11.2.5 Tunnel

(1) Kok-Ing Tunnel

(a) Classifications of the Grade of Grand for Kok-Ing No.1 Tunnel

Kok-Ing No.1 tunnel is planned to cross under the low mountainous area between Kok river basin and Tak river basin. The overburden of the tunnel is rather shallow to be average about 50 m and consists of slightly weathered rhyolite and tuff about 1 km length, of highly weathered and moderately-intensely fractured shale, sandstone and tuff alteration about 2 km length of this tunnel. Most high two peaks of mountain are formed look like of a camel's hump with overburden about 185 and 160 m and the geological condition is said slightly weathered rhyolite and tuff.

Shallow overburdens at about 500 m from two tunnel portals, inlet and outlet, consist of loose sediment and intensely fractured materials. It is expected three (3) faults crossing the tunnel alignment. The fault exists at middle of tunnel alignment might be rather big and the tuff materials in the fault are intensely fractured. Water discharge to the tunnel would be also expected in this fault.

The tunnel excavation by forepiling method is necessary at alluvium loose sand and clay at both portal area and the above mentioned crossing with fault portions, and finally more than 50 % of tunnel length is planned to be E type on grade of ground taking shallow overburden, weathered sedimentary rocks and rather big faults into considerations.

The final assumption of classifications for grade of ground on Kok-Ing No.1 tunnel is as following table and in the Database Maps.

Table 11.2.5.(3)-9 Assumption of Grade of Ground for Kok-Ing No.1 Tunnel

Grade of Ground	Length (m)	Ratio (%)
B	0.00	0.00
C1	50.00	1.64
C2	440.00	14.44
D1	460.00	15.10
D2	560.00	18.38
E1	530.00	17.39
E2	1,006.99	33.05
Total	3,046.99	100.00

(b) Classifications of the Grade of Grand for Kok-Ing No.2 Tunnel

Kok-Ing No.2 tunnel is planned to connect the diversion canal at Tak river and Ing river basin crossing crossing a slightly higher mountaina area. The tunnel will pass about 150 m under the surface of mountain which mainly consists of shale interbedded with thin sandstone layer. There exists a limestone zone of approximate 200 m width and a basalt intrusion is expected at around 3,600 m from the inlet portal. It is expected water discharge from these cracky limestone zone and

fractured basaltic intrusion. The shall overburden of the tunnel extending about 800 m. far from the inlet consists of weathered shale and sandstone and is soft. The shallow overburden extending about 800 m. from the outlet consists of highly weathered and cracky black shale and also very soft.

More than ten (10) numbers of faults cross the tunnel alignment and some of these faults are rather thick.

The tunnel excavation by forepiling method will be needed at above mentioned shallow overburden portions and crossing with fault portions, and finally more than 50 % of tunnel length is planned to be E type on grade of ground taking shallow overburden with long distances at both side of inlet and outlet, weathered sedimentary rocks and rather big faults into considerations.

The final assumption of classifications for grade of ground on Kok-Ing No.2 tunnel is as following table and in the Data Base Map.

Table 11.2.5.(3)-10 Assumption of Grade of Ground for Kok-Ing No.2 Tunnel

Grade of Ground	Length (m)	Ratio (%)
B	0.00	0.00
C1	480.00	8.86
C2	790.00	14.59
D1	620.00	11.45
D2	660.00	12.19
E1	750.00	13.85
E2	2,115.02	39.06
Total	5,415.02	100.00

(2) **Ing-Yot No.1 Tunnel**

(a) Entrance of Tunnel

Finally, the location of inlet and outlet for No.1 tunnel are determined at the skirts of mountain with slightly sharp slope covered with a bamboo and bush thicket, as follows.

No.1 Tunnel

Inlet :

Coordinates	2,174,143.057-N, 626,502.420-E
Station No.	KM. 2+560.00
Grand elevation	GL.376.8 m.
Land use coditions	banboo and bush thicket
Slope gradient	gentl slope
Overburden	14 m.
Geological condition	Lapilly tuff to tuff breccia
Distance from village	0.6 km. from Ban Thung Khan Chai
Distance from Wat	0.3 km. from Wat Thung Khan Chai

Outlet :

Coordinates	2,174,296.886-N, 628,357.781-E
Station No.	KM. 4+560.000
Grand elevation	GL.394.4 m.
Land use coditions	broad-leaved trees and banboo thicket
Slope gradient	slightly sharp slope
Overburden	12 m.
Geological condition	lapilly tuff to tuff breccia
Distance from village	3 km. from Ban Pa Chi
Distance from river	0.5 km. from Lao river

(b) Final Alignment of Tunnel

Final alignment shall be considered the topographic feature and geological conditions, moreover, to avoid the shallow overburden at the crossing with gradient slope, and finally decided as follows.

No.1 Tunnel

Inlet :

Coordinates	2,174,143.057-N, 626,502.420-E
Station No.	KM. 2+560.00
Invert elevation	EL.353.37 m.

Turning Point (T.P.) :

Coordinates	2,174,384.992-N, 626,024.666-E
Distance from Inlet	679.032 m.

Outlet :

Coordinates	2,174,296.886-N, 628,357.781-E
Station No.	KM. 4+560.000
Invert elevation	EL.352.58 m.
Distance from T.P.	1,338.181 m.

Total Length of No.1 tunnel : 2,008.21 m. with one (1) turning point

(c) Classifications of the Grade of Grand for Ing-Yot No.1 Tunnel

Ing-Yot No.1 tunnel is planned to cross under the low mountainous area between Ing river and Lao river. The most high overburden of this tunnel is about 125 m and consists of moderately to highly weathered sandstone for along the alignment.

Shallow overburdens at both site from tunnel portals, inlet and outlet, consist of loose sediment and intensely fractured materials. The tunnel excavation by forepiling method is necessary at both portal area. It is expected one (1) fault crossing at middle of the tunnel alignment which might be slightly small scale and the sandstone materials in the fault are intensely fractured. Water discharge to the tunnel would be not so anxious about in this fault.

B and C1 type of grade of ground wouldn't be applied for this Ing-Yot No.1 tunnel, because of these type to be applied rather favorable geological conditions are excavated by the top heading and short bench and reinforced with only rock bolt but without steel support.

And finally 95 % of tunnel length is planned to be D and E type on grade of ground taking shallow overburden, weathered sedimentary rocks and fault into considerations.

The final presumption of classifications for grade of ground on Ing-Yot No.1 tunnel is as following table and in the Data Base Map.

Table 11.2.5.(3)-11 Presumption of Grade of Ground for Ing-Yot No.1 Tunnel

Grade of Ground	Length (m)	Ratio (%)
B	0.00	0.00
C1	0.00	0.00
C2	100.00	5.00
D1	400.00	19.92
D2	850.00	42.32
E1	350.00	17.42
E2	308.21	15.34
Total	2,008.21	100.00

(3) Ing-Yot No.2 Tunnel

(a) Entrance of Tunnel

The location of the inlet for the Ing-Yot No.2 tunnel is selected at the same place of the stage of Phase 1, namely, at gently slope hills covered with bamboo thicket about 200 m from the nearest village named "Ban Don Chai".

The tunnel outlet has been shifted by about 1 km to the north of the Phase 1 location, taking into account social and environmental impact on "Ban Phalak" which is located near the original tunnel alignment and the need to relocate the provincial road.

Finally, the location of outlet for No.2 tunnel was determined at the gentle hills covered with bamboo and bush thicket, and final location of the inlet and outlet are shown as follows.

- Inlet :

Coordinates	2,174,211.071-N, 635,713.745-E
Station No.	KM. 13+836.952
Ground elevation	GL.365 m
Land use conditions	banboo and bush thicket
Slope gradient	very gentle slope
Overburden	20 m
Geological conditions	weathered shale, sandstone and tuff alternation
Distance from village	200 m. from Ban Don Chai

- Outlet :

Coordinates	2,144,860.00-N, 669,170.00-E
Station No.	KM. 64+711.952
Ground elevation	GL.335 m.
Land use conditions	bush thicket
Slope gradient	very gentle slope
Overburden	10 m.
Geological conditions	highly weathered sandy tuff, tuffaceous shale alternation
Distance from village	1.7 km. from Ban Phalak

(b) Final Alignment of Tunnel

Ing-Yot No.2 tunnel is an ultra long tunnel of 50,895 m drawing an arc through the northern mountains area of Lao river plain at Amphoe Chiang Kham and crossing the high mountains area between Lao river basin and Yot river basin, a tributary of Yao river.

Final selection of tunnel alignment was also a very important factor. As studied in section 11.1.4 Alternative Water Diversion Plan, and 11.2.5 Preliminary Design of Tunnel, the final route for the diversion tunnel was selected section by section with careful consideration on total comparative study such as various conditions inclusive of the topographic feature of wide range of areas

surrounding the planned route, geological conditions, environment, village location and road condition of the access road for construction as follows.

From Inlet to First Turning Point (TP.1)

As studied in section 11.1.5 (7) (b) Selection of Ing-Yot No.2 Tunnel Route, two (2) inlets were selected for the alignments, namely, A and B tunnel route. Finally, B tunnel route was selected as the most suitable one. As mentioned above, the alternative route, A tunnel route was cross the large alluvial plain in the Ing-Lao basin, passing through many farm lands along the tributaries of the Ing-Lao.

The most important thing in selecting the tunnel route are overburden and geological conditions. If the tunnel route was selected in this alluvial plain, the tunnel will pass through selecting area with shallow overburden of about 50 m and below and consisting of completely weathered rock formation with many crushed fault zones along the tributaries of the Lao river.

After selecting B tunnel route, the alignment to the inlet was selected to north-east of about 3 km consisting of sandstone, shale, tuff, lapilly tuff, where the formative period of the geological age is middle-upper Triassic, to metasandstone interbedded with shale in Permian-Carboniferous. Before changing from location in the middle-upper Triassic to Permian-Carboniferous formation, the route was almost in the east direction. The coordinates of the TP.1 is 2,175,675.00-N and 638,000.00-E, and distance from inlet to TP.1 is 2,718.52 m.

From TP.1 to TP.2

The tunnel alignment after TP.1 is runs eastwards for about 4 km composing of metasandstone interbedded with shale in Permian Carboniferous with the overburden depth of about 100 m to 200 m or more. Finally, TP.2 is selected at the coordinates 2,176,000.00-N and 642,000.00-E, and the distance between TP.1 and TP.2 is 4,013.18 m.

From TP.2 to TP.3

The direction of the tunnel alignment after TP.2 was selected in the east-north-east direction about 6.3 km, drawn along the arc through the northern mountains area of Ing-Lao river plain just like the wrapping at Amphoe Chiang Kham consisting of slate, quartzite interbedded with sandstone foliated and metasandstone interbedded with shale in Permian Carboniferous. Finally, TP.3 was selected at the coordinates 2,174,000.00-N and 648,000.00-E, and the distance between TP.2 and TP.3 is 6,324.56 m.

From TP.3 to TP.4

The direction of the tunnel alignment after TP.3 was selected in south-east-south for about 5.4 km along the national borderline between Thailand and Laos of about 2 km from borderline. The route is consisted of slate, quartzite interbedded with sandstone foliated in Permian Carboniferous. Finally, TP.4 was selected at the coordinates 2,169,000.00-N and 650,000.00-E, and the distance between TP.3 and TP.4 is 5,385.16 m.

From TP.4 to TP.5

The direction of the tunnel alignment after TP.4 was selected to the Grid-south just 6 km along drawing an arc through the northern mountains area of Ing-Lao river plain just like the wrapping at Amphoe Chiang Kham a consisting of slate, quartzite interbedded with sandstone foliated in Permian Carboniferous. Finally, TP.5 was selected at the coordinates 2,163,000.00-N and 650,000.00-E, and the distance between TP.4 and TP.5 is just 6 km.

From TP.5 to TP.6

The direction of the tunnel alignment after TP.5 was selected at 45 degrees from Grid-north to south-east through the northern high mountains area about 21.2 km consisting of igneous rocks such as andesite, rhyolite, dacite, tuff agglomerate in Triassic-Permian, and lime stone, sandstone, tuff interbedded with shale in middle-upper Triassic. Finally, TP.6 was selected at the coordinates 2,148,000.00-N and 665,000.00-E, and the distance between TP.5 and TP.6 is 21,213.20 m.

From TP.6 to Outlet

The direction of the tunnel alignment after TP.6 was selected in the south-east direction and connected with the outlet site as mentioned above under passing the small hill of limestone about 5.2 km consisting of sandstone, tuff interbedded with shale in middle-upper Triassic. Finally, distance between TP.6 and outlet is calculated 5,220.00 m and total length of Ing-Yot No.2 tunnel is reaches 50,875 m.

(c) Necessity of Inclined Shaft

Ing-Yot No.2 tunnel is an ultra long tunnel of 50,895 m in length. Accordingly, it takes about thirty (30) years to construct if excavation is done from both sides of the tunnel, :e, the inlet and outlet. The Ing-Yot No.2 tunnel, hence, requires an optimum number of supplementary construction tunnel intending to minimize total construction period and cost. There are three (3) kinds of supplementary construction tunnel for the purpose, horizontal adit, inclined shaft and vertical shaft.

These supplementary construction tunnel are selected by topographical conditions and elevation difference between designed main tunnel and portal elevation of supplementary construction tunnel. Horizontal adit is adopted if they are at almost the same elevation. Vertical shaft is adopted if the difference between bottom elevation of main tunnel and ground surface is less then 100 m.

The inclined shaft is adopted when neither of the horizontal or vertical shaft can be adopted. Topographical conditions and elevation difference between the designed main tunnel and portal elevation at proposed site is more than 100 m and the conditions of access road to the proposed portal site is fairly easy in the Ing-Yot No.2 tunnel. The inclined shaft is called the "adit" in this report.

(d) Selection of Numbers of Adit

The adit itself is used as the supplementary construction tunnel for the construction work of the main tunnel. The construction cost of the adit should be minimized. Total numbers of adit should also be minimum. The tunnel construction period for excavation work is planned for six (6) years. Hence, seven (7) adits are selected in total, after carefully trial study of each construction period calculated on the cycle time for the presumed grade of ground.

(e) Selection of Portal Site and Alignment of Adit

The site selection of portals is also a very important factor. Functionally, the portal is regarded as a sort of retaining wall to protect the adit. The commonly-employed method in building portals avoids making cuts near the entrance as much as possible, in order to limit the loosening of ground to a minimum. In some cases, entrances have to be built in unfavorable positions with possible threat of landslide or slope failure, or are under uneven earth pressure or poor ground bearing capacity. Dealing with these construction problems is another important points to be further studied.

The location of the each portal for the adits were decided with careful consideration on various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route and site, geological conditions, environment, existing land use conditions of the surrounding for site proposed, village location and road condition to be used for access road during construction. In addition, the selected portal shall be used not only during construction, but also for operation and maintenance period in the feature.

The final routes for the adits were selected site by site with careful consideration to total comparative study such as various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route, geological conditions and environment.

The portal site of each adit and route from portal to main tunnel were careful studied as follows.

No.1 Adit

The crossing point between main tunnel and the No.1 adit tunnel was decided about 6 to 8 km from inlet of No.2 tunnel by the trial calculation of construction periods for division No.1, consisting upstream side from the inlet to the crossing point of No.1 adit and the downstream side from same point to division No.2 adit.

Portal site of adit No.1 were nominated at two (2) places, one is located at 1 km north of "Ban Pha Lat Luang" and other is located at 1 km north of "Ban Thung Tiu". In case of former, the access road has to pass the existing village road, but there is no objection the connecting road from village to adit to renew about one (1) km. of length. Various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route and site of adit, geological conditions, environment and existing land use conditions of the surrounding for site proposed are suitable than the latter.

Because, in case of latter, the access road from "Ban Thung Tiu" to adit site shall be used the

existing paved road, catchment area of rain fed is very wide range and geological condition is very bad due to the big landslide or slope failure is already appeared at the slope of cutting face of road. Finally, the location of portal for No.1 adit is selected at the said former site.

No.2 Adit

The crossing point between main tunnel and the No.2 adit tunnel has fixed at about 11 to 13 km from inlet of No.2 tunnel by trial calculation of construction periods for division No.2, consisting of the upstream side from division No.1 to the crossing point of No.2 adit, and the downstream side from same point to division No.3.

Portal site of adit No.2 was nominated at two (2) places, one is located at 1 km east of "Ban Phu Sang" and other side is located at 3 km east of "Ban Phu Sang". In case of former, the access road can use the existing village road and farm road. There is no existing road from the nearest village to the adit in case of latter. It is necessary to construct the access road for about 3 km. In addition, there are many tributaries in the nominated adit site. The runoff of there tributaries could be problem in rainy seasons. Various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route and site of adit, geological conditions, environment and existing land use conditions of the surrounding for site proposed are suitable than the latter.

From the result of TDEM analysis, the proposed alignment of adit No.2, around crossing point area is geologically not so suitable as the crossing point with the main tunnel. It'll be shifted eastward for about 1 km from the proposed site and alignment in the next detailed design stage.

No.3 Adit

The crossing point between main tunnel and the No.3 adit tunnel is at around 18 to 20 km from the inlet of No.2 tunnel by trial calculation of construction periods for division No.3, consisting of the upstream side from division No.3 to the crossing point of No.3 adit, and the downstream side from same point to division No.4 adit.

Portal site of adit No.3 was also nominated at two (2) places, one is located at 0.6 km east of "Ban Hua Na" and other is located at 0.2 km east of "Ban Sa Mai" near the irrigation reservoir. In case of former, the access road can use the existing village road, and there is no objection at all from village to adit and muck disposal area. Various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route and site of adit, geological conditions, environment and existing land use conditions of the surrounding for site proposed are suitable than the latter.

Because, in case of latter, the access road from "Ban Sa Mai" to adit site shall be used the existing road, but it is very closely with the existing reservoir, supplemental works such grouting method to avoid the leakage water from reservoir into adit. Finally, the location of portal for No.3 adit was selected at the former site.

No.4 Adit

The crossing point between main tunnel and the No.4 adit tunnel is at around 25 to 27 km from the inlet of No.2 tunnel by trial calculation of construction periods for division No.4, consisting

of the upstream side from division No.3 to the crossing point of No.4 adit and the downstream side from same point to division No.5 adit.

Portal site of adit No.4 was nominated at two (2) places, one is located at 1.3 km. north-east from the route 1160 going to "Ban Pang Pop" and other side is located at four (4) km east of "Ban Pracha Phakdi". In case of former, the access road has to pass the existing village road of steep, but it is needed to renew from junction point of route 1160 to adit about 1.3 km and 2 km more from adit to muck disposal area. Various conditions inclusive of the topographic feature of wide range of areas surrounding the planned route and site of adit, geological conditions, environment and existing land use conditions of the surrounding for site proposed are suitable than the latter.

Because, in case of latter, the access road from "Ban Pracha Phakdi" to adit site shall be used the existing paved road about 2.5 km in 4 km, 1.5 km shall be newly constructed for access road, and catchment area is very large and it is rather suitable location at the site for dam construction. Finally, the location of portal for No.4 adit was selected at the former site in land cultivated to cotton.

e) No.5 Adit

The crossing point between main tunnel and the No.5 adit tunnel is around 30 to 32 km from the inlet of No.2 tunnel by trial calculation of construction periods for division No.5, consisting of the upstream side division No.4 to the crossing point of No.5 adit and the downstream side from same point to division No.6 adit.

The portal site of adit No.5 was nominated at only one (1) place, because there is high limestone mountain named "Doi Pha Kham" that it is not suitable to construct the adit. The adit site itself is selected about 1 km south-east of "Ban Pang Tham".

According to the results of TDEM prospecting reveal the existence of fractured zone on a large scale caused by faulting around intersection point to tunnel line on the basis of reversal transient phenomena. Therefore, attention must be paid to the presence of this fault during tunnel construction.

No.6 Adit

The crossing point between main tunnel and the No.6 adit tunnel is around 38 to 40 km from the inlet of No.2 tunnel by trial calculation of construction periods for division No.6, consisting of the upstream side from division No.5 to the crossing point of No.6 adit, and the downstream side from same point to division No.7 adit.

The portal site of adit No.6 is nominated at only one (1) place, because there is no access road at all around the areas. The adit alignment is situated under a steep mountain, which is land used for cultivation, such as corn and cotton.

Finally, the access road was selected about 3 km from No.5 adit along with the Yuan river and the adit portal site was selected at left side bank of the river.

No.7 Adit

The crossing point between main tunnel and the No.7 adit tunnel is around 43 to 45 km from the inlet of No.2 tunnel by the trial calculation of construction periods for division No.7, consisting of the upstream side from division to the crossing point of No.7 adit and the downstream side from same point to the outlet of No.2 tunnel.

The portal site of adit No.7 was nominated at only one (1) place, because there is high steep mountain area, and no access road at all around these areas except only one road with 1.5 km from the village "Ban Yot". The adit alignment is situated under a steep mountain, and the area near the portal of adit is not land used for cultivation.

Hence, finally seven (7) inclined adits will be constructed to avail access to the construction of the main tunnel. The adit locations were selected outside of 1A areas as shown in the Data Base Map and the outline of the adits is as follows ;

Table 11.2.5.(3)-13 The Outline of the Adit

Adit No.	Distance Remark (m)	Invert Elevation at Crossing Point (m)	Portal Elevation of Adit (m)	Difference Height (m)	Length of Adit (m)	Gradient of Adit (%)
(Inlet)	0	(348.2)				
1	5,727	345.9	457.5	111.6	1,982	5.6
2	10,919	343.8	460.0	116.2	1,785	6.5
3	18,442	340.8	506.0	165.2	2,194	7.6
4	25,510	338.0	510.0	172.0	3,171	5.4
5	31,958	335.4	508.0	172.6	2,476	7.0
6	38,156	332.9	570.0	237.1	3,339	7.1
7	44,870	315.0	430.0	115.0	2,432	4.7
(Outlet)	50,875	(327.9)				
Total	50,875				17,379	

(f) Selection of Inner Shape and Size of Adit

The type of shape of adit inner cross section to be applied will be decided based on the judgement or evaluation for geology and construction machines passing through the adit, tunneling workability and cost of construction, and method of tunnel construction.

Generally two types of inner shape are adopted for adit, horseshoe and circular shape. The choice of horseshoe or circular shape is mainly dependent on one (1) factor, tunnel excavation to be done by conventional tunneling method or by tunnel boring machine method (TBM). The choice of standard horseshoe or widened horseshoe shape is mainly determined by the size of tunnel, and workability of construction.

The horseshoe shape of inner section is favorable in workability and maintenance of tunnel comparing with circular shape, when NATM is applicable method of tunneling and TBM is so far illuminated at this stage. The standard horseshoe shape of inner cross-section is adopted for the adit with the following reasons.

If the circular shape section is adopted for the adit, the arc at the tunnel invert shall be filled

up with concrete in order to provide a flat area in the invert to haul the tunnel excavation material and concrete material during construction and to provide transit for inspection car during operation and maintenance.

The standard horseshoe shape cross-section of the adit is formed as a 3-center circle, usually with an arched ceiling so that axial force can be delivered smoothly against earth pressure and other loads and bending moment produced can be held at a minimum level.

Further, the applied horseshoe shape cross-section has a wider invert width which can be used for easy and smooth transport in the tunnel not only during construction but also operation and maintenance.

Based on the above conclusions, the NATM with standard horseshoe shape closely with widened horseshoe shape are chosen as the standard adit type for Ing-Yot's seven (7) adits.

Radius of the upper half is selected as 3.75 m. for the purpose of easy, smooth and safe transportation in the adit and from the economical point of view.

(g) Classifications of the Grade of Ground for No.2 Tunnel

Ing-Yot Tunnel is a long tunnel of 50,875 m. of length drawing an arc through the northern mountains area of Ing-Lao river plain at Amphoe Chiang Kham and then crossing over the high mountains area between Lao river basin and Yot river basin. The tunnel is will be constructed in nine (9) divisions. Seven (7) divisions except for the inlet and the outlet division are planned to have adits. The grade of ground for No.2 tunnel is classified by the geological conditions along the tunnel alignment as follows.

Inlet to Sta.1+150

The geological condition of section from tunnel inlet to Sta.0+800 is composed of weathered shale and sandstone, which is soft and intensely fractured rock faces of the middle-upper Triassic age and is classified into D to CL class of rock mass classification. And, overburden condition is remarkably shallow, 30 to 105 m.

Furthermore, according to the refraction survey results (S2B0 line), around the tunnel inlet, analysis profile shows 3 layer structures with wide variety of Vp (P wave velocity) 2.0 to 4.0 km/s in maximum.

The tunnel excavation by forepiling method is necessary for shallow overburden about 570 m from the inlet, consist of loose and intensely fractured materials. Finally 100 % of tunnel length is planned to E class of grade of ground for this section.

The geological condition of section from Sta.0+800 to Sta.1+500 is underlain by medium hard to hard tuff and lapilly tuff of the Permian-Triassic age, which is accompanied by porphyry (granite porphyry) intrusion. In this case, according to the results of drilling, DHB-1SP, porphyry intrusion is 40 m or more in thickness. The rock faces of the section is hard and relatively massive and is classified into CM to CH class. Finally 100 % of tunnel length of this section is planned to E and D class of grade of ground.

Sta.1+150 to Sta.3+140

The geological condition of section from Sta.1+500 to Sta.3+140 is composed of shale, sandstone and tuff by the middle-upper Triassic age. It is inferred that rock faces along the tunnel invert level show CM to CH class excluding nearby presumed fracture zone.

The type C2 and C1 classes of grade of ground are adopted at CM to CH class about 1,360 m. of length from Sta.2+20 to Sta.2+490, and type D and E classes of grade are adopted from Sta.2+490 to Sta.3+140.

Sta.3+140 to Sta.3+250

As for this section, the existence of a large scale fault valley has clarified with aerial photographs and satellite images, and the results of drilling DHB-4 also revealed the existence of a fractured and altered rock features along the fault zone and the existing of limestone, simultaneously. Moreover, the results of seismic reflection prospecting (SB0-Main line) and TEM prospecting (electromagnetic prospecting survey, TMB3.1 line) also indicate the existence of clear structural feature and broad low resistivity zone, respectively. All point the fact that fractured zone caused by faulting exists in this area. These information conforms with the evidence obtained from other investigation.

In this case, special attention should be paid to the presence of the fractured rock and fault clay and removal of groundwater in this section.

The tunnel excavation by forepiling method is necessary for about 150 m, consisting of fractured and altered rock features along the fault zone and existing of limestone, simultaneously, and finally 100 % of the tunnel length is planned to E class of grade of ground for this section.

Sta.3+250 to Sta.6+950

Geological condition of this section consists of the Carboniferous-Permian age characterized by brown to dark gray metasandstone interbedded with slate. This section shows relatively thick overburden condition, 150 to 280 m in thickness. Rock conditions along the tunnel invert level indicate stable faces and are classified into to CM to CH class, excluding the area around the fractured zone caused by faulting.

The type C1 class of grade of ground is adopted at each CH class, and C2 class is applied at each CM class, and D to E1 classes are adopted for other rock class section.

Sta.6+950 to Sta.7+050

This section corresponds to a remarkable thrust fault along tectonic valley, which is clearly described in published geological map of "Amphoe Chiang Kham, 50,000 in scale" by DMR. According to the drilling data, DHB-8SP, shows intensely fractured and altered clayey rock feature (D to CL class) as a whole. Moreover, the results of seismic reflection prospecting (SB8-RFL1 line) and TEM prospecting (TMB 8.1 line) indicate the existence of clear structural feature and broad low resistivity zone, respectively, from which is inferred that a fractured zone caused by faulting exists in this area. In this case, special attention should be paid to the presence of the fractured rock and

fault clay and removal of groundwater on this section.

And finally 100 % of tunnel length is planned to E1 class of grade of ground for this section.

Sta.7+050 to Sta.10+000

Geological condition of the section consists of the Carboniferous-Permian age formation, which is characterized by foliated dark gray slate interbedded with sandstone. Overburden condition is 120 to 340 m thick and rock facies indicate medium hard to hard but somewhat breakable along bedding plain of slate. Rock mass along tunnel invert level is classified into CM to CH class, excluding the presumed fault zone.

The type C1 and C2 classes of grade of ground are adopted at CH to CM class, and D1 to D2 classes are adopted at other rock class section.

Sta.10+000 to Sta.11+200

This section is located in northern part of the heated groundwater area (Phu Sang spring area). Geological condition of the section consists of the Carboniferous-Permian age characterized by foliated dark gray slate interbedded with sandstone. According to the drilling data, DHB-5, the geological condition shows sandstone and slate facies and indicate CM to CH class of rock mass classification. Nevertheless the existence of CL class is found from 50 to 85 m in depth.

The type C1 and C2 class of grade of ground are adopted at CH to CM class as rock mass classification, and D1 to D2 classes are adopted at other rock mass class.

The hot spring water shows 27.5° C (river water shows 24.5° C) in temperature and 498 micro-s/cm in conductivity. The results of TEM prospecting reveals the existence of extremely low resistivity (5 to 10 ohm-m or less), from which is inferred that cracks of basement rock in this area may be partly filled with the heated water. In addition, the resistivity values also support the speculation that geological condition in this area is derived from marine sediments. Furthermore, their thermal origin is presumed to be related to the igneous rocks (granite or porphyry), which is continued to great depths, and some faults located around this section may be the passages of the heated groundwater.

Taking the whole geological information into consideration, it is inferred that tunnel alignment, which passes around DHB5 location, is situated on the outside of the zone strongly affected by heated groundwater because that is located outside of remarkably low resistivity area. However, as for adit No.2 alignment, adit construction must take the potential hazards into account because the location is presumed to be situated in area of remarkably low velocity. Furthermore, clear solution to these matter should be further studied in detail based on the additional investigation from the viewpoint of hydrogeological, for example drilling investigation, physical survey, including detailed groundwater quality tests etc. In addition, it is required to pay attention to the influence on the quality and quantity of hot spring water during tunnel construction stage.

The tunnel excavation by forepiling method is necessary in these areas, consist of fractured and altered rock features along the fault zone with heated water, and finally 100 % of tunnel length is planned to E class of grade of ground for these low resistivity area.

Sta.11+200 to Sta.25+900

This long section is underlain by the Carboniferous-Permian age, which is mainly composed of slate interbedded with sandstone and quartzite, and rock mass class along the tunnel invert level shows CM, CH and B class as a whole, excluding the fractured zone caused by faulting. And, overburden condition of this section reaches 200 to 700 m.

The type B class of grade of ground is applied to about 1,350 m of B class of rock mass classification, C1 and C2 classes of grade of ground are adopted for CH to CM class of rock mass classification, and D1 to D2 classes are adopted for other rock mass class section.

Three deep drilling (DHBJ-16.5, DHBJ-18 and DHBJ-22.5), by JICA were carried out to confirm/investigate a large scale fault zone suspected along river course.

However, rock features of drilling core indicate relatively good condition in spite of breakable along bedding plane of slate, excluding the existence of fractured zone on a small scale, and rock mass class of these three drilling are CM to CH class as a whole, excluding around fault zone. In this case, there is a possibility that the above fault is high angle dip, so that drilling results have overlooked the existence of the large scale fault. Furthermore, the results of seismic reflection prospecting reveal some existence of tectonic features in this area.

The type C1 and C2 classes of grade of ground are adopted for CH to CM class of rock mass classification, and D1 to D2 classes are adopted for other rock mass class.

In addition, according to the results of logging test, this formation (CPnb) indicates a range 4.0 to 4.9 km/sec (in average of CH and CM class) in seismic P-wave velocity measured by sonic logging and shows a range from 10 to 50 ohm-m (in average by DHBJ-16.5, DHBJ-18.0) and 40 to 240 ohm-m (in average by DHBJ-22.5) as resistivity (values by long normal) measured by electric logging.

Furthermore, DHBJ-18.0 and DHBJ-22.5 revealed the existence of confined aquifers between 185 and 195 m. and between 170 and 195 m in depth, respectively. In this case, particular attention should be paid to the occurrence of unexpected groundwater discharge during tunnel construction.

The type E1 class of grade of ground is adopted around the above mentioned fault zone and low resistivity area.

Sta.25+900 to Sta.28+550

Geological condition of this section is composed of Permian-Triassic age, which is made up of grayish green tuff interbedded with andesite, rhyolite and dacite, and overburden condition reaches 440 to 680 m.

According to the rock feature of deep drilling performed by JICA at DHBJ-26.0, rock mass along tunnel invert level shows hard and massive in spite of somewhat breakable along latent crack and totally indicates CH to B class. In this case, it is judged that rock condition of this formation corresponds to the most excellent one as for rock mechanical property on the basis of drilling core condition, the results of logging etc.

In addition, according to the results of logging test (DHBJ-26.0), this formation (PTRv) indicates a range from 5.2 to 5.9 km/sec (in average of B, CH and CM class) in seismic P-wave velocity measured by sonic logging and shows a range from 4,400 to 6,700 ohm-m (in average, maximum data shows 10,000 ohm-m or more).

Furthermore, DHBJ-26.0 revealed the existence of excellent confined aquifers at the deeper depth from 276 m, which was reported as 78 litters/minute in maximum outflow quantities at the top of casing. In this case, special attention should be paid to the occurrence of unexpected groundwater discharge during tunnel construction.

The type C2 class of grade of ground is adopted in spite of B to CM class for rock mass classification because of above mentioned reason, and D1 to D2 classes are adopted for other rock mass class section.

Sta.28+550 to Sta.30+100

At this section, tunnel line passes under high limestone mountains. This limestone is of TRpl formation in middle-upper Triasssic age and is inferred to have been elevated in fault contact with the CPnb formation in Carboniferous-Permian age.

Furthermore, this fault line is clearly described on the geological map "Chiang Kham (50,000 in scale)" by DMR. Rock mass class of limestone shows CH class as a whole except for area around the fault zone.

At the surface of this limestone mountain, many dolines are observed, and surface water flows into them and flows out from caves located near the Yuan river. Moreover, according to the results of TDEM survey, this limestone is widespread toward great depths and shows high resistivity (5,500 to 10,000 ohm-m or more) as a whole.

However, on this analyzed section of TDEM prospecting, low velocity zone (about 1,000 ohm-m) are found locally. In this case, there is a possibility that this low resistivity zone signify limestone cave with groundwater flow.

However, since the results of this TDEM prospecting, which has only one survey line in this limestone mountain area is insufficient to permit any definite conclusions on the mechanism of groundwater flow, it should be further studied in detail, using additional investigation results.

Moreover, during tunnel construction at this section, the most significant problem is the removal of groundwater deriving from limestone cave and special attention should be paid to this matter.

The type C2 class of grade of ground is adopted in spite of CH class of limestone as rock mass classification because of above mentioned reason, and D1, D2 and E1 classes are adopted for other rock mass class.

Sta.30+100 to Sta.38+000

This section is overlain by stable rocks belonging to the TRhf formation in middle-upper Triassic age, which consists of greenish gray sandstone and tuff interbedded with thin shale (slate).

Overburden condition of the section reaches 230 to 600 m thick. And, rock mass shows CH to B class, except for the fault zone.

At this section, three drillings, DHBJ-33.0, DH5AD1 and DH6AD1SP, and two lines of TDEM prospecting (TMB30 and TMB35 line) and seismic prospecting survey were carried out along/around tunnel line.

According to the results of logging test (DHBJ-33.0), this formation (TRhf) indicates a range of 5.1 to 5.3 km/sec (in average of CH and CM class) in seismic P-wave velocity measured by sonic logging and shows a range from 1,100 to 2,800 ohm-m (in average, maximum data shows 5,000 ohm-m or more).

At this section, the existence of fault zone is confirmed with the results of TEM prospecting and seismic reflection prospecting.

Especially, the results of TEM prospecting (TMB 30 line) reveals excellently the fractured zone or fault zone elongating in the southward of tunnel line on the basis of confirmed reversal transient phenomena. Moreover, the results of TEM survey clarified the existence of fault by confirmed structural discontinuities from Sta.35+600 to Sta.35+750 nearby the Yuan river.

The existence of this fault was also confirmed with aerial photograph. In this case, special attention should be paid to the presence of the fractured rock and fault clay and removal of groundwater in this fault zone area.

The type B class of grade of ground is applied to about 620 m in total of B class of rock mass classification, C1 and C2 classes of grade of ground are adopted of CH to CM class of rock mass classification, and D1 to E1 classes are adopted for other rock mass class.

Sta.38+000 to Sta.46+100

At this section, the tunnel passes under the highest mountain (about 1,600 m above M.S.L) in Ing-Yot No.2 tunnel. The geological condition along the tunnel invert level consists of the TRhf formation in middle-upper Triassic age, which continue on the former section.

Furthermore, the summit area of mountain range is covered by the Jurassic age formation, which consists of tuff, shale and sandstone. Overburden condition of the tunnel is thick and reaches 600 to 1,240 m in thick. Rock mass of section shows CH to B class as a whole, except for fault zone.

The type B class of grade of ground is applied to about 660 m of B class of rock mass classification, C1 and C2 classes of grade of ground are adopted for CH to CM class of rock mass classification, and D1 to E1 classes are adopted for other rock mass class.

Sta.46+100 to Sta.47+200

Tunnel line passes under a limestone mountain, which is in fault contact with alternation of sandstone, tuff and shale belonging to the TRhf formation in middle-upper Triassic age at Sta.46+100, on this section.

This limestone can be observed in the drilling DHB-7 and DHB46SP and is accompanied by

thin shale layer. In addition, the existence of limestone cave, which is filled with loose quaternary sediment, is found by drilling.

Overburden condition shows a range of 160 to 300 m. Rock mass class is CM to CH class as a whole, excluding the area around fault.

The above two drilling, TEM prospecting and seismic prospecting survey were performed at/around this site. Core condition by drilling is hard and massive fresh rock as a whole. And, resistivity measured by TEM prospecting shows a range from 1,000 to 10,000 ohm-m or more.

Moreover, during tunnel construction in this section, the most significant problem is the removal of groundwater from limestone cave as well as the section Sta.28+550 - Sta.30+100, and special attention should be paid to this matter.

The type C2 class of grade of ground is applied to CH class of rock mass classification, D1 and D2 classes of grade of ground are adopted for CM class as rock mass classification, and E1 and E2 classes are adopted for other rock mass class.

Sta.47+200 to Sta.49+900

This section is underlain by dark gray tuff, sandstone interbedded with shale, which belongs to the TRhf formation in middle-upper Triassic age. Fresh rocks are characterized by partly silicified and hard facies.

Overburden condition ranges from 85 to 410 m thick. And, rock mass class indicates CH to B class as a whole, except for the fault zone.

The type C1 and C2 class of grade of ground is applied to CH to B class of rock mass classification, D1 and D2 classes of grade of ground are adopted for CM class of rock mass classification, and E1 and E2 classes are adopted for other rock mass class.

Sta.49+900 to Sta.50+400

The tunnel line of this section passes through small limestone mountain, which is in fault contact with the TRhf formation. Overburden condition is 60 to 200 m thick. And, rock mass class indicates CM to CH class as a whole, except for the fault zone.

Furthermore, limestone cave is found in the limestone mountain. Therefore, special attention should be paid to the removal of groundwater during tunnel construction.

The type C2 class of grade of ground is applied to CM to CH class of rock mass classification, D1 and D2 classes of grade of ground are adopted for CM class of rock mass classification, and E1 and E2 classes are adopted for other rock mass class.

Sta.50+400 to Tunnel outlet

The geological condition of this section also consists of TRhf formation. However, overburden condition is shallow and rock mass shows highly weathered facies (D to CL class).

The type E1 and E2 classes of grade of ground are applied to this section, because of above mentioned reason.

The final presumption of classification of grade of ground in Ing-Yot No.2 tunnel is given in the following table and Database Maps.

Table 11.2.5.(3)-12 Presumption of Grade of Ground for Ing-Yot No.2 Tunnel

Grade of Ground	Length (m)	Ratio (%)
B	2,830.0	5.6
C1	10,540.0	20.7
C2	17,880.0	35.1
D1	9,110.0	17.9
D2	6,470.0	12.7
E1	2,430.0	4.8
E2	1,604.6	3.2
Total	50,874.6	100.00

Seven (7) inclined shaft are planned as the adits for the construction of Ing-Yot No.2 Tunnel and the grade of ground for each adit is classified by the geological conditions along each of the adit alignment as follows.

No.1 Adit

This adit was selected under the hilly area, and the geological condition is composed of metasandstone interbedded with calcareous shale (slate), which belong to CPhk formation. Drilling data, DH1Ad1, shows highly weathered condition up to about 50 m deep.

Rock mass along the adit is classified into D to CL class at the first half about 800 m, and CM to CH class at the last half, about 1,200 m.

No.2 Adit

The adit is located in a small scale mountain near Phu Sang spring area. The geological condition consists of metasandstone interbedded with calcareous shale (slate), which belong to CPhk formation. Drilling data, DH2AD1SP, shows the existence of dark gray foliated slate interbedded with sandstone and indicates highly weathered condition up to about 75 m deep.

Rock mass along the adit is classified into D to CL class at the first half about 1,000 m, and CM to CH class at the last half, about 800 m.

Furthermore, according to the results of TEM prospecting, as for No.2 adit alignment, adit construction must take the potential hazards into account because the location is presumed to be situated in remarkably low resistivity area, which may be affected by heated groundwater and cracks of basement rock at this section may be partly filled with heated water.

Nevertheless the solution for this matter should be further studied in detail based on the

additional investigation from the viewpoint of hydrogeological, for example with drilling investigation, physical survey, including detailed groundwater quality tests.

No.3 Adit

The adit alignment is located under the steep mountains, which is mainly consisted of dark gray foliated slate interbedded with sandstone of the CPhk formation. Drilling data, DH3Ad1, shows highly weathered condition up to about 40 m deep.

Rock mass along the adit is classified into D to CL class at the first half about 650 m and CM to CH class at the last half about 1,600 m.

No.4 Adit

The adit line is situated in the steep mountains, which is mainly composed of the CPhk formation (metasandstone interbedded with slate) and the CPnb formation (slate interbedded with foliated sandstone). Drilling data, DH4Ad1, is characterized by the existence of sandstone and slate showing weathered rock condition up to the bottom of borehole. Rock mass along the adit is classified into D to CL class at the first half about 500 m, and CM to CH class at the last half, about 2,600 m.

No.5 Adit

The tunnel alignment is situated under a mountain range, which is composed of greenish gray sandstone and tuff interbedded with thin shale layer of the TRhf formation. Drilling hole, DH5Ad1, is characterized by the existence of thick sandstone showing weathered rock condition up to about 15 m deep. Rock mass along the adit is mainly classified into CM to CH class, excluding the area around the portal of adit.

Furthermore, the results of TDEM prospecting reveal the existence of a large scale fractured zone caused by faulting around intersection point with the main tunnel on the basis of reversal transient phenomena. In this case, attention must be paid to the presence fault during tunnel construction.

No.6 Adit

The adit alignment is situated under a steep mountain, which is composed of greenish gray sandstone and tuff interbedded with thin shale layer of the TRhf formation. Drilling hole, DH6Ad1SP, is characterized by the existence of thick sandstone showing weathered rock condition up to about 26 m deep. Rock mass along the adit is mainly classified into CH to B class, excluding the area around the portal of adit.

No.7 Adit

The adit alignment is situated under a steep mountain, which is composed of greenish gray sandstone and tuff interbedded with thin shale layer of the TRhf formation. Drilling hole, DH7Ad1, is characterized by the presence of thick sandstone showing weathered rock condition up to about 26 m deep.

Rock mass along the adit is mainly classified into CH to B class, excluding around portal of adit.

The final presumption of classifications for grade of ground for seven (7) adits are shown in the following table and in the Data Base Map.

Table 11.2.5.(3)-14 Presumption of Grade of Ground for Seven (7) Adits

Grade of Ground	No.1 Adit		No.2 Adit		No.3 Adit		No.4 Adit		No.5 Adit		No.6 Adit		No.7 Adit		Total	
	Length	%	Length	%	Length	%	Length	%	Length	%	Length	%	Length	%	Length	%
B	0	0	0	0	600	27.4	541	17.1	330	13.3	1,109	33.2	692	28.5	3,272	18.8
C1	490	24.7	110	6.2	784	35.7	1,550	48.9	656	26.5	1,060	31.7	980	40.3	5,630	32.4
C2	260	13.1	535	30.0	150	6.8	540	17.0	510	20.6	820	24.6	460	18.9	3,275	18.8
D1	452	22.8	550	30.8	170	7.7	130	4.1	350	14.1	80	2.4	170	7.0	1,902	10.9
D2	80	4.0	150	8.4	160	7.3	130	4.1	270	10.9	90	2.7	70	2.9	950	5.5
E1	150	7.6	170	9.5	150	6.8	130	4.1	280	11.3	90	2.7	30	1.2	1,000	5.8
E2	550	27.7	270	15.1	180	8.2	150	4.7	80	3.2	90	2.7	30	1.2	1,350	7.8
Total	1,982	100	1,785	100	2,194	100	3,171	100	2,476	100	3,339	100	2,432	100	17,379	100

Figure 11.2.5(3)-2 Percentage of Tunnel Type (Kok-Ing No.1,2 & Ing-Yot No.1)

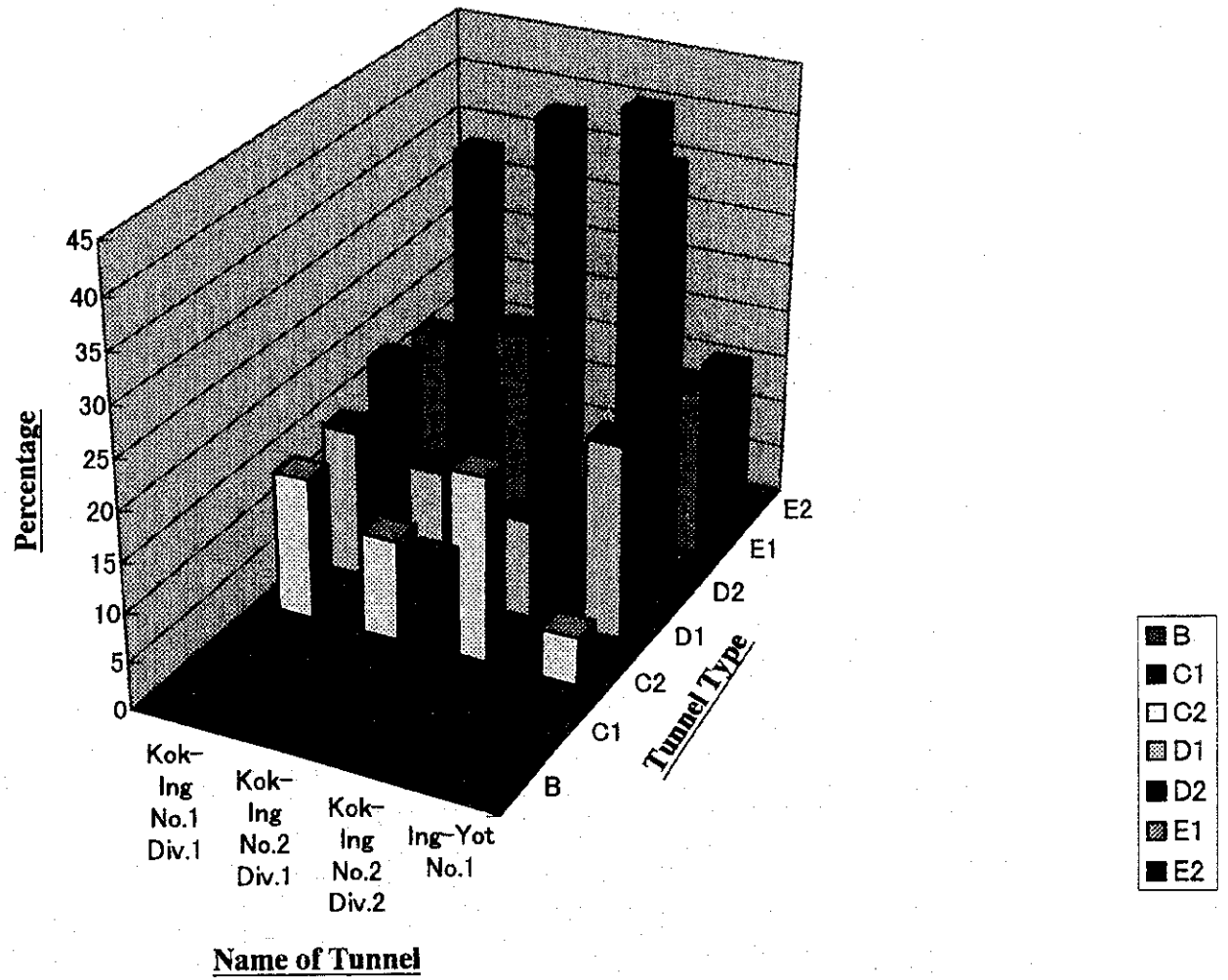


Figure 11.2.5(3)-3 Percentage of Presumption of Tunnel Type (Ing-Yot No.2 Div.1,2,3)

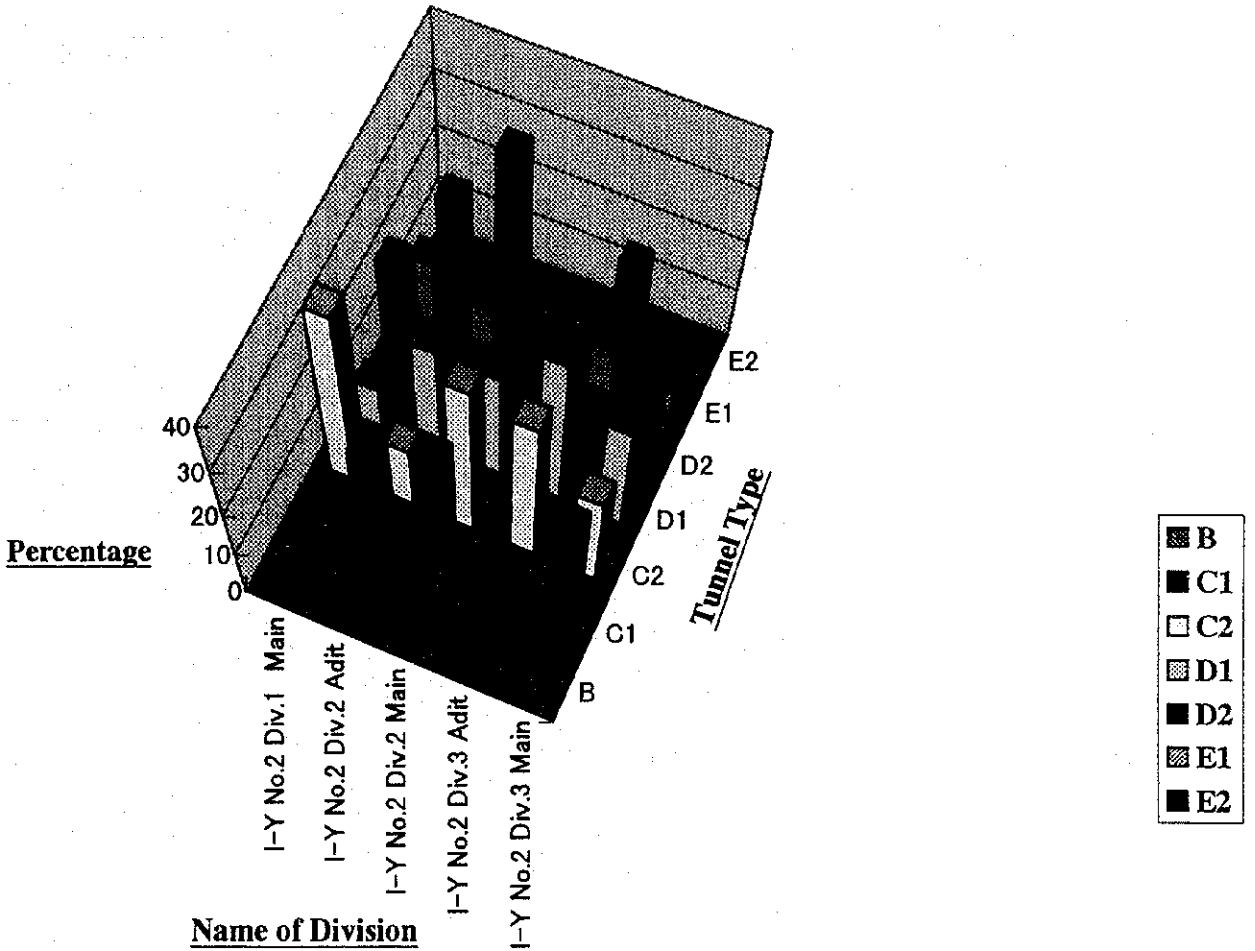


Figure 11.2.5(3)-4 Percentage of Presumption of Tunnel Type (Ing-Yot No.2 Div.4,5,6)

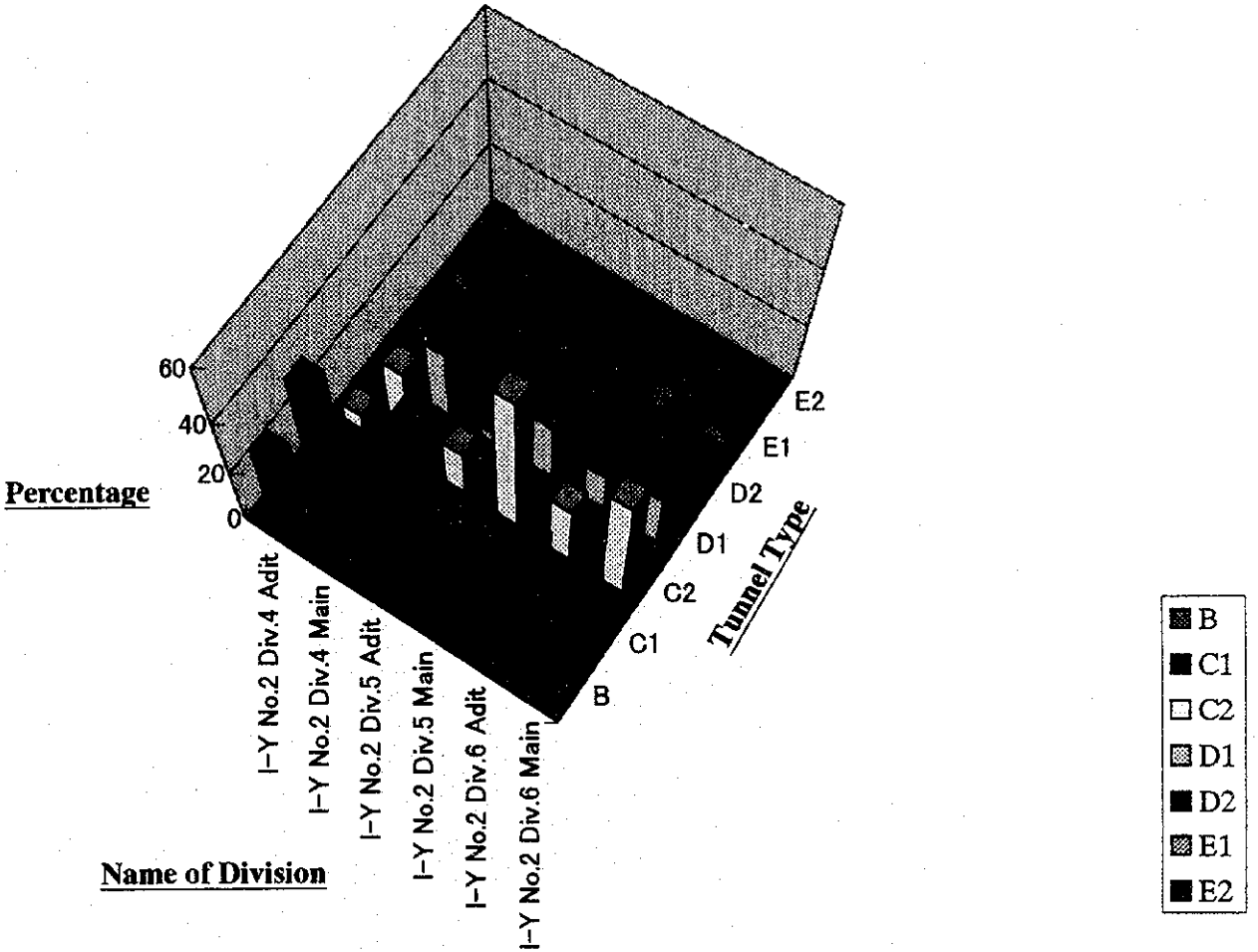


Figure 11.2.5(3)-5 Percentage of Presumption of Tunnel Type (Ing-Yot Mo.2 Div.7,8,9)

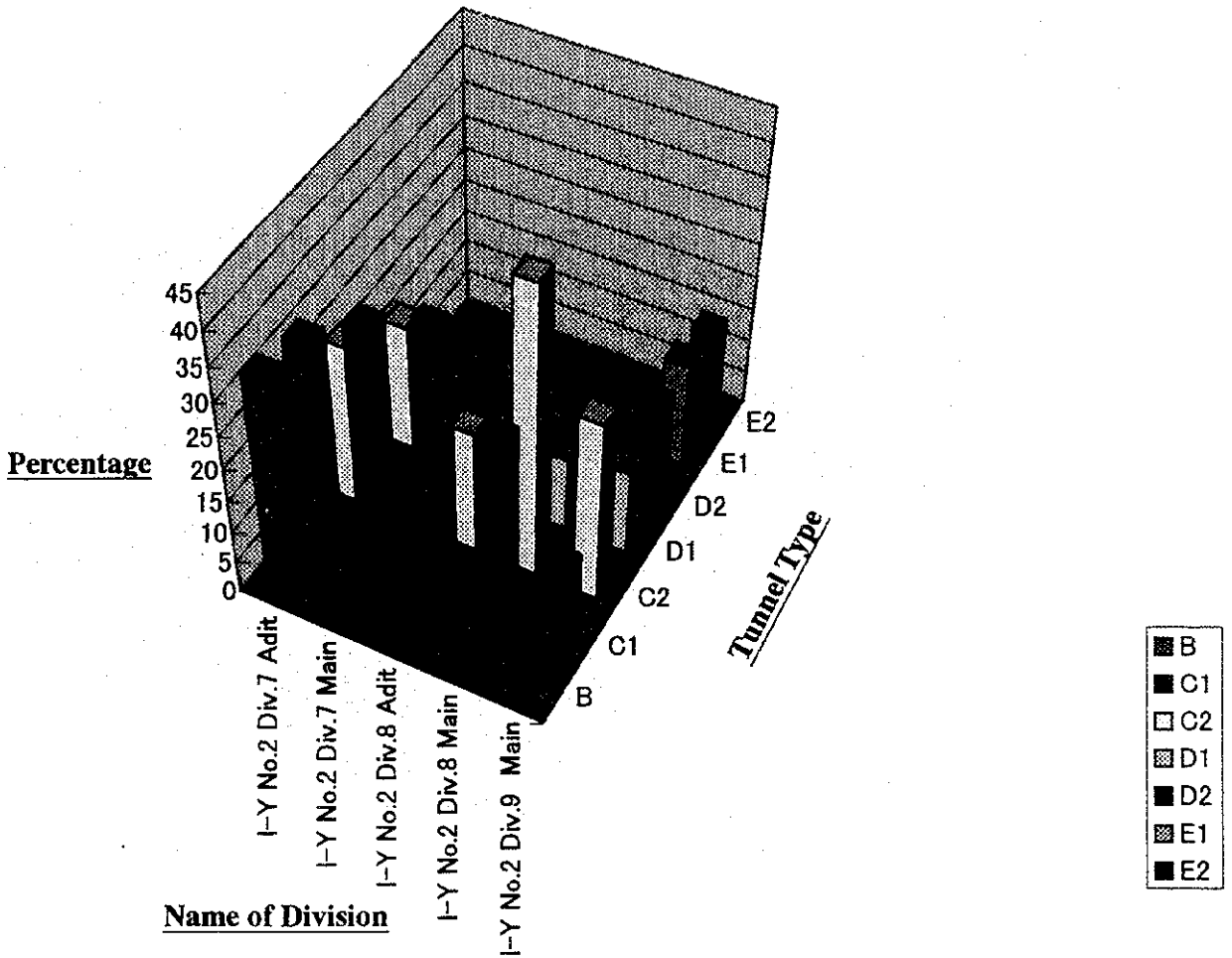
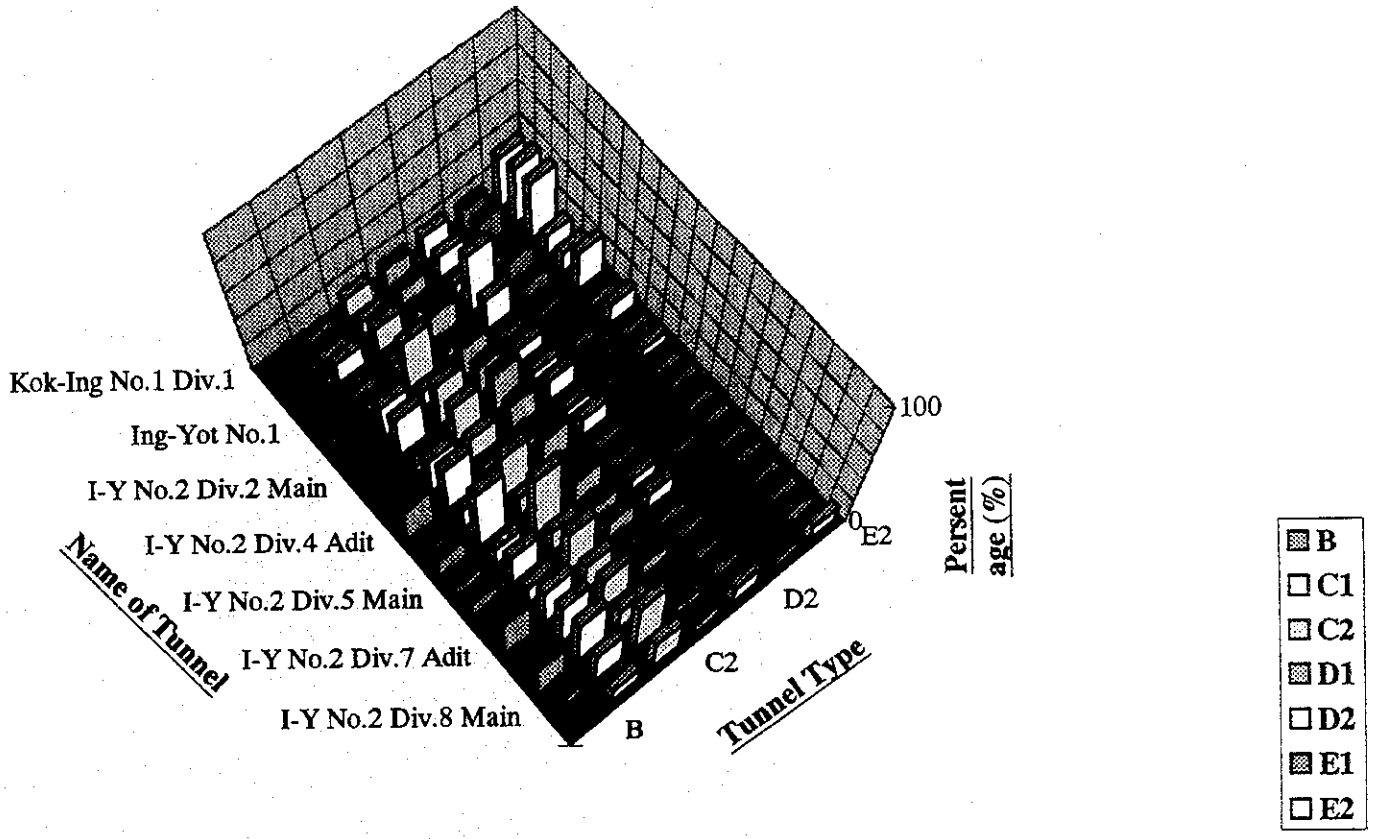


Figure 11.2.5(3)-6 Percentage of Presumption of Kok-Ing-Nan Tunnel Type



11.2.6 Yao Flood Control Dam

(1) Design Concept and Criteria

(a) Geological Condition at Dam Site

The Yao flood control dam is planned at the Yao river beside King Amphoe Song Khwae. The dam site is situated about 3.5 km in the southeast direction from the confluence of the Yot and Yao Rivers.

The gentle mountains and hills surround the proposed dam site with an altitude of 350 m to 400 m. The abutment of the dam on the right bank side has somewhat steep gradient in comparison with that on left bank side that locates on isolated hill lying along the mountain ridge.

Geological condition mainly consists of sedimentary rocks (shale, sandstone and tuff) of Permian-Triassic in age. According to the results of geological investigation, drilled cores along the proposed dam axis indicates hard and dense, however, those contain many cracks up to deeper portion, excluding drilling hole (DH. 1) at the right abutment.

Moreover, drilled core on the spillway alignment has similar characteristics to that along dam axis. Permeability of dam foundation indicates 10-4 cm/sec in order up to about 20 m in depth. The borehole (DH. 4) at the left abutment shows high permeability ranging from 10^{-3} cm/sec to 10^{-4} cm/sec in order.

(b) Layout Plan

These structures have been studied based on topographical maps with a scale of 1 to 2,000 and contour interval of 2 m covering the proposed structure sites and that with a scale of 1 to 10,000 and contour interval of 10 m including the proposed reservoir area and structure sites.

The Yao flood control dam comprises; 1) connection channel between the Ing-Yot tunnel and the Yot River, 2) a reservoir, 3) a main dam, 4) a spillway, 5) river diversion tunnel and river outlet, 6) relocation of the existing road and bridge.

Connection channel between the Ing-Yot tunnel and Yot River

The Ing-Yot tunnel has the outlet at the small stream joining the Yot river at 7 km upstream of the confluence with the Yao river. The connection channel is laid out along this small stream. The connection channel with a total length of 1,470 m has a bottom width of 15 m, riverbed slope of 1 to 1,000, drop structures of about 1 m height at seven (7) locations. The channel section is designed at flow velocity of 2.0 m for the design discharge of 175 cu.m/s.

Yao Reservoir

The proposed reservoir with the design water level of 320 m have an area of 293 ha and the gross storage volume of 32.8 million cu.m. The upstream end of reservoir along the Yao river locates just downstream of Ban Huai Lao according to the river cross section survey made by the JICA Study Team. Also, it along the Phang river, a tributary of the Yao river, reaches about 1.5 km upstream from the confluence of the Yao and Phang rivers.

Main Dam

Taking into accounts the geological foundation condition, a homogeneous earth fill-type or rock-fill type dam is possible dam type for the Yao flood control dam based on the geological investigation.

Whilst, one of significant issues on design of the Yao flood control dam is rapid draw-down of reservoir water level for releasing stored flood discharges. Draw-down rate is 20 m for two days in the minimum.

In order to maintain the safety of dam against the rapid draw-down, applicability of rock-fill type dam is further studied, especially for availability of rock material for pervious zone and riprap of the dam body. As source of rock material, the excavated rock of the Ing-Yot tunnel is expected to be available. Consequently, the rock-fill type dam is proposed for the Yao flood control dam.

Its up- and downstream embankment slope is set at 1 to 3 and 1 to 2.5, respectively. It is noted that any mechanical tests have not been executed for embankment material by the Study and suggested that it be done in the next stage of the Project.

Also, it is suggested that upstream surface be protected by means of rip raping and that the counter weight is provided at the downstream toe of dam embankment. The proposed dam has the maximum height of 50 m above the riverbed and the crest length of 250 m. The crest elevation of the dam is set at EL. 325 m securing a free board of 5 m above the design water level. The proposed dam comprises the earth, drainage and filter zones. The reservoir have a gross storage capacity of 32.8 MCM with the high water level of EL. 320 m and the low water level of EL. 298.5 m.

Spillway

A spillway is proposed to locate on the hill on the left bank side, and design flood discharge is suggested to be diverted from the Yao reservoir to the Ma-up River. Spillway comprises non-gated overflow weir and chute way. The spillway is designed at flood discharge of 1,000 cu.m/sec with a return period of 1,000 years.

River diversion tunnel and river outlet for release of diverted water

It is proposed to provide a river diversion tunnel with a length of about 300 m and a diameter of 6.5 m at about 200m upstream from the dam axis on the left bank. The flow capacity of the diversion tunnel is designed at 200 cu.m/s, assumed that tunnel work be carried out during a dry season and that the upstream coffer dam and reservoir will regulate the peak discharge of 570 cu.m/s in 25-year probable flood to 200 cu.m/s.

The river outlet consists of a bell mouth entrance structure, inclined gate and transition section which is connected to a pressure tunnel, using a diversion tunnel. The entrance structure is planned to be equipped with fixed trash racks. The elevation of entrance sill will be set at an altitude of 299 m above the dead water level. The entrance structure is designed so that the inflow velocity will not exceed 0.5 m/s even when the maximum discharge of 175 cu.m/s is released. For closing the pressure tunnel, a roller gate is equipped at the end of the pressure tunnel, which will be operated by hoisting machine through the inclined gate shaft. Considering the difficulty in estimating

sedimentation, such measures as a stop-log structure may be desirable in front of the intake entrance to protect the intake from being subjected to a possible silting.

(2) Review of Thai Design

Table 11.2.6-1 Main Features designed by Team J/V and JICA Study Team

Main Features	Team J/V	JICA Study Team
a) HWL	EL. 320.0 m	Same reservoir level
b) LWL	EL. 298.5 m	Same level
c) Type of dam	Earth-fill type	Rock-fill type
d) Layout of spillway	Left bank to the Yao River	Left bank to the Thong River
e) Spillway type	Gated spillway	Side channel (non-gated type)
f) Design discharge of spillway	960 cu.m/s	1,000 cu.m/s
g) River outlet	Sill level : EL 275 m	Sill Level : EL. 299 m
h) Design discharge of diversion	200 cu.m/s	200 cu.m/s

The major difference issues are selection of dam type, spillway type and layout. In order to finalize design of the Yao flood control dam, further geotechnical investigation at the dam site, and material survey and testing are indispensable for clarifying extent and characteristics of geologically poor portion on the left abutment, verifying availability of excavated material for tunnel construction, and so on.

(3) Design of JICA Study Team

The proposed structures are drawn as given in Figures 11.2.6-1 to -3. The main features of structures are described as follows:

1) Reservoir

Catchment area	:	327 km^2
High water level	:	EL. 320.0 m
Low water level	:	EL. 298.5 m
Reservoir surface area	:	2.93 km^2
Gross storage volume	:	32.8 million m^3
Effective storage volume	:	30.3 million m^3

2) Dam

Type	:	
Crest elevation	:	EL. 325.0 m
Dam height	:	58 m
Crest length	:	250 m
Upstream slope	:	1 to 3.0
Downstream slope	:	1 to 2.5

3) Spillway

Type	:	Side channel (non-gated type)
Flow capacity	:	1,000 cu.m/s at the flood water level
Length of overflow section	:	100 m
Spillway channel width	:	20 m to 50 m

4) *River outlet and diversion tunnel*

Type	:	Vertical inlet
Gate type	:	Roller gate
Gate size	:	1 no. with 6.5 m (width) and 7.0 m (height)
Tunnel type	:	Horse-shoe section
Length	:	300 m
Diameter	:	6.5 m

5) *Connection channel of tunnel with reservoir*

Length	:	1,470 m
Channel type	:	Trapezoid channel type with a bottom width of 15 m
Channel Slope	:	1 to 1,000 with drop structures (7 nos.)

11.2.7 Yao River Training

(1) Design Concept and Criteria

River training works are comprised of; 1) improvement of riverbed profile, 2) re-forming river channel with enough flow capacity, 3) construction of consolidation sill, 4) provision of groundsill, 5) revetment for river bank protection, and 6) other related works such as replacement of the existing bridges and provision of new bridges.

(a) Riverbed Profile

Riverbed profile along the Yao and Yot Rivers are designed on the basis of the average riverbed slope of the current river channel as given in Figures 11.2.7-1 and -2 so as not to induce large adverse effect on riverbed movement. As given in the Figure, the several channels have a higher riverbed elevation by which smooth flood flow has been obstructed. Therefore, excavation work is planned to improve such part of river channel.

While, in the river stretches with a comparatively steep slope, it is designed to make the incremental sediment transportation capacity small by means of provision of consolidation sills with a height of less than 2.5 m, which are expected to form moderate riverbed slope with a half of the average one due to sedimentation in the upstream river channel.

It, also, is planned to provide the groundsills at the existing bridge sites in the river improvement stretches in order to protect the bridge piers from the assumed riverbed degradation. The main features of the riverbed profiles are described as follows:

Table 11.2.7-1 Main Features of the Proposed River Training Works

River Stretches to be improved	River Length	Design Riverbed Slope	Proposed Improvement Works
Yao River			
0.0 km to 13.5 km	13.5 km	1: 1,070	Riverbed excavation
13.5 km to 19.0 km	5.5 km	(1:600 to 1 to 1,200)	Provision of consolidation sill 15.0 km : 1 no. and 2.5 m height 18.0 km : 1 no. and 1.8 m height
19.0 km to 23.8 km	4.8 km	1 : 400 to 1 : 550	Riverbed excavation, and Provision of groundsill (2 nos.: 20.5 km and 22.0 km)
23.8 km to 30.5 km	6.7 km	(1: 1,100)	Provision of consolidation sill 24.5 km : 1 no. and 2.0 m height 26.7km : 1 no. and 2.0 m height
30.5 km to 41.8 km	11.3 km	1: 550 to 1: 1,100	Riverbed excavation, and Provision of groundsill (3 nos.: 32.0 km, 40.3 km and 41.8 km)
41.8 km to 56.0 km	14.2 km	(1 : 300)	Construction of flood control dam and reservoir with a height of about 50 m and gross storage volume of 30 MCM.
Yot River			
0. 0 km to 7.1 km	7.1 km	(1: 300 to 1: 380)	4 nos. of consolidation sills with a height of 2.5 m

Note : Riverbed slope in parenthesis indicates the average one.

(b) River cross section

The existing river channel has a bottom width of about 10 m to 20 m in the river improvement stretches. While, the river training plan established by the Team J/V is currently proposed to widen the bottom width to 20 m to 60 m. A designed typical cross section is illustrated as follows:

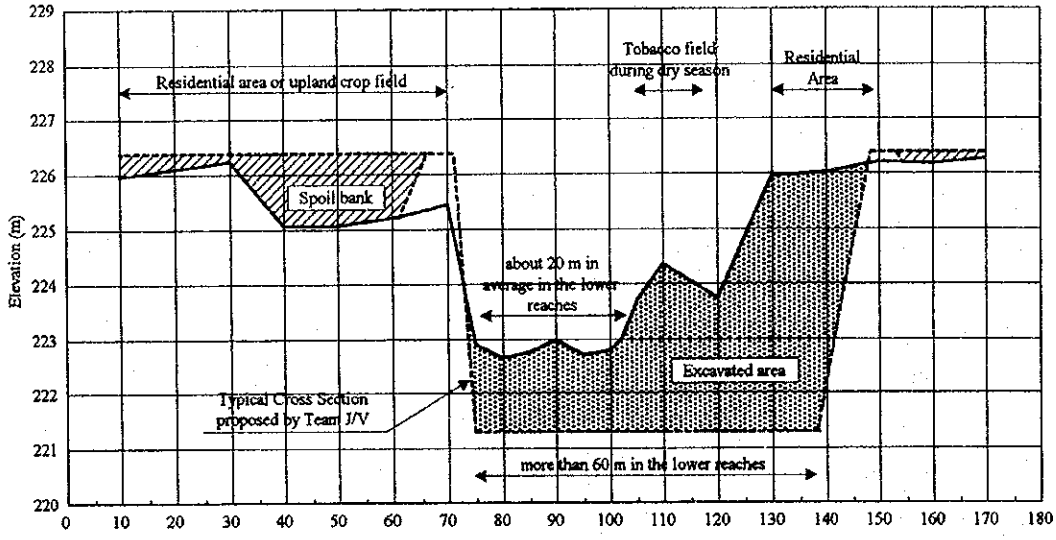


Figure 11.2.7-3 Typical River Cross Section Designed by Team J/V

The proposed excavation work will have a large loss of land with a width of about 40 m, where the village people uses as residential area or upland crop field. This typical cross section is based the assumption that the water level profile formed by the mean monthly flow discharge would not be changed even after passing the diverted water of 175 cu.m/s.

In order to reduce land loss, the following design concept is proposed as one of the alternative options:

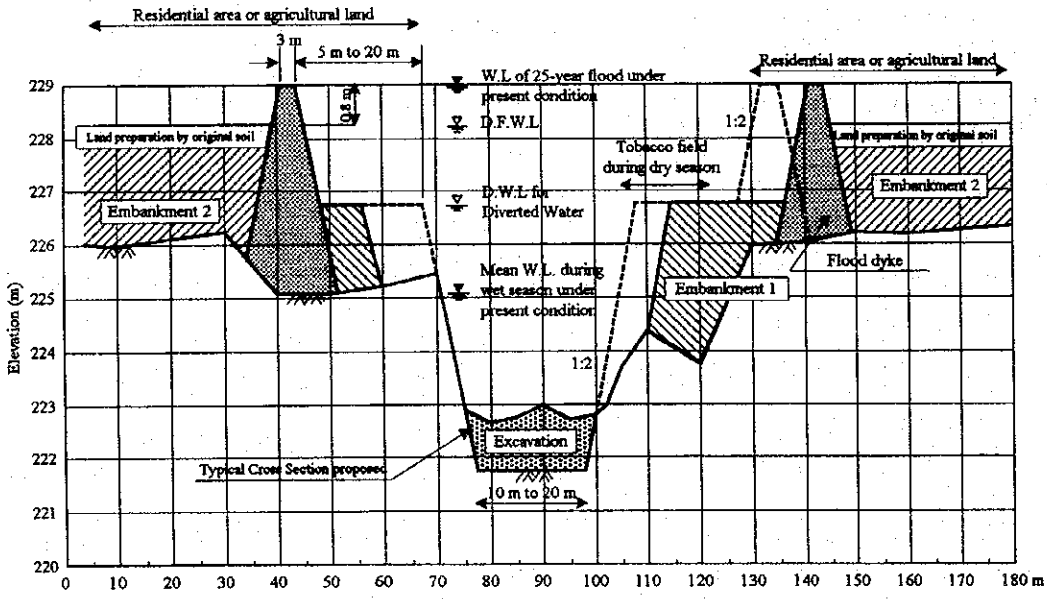


Figure 11.2.7-4 Alternative Typical River Cross Section

- Riverbed excavation is provided, in case that the current riverbed of the existing channel is higher than the average riverbed elevation as explained in the design of river profile.
- A bottom width is set out at the average bottom width in each river improvement stretch and the current riverbank is excavated at a slope gradient of 1 to 2, if necessary.
- Location of flood dykes on the both sides is provided at 5 m or 20 m far from the riverbank. The length of 20 m is planned to apply for the river improvement stretch from 0.0 km to 13.5 km, and 5 m for other improvement stretches.
- Land elevation of riverside area from the flood dyke, where the flood water covers several times a year and is utilized as agricultural land during dry season, is proposed to be heightened in accordance with needs of inhabitants (embankment 1 in the Figure).
- Land elevation of the protection area, also, is heightened to avoid drainage congestion in this area. A side-ditch is provided at the toe of flood dyke. Especially, it is necessary for use of residence or agricultural land to provide land preparation by utilizing the existing surface soil.

Assuming that the embankment 1 and 2 is possible to uses after construction works, the land loss is probably reduced about 40 % comparing with the aforesaid proposal by the Team J/V.

(c)Consolidation sills, ground sill and revetment works

Type of the proposed consolidation sill, groundsill and revetment works is given in Figures 11.3.6-5 and -6. It is suggested to provide revetment works at meandering part, river channel along residential area in the river improvement stretches, up- and downstream of the bridges and groundsills. Location of the propose sites for providing these structures is described as follows:

Table 11.2.7-2 Location and Features of the Proposed Consolidation Sill, Groundsill and Revetment Work

Construction works	Location	Features
Consolidation sill	Distance from the Confluence with the Nan River	
	No. 1 : 15.0 km	Height: 2.5 m Riverbed Elevation: 236.2 m
	No. 2 : 18.0 km	1.8 m 240.5 m
	No. 3 : 24.5 km	2.0 m 255.2 m
	No. 4 : 26.7km	2.0 m 259.2 m
	Distance from the Confluence with the Yao River	
	No. 5 : 2.2 km	2.5 m 301.0 m
	No. 6 : 3.2 km	2.5 m 306.0 m
	No. 7 : 4.1 km	2.5 m 311.0 m
	No. 8 : 5.1 km	2.5 m 316.0 m
Groundsill	Distance from the Confluence with the Nan River	Crest Elevation (design riverbed elevation):
	No. 1 : 20.5 km	244.9 m
	No. 2 : 22.0 km	248.7 m
	No. 3 : 32.0 km	266.8 m
	No. 4 : 40.3 km	274.4 m
	No. 5 : 41.8 km	276.0 m
Revetment works	0.0 km to 13.5 km	16 locations : 4,550 m
	19.0 km to 23.8 km	3 locations : 2,100 m
	30.5 km to 41.8 km	9 locations : 3,810 m
	Total	28 locations : 10,460 m

(d) Replacement of the Existing Bridges and Provision of New Bridges

There is no structural data on the existing bridges constructed by the Highway Department, excluding their girder elevation and span length. In the Study, replacement of the existing bridges is assumed for estimate of project cost.

According to the social hearing survey made by the Team J/V, the inhabitants living along the river improvement stretches desire additional new bridges.

The proposed bridges are listed as follows:

Table 11.2.7-3 Location of Proposed Bridges

Location	Required Span Length	Lowest Elevation of Bridge Girder
No. 1 : 3.4 km (New)	85 m	EL. 229.3 m
No. 2 : 3.9 km (Existing)	85 m	EL. 229.8 m
No. 3 : 10.9 km (Existing)	85 m	EL. 236.1 m
No. 4 : 13.3 km (New)	60 m	EL. 238.6 m
No. 5 : 20.6 km (Existing)	50 m	EL. 251.0 m
No. 6 : 31.8 km (Existing)	40 m	EL. 272.2 m
No. 7 : 37.0 (New)	40 m	EL. 278.2 m
No. 8 : 39.5 (New)	40 m	EL. 280.5 m
No. 9 : 40.3 (Existing)	40 m	EL. 281.2 m
No. 10: 42.4 (Existing)	40 m	EL. 282.6 m
No. 11: Spillway bridge	60 m	

Note: The required span length are based on typical cross section and will be finalized on the basis of the river cross section surveyed by RID and JICA.

In addition to the above bridges, it is identified that additional bridges be provided for communication of village peoples, since the village peoples cross the shallow river at several places by foot even during the wet season and the proposed water diversion affects such activities.

Most of such places are planned to provide the new bridges, but the following places are still required to construct new bridges; 1) 1.9 km from the confluence of the Nan River, 2) 20.3 km, and 3) 40.7 km.

(2) Review of Designs Made by the Team J/V

The JICA Study Team has reviewed the result of design made by the Team J/V through the different concept of design, especially cross sections.

The Team J/V was planned the river cross section with a dyke system. However, the consultation with the village peoples indicated that they would not like to provide such the dyke system, since they were anxious about sudden failure of the dyke and damages and drainage congestion due to insufficiency of the capacity and closure of the current drainage direction.

Through the result of consultation with the village peoples, the Team J/V has proposed the excavated river cross section with the double or triple riverbed width of the existing river channel and without any dyke system.

The JICA Study Team has studied the river channel improvement with a dyke section, since the anxiety of village peoples about technical points could be solved and provision of additional consideration to the dyke system envisaged by the Team J/V would give incentive to the village peoples by the dyke system concept.

From the viewpoints mentioned, the JICA Study Team has made comparative studies. Result of the study is given as follows:

Table 11.2.7-4 Evaluation of Flood Dyke and Excavated Channel Concepts

Issues		Flood Dyke Concept	Excavated Channel Concept
Engineering	Advantage	• Excavated soil to be produced by the proposed dam construction can be used for dyke and embankment and will not require the wide spoil bank for dam construction works.	• No drainage congestion, but rise of safety level against flood is envisaged in the channel design. •More safety than the Flood Dyke Concept, against flood with a magnitude lather than planned because of no sudden failure of dyke. •Excess flood will spread village area gradually.
	Disadvantage	•Inland drainage system should be provided, but not completely drained out, when the river water level is higher than inland elevation. •Excess flood larger than planned one (25-year flood) will break the dyke suddenly and cause damage in the village areas.	•Large amount of excavated material (4 million cu.m) will require wide spoil bank along the river course.
Social Impacts	Advantage	•Existing agricultural land along the riverbank could be used as present, excluding alignment of dyke area. •Embankment 1 could provide agricultural land during the normal wet season (inundation once in 2 or 3 years). •Less land acquisition and land loss	•Inhabitants will not be anxious about failure of flood dyke during the wet season and drainage congestion.
	Dis-advantage	•Approach to the river will not be better than the present, even providing approach way and steps to river.	•Land loss will be larger than Flood Dyke Concept.
Natural Environment	Advantage	•Least excavation of riverbed could not change the present environmental situation significantly.	
	Disadvantage	•Less impact than Excavated Channel	•Excavated river channel will have a width of double of the existing one in the upstream and triple in the downstream and will make flat bed, which possibly give large impact on ecology and fishes due to change of water depth. •It is necessary to provide counter-measures for such impact.

Through the review of the mentioned, most important issues are the public acceptance, for which the Team J/V has intensively made public consultation and participation in the planning stage.

Through these activities, the village peoples select the currently proposed excavated channel

with river structures.

The JICA Study Team evaluates that the proposed excavated channel plan is applicable option for passing the diverted water through the river channel of the Yao river, taking into account the village peoples intention.

Whilst, the spoil banks for the excavated material of 4 million cu.m will require the wide areas along the river reaches to be improved.

It is recommended that further consultation be made in the next stage of the Project and that a combined concept heightening of ground elevation in the low land areas might provide one of solution for requirement of spoil bank.

(3) Design of JICA Team

The layout plan and typical river cross sections along the Yao River are illustrated in Figures 11.2.7-7 to -17. The main features of the project facilities are summarized as follows:

1) Flood dike	• Length of flood dyke	
	Left bank	: 15.1 km
	Right bank	: 11.5 km
	Total	: 26.6 km
	• Average height	
	Left bank	: 2.6 m
	Right bank	: 2.4 m
	• Embankment volume	: 578 thousand m3
	• Excavation volume	: 646 thousand m3
2) Heightening of ground elevation behind the flood dike	• Embankment volume	: 1,082 thousand m3
3) Revetment	• Locations	: 28
	• Length	: 10,460 m
4) Drainage sluice	• 54 nos. (diameter 1.5 m and pipe length 10m)	
5) Consolidation sill	• 8 nos.	
6) Groundsill	• 5 nos.	
7) Bridge structure	• Road bridge	: 11 nos.
	• Communication bridge	: 3 nos.

11.4 Project Cost Estimation

11.4.1 Summary of Project Cost

The whole Project cost is consisting of the costs for ① Kok-Ing-Nan Water Diversion Project, ② Associate Irrigation Project, ③ Environmental Impact Mitigation, ④ Existing Beneficial Area in Lower Nan and Delta and ⑤ New Beneficial Area in Lower Nan and summarized as follows;

And the cost is estimated by 35 Baht/U.S.$., average of on 1998.

Table 11.4.1 Summary of Project Cost

(Unit Million Baht)

Items	A Plan			B Plan			Remark
	F.C	L.C	Total	F.C	L.C	Total	
(1) Kok-Ing-Nan Project	31,416	11,970	43,386	31,416	11,970	43,386	Refer to Table 11.4.1.(1)
(2) Associate Irrigation Project	2,500	1,313	3,813	2,500	1,313	3,813	Refer to Table 11.4.1.(2)
(3) Environmental Impact Mitigation	380	420	800	380	420	800	- do -
(4) Existing Beneficial Area in Lower Nan & Delta	-	944	944	-	944	944	- do -
(5) New Beneficial Area in Lower Nan	7,000	3,620	10,620	-	-	-	- do -
Total	41,296	18,267	59,563	34,296	14,647	48,943	

Remark; A plan includes the development of new beneficial area in the lower Nan (with new beneficial area), while B plan is without new beneficial area.

(1) Kok-Ing-Nan Project Cost

The Kok-Ing-Nan Project cost is summarized as follows;

Table 11.4.1.(1) Summary of Kok-Ing-Nan Project Cost

Items	Amount (Million Baht)			Remark
	F.C	L.C	Total	
(1) Construction Cost	24,987	7,232	32,219	
(2) Engineering Cost	1,539	1,565	3,104	
(3) Administration Cost	0	645	645	
(4) O/M Equipment	166	0	166	
(5) Total (1)~(4)	26,692	9,442	36,134	
(6) Total with Contingency (5) × 110%	29,361	10,386	39,747	
(7) Total with Tax (6) × 107%	31,416	11,113	42,529	
(8) Land Acquisition	0	857	857	
(9) Project Cost Total (7)+(8)	31,416	11,970	43,386	

(2) Other Costs related to the Kok-Ing-Nan Project

The other costs for Associate Irrigation, Environmental Impact Mitigation, Existing Beneficial Area and New Beneficial Area which are related to the Kok-Ing-Nan Project are estimated preliminary as shown in Table 11.4.1.(2)

Table 11.4.1.(2) Other Costs related to Kok-Ing-Nan Project

Remark	Unit	Quantity	Unit Price (Baht)			Amount (Million Baht)		
			F.C	L.C	Total	F.C	L.C	Total
1. Associate Irrigation Project								
(1) Irrigation System in New Area								
Kok-Ing Beneficial Area	Rai	200,000	10,000	5,000	15,000	2,000	1,000	3,000
Upper Nan Beneficial Area	Rai	50,000	10,000	5,000	15,000	500	250	750
Sub-total	Rai	250,000				2,500	1,250	3,750
(2) Land Consolidation for Perennial Crops								
Kok-Ing Beneficial Area	Rai	25,000	-	2,000	2,000	-	50	50
Upper Nan Beneficial Area	Rai	6,500	-	2,000	2,000	-	13	13
Sub-total	Rai	31,500				-	63	63
Total						2,500	1,313	3,813
2. Environmental Impact Mitigation								
(1) Reforestation Center	Place	3	-	-	-	90	60	150
(2) Diversified Crop Center	Place	3	-	-	-	30	30	60
(3) Eco-Tourism Area	Place	2	-	-	-	150	150	300
(4) Hatchery Facility	Place	4	-	-	-	50	50	100
(5) Animal Dispensary	Place	2	-	-	-	60	30	90
(6) Resettlement	L.S	-	-	-	-	-	100	100
Total						380	420	800
3. Existing Beneficial Area in Lower Nan & Delta								
	Rai	377,000	-	2,000	2,000	-	754	754
- do.- in Lower Nan	Rai	95,000	-	2,000	2,000	-	190	190
Total	Rai	472,000				-	944	944
4. New Beneficial Area in Lower Nan								
New Irrigation System	Rai	700,000	10,000	5,000	15,000	7,000	3,500	10,500
Land Consolidation	Rai	60,000	-	2,000	2,000	-	120	120
Total	Rai	760,000				7,000	3,620	10,620

11.4.2 Kok-Ing-Nan Project Cost

(1) Construction Cost

The construction works will be carried out on the contract basis under the international tender because the construction is composed of the large scale, complicated and difficult works such as the diversion weir and canals to release the large discharge capacity of 175 cu.m/sec, tunnel with the large diameter of 11.0 m and long distance of more than 50 km and the dam with the large outlet discharge capacity of 200 cu.m/sec.

The construction works also will be carried out by the following 11 construction diversions taking into account the kinds of works, scale of works, construction cost, etc.

Kok-Ing Diversion Canal

1) Kok intake, Kok canal and Kok-Ing No.1 tunnel
2) Tak canal

3) Kok-Ing No.2 tunnel
4) Ing canal and Ing weir

Ing-Yot Diversion Canal and Tunnel

5) Ing-Yot canal including Ing-Yot No.1 tunnel
6) Ing-Yot culvert and Ing-Yot No.2 tunnel, Diversion 1
7) Ing-Yot No.2 tunnel, Diversion 2 and 3
8) Ing-Yot No.2 tunnel, Diversion 4 and 5
9) Ing-Yot No.2 tunnel, Diversion 6 and 7
10) Ing-Yot No.2 tunnel, Diversion 8 and 9

Yao River

11) Yao Dam and Yao River Training

(a) Estimation of Unit Rate for the Works

Although the unit rate for the works is estimated by Thai side study, it is very difficult to review it due to lack of back data for the cost estimation.

JICA Team accordingly has studied the unit rate for the works preparing the basic rate for labor, construction materials and hiring cost of construction equipment for the works and comparing with the rate estimated by Thai side study.

The unit rate for tunnel construction is studied more carefully through classifying into tunnel types based on the geological conditions along the tunnel route, because the direct construction cost of about 22,000 million Baht in the Project will occupy as much as 70% of the total construction cost and give the large influence to the Project cost and economy.

The unit rate also is divided into the foreign and local currency in order to judge the foreign and local currency portion of the construction cost.

- Basic Rate

The basis of applied basic rate is Thailand fiscal year 1998 Rates. The basic rate for labor , materials and construction equipment is shown in Table 11.4.2.(1)-1 ,Table 11.4.2.(1)-2 and Table 11.4.2.(1)-3.

As regards foreign and local currency portions for the major construction materials , the following rates are applied :

Materials	Foreign Currency (%)	Local Currency (%)
Labor	0	100
Cement	70	30
Reinforced bar	90	10
Fuel and Oil	50	50
Timber	0	100
Explosive	100	0
Steel Production	90	10
Construction Equipment	100	0

Table 11.4.2.(1)-1 Basic Rate of Labor for Construction

Unit :Baht

Labor Rate (L.C.)				
No.	**Item**	**Unit**	**Basic Rate**	**Basic Rate for Tunnel**
1	Foreman Tunnel	day	0	720
2	Foreman	day	350	460
3	Skilled Labor	day	200	260
4	Common Labor	day	180	230
5	Operator of Heavy Equipment	day	350	460
6	Assistant of Operator	day	200	260
7	Driller	day	270	350
8	Driver	day	270	350
9	Steel Worker (Bender/Fixer)	day	270	350
10	Welder (Steel Pipe)	day	350	460
11	Form-work Labor (Carpenter)	day	300	390
12	Mechanics	day	300	390
13	Electrician	day	300	390
14	Concrete Worker	day	250	330
15	Mason (Stone Worker)	day	250	330

Table 11.4.2.(1)-2 Basic Rate of Material for Construction

Unit : Baht

Material Rate							
No.	Item	Unit	Basic Rate	Rate (%)		Basic Rate	
				F.C.	L.C.	F.C.	L.C.
1	Portland Cement Type I	ton	1,480	70	30	1,036	444
2	Portland Cement Type II	ton	2,380	70	30	1,666	714
3	Ready Mixed Concrete 350kg/cm2	m3	1,730	55	45	952	778
4	Ready Mixed Concrete 320kg/cm2	m3	1,660	55	45	913	747
5	Ready Mixed Concrete 210kg/cm2	m3	1,530	55	45	842	688
6	Ready Mixed Concrete 180kg/cm2	m3	1,420	55	45	781	639
7	Ready Mixed Concrete 135kg/cm2	m3	1,340	55	45	737	603
8	Concrete Admixture	liter	440	95	5	418	22
9	Mortar 1:3	m3	3,100	55	45	1,705	1,395
10	Fine Sand for Aggregate	m3	220	0	100	0	220
11	Coarse Sand for Aggregate(Gravel)	m3	220	0	100	0	220
12	Sand	m3	70	0	100	0	70
13	Stone for Riprap	m3	490	0	100	0	490
14	Cobblestone	m3	290	0	100	0	290
15	Crushed Aggregate for Road	ton	160	0	100	0	160
16	Clay (Laterite)	m3	40	0	100	0	40
17	Reinforce Bar <= D13	ton	15,320	90	10	13,788	1,532
18	Reinforced Bar D16~D25	ton	14,560	90	10	13,104	1,456
19	Timber	m3	9,800	0	100	0	9,800
20	Timber (Soft)	m3	8,200	0	100	0	8,200
21	Wood for Form	m2	160	0	100	0	160
22	P.C. Pile ϕ 600 *10 m	no.	12,400	10	90	1,240	11,160
23	P.C. Pile ϕ 500 *10 m	no.	9,000	10	90	900	8,100
24	P.C. Pile ϕ 300 *10 m	no.	3,900	10	90	390	3,510
25	S.P. Pile ϕ 450 *10 m (t=9mm)	no.	24,100	90	10	21,690	2,410
26	Steel Pipe D1000mm , t=8.7mm	m	10,400	90	10	9,360	1,040
27	H Beam	kg	24	90	10	22	2
28	Stainless Steel	kg	300	90	10	270	30
29	Steel Processing	kg	18	10	90	2	16
30	Prefabrication Steel Work	kg	18	20	80	4	14
31	Sheet Pile Type II	ton	18,000	90	10	16,200	1,800
32	Sheet Pile Type III	ton	30,000	90	10	27,000	3,000
33	Gasoline	little	12	50	50	6	6
34	Diesel Oil	little	10	50	50	5	5
35	Industrial Oil	little	5	50	50	3	2
36	Dynamite	kg	130	100	0	130	0
37	Detonator	P.C.	30	100	0	30	0
38	Electric Charge	kWh	3	0	100	0	3
39	Cross Bit RM 8-25	Pcs	3,500	100	0	3,500	0
40	Accelerator for Shotcrete	Kg	100	100	0	100	0
41	Rock Bolt 18t L=3m	Pcs	600	90	10	540	60
42	Rock Bolt 18t L=4m	Pcs	790	90	10	711	79
43	Rock Bolt 18t L=6m	Pcs	1,200	90	10	1,080	120
44	Square Washer 150 x 150 x 9	Pcs	116	90	10	104	12
45	Wire Mesh 150 x 150 x D6	m^2	30	90	10	27	3
46	Nut M24	Pcs	10	90	10	9	1
47	H-Steel Tunnel Support	t	45,000	90	10	40,500	4,500
48	H-Steel Bending Extra H125~H200	t	1,610	90	10	1,449	161
49	H-Steel Rounding Extra	t	2,150	90	10	1,935	215
50	Joint Plate	t	6,030	90	10	5,427	603
51	Filter mat W300, t=20	m^2	260	100	0	260	0
52	Waterproof Sheet for NATM 0.8mm	m^2	660	100	0	660	0
53	Waterproof Sheet for NATM 1.0mm	m^2	750	100	0	750	0
54	Concrete Pipe D150	m	400	10	90	40	360
55	Concrete Pipe D300, m/Hole L=2m	m	900	10	90	90	810
56	Drain Pit 200BK	Pcs	8,000	0	100	0	8,000
57	Dry Mortar	Kg	14	55	45	8	6

Table 11.4.2.(1)-3 Basic Rate & Operation Cost of Construction Equipment

Unit : Baht (1/3)

No.	Item	Construction Equipment (F.C.)					Fuel Cost (l/Hr or l/7Hr/day)					Operation Cost of Construction Equipment					
		Capital Cost	Power	Unit	Basic Rate	Basic Rate	Oil or Power	Foreign Currency		Local Currency		Common Works (Baht/(Hr or day))			Tunnel Works (Baht/(Hr or day))		
		(1,000 Baht)	(PS,Kw)		(Baht)	or Tunnel (Baht	little or Kw	Basic Rate	Cost(Baht)	Basic Rate	Cost(Baht)	F.C.	L.C.	Total Cost	F.C.	L.C.	Total Cost
1	Bulldozer 11t	2,290	78	Hr	980	1,080	11	5	55	5	55	1,035	55	1,090	1,135	55	1,190
2	Bulldozer 15t	3,040	100	Hr	1,300	1,430	14	5	70	5	70	1,370	70	1,440	1,500	70	1,570
3	Bulldozer 21t	5,020	152	Hr	2,160	2,380	21	5	105	5	105	2,265	105	2,370	2,485	105	2,590
4	Bulldozer 32t	7,330	208	Hr	3,150	3,470	29	5	145	5	145	3,295	145	3,440	3,615	145	3,760
5	Ripper Bulldozer 21t	5,530	130	Hr	1,110	1,220	18	5	90	5	90	1,200	90	1,290	1,310	90	1,400
6	Ripper Bulldozer 32t	8,310	170	Hr	1,660	1,830	24	5	120	5	120	1,780	120	1,900	1,950	120	2,070
7	Backhoe Shovel 0.35m3	1,730	60	Hr.	480	530	9	5	45	5	45	525	45	570	575	45	620
8	Backhoe Shovel 0.6 m3	3,040	104	Hr	830	910	15	5	75	5	75	905	75	980	985	75	1,060
9	Backhoe Shovel 1.2 m3	5,270	165	Hr	1,440	1,580	23	5	115	5	115	1,555	115	1,670	1,695	115	1,810
10	Backhoe Shovel 2.0 m3	10,360	270	Hr	2,820	3,100	38	5	190	5	190	3,010	190	3,200	3,290	190	3,480
11	Drugline 1.2m3	10,620	97	Hr	2,450	2,700	14	5	70	5	70	2,520	70	2,590	2,770	70	2,840
12	Wheel Loader 1.2m3	1,340	62	Hr	480	530	8	5	40	5	40	520	40	560	570	40	610
13	Wheel Loader 1.5m3	2,270	81	Hr	820	900	10	5	50	5	50	870	50	920	950	50	1,000
14	Wheel Loader 2.0m3	3,000	91	Hr	1,090	1,200	11	5	55	5	55	1,145	55	1,200	1,255	55	1,310
15	Tractor Shovel 2.3m3 wheel type	3,510	103	Hr.	1,270	1,400	12	5	60	5	60	1,330	60	1,390	1,460	60	1,520
16	Loader Crawler Type 1.2m3	1,880	68	Hr	690	760	10	5	50	5	50	740	50	790	810	50	860
17	Dump Truck 8t	1,600	179	Hr	410	450	8	5	40	5	40	450	40	490	490	40	530
18	Dump Truck 11t	2,100	246	Hr	530	580	10	5	50	5	50	580	50	630	630	50	680
19	Dump Truck 15t	3,220	153	Hr	740	810	10	5	50	5	50	790	50	840	860	50	910
20	Dump Truck 20t	5,400	218	Hr	1,250	1,380	14	5	70	5	70	1,320	70	1,390	1,450	70	1,520
21	Truck with Crane 4t x 2.9t lift	1,330	132	Hr.	360	400	5	5	25	5	25	385	25	410	425	25	450
22	Truck with Crane 15t	4,070	169	Hr	1,000	1,100	7	5	35	5	35	1,035	35	1,070	1,135	35	1,170
23	Truck with Crane 20t	6,580	165	Hr	1,600	1,760	7	5	35	5	35	1,635	35	1,670	1,795	35	1,830
24	Truck with Crane 35t	8,730	250	Hr	2,120	2,330	10	5	50	5	50	2,170	50	2,220	2,380	50	2,430
25	Truck 10t	2,220	233	Hr	710	780	10	5	50	5	50	760	50	810	830	50	880
26	Trailer 25t	3,470	235	Hr	970	1,070	14	5	70	5	70	1,040	70	1,110	1,140	70	1,210
27	Crawler Crane 20t	3,980	71	Hr	1,150	1,270	5	5	25	5	25	1,175	25	1,200	1,295	25	1,320

Table 11.4.2.(1)-3 Basic Rate & Operation Cost of Construction Equipment

Unit : Baht (2/3)

No.	Item	Construction Equipment (F.C.)					Fuel Cost (l/Hr or l/7Hr/day)					Operation Cost of Construction Equipment					
		Capital Cost	Power	Unit	Basic Rate	Basic Rate	Oil or Power	Foreign Currency		Local Currency		Common Works (Baht/(Hr or day))			Tunnel Works (Baht/(Hr or day))		
		(1,000 Baht)	(PS,Kw)		(Baht)	or Tunnel (Baht	litte or Kw	Basic Rate	Cost(Baht)	Basic Rate	Cost(Baht)	F.C.	L.C.	Total Cost	F.C.	L.C.	Total Cost
28	Crawler Crane 50t	9,240	102	Hr	2,680	2,950	8	5	40	5	40	2,720	40	2,760	2,990	40	3,030
29	Crawler Crane 100t	22,090	193	Hr	6,400	7,040	14	5	70	5	70	6,470	70	6,540	7,110	70	7,180
30	Motor Grader Blade with 3.7m	3,160	115	Hr	1,220	1,340	10	5	50	5	50	1,270	50	1,320	1,390	50	1,440
31	Tamping Roller 13.5~20t	4,470	110	Hr	2,200	2,420	13	5	65	5	65	2,265	65	2,330	2,485	65	2,550
32	Tire Roller 20t	1,730	71	Hr	640	700	6	5	30	5	30	670	30	700	730	30	760
33	Road Roller 8-10t	1,960	26	Hr	670	740	3	5	15	5	15	685	15	700	755	15	770
34	Vibrating Roller 3 ~ 5t	1,010	20	Hr	500	550	3	5	15	5	15	515	15	530	565	15	580
35	Vibrating Roller 10 ~ 12t	3,160	97	Hr	1,550	1,710	12	5	60	5	60	1,610	60	1,670	1,770	60	1,830
36	Rock Breaker 800kg	3,680	104	Hr	2,160	2,380	15	5	75	5	75	2,235	75	2,310	2,455	75	2,530
37	Rock Breaker 1300kg	4,090	104	Hr	3,520	3,870	15	5	75	5	75	3,595	75	3,670	3,945	75	4,020
38	Crawler Drill 150kg	5,560	30	Hr	2,720	2,990	5	5	25	5	25	2,745	25	2,770	3,015	25	3,040
39	Compressor 15.0m3/min	1,300	107	day	1,730	1,900	117	5	585	5	585	2,315	585	2,900	2,485	585	3,070
40	Water Tank Lorry 3.8 m3	1,030	118	Hr	300	330	4	5	20	5	20	320	20	340	350	20	370
41	Water Tank Lorry 5.0 m3	1,360	132	Hr	400	440	4	5	20	5	20	420	20	440	460	20	480
42	Agitator Car (Truck Mixer) 1.7 m3	920	138	Hr	220	240	9	5	45	5	45	265	45	310	285	45	330
43	Agitator Car (Truck Mixer) 3.2 m3	1,340	162	Hr	340	370	11	5	55	5	55	395	55	450	425	55	480
44	Agitator Car (Truck Mixer) 4.5 m3	2,040	213	Hr	500	550	14	5	70	5	70	570	70	640	620	70	690
45	Agitator Car 5 m3 (without Truck)	2,470	22	Hr	1,060	1,170	2	5	10	5	10	1,070	10	1,080	1,180	10	1,190
46	Concrete Mixer 0.5m3	500	4.8	Hr	1,400	1,540	1	5	5	5	5	1,405	5	1,410	1,545	5	1,550
47	Concrete Plant 1.0*2 m3 (25~30m3/l	6,890	56	Hr	1,760	1,940	4	5	20	5	20	1,780	20	1,800	1,960	20	1,980
48	Concrete Plant 0.75*3 m3 (45m3/h	11,070	75	Hr	2,840	3,120	5	5	25	5	25	2,865	25	2,890	3,145	25	3,170
49	Concrete Pump 30m3/h	3,180	103	Hr	750	830	7	5	35	5	35	785	35	820	865	35	900
50	Concrete Pum Pipe 90-100m3/hr.	5,070	141	Hr	1,600	1,760	9	5	45	5	45	1,645	45	1,690	1,805	45	1,850
51	Concrete Pum Boom 90-110 m3/hr.	7,310	199	Hr	1,730	1,900	13	5	65	5	65	1,795	65	1,860	1,965	65	2,030
52	Pile Driver for 500~600mm 3.5t	2,290	107	day	4,650	5,120	48	5	240	5	240	4,890	240	5,130	5,360	240	5,600
53	Vibratory Hammer 30kw (141Kw)	10,160	141	day	11,610	12,770	302	0	0	3	906	11,610	906	12,516	12,770	906	13,676
54	Vibratory Compactor 100kg (gasolin	52	4	day	130	140	7	6	42	6	42	172	42	214	182	42	224

Table 11.4.2.(1)-3 Basic Rate & Operation Cost of Construction Equipment

Unit : Baht

No.	Item	Construction Equipment (F.C.)					Fuel Cost (l/Hr or l/7Hr/day)					Operation Cost of Construction Equipment					
		Capital Cost	Power	Unit	Basic Rate	Basic Rate	Oil or Power	Foreign Currency		Local Currency		Common Works (Baht/(Hr or day))			Tunnel Works (Baht/(Hr or day))		
		(1,000 Baht)	(PS,Kw)		(Baht)	or Tunnel (Baht	little or Kw	Basic Rate	Cost(Baht)	Basic Rate	Cost(Baht)	F.C.	L.C.	Total Cost	F.C.	L.C.	Total Cost
55	Sand Pump ϕ 100 H=10m (gasoline	46	5.5	day	110	120	15	6	90	6	90	200	90	290	210	90	300
56	Sand Pump ϕ 100 H=25m (gasoline	91	11	day	220	240	29	6	174	6	174	394	174	568	414	174	588
57	Blower 65m3 1.1kg/cm2	4,360	150	day	4,570	5,030	123	5	615	5	615	5,185	615	5,800	5,645	615	6,260
58	Diesel Generator 45KVA	440	41.9	day	710	780	38	5	190	5	190	900	190	1,090	970	190	1,160
59	Diesel Generator 75KVA	690	68.8	day	1,110	1,220	62	5	310	5	310	1,420	310	1,730	1,530	310	1,840
60	Soft Rock Tunnel Cutter 200kw	24,220	224	Hr	0	8,450	31	5	155	5	155	0	0	0	8,605	155	8,760
61	Jumbo Drill, Crawler 2Booms, 150k	16,180	51	Hr	0	7,200	7	5	35	5	35	0	0	0	7,235	35	7,270
62	Shotcrete Shooter (Wet 10~15m3/hr	4,310	30	Hr	0	3,080	5	5	25	5	25	0	0	0	3,105	25	3,130
63	Shotcrete Robot Shot Radius 8m	2,580	11	Hr	0	2,160	2	5	10	5	10	0	0	0	2,170	10	2,180
64	Dust Collector 300m3/hr, 30kw	1,750	30	Hr	0	1,290	21	0	0	3	63	0	0	0	1,290	63	1,353
65	Accelerator Supplier 5.5kw	730	5.5	day	0	1,130	18	0	0	3	54	0	0	0	1,130	54	1,184
66	Grout Mixer 100liter Type	60	2	day	80	110	3	5	15	5	15	95	15	110	125	15	140
67	Grout Pump Single, 15~30liter/min	140	2.4	day	220	280	3	5	15	5	15	235	15	250	295	15	310
68	Vibrator Converter 60mm	40	1.1	day	70	90	3	6	18	6	18	88	18	106	108	18	126

(b) Estimation of Construction Cost

The construction cost for the Project is estimated based on the Bill of Quantity for 11 construction diversions as shown in the supporting report and summarized in Table 11.4.2.(1)-4.

The total construction cost of the Project is 32,219 million Baht consisting of the foreign currency of 24,987 million Baht and the local currency of 7,232 million Baht.

Table 11.4.2.(1)-4 Construction Cost

(1,000Baht)

Item	Unit	Project Cost × 1,000Baht			Remarks
		F.C.	L.C.	Total	
B.Q-1 Construction Cost of Kok Intake, Kok Canal & Kok-Ing No.1 Tunnel					
(1) Kok Intake	L.S.	219,445	99,265	318,710	
(2) Kok Open Canal	L.S.	390,282	179,577	569,859	
(3) Kok-Ing No.1 Tunnel	L.S.	827,178	234,790	1,061,968	
(4) Main O/M Office	L.S.	205,590	82,583	288,173	
Sub-Total ("(1)"+~+"(4)")		**1,642,000**	**596,000**	**2,238,000**	**× 1,000Baht**
B.Q-2 Construction Cost of Tak Canal					
(1) Tak Open Canal	L.S.	215,212	78,749	293,961	
(2) Tak Culvert Canal	L.S.	1,412,302	344,944	1,757,246	
Sub-Total ("(1)"+"(2)")		**1,628,000**	**424,000**	**2,052,000**	**× 1,000Baht**
B.Q-3 Construction Cost of Kok-Ing No.2 Tunnel					
(1) Kok-Ing No.2 Tunnel	L.S.	1,414,000	388,000	1,802,000	
Sub-Total		**1,414,000**	**388,000**	**1,802,000**	**× 1,000Baht**
B.Q-4 Construction Cost of Ing Canal & Ing Weir/Intake					
(1) Ing Open Canal	L.S.	623,834	242,894	866,728	
(2) Ing Culvert Canal	L.S.	246,877	67,967	314,844	
(3) Ing Weir	L.S.	273,904	79,767	353,671	
(4) Ing Intake	L.S.	277,992	121,150	399,142	
Sub-Total ("(1)"+~+"(4)")		**1,423,000**	**512,000**	**1,935,000**	**× 1,000Baht**
B.Q-5 Construction Cost of Ing-Yot Canal & Ing-Yot No.1 Tunnel					
(1) Ing-Yot Open Canal	L.S.	65,564	15,921	81,485	
(2) Ing-Yot Culvert Canal (1)	L.S.	1,434,946	342,254	1,777,200	
(3) Ing-Yot No.1 Tunnel	L.S.	594,877	163,114	757,991	
Sub-Total ("(1)"+~+"(3)")		**2,095,000**	**521,000**	**2,616,000**	**× 1,000Baht**
B.Q-6 Construction Cost of Ing-Yot Culvert & Ing-Yot No.2 Tunnel Div.1					
(1) Ing-Yot Culvert Canal (2)	L.S.	1,434,946	342,254	1,777,200	
(2) Ing-Yot No.2 Tunnel Division 1	L.S.	1,270,858	358,392	1,629,250	
Sub-Total ("(1)"+"(2)")		**2,706,000**	**701,000**	**3,407,000**	**× 1,000Baht**
B.Q-7 Construction Cost of Ing-Yot No.2 Tunnel Div.2 & Div.3					
(1) Ing-Yot No.2 Tunnel Division 2	L.S.	1,389,592	393,885	1,783,477	
(2) Ing-Yot No.2 Tunnel Division 3	L.S.	1,599,635	438,305	2,037,940	
Sub-Total ("(1)"+"(2)")		**2,989,000**	**832,000**	**3,821,000**	**× 1,000Baht**
B.Q-8 Construction Cost of Ing-Yot No.2 Tunnel Div.4 & Div.5					
(1) Ing-Yot No.2 Tunnel Division 4	L.S.	1,940,864	503,636	2,444,500	
(2) Ing-Yot No.2 Tunnel Division 5	L.S.	1,801,914	465,103	2,267,017	
Sub-Total ("(1)"+"(2)")		**3,743,000**	**969,000**	**4,712,000**	**× 1,000Baht**
B.Q-9 Construction Cost of Ing-Yot No.2 Tunnel Div.6 & Div.7					
(1) Ing-Yot No.2 Tunnel Division 6	L.S.	1,837,916	481,022	2,318,938	
(2) Ing-Yot No.2 Tunnel Division 7	L.S.	1,704,036	441,895	2,145,931	
Sub-Total ("(1)"+"(2)")		**3,542,000**	**923,000**	**4,465,000**	**× 1,000Baht**
B.Q-10 Construction Cost of Ing-Yot No.2 Tunnel Div.8 & Div.9					
(1) Ing-Yot No.2 Tunnel Division 8	L.S.	1,357,340	377,450	1,734,790	
(2) Ing-Yot No.2 Tunnel Division 9	L.S.	1,272,688	359,035	1,631,723	
Sub-Total ("(1)"+"(2)")		**2,630,000**	**736,000**	**3,366,000**	**× 1,000Baht**
B.Q-11 Construction Cost of Yao Dam & Yot and Yao River Training					
(1) River Diversion Works	L.S.	72,574	35,001	107,575	
(2) Intake Works	L.S.	91,716	41,281	132,997	
(3) Outlet Works	L.S.	67,179	27,584	94,763	
(4) Coffer Dam	L.S.	26,029	15,202	41,231	
(5) Main Dam	L.S.	126,737	44,219	170,956	
(6) Spillway	L.S.	378,078	125,898	503,976	
(7) Control House Yard	L.S.	30,324	16,367	46,691	
(8) Yot River Training	L.S.	90,307	17,516	107,823	
(9) Flood Protection Dike	L.S.	96,247	31,030	127,277	
(10) River Improvement	L.S.	195,603	276,177	471,780	
Sub-Total ("(1)"+~+"(10)")		**1,175,000**	**630,000**	**1,805,000**	**× 1,000Baht**
Total ("B.Q-1"+~+"B.Q-11")		**24,987,000**	**7,232,000**	**32,219,000**	**without Tax**

Table B,Q-1 Construction Cost of Kok Intake, Kok Canal & Kok-Ing No.1 Tunnel

(1/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Kok Intake								
1-1 Temporary Works	%	"1-2 (16)"×5%	5%	5%	9,500	4,297	13,797	
1-2 Direct Construction Cost								
(1) Site Clearing	ha	13	-	34,400	-	447	447	
(2) Stripping	m^3	65,000	53	6	3,445	390	3,835	
(3) Excavation, Common	m^3	500,000	61	7	30,500	3,500	34,000	
(4) Fill & Backfill	m^3	173,000	48	6	8,304	1,038	9,342	
(5) Concrete Pile ϕ 600	m	4,500	174	1,566	783	7,047	7,830	
(6) Steel Sheet Pile	m^2	1,700	4,050	450	6,885	765	7,650	
(7) Plain Concrete at Canal Slope	m^3	36,000	1,370	666	49,320	23,976	73,296	
(8) Structure Concrete	m^3	18,000	1,529	972	27,522	17,496	45,018	
(9) Form work	m^2	11,000	104	401	1,144	4,411	5,555	
(10) Reinforced Bar	ton	1,500	20,691	2,739	31,037	4,109	35,146	
(11) Intake Gate	ton	139	90,000	60,000	12,510	8,340	20,850	
(12) Trash Rack	ton	221	18,000	12,000	3,978	2,652	6,630	
(13) Stoplog	ton	92	60,000	40,000	5,520	3,680	9,200	
(14) Control house	m^2	500	-	8,000	-	4,000	4,000	
(15) Miscellaneous	%	5			9,047	4,093	13,140	
(16) Subtotal ("(1)"+–+"(15)")					189,995	85,944	275,939	
1-3 Subtotal ("1-1"+"1-2")					199,495	90,241	289,736	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	19,950	9,024	28,974	
1-5 Subtotal ("1-3"+"1-4")					**219,445**	**99,265**	**318,710**	
2 Kok Open Canal								
2-1 Temporary Works	%	"2-2 (18)"×5%	5%	5%	16,895	7,774	24,669	
2-2 Direct Construction Cost								
(1) Site Clearing	ha	120	0	34,400	0	4,128	4,128	
(2) Stripping	m^3	193,000	53	6	10,229	1,158	11,387	
(3) Excavation, Common	m^3	1,916,000	61	7	116,876	13,412	130,288	
(4) Fill & Backfill	m^3	274,000	48	6	13,152	1,644	14,796	
(5) Laterite Paving	m^3	17,900	22	198	394	3,544	3,938	
(6) Lining Concrete	m^3	53,260	1,370	666	72,966	35,471	108,437	
(7) Structure Concrete	m^3	15,980	1,529	972	24,433	15,533	39,966	
(8) Form work	m^2	16,880	104	401	1,756	6,769	8,525	
(9) Reinforced Bar	ton	1,780	20,691	2,739	36,830	4,875	41,705	
(10) Overchute	No.	29	L.S.	L.S.	4,000	9,000	13,000	
(11) Highway Bridge	No.	3	L.S.	L.S.	16,000	7,000	23,000	
(12) Roadway Bridge	No.	7	L.S.	L.S.	7,000	17,000	24,000	
(13) Farm & O/M Roadway Bridge	No.	14	L.S.	L.S.	10,000	23,000	33,000	
(14) Drainage Culvert	No.	1	L.S.	L.S.	1,000	2,000	3,000	
(15) Check Structure (Gate)	No.	1	L.S.	L.S.	7,000	3,000	10,000	
(16) Turn-out	No.	6	30,000	90,000	180	540	720	
(17) Miscellaneous	%	5			16,091	7,404	23,495	
(18) Subtotal ("(1)"+–+"(17)")					337,907	155,478	493,385	
2-3 Subtotal ("2-1"+"2-2")					354,802	163,252	518,054	
2-4 Overhead Cost ("2-3"×10%)	%		10%	10%	35,480	16,325	51,805	
2-5 Subtotal ("2-3"+"2-4")					**390,282**	**179,577**	**569,859**	

Table B,Q-1 Construction Cost of Kok Intake, Kok Canal & Kok-Ing No.1 Tunnel

(2/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
3 Kok-Ing No.1 Tunnel								
3-1 Common Temporary Works	L.S.	"3-2 (7)"×5%	5%	5%	32,671	6,949	39,620	
3-2 Direct Construction Cost								
(1) Excavation	m	3,046.99	L.S.	L.S.	129,875	12,402	142,277	
(2) Shotcrete	m	3,046.99	L.S.	L.S.	97,556	19,201	116,757	
(3) Rock Bolts	m	3,046.99	L.S.	L.S.	119,164	33,468	152,632	
(4) Steel Support	m	3,046.99	L.S.	L.S.	166,483	18,121	184,604	
(5) Concrete Lining	m	3,046.99	L.S.	L.S.	139,432	51,543	190,975	
(6) Drain Pipe	m	3,046.99	L.S.	L.S.	900	4,250	5,150	
(7) Subtotal ("(1)"+ ~ +"(6)")					653,410	138,985	792,395	
3-3 Subtotal ("3-1"+"3-2")					686,081	145,934	832,015	
3-4 Temporary Works								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	12,346	58,885	71,231	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	53,553	8,626	62,179	
(3) Subtotal ("(1)"+"(2)")					65,899	67,511	133,410	
3-5 Subtotal ("3-3"+"3-4")					751,980	213,445	965,425	
3-6 Overhead Cost ("3-5"×10%)	%		10%	10%	75,198	21,345	96,543	
3-7 Subtotal ("3-5"+"3-6")					**827,178**	**234,790**	**1,061,968**	
4 Main O/M Office								
4-1 Common Temporary Works	L.S.	"4-2 (7)"×5%	5%	5%	8,900	3,575	12,475	
4-2 Direct Construction Cost								
(1) Main Office	m2	2,000	0	8,000	0	16,000	16,000	
(2) Residential Quarters (150m*20m)	m2	3,000	0	12,000	0	36,000	36,000	150m×20m
(3) Repair Shop	m2	1,000	0	5,000	0	5,000	5,000	
(4) Store Shop	m2	2,000	0	5,000	0	10,000	10,000	
(5) Motor Pool	m2	3,000	0	1,500	0	4,500	4,500	
(6) Others (Control System Equipment)	L.S.	-	L.S.	0	178,000	0	178,000	
(7) Subtotal ("(1)"+ ~ +"(6)")					178,000	71,500	249,500	
4-3 Subtotal ("4-1"+"4-2")					186,900	75,075	261,975	
4-4 Overhead Cost ("4-3"×10%)	%		10%	10%	18,690	7,508	26,198	
4-5 Subtotal ("4-3"+"4-4")					**205,590**	**82,583**	**288,173**	
5 Sub-Total ("1"+~+"4")					**1,642,000**	**596,000**	**2,238,000**	
6 Taxes ("5"×7%)	7%		7%	7%	**115,000**	**42,000**	**157,000**	
7 Total Cost ("5"+"6")					**1,757,000**	**638,000**	**2,395,000**	**×1,000Baht**

Table B,Q-2 Construction Cost of Tak Canal

(1/1)

Item	Unit	Quantity	Rate		Cost × 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Tak Open Canal								
1-1 Temporary Works	%	"1-2 (14)"×5%	5%	5%	9,317	3,409	12,726	
1-2 Direct Construction Cost								
(1) Site Clearing	ha	70	0	34,400	0	2,408	2,408	
(2) Stripping	m^3	119,000	53	6	6,307	714	7,021	
(3) Excavation, Common	m^3	1,581,000	61	7	96,441	11,067	107,508	
(4) Fill & Backfill	m^3	155,000	48	6	7,440	930	8,370	
(5) Laterite Paving	m^3	8,700	22	198	191	1,723	1,914	
(6) Lining Concrete	m^3	31,400	1,370	666	43,018	20,912	63,930	
(7) Overchute	No.	5	L.S.	L.S.	1,000	2,000	3,000	
(8) Highway Bridge	No.	1	L.S.	L.S.	8,000	4,000	12,000	
(9) Road way Bridge	No.	2	L.S.	L.S.	3,000	6,000	9,000	
(10) Farm Roadway Bridge	No.	6	L.S.	L.S.	5,000	12,000	17,000	
(11) Check Structure (Gate)	No.	1	L.S.	L.S.	7,000	3,000	10,000	
(12) Turn-out	No.	2	30,000	90,000	60	180	240	
(13) Miscellaneous	%	5			8,873	3,247	12,120	
(14) Subtotal ("(1)"+~+"(13)")					186,330	68,181	254,511	
1-3 Subtotal ("1-1"+"1-2")					195,647	71,590	267,237	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	19,565	7,159	26,724	
1-5 Subtotal ("1-3"+"1-4")					**215,212**	**78,749**	**293,961**	
2 Tak Culvert Canal								
2-1 Temporary Works	%	"2-2 (12)"×5%	5%	5%	61,139	14,933	76,072	
2-2 Direct Construction Cost								
(1) Site Clearing	ha	40	0	34,400	0	1,376	1,376	
(2) Stripping	m^3	160,000	53	6	8,480	960	9,440	
(3) Excavation, Common	m^3	3,099,000	46	5	142,554	15,495	158,049	
(4) Excavation, Weathered Rock	m^3	770,000	87	9	66,990	6,930	73,920	
(5) Excavation, Rock	m^3	203,000	525	31	106,575	6,293	112,868	
(6) Backfill	m^3	3,568,000	48	6	171,264	21,408	192,672	
(7) Laterite Paving	m^3	8,060	22	198	177	1,596	1,773	
(8) Culvert Concrete	m^3	169,580	1,529	972	259,288	164,832	424,120	
(9) Form work	m^2	29,360	104	401	3,053	11,773	14,826	
(10) Reinforced Bar	ton	19,630	20,691	2,739	406,164	53,767	459,931	
(11) Miscellaneous	%	5			58,227	14,222	72,449	
(12) Subtotal ("(1)"+~+"(11)")					1,222,772	298,652	1,521,424	
2-3 Subtotal ("2-1"+"2-2")					1,283,911	313,585	1,597,496	
2-4 Overhead Cost ("2-3"×10%)	%		10%	10%	128,391	31,359	159,750	
2-5 Subtotal ("2-3"+"2-4")					**1,412,302**	**344,944**	**1,757,246**	
3 Sub-Total ("1"+"2")					**1,628,000**	**424,000**	**2,052,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**114,000**	**30,000**	**144,000**	
5 Total Cost ("3"+"4")					**1,742,000**	**454,000**	**2,196,000**	× 1,000Baht

Table B,Q-3 Construction Cost of Kok-Ing No.2 Tunnel

(1/1)

Item	Unit	Quantity	Rate		Cost x 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
Kok-Ing No.2 Tunnel								
1 Common Temporary Works	L.S.	"2-7"×5%	5%	5%	57,344	12,135	69,479	
2 Direct Construction Cost								
2-1 Excavation	m	5,415.02	L.S.	L.S.	241,093	22,252	263,345	
2-2 Shotcrete	m	5,415.02	L.S.	L.S.	172,157	33,745	205,902	
2-3 Rock Bolts	m	5,415.02	L.S.	L.S.	206,099	57,902	264,001	
2-4 Steel Support	m	5,415.02	L.S.	L.S.	278,723	30,360	309,083	
2-5 Concrete Lining	m	5,415.02	L.S.	L.S.	247,204	90,881	338,085	
2-6 Drain Pipe	m	5,415.02	L.S.	L.S.	1,603	7,569	9,172	
2-7 Subtotal ("2-1"+ ~ +"2-6")					1,146,879	242,709	1,389,588	
3 Subtotal ("1"+"2")					1,204,223	254,844	1,459,067	
4 Temporary Works								
4-1 Temporary Works of Inside Tunnel			L.S.	L.S.	21,779	88,843	110,622	
4-2 Temporary Works of Outside Tunnel			L.S.	L.S.	59,875	9,214	69,089	
4-3 Subtotal ("4-1"+"4-2")					81,654	98,057	179,711	
5 Subtotal ("3"+"4")					1,285,877	352,901	1,638,778	
6 Overhead Cost ("5"×10%)	%		10%	10%	128,588	35,290	163,878	
7 Subtotal ("5"+"6")					**1,414,000**	**388,000**	**1,802,000**	
8 Taxes ("7"×7%)	7%		7%	7%	**99,000**	**27,000**	**126,000**	
9 Total Cost ("7"+"8")					**1,513,000**	**415,000**	**1,928,000**	x 1,000Baht

Table B,Q-4 Construction Cost of Ing Canal & Ing Weir

(1/2)

Item	Unit	Quantity	Rate		Cost × 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing Open Canal								
1-1 Temporary Works	%	"1-2 (19)"×5%	5%	5%	27,006	10,515	37,521	
1-2 Direct Construction Cost								
(1) Site Clearing	ha	256	0	34,400	0	8,806	8,806	
(2) Stripping	m^3	425,220	53	6	22,537	2,551	25,088	
(3) Excavation, Common	m^3	3,779,600	61	7	230,556	26,457	257,013	
(4) Fill & Backfill	m^3	1,040,800	48	6	49,958	6,245	56,203	
(5) Laterite Paving	m^3	37,400	22	198	823	7,405	8,228	
(6) Lining Concrete	m^3	99,520	1,370	666	136,342	66,280	202,622	
(7) Structure Concrete	m^3	0	1,529	972	0	0	0	
(8) Form work	m^2	0	104	401	0	0	0	
(9) Reinforced Bar	ton	0	20,691	2,739	0	0	0	
(10) Overchute	No.	12	L.S.	L.S.	2,000	5,000	7,000	
(11) Highway Bridge	No.	2	L.S.	L.S.	12,000	6,000	18,000	
(12) Roadway Bridge	No.	18	L.S.	L.S.	15,000	34,000	49,000	
(13) Farm & O/M Roadway Bridge	No.	14	L.S.	L.S.	8,000	19,000	27,000	
(14) Drain Culvert	No.	12	L.S.	L.S.	2,000	3,000	5,000	
(15) Drops	No.	2	L.S.	L.S.	14,000	6,000	20,000	
(16) Check Structure (Gate)	No.	3	L.S.	L.S.	21,000	9,000	30,000	
(17) Turn-out	No.	6	30,000	90,000	180	540	720	
(18) Miscellaneous	%	5			25,720	10,014	35,734	
(19) Subtotal ("(1)"+~+"(18)")					540,116	210,298	750,414	
1-3 Subtotal ("1-1"+"1-2")					567,122	220,813	787,935	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	56,712	22,081	78,793	
1-5 Subtotal ("1-3"+"1-4")					**623,834**	**242,894**	**866,728**	
2 Ing Culvert Canal								
2-1 Temporary Works	%	"2-2 (12)"×5%	5%	5%	10,687	2,942	13,629	
2-2 Direct Construction Cost								
(1) Site Clearing	ha	6	0	34,400	0	206	206	
(2) Stripping	m^3	27,200	53	6	1,442	163	1,605	
(3) Excavation, Common	m^3	400,000	46	5	18,400	2,000	20,400	
(4) Excavation, Weathered Rock	m^3	100,000	87	9	8,700	900	9,600	
(5) Excavation, Rock	m^3	26,300	525	31	13,808	815	14,623	
(6) Backfill	m^3	411,600	48	6	19,757	2,470	22,227	
(7) Laterite Paving	m^3	2,100	22	198	46	416	462	
(8) Culvert Concrete	m^3	36,000	1,529	972	55,044	34,992	90,036	
(9) Form work	m^2	6,840	104	401	711	2,743	3,454	
(10) Reinforced Bar	ton	4,140	20,691	2,739	85,661	11,339	97,000	
(11) Miscellaneous	%	5			10,178	2,802	12,980	
(12) Subtotal ("(1)"+~+"(11)")					213,747	58,846	272,593	
2-3 Subtotal ("2-1"+"2-2")					224,434	61,788	286,222	
2-4 Overhead Cost ("2-3"×10%)	%		10%	10%	22,443	6,179	28,622	
2-5 Subtotal ("2-3"+"2-4")					**246,877**	**67,967**	**314,844**	

Table B,Q-4 Construction Cost of Ing Canal & Ing Weir

(2/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
3 Ing Weir								
3-1 Temporary Works	%	"3-2 (17)"×5%	5%	5%	11,857	3,453	15,310	
3-2 Direct Construction Cost								
(1) Clearing	ha	6	0	34,400	0	206	206	
(2) Stripping	m^3	29,000	53	6	1,537	174	1,711	
(3) Excavation, Common	m^3	110,000	61	7	6,710	770	7,480	
(4) Excavation, River Training	m^3	1,000,000	61	7	61,000	7,000	68,000	
(5) Fill & Backfill	m^3	120,000	48	6	5,760	720	6,480	
(6) Concrete Pile ϕ 600	m	3,200	174	1,566	557	5,011	5,568	
(7) Steel Sheet Pile	m^2	1,800	4,050	450	7,290	810	8,100	
(8) Foundation Concrete	m^3	25,000	1,393	670	34,825	16,750	51,575	
(9) Structure Concrete	m^3	20,000	1,529	972	30,580	19,440	50,020	
(10) Form work	m^2	9,800	104	401	1,019	3,930	4,949	
(11) Reinforced Bar	ton	1,600	20,691	2,739	33,106	4,382	37,488	
(12) Rubber Gate 32m×3.3m×2span	L.S.	2	21,000,000	2,000,000	42,000	4,000	46,000	
(13) Control Gate	ton	11	90,000	60,000	990	660	1,650	
(14) Stoplog	ton	8	60,000	40,000	480	320	800	
(15) Control House	m2	200	0	8,000	0	1,600	1,600	
(16) Miscellaneous	%	5			11,293	3,289	14,582	
(17) Subtotal ("(1)"+~+"(16)")					237,147	69,062	306,209	
3-3 Subtotal ("3-1"+"3-2")					249,004	72,515	321,519	
3-4 Overhead Cost ("3-3"×10%)	%		10%	10%	24,900	7,252	32,152	
3-5 Subtotal ("3-3"+"3-4")					**273,904**	**79,767**	**353,671**	
4 Ing Intake								
4-1 Temporary Works	%	"4-2 (16)"×5%	5%	5%	12,034	5,245	17,279	
4-2 Direct Construction Cost								
(1) Site Clearing	ha	17.5	0	34,400	0	602	602	
(2) Stripping	m^3	88,000	53	6	4,664	528	5,192	
(3) Excavation, Common	m^3	580,000	61	7	35,380	4,060	39,440	
(4) Fill & Backfill	m^3	360,000	48	6	17,280	2,160	19,440	
(5) Concrete Pile ϕ 600	m	5,200	174	1,566	905	8,143	9,048	
(6) Steel Sheet Pile	m^2	2,000	4,050	450	8,100	900	9,000	
(7) Plain Concrete	m^3	37,000	1,393	670	51,541	24,790	76,331	
(8) Structure Concrete	m^3	25,000	1,529	972	38,225	24,300	62,525	
(9) Form work	m^2	18,600	104	401	1,934	7,459	9,393	
(10) Reinforced Bar	ton	2,000	20,691	2,739	41,382	5,478	46,860	
(11) Intake Gate	ton	169	90,000	60,000	15,210	10,140	25,350	
(12) Trash Rack	ton	438	18,000	12,000	7,884	5,256	13,140	
(13) Stoplog	ton	112	60,000	40,000	6,720	4,480	11,200	
(14) Control House	m2	200	0	8,000	0	1,600	1,600	
(15) Miscellaneous	%	5			11,461	4,995	16,456	
(16) Subtotal ("(1)"+~+"(15)")					240,686	104,891	345,577	
4-3 Subtotal ("4-1"+"4-2")					252,720	110,136	362,856	
4-4 Overhead Cost ("4-3"×10%)	%		10%	10%	25,272	11,014	36,286	
4-5 Subtotal ("4-3"+"4-4")					**277,992**	**121,150**	**399,142**	
5 Sub-Total ("1"+~+"4")					**1,423,000**	**512,000**	**1,935,000**	
6 Taxes ("5"×7%)	7%		7%	7%	**100,000**	**36,000**	**136,000**	
7 Total Cost ("5"+"6")					**1,523,000**	**548,000**	**2,071,000**	×1,000Baht

Table B,Q-5 Construction Cost of Ing-Yot Canal & Ing-Yot No.1 Tunnel

(1/2)

Item	Unit	Quantity	Rate		Cost x 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot Open Canal								
1-1 Temporary Works	%	"1-2 (14)"×5%	5%	5%	2,838	689	3,527	
1-2 Direct Construction Cost								
(1) Site Clearing	ha	19	0	34,400	0	654	654	
(2) Stripping	m^3	50,900	53	6	2,698	305	3,003	
(3) Excavation, Common	m^3	387,300	61	7	23,625	2,711	26,336	
(4) Fill & Backfill	m^3	264,900	48	6	12,715	1,589	14,304	
(5) Laterite Paving	m^3	2,970	22	198	65	588	653	
(6) Lining Concrete	m^3	10,880	1,370	666	14,906	7,246	22,152	
(7) Structure Concrete	m^3	0	1,529	972	0	0	0	
(8) Form work	m^2	0	104	401	0	0	0	
(9) Reinforced Bar	ton	0	20,691	2,739	0	0	0	
(10) Highway Bridge	No.	0	L.S.	L.S.	0	0	0	
(11) Roadway Bridge	No.	0	L.S.	L.S.	0	0	0	
(12) Trashrack	ton	3	18,000	12,000	54	36	90	
(13) Miscellaneous	%	5			2,703	656	3,359	
(14) Subtotal ("(1)"+~+"(13)")					56,766	13,785	70,551	
1-3 Subtotal ("1-1"+"1-2")					59,604	14,474	74,078	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	5,960	1,447	7,407	
1-5 Subtotal ("1-3"+"1-4")					**65,564**	**15,921**	**81,485**	
2 Ing-Yot Culvert Canal (1)								
2-1 Temporary Works	%	"2-2 (12)"×5%	5%	5%	62,119	14,816	76,935	
2-2 Direct Construction Cost								
(1) Site Clearing	ha	29	0	34,400	0	998	998	
(2) Stripping	m^3	139,000	53	6	7,367	834	8,201	
(3) Excavation, Common	m^3	3,268,500	46	5	150,351	16,343	166,694	
(4) Excavation, Weathered Rock	m^3	815,000	87	9	70,905	7,335	78,240	
(5) Excavation, Rock	m^3	215,000	525	31	112,875	6,665	119,540	
(6) Backfill	m^3	3,783,000	48	6	181,584	22,698	204,282	
(7) Laterite Paving	m^3	14,050	22	198	309	2,782	3,091	
(8) Culvert Concrete	m^3	163,650	1,529	972	250,221	159,068	409,289	
(9) Form works	m^2	29,100	104	401	3,026	11,669	14,695	
(10) Reinforced Bar	ton	19,650	20,691	2,739	406,578	53,821	460,399	
(11) Miscellaneous	%	5			59,161	14,111	73,272	
(12) Subtotal ("(1)"+~+"(11)")					1,242,377	296,324	1,538,701	
2-3 Subtotal ("2-1"+"2-2")					1,304,496	311,140	1,615,636	
2-4 Overhead Cost ("2-3"×10%)	%		10%	10%	130,450	31,114	161,564	
2-5 Subtotal ("2-3"+"2-4")					**1,434,946**	**342,254**	**1,777,200**	
3 Ing-Yot No.1 Tunnel								
3-1 Common Temporary Works	L.S.	"3-2 (7)"×5%	5%	5%	23,385	4,960	28,345	
3-2 Direct Construction Cost								
(1) Excavation	m	2,008.213	L.S.	L.S.	98,176	9,028	107,204	
(2) Shotcrete	m	2,008.213	L.S.	L.S.	69,869	13,454	83,323	
(3) Rock Bolts	m	2,008.213	L.S.	L.S.	83,872	23,835	107,707	
(4) Steel Support	m	2,008.213	L.S.	L.S.	117,845	12,738	130,583	
(5) Concrete Lining	m	2,008.213	L.S.	L.S.	97,312	36,742	134,054	
(6) Drain Pipe	m	2,008.213	L.S.	L.S.	621	3,397	4,018	
(7) Subtotal ("(1)"+ ~ +"(6)")					467,695	99,194	566,889	
3-3 Subtotal ("3-1"+"3-2")					491,080	104,154	595,234	

Table B,Q-5 Construction Cost of Ing-Yot Canal & Ing-Yot No.1 Tunnel

(2/2)

Item	Unit	Quantity	Rate		Cost × 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
3-4 Temporary Works								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	8,247	39,265	47,512	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	41,470	4,866	46,336	
(3) Subtotal ("(1)"+"(2)")					49,717	44,131	93,848	
3-5 Subtotal ("3-3"+"3-4")					540,797	148,285	689,082	
3-6 Overhead Cost ("3-5"×10%)	%		10%	10%	54,080	14,829	68,909	
3-7 **Subtotal ("3-5"+"3-6")**					**594,877**	**163,114**	**757,991**	
4 Sub-Total ("1"+—+"3")					**2,095,000**	**521,000**	**2,616,000**	
5 Taxes ("4"×7%)	7%		7%	7%	**147,000**	**36,000**	**183,000**	
6 Total Cost ("4"+"5")					**2,242,000**	**557,000**	**2,799,000**	**× 1,000Baht**

Table B,Q-6 Construction Cost of Ing-Yot Culvert & Ing-Yot No.2 Tunnel Div.1

Item	Unit	Quantity	Rate		Cost × 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot Culvert Canal (2)								
1-1 Temporary Works	%	"1-2 (12)"×5%	5%	5%	62,119	14,816	76,935	
1-2 Direct Construction Cost								
(1) Site Clearing	ha	29	0	34,400	0	998	998	
(2) Stripping	m^3	139,000	53	6	7,367	834	8,201	
(3) Excavation, Common	m^3	3,268,500	46	5	150,351	16,343	166,694	
(4) Excavation, Weathered Rock	m^3	815,000	87	9	70,905	7,335	78,240	
(5) Excavation, Rock	m^3	215,000	525	31	112,875	6,665	119,540	
(6) Backfill	m^3	3,783,000	48	6	181,584	22,698	204,282	
(7) Laterite Paving	m^3	14,050	22	198	309	2,782	3,091	
(8) Culvert Concrete	m^3	163,650	1,529	972	250,221	159,068	409,289	
(9) Form works	m^2	29,100	104	401	3,026	11,669	14,695	
(10) Reinforced Bar	ton	19,650	20,691	2,739	406,578	53,821	460,399	
(11) Miscellaneous	%	5			59,161	14,111	73,272	
(12) Subtotal ("(1)"+~+"(11)")					1,242,377	296,324	1,538,701	
1-3 Subtotal ("1-1"+"1-2")					1,304,496	311,140	1,615,636	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	130,450	31,114	161,564	
1-5 Subtotal ("1-3"+"1-4")					**1,434,946**	**342,254**	**1,777,200**	
2 Ing-Yot No.2 Tunnel Division 1								
2-1 Common Temporary Works	L.S.	"2-2 (7)"×5%	5%	5%	51,498	10,573	62,071	
2-2 Direct Construction Cost								
(1) Excavation	m	4,910.0	L.S.	L.S.	269,566	22,278	291,844	
(2) Shotcrete	m	4,910.0	L.S.	L.S.	149,665	28,732	178,397	
(3) Rock Bolts	m	4,910.0	L.S.	L.S.	169,005	47,115	216,120	
(4) Steel Support	m	4,910.0	L.S.	L.S.	228,340	24,776	253,116	
(5) Concrete Lining	m	4,910.0	L.S.	L.S.	211,874	80,286	292,160	
(6) Drain Pipe	m	4,910.0	L.S.	L.S.	1,514	8,269	9,783	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,029,964	211,456	1,241,420	
2-3 Subtotal ("2-1"+"2-2")					1,081,462	222,029	1,303,491	
2-4 Temporary Works								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	19,759	94,849	114,608	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	54,104	8,933	63,037	
(3) Subtotal ("(1)"+"(2)")					73,863	103,782	177,645	
2-5 Subtotal ("2-3"+"2-4")					1,155,325	325,811	1,481,136	
2-6 Overhead Cost ("2-5"×10%)	%		10%	10%	115,533	32,581	148,114	
2-7 Subtotal ("2-5"+"2-6")					**1,270,858**	**358,392**	**1,629,250**	
3 Sub-Total ("1"+"2")					**2,706,000**	**701,000**	**3,407,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**189,000**	**49,000**	**238,000**	
5 Total Cost ("3"+"4")					**2,895,000**	**750,000**	**3,645,000**	**× 1,000Baht**

Table B,Q-7 Construction Cost of Ing-Yot No.2 Tunnel Div.2 & Div.3 (1/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot No.2 Tunnel, Division 2 with Adit No.1								
1-1 Common Temporary Works	L.S.	"1-2-3"×5%	5%	5%	55,733	11,172	66,905	
1-2 Direct Construction Cost								
1-2-1 Main Tunnel : Div.2 L=4,550.0m								
(1) Excavation	m	4,550.00	L.S.	L.S.	293,315	21,497	314,812	
(2) Shotcrete	m	4,550.00	L.S.	L.S.	114,867	22,333	137,200	
(3) Rock Bolts	m	4,550.00	L.S.	L.S.	125,794	35,261	161,055	
(4) Steel Support	m	4,550.00	L.S.	L.S.	122,610	13,276	135,886	
(5) Concrete Lining	m	4,550.00	L.S.	L.S.	157,141	62,444	219,585	
(6) Drain Pipe	m	4,550.00	L.S.	L.S.	1,385	6,619	8,004	
(7) Subtotal ("(1)"+ ~ +"(6)")					815,112	161,430	976,542	
1-2-2 Adit No.1 L=1,981.99 m								
(1) Excavation	m	1,981.99	L.S.	L.S.	66,336	5,851	72,187	
(2) Shotcrete	m	1,981.99	L.S.	L.S.	47,241	9,117	56,358	
(3) Rock Bolts	m	1,981.99	L.S.	L.S.	55,024	15,642	70,666	
(4) Steel Support	m	1,981.99	L.S.	L.S.	66,087	7,247	73,334	
(5) Concrete Lining	m	1,981.99	L.S.	L.S.	64,398	22,457	86,855	
(6) Drain Pipe	m	1,981.99	L.S.	L.S.	469	1,705	2,174	
(7) Subtotal ("(1)"+ ~ +"(6)")					299,555	62,019	361,574	
1-2-3 Subtotal ("1-2-1" +"1-2-2")					1,114,667	223,449	1,338,116	
1-3 Subtotal ("1-1"+"1-2")					1,170,400	234,621	1,405,021	
1-4 Temporary Works								
1-4-1 Main Tunnel : Div.2 L=4,550.0m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	17,965	79,136	97,101	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	51,780	6,081	57,861	
(3) Subtotal ("(1)"+"(2)")					69,745	85,217	154,962	
1-4-2 Adit No.1 L=1,981.99 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	7,945	32,882	40,827	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	15,175	5,357	20,532	
(3) Subtotal ("(1)"+"(2)")					23,120	38,239	61,359	
1-4-3 Subtotal ("1-4-1"+"1-4-2")					92,865	123,456	216,321	
1-5 Subtotal ("1-3"+"1-4")					1,263,265	358,077	1,621,342	
1-6 Overhead Cost ("1-5"×10%)	%		10%	10%	126,327	35,808	162,135	
1-7 **Subtotal ("1-5"+"1-6")**					**1,389,592**	**393,885**	**1,783,477**	

Table B,Q-7 Construction Cost of Ing-Yot No.2 Tunnel Div.2 & Div.3

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
2 Ing-Yot No.2 Tunnel, Division 3 with Adit No.2								
2-1 Common Temporary Works	L.S.	"2-2-3"×5%	5%	5%	64,283	12,977	77,260	
2-2 Direct Construction Cost								
2-2-1 Main Tunnel : Div.3 L=5,435.0 m								
(1) Excavation	m	5,435.00	L.S.	L.S.	343,666	25,731	369,397	
(2) Shotcrete	m	5,435.00	L.S.	L.S.	144,322	28,101	172,423	
(3) Rock Bolts	m	5,435.00	L.S.	L.S.	161,433	45,527	206,960	
(4) Steel Support	m	5,435.00	L.S.	L.S.	167,680	18,129	185,809	
(5) Concrete Lining	m	5,435.00	L.S.	L.S.	201,775	79,190	280,965	
(6) Drain Pipe	m	5,435.00	L.S.	L.S.	1,662	7,943	9,605	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,020,538	204,621	1,225,159	
2-2-2 Adit No.2 L=1,785.19 m								
(1) Excavation	m	1,785.19	L.S.	L.S.	57,312	5,177	62,489	
(2) Shotcrete	m	1,785.19	L.S.	L.S.	41,316	8,007	49,323	
(3) Rock Bolts	m	1,785.19	L.S.	L.S.	48,930	13,886	62,816	
(4) Steel Support	m	1,785.19	L.S.	L.S.	62,004	6,788	68,792	
(5) Concrete Lining	m	1,785.19	L.S.	L.S.	55,144	19,543	74,687	
(6) Drain Pipe	m	1,785.19	L.S.	L.S.	420	1,522	1,942	
(7) Subtotal ("(1)"+ ~ +"(6)")					265,126	54,923	320,049	
2-2-3 Subtotal ("2-2-1"+"2-2-2")					1,285,664	259,544	1,545,208	
2-3 Subtotal ("2-1"+"2-2")					1,349,947	272,521	1,622,468	
2-4 Temporary Works								
2-4-1 Main Tunnel : Div.3 L=5,435.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	21,139	81,375	102,514	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	54,893	7,050	61,943	
(3) Subtotal ("(1)"+"(2)")					76,032	88,425	164,457	
2-4-2 Adit No.2 L=1,785.19 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	7,215	30,917	38,132	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	21,020	6,596	27,616	
(3) Subtotal ("(1)"+"(2)")					28,235	37,513	65,748	
2-4-3 Subtotal ("2-4-1"+"2-4-2")					104,267	125,938	230,205	
2-5 Subtotal ("2-3"+"2-4")					1,454,214	398,459	1,852,673	
2-6 Overhead Cost ("2-5"×10%)	%		10%	10%	145,421	39,846	185,267	
2-7 Subtotal ("2-5"+"2-6")					**1,599,635**	**438,305**	**2,037,940**	
3 Sub-Total ("1"+"2")					**2,989,000**	**832,000**	**3,821,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**209,000**	**58,000**	**267,000**	
5 Total Cost ("3"+"4")					**3,198,000**	**890,000**	**4,088,000**	×1,000Baht

Table B,Q-8 Construction Cost of Ing-Yot No.2 Tunnel Div.4 & Div.5

(1/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot No.2 Tunnel, Division 4 with Adit No.3								
1-1 Common Temporary Works	L.S.	"1-2-3"×5%	5%	5%	78,446	15,550	93,996	
1-2 Direct Construction Cost								
1-2-1 Main Tunnel : Div.4 L=7,215.0 m								
(1) Excavation	m	7,215.00	L.S.	L.S.	457,973	34,010	491,983	
(2) Shotcrete	m	7,215.00	L.S.	L.S.	181,463	35,580	217,043	
(3) Rock Bolts	m	7,215.00	L.S.	L.S.	204,112	57,096	261,208	
(4) Steel Support	m	7,215.00	L.S.	L.S.	208,888	22,613	231,501	
(5) Concrete Lining	m	7,215.00	L.S.	L.S.	250,552	99,584	350,136	
(6) Drain Pipe	m	7,215.00	L.S.	L.S.	2,196	10,485	12,681	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,305,184	259,368	1,564,552	
1-2-2 Adit No.3 L=2,193.75 m								
(1) Excavation	m	2,193.75	L.S.	L.S.	87,164	6,587	93,751	
(2) Shotcrete	m	2,193.75	L.S.	L.S.	40,022	7,809	47,831	
(3) Rock Bolts	m	2,193.75	L.S.	L.S.	40,662	11,632	52,294	
(4) Steel Support	m	2,193.75	L.S.	L.S.	36,020	3,954	39,974	
(5) Concrete Lining	m	2,193.75	L.S.	L.S.	59,348	19,797	79,145	
(6) Drain Pipe	m	2,193.75	L.S.	L.S.	513	1,857	2,370	
(7) Subtotal ("(1)"+ ~ +"(6)")					263,729	51,636	315,365	
1-2-3 Subtotal ("1-2-1" +"1-2-2")					1,568,913	311,004	1,879,917	
1-3 Subtotal ("1-1"+"1-2")					1,647,359	326,554	1,973,913	
1-4 Temporary Works								
1-4-1 Main Tunnel : Div.4 L=7,215.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	27,558	82,094	109,652	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	63,459	9,555	73,014	
(3) Subtotal ("(1)"+"(2)")					91,017	91,649	182,666	
1-4-2 Adit No.3 L=2,193.75 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	8,725	34,849	43,574	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	17,321	4,799	22,120	
(3) Subtotal ("(1)"+"(2)")					26,046	39,648	65,694	
1-4-3 Subtotal ("1-4-1"+"1-4-2")					117,063	131,297	248,360	
1-5 Subtotal ("1-3"+"1-4")					1,764,422	457,851	2,222,273	
1-6 Overhead Cost ("1-5"×10%)	%		10%	10%	176,442	45,785	222,227	
1-7 **Subtotal ("1-5"+"1-6")**					**1,940,864**	**503,636**	**2,444,500**	

Table B,Q-8 Construction Cost of Ing-Yot No.2 Tunnel Div.4 & Div.5

(2/2)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
2 Ing-Yot No.2 Tunnel, Division 5 with Adit No.4								
2-1 Common Temporary Works	L.S.	"2-2-3"×5%	5%	5%	72,462	14,005	86,467	
2-2 Direct Construction Cost								
2-2-1 Main Tunnel : Div.5 L=6,440.0 m								
(1) Excavation	m	6,440.00	L.S.	L.S.	429,454	30,743	460,197	
(2) Shotcrete	m	6,440.00	L.S.	L.S.	147,777	29,087	176,864	
(3) Rock Bolts	m	6,440.00	L.S.	L.S.	160,922	44,322	205,244	
(4) Steel Support	m	6,440.00	L.S.	L.S.	152,135	16,535	168,670	
(5) Concrete Lining	m	6,440.00	L.S.	L.S.	207,087	83,035	290,122	
(6) Drain Pipe	m	6,440.00	L.S.	L.S.	1,957	9,345	11,302	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,099,332	213,067	1,312,399	
2-2-2 Adit No.4 L=3,171.48 m								
(1) Excavation	m	3,171.48	L.S.	L.S.	127,193	9,374	136,567	
(2) Shotcrete	m	3,171.48	L.S.	L.S.	54,489	10,571	65,060	
(3) Rock Bolts	m	3,171.48	L.S.	L.S.	51,923	14,730	66,653	
(4) Steel Support	m	3,171.48	L.S.	L.S.	36,301	3,981	40,282	
(5) Concrete Lining	m	3,171.48	L.S.	L.S.	79,262	25,711	104,973	
(6) Drain Pipe	m	3,171.48	L.S.	L.S.	740	2,672	3,412	
(7) Subtotal ("(1)"+ ~ +"(6)")					349,908	67,039	416,947	
2-2-3 Subtotal ("2-2-1"+"2-2-2")					1,449,240	280,106	1,729,346	
2-3 Subtotal ("2-1"+"2-2")					1,521,702	294,111	1,815,813	
2-4 Temporary Works								
2-4-1 Main Tunnel : Div.5 L=6,440.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	24,550	70,473	95,023	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	59,211	8,459	67,670	
(3) Subtotal ("(1)"+"(2)")					83,761	78,932	162,693	
2-4-2 Adit No.4 L=3,171.48 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	12,393	42,788	55,181	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	20,248	6,990	27,238	
(3) Subtotal ("(1)"+"(2)")					32,641	49,778	82,419	
2-4-3 Subtotal ("2-4-1"+"2-4-2")					116,402	128,710	245,112	
2-5 Subtotal ("2-3"+"2-4")					1,638,104	422,821	2,060,925	
2-6 Overhead Cost ("2-5"×10%)	%		10%	10%	163,810	42,282	206,092	
2-7 **Subtotal ("2-5"+"2-6")**					**1,801,914**	**465,103**	**2,267,017**	
3 Sub-Total ("1"+"2")					**3,743,000**	**969,000**	**4,712,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**262,000**	**68,000**	**330,000**	
5 Total Cost ("3"+"4")					**4,005,000**	**1,037,000**	**5,042,000**	×1,000Baht

Table B,Q-9 Construction Cost of Ing-Yot No.2 Tunnel Div.6 & Div.7

(1/2)

Item	Unit	Quantity	Rate		Cost × 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot No.2 Tunnel, Division 6 with Adit No.5								
1-1 Common Temporary Works	L.S.	"1-2-3"×5%	5%	5%	74,356	14,776	89,132	
1-2 Direct Construction Cost								
1-2-1 Main Tunnel : Div.6 L=6,400 m								
(1) Excavation	m	6,400.0	L.S.	L.S.	404,516	30,244	434,760	
(2) Shotcrete	m	6,400.0	L.S.	L.S.	162,966	31,712	194,678	
(3) Rock Bolts	m	6,400.0	L.S.	L.S.	179,822	50,233	230,055	
(4) Steel Support	m	6,400.0	L.S.	L.S.	194,403	21,073	215,476	
(5) Concrete Lining	m	6,400.0	L.S.	L.S.	228,087	89,933	318,020	
(6) Drain Pipe	m	6,400.0	L.S.	L.S.	1,952	9,333	11,285	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,171,746	232,528	1,404,274	
1-2-2 Adit No.5 L=2,476.0 m								
(1) Excavation	m	2,476.0	L.S.	L.S.	90,611	7,304	97,915	
(2) Shotcrete	m	2,476.0	L.S.	L.S.	48,683	9,416	58,099	
(3) Rock Bolts	m	2,476.0	L.S.	L.S.	51,545	14,724	66,269	
(4) Steel Support	m	2,476.0	L.S.	L.S.	55,457	6,078	61,535	
(5) Concrete Lining	m	2,476.0	L.S.	L.S.	68,499	23,380	91,879	
(6) Drain Pipe	m	2,476.0	L.S.	L.S.	579	2,094	2,673	
(7) Subtotal ("(1)"+ ~ +"(6)")					315,374	62,996	378,370	
1-2-3 Subtotal ("1-2-1"+"1-2-2")					1,487,120	295,524	1,782,644	
1-3 Subtotal ("1-1"+"1-2")					1,561,476	310,300	1,871,776	
1-4 Temporary Works								
1-4-1 Main Tunnel : Div.6 L=6,400 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	24,525	76,108	100,633	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	59,294	8,516	67,810	
(3) Subtotal ("(1)"+"(2)")					83,819	84,624	168,443	
1-4-2 Adit No.5 L=2,476.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	9,798	36,851	46,649	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	15,740	5,518	21,258	
(3) Subtotal ("(1)"+"(2)")					25,538	42,369	67,907	
1-4-3 Subtotal ("1-4-1"+"1-4-2")					109,357	126,993	236,350	
1-5 Subtotal ("1-3"+"1-4")					1,670,833	437,293	2,108,126	
1-6 Overhead Cost ("1-5"×10%)	%		10%	10%	167,083	43,729	210,812	
1-7 **Subtotal ("1-5"+"1-6")**					**1,837,916**	**481,022**	**2,318,938**	

Table B,Q-9 Construction Cost of Ing-Yot No.2 Tunnel Div.6 & Div.7

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
2 Ing-Yot No.2 Tunnel, Division 7 with Adit No.6								
2-1 Common Temporary Works	L.S.	"2-2-3"×5%	5%	5%	68,092	13,017	81,109	
2-2 Direct Construction Cost								
2-2-1 Main Tunnel : Div.7 L=6,060.0 m								
(1) Excavation	m	6,060.0	L.S.	L.S.	422,984	29,386	452,370	
(2) Shotcrete	m	6,060.0	L.S.	L.S.	137,039	26,763	163,802	
(3) Rock Bolts	m	6,060.0	L.S.	L.S.	142,579	39,677	182,256	
(4) Steel Support	m	6,060.0	L.S.	L.S.	109,995	11,931	121,926	
(5) Concrete Lining	m	6,060.0	L.S.	L.S.	196,823	78,278	275,101	
(6) Drain Pipe	m	6,060.0	L.S.	L.S.	1,843	8,794	10,637	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,011,263	194,829	1,206,092	
2-2-2 Adit No.6 L=3,338.6m								
(1) Excavation	m	3,338.6	L.S.	L.S.	138,135	9,809	147,944	
(2) Shotcrete	m	3,338.6	L.S.	L.S.	52,342	10,402	62,744	
(3) Rock Bolts	m	3,338.6	L.S.	L.S.	48,697	13,607	62,304	
(4) Steel Support	m	3,338.6	L.S.	L.S.	31,013	3,398	34,411	
(5) Concrete Lining	m	3,338.6	L.S.	L.S.	79,608	25,492	105,100	
(6) Drain Pipe	m	3,338.6	L.S.	L.S.	777	2,803	3,580	
(7) Subtotal ("(1)"+ ~ +"(6)")					350,572	65,511	416,083	
2-2-3 Subtotal ("2-2-1"+"2-2-2")					1,361,835	260,340	1,622,175	
2-3 Subtotal ("2-1"+"2-2")					1,429,927	273,357	1,703,284	
2-4 Temporary Works								
2-4-1 Main Tunnel : Div.7 L=6,060.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	23,170	66,556	89,726	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	57,657	7,959	65,616	
(3) Subtotal ("(1)"+"(2)")					80,827	74,515	155,342	
2-4-2 Adit No.6 L=3,338.6m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	12,983	44,729	57,712	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	25,387	9,122	34,509	
(3) Subtotal ("(1)"+"(2)")					38,370	53,851	92,221	
2-4-3 Subtotal ("2-4-1"+"2-4-2")					119,197	128,366	247,563	
2-5 Subtotal ("2-3"+"2-4")					1,549,124	401,723	1,950,847	
2-6 Overhead Cost ("2-5"×10%)	%		10%	10%	154,912	40,172	195,084	
2-7 Subtotal ("2-5"+"2-6")					**1,704,036**	**441,895**	**2,145,931**	
3 Sub-Total ("1"+"2")					**3,542,000**	**923,000**	**4,465,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**248,000**	**65,000**	**313,000**	
5 Total Cost ("3"+"4")					**3,790,000**	**988,000**	**4,778,000**	**×1,000Baht**

Table B,Q-10 Construction Cost of Ing-Yot No.2 Tunnel Div.8 & Div.9 (1/1)

Item	Unit	Quantity	Rate		Cost x 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 Ing-Yot No.2 Tunnel, Division 8 with Adit No.7								
1-1 Common Temporary Works	L.S.	"1-2-3"×5%	5%	5%	53,729	10,235	63,964	
1-2 Direct Construction Cost								
1-2-1 Main Tunnel : Div.8 L=4,950.0 m								
(1) Excavation	m	4,950.00	L.S.	L.S.	343,333	23,971	367,304	
(2) Shotcrete	m	4,950.00	L.S.	L.S.	110,295	21,470	131,765	
(3) Rock Bolts	m	4,950.00	L.S.	L.S.	113,026	31,108	144,134	
(4) Steel Support	m	4,950.00	L.S.	L.S.	94,135	10,247	104,382	
(5) Concrete Lining	m	4,950.00	L.S.	L.S.	159,132	63,110	222,242	
(6) Drain Pipe	m	4,950.00	L.S.	L.S.	1,505	7,182	8,687	
(7) Subtotal ("(1)"+ ~ +"(6)")					821,426	157,088	978,514	
1-2-2 Adit No.7 L=2,431.92m								
(1) Excavation	m	2,431.92	L.S.	L.S.	100,751	7,189	107,940	
(2) Shotcrete	m	2,431.92	L.S.	L.S.	38,211	7,533	45,744	
(3) Rock Bolts	m	2,431.92	L.S.	L.S.	35,968	10,164	46,132	
(4) Steel Support	m	2,431.92	L.S.	L.S.	20,476	2,237	22,713	
(5) Concrete Lining	m	2,431.92	L.S.	L.S.	57,184	18,448	75,632	
(6) Drain Pipe	m	2,431.92	L.S.	L.S.	564	2,037	2,601	
(7) Subtotal ("(1)"+ ~ +"(6)")					253,154	47,608	300,762	
1-2-3 Subtotal ("1-2-1"+"1-2-2")					1,074,580	204,696	1,279,276	
1-3 Subtotal ("1-1"+"1-2")					1,128,309	214,931	1,343,240	
1-4 Temporary Works								
1-4-1 Main Tunnel : Div.8 L=4,950.0 m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	19,373	77,415	96,788	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	52,242	6,509	58,751	
(3) Subtotal ("(1)"+"(2)")					71,615	83,924	155,539	
1-4-2 Adit No.7 L=2,431.92m								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	9,593	36,827	46,420	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	24,428	7,454	31,882	
(3) Subtotal ("(1)"+"(2)")					34,021	44,281	78,302	
1-4-3 Subtotal ("1-4-1"+"1-4-2")					105,636	128,205	233,841	
1-5 Subtotal ("1-3"+"1-4")					1,233,945	343,136	1,577,081	
1-6 Overhead Cost ("1-5"×10%)	%		10%	10%	123,395	34,314	157,709	
1-7 **Subtotal ("1-5"+"1-6")**					**1,357,340**	**377,450**	**1,734,790**	
2 Ing-Yot No.2 Tunnel, Division 9								
2-1 Common Temporary Works	L.S.	"2-2 (7)"×5%	5%	5%	51,207	10,504	61,711	
2-2 Direct Construction Cost								
(1) Excavation	m	4,914.6	L.S.	L.S.	278,043	22,514	300,557	
(2) Shotcrete	m	4,914.6	L.S.	L.S.	147,765	28,489	176,254	
(3) Rock Bolts	m	4,914.6	L.S.	L.S.	167,562	46,896	214,458	
(4) Steel Support	m	4,914.6	L.S.	L.S.	219,319	23,789	243,108	
(5) Concrete Lining	m	4,914.6	L.S.	L.S.	209,935	80,090	290,025	
(6) Drain Pipe	m	4,914.6	L.S.	L.S.	1,517	8,296	9,813	
(7) Subtotal ("(1)"+ ~ +"(6)")					1,024,141	210,074	1,234,215	
2-3 Subtotal ("2-1"+"2-2")					1,075,348	220,578	1,295,926	
2-4 Temporary Works								
(1) Temporary Works of Inside Tunnel			L.S.	L.S.	19,766	94,850	114,616	
(2) Temporary Works of Outside Tunnel			L.S.	L.S.	61,875	10,967	72,842	
(3) Subtotal ("(1)"+"(2)")					81,641	105,817	187,458	
2-5 Subtotal ("2-3"+"2-4")					1,156,989	326,395	1,483,384	
2-6 Overhead Cost ("2-5"×10%)	%		10%	10%	115,699	32,640	148,339	
2-7 **Subtotal ("2-5"+"2-6")**					**1,272,688**	**359,035**	**1,631,723**	
3 Sub-Total ("1"+"2")					**2,630,000**	**736,000**	**3,366,000**	
4 Taxes ("3"×7%)	7%		7%	7%	**184,000**	**52,000**	**236,000**	
5 Total Cost ("3"+"4")					**2,814,000**	**788,000**	**3,602,000**	**x 1,000Baht**

Table B,Q-11 Construction Cost of Yao Dam & Yot and Yao River Training

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
1 River Diversion Works								
1-1 Temporary Works	%	"1-2 (11)"×5%	5%	5%	3,142	1,515	4,657	
1-2 Direct Construction Cost								
(1) Tunnel Excavation	m^3	15,000	1,150	230	17,250	3,450	20,700	
(2) Steel Support	ton	220	22,000	2,000	4,840	440	5,280	
(3) Tunnel Concrete	m^3	4,000	1,470	780	5,880	3,120	9,000	
(4) Steel Liner	ton	610	36,000	27,000	21,960	16,470	38,430	
(5) Plug Concrete	m^3	1,500	1,172	959	1,757	1,438	3,195	
(6) Form works	m^2	7,200	104	401	749	2,887	3,636	
(7) Reinforced Bar	ton	40	20,691	2,739	828	110	938	
(8) Curtain Grout	m	400	2,990	430	1,196	172	1,368	
(9) Consolidation Grout	m	1,800	2,990	430	5,382	774	6,156	
(10) Miscellaneous	%	5			2,992	1,443	4,435	
(11) Subtotal ("(1)"+~+"(10)")					62,834	30,304	93,138	
1-3 Subtotal ("1-1"+"1-2")					65,976	31,819	97,795	
1-4 Overhead Cost ("1-3"×10%)	%		10%	10%	6,598	3,182	9,780	
1-5 Subtotal ("1-3"+"1-4")					**72,574**	**35,001**	**107,575**	
2 Intake Works								
2-1 Temporary Works	%	"2-2 (17)"×5%	5%	5%	3,970	1,787	5,757	
2-2 Direct Construction Cost								
(1) Site Clearing	ha	1.1	-	34,400	-	38	38	
(2) Stripping	m^3	6,000	61	11	366	66	432	
(3) Excavation, Common	m^3	17,000	62	11	1,054	187	1,241	
(4) Excavation, Weathered Rock	m^3	23,000	100	16	2,300	368	2,668	
(5) Excavation, Rock	m^3	29,000	238	30	6,902	870	7,772	
(6) Fill & Backfill	m^3	6,000	54	13	324	78	402	
(7) Plain Concrete	m^3	7,500	1,393	670	10,448	5,025	15,473	
(8) Structure Concrete	m^3	14,000	1,529	972	21,406	13,608	35,014	
(9) Form works	m^2	12,000	104	401	1,248	4,812	6,060	
(10) Reinforced Bar	ton	1,200	20,691	2,739	24,829	3,287	28,116	
(11) Closure Gate	ton	23	60,000	40,000	1,380	920	2,300	
(12) Intake Gate	ton	30	90,000	60,000	2,700	1,800	4,500	
(13) Intake Trash rack	ton	75	18,000	12,000	1,350	900	2,250	
(14) Intake Stoplog	ton	22	60,000	40,000	1,320	880	2,200	
(15) Control House	m2	150	-	8,000	-	1,200	1,200	
(16) Miscellaneous	%	5			3,781	1,702	5,483	
(17) Subtotal ("(1)"+~+"(16)")					79,408	35,741	115,149	
2-3 Subtotal ("2-1"+"2-2")					83,378	37,528	120,906	
2-4 Overhead Cost ("2-3"×10%)	%		10%	10%	8,338	3,753	12,091	
2-5 Subtotal ("2-3"+"2-4")					**91,716**	**41,281**	**132,997**	

Table B,Q-11 Construction Cost of Yao Dam & Yot and Yao River Training

(2/5)

Item	Unit	Quantity	Rate		Cost x 1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
3 Outlet Works								
3-1 Temporary Works	%	"3-2 (15)"×5%	5%	5%	2,908	1,194	4,102	
3-2 Direct Construction Cost								
(1) Site Clearing	ha	2	-	34,400	-	69	69	
(2) Stripping	m^3	10,000	61	11	610	110	720	
(3) Excavation, Common	m^3	34,000	62	11	2,108	374	2,482	
(4) Excavation, Weathered Rock	m^3	14,000	100	16	1,400	224	1,624	
(5) Plain Concrete	m^3	2,800	1,393	670	3,900	1,876	5,776	
(6) Structure Concrete	m^3	11,000	1,529	972	16,819	10,692	27,511	
(7) Form works	m^2	8,500	104	401	884	3,409	4,293	
(8) Reinforced Bar	ton	800	20,691	2,739	16,553	2,191	18,744	
(9) Fixed Roller Gate	ton	30	90,000	60,000	2,700	1,800	4,500	
(10) Stoplog	ton	22	60,000	40,000	1,320	880	2,200	
(11) Hollow Jet Valve 2,000 mm	No.	1	6,300,000	-	6,300	-	6,300	
(12) Guard Valve 1,000 mm	No.	1	2,800,000	-	2,800	-	2,800	
(13) Control House	m^2	140	-	8,000	-	1,120	1,120	
(14) Miscellaneous	%	5			2,770	1,137	3,907	
(15) Subtotal ("(1)"+~+"(14)")					58,164	23,882	82,046	
3-3 Subtotal ("3-1"+"3-2")					61,072	25,076	86,148	
3-4 Overhead Cost ("3-3"×10%)	%		10%	10%	6,107	2,508	8,615	
3-5 Subtotal ("3-3"+"3-4")					**67,179**	**27,584**	**94,763**	
4 Coffer Dam								
4-1 Temporary Works	%	"4-2 (10)"×5%	5%	5%	1,127	658	1,785	
4-2 Direct Construction Cost								
(1) Site Clearing	ha	1	-	34,400	-	34	34	
(2) Stripping	m^3	6,000	61	11	366	66	432	
(3) Excavation, Common	m^3	29,000	62	11	1,798	319	2,117	
(4) Excavation, Weathered Rock	m^3	12,000	100	16	1,200	192	1,392	
(5) Embankment, Core	m^3	39,000	123	20	4,797	780	5,577	
(6) Embankment Filter	m^3	36,000	72	234	2,592	8,424	11,016	
(7) Embankment Rock	m^3	150,000	63	16	9,450	2,400	11,850	
(8) Embankment Riprap	m^3	20,000	63	16	1,260	320	1,580	
(9) Miscellaneous	%	5			1,073	627	1,700	
(10) Subtotal ("(1)"+~+"(9)")					22,536	13,162	35,698	
4-3 Subtotal ("4-1"+"4-2")					23,663	13,820	37,483	
4-4 Overhead Cost ("4-3"×10%)	%		10%	10%	2,366	1,382	3,748	
4-5 Subtotal ("4-3"+"4-4")					**26,029**	**15,202**	**41,231**	

Table B,Q-11 Construction Cost of Yao Dam & Yot and Yao River Training

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
5 Main Dam								
5-1 Temporary Works	%	"5-2 (13)"×5%	5%	5%	5,486	1,914	7,400	
5-2 Direct Construction Cost								
(1) Site Clearing	ha	6	-	34,400	-	206	206	
(2) Stripping	m^3	31,000	61	11	1,891	341	2,232	
(3) Excavation, Common	m^3	84,000	62	11	5,208	924	6,132	
(4) Excavation Weathered Rock	m^3	36,000	100	16	3,600	576	4,176	
(5) Embankment, Core	m^3	95,000	123	20	11,685	1,900	13,585	
(6) Embankment Filter	m^3	85,000	72	234	6,120	19,890	26,010	
(7) Embankment Random	m^3	260,000	15	5	3,900	1,300	5,200	
(8) Embankment Rock	m^3	250,000	13	5	3,250	1,250	4,500	
(9) Embankment Riprap	m^3	25,000	63	16	1,575	400	1,975	
(10) Curtain Grout	m	18,000	2,990	430	53,820	7,740	61,560	
(11) Blanket Grout	m	4,500	2,990	430	13,455	1,935	15,390	
(12) Miscellaneous	%	5			5,225	1,823	7,048	
(13) Subtotal ("(1)"+~+"(12)")					109,729	38,285	148,014	
5-3 Subtotal ("5-1"+"5-2")					115,215	40,199	155,414	
5-4 Overhead Cost ("5-3"×10%)	%		10%	10%	11,522	4,020	15,542	
5-5 Subtotal ("5-3"+"5-4")					**126,737**	**44,219**	**170,956**	
6 Spillway								
6-1 Temporary Works	%	"6-2 (13)"×5%	5%	5%	16,367	5,450	21,817	
6-2 Direct Construction Cost								
(1) Site Clearing	ha	6	-	34,400	-	206	206	
(2) Stripping	m^3	28,000	61	11	1,708	308	2,016	
(3) Excavation, Common	m^3	475,000	68	12	32,300	5,700	38,000	
(4) Excavation weathered Rock	m^3	285,000	107	17	30,495	4,845	35,340	
(5) Excavation Rock	m^3	190,000	246	32	46,740	6,080	52,820	
(6) Backfill	m^3	21,000	54	13	1,134	273	1,407	
(7) Plain Concrete	m^3	43,000	1,370	666	58,910	28,638	87,548	
(8) Structure Concrete	m^3	36,000	1,529	972	55,044	34,992	90,036	
(9) Form work	m^2	29,000	104	401	3,016	11,629	14,645	
(10) Reinforced Bar	ton	3,000	20,691	2,739	62,073	8,217	70,290	
(11) Curtain Grout	m	6,800	2,990	430	20,332	2,924	23,256	
(12) Miscellaneous	%	5			15,588	5,191	20,779	
(13) Subtotal ("(1)"+~+"(12)")					327,340	109,003	436,343	
6-3 Subtotal ("6-1"+"6-2")					343,707	114,453	458,160	
6-4 Overhead Cost ("6-3"×10%)	%		10%	10%	34,371	11,445	45,816	
6-5 Subtotal ("6-3"+"6-4")					**378,078**	**125,898**	**503,976**	

Table B,Q-11 Construction Cost of Yao Dam & Yot and Yao River Training

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
7 Control House Yard								
7-1 Temporary Works	%	"7-2 (10)"×5%	5%	5%	1,313	709	2,022	
7-2 Direct Construction Cost								
(1) Site Clearing	ha	3	-	34,400	-	103	103	
(2) Stripping	m^3	15,000	61	11	915	165	1,080	
(3) Excavation, Common	m^3	144,000	68	12	9,792	1,728	11,520	
(4) Excavation Weathered Rock	m^3	110,000	107	17	11,770	1,870	13,640	
(5) Backfill	m^3	2,000	54	13	108	26	134	
(6) Plain Concrete	m^3	1,500	1,370	666	2,055	999	3,054	
(7) Form work	m^2	3,500	104	401	364	1,404	1,768	
(8) Control House	m^2	900	-	8,000	-	7,200	7,200	
(9) Miscellaneous	%	5			1,250	675	1,925	
(10) Subtotal ("(1)"+~+"(9)")					26,254	14,170	40,424	
7-3 Subtotal ("7-1"+"7-2")					27,567	14,879	42,446	
7-4 Overhead Cost ("7-3"×10%)	%		10%	10%	2,757	1,488	4,245	
7-5 Subtotal ("7-3"+"7-4")					**30,324**	**16,367**	**46,691**	
8 Yot River Training								
8-1 Temporary Works	%	"8-2 (7)"×5%	5%	5%	3,909	758	4,667	
8-2 Direct Construction Cost								
(1) Site Clearing	ha	13	-	34,400	-	447	447	
(2) Excavation, Common	m^3	729,000	61	7	44,469	5,103	49,572	
(3) Excavation, Weathered Rock	m^3	238,000	100	16	23,800	3,808	27,608	
(4) Plain Concrete	m^3	4,000	1,393	670	5,572	2,680	8,252	
(5) Form work	m^2	6,000	104	401	624	2,406	3,030	
(6) Miscellaneous	%	5			3,723	722	4,445	
(7) Subtotal ("(1)"+~+"(6)")					78,188	15,166	93,354	
8-3 Subtotal ("8-1"+"8-2")					82,097	15,924	98,021	
8-4 Overhead Cost ("8-3"×10%)	%		10%	10%	8,210	1,592	9,802	
8-5 Subtotal ("8-3"+"8-4")					**90,307**	**17,516**	**107,823**	
9 Flood Protection Dike								
9-1 Temporary Works	%	"9-2 (6)"×5%	5%	5%	4,167	1,343	5,510	
9-2 Direct Construction Cost								
(1) Site Clearing	ha	31	-	34,400	-	1,066	1,066	
(2) Stripping	m^3	156,000	53	6	8,268	936	9,204	
(3) Fill	m^3	578,000	123	20	71,094	11,560	82,654	
(4) Sodding	ha	37	-	325,000	-	12,025	12,025	
(5) Miscellaneous	%	5			3,968	1,279	5,247	
(6) Subtotal ("(1)"+~+"(5)")					83,330	26,866	110,196	
9-3 Subtotal ("9-1"+"9-2")					87,497	28,209	115,706	
9-4 Overhead Cost ("9-3"×10%)	%		10%	10%	8,750	2,821	11,571	
9-5 Subtotal ("9-3"+"9-4")					**96,247**	**31,030**	**127,277**	

Table B,Q-11 Construction Cost of Yao Dam & Yot and Yao River Training

(5/5)

Item	Unit	Quantity	Rate		Cost ×1,000Baht			Remarks
			F.C.	L.C.	F.C.	L.C.	Total	
10 River Improvement								
10-1 Temporary Works	%	"10-2 (16)"×5%	5%	5%	8,468	11,956	20,424	
10-2 Direct Construction Cost								
(1) Site Clearing	ha	107	-	34,400	-	3,681	3,681	
(2) Stripping	m^3	534,000	53	6	28,302	3,204	31,506	
(3) River Channel Excavation	m^3	646,000	62	11	40,052	7,106	47,158	
(4) Fill	m^3	1,082,000	48	6	51,936	6,492	58,428	
(5) Gabion Mattress	m^3	178,000	-	775	-	137,950	137,950	
(6) Approach Step	No.	58	25,000	25,000	1,450	1,450	2,900	
(7) Drainage Sluice	No.	54	-	50,000	-	2,700	2,700	
(8) Consolidation Sill	No.	8	1,700,000	1,700,000	13,600	13,600	27,200	
(9) Ground Sill	No.	5	250,000	250,000	1,250	1,250	2,500	
(10) Road Bridge L = 85 m.	No.	4	2,066,000	4,820,000	8,264	19,280	27,544	
(11) Road Bridge L = 60 m.	No.	1	1,458,000	3,402,000	1,458	3,402	4,860	
(12) Road Bridge L = 50 m.	No.	3	1,215,000	2,835,000	3,645	8,505	12,150	
(13) Road Bridge L = 40 m.	No.	6	972,000	2,268,000	5,832	13,608	19,440	
(14) Access Road	m	11,000	500	500	5,500	5,500	11,000	
(15) Miscellaneous	%	5			8,064	11,386	19,450	
(16) Subtotal ("(1)"+~+"(15)")					169,353	239,114	408,467	
10-3 Subtotal ("10-1"+"10-2")					177,821	251,070	428,891	
10-4 Overhead Cost ("10-3"×10%)	%		10%	10%	17,782	25,107	42,889	
10-5 Subtotal ("10-3"+"10-4")					**195,603**	**276,177**	**471,780**	
11 Sub-Total ("1"+~+"10")					**1,175,000**	**630,000**	**1,805,000**	
12 Taxes ("11"×7%)	7%		7%	7%	**82,000**	**44,000**	**126,000**	
13 Total Cost ("11"+"12")					**1,257,000**	**674,000**	**1,931,000**	**×1,000Baht**