14 RATE OF TOTAL VOC PER FUEL COST

| Speed (km/H) | 60 | 57 | 53 | 50 | 34 | 22 | 20 |
|---|---|---|---|---|---|---|---|
| Light Truck | 2.918 | 2.948 | 2,989 | 3.020 | 2.916 | 2.670 | 2.617 |
| Medium Truck | 5.859 | 5.883 | 5.916 | 5.941 | 5.556 | 4.988 | 4.883 |
| Heavy Truck | 5.985 | 6.013 | 6.051 | 6.080 | 5.693 | 4.981 | 4.853 |
| Passenger Car | 3.661 | 3.624 | 3.574 | 3.538 | 3.390 | 2.968 | 2.896 |
| Light Bus | 4.211 | 4.201 | 4.187 | 4.177 | 3.810 | 3.243 | 3.143 |
| M/H Bus | 5.346 | 5.384 | 5.435 | 5.474 | 5.007 | 4.255 | 4.113 |

Note : M/H Bus is the average of Medium and Heavy buses.

Source : "Feasibility Study on the Second Stage Expressway System in the Greater Bangkok", by JICA in August, 1983

Based on these rates, economic vehicle operating costs for each alternative were stimated as shown in Table 5.15.

Operating cost items to be added to the above estimated vehicle operating cost are enumerated as follows:

- for "without project" case and Alternative 2
    1) economic shipping cost of cement from Kantang port to Phuket
    2) economic shipping cost of export cargo from Bangkok/Laem Chabang ports to near Phuket
- for Alternative 1
    1) economic railway operating cost for the estimated transportation demand on East-West Rail Link

Table 5.15 ECONOMIC TOTAL VOC

Unit: million baht/year

| | | | 1995 | | | 2005 | | | 015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | M | H | L | M | H | L | M | H |
| Without | Cargo | EW | 194.9 | 281.0 | 180.9 | 548.2 | 665.9 | 360.6 | 873.0 | 1,037.6 | 529.5 |
| | | Others | 135.9 | 383.2 | 435.9 | 193.0 | 544.2 | 636.0 | 236.8 | 668.4 | 774.6 |
| | Pass. | EW | 82.6 | 69.5 | 50.5 | 160.3 | 132.0 | 89.4 | 206.8 | 171.9 | 110.6 |
| | | Others | 46.5 | 69.9 | 59.3 | 78.7 | 117.9 | 100.5 | 102.9 | 154.1 | 131.5 |
| | Total | | 459.9 | 803.6 | 726.6 | 980.2 | 1,460.0 | 1,186.5 | 1,419.5 | 2,032.0 | 1,546.2 |
| Alt. 1 | Cargo | EW | 151.8 | 200.6 | 102.2 | 393.7 | 466.7 | 227.7 | 745.8 | 816.9 | 378.0 |
| | | Others | 70.4 | 198.4 | 154.4 | 101.5 | 286.4 | 221.9 | 125.9 | 355.9 | 275.4 |
| | Pass. | EW | 58.3 | 38.6 | 25.8 | 97.6 | 67.8 | 43.6 | 142.2 | 97.7 | 50.6 |
| | | Others | 10.3 | 15.2 | 12.8 | 16.5 | 24.8 | 20.8 | 21.2 | 32.0 | 27.3 |
| | Total | | 290.8 | 452.8 | 295.2 | 609.3 | 845.7 | 514.0 | 1,035.1 | 1,302.5 | 731.3 |
| Alt. 2 | Cargo | EW | 164.6 | 246.1 | 138.3 | 352.5 | 488.1 | 256.8 | 546.5 | 731.8 | 372.3 |
| | | Others | 135.9 | 383.2 | 435.9 | 193.0 | 544.2 | 636.0 | 236.8 | 668.4 | 774.6 |
| | Pass. | EW | 73.2 | 56.4 | 40.6 | 115.3 | 90.5 | 65.2 | 145.0 | 115.0 | 83.4 |
| | | Others | 46.5 | 69.9 | 59.3 | 78.7 | 117.9 | 100.5 | 102.9 | 154.1 | 131.5 |
| | Total | | 420.2 | 755.6 | 674.1 | 739.5 | 1,240.7 | 1,058.5 | 1,031.2 | 1,669.3 | 1,361.8 |

8) Additional Operating Costs for "without project" case and Alternative 2

Economic shipping cost of cement from Kantang port to Phuket was estimated as shown below:

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Cement (1,000 ton/year) | 158.8 | 320.5 | 405.0 |
| Economic shipping cost (mil. baht/year) | 8.1 | 16.4 | 20.7 |

Direct distance from Kantang port to Phuket is 190 km. Though diesel consumption rates in coastal shipping are highly dependent on speed of vessels, time spent at port and average load factors, it was assumed at 21 liters per 1,000 ton kms by referring to "Study of Energy Policies for the Transportation Sector" by MOC in June, 1982. A factor of 2.1 was applied to convert the estimated economic fuel cost to economic shipping cost.

Economic shipping cost of export cargo from Bangkok/Laem Chabang ports to near Phuket was estimated as shown below:

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Export Cargo (1,000 ton/year) | 422.1 | 562.4 | 649.2 |
| Economic shipping cost (mil. baht/year) | 106.4 | 141.7 | 163.6 |

The distance from Bangkok/Laem Chabang ports to near Phuket via Singapore is about 2,600 km. International vessels of 10,000 DWT are assumed to navigate at the speed of 13 knot per hour. The fuel consumption is assumed of 27 kℓ per day. It is also assumed that this size of vessel carries cargo of 6,800 tons. A factor of 2.1 was applied to convert the estimated economic fuel cost to economic shipping cost.

In estimating the above shipping costs, there are a number of unclear factors at this moment. The accuracy of these estimations will affect the result of the economic feasibility of Alternative 1, while the economic feasibility of Alternative 2 is not influenced by this accuracy because these economic shipping costs are to be offset through the process of benefit calculation. So as to avoid misjudgement of the economic feasibility of Alternative 1, the assumptions adopted in this sequence have a tendency of underestimation.

9) Railway Operating Cost for Alternative 1

Transportation demand on East-West Rail Link shown in Table 5.1 was converted to economic fuel cost as shown in Table 5.16. Fuel consumption rates of cargo and passenger by railway are quoted from "Study of Energy Policies for the Transportation Sector" by MOC in June, 1982.

Table 5.16 ECONOMIC FUEL COST OF RAILWAY

| CARGO | | 1,000 tkm/year | | | Economic Fuel Cost (1,000 baht) | | |
|---|---|---|---|---|---|---|---|
| | KM | 1995 | 2005 | 2015 | 1995 | 2005 | 2015 |
| Phangnga-Chumphon | 265 | 238 | 345 | 503 | | | |
| -BKK/Others | 750 | 127,050 | 191,625 | 245,925 | | | |
| Phuket -Chumphon | 338 | 1,724 | 3,177 | 4,394 | | | |
| -BKK/Others | 823 | 166,740 | 216,943 | 248,381 | | | |
| Thung Song-Phangnga | 229 | 27,045 | 53,586 | 67,303 | | | |
| -Phuket | 302 | 47,958 | 96,791 | 122,310 | | | |
| Ratchaburi-Phuket Ports | 714 | 301,379 | 401,554 | 463,529 | | | |
| Total | | 672,134 | 964,021 | 1,152,345 | 73,343 | 105,194 | 125,743 |

| PASSENGER | | 1,000 pkm/year | | | Economic Fuel Cost (1,000 baht) | | |
|---|---|---|---|---|---|---|---|
| | KM | 1995 | 2005 | 2015 | 1995 | 2005 | 2015 |
| Surat-Phangnga | 103 | 6,262 | 8,497 | 9,909 | | | |
| -Phuket | 176 | 7,216 | 12,531 | 16,526 | | | |
| Phangnga-Phuket | 73 | 4,964 | 7,577 | 9,366 | | | |
| Phangna-Chumphon | 265 | 10,414 | 14,257 | 16,695 | | | |
| -BKK/Others | 750 | 163,725 | 236,025 | 283,425 | | | |
| Phuket-Chumphon | 338 | 710 | 1,352 | 1,825 | | | |
| -BKK/Others | 823 | 408,455 | 746,296 | 1,008,669 | | | |
| Total | | 601,746 | 1,026,535 | 1,346,415 | 24,089 | 41,094 | 53,900 |
| Total of Cargo and Passenger | | | | | 97,432 | 146,288 | 179,643 |

Note: 1) Fuel cost for cargo

16.9 goe/tkm ÷ 937 goe/liter x 6.05 baht/liter x (1,000 tkm/year)

2) Fuel cost for passenger

6.2 goe/pkm ÷ 937 goe/liter x 6.05 baht/liter x (1,000 pkm/year)

The estimated economic fuel cost was then converted to economic train operating cost based on the operating expenses of SRT in 1982 which is estimated as shown in Table 5.17.

Table 5.17 OPERATING EXPENSES OF SRT IN 1982

Unit: mil. baht/year

| | Personnel | Supply | Fuel | Depreciation | Expenditure |
|---|---|---|---|---|---|
| Maintenance of Way & Structure | 408.1 | 246.2 | - | 98.6 | 752.9 |
| Maintenance of Equipment | 464.9 | 280.5 | - | 112.5 | 857.9 |
| Traffic & Transportation | 438.8 | 264.7 | 711.5 | - | 1,415.0 |
| Miscellaneous Operation | 62.1 | 37.4 | - | - | 99.5 |
| General Expence | 219.1 | - | - | - | 219.1 |
| EXPENDITURE | 1,593.0 | 828.8 | 711.5 | 211.1 | 3,344.4 |

The factor to convert fuel cost to train operating cost is calculated at 1.99 (= 1,415.0 ÷ 711.5) based on the cost item of "Traffic & Transportation". The balance of 1,929.4 million baht (= 3,344.4 - 1,415.0) is considered as a maintenance and managing cost for railway operation of 30.554 million train kilometers by revenue. Unit cost of maintenance and management is calculated at 63.15 baht per train kilometer for financial cost and assumed at 56.8 baht for economic cost. Maintenance and managing cost is estimated by multiplying the future train kilometers by the economic unit cost. Railway operating cost is thus estimated as shown in Table 5.18.

Table 5.18 ECONOMIC RAILWAY OPERATING COST

Unit: mil. baht/year

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Train Operating Cost | 193.9 | 291.1 | 357.5 |
| Maintenance & Managing Cost | 118.7 | 178.2 | 218.8 |
| Total Operating Cost | 312.6 | 469.3 | 576.3 |

Economic operating costs for each alternative and economic benefit for Alternative 1 and 2 are as shown in Table 5.19 and 5.20, respectively.

Table 5.19 ECONOMIC TOTAL OPERATING COST

Unit: million baht/year

| | | 1995 | 2005 | 2015 |
|---|---|---|---|---|
| Without | VOC | 1,990.1 | 3,626.7 | 4,997.7 |
| | Cement Ship | 8.1 | 16.4 | 20.7 |
| | Export Ship | 106.4 | 141.7 | 163.6 |
| | Total | 2,104.6 | 3,784.8 | 5,182.0 |
| Alternative 1 | VOC | 1,038.8 | 1,969.0 | 3,068.9 |
| | Railway | 312.6 | 469.3 | 576.3 |
| | Total | 1,351.4 | 2,438.3 | 3,645.2 |
| Alternative 2 | VOC | 1,849.9 | 3,038.7 | 4,062.3 |
| | Cement Ship | 8.1 | 16.4 | 20.7 |
| | Export Ship | 106.4 | 141.7 | 163.6 |
| | Total | 1,964.4 | 3,196.8 | 4,246.6 |

Table 5.20 ECONOMIC BENEFIT

Unit: mil. baht/year

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Without - Alternative 1 | 753.2 | 1,346.5 | 1,536.8 |
| Without - Alternative 2 | 140.2 | 588.0 | 935.4 |

### 5.1.2 Estimation of Cost Stream

1) Yearly Allocation of Construction Cost

Total construction cost for each alternative was allocated to every year from 1986 to 1994 in accordance with the stipulated construction schedule shown in Fig. 5.17, vol. 2, of Final Report. Construction cost for "without project" case is composed of the estimated disbursement during the Fifth Five Year Plan period to complete the prototype East-West Road Link and the cost to widen the surface from 6 m to 7 m where considered necessary. Construction cost for Alternative 1 and 2 during the Fifth Five Year Plan period is half of the engineering study cost which is assumed to be disbursed in 1986 and 1987. Taking account that this disbursement schedule will favor "with project" cases, however, construction cost during the Fifth Five Year Plan was neglected for calculating the economic internal rates of return.

2) Maintenance Cost of East-West Road Link

Maintenance includes periodic maintenance which is assumed to take place at every eight year and routine maintenance in every year. Unit cost of periodic maintenance is assumed at 133 baht per square meter for the replacement of the surface and tack coat. Periodic maintenance cost is calculated by multiplying the total square meters of the road link by this unit cost in accordance with the year of completion of each section. Unit cost of routine maintenance is calculated based on the following formula:

Cost (baht/km) = 32,900 + 0.15 ADT

ADT : Average Daily Traffic

Source : "Highway Sector Project", by DOH in February, 1983

3) Maintenance Cost of Railway

East-West Rail Link can perform its major functions when it is connected with Bangkok through the Southern Main Line. So as to provide a sound base for economic evaluation, it will be necessary to take account of some portion of the maintenance cost of the Southern Line as a cost for East-West Rail Link. 40 percent of the maintenance cost incurred by train kilometers between East-West Rail Link and Bangkok is assumed to constitute a cost for East-West Link.

4) Purchasing Cost of Rolling Stock

The estimated number of rolling stocks in 2000 is re-allocated to the years of 1995, 2000, 2005, 2010 and 2015 in accordance with the estimated transportation demand. Rolling stocks are assumed to be procured at every five year. Service life of rolling stocks is assumed 20 years for diesel locomotive and 33 years for freight and passenger cars.

5) Residual Value

It is assumed that land and rolling stocks will have their residual values at the end of project life. The right of ways which will be procured for the new development sections of Alternative 1 and 2 are considered to have their residual values. Rolling stocks which still have service life are also considered to have their residual values.

Cost streams of each alternative are thus estimated, and the results are as shown in Table 5.21.

6) Factors to Convert Market Price to Economic Value

By referring to the feasibility studies carried out in recent years, conversion factors are assumed as shown below:

| | |
|---|---|
| - costs related to road link | 87 percent |
| - costs related to rail link excluding rolling stocks | 87 percent |
| - cost of rolling stocks | 82 percent |

Table 5.21 FINANCIAL COSTS FOR ALTERNATIVES

Unit: million baht/year

| | | Without | | | | Alternative 2 | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Year | Const. | P. Maint. | R. Maint. | Total | Const. | P. Maint. | R. Maint. | Total |
| 1 | 1984 | | | | | | | | |
| 2 | 85 | | | | | | | | |
| 3 | 86 | | | | | | | | |
| 4 | 87 | | 99.7 | 8.2 | 107.9 | 133.1 | | 8.2 | 141.3 |
| 5 | 88 | | | 8.2 | 8.2 | 274.2 | | 7.5 | 281.7 |
| 6 | 89 | | | 8.2 | 8.2 | 240.3 | | 6.5 | 246.8 |
| 7 | 1990 | | | 8.3 | 8.3 | 488.6 | | 6.6 | 495.2 |
| 8 | 91 | | | 8.3 | 8.3 | 663.7 | | 6.0 | 669.7 |
| 9 | 92 | | | 8.3 | 8.3 | 628.4 | | 4.8 | 633.2 |
| 10 | 93 | | | 8.3 | 8.3 | 309.3 | | 6.4 | 315.7 |
| 11 | 94 | 59.9 | 200.8 | 8.3 | 269.0 | 204.1 | | 6.7 | 210.8 |
| 12 | 95 | | | 8.3 | 8.3 | | | 7.5 | 7.5 |
| 13 | 96 | | | 8.3 | 8.3 | | | 7.5 | 7.5 |
| 14 | 97 | | | 8.3 | 8.3 | | 33.3 | 7.5 | 40.8 |
| 15 | 98 | | | 8.3 | 8.3 | | 51.6 | 7.6 | 59.2 |
| 16 | 99 | | | 8.3 | 8.3 | | 28.3 | 7.6 | 35.9 |
| 17 | 2000 | | | 8.3 | 8.3 | | 177.1 | 7.6 | 184.7 |
| 18 | 01 | | | 8.4 | 8.4 | | 47.5 | 7.6 | 55.1 |
| 19 | 02 | | 227.6 | 8.4 | 236.0 | | 79.3 | 7.6 | 86.9 |
| 20 | 03 | | | 8.4 | 8.4 | | - | 7.7 | 7.7 |
| 21 | 04 | | | 8.4 | 8.4 | | - | 7.7 | 7.7 |
| 22 | 05 | | | 8.4 | 8.4 | | 33.3 | 7.7 | 41.0 |
| 23 | 06 | | | 8.4 | 8.4 | | 51.6 | 7.7 | 59.3 |
| 24 | 07 | | | 8.4 | 8.4 | | 28.3 | 7.7 | 36.0 |
| 25 | 08 | | | 8.4 | 8.4 | | 177.1 | 7.7 | 184.8 |
| 26 | 09 | | | 8.4 | 8.4 | | 47.5 | 7.7 | 55.2 |
| 27 | 2010 | | 227.6 | 8.4 | 236.0 | | 79.3 | 7.7 | 87.0 |
| 28 | 11 | | | 8.5 | 8.5 | | - | 7.8 | 7.8 |
| 29 | 12 | | | 8.5 | 8.5 | | - | 7.8 | 7.8 |
| 30 | 13 | | | 8.5 | 8.5 | | 33.3 | 7.8 | 41.1 |
| 31 | 14 | | | 8.5 | 8.5 | | 51.6 | 7.8 | 59.4 |
| 32 | 15 | | | 8.5 | 8.5 | | 28.3 | 7.8 | 36.1 |
| 33 | 16 | | | 8.5 | 8.5 | | 177.1 | 7.8 | 184.9 |
| 34 | 17 | | | 8.5 | 8.5 | | 47.5 | 7.8 | 55.3 |
| 35 | 18 | | 227.6 | 8.5 | 236.1 | | 79.3 | 7.8 | 87.1 |
| 36 | 19 | | | 8.5 | 8.5 | -232.9 | - | 7.8 | -225.1 |
| Total | | 59.9 | 983.3 | 276.4 | 1,319.7 | 2,708.8 | 1,251.3 | 245.0 | 4,205.1 |

Table 5.21 FINANCIAL COSTS FOR ALTERNATIVES (Cont'd)

Unit: million baht/year

Alternative 1

| | | Road Link | | | | Rail Link | | | | G. Total |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Year | Const. | P. Maint. | R. Maint. | Total | Const. | P. Maint. | R. Maint. | Total | |
| 1 | 1984 | | | | | | | | | |
| 2 | 85 | | | | | | | | | |
| 3 | 86 | | | | | | | | | |
| 4 | 87 | 806 | | 8.2 | 88.8 | 31.4 | | | 31.4 | 120.2 |
| 5 | 88 | 196.2 | | 7.5 | 203.7 | 90.6 | | | 90.6 | 294.3 |
| 6 | 89 | 177.1 | | 4.8 | 181.9 | 90.6 | | | 90.6 | 272.5 |
| 7 | 1990 | 404.7 | | 5.9 | 410.6 | 115.6 | | | 115.6 | 526.2 |
| 8 | 91 | 294.9 | | 6.2 | 301.1 | 132.3 | | | 132.3 | 433.4 |
| 9 | 92 | 198.8 | | 5.7 | 204.5 | 452.7 | | | 452.7 | 657.2 |
| 10 | 93 | | | 7.5 | 7.5 | 465.1 | | | 465.1 | 472.6 |
| 11 | 94 | | | 7.5 | 7.5 | 32.8 | 1,052.3 | | 1,085.1 | 1,092.6 |
| 12 | 95 | | | 7.5 | 7.5 | | | 94.2 | 94.2 | 101.7 |
| 13 | 96 | | | 7.5 | 7.5 | | | 98.1 | 98.1 | 105.6 |
| 14 | 97 | | 16.7 | 7.5 | 24.2 | | | 102.2 | 102.2 | 126.4 |
| 15 | 98 | | 70.8 | 7.5 | 78.3 | | | 106.4 | 106.4 | 184.7 |
| 16 | 99 | | 52.4 | 7.5 | 59.9 | | | 110.8 | 110.8 | 170.7 |
| 17 | 2000 | | 68.6 | 7.5 | 76.1 | | 239.1 | 115.4 | 354.5 | 430.6 |
| 18 | 01 | | - | 7.6 | 7.6 | | | 120.2 | 120.2 | 127.8 |
| 19 | 02 | | - | 7.6 | 7.6 | | | 125.2 | 125.2 | 132.8 |
| 20 | 03 | | - | 7.6 | 7.6 | | | 130.4 | 130.4 | 138.0 |
| 21 | 04 | | - | 7.6 | 7.6 | | | 135.8 | 135.8 | 143.4 |
| 22 | 05 | | 16.7 | 7.6 | 24.3 | | 302.6 | 141.4 | 444.0 | 468.3 |
| 23 | 06 | | 70.8 | 7.6 | 78.4 | | | 144.3 | 144.3 | 222.7 |
| 24 | 07 | | 52.4 | 7.6 | 60.0 | | | 147.3 | 147.3 | 207.3 |
| 25 | 08 | | 68.6 | 7.7 | 76.3 | | | 150.4 | 150.4 | 226.6 |
| 26 | 09 | | - | 7.7 | 7.7 | | | 153.5 | 153.5 | 161.2 |
| 27 | 2010 | | - | 7.7 | 7.7 | | 164.6 | 156.7 | 32 .3 | 329.0 |
| 28 | 11 | | - | 7.7 | 7.7 | | | 159.9 | 159.9 | 167.6 |
| 29 | 12 | | - | 7.7 | 7.7 | | | 163.2 | 163.2 | 170.9 |
| 30 | 13 | | 16.7 | 7.8 | 24.5 | | | 166.6 | 166.6 | 191.1 |
| 31 | 14 | | 70.8 | 7.8 | 78.6 | | | 170.1 | 170.1 | 248.7 |
| 32 | 15 | | 52.4 | 7.8 | 60.2 | | 629.9 | 173.6 | 803.5 | 863.7 |
| 33 | 16 | | 68.6 | 7.8 | 76.4 | | | 177.2 | 173.6 | 250.0 |
| 34 | 17 | | - | 7.8 | 7.8 | | | 177.2 | 177.2 | 185.0 |
| 35 | 18 | | - | 7.8 | 7.8 | | | 177.2 | 177.2 | 185.0 |
| 36 | 19 | -174.3 | - | 7.8 | -166.5 | -208.3 | -909.4 | 177.2 | -940.5 | -1,107.0 |
| | Total | 1,178.0 | 625.5 | 244.6 | 2,048.1 | 1,202.8 | 1479.1 | 3,574.5 | 6,256.4 | 8,304.5 |

## 5.2 FINANCIAL EVALUATION OF RAIL LINK

### 5.2.1 Method of Financial Evaluation

Preliminary financial evaluation of East-West Rail Link was conducted from a viewpoint of the idea to estimate the earning power of total investment on East-West Rail Link regardless of financial sources. In other words, this evaluation is based on the estimated profit and loss statement excluding interest payment and depreciation allowances. It is assumed that the effects of inflation and railway fare rise will be neutralized as the latter will continuously be adjusted to the inflation in the long run. Financial internal rate of return is calculated based on the estimated revenue and expenditures directly related to the construction, operation and management of East-West Rail Link.

### 5.2.2 Estimation of Revenue

Revenues to be produced by East-West Rail Link are estimated by multiplying the estimated ton kilometers by the present rate of freight fare for cargo transportation, and multiplying the estimated passenger kilometers by the present rate of passenger fare for passenger transportation.

The present railway fare is as shown in Table 5.22. Freight fare of class 3 is applied to the exporting cargo from the Western Region through Phuket Deep Seaport, that of class 4 is applied to cement and that of the average of class 3 and 4 to the other ramaining cargoes. Passenger fare of second class is applied to passenger transportation, taking account that the average travel distance of passengers on first and second classes amounts to 610 km while that of passengers on third class only to 110 km. It is assumed that 10 percent of the passengers between Bangkok and Phangnga/Phuket will use the first class car. Railway fare between each origin and destination pair is calculated based on the railway fare table which shows decreasing fare rate against distance. Transportation demand of cargo and passenger on East-West Rail Link is as shown in Table 5.1.

Table 5.22 RAILWAY FARE

Freight Fare

| Distance km. | Rate per ton (in Baht) Class 3 | Class 4 | Petroleum |
|---|---|---|---|
| 50 | 26.80 | 23.30 | 21.80 |
| 100 | 53.50 | 46.50 | 43.50 |
| 150 | 77.00 | 67.00 | 65.30 |
| 200 | 100.50 | 87.50 | 87.00 |
| 300 | 143.50 | 125.00 | 126.00 |
| 500 | 225.00 | 196.00 | 201.00 |
| 700 | 301.50 | 262.50 | 273.00 |
| 1.000 | 415.50 | 361.50 | 375.00 |

Note: 1) Carload rates

2) Class 3: electrical appliance, motor car, tin, steel coil, log, timber, tile.

3) Class 4: fresh fish, rice, maize, rubber, jute, kenaf, cement, lignite, fluorspar, manganese, gypsum, fertilizer, fresh fruits, paddy, bran, marl, sand, gravel, vegetables, coconuts.

Passenger Fare

| km. | First Class Baht | Second Class Baht | Third Class Baht |
|---|---|---|---|
| 100 | 70.00 | 38.00 | 20.00 |
| 150 | 102.00 | 54.00 | 28.00 |
| 200 | 134.00 | 70.00 | 36.00 |
| 300 | 193.00 | 99.00 | 49.00 |
| 400 | 249.00 | 125.00 | 61.00 |
| 500 | 305.00 | 151.00 | 73.00 |
| 700 | 417.00 | 203.00 | 97.00 |
| 900 | 529.00 | 255.00 | 121.00 |

| Distance km. | Fares per km. (in Stang) First Class | Second Class | Third Class |
|---|---|---|---|
| 1 - 100 | 70 | 38 | 20 |
| 101 - 200 | 64 | 32 | 16 |
| 201 - 300 | 59 | 29 | 13 |
| 301 and over | 56 | 26 | 12 |

The estimated total revenues for respective target years are as shown in Table 5.23.

Table 5.23 REVENUE OF EAST-WEST RAIL LINK

Unit: mil. baht/year

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Cargo | 278.7 | 399.9 | 477.8 |
| Passenger | 191.5 | 326.2 | 427.7 |
| Total | 470.2 | 726.1 | 905.5 |

5.2.3 Estimation of Operational Expenditures

Fuel cost incurred by train operation on East-West Rail Link is estimated by multiplying the estimated ton kilometers and passenger kilometers shown in Table 5.16 by the present market price of diesel oil of 6.99 baht per liter.

The thus estimated fuel cost is converted to traffic and transportation cost by applying a factor of 1.99 (= 1,415.0 ÷ 711.5) which is obtainable from Table 5.17. Maintenance and managing cost of East-West Rail Link is estimated by multiplying the estimated train kilometers on East-West Rail Link by unit cost of 63.15 baht per train kilometer. Total operational expenditure is estimated as shown in Table 5.24.

Table 5.24 OPERATIONAL EXPENDITURES OF EAST-WEST RAIL LINK

Unit: mil. baht/year

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| Traffic and Transportation Cost | 224.0 | 336.4 | 413.0 |
| Maintenance and Managing Cost | 132.0 | 198.1 | 243.3 |
| Operational Expenditures | 356.0 | 534.5 | 656.3 |
| Total Revenue | 470.2 | 726.1 | 905.5 |
| Profit | 114.2 | 191.6 | 249.2 |

### 5.2.4 Financial Evaluation

Financial internal rates of return are calculated for the two cases; the one (case 1) including every cost of construction, rolling stocks and operational expenditures, and another (case 2) including costs of rolling stocks and operational expenditures. Input data for these two cases are as shown in Table 5.25. The internal rate of return for case 1 is calculated at 3.7 percent and that for case 2 at 11.8 percent. Judging from these indicators, East-West Rail Link will be financially viable only if construction cost is subsidized by the government, though the railway fare is kept at rather low rate, it will be difficult to raise the fare to make up for the deficit of construction cost particularly in the face of keen competition with road transport as well as the expected railway function to social welfare.

Table 5.25 FINANCIAL ANALYSIS OF EAST-WEST RAIL LINK

Unit: million baht/year

| No. | Year | Cost: 1. Const. | Cost: 2. R. Stock | Cost: 3. T/M | Case 1: 1+2+3 | Case 2: 2+3 | Revenue |
|---|---|---|---|---|---|---|---|
| 1 | 1984 | | | | | | |
| 2 | 85 | | | | | | |
| 3 | 86 | 31.3 | | | 31.3 | - | |
| 4 | 87 | 31.4 | | | 31.4 | - | |
| 5 | 88 | 90.6 | | | 90.6 | - | |
| 6 | 89 | 90.6 | | | 90.6 | - | |
| 7 | 1990 | 115.6 | | | 115.6 | - | |
| 8 | 91 | 132.3 | | | 132.3 | - | |
| 9 | 92 | 452.7 | | | 452.7 | - | |
| 10 | 93 | 465.1 | | | 465.1 | - | |
| 11 | 94 | 32.8 | 1,052.3 | | 1,085.1 | 1,052.3 | |
| 12 | 95 | | | 356.0 | 356.0 | 356.0 | 470.2 |
| 13 | 96 | | | 370.7 | 370.7 | 370.7 | 491.1 |
| 14 | 97 | | | 386.1 | 386.1 | 386.1 | 512.9 |
| 15 | 98 | | | 402.1 | 402.1 | 402.1 | 535.7 |
| 16 | 99 | | | 418.8 | 418.8 | 418.8 | 559.5 |
| 17 | 2000 | | 239.1 | 436.2 | 675.3 | 675.3 | 584.3 |
| 18 | 01 | | | 454.2 | 454.2 | 454.2 | 610.2 |
| 19 | 02 | | | 473.1 | 473.1 | 473.1 | 637.4 |
| 20 | 03 | | | 492.7 | 492.7 | 492.7 | 665.7 |
| 21 | 04 | | | 513.1 | 513.1 | 513.1 | 695.2 |
| 22 | 05 | | 302.6 | 534.5 | 837.1 | 837.1 | 726.1 |
| 23 | 06 | | | 545.5 | 545.5 | 545.5 | 742.3 |
| 24 | 07 | | | 556.8 | 556.8 | 556.8 | 758.9 |
| 25 | 08 | | | 568.4 | 568.4 | 568.4 | 775.8 |
| 26 | 09 | | | 580.2 | 580.2 | 580.2 | 793.1 |
| 27 | 2010 | | 164.6 | 592.2 | 756.8 | 756.8 | 810.8 |
| 28 | 11 | | | 604.5 | 604.5 | 604.5 | 829.0 |
| 29 | 12 | | | 617.1 | 617.1 | 617.1 | 847.5 |
| 30 | 13 | | | 629.9 | 629.9 | 629.9 | 866.4 |
| 31 | 14 | | | 642.9 | 642.9 | 642.9 | 885.7 |
| 32 | 15 | | 629.9 | 656.3 | 1,286.2 | 1,286.2 | 905.5 |
| 33 | 16 | | | 656.3 | 656.3 | 656.3 | 905.5 |
| 34 | 17 | | | 656.3 | 656.3 | 656.3 | 905.5 |
| 35 | 18 | | | 656.3 | 656.3 | 656.3 | 905.5 |
| 36 | 19 | -208.3 | -909.4 | 656.3 | -461.4 | -253.1 | 905.5 |
| Total | | 1,234.1 | 1,479.1 | 13,456.5 | 16,169.7 | 14,935.6 | 18,325.3 |

# 6. KHANOM DEEP SEAPORT

## 6.1 ALTERNATIVE LOCATIONS OF THE PORT

### 6.1.1 The Selection of Alternative Locations

Various factors were considered in the selection of alternative locations for Khanom Deep Seaport. These are the availability of port area and industrial area, the possibility of utilizing existing facilities, natural conditions such as siltation, waves and tidal current, soil characteristics, dredging volume, the easy approach by ocean-going vessels, inland transportation, and environmental conditions.

The alternatives which were selected are as follows:

A North Ban Tha Krachai

B Tha Thong

C Don Sak

D East Don Sak

E Khanom

F South Khanom

Those locations are shown in Figure 6.1.
These alternatives each have their own characteristics.
Alternative B (Tha Thong) was chosen in order to make full use of the existing port facilities while preventing continuous siltation by constructing a revetment and using a barge system to connect the port with an anchorage area for ocean-going vessels. However, this idea contains such vital problems as conflicts with ongoing fish/shrimp farming projects, environmental destruction and the high cost of capital dredging and maintenance dredging.

### 6.1.2 The Selection Criterion

The selection criterion and the results of the appraisal of each of the alternatives are shown in Table 6.1.
As ports are operated on a commercial basis, competing with other ports, it is natural to minimize capital cost and maintenance cost and to operate the port efficiently. The port should have the capacity to accommodate ocean-going vessels at any time, to dispatch vessels quickly, and to handle commodities at low cost and without damage.
Especially in the early stage after the port opens, it should make special efforts to attract vessels and cargoes because it has less competitiveness than other proceeding ports. In other words, the port should be attractive to vessels and cargoes, and ensuring the easy access to the port is very important.

It is also necessary to secure sufficient space not only for the present development project but also for the future development because the Deep Seaport brings with it the possibility for extensive regional development.

Therefore, maneuverability of ocean-going vessels, the possibility of port expansion in the future, construction cost and maintenance cost are key factors on the basis of which the site selection for the Khanom Deep Seaport can be carried out.

### 6.1.3 The Selection of the Construction Site

Alternatives E and F present lower construction and maintenance costs than the other alternatives. However, there is no possibility for future port expansion at alternative E.
Alternative F is also superior to alternative E in maneuverability of ocean-going vessels.
According to Table 6.1 COMPARISON OF ALTERNATIVES, alternative F, South Khanom, is the most suitable location to the Surat Thani Area for constructing the Deep Seaport.

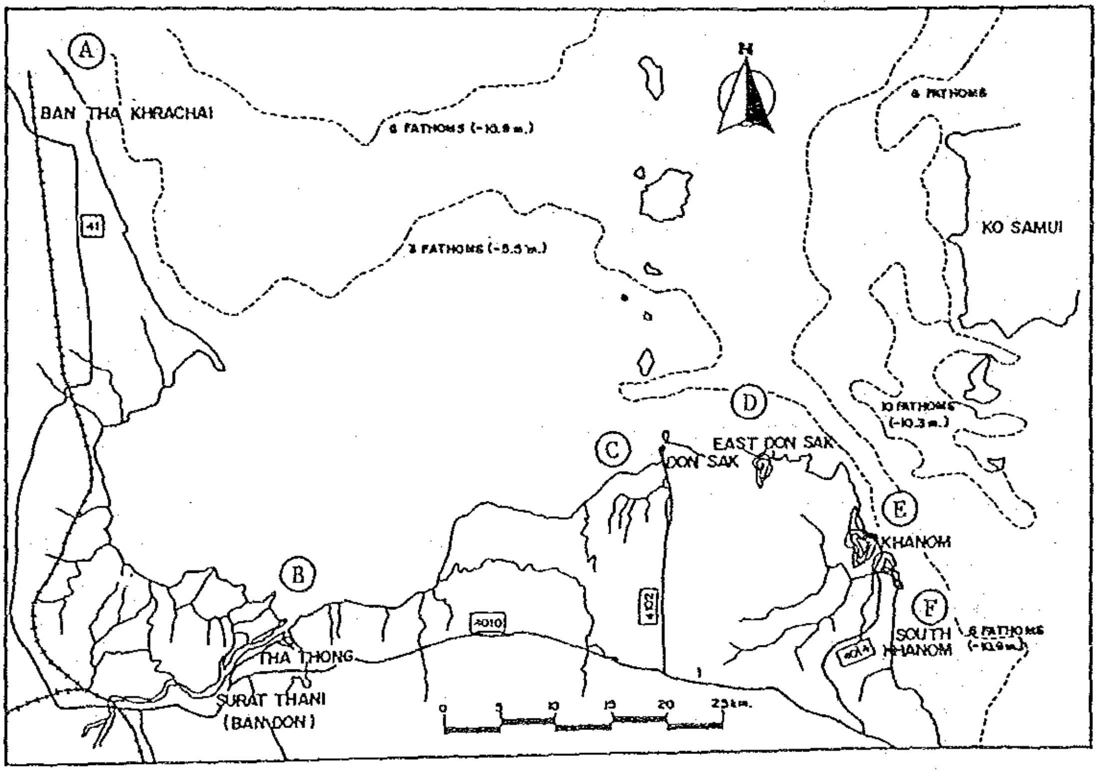


Fig. 6.1 ALTERNATIVE LOCATIONS FOR KHANOM DEEP SEAPORT

Table 6.1 COMPARISON OF ALTERNATIVES FOR KHANOM DEEP SEAPORT

| | Alternatives | (1) Distance from Surat Thani by Road | (2) Availability of Transportation | |
|---|---|---|---|---|
| | | | 1) Inland Transportation | 2) Distance to the Open Sea (to International Route) |
| A. | North Ban Tha Krachai | 70 KM | close to the existing railaway | 120 KM |
| B. | Tha Thong | 7 KM | - | 100 KM |
| C. | Don Sak | 80 KM | - | 60 KM |
| D. | East Don Sak | 80 KM | - | 50 km |
| E. | Khanom | 80 KM | - | near |
| F. | South Khanom | 80 KM | - | directly to the Open Sea |

| | (3) Natural Conditions | | | | |
|---|---|---|---|---|---|
| | 1) Topography | 2) Water Depth | 3) Waves | 4) Tidal current | 5) Soil |
| A. | sea shore | -2 M | calm | slow | sand |
| B. | at the mouth of the Tapi River | -2 M | very calm | slow | mud |
| C. | in the estuary of the Don Sak River | -1 M | very calm | slow | mud and rock partially |
| D. | sea shore | -1 M | calm | very slow | mud |
| E. | at the mouth of the Khanom River | -2 M | very calm | slow | mud |
| F. | sea shore | -6 M | calm | slow | sand |

| | (4) Influence on Fishery | (5) Availability of Port Development Area | |
|---|---|---|---|
| | | 1) Land Area | 2) Port Area |
| A. | small | a wide and flat area is available | easy |
| B. | large | the area necessary for the time being is available | limited |
| C. | large | difficult, especially for industrial area | limited |
| D. | small | the area necessary for the time being is available | easy |
| E. | small | not easy | limited |
| F. | small | a large wide and flat area is available | very easy |

| | (6) Availability of Water Channel | | | | | |
|---|---|---|---|---|---|---|
| | 1) Length of Channel | 2) Existing Depth of Channel | 3) Capital Dredging Volume | 4) Volume of Siltation | 5) Volume of Littoral Drift | 6) Maintenance Dredging Volume |
| A. | 5.5 KM | -2M ~ -10M | large | - | large | large |
| B. | 37.0 KM | -2M ~ -6M | extremely large | extremely large | - | extremely large |
| C. | 13.9 KM | -1M ~ -10M | extremely large | extremely large | - | extremely large |
| D. | 8.5 KM | -1M ~ -10M | very large (13.4 mil $m^3$) | very large | - | very large |
| E. | 3.0 KM | -2M ~ -10M | small | small | - | small |
| F. | 2.4 KM | -6M ~ -10M | small (1.9 mil $m^3$) | - | extremely small | extremely small |

| | (7) Construction Works | | (8) Maneuverability of Oceangoing Vessels |
|---|---|---|---|
| | 1) Capital Construction Work | 2) Maintenance Work | |
| A. | easy | easy | not so good |
| B. | difficult (attention to the fishery farm is necessary) | difficult | difficult |
| C. | difficult (attention to the fishery farm, soft ground and hard rocks is necessary) | difficult | difficult |
| D. | difficult (consideration for soft foundations is necessary) | difficult | difficult |
| E. | difficult (foundation is soft and near to the existing channel) | difficult | easy |
| F. | easy | easy | very easy |

| | (9) Possibility of Port Expansion in the Future | (10) Approximate Construction Cost | (11) Approximate Maintenance Cost |
|---|---|---|---|
| A. | great | low | high |
| B. | very limited | extremely high | extremely high |
| C. | limited | very high | extremely high |
| D. | limited | high (฿1.7 billion) | very high |
| E. | none | low | low |
| F. | extremely great | low (฿1.0 billion) | low |

## 6.2 PRELIMINARY EVALUATION

### 6.2.1 Method of Evaluation

The evaluation criterion used for comparing benefit and cost streams is internal rate of return (IRR). Benefit to be taken into account is limited to the reductions in inland transportation cost, though the effects of port development extend to a variety of aspects, either directly or indirectly.

Benefit attributable to Khanom Deep Seaport is estimated based on the savings on inland transportation cost of cargoes which are innevitably forwarded to Songkhla, Phuket and Bangkok ports in case of "without the project" case. The benefit stream is estimated based on the cargo handling volumes of the year 1991 and 2000, the cargo handling volume in 1991 being estimated by applying a growth rate of GRP for the period of 1991-2000 to the estimated cargo handling volume in 2000. Construction cost and operating/managing cost are incorporated into the project cost which is then allocated to each year based on the phased construction plan. Project life is assumed to be thirty years.

### 6.2.2 Benefit Estimation

Fig. 6.2 shows the procedure to estimate the benefit. Cargo handling volume of Khanom Deep Seaport is estimated at 330.6 thousand tons in 1991 and 623.3 thousand tons in 2000 excluding gypsum which can be exported through a private jetty at Khanom even under "without the project" case, as shown in Table 6.2. For "without the project" case, percentage share of such substitutional ports as Bangkok, Songkhla and Phuket is assumed to be inversely proportional to the distance from each zone of the Upper South to the substitutional ports, while the whole volume will be forwarded to Songkhla Port from the provinces outside the Upper South.

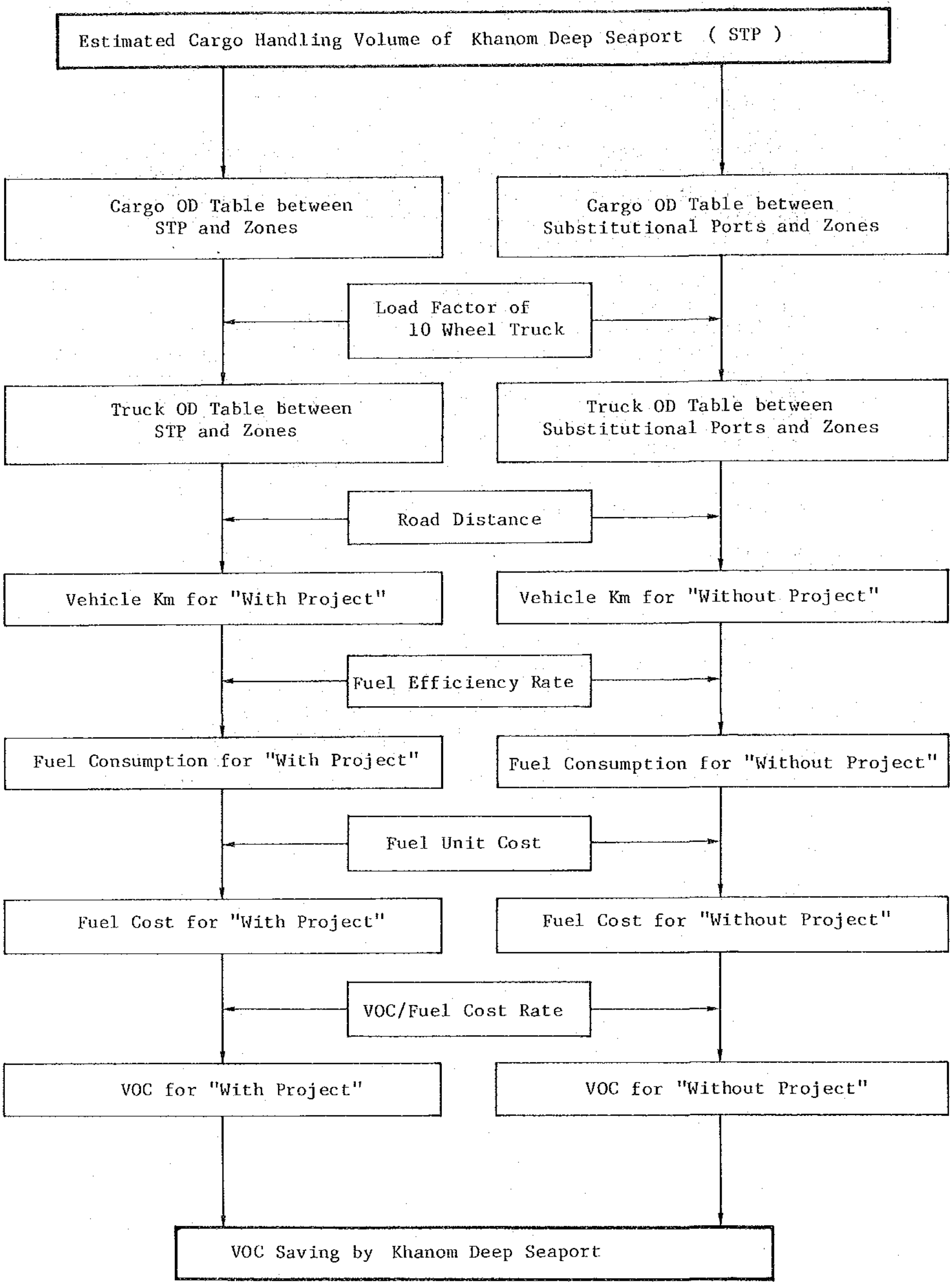


Fig. 6.2 PROCEDURE TO ESTIMATE BENEFIT

Table 6.2 OD TABLE OF THE CARGOES TO BE HANDLED AT KHANOM DEEP SEAPORT

Unit: 1,000 tons/year

| | With project | | Without project | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Khanom | | 1991 | | | 2000 | | |
| | 1991 | 2000 | Bangkok | Songkhla | Phuket | Bangkok | Songkhla | Phuket |
| Surat Thani | 140.7 | 277.2 | 47.8 | 92.9 | - | 94.2 | 183.0 | - |
| Phangnga | 2.9 | 9.7 | 0.7 | 1.2 | 1.0 | 2.4 | 4.1 | 3.2 |
| Phuket | 23.0 | 50.2 | 7.6 | 7.8 | 7.6 | 16.6 | 17.1 | 16.5 |
| Krabi | 21.7 | 44.8 | 6.7 | 15.0 | - | 13.9 | 30.9 | - |
| Nakhom S.T. | 95.0 | 161.1 | - | 95.0 | - | - | 161.1 | - |
| Trang | 29.0 | 49.2 | - | 29.0 | - | - | 49.2 | - |
| Phatthalung | 18.3 | 31.1 | - | 18.3 | - | - | 31.1 | - |
| Total | 330.6 | 623.3 | 62.8 | 259.2 | 8.6 | 127.1 | 476.5 | 19.7 |

Note : Gypsum is excluded

Source : The Team

The OD tables for "with and without the project" cases are converted into vehicle operating cost (VOC) by applying the below-mentioned factors to each step of the procedure:

- Load factor of 10 wheel truck: 7.2 ton/truck

- Road distance (KM):

| | Khanom | Bangkok | Songkhla | Phuket |
|---|---|---|---|---|
| Surat Thani | 74 | 644 | 327 | - |
| Phangnga | 212 | 747 | 429 | 86 |
| Phuket | 291 | 825 | 507 | 7 |
| Krabi | 193 | 764 | 343 | - |
| Nakhom S.T. | 107 | - | 178 | - |
| Trang | 241 | - | 194 | - |
| Phatthalung | 221 | - | 139 | - |

- Fuel efficiency rate: diesel oil of 200 liter/1,000 km at 50 km/H, based on "Feasibility Study on the Second Stage Expressway System in the Greater Bangkok" by JICA, in 1984.

- Unit economic cost of fuel: 6.05 baht/liter based on the above

- Total VOC/Fuel cost ratio: 6.08 based on the above

Total volume and amount estimated for each item of the procedure are summarized as shown in Table 6.3. Vehicle operating cost saving to be generated by Khanom Deep Seaport is estimated at 66.2 million baht in 1991 and 131.6 million baht in 2000.

Table 6.3 ESTIMATED VEHICLE OPERATING COST

| | With | | Without | |
|---|---|---|---|---|
| | 1991 | 2000 | 1991 | 2000 |
| Vehicle kilometer (1,000 km/year) | 5,987.0 | 11,359.7 | 14,987.1 | 29,246.3 |
| Fuel consumption (1,000 ℓ/year) | 1,197.4 | 2,271.9 | 2,997.4 | 5,849.3 |
| Economic fuel cost (1,000 ฿/year) | 7,244.3 | 13,745.0 | 18,134.3 | 35,388.3 |
| Economic VOC (mil. ฿/year) | 44.0 | 83.6 | 110.2 | 215.2 |

Benefits for the years before 1991 are estimated by extrapolation with an annual growth rate from 2000 to 1991. Those for the period of 1992-1999 are estimated by interpolation with an annual growth rate from 1991 to 2000, and those for the period of 2001-2005 are estimated by extrapolation with an annual growth rate from 1991 to 2000. Benefits for the period of 2006-2010 are estimated by extrapolation with half of the annual growth rate from 1991 to 2000, and those for the period after 2010 are assumed to remain constant due to the capacity limit of Khanom Deep Seaport.

### 6.2.3 Cost Estimation

The estimated construction cost of 1,019.6 million baht are allocated to each year with an idea of phased construction plan. The construction plan is phased into three stages; berths 1, 5 and 6 for the first stage from 1987 to 1989, berth 2 and jetty for the second stage from 1992 to 1993, and berths 3 and 4 for the third stage from 1996 to 1998. The first stage construction is planned to immediately follow the completion of Songkhla Deep Seaport. Construction costs of each stage are estimated at 471.8 million baht for the first stage, 194.3 million baht for the second stage and 353.5 million baht for the third stage.

Annual operating and maintenance cost is estimated at 44.0 million baht excluding maintenance dredging cost of 2.4 million baht for the full scaled operation. The estimated annual operating and maintenance cost is allocated to each year in correspondence with the phased development plan. Maintenance dredging cost of 2.4 million baht is added to the thus estimated operating and maintenance cost for the years after 1989 when capital dredging is to be completed.

The construction cost and the operating and maintenance cost which are estimated on the basis of market price are then converted to economic cost with a conversion factor of 0.87.

## 6.3 NECESSITY OF DEEP SEAPORT IN EAST COAST OF UPPER SOUTH AND ITS RELATION WITH SONGKHLA DEEP SEAPORT

Surat Thani Area, which will be the major hinterland of Khanom Deep Seaport, is situated in the east portion of the Upper South. The area is abundant in natural resources such as agricultural and mining products, some of which are exported abroad and contribute greatly to the regional economy. The export of regional products and import of materials for regional development will increase greatly with the implementation of the above-mentioned plan.

The cargo volume handled at Tha Thong Port in 1981 amounted to 407,800 tons of domestic trade and no foreign trade.
Fishery products and petroleum products amounted to 81,900 and 212,400 tons respectively, and the remaining volume was 113,500 tons.

The cargo volume to be handled in the Surat Thani Area in 2000 was forecast. The results are shown in Table 6.4. The cargo volume handled at Khanom Deep Seaport in 2000 will be 133,200 tons assuming that petroleum products are handled at the existing private oil jetties near Tha Thong Port. The foreign cargo volume handled at Khanom Deep Seaport will be 823,300 tons while domestic cargo volume will be 509,900 tons.

Thus, an overseas outlet is indispensable for this region. However, there is presently no deep seaport which can accommodate ocean-going vessels in the area, except an old private gypsum loading jetty at Khanom, and foreign trade commodities are transshipped to other ports outside of the area.
Fortunately, the natural conditions of Khanom are suitable for a deep seaport. Khanom also has the advantage of proximity to the international shipping route in the Gulf of Thailand.

Of course, there is Songkhla Deep Seaport, development of which is ongoing, about 300 kilometers south of Surat Thani. However, it is too far for the Upper South to export/import products/materials effectively. On the other hand, the Khanom Deep Seaport development project is estimated to be feasible. (EIRR=11.3 percent)

Furthermore, there is enough land space and water resources for full-scale industry just behind the port. This is the best advantages for the port. Then, this area is clearly suitable to become an industrial center for the nation.
Therefore, Khanom Deep Seaport is expected to function not only as a foreign trade port, but also as an industrial port in conjunction with waterfront-oriented industry. This industrial development will be planned to start following the Eastern Seaboard Development Program.

Table 6.4 FORECAST CARGO HANDLING VOLUME AT KHANOM DEEP SEAPORT

Unit: 1,000 tons/year

| | 1981 | | 2000 | | Total | | |
|---|---|---|---|---|---|---|---|
| | Domestic | Foreign | Domestic | Foreign | 1981 | 2000 | %pa |
| Rubber | - | - | - | 379.0 | - | 379.0 | - |
| Fish | 81.7 | - | 83.0 | 18.6 | 81.7 | 101.6 | 1.2 |
| Forestry | 23.9 | - | 27.9 | - | 23.9 | 27.9 | 0.8 |
| Petroleum | 212.4 | - | 886.2 | - | 212.4 | 886.2 | 7.8 |
| Others | 89.6 | - | 191.3 | 180.1 | 89.6 | 371.4 | 7.8 |
| Fertilizer | - | - | 207.7 | 45.6 | - | 253.3 | - |
| Gypsum | - | - | - | 200.0 | - | 200.0 | - |
| G. Total | 407.6 | 0.0 | 1,396.1 | 823.3 | 407.6 | 2,219.4 | 9.3 |
| G. Total (ex, Petro) | 195.2 | 0.0 | 509.9 | 823.3 | 195.2 | 1,333.2 | 10.6 |

Note: In "G. Total (ex. Petro)", 18.6 thousand tons of fish in 2000 is included as an export goods.

## 6.4 PORT MANAGEMENT

(1) Khanom Deep Seaport has two roles. One is to contribute to regional development in the Upper South and another is to contribute to national industrial development.

(2) To fulfill these roles, its port and port-related facilities should be developed in response to progress of the development in its hinterland. The port should be properly operated to promote regional and industrial development. Investment for port/port-related and industrial facilities by the private sector should also take place.

(3) Port management by the public sector should also be considered from a viewpoint of multi-purpose space utilization based on effective utilization of precious land space and environmental conservation.

(4) These are public objectives that should be persued by national and regional governments.

(5) Therefore, the port should be managed by national and regional governments corresponding to public objectives.

(6) Furthermore, the port has two major aspects: it functions as a public physical infrastructure and as a business undertaking.

(7) That is, on the one hand the port should achieve public objectives of regional and industrial development; on the other hand the port should be operated efficiently and economically.

(8) As competition among neighboring ports is inevitable, promoting port sales activities is a necessary part of port operations. Such competition is positive: it leads to increased efficiency.

(9) In this sense, a port authority system is the best port management organization. It can cover the functions required in (5) and (8).

(10) The port authority should be independent of government authorities and other port authorities to achieve the aims mentioned in (7).

(11) However, Thailand is also under world-wide economic depression and government budget is very crucial.
To lessen the budgetary burden of the government, private capital should be positively introduced as much as possible, as long as (1) - (10) can be maintained.

(12) Initiatives of the government in port management are also indispensable for investment by private firms.

(13) If governments concerned invest positively, it shows their firm decision to promote the project and encourages private investors.

(14) Considering (5), (11) and (13), such basic port facilities as a water channel, a breakwater and an access road should be constructed by the governments concerned and such facilities as quaywalls operated dominantly by private firms should be constructed by the private sector.

(15) All the points mentioned above are summarized as follows:

1) The port should be operated under initiative of government concerned with appropreate introduction of private capital.

2) The port management body should be the responsible port authority. The management body should include representative of the national government, the regional government and private users.

3) Basic port facilities should be financed by the governments concerned.

4) Port facilities used mainly by specified private users should be constructed by the private sector.

## 6.5 SHIP SIZE OF OCEAN-GOING VESSELS

The ship size of ocean-going vessels calling at Bangkok Port is shown in Table 6.5. According to this table, it can be safely said that it is likely that ocean-going vessels up to 15,000 DWT will call at Khanom Deep Seaport. Therefore, port facilities should be designed for ships of the 15,000 DWT class.

Table 6.5 SHIP SIZE OF FEEDER AND COMBO SHIPS CALLING AT BANGKOK PORT

| Ship Size (DWT) | Standard Berth Depth (m) | No. of Vessels | DWT | |
|---|---|---|---|---|
| | | | Amount | Mean |
| - 5,000 | 7.5 | 6 | 19,092 | 3,182 |
| 5,001 - 10,000 | 9.0 | 59 | 441,212 | 7,478 |
| 10,000 - 15,000 | 10.0 | 43 | 526,613 | 12,247 |
| 15,001(-28,864) | 10.0 (-12.0) | 21 | 451,817 | 21,515 |
| Total | - | 129 | 1,438,734 | 11,153 |

Source: Container Handling at Bangkok Port, United Nations, May 1984

Notes: Based on the data of a period Oct. 1982-Feb. 1983

: Excluding vessels the size of which are not available

## 6.6 FIELD SURVEYS

### 6.6.1 Relationship between the Port and Natural Conditions

1) Soil

Soil conditions should be considered in port planning. They affect greatly not only port facilities' structure but also construction costs.

2) Waves

Such wave conditions as wave height and direction should be considered in selecting port location and determining port layout. Especially, workability of a port and necessity of a breakwater are greatly influenced by wave conditions. They also affect not only the structure of breakwaters but also construction costs of breakwaters.

3) Siltation/Sand drift

When a large volume of siltation happens, maintenance dredging is unavoidable in water channels.
According to the AIT Report "NAVIGATION CHANNEL IMPROVEMENT FOR THE DEVELOPMENT OF BANDON HARBOUR" by Dr. Suphat Vongvissessomjai et al., the existing navigation channel is subjected to a deposit rate of about 10 centimeters per year.
Therefore, a siltation survey is necessary even though the proposed port location is outside of Bandon Bay.

4) Tide

Tidal level affects structure, especially crown heights of port facilities.

5) Tidal current

Tidal current affects maneuverability of vessels and port construction work.
It indirectly influences siltation and scouring.

6) Wind

Such wind conditions as wind velocity and direction affect port workability, maneuverability and construction work.

7) Topography and Hydrography

They should be considered in selecting port location and port planning.
They also affect the structure of port and land facilities and their construction cost.

6.6.2 Availability of Necessary Data

Wave observation was conducted not at the proposed site but at three points in the central part of the Bay of Thailand for off-shore petroleum facilities by A.H. GLENN and ASSOCIATES. The observed data are relevant to some extent but cannot be used as foundation data for port planning and construction.

6.6.3 Necessity of Field Surveys

A port project should be studied based on through and satisfactory data obtained at the proposed site.
However, such data are not available so far. Therefore, field surveys of natural conditions should be conducted at the proposed port site.

6.7 CONSIDERATIONS FOR NECESSITY OF A BREAKWATER

(1) Generally speaking, the necessity of breakwaters is studied based mainly on wave conditions and required rate of utilization of the port.

(2) As to wave conditions, wave data observed at the proposed construction site are used for analysis.

(3) Generally, sea conditions at Khanom are relatively calm since Khanom is sheltered by the Indo-Chinese Peninsula from waves generated in the South-China Sea and waves generated by monsoons from the south and west do not influence Khanom, which faces the bay to the east.

(4) According to wave analysis observed in the deepwater (-35m)of the Gulf of Thailand, the occurrence rate of observed waves lower than 1.8 m in significant wave height is 85.6% (see Fig. 6.3 and Table 6.6).
It leads that the workability of Khanom Deep Seaport will be expected to be around 80 or 85% even without the breakwater considering the wind histograms shown in Fig. 6.4.

(5) This means that a breakwater will not be necessary until the number of ship calls per year exceeds the number of vessels which can be accommodated at the port in a year considering its workability (80 - 85%), which is determined by the occurrence rate of waves less than 1.5 - 1.8 M in significant wave height. In other words, breakwaters will not be necessary until a significant number of ships begin queuing.

(6) However, the necessity of a breakwater should be studied firmly based on analysis of observed wave data after completion of wave observations at the proposed site as part of the forthcoming feasibility study.

(7) When fully developed after the year 2000, a breakwater as shown in Fig. 6.3 will be constructed according to the proposed port plan. The length of the breakwater is about 1,250 m. It will cost 250 million baht.

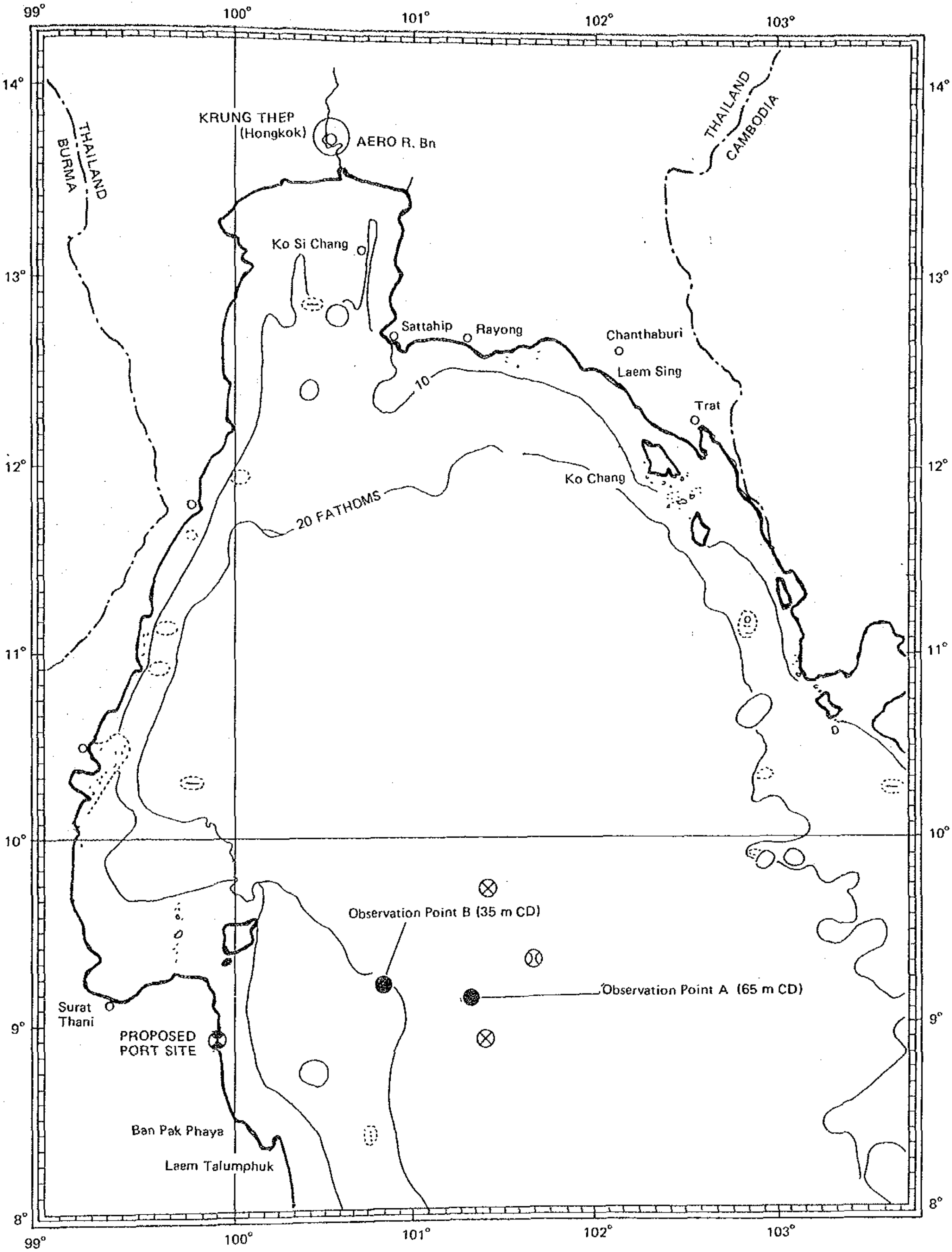


Fig. 6.3 Location of Wave Observation

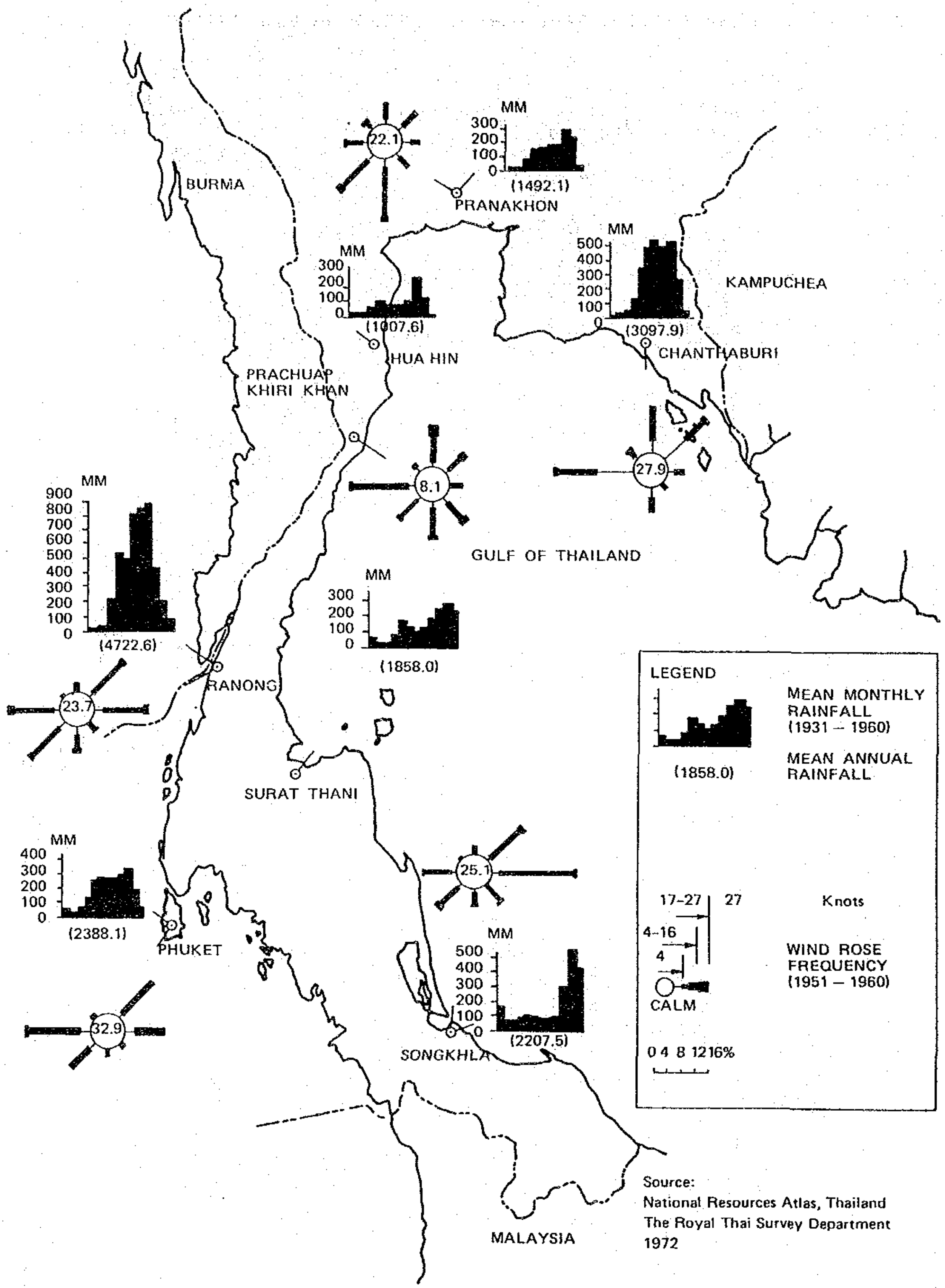


Fig. 6.4 Climate Map

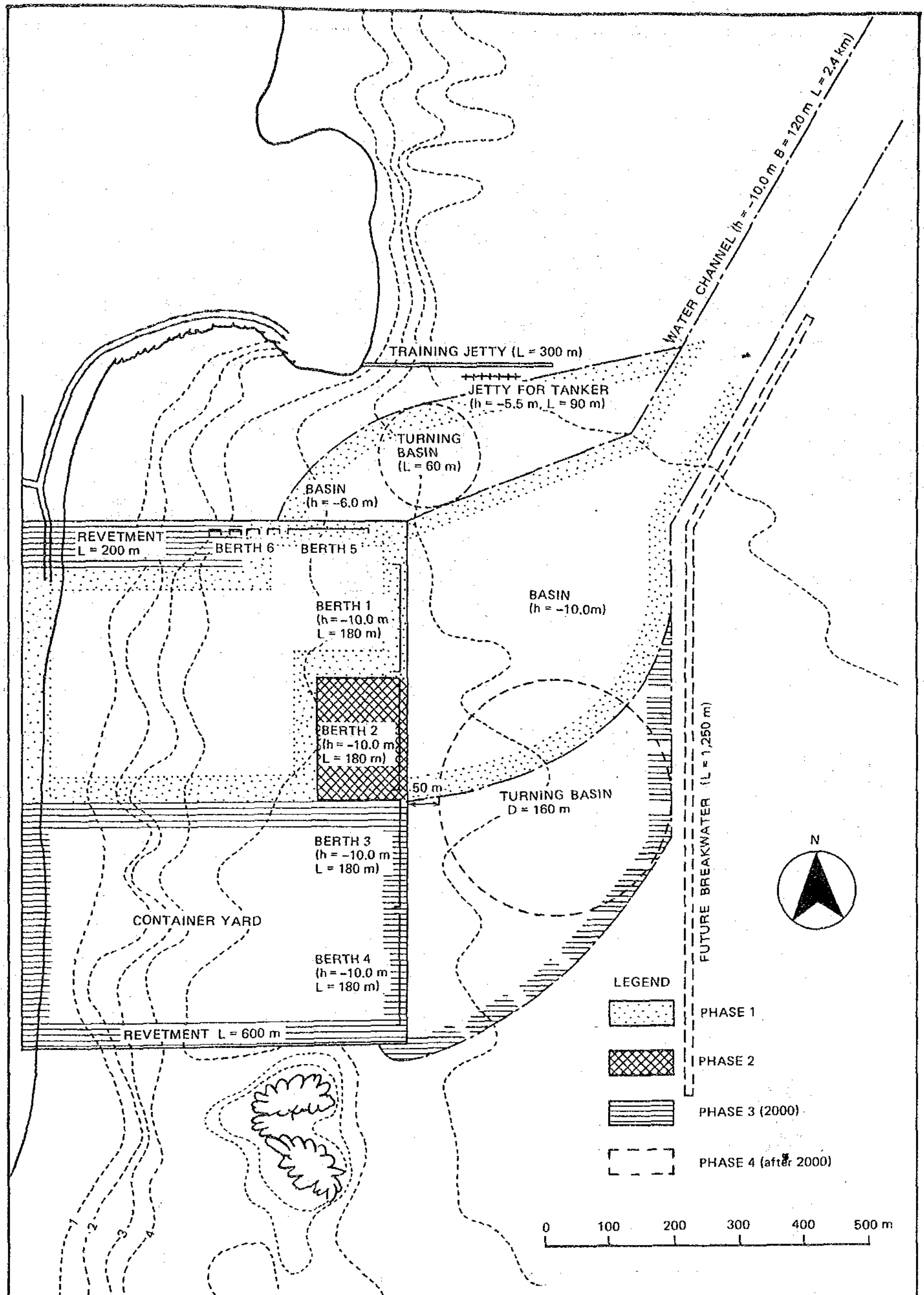


Fig 6.5 Layout of a Breakwater

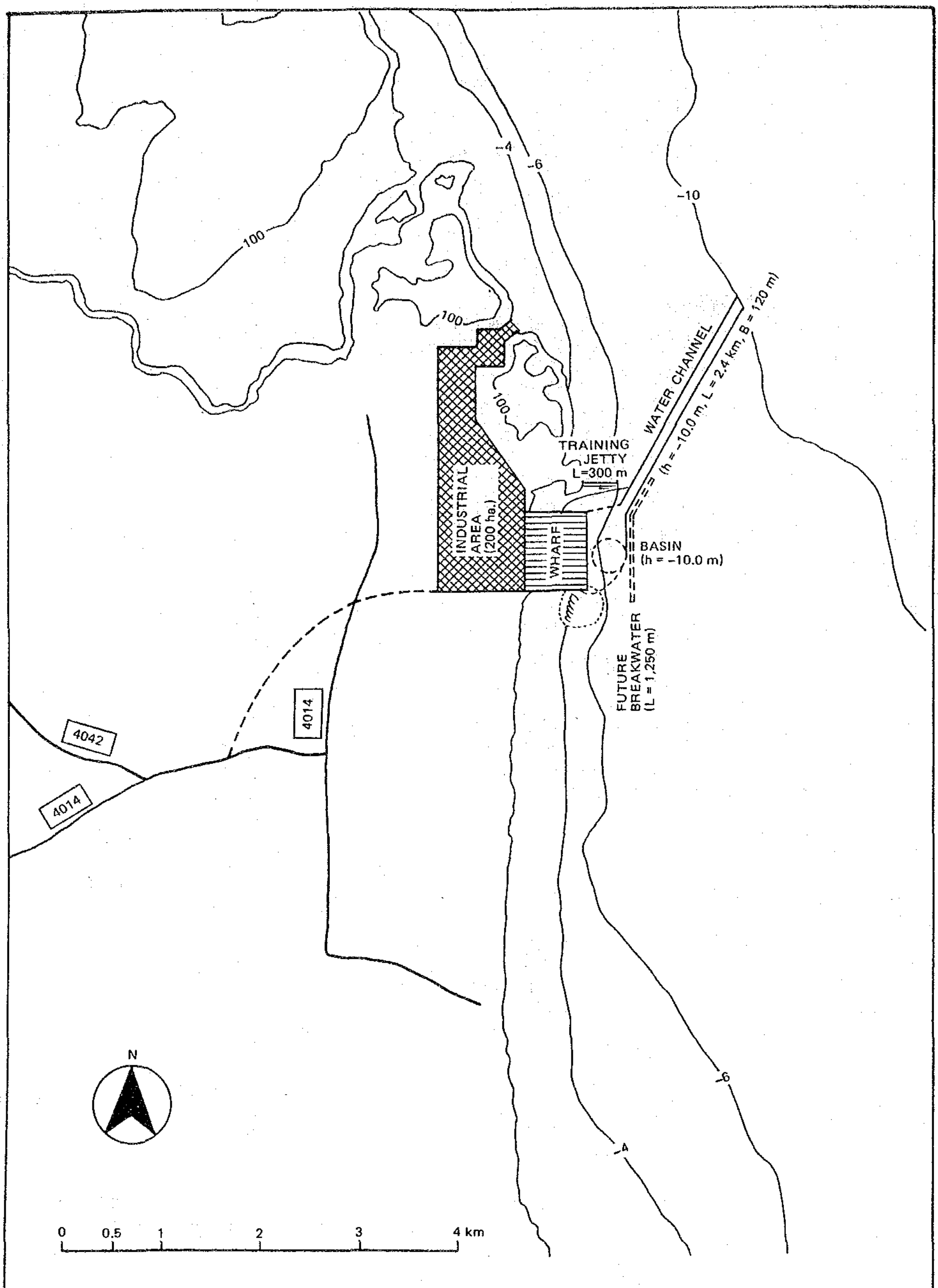


Fig. 6.6 **Port Layout**

Table 6.6 OCCURRENCE RATE OF WAVES

Observation point A (65 m CD)

| Significant Wave Height (m) | 0 - 0.5 | 0.6 - 1.2 | 1.3 - 1.8 | 1.9 - 2.4 | 2.5 - 3.0 | 3.1 - |
|---|---|---|---|---|---|---|
| Percentage | 24.8 | 34.2 | 22.5 | 11.7 | 4.7 | 2.1 |

Observation point A (35 m CD)

| Significant Wave Height (m) | 0 - 0.5 | 0.6 - 1.2 | 1.3 - 1.8 | 1.9 - 2.4 | 2.5 - 3.0 | 3.1 - |
|---|---|---|---|---|---|---|
| Percentage | 30.0 | 34.9 | 20.7 | 9.8 | 3.4 | 1.2 |

## 6.8 FURTHER UTILIZATION OF PHUKET PORT

(1) Additional port functions for foreign trade will grow both at Phuket and at Surat Thani.

(2) Domestic trade functions will also be indispensable at these ports. Domestic trade will also increase with development of foreign trade functions at these ports.

(3) International trade will take place at Khanom and Phuket Deep Seaports. Domestic trade will take place at existing Tha Thong and Phuket Ports.

(4) Therefore, the existing Phuket Port will be utilized more as a coastal ports in connection with Phuket Deep Seaport with the implementation of the regional development program.

7. PHUKET-KRABI FERRY LINK

Despite that Phuket is expected to be a growth center on the Andaman Sea coast, its sphere of influence is inclined northward due to its locational constraint. In order to extend its sphere of influence to Krabi and Trang direction, ferry connection between Phuket and Krabi is considered effective. This connection will form a Phangnga Bay Link, which is expected to promote the tourism development in the area.

Transportation demand for this link was again estimated based on the cargo and person OD tables in 2000. The possible OD pairs are Phuket - Krabi, Phuket - Songkhla and Phuket - Other Lower South. Cement transportation from Thung Song, however, was excluded from this estimation, considering that the proposed extension of railway from Khiri Ratthanikhom to Phuket would accommodate this bulk cargo. The daily number of vehicles for cargo and passenger transportation was estimated to be 570 vehicles for the former and 360 vehicles for the latter.

8. PHUKET INTERNATIONAL AIRPORT

International scheduled flight was introduced to Bangkok - Phuket - Singapore route in December 1983. The flight is operated on every Sunday and Tuesday for both directions. The load factor has accounted for as much as 90 percent for these three months, though it is not certain whether the high load factor can be attributable to this new opening or seasonal increase of tourists.

The improvement program of this port is scheduled under the Fifth Five Year Plan with a budget of 58 million baht. This program includes the extension and strengthening of runway (3,000 meter, B-747 acceptable), the expansion of terminal building and the improvement of apron.

The annual transportation demand for Phuket International Airport in 2000 was estimated to be 830 thousand passengers as a total of departure and arrival. The annual growth rate was calculated at 8.8 percent from 1982. The number of flight per day is roughly estimated to be 32 flights for B-747, 20 flights for B-727 or seven flights for B-737 on the assumptions of a load factor of 70 percent and a peak day ratio to a year of 1/330. The result of this estimation is slightly higher than the future framework established by Airport Development Master Plan by 55.5 thousand passengers per year. It is considered that a few years accelerated implementation of the master plan can accommodate the estimated traffic increase.

However, it is expected that cargo transportation of Phuket International Airport will substantially increase due to the industrial development in the area adjacent to the airport. High tech and high value added products are planned to be manufactured in the area and dispatched to international market by air.
Air cargo handling volume related to Phuket Airport Industrial Estate is roughly estimated at 2,000 - 2,500 thousand tons in 2000 as a total of loading and unloading, though it was about 220 tons in 1982.

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