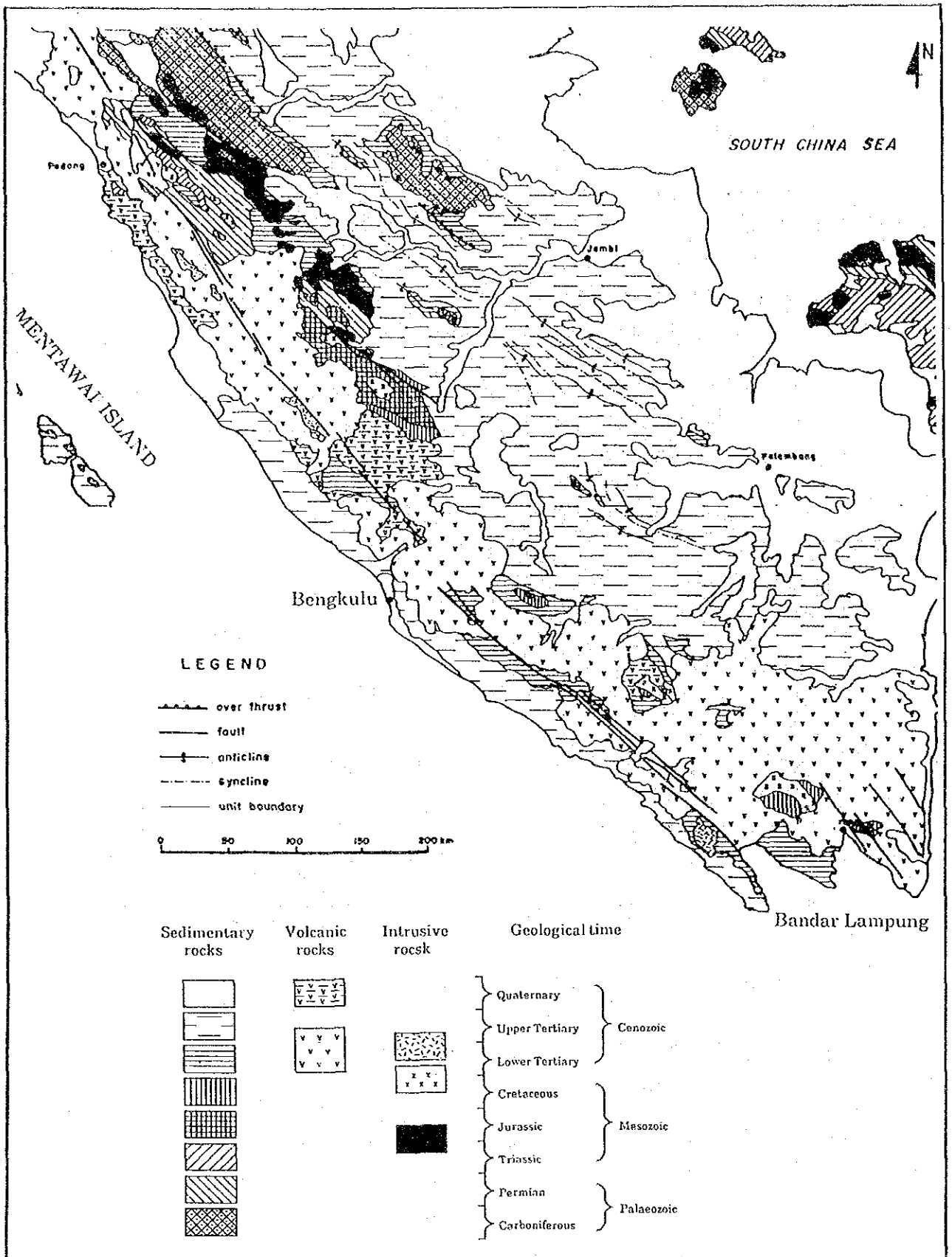


COASTAL ROADS
IN
EAST COAST OF SUMATRA

Fig. 9.3
Simplified Geological Map of Southern Sumatra

2) Characteristics of the Formations

- The area along the project road consist of hilly land and lowland in southeastern Sumatra and is identified as descending from west to east with height between 56 m and 3 m above sea level.
  Hilly land is used for farming and planting areas are widely distributed at elevation between 25 m and 0 m above sea level.
  Large and small rivers flow in the northeast direction.
  The basins along the large rivers and lowland form soft ground.

- Geology of the area is composed of sedimentary rock of Pliocene and Pleistocene age which form the base of the area. The low land is formed of alluvium and swamp deposits of recent age.

- Muaraenim Formation (Tmpm)
  This formation is composed of claystone, siltstone and tuffaceous sandstone with intercalations of coal.
  Claystone is gray, brownish, bedded, soft to rather dense and contains carbonaceous material.
  Siltstone and tuffaceious sandstone are white, gray, yellowish in colour, soft, thinly to thickly bedded and contain components of quarts, feldspar, lithic fragment and are carbonaceous.
  The lower part is composed of sandstone and tuffaceous siltstone with intercalations of carbonaceous siltstone, not so well-bedded, fine grained with rounded to subrounded components. Coal seams in this part of the formation are 5 m thick or more, as found in the west of Kendi Hill, Tanjungenim.
  The middle part is composed of sandstone, tuffaceous siltstone with coal intercalations or carbonaceous brown claystone-siltstone. Commonly, the rock is thick-bedded. The coal seams in this part of the formation attain a thickness of more than 10 m, such as for example in the area of Benakat and near Kendi Hill.
  The upper part consists of tuffaceous claystone to siltstone, thinly bedded to more than 1 m, gray, purplish (molted), greenish and bluish in colour. Commonly, this part is characterized by high iron oxide contents. In this part of the formation the coal seams have a thickness varying between 1 m to more than 3 m, as for example near the village of Minyakbasar.
  De Coster (1974), based on its stratigraphic position, inferred the formation to be of late Miocene to Pliocene age. The depositional environment was shallow sea to transitional area.

The Muaraenim formation is rather widely exposed, extending in the same direction as the direction of the fold axis, such as near Prabumlish and south of Muaraenim, and overlying conformably Airbenakat formation, thickness between 200 and 700 m.

- Kasai Formation (QTK)

  This formation consist of tuff, sandy tuff and tuffaceous sandstone containing pumice. Commonly, the rocks are light gray, white, yellowish, brownish, violet tinge and soft with a thicknesses from some centimeters to more than 1 m, and in some places massive.

  Fine to coarse grained rock is made up of quartz, glass, pumice, feldspar, mica and lithic fragments.

  The lower part is composed of tuffaceous sandstone with coarse to medium-grained of rounded to subangular.

  Commonly, the components are quartz, sedimentary rocks, igneous rocks, metamorphics and altered rocks, gray, dark red and green in colour. Thin lenses of coal are found in some places and attain a thickness of 4 cm. This part of the formation is commonly thinly bedded with thicknesses in the range of some centimeters to 30 centimeters, and showing cross-bedding, also load-cast structure was found.

  Upward the layering becomes indirect. Intercalations of quartz silt or white and light gray clay were found thinly bedded to about 20 centimeters. Many silicified plant remains are seen. The age of this formation could not be fixed but is presumed to be Plio-Pleistocene and deposited in a terrestrial environment.

  The thickness varies between 200 and more than 500 m. Large exposures are present north of Prabumulish, north of Muaraenim, and in the eastern portion of the Quadrangle.

  The Kasai formation underlies the Muaraenim formation conformably but locally, in Tanjungenim area, there is unconformity as indicated by a rather distinct zone of oxidation. The type locality of Kasai formation is the Kasai river, a tributary of Benakat river, some 40 km northeast of Muaraenim.

- Alluvium (Qa) and Swamp (Qs) deposits

  These deposits are widely distributed in almost all the east coastal area of south Sumatra and consist of Alluvium and swamp deposits. Alluvium is mainly distributed along the basins of the large rivers and consist of sand, silt and clay.

The thickness of the soil layer is an average 9 m and maximum 22 m. N-value ranges from 2 to 14 and natural water content of cohesive soil ranges from 25.4% to 63.4%.

Swamp deposits are extensively distributed in the east coastal area and consist commonly of tuffaceous clay, silt, humus soil and sand.

The thickness of the deposit is about 10 m. N-value is 0 and natural water content of cohesive soil ranges from 95.6% to 170.1%.

The deposit is spread in the areas of Musi, Lematang, Ogan, Komering, and west of Kayuagung.

(3) Determination of Soil Tests Value

1) General

The soils subject to analysis for the earth work design are swamp and Alluvium deposits (Ac1, Ac2 deposits) of which a total 59 undisturbed samples were taken, mainly by thin walled tube sampling, and analyzed for the following soil categories:

Swamp deposit:	Ac1 cohesive soils	2 samples
Alluvium deposit:	Ac2 cohesive soils	57 samples
	Total	59 samples

Test results of disturbed samples are referred to in the analysis as the following soil categories:

Swamp deposit:	Ac1 deposit	6 samples
Alluvium deposit:	Ac2 deposit	139 samples
Borrow pit materials		30 samples
	Total	175 samples

Laboratory Tests

Test	Standard	Unit	Quantities
Specific gravity	ASTM-D-854	test	234
Natural water content	ASTM-D-2216	test	234
Particle size analysis	ASTM-D-422	test	234
Liquid limit	ASTM-D-423	test	234
Plastic limit & index	ASTM-D-424	test	234
Wet weight	calipers method	test	59
Uncomprised compression	ASTM-D-2166	test	54
Triaxial compression (UU)	ASTM-D-2850	test	59
Consolidation	ASTM-D-2435	test	57
Compaction	ASTM-D-698	test	30
Laboratory CBR	ASTM-D-1883	test	30

2) Soil laboratory test result

(a) Physical test

- Particle size gradation

The gradation of four soil categories is shown in Table 9.2. Deposits Ac1 and Ac2 contain fine particles of clay and silt more than 93.5% and 82% by total weight.

Table 9.2 Particle Size Gradation

Gradation Item / Deposit	Gravel (%)	Sand (%)	Silt-Clay (%)	No. 10 (2.00 mm) (%)	No. 40 (0.425 mm) (%)	No. 200 (0.075 mm) (%)
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Qs (Ac 1) Cohesive Soil	-	6.3	93.9	100.0	97.3	93.9
	-	4.0 ~ 12.9	87.1 ~ 98.8	-	93.6 ~ 99.0	87.1 ~ 98.8
Qa (Ac 2) Cohesive Soil	0.7	17.3	82.0	99.4	94.7	82.0
	0 ~ 17.0	0.4 ~ 35.5	62.5 ~ 99.1	97.0 ~ 100.0	84.5 ~ 100.0	62.5 ~ 99.1

- Consistency

The objective of the test is to classify soil with particle size gradation. The character of consistency is summarized in Table 9.3 and is shown in Figs. 9.4 and 9.5.

- No change of consistency is observed with increasing depth
- According to the consistency chart, Ac1 deposit is to be classified into CH. Ac2 deposit is to be classified into CH: 76%, NH or OH: 15%, and CL: 5%.
- Colloidal activity

  Ac1 deposit is to be classified into activity clay,

  Ac2 deposit is to be classified as non activity clay, ordinary clay: 61% and activity clay: 39%
- Ac1 deposit is classified as being in an unstable condition as $WL \leq Wn$ and $Ic = 0 \sim 0.11$
- Ac2 deposit is classified as being in a stable to unstable condition as $WL \leq WL$ and $Ic = -0.09 \sim 1.06$

Table 9.3 Consistency

Consistency Item / Deposit	Wn (%)	Wl (%)	Ip	If	It	Ic	Activity Ratio
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Qs (Ac 1)	125.3	146.0	109.4	30.9	3.45	0.18	2.47
Cohesive Soil	95.6 ~ 170.1	118.9 ~ 149.1	82.3 ~ 134.3	20.0 ~ 39.6	2.08 ~ 6.72	0 ~ 0.48	1.18 ~ 6.72
Qa (Ac 2)	44.4	75.9	45.6	24.9	1.94	0.67	1.29
Cohesive Soil	25.4 ~ 63.4	55.2 ~ 96.6	28.2 ~ 63.0	16.7 ~ 33.1	1.04 ~ 2.84	0.28 ~ 1.06	0.61 ~ 1.97

Note: CH: High plasticity and cohesive clay, non organic

OH: Organic clay with medium plasticity

MH: Non-organic silt, Mica or diatomaceous fine sand/silt and elastic silt

CL: Low to medium plasticity silt, clay with sand or gravel, and low cohesive clay

Wn: Natural water content

WL: Liquid limit

Ip: Plasticity index

If: Flow index

It: Toughness index (It = Ip/If)
Degree of shear strength at plastic limit

Ic: Consistency index (Toughness and stability of cohesive soil)
Ic = WL - Wn/Ip
Ic ≥ 1 Stable condition
Ic = 0 Unstable Condition: Liquidizes by disturbance

Colloidal activity: Colloidal activity has deep ties with clay mineral and geological condition of sediment, and is defined by Skempton.

Clay is classified into four group from non activity clay to high activity clay as more than 2. It is shown as the following formula

$$\text{Colloidal activity} = \frac{\text{Plasticity index Ip}}{\text{Soil particle (\%) of less than } 2\mu}$$

Table 9.4 Classification by Colloidal Activity

Activity Ratio	Kind of Cohesional Soil by Activity Ratio	Main Clay Mineral	Deposit Condition
A < 0.75	Non activity clay	Kaolinite	• Clay of aqueous and fresh water sediment • Clay of marine deposit which has been leaching
A = 0.75 ~ 1.20	Ordinary clay	Illite	Clay of marine and estuarine deposit
A > 1.25	Activity clay	• Including organic colloid • A = 2 is including Montmorillonite	-

- Specific gravity, Wet density and Void ratio

  The above are summarized in Table 9.5 and shown in Figs. 9.6 and 9.7.

Table 9.5 Specific Gravity, Wet Density and Void Ratio

Soil Properties / Deposit	Specific gravity Gs	Wet Density t(t/m³)	Void Ratio e
	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range
Qs (Ac 1) Cohesive Soil	2.428	1.406	2.463
	2.374 ~ 2.461	1.373 ~ 1.438	2.299 ~ 2.626
Qa (Ac 2) Cohesive Soil	2.645	1.648	1.296
	2.575 ~ 2.715	1.519 ~ 1.777	0.889 ~ 1.703

- Specific gravity

  The test results yield reasonable values with a standard deviation of less than 0.07.

- Wet density γt

  The tests show reasonable values (Fig. 9.7). Relationships and other factors are shown in the following formula:

$$\gamma t = \frac{1 + Wn/100}{\frac{1}{Gs} + \frac{Wn/100}{Sr/100}} \cdot \gamma w$$

where, γt : Wet density of soil (t/m^3)

Wn : Natural water content (%)

Sr : Degree of saturation (%)

γw : Density of water (= 1.00 t/m^3)

Gs : Specific gravity

If the soil samples are fully saturated by water due to high ground water conditions at the project site: Sr = 100% is applied to the above formula and the formula becomes the function of natural water content (Gs = Constant)

$$\gamma t = \frac{1 + Wn/100}{1/Gs + Wn/100} \quad (t/m^3)$$

The values of Gs and Wn are plotted in Fig. 9.6 and the mean values of wet density are taken as representative due to plots concentrated below the curve in Fig. 9.7.

The mean values are shown below:

Deposit	Wet density γt (t/m^3)
Ac1	1.40
Ac2	1.65

- Void ratio e

Void ratio is indicated in relation to natural water content (Fig. 9.6) with high correlation as follows:

for Ac1 and Ac2 deposit

$e = 0.0197\ Wn + 0.381$

Variance = 9.693

Correlation coefficient = 0.975

(b) Mechanical properties of soils

- Unconfined compressive strength

  The unconfined compressive strength is compiled in the following relative charts:

  Fig. 9.8 : Relative chart of qu and E_{50}, Wn

  Table 9.6 : Result of soil mechanical properties

  Unconfined compressive strength is indicated in relationship to modulus of deformation with high correlation as follows:

$$E_{50} = 16.048\ qu + 0.58$$

  Variance = 1.693

  Correlation coefficient = 0.924

  Unconfined compressive strength (qu) - Natural water content (Wn) from Figure 9.8 with medium correlation

$$qu = -0.0084\ Wn + 0.952$$

  Variance = -4.712

  Correlation coefficient = 0-0.539

  From the test results, compressive strain indicates a high value from 7.2% to 15.0% for both deposits.

Table 9.6 Soil Mechanical Properties

Dynamic Soil Properties / Deposit	Unconfined Compression			Triaxial Compression	
	Qu	E50	Σ	Cuu	Øuu
	Qu (Kg/cm²)	E50 (Kg/cm²)	Σ (%)	Cuu (Kg/cm²)	Øuu (Degree)
	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Qs (Ac 1)	0.066	0.83	13.5	0.06	2
Cohesive Soil	0.053 ~ 0.078	0.78 ~ 0.88	12.0 ~ 15.0	0.05 ~ 0.07	-
Qa (Ac 2)	0.954	17.1	9.7	0.45	10.0
Cohesive Soil	0.140 ~ 1.768	2.90 ~ 31.3	7.2 ~ 12.2	0.11 ~ 0.79	3.3 ~ 16.7

- Triaxial compressive strength

  The triaxial compressive strengths as shown in Table 9.6 were executed under unconsolidated and undrained conditions.

- Consolidation

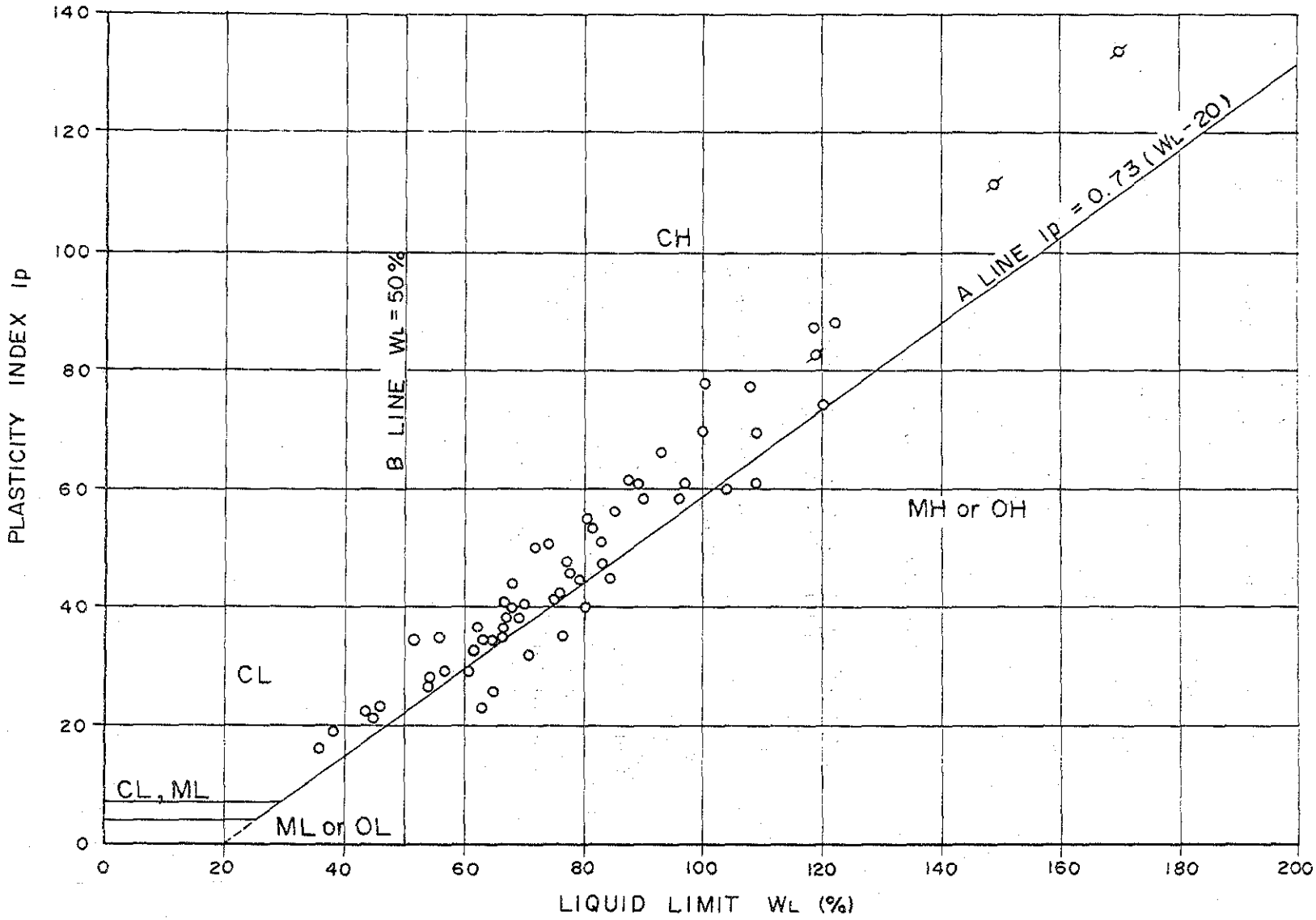
  The test results of consolidation are shown in Table 9.7 and in the following figures:

  Fig. 9.12 : e - log p curve

  Fig. 9.13 : log Cv - log p curve

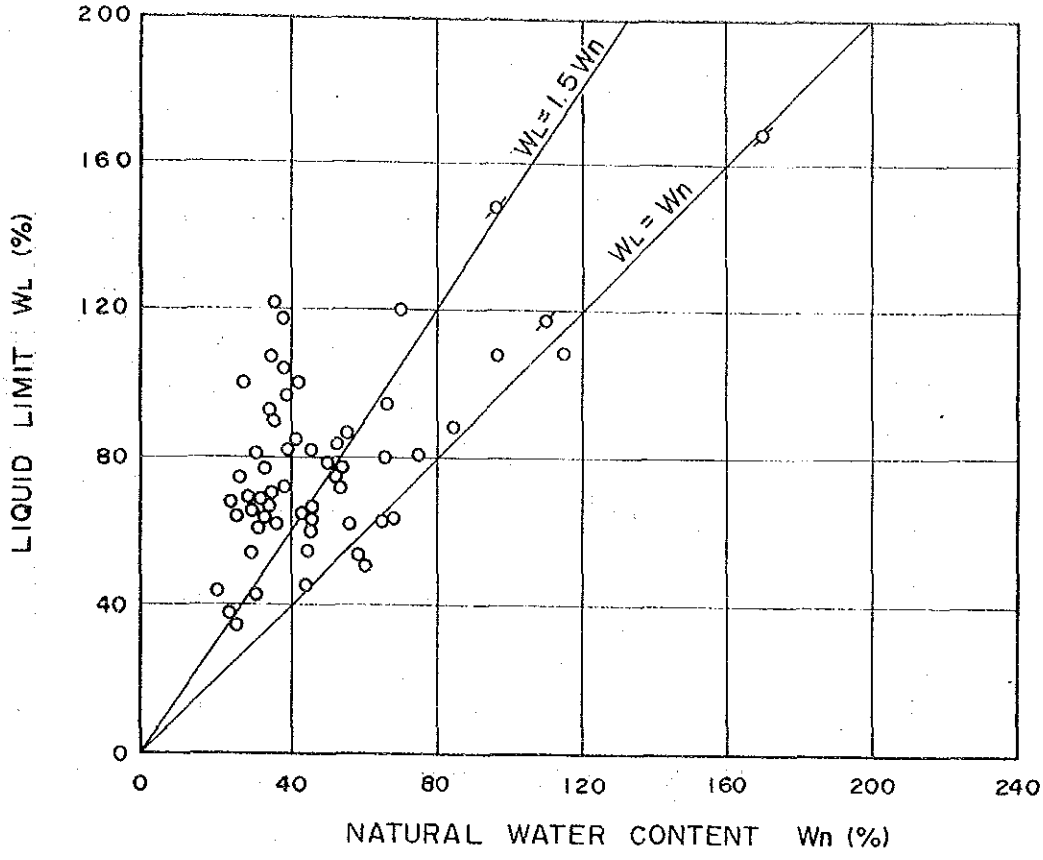
Table 9.7 Consolidation

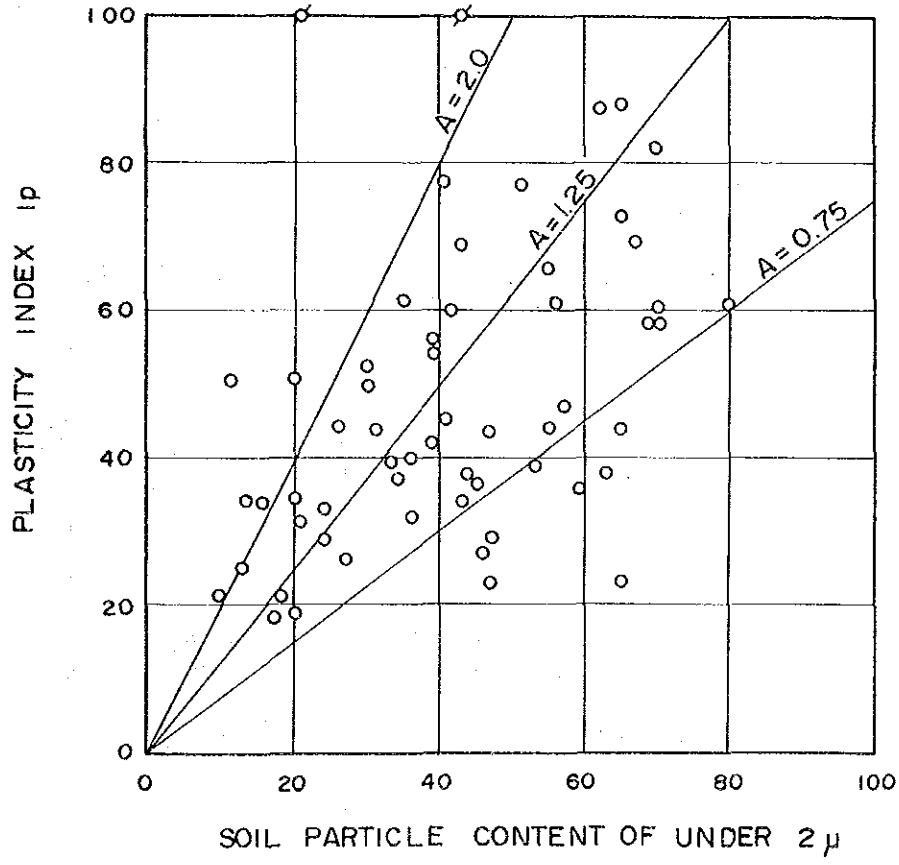
Consolidation Item / Deposit	Yield Stress of Consolidation Pc (kg/cm²)	Consolidation Index Cc
	Average Value	Average Value
	Representative Range	Representative Range
Qs (Ac 1) Cohesive Soil	0.61	0.744
	0.60 ~ 0.61	0.720 ~ 0.767
Qa (Ac 2) Cohesive Soil	1.04	0.357
	0.70 ~ 1.38	0.125 ~ 0.589



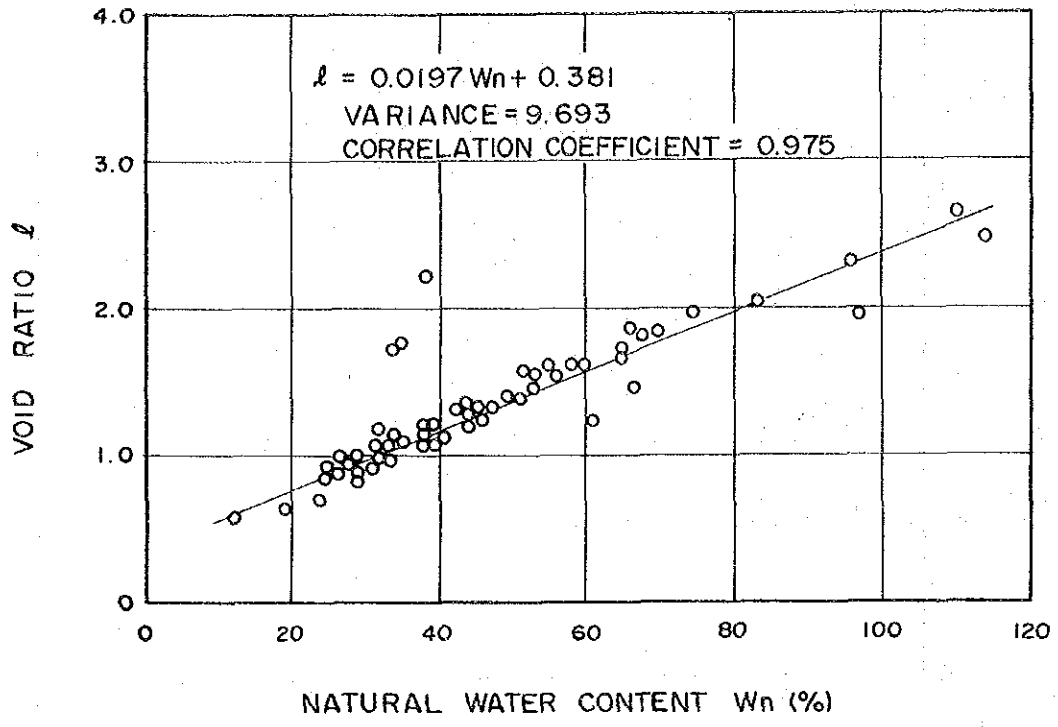
COASTAL ROADS IN EAST COAST OF SUMATRA

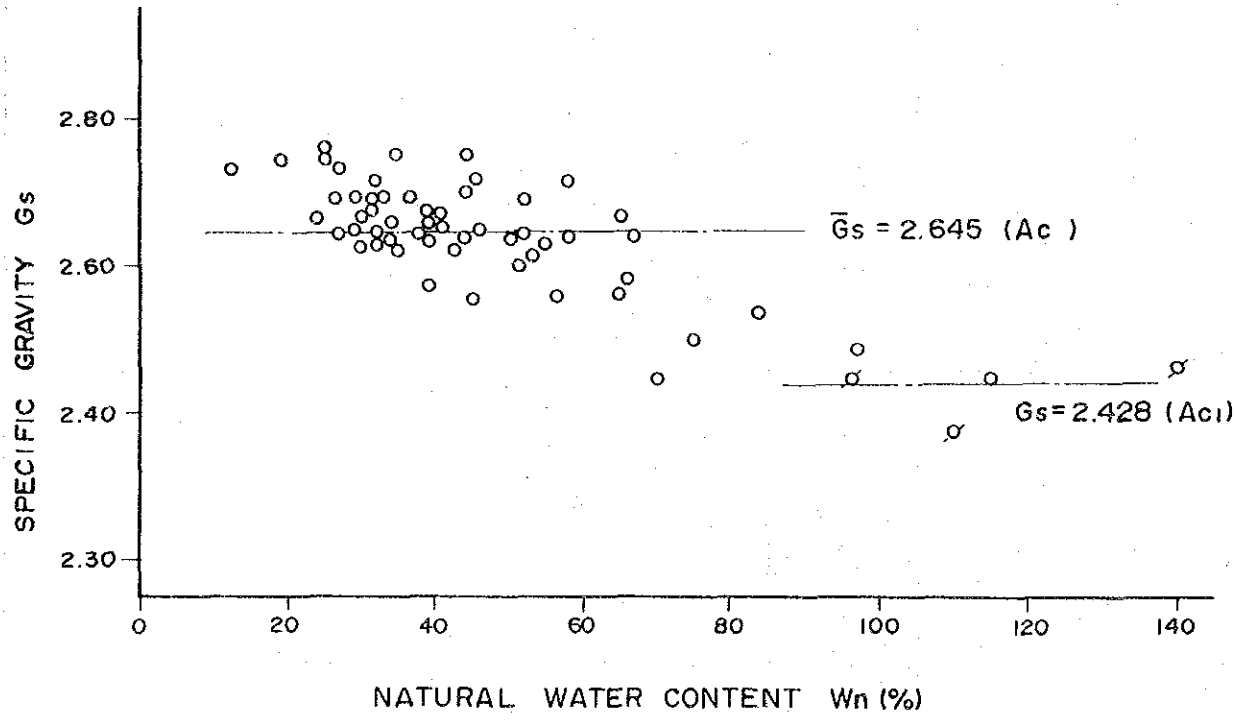
FIG. 9.4 CONSISTENCY CHART



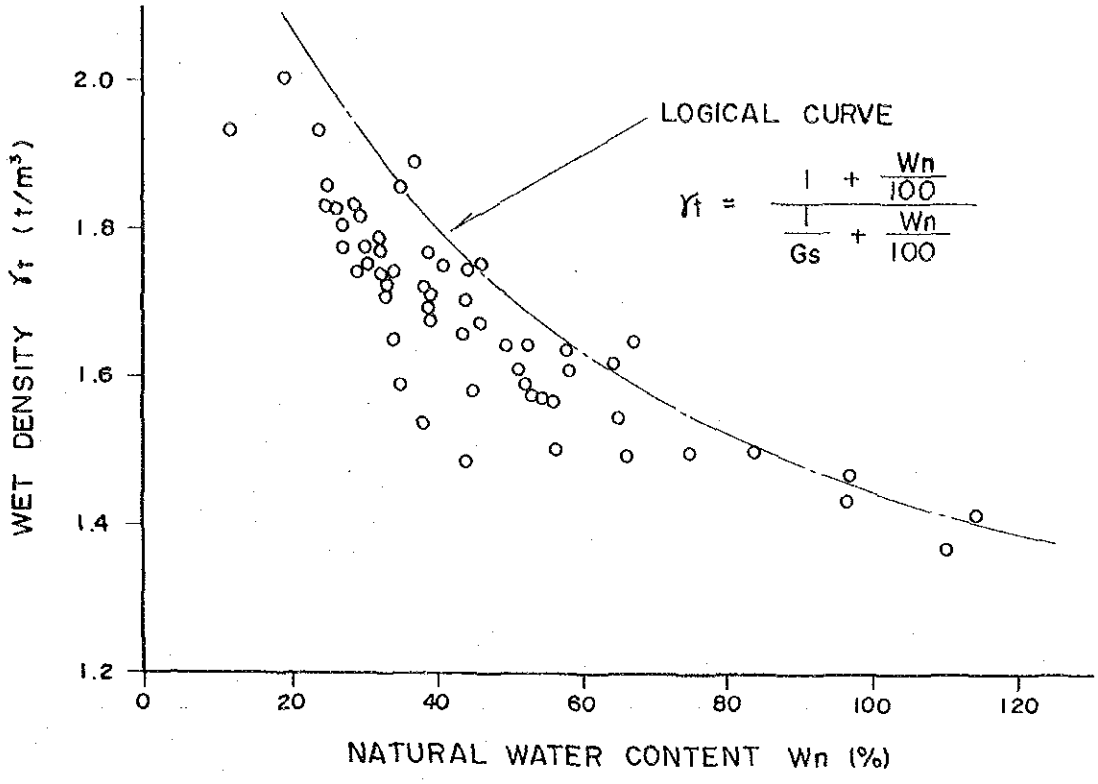


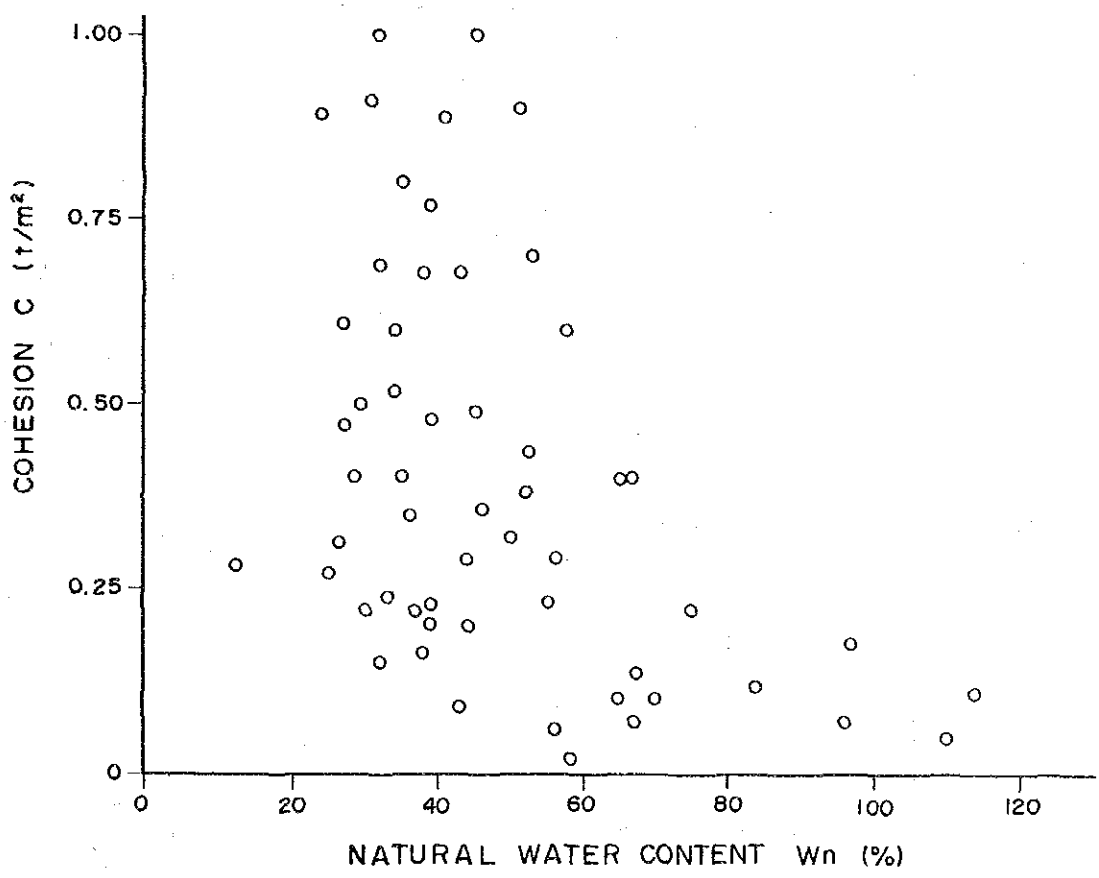
COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.5	RELATIVE CHART OF Wn AND WL COLLOIDAL ACTIVITY



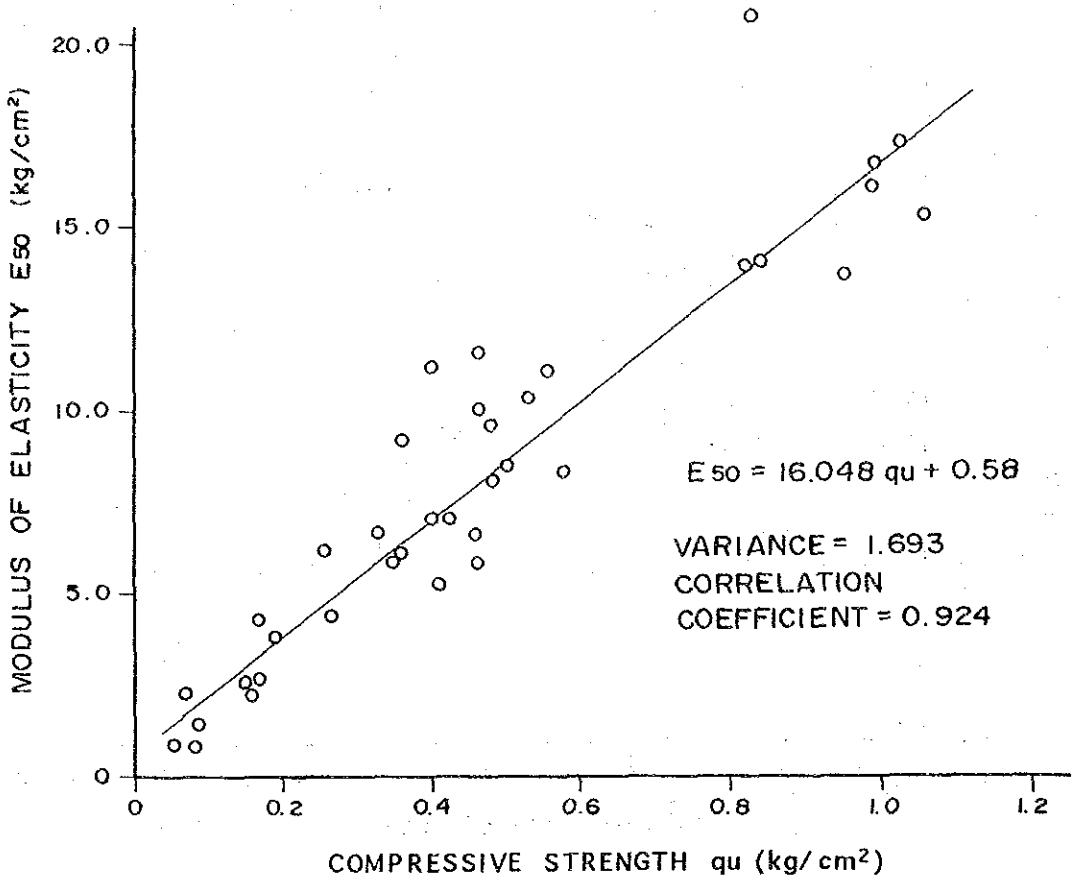


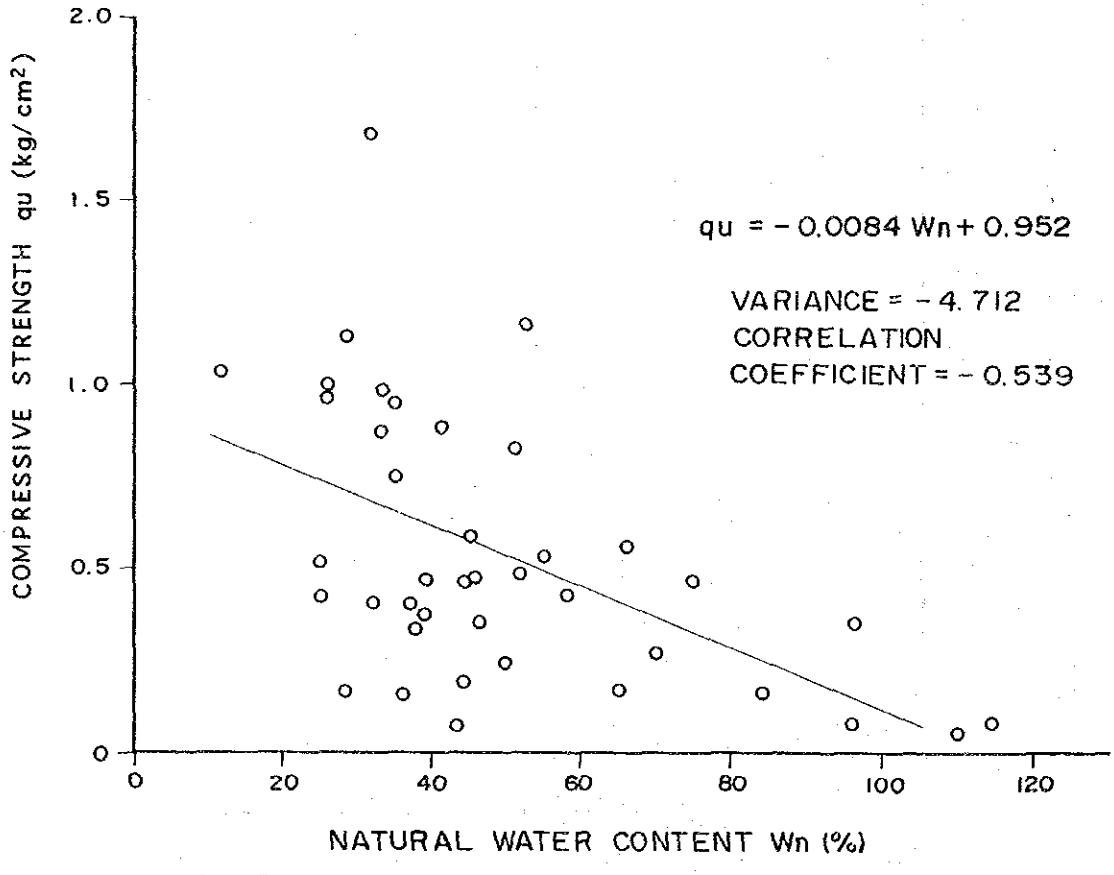
COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.6	RELATIVE CHART OF Wn (%) AND ℓ, Gs





COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.7	RELATIVE CHART OF Wn (%) AND γt (t/m³), Cu (t/m²)





COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.8 RELATIVE CHART OF qu AND E_{50}, Wn

(4) Borrow Pit Materials

1) General

Borrow pit materials surveys were carried out at intervals of about 10 km along the project road for earthworks where there will be new and improved road. Disturbed samples were taken at 15 location as follows and analyzed. The samples were examined as to suitability for embankment materials.

TP No.	STA. No.	Interval (km)	Samples
TP. 92.01	5 ~ 500*	5.5	2
TP. 92.02	15 ~ 500	10.0	2
TP. 92.03	29 ~ 000	13.5	2
TP. 92.04	55 ~ 560	26.56	2
TP. 92.05	56 ~ 900	1.34	2
TP. 92.06	62 ~ 000	5.1	2
TP. 92.07	68 ~ 000	6.0	2
TP. 92.08	81 ~ 300	13.3	2
TP. 92.09	91 ~ 150	18.3	2
TP. 92.10	80 ~ 000**	10.85	2
TP. 92.11	65 ~ 250	14.75	2
TP. 92.12	48 ~ 400	16.85	2
TP. 92.13	30 ~ 500	17.9	2
TP. 92.14	20 ~ 150	10.35	2
TP. 92.15	10 ~ 650	9.5	2
Total		11.1 (average)	30

Note: * Length from Sp. Sriguna (PLG 80 km)

** Length from Menggala (TLB 119 km)

2) Physical test

- Particle size gradation

  The gradation of four soil categories is shown in Table 9.8. Borrow pit materials contain fine particles of clay and silt more than 78% total in weight.

Table 9.8 Particle Size Gradation

Gradation Item / Borrow Pits	Gravel (%)	Sand (%)	Silt-Clay (%)	No. 10 (200 mm) (%)	No. 40 (0.425 mm) (%)	No. 200 (0.075 mm) (%)
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Embankment Materials	-	21.6	78.4	98.3	88.4	78.4
	-	7.2 ~ 36.0	63.9 ~ 92.9	97.7 ~ 100.0	78.4 ~ 98.4	63.9 ~ 92.9

- Consistency

  The objective of the test is to classify soil with particle size gradation. The character of consistency is summarized in Table 9.9 and is shown Fig. 9.9.

  - According to the consistency chart, Ac and Mc-deposits are to be classified into CH: 90% and CL: 10%.

  - Colloidal activity

    77% of borrow pit materials are to be classified as non activity clay (mainly Kaolinite) and ordinary clay (mainly Illite).

  - Borrow pit materials are classified as being in a stable condition as $Wn \fallingdotseq Wp$ and $Ic = 0.92 \sim 1.12$.

Table 9.9 Consistency

Consistency Item / Borrow Pits	Wn (%)	Wl (%)	Ip	If	It	Ic	Activity Ratio
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Embankment Materials	26.7	71.2	44.0	26.3	1.74	1.02	1.03
	20.5 ~ 32.9	56.4 ~ 86.0	33.6 ~ 54.4	20.2 ~ 32.4	1.18~ 2.30	0.92 ~ 1.12	0.79 ~ 1.31

- Specific gravity

  The test results yield reasonable values with a standard deviation of less than 0.027.

Table 9.10 Specific Gravity

Soil Properties / Borrow Pits	Specific gravity Gs	Wet Density t(t/m³)	Void Ratio e
	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range
Embankment Materials	2.626	-	-
	2.599 ~ 2.653	-	-

3) Mechanical properties

- Compaction test

  The test results using ASTM-D-2166 are shown in Table 9.11 and Fig. 9.10.

  The maximum dry density (γd max x 95%) can be obtained for all borrow pit materials at near to natural water contents as shown below:

Natural water content	Wn = 20.5 ~ 32.9 %
	Wn = 26.7 %
Optimum moisture content	Wopt = 24.2 ~ 33.6 %
	Wopt = 28.9 %

- Laboratory CBR test

  The CBR test results using ASTM-D-1883 are shown in Table 9.11 and Fig. 9.10. The test was carried out on three days soaked samples with 95 % of maximum dry density obtained by compaction test.

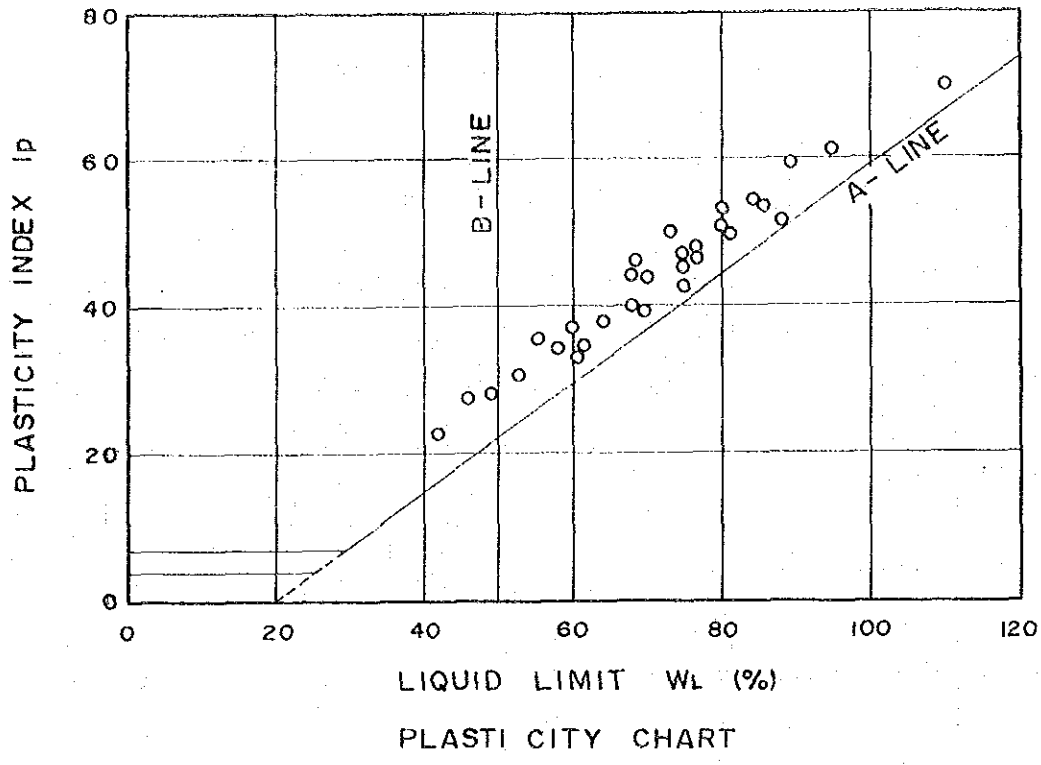
  The test results are summarized as follows:

CBR-value	:	more than 3 %
Swell value	:	less than 3 %

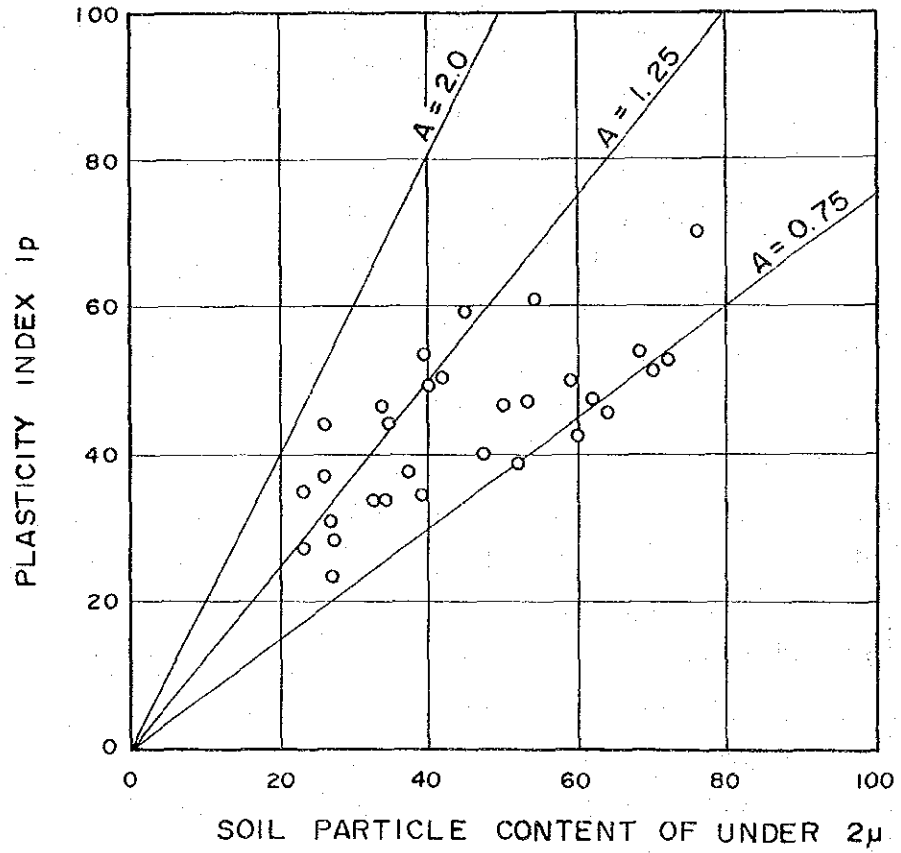
Table 9.11 Compaction and CBR Tests

Test Pit Sampling			Compaction (D-698)			CBR (D-1883)				Note
STA. NO.	TP-NO.	Depth	Wn (%)	Wopt (%)	Max. γd (t/m^3)	W (%)	γd (t/m^3)	CBR (%)	Swell (%)	
5+500*	TP.92.01	0.30~1.50	28.5	29.5	1.422	33.0	1.350	4.4	0.70	Good
		1.50~2.60	27.6	35.3	1.290	41.4	1.226	4.0	1.26	Good
15+500	TP.92.02	0.30~0.90	27.6	29.7	1.437	31.5	1.365	5.0	0.72	Good
		0.90~1.50	26.9	31.5	1.384	36.3	1.315	2.0	1.17	Poor
29+000	TP.92.03	0.50~1.50	30.2	30.2	1.425	36.0	1.354	5.5	0.48	Good
		1.50~2.00	29.4	31.5	1.323	41.5	1.257	2.7	3.94	Poor
55+560	TP.92.04	0.20~1.00	27.6	29.0	1.390	35.0	1.321	2.8	0.36	Poor
		1.00~1.40	28.2	33.2	1.320	39.5	1.254	3.0	3.98	Poor
56+900	TP.92.05	0.20~2.00	19.2	21.0	1.620	23.5	1.539	4.6	0.07	Good
		2.00~2.50	15.9	25.6	1.550	31.0	1.473	4.3	0.24	Good
62+000	TP.92.06	0.30~0.90	28.1	28.2	1.424	32.5	1.353	3.5	1.30	Good
		0.90~1.20	36.1	32.4	1.285	39.0	1.221	3.5	3.03	Good
68+000	TP.92.07	0.60~1.20	19.5	23.3	1.555	25.0	1.477	3.0	0.07	Good
		1.20~2.00	28.7	29.0	1.426	32.0	1.355	2.9	1.76	Poor
81+300	TP.92.08	0.20~1.00	27.5	30.0	1.405	34.5	1.335	4.0	0.58	Good
		1.00~1.50	31.0	31.7	1.374	38.0	1.305	3.8	2.10	Good
92+150	TP.92.09	0.15~1.50	32.0	31.0	1.392	36.0	1.322	3.6	0.85	Good
		1.50~2.50	43.6	39.9	1.215	44.0	1.154	3.6	2.30	Good
80+000**	TP.92.10	0.20~0.75	24.2	22.7	1.550	27.0	1.473	3.4	0.78	Good
		0.75~1.40	35.3	31.8	1.360	38.0	1.292	5.1	1.68	Good
65+250	TP.92.11	0.15~0.60	24.0	28.1	1.444	32.0	1.372	5.1	0.33	Good
		0.60~1.20	30.5	31.5	1.360	37.0	1.292	2.6	4.23	Poor
48+400	TP.92.12	0.50~1.90	21.8	29.2	1.438	30.0	1.366	5.5	0.92	Good
		1.90~2.50	27.0	34.6	1.325	41.0	1.259	3.4	2.57	Good
30+500	TP.92.13	0.30~1.10	20.1	29.3	1.415	33.0	1.344	3.3	0.15	Good
		1.10~1.90	33.7	27.4	1.458	32.0	1.385	4.2	0.67	Good
20+150	TP.92.14	0.50~1.70	15.2	27.9	1.455	33.5	1.352	5.1	0.04	Good
		1.70~3.60	21.5	26.8	1.489	31.0	1.414	3.7	0.15	Good
10+650	TP.92.15	0.15~2.30	18.2	18.1	1.694	22.0	1.609	4.9	0.08	Good
		2.30~5.80	20.6	18.0	1.700	22.3	1.615	3.0	1.48	Good
Average		$\bar{\chi}$	26.7	28.9	1.431	33.6	1.359	3.9	1.266	
Standard deviation		σ_n	6.2	4.7	0.111	5.6	0.105	0.9	1.21	

Note: * Length from Sp. Sriguna (PLG 80 km)
** Length from Menggra (TLB 119 km)

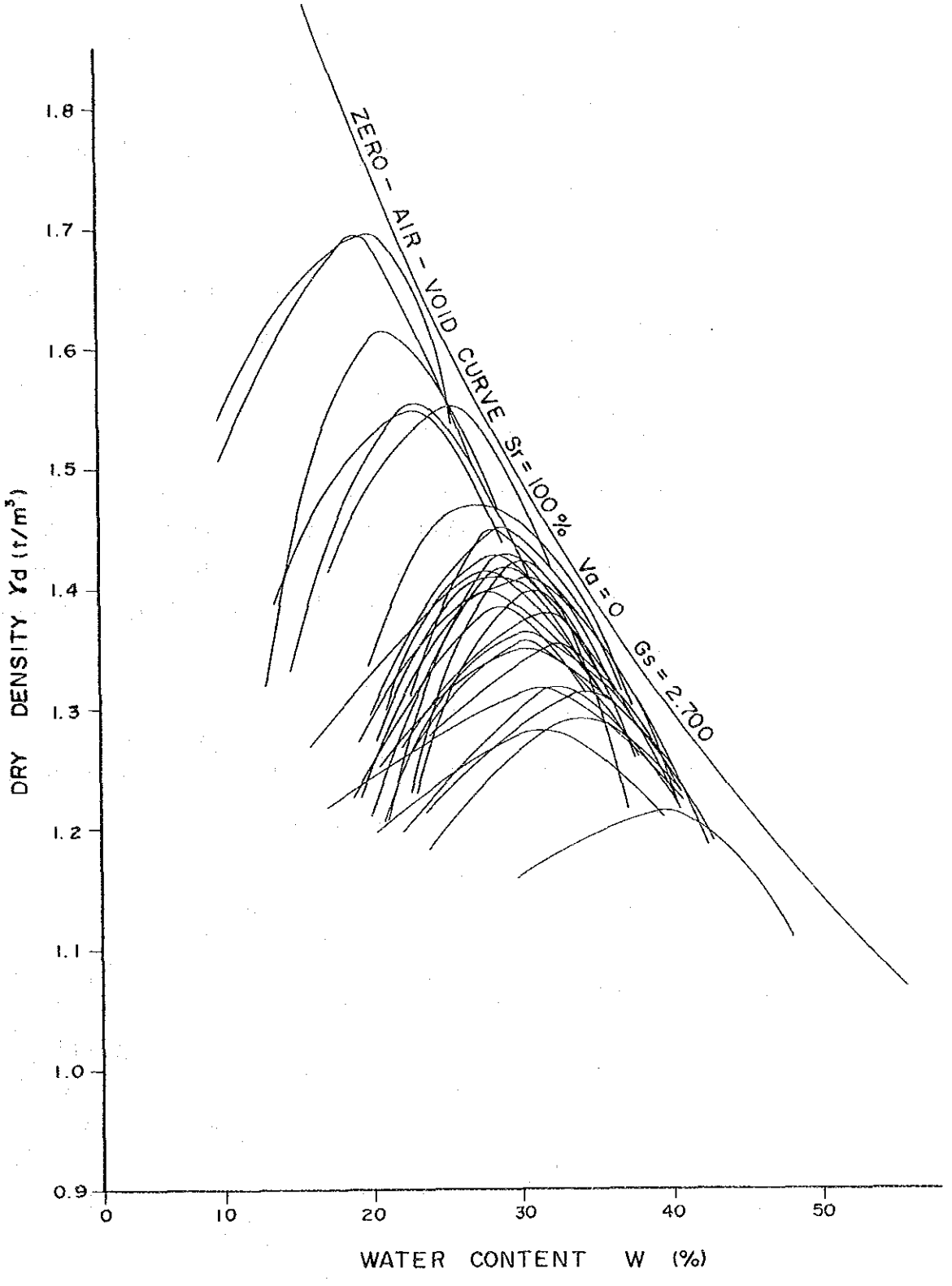


PLASTI CITY CHART



COLLOIDAL ACTIVITY

COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.9 CONSISTENCY CHART FOR BORROW PIT MATERIALS



COASTAL ROADS IN EAST COAST OF SUMATRA	FIG. 9.10 COMPACTION CURVE FOR BORROW PIT MATERIALS

(5) Foundation Strata for Structural Design

(a) Criteria and Distribution of Bearing Strata

The load bearing strata for structures is assessed depending on importance of the structure and the longitudinal forces to be carried by the structure.

In general, the criteria for spread or piled foundations of bridge abutments and piers is defined as the following N-values:

Sandy soil	N > 30
Cohesive soil	N > 20

From soil investigation, the depth of bearing strata of the above N-values range from 4 m to 22 m and the average depth is 9.3 m. The depth of bearing strata of N-value more than 50 range from 6 m to 39.5 m and the average is 17 m. These are shown in Table 9.14A and 14B Bearing Strata for Structural Design.

(b) Soil Values of Bearing Strata

Soil values to decide the bearing strata for structures are summarized in Table 9.12.

Table 9.12 Soil Values of Bearing Strata

Division of soil	Wet density γt (t/m^3)	Cohesion of the first stage c (t/m^2)	Internal friction angle $\varnothing$ (Degree)	Modulus of elasticity Eo (kg/cm^2)
Ac1	1.40	0.60	–	Fig. 9.8
Ac2	1.65	0.625N	–	Fig. 9.8
As	Table 9.13	–	Fig. 9.11	–
Dc	Table 9.13	0.625N	–	28N
Ds	Table 9.13	–	Fig. 9.11	–

Note: N-values and ground water level are shown in the boring log.

Fig. 9.11 Relative Chart for N-value and Internal Friction Angle

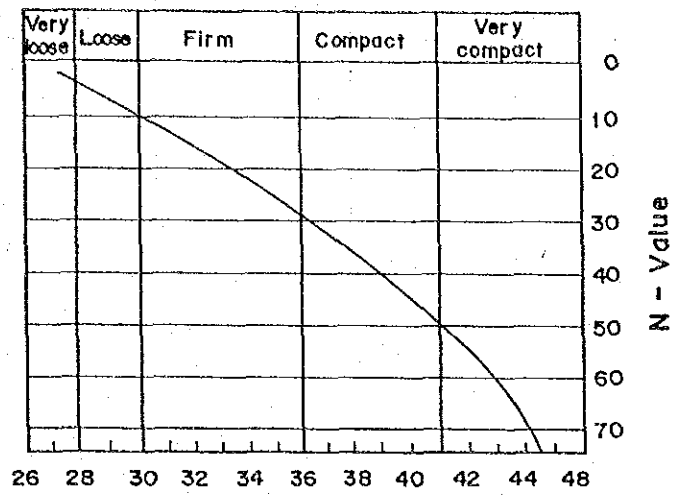


Table 9.13 Wet Density of Soil

Soil		Condition of Soil		Wet density(t/m^3)	Symbols
Embakment	Sand mixed gravel	Compact		2.0	GW, GP
	Sand	Compact	good gradation	2.0	SW, SP
			No good gradation	1.9	
	Sandy soil	Compact		1.8	SM, SC
	Cohesive soil	Compact		1.7	ML, CL, (MH, CH)
	Volcanic cohesive soil	Compact		1.4	VH
Natural ground	gravel	Compat or good gradation		2.0	GW, GP
		Loose or no good gradation		1.8	
	Sand mixed gravel	Compact		2.1	GW, GP
		Loose		1.9	
	Sand	Compact or good gradation		2.0	SW, SP
		Loose or no good gradation		1.8	
	Sandy soil	Compact		1.9	SM, SC
		Loose		1.7	
	Cohesive soil	hard		1.8	ML, CL
		soft		1.6	
	Silt	hard		1.6	ML
		Soft		1.4	
	Clay	hard		1.7	CH, MH
		Soft		1.5	
	Volcanic cohesive soil			1.4	VH

Table 9.14A Bearing Strata for Structural Design

STATION No.	Name of Bridge	Machine Boring No.	Bearing Strata				Note
			N-Value more than 20(c) 30(s)		N-Value more than 50		
			Depth	Soil	Depth	Soil	
PLG 72+030	A. Dusun Anyar	MB.92.01 A.B	14.0	Tuffaceous Clay	39.5	Silty Sand	
PLG 78+063	A.Segonang	MB.92.02 A.B	16.0~18.0	Fine to Coarse Sand	34.0~36.0	Tuffaceous Clay Stone	
PLG 80+231	Way Talang Pangeran	MB.92.03 A.B	20.0~10.0	Fine to Coarse Sand	20.0~16.0	Fine to Couse Sand Clay Stone	
PLG 93+855	Way Lebak Bunut 1	MB.92.04	22.0	Tuffaceous Clay	36.0	Tuffaceous Clay	
PLG 112+614	Way Menanga	MB.92.05	7.5	Tuffaceous Clay	31.5	Tuffaceous Sandy Clay	
PLG 114+396	Way Jahe	MB.92.06	9.5	Fine Sand	15.0	Silty Sand	
PLG 116+700	Way Burnai	MB.92.07	9.5	Fine to Coarse Sand	22.0	Tuffaceous Silty Clay	
PLG 117+277	Way Temburuntul 1	MB.92.08	9.0	Tuffaceous Clay	34.0	Tuffaceous Silty Clay	
PLG 120+418	Way Kubangan	MB.92.09	5.3	Fine to Coarse Sand	15.5	Tuffaceous Sandy Clay	
PLG 128+341	Way Tembesu	MB.92.10	-	Loose Sand	21.5	Clayey Sand	
PLG 139+818	Way Deras	MB.92.11	28.0	Tuffaceous Clay	32.0	Tuffaceous Sandy Silt	
PLG 143+495	Kali Badak	MB.92.12	14.0	Sandy Clay	18.0	Tuffaceous Clay	
PLG 147+185	Sei Kali	MB.92.13	9.5	Fine to Coarse Sand	20.0	Tuffaceous Silty Clay	Box
PLG 147+934	Tebing Suluh	MB.92.14 A.B	6.0~11.0	Clayey Sand Tuffaceous Clay	25.5~27.0	Tuffaceous Clay	
PLG 157+675	Way Gadis	MB.92.15	6.0	Tuffaceous Clay	28.0	Tuffaceous Silty Clay	
PLG 159+820	Way Dabuk	MB.92.16	10.0	Tuffaceous Clay	16.0	Tuffaceous Sandy Clay	
PLG 165+043	Way Sungai I	MB.92.17	2.0	Tuffaceous Clay	6.0	Tuffaceous Siltstone	
PLG 165+501	Way Sungai II	MB.92.18	-	Medium Silty Clay	6.0	Tuffaceous Clay	
PLG 169+912	Way Ulak	MB.92.19	2.0	Clay	8.0	Tuffaceous Clay	
TLB 200+059	Way Mesuji	MB.92.20 A.B	16.0~12.0	Tuffaceous Clay,Fine to Coarse Sand	34.0~32.0	Silty Sand Medium Sand	
TLB 196+445	Way Buntu	MB.92.21	7.5	Sandy Clay Stone	10.0	Sandy Clay Stone	
TLB 195+420	Way Kem Deras	MB.92.22	5.5	Clay	8.0	Clay to Clayey Sand	
TLB 194+741	Way Balak	MB.92.23	10.0	Tuffaceous Clay	12.0	Tuffaceous Clay	
TLB 193+492	Way Gajah	MB.92.24	2.0	Clay	10.0	Tuffaceous Clay	
TLB 188+194	Way Iriasi	MB.92.25	8.0	Tuffaceous Clayey Silt	10.0	Tuffaceous Clayey Silt	
TLB 186+910	Way Penimbakan	MB.92.26	4.0	Sandy Clay	11.5	Clay	
TLB 186+730	Way Penyandangan	MB.92.27	6.0	Clay	14.0	Clayey Sand	
TLB 185+021	Way Harapan Jaya	MB.92.28	11.5	Tuffaceous Clay	29.5	Tuffaceous Clay	
TLB 184+100	Way Harapan I	MB.92.29	-	Clay Sand	8.0	Alternation of Clay and Sand	
TLB 183+154	Way Biawak II	MB.92.30	13.0	Clay	33.0	Sandy Clay	
TLB 179+591	Way Tulung II	MB.92.31	4.0	Sandy Clay	8.0	Tuffaceous Clay	

Note: (c) Cohesive soil, (s) Sandy soil

Table 9.14B Bearing Strata for Structural Design

STATION No.	Name of Bridge	Machine Boring No.	Bearing Strata				Note
			N-Value more than 20(c) 30(s)		N-Value more than 50		
			Depth	Soil	Depth	Soil	
TLB 178+379	Way Tulung I	MB.92.32	4.0	Tuffaceous Clay	18.0	Fine Sand	
TLB 176+977	Way Talang Gunung III	MB.92.33	5.5	Clay	13.5	Fine to Medium Sand	
TLB 176+263	Way Talang Gunung II	MB.92.34	8.0	Tuffaceous Clay	12.0	Tuffaceous Clay	
TLB 175+063	Way Talang Gunung I	MB.92.35	-	Soft Sandy Clay	6.0	Tuffaceous Clay	
TLB 174+037	Way Talang Gunung	MB.92.36	-	Stiff Silty Clay to Clay	9.5	Clay Stone	
TLB 173+190	Way Manggris	MB.92.37	4.0	Tuffaceous Clay	16.0	Clay to Sandy Clay	
TLB 172+052	Way Akuan	MB.92.38	6.0	Clay	8.0	Clay	
TLB 171+250	Way Buaya Akuan	MB.92.39	8.0	Sandy Clay	10.0	Tuffaceous Clay	
TLB 169+989	Way Buaya II	MB.92.40	8.0	Sandy Clay	10.0	Tuffaceous Clay	
TLB 169+012	Way Kilang	MB.92.41	-	Silty to Sandy Clay	16.0	Clayey Sand to Sandy Clay	
TLB 168+112	Way Buaya I	MB.92.42	-	Clay to Clayey Sand	10.0	Clayey Sand	
TLB 166+419	Way Buaga II	MB.92.43	5.5	Tuffaceous Clay	15.5	Clay Stone	
TLB 164+160	Way Pasir II	MB.92.44	-	Silty Clay to Sand	6.0	Clayey Sand	
TLB 161+851	Way Asahan I	MB.92.45	-	Clay to Sand	10.0	Tuffaceous Clay	
TLB 161+053	Way Pasir	MB.92.46	6.0	Tuffaceous Clay	12.0	Sandy Clay	
TLB 160+346	Way Bujuk Agung III	MB.92.47	10.0	Tuffaceous Clay	16.0	Tuffaceous Clay	
TLB 159+936	Way Bujuk Agung II	MB.92.48	8.0	Tuffaceous Clay	18.0	Clay Stone	
TLB 159+962	Way Bujuk Agung I	MB.92.49	8.0	Sandy Clay	18.0	Clay to Sandy Clay	
TLB 154+362	Way Bujuk	MB.92.50	-	Silty Sand to Clay	10.0	Clayey Sand to Sandy Clay	
TLB 143+253	Way Pedada	MB.92.51 A.B	8.0~6.0	Tuffaceous Clay	10.0~14.0	Sandy Clay to Clay	
TLB 140+636	Way Telow	MB.92.52	4.0	Tuffaceous Clay	12.0	Sand Clay	
TLB 133+756	Way Badak	MB.92.53	4.0	Sandy to silty Clay	16.0	Clayey Sand to Sandy Clay	
TLB 128+138	Way Cekat Nyenyek II	MB.92.54	14.0	Clay to Sand	20.0	Clayey Sand	
TLB 127+519	Way Tulang Bawang	MB.92.55 A.B	20.0~14.0	Sandy Clay	24.0~20.0	Sandy to Silty Clay	
TLB 124+956	Way Buluran II	MB.92.56	-	Clay, Silty Clay	16.0	Sandy Clay	Box

Note: (c) Cohesive soil, (s) Sandy soil

(6) Design Soil Value and Design Condition

- Design soil value

  Along the Mesuje river basin soft clay, and humus clay are distributed and are classified as swamp deposit Ac1. The thickness is 10 meters.

  Design soil value of the soft deposit is summarized in Table 9.15.

Table 9.15 Design Soil Value

Soils	Wet Density γt (t/m^3)	Cohesion of the Initial Condition Co (t/m^2)	Internal Friction Angle Ø (Degree)	e - log Curve	log - Cv log p	The Rate of Strength Increase m	Consolid-ation Yield Stress Pc (t/m^2)
Ac1	1.40	0.60	-	Fig. 9.12	Fig. 9.13	0.30	2.40

- Design condition

  - Kind of load

    Load is only embankment material.

  - Embankment material

    Borrow pit materials from 15 locations for which materials surveys have been carried out are used. Embankment materials and sand mat are identified for simplification.

    . Wet density

    $\gamma t = 1.80\ t/m^3$

    . Cohesion and internal friction angle

    $C = 2.0\ t/m^2$

    $\phi = 10$ degree

    Form of embankment is shown in Fig. 9.15.

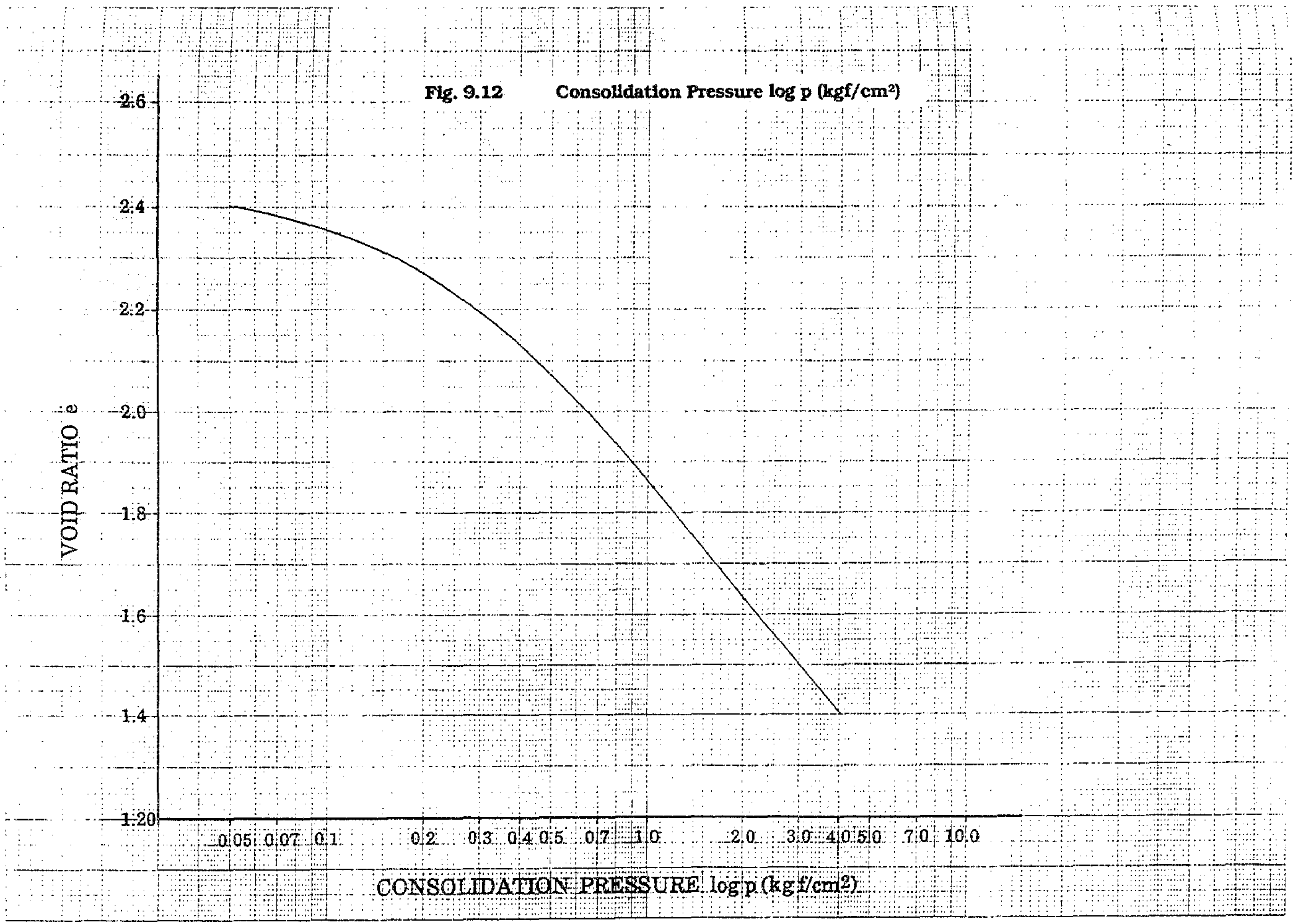
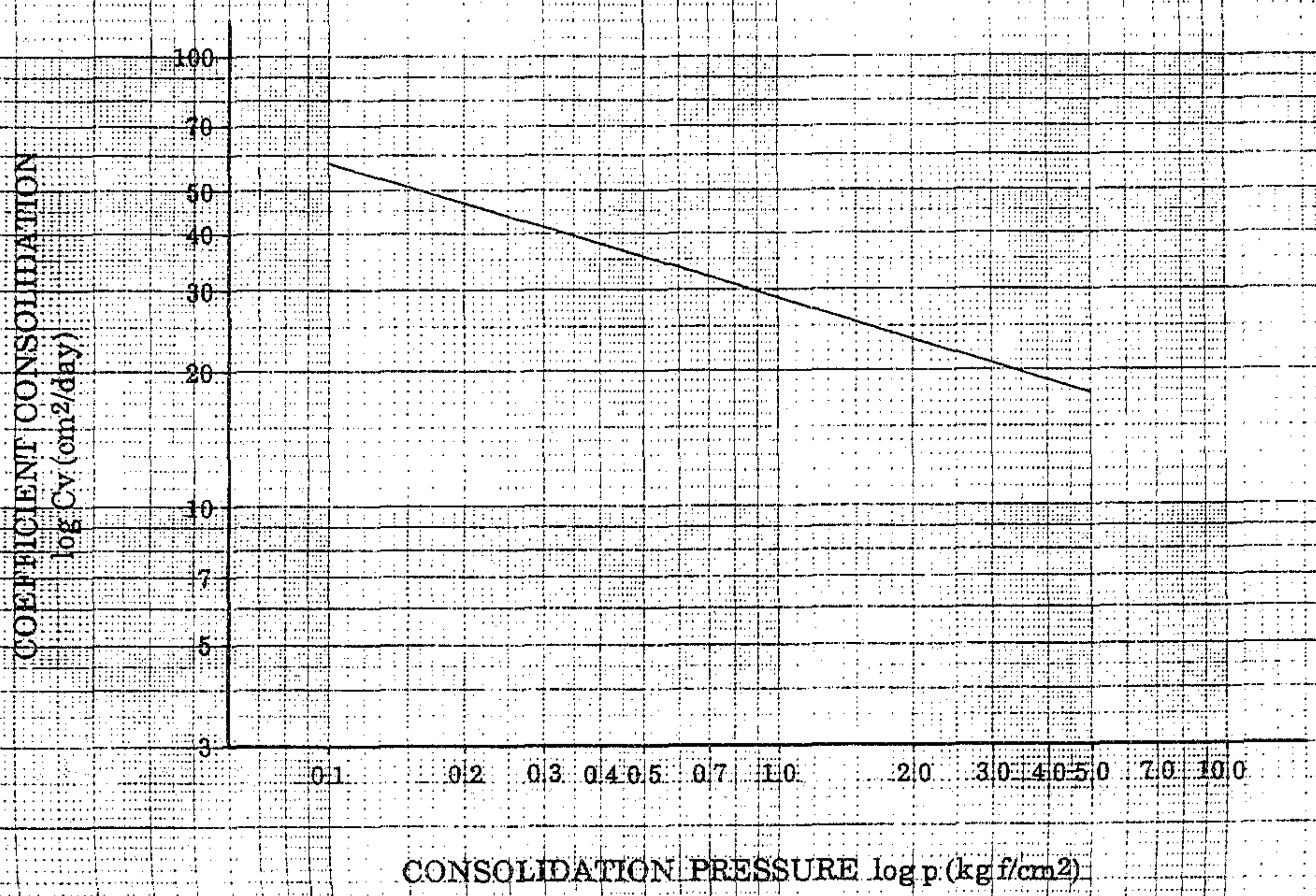


Fig. 9.12 Consolidation Pressure log p (kgf/cm²)

FIG 9-13 log Cv-log p DESIGN CURVE



(7) Soft Ground Analysis

1) General

The standard section for soft ground analysis is situated at the approach road in the direction of Lampung about 2 km from Mesuji bridge. (See Fig. 9.15)

Schedule of the embankment work is programmed as follows:

- The embankment for pre-loading was constructed by slow banking method in 1991
- The embankment sits for 5 years
- The embankment is improved for widening and for lack of embankment height in 1995

Soft ground and embankment conditions are as follows:

Length of embankment	:	Lampung side 2 km
Embankment height	:	Average 2.5 m
Deposit	:	Swamp deposit (Ac1) clay and humus clay
Thickness of stratum	:	10 meters

The section, stability and settlement values which will be improved in 1995 were analyzed.

2) Result of soft ground analysis for standard section

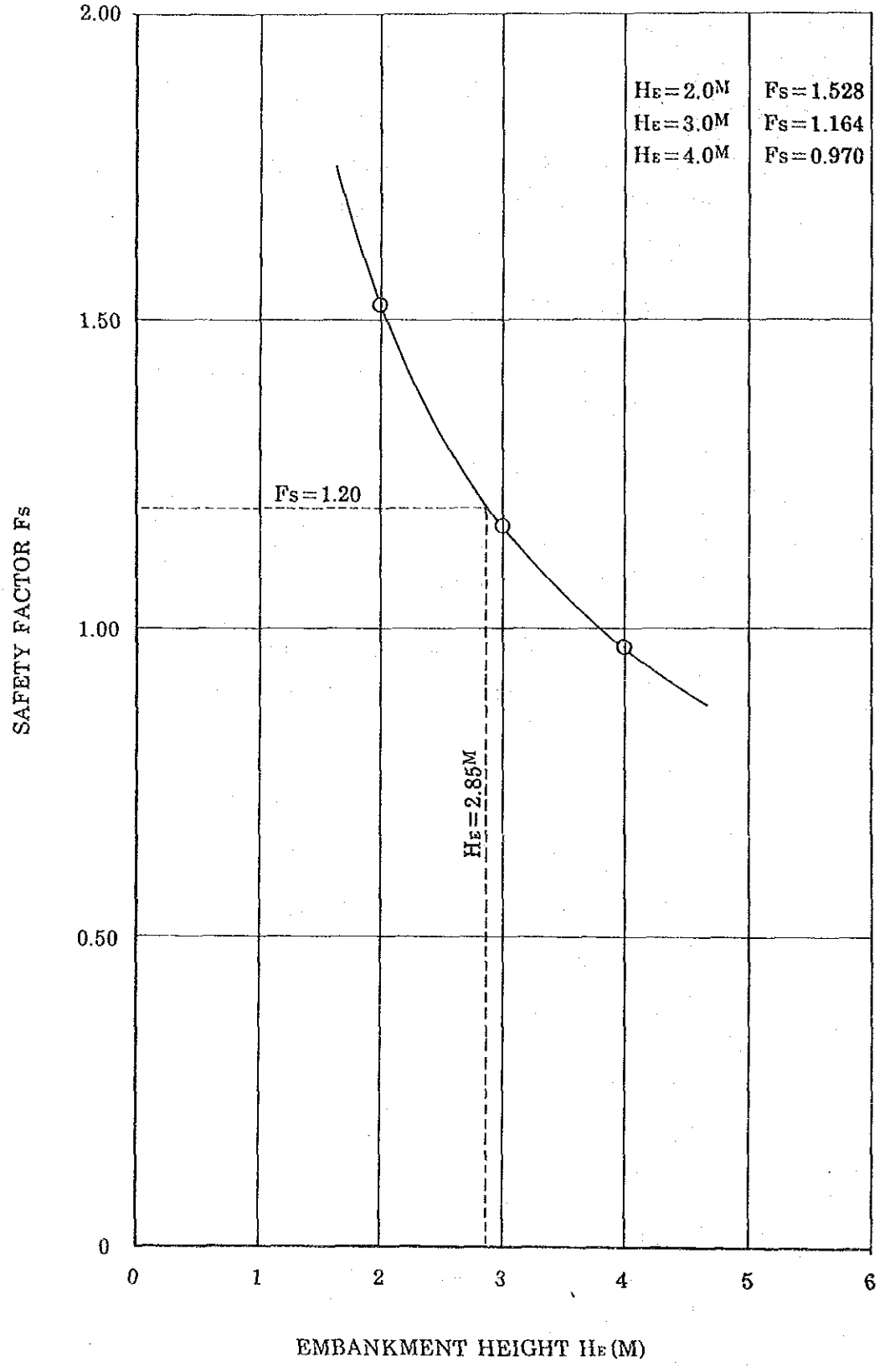
- Safety factor

Embankment height HE (m)	Safety factor Fs	Lack of embankment height (m) (Settlement value)
2.0	1.528	0.315
3.0	1.164	0.450
4.0	0.970	0.560

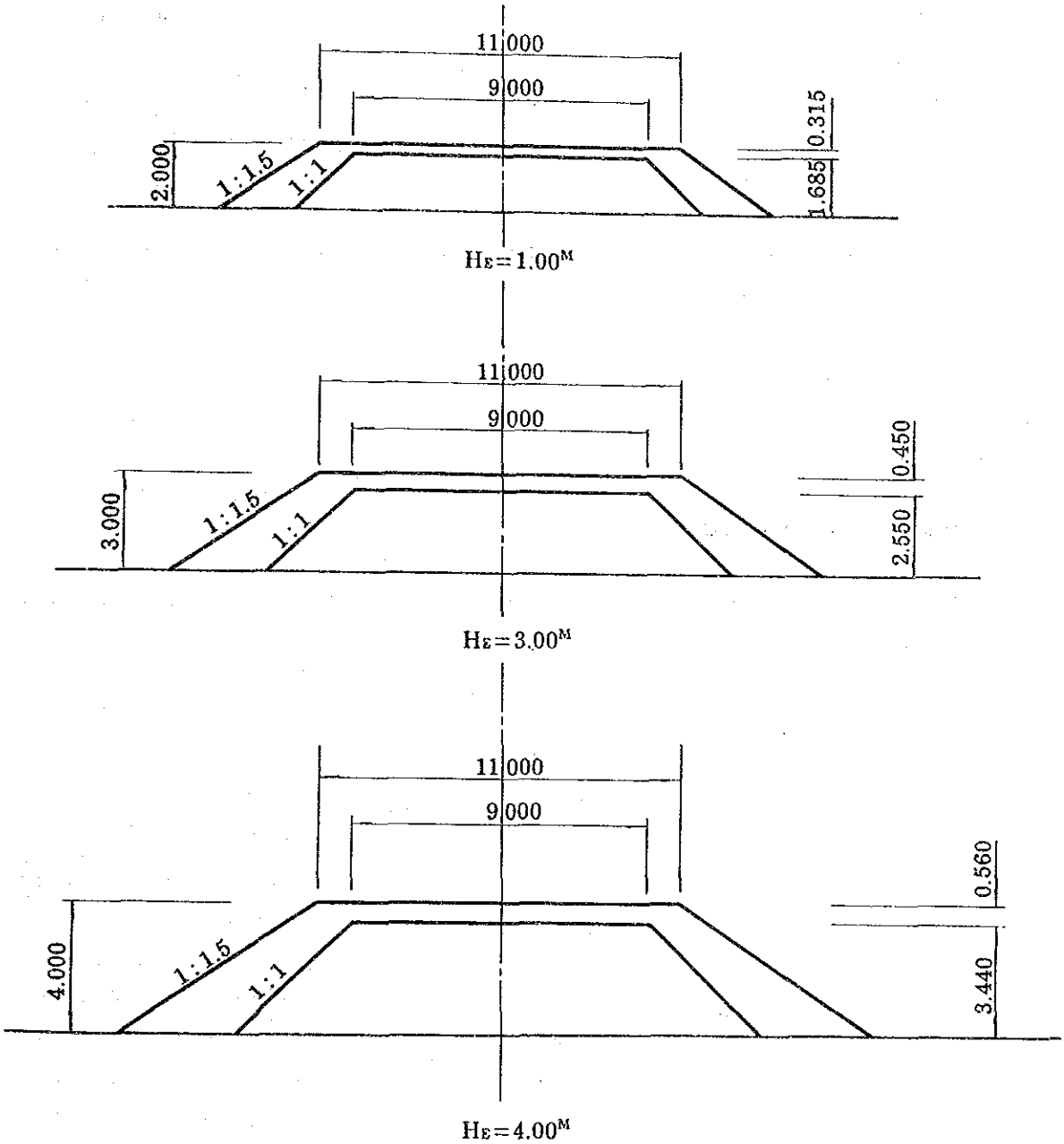
- Limited embankment height

HE = 2.85 m

The safety factor/embankment height is illustrated in Fig. 9.14 and the analysis data are shown in Appendix A-9.1.



COASTAL ROADS IN EAST COAST OF SUMATRA	FIG 9.14	RELATIVE CHART OF EMBANKMENT HEIGHT AND SAFETY FACTOR



COASTAL ROADS IN EAST COAST OF SUMATRA	FIG 9.15 EMBANKMENT HEIGHT AND TYPE

9.3 Design

9.3.1 Difference from the Pre-Feasibility Study

The field survey and soils investigation were performed to obtain more detailed information in order to improve the degree of precision as the basis for the design. For this reason, the design conditions and standards are the same as those for the Pre-Feasibility Study and will not be repeated here. The Feasibility Study will cover the following items:

A) The Contents of Road Rehabilitation (Improvement of Horizontal and Vertical Alignment, etc.).
B) The Required Number of Traffic Lanes (1997 and 2010).
C) Earthwork Design.
D) Design of Pavements.
E) Bridge Design.

9.3.2 Items to be Rehabilitated

Rehabilitation of the road sections will be performed where the following conditions pertain:

A) Road sections with a horizontal curve radius less than R = 115 m.
B) Road sections with vertical gradients of more than 5 %.
C) Road sections that are over-topped by flood waters (raise road bed).
D) Bridge approach sections where bridges have been replaced.
E) Road sections that have been widened or the pavement strengthened (all road sections).

The road rehabilitation works are described in Table 9.16 and will be divided into the following two classifications. Horizontal alignment will be rehabilitated for about 8 % of the total road section length, L = 183 km, while rehabilitation of road widening and pavement strengthening will be for the entire road section.

Table 9.16 Items to be Rehabilitated

Reason	No. of Sites	Length (km)
Rehabilitation of horizontal alignment	40	6.4
Rehabilitation of vertical alignment	5	3.0
Raising of road bed	7	4.8
Rehabilitation of Bridges, and other rehabilitation	2	0.8
Widening of road and pavement strengthening	-	183.0

9.3.3 Required Number of Lanes

Based on the traffic volume calculated in the Pre-Feasibility Study (see paragraph 8.3, Road Traffic Volume and the Required Number of Lanes), and the planned traffic volume in 1997 and 2010, the required number of lanes are determined (See Table 9.17).

Table 9.17 Number of Lanes

(Unit: pcu/day)

		Existing Road	Proposed Road	Bridge
Number of Lanes		1	2	2
Width of Carriage way		1 x 4.5 m	2 x 3.5 m	1 x 3.0 m
Basic Highway Capacity		3,000	45,000	20,000
Design	Year 1997	-	6,000	-
Traffic	Year 2010	-	18,000	-
Required Number of Lanes: V/C		-	2	-

From the above table, the following comments can be made:

- in 1997, it will be necessary to change the present single lane road to a 2-lane road;
- the proposed 2-lane road section is considered to be able to handle the traffic volume efficiently in 2010. Otherwise, the future traffic demand (18,000 PCU vehicles /day) to the present bridge capacity (6.0 meter width) ratio will be assumed to be 0.78.

9.3.4 Design of Earthworks

There are two types of road earthworks which can be combined for the earthworks required:

Table A

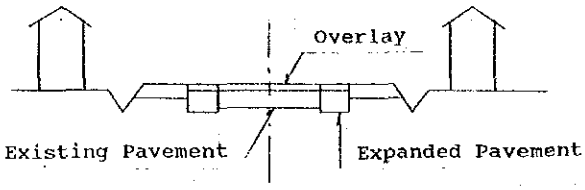
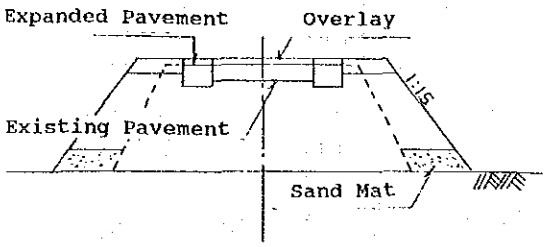


Table B



- Table A — This road structure will be used in the hilly country sections where there are residences along the road. The road will be of flexible construction.

- Table B — This type of road structure is to be used in the section traversing the swamplands and mountainous areas. The roadway will consist of cut and fill with paved road surface.

- The earth fill materials will be obtained from borrow sites along the road side, and the base course earth materials will be transported from the mountain areas on the west. (locations of borrow materials are described in 9.4, Construction Planning)

- The structure of the roadways to be widened in the swamplands will consist of sand mats with embankment widening by earth fill materials and side slope protection where required.

- Slope protection will be provided in the sections where the side slopes are presently protected with concrete block slabs.

- Earthwork will be provided in soft ground sections as described in Paragraph 9.2.2 (7)

9.3.5 Design of the Road Pavement

a) Method of Design

The AASHTO Design Guide for Pavement Structure, 1986, will be used as a design reference.

b) Design CBR

A design CBR of 3.0 % will be used based on the results of the CBR Test conducted for soil samples obtained from the borrow areas.

c) Design Life Period

The design life period will be 10 years.

d) Designed Traffic Volume for Pavement Design

Designed traffic volume for the pavement design will be for the period from 1997 to 2007, a period of 10 years. (The highway will be opened to the public in 1997)

- operation year of roadways will be 1997,
- the mid-point of construction will be 2002,
- the composition of vehicles is based on the National O-D Survey conducted in 1991.

The designed traffic volume to be used for the pavement design is given in Table 9.18.

Table 9.18 Designed Traffic Volume for Pavement Design

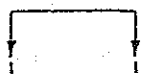
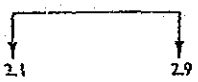
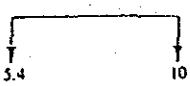
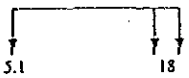
Vehicle Type	Vehicle Fleet Composition (%)	Year 2010 (PCU/day)	Year 1997 (PCU/day)	Year 2002 (PCU/day)
Passenger Car	28	5,600	2,240	3,640
Mini Bus, Pick-up	27	5,400	2,160	3,510
Large Bus	9	1,800	720	1,170
Small Trunk (2-Axles/4-Tires)	23	4,600	1,840	2,990
Medium Truck (2-Axles/6-Tires)	10	1,200	800	1,300
Heavy Truck (3-Axles)	2.5	500	200	325
Trailer	0.5	100	40	65
Total	100	20,000	8,000	13,000

e) Axle-Load Model

The Government of Indonesia has increased the axle-load requirement for Heavy Loaded Roads for 1-Axle from 8 ton to 10 ton, and for 2-Axles from 15 ton to 18 ton.

The Study Team decided on Axle-Load Models shown in Table 9.19.

Table 9.19 Axle-Load Model

NO.	VEHICLE TYPE	MODEL OF LOAD DISTRIBUTION (TON)	DAMAGING FACTOR
1	PASSENGER CAR PICK-UP MINI-BUS		0.0006
2	LARGE BUS		1.172
3	SMALL TRUCK		0.022
4	MEDIUM TRUCK		2.692
5	HEAVY TRUCK		2.464
6	TRAILER		5.13

f) Other Miscellaneous Design Conditions

For other design references given in the above, the following material has been referred to:

- *Design Guide for Pavement Structures (AASHTO), 1986.*
- "Heavy Loaded Road Improvement Programme.
  Province: South Sumatra", Pavement Design Report.
- "Manual, Permeriksaan Perkerasam Jalan dengan Alat Benkelman Beam", No. 01/MN/B/1983.

g) Pavement Structures

Based on the basic design conditions described above, the pavement structure and thickness for new and overlay pavement are given in Fig. 9.16.

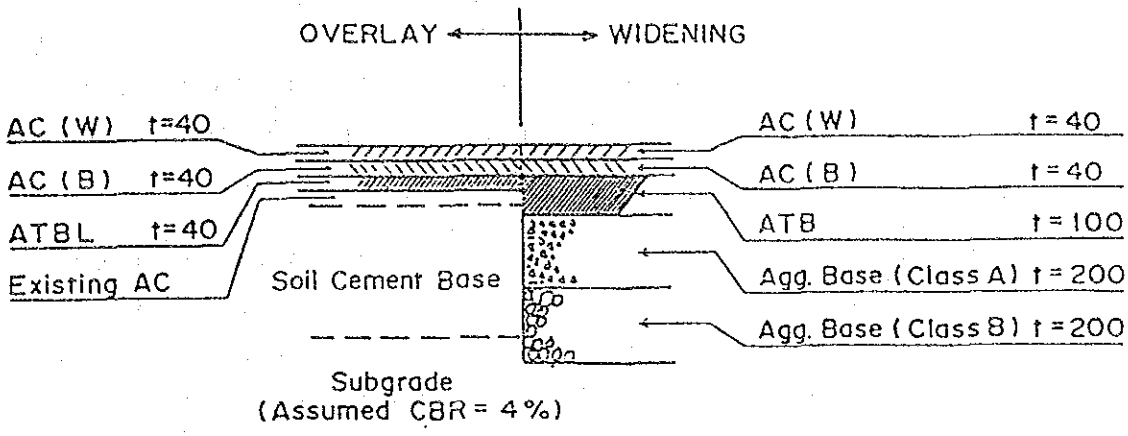


Fig. 9.16 Pavement Structure

9.3.6 Bridge Design

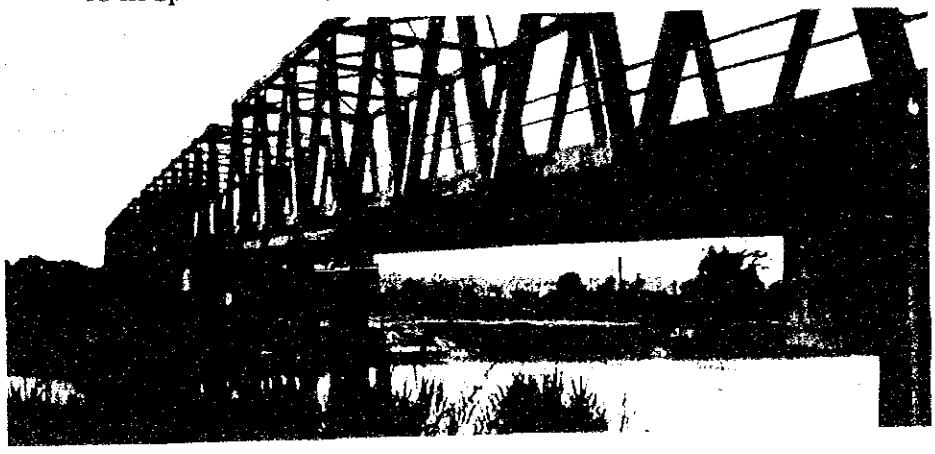
Of the bridges for the road section described in the Feasibility Study, the following two bridges will require rehabilitation work:

a) Tulang Bawang Bridge
b) Pedada Bridge

The bridges will generally be widened to 7.0 m as determined by the Government of Indonesia.

a) Tulang Bawang Bridge (Refer to Fig. 9.17)

- The present bridge is of trussed steel construction (Width 4.5 m, Spans 3-40 m span = 120 m), and was constructed in 1985.



- Widening of the existing trussed bridge will require strengthening of the trussed section and the main beams, and it is not possible to perform this work.

- There are two methods that can be considered to improve the bridge by widening. One method is to construct a duplicate trussed bridge 4.5 m wide parallel to the existing bridge. The other method is to construct a new 7.0 m wide trussed bridge. (Refer to Table 9.16)

- The reason for selecting a trussed bridge is that the existing bridge is a long bridge. Pre-constructed trussed standardized bridges imported from Australia (35, 40, 45, 50, 55 m span, 4.5, 6.0, 7.0 m width) are available and are widely used in Indonesia. Their use will reduce construction and maintenance costs. For this reason it has been recommended to use a bridge similar to the existing one.

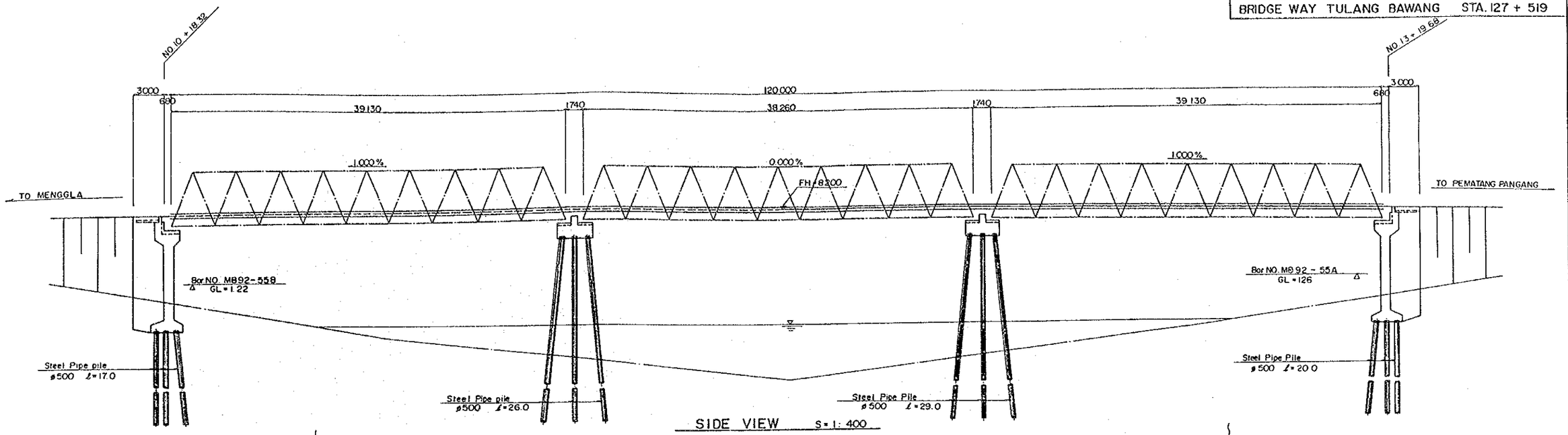
Comparison of Alternatives is shown in Table 9.20.

Table 9.20 Comparison of Alternatives

Duplication of Steel Truss with 4.5 m Width	- Traffic flow in 2-directions is separated. - Construction cost is comparatively lower than that of the bridge with 7.0 m width, due to the construction of bridge with 4.5 m width roadway. - Conveniences of road utilization for road users are less than those in the bridge with 7.0 m width, for example, the passing ahead of vehicles is inconvenient due to one lane in the separated roadway.
Replacement of Steel Truss with 7.0 m Width	- Construction cost is comparatively higher than that of the bridge with 4.5 m width. - Conforming to the design standard of the bridge with 7.0 m width in Indonesia. - Conveniences of road utilization for road users are more than those in the bridge with 4.5 m width. Even in the case of the passing ahead of vehicles and the stopping of vehicles by accicidents, there is little problem.

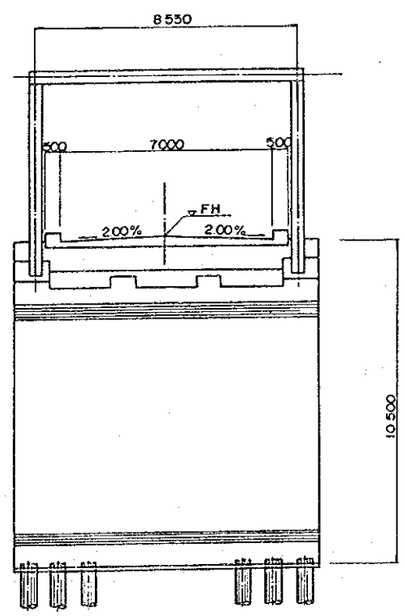
As a result of comparison above, the alternative of the replacement of bridge with 7.0 m width (the design standard in Indonesia) is judged to be recommendable taking the conveniences of road utilization for road users into account, in spite of comparatively higher construction cost.

PROJECT	PROVINCE	SHEET NO.	TOTAL SHEET
COASTAL ROADS IN EAST COAST OF SUMATRA	LAMPUNG		
PLAN AND PROFILE		SCALE = 1: 400	
BRIDGE WAY TULANG BAWANG		STA. 127 + 519	

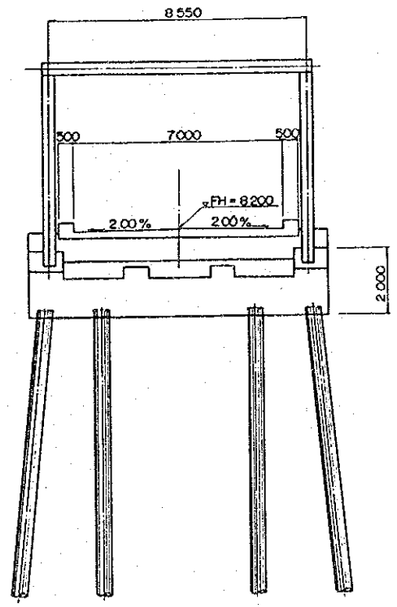


SIDE VIEW S = 1: 400

PLAN S = 1: 400



CROSS SECTION (ABUTMENT)
S = 1: 200

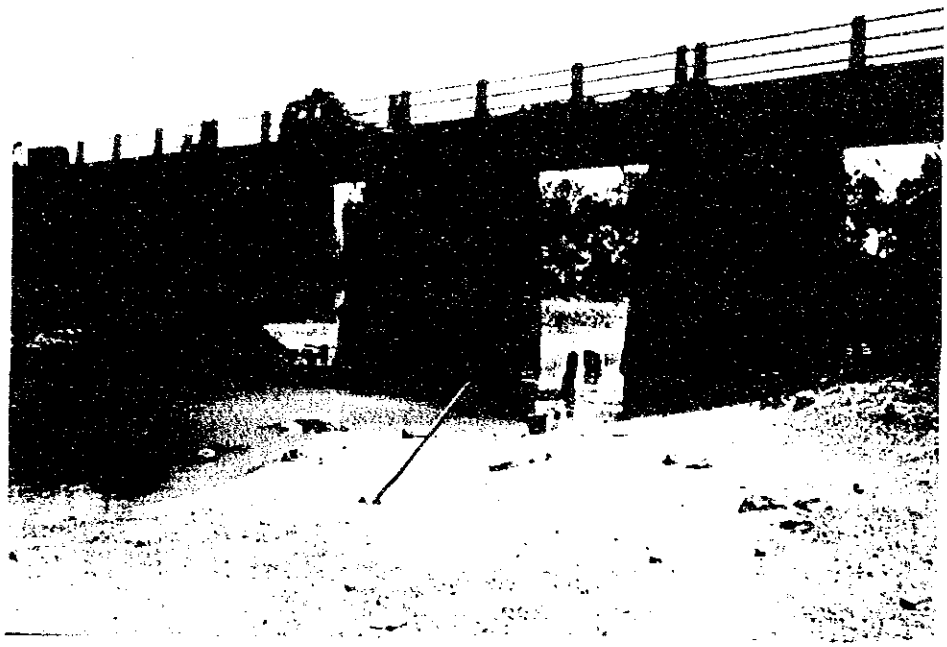


CROSS SECTION (PIER)
S = 1: 200

Fig. 9.17 **General Plan and Profile of Tulang Bawang Bridge**

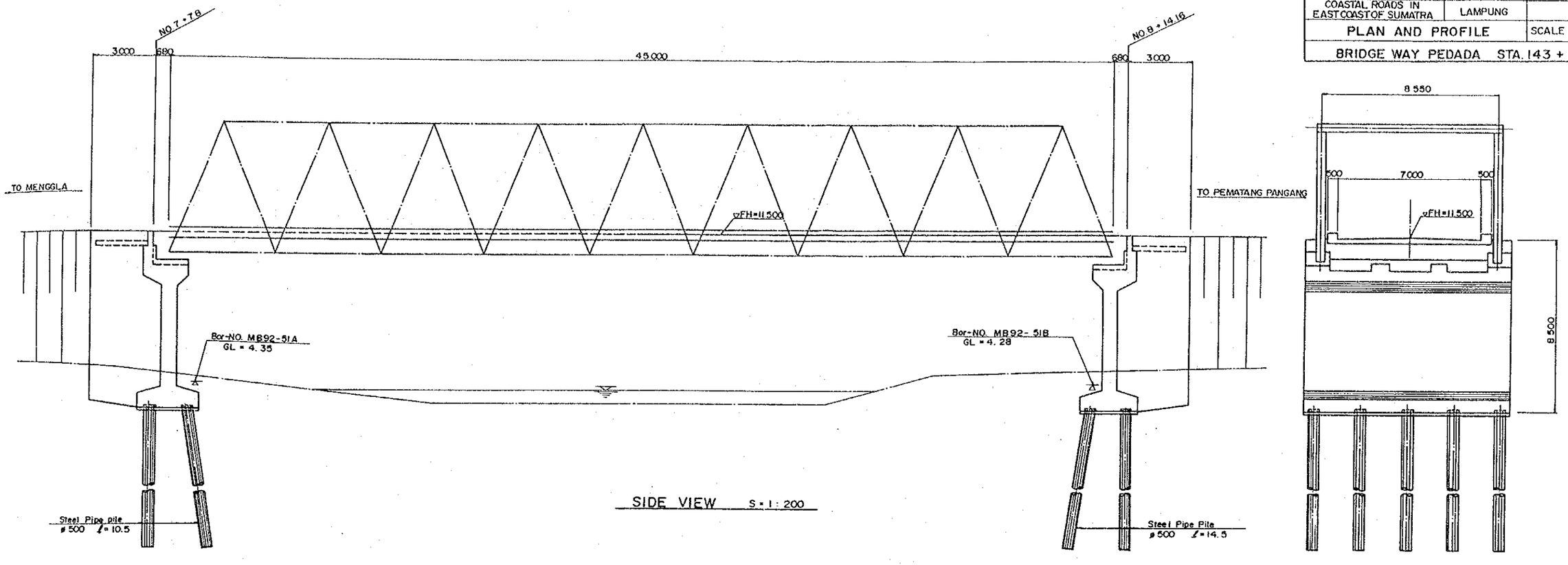
b) Pedada Bridge (Refer to Fig. 9.18)

- The existing bridge is a steel bridge (4.5 m wide, 4 x 8.9 m = 35.3 m) constructed in 1980.



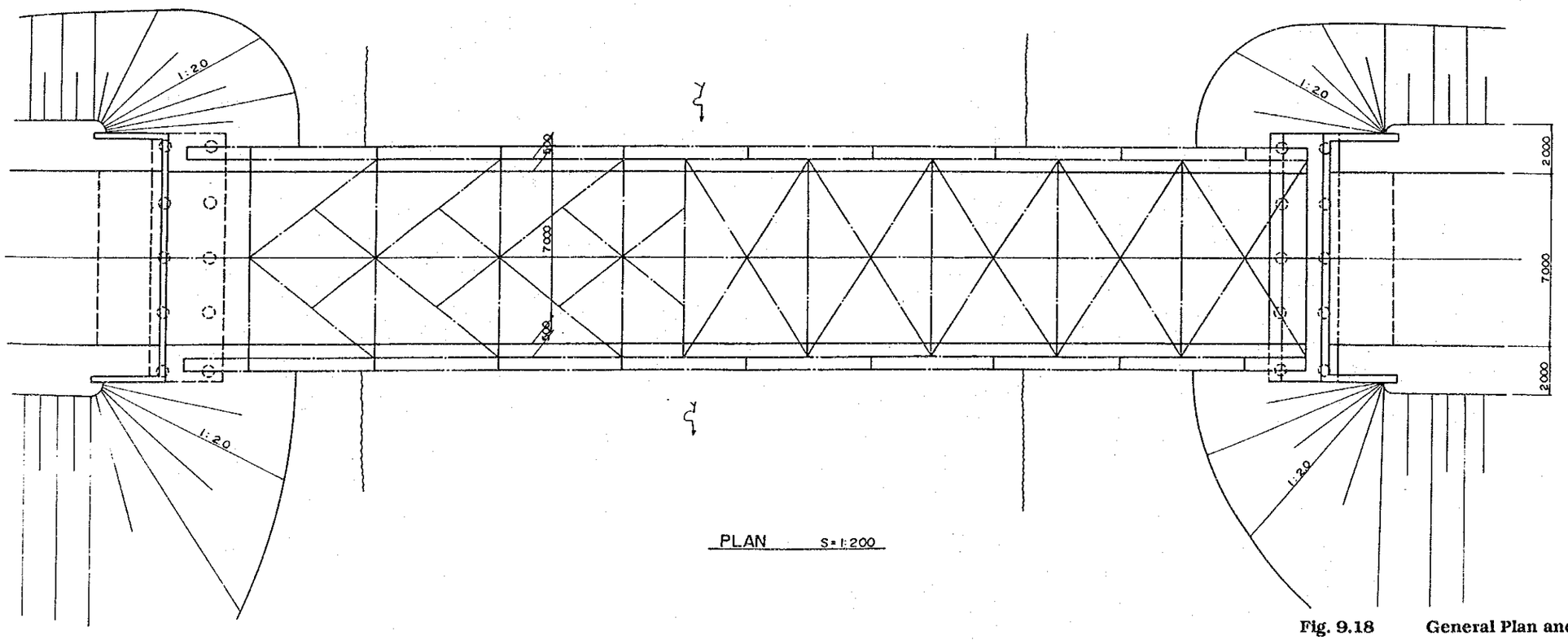
- The river at the bridge site is narrow, the river flow is restricted, and there is heavy scouring of the abutments on both sides.
- For this reason it has been proposed to rehabilitate the bridge by widening and lengthening of the bridge itself.
- Bina Marga has a plan to replace the existing bridge with a steel bridge (Width W = 6.0 m, Span 45 m), but has not yet implemented the plan.
- In view of the future traffic demand, it is recommended to replace the bridge with a steel bridge (Width 7.0 m, Span 45 m).

PROJECT	PROVINCE	SHEET NO.	TOTAL SHEET
COASTAL ROADS IN EAST COAST OF SUMATRA	LAMPUNG		
PLAN AND PROFILE		SCALE = 1 : 200	
BRIDGE WAY PEDADA STA. 143 + 253			



SIDE VIEW S = 1 : 200

CROSS SECTION (ABUT MENT) S = 1 : 200



PLAN S = 1 : 200

Fig. 9.18 General Plan and Profile of Pedada Bridge

9.4 Construction Planning

9.4.1 Scope of Construction

(1) General Description of the Construction Works:

The construction works consist of rehabilitation of the road from Kayuagung to Menggala, a distance of 183 km, and the replacement of two bridges. The detailed description is as follows:

1) Road Rehabilitation Works

- Total Length: 183 km (101 km within South Sumatra Province and 82 km within Lampung Province)
- Number of Lanes and Width:
  - Before Reconstruction: 1-lane, 4.5 m width (partially 2-lane, 2x3.0= 6.0m)
  - After Reconstruction: 2-lane, 2 x 3.5 = 7.0 m
- Shoulder Width:
  - Before Reconstruction: 1.0 m (partially 1.5 m or 2.0 m)
  - After Reconstruction: 2.0 m
- Pavement: Asphalt Pavement:
  - Existing paved road with overlay pavement.
  - Widened road sections and road sections with improved horizontal and vertical alignment with new pavement.

2) Bridge Replacement Works

Tulang Bawang:

- Location: Lampung Province, 8.5 km north of Menggala (TLB 127.5 km)
- Length: 3 x 40 m = 120 m
- Number of Lanes and Width: 2-lanes, 2 x 3.5 = 7.0 m
- Bridge Structure: Super Structure ---------- Trussed Bridge
  Sub Structure ---------- Reinf. Concrete Inverted T-Beam Abutment, Pile-Bent Bridge Pier
  Foundation ---------- Steel Pipe Pile
- Detour Bridge: Use existing bridge (W = 4.5 m)

Pedada Bridge:

- Location: Lampung Province, 24.3 km north of Menggala, (TLB 143.3 km)
- Length: 45 m
- Number of Lanes and Width: 2-lanes, 2 x 3.5 = 7.0 m
- Bridge Structure: Super Structure ---------- Trussed Bridge
  Sub Structure ---------- Reinf. Concrete Inverted T-Beam Abutment
  Foundation ---------- Steel Pipe Pile
- Detour Bridge: Use existing bridge (W = 3.8 m)

(2) Road Construction Sectors

The road construction will be divided into the following packages giving consideration to local contract methods and construction capacity.

Package-1:	South Sumatra Province, PLG 72 - PLG 131	(L = 57 km)
Package-2:	South Sumatra Province, PLG 131 - PLG 175	(L = 44 km)
Package-3:	Lampung Province, TLB 119 - TLB 161	(L = 42 km)
Package-4:	Lampung Province, TLB 161 - TLB 201	(L = 40 km)
Package-5:	Lampung Province, Tulang Bawang and Pedada Bridges.	

(3) The Principal Construction Quantities

The principal construction quantities are given in Table 9.26, Paragraph 9.5.

9.4.2 Construction Materials

(1) Procurement of Materials

The main materials to be procured are as follows:

1) Earth Fill Materials

The earth fill materials will be hauled to the fill site from borrow pits found along the project road all within a distance of 10 km. For a description of the borrow pit locations and quality of soils refer to Paragraph 9.2.2, Soils Characteristics and Materials Procurement.

2) Aggregates

River aggregates for use in paving and concrete are available in the vicinity of Kayuagung, otherwise aggregates are not available from along the project roads. Aggregates for Packages 1 and 2 can be obtained from the many rock quarries and rock crushing plants found along the Trans Sumatra Highway. Aggregates for Packages 3 to 5 are available from the rock crushing plants found in the hilly sites in the southeastern part of Lampung Province. The sites producing aggregate are shown in Fig. 9.16

3) Asphalt Concrete Mix and Ready Mix Concrete

Asphalt concrete mix and ready-mix concrete can be obtained from asphalt and concrete plants constructed temporarily within the project sites.

4) Steel

Reinforcing steel and structural steel can be obtained from the capital cities of Palembang and Bandar Lampung, and steel for bridge trusses and pipe piles and other special steels can be procured from Java.

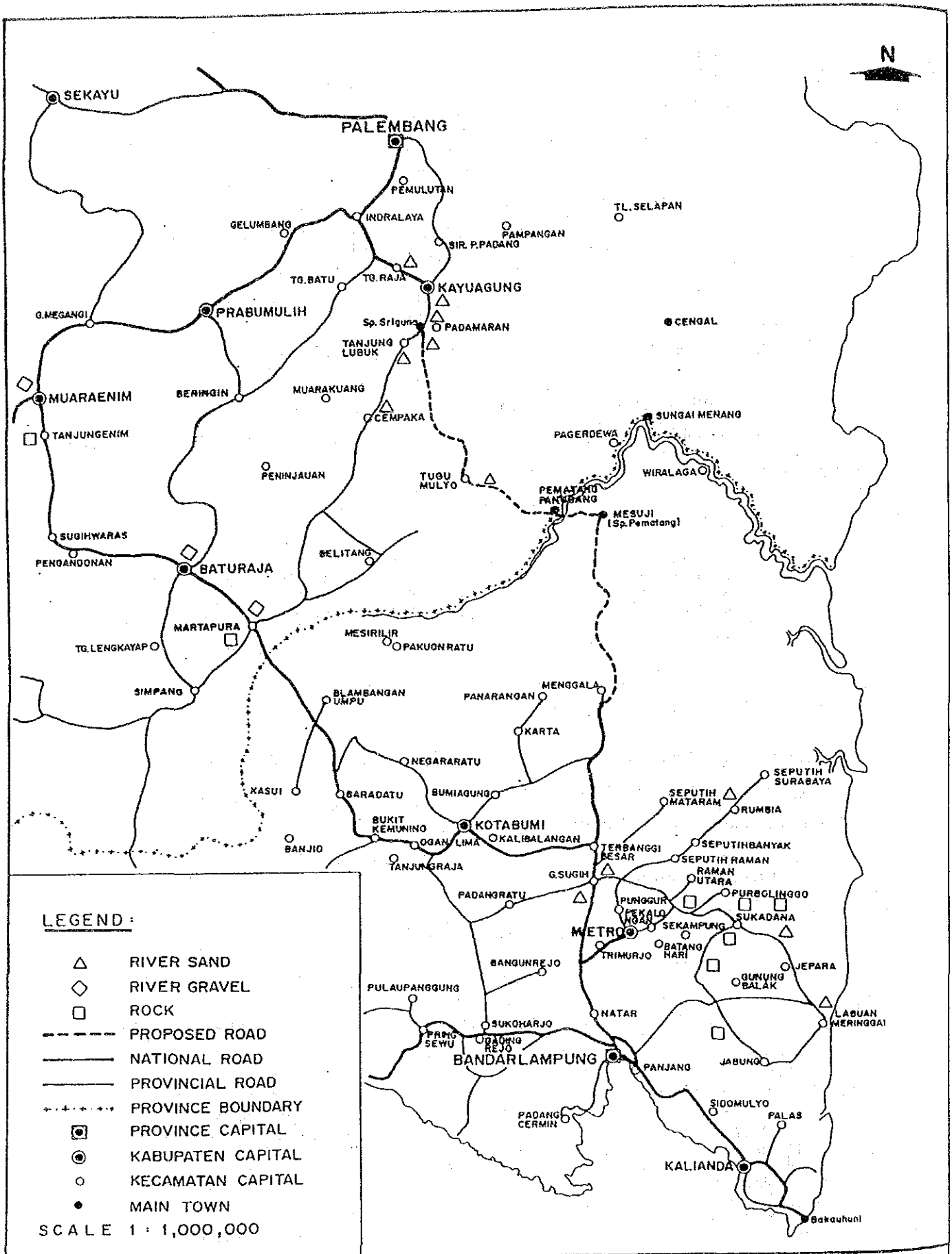
(2) Construction Equipment

The principal items of construction equipment required for the project are listed in Table 9.21 to Table 9.23 by the type of work. The equipment is available from the capital cities in Sumatra and Java.

1) Earthwork Equipment:

Table 9.21 Earthwork Equipment

Main Works	Equipment	
	Hauling distance less than 100 m	Hauling distance more than 100 m
Clearing and Grubbing	Bulldozer	
Excavation Loading Hauling	Bulldozer - Bulldozer	Tractor Shovel/Back Hoe Tractor Shovel/Back Hoe Dump Truck
Spreading	Bulldozer/Motor grader	
Compaction	Tamping Roller/Tire Roller	



COASTAL ROADS
IN
EAST COAST OF SUMATERA

Fig. 9.19 Location of Material Sources

2) Paving Equipment:

Table 9.22 Paving Work Equipment

Main Work	Equipment
Subgrade Preparation	Motor Grader, Tire Roller, Macadam Roller
Subbase	Motor Grader, Tire Roller, Macadam Roller
Granular Base	Motor Grader, Tire Roller, Macadam Roller
Prime/Tack Coat	Asphalt Distributor
ATB/Binder/Surface Course	Asphalt Mixing Plant, Asphalt Finisher, Macadam Roller, Tire Roller,

3) Bridge Construction Equipment:

Table 9.23 Bridge Construction Equipment

Main Work	Equipment
Foundation	*Diesel Pile Hammer, Pile Driver, Crawler Crane, Barge, Tugboat*
Structure Excavation	Clamshell, Back Hoe, Dump Truck
Substructure	Transit Mixer, Concrete Skip, Barge, Tugboat
Superstructure	Crawler Crane, Mobile Crane

9.4.3 Construction Methods

(1) Road Rehabilitation Works

The road rehabilitation works will generally be as follows: Refer to the Construction Schedule.

- Extension of box and pipe culverts.
- Earthworks (cut, fill, sand mats).
- Road widening and pavement works when granular materials will be used for road bases.
- Top base courses stabilized with bituminous materials for total road lengths (pavement rehabilitation will consist of preparation with this type of material).
- Base courses, surface course and shoulder works for all road sections.
- Slope stabilization works and ditch construction at toe of slopes.

(2) Bridge Works

Bridge works will be performed as follows: See Construction Schedule.

- Foundation works using steel pipe piles.
- Construction of bridge abutments and piers.
- Assembling of trusses with mobile crane.
- Flat bridge works (bridge decks, bridge expansion joints, bridge pavement).
- Other related works (stone works, protection of slopes).

9.4.4 Implementation Schedules

(1) Construction Schedule:

The construction schedule has been prepared taking into account the rainfall data of Table 9.24 (See Table 9.25).

Table 9.24 Number of Rainy Days in the Project Area (1981 - 1990)

Place	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
Palembang	20	20	21	20	15	9	8	7	11	14	18	18
Lampung	21	20	15	14	12	9	8	6	9	11	16	17
Average	21	20	18	17	14	9	8	7	10	13	17	18

Source : Meteological Agency

Table 9.25 Number of Working Days

Item	Dry Season May - Oct. (6 months)	Rainy Season Nov. - Apr. (6 months)	Annual
Average number of rainy days	9.9 days/month	18.3 days/month	169.0 days
Working efficiency on rainy days	65 %	35 %	100 %
Number of holidays	5.0 days/month	5.0 days/month	60.0 days
Number of actual working days	21.5 days/month	13.1 days/month	207.6 days
Working efficiency in a month	72 %	44 %	58 %

Road Section

Item \ Month	0	2	4	6	8	10	11	12	14	16	18	20	22	24	26	28
Preparation																
Earthwork																
Structure(Culverts, etc.)																
Pavement																
Miscellaneous Works																
Finishing																

Bridge Section (Tulang Bawang Bridge ··· A, Pedada Bridge ··· B)

Item \ Month	0	2	4	6	8	10	11	12	14	16	18	20	22	24	26	28
Preparation																
Substructure		A						B								
Super Structure							A				B					
Miscellaneous Works										A			B			
Finishing																

Fig. 9.20 Construction Schedule of Bridge

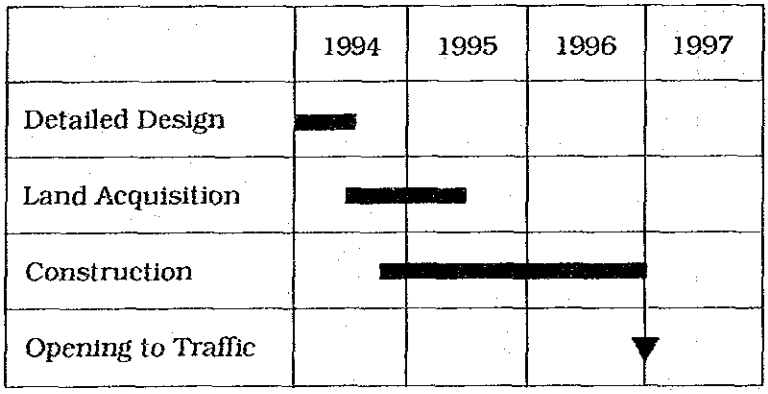
The various work schedules have been established with reference to the number of working days, work scope and construction equipment.

- Preparatory Works : 3 months
- Earthworks : Approximately 10,000 m^3/month
- Paving Works : Approximately 4 km/month
- Bridge Works : Bridge Length 50 m/8 months
  Bridge Length 100 m/15 months
- Clean Up : 2 months

From the above data, the construction schedule was prepared. The schedule indicates that the construction period will be 27 months. (See Fig. 9.20)

(2) Project Implementation Schedule:

On the assumption of commencement of the Detailed Design works from the beginning of 1994, the opening of the project to the public will be early 1997. The project implementation period will be 3 years (see the following figure).



9.5 Project Cost Estimate

9.5.1 Construction Costs Estimate

Table 9.26 gives respective data for calculation of construction cost. Estimation conditions are as follows:

(1) Establishment of Estimating Conditions:

The project costs will consist of the construction costs, contingency costs, technical costs, land compensation costs, and environment protection costs. To calculate these costs, the basic conditions will be as follows:

1) All construction works will be performed by Indonesian contractors.

2) The Indonesian value-added taxes (10 %) will be levied on the construction contractors.

3) The project costs will be assessed at the economic values in 1992.

4) The construction costs will consist of the permanent project costs, temporary (preparatory) costs, and miscellaneous costs. The permanent costs were calculated by obtaining quantities from the preliminary design drawings and multiplying by the unit cost for the construction operations of recent tender prices. The temporary costs and miscellaneous costs were assumed as 5 % and 10 % of the permanent costs respectively.

5) The contingency cost was assumed at 10 % of the construction costs.

6) The technical costs consist of consultant's cost for preparation of the detailed design drawings and construction supervision costs, and is assumed as 10 % of the total of the construction cost and the contingency.

7) Land compensation cost will be calculated from the road area required for road widening and for road alignment improvement, and the land compensation unit costs obtained from field investigations. The land compensation cost will not include any taxes.

Table 9.26 Project Cost

ITEM	UNIT	Financial Unit Cost (Rupiah)	Quantity	Financial Total Cost (1,000 Rupiah)
EARTHWORK				
Grade Preparation	m^2	900	804,510	724,059
Excavation (Common)	m^3	2,500	195,600	489,000
Embankment (borrow)	m^3	14,600	523,500	7,643,100
Sand Mat (t = 50 cm)	m^3	19,800	4,000	79,200
SUB-TOTAL				8,935,359
SUBBASE AND BASE				
Aggregate Subbase (Class B)	m^3	31,800	144,860	4,606,548
Aggregate Base (Class A)	m^3	37,400	144,860	5,417,764
Asphalt Treated Base (A.T.B)	m^3	189,000	94,560	17,871,840
Shoulder (Soil Aggregate)	m^3	15,000	219,000	3,285,000
SUB-TOTAL				31,181,152
SURFACE				
Asphaltic Prime Coat	L	700	724,310	507,017
Asphaltic Tack Coat	L	1,500	621,680	932,520
Asphaltic Concrete Binder (t = 4 cm)	m^2	8,400	1,277,570	10,731,588
Asphaltic Concrete Surface (t = 4 cm)	m^2	8,400	1,277,570	10,731,588
SUB-TOTAL				22,902,713
STRUCTURE				
RC Pipe Culvert (D < 45 cm)	m	116,000	95	11,020
(45 < D < 75 cm)	m	139,000	1,796	249,644
(75 < D < 120 cm)	m	208,000	818	170,144
RC Box Culvert (2.0 x 1.5 cm)	m	700,000	540	378,000
(3.0 x 2.0 cm)	m	1,160,000	366	424,560
(3.0 x 3.0 cm)	m	1,450,000	542	785,900
Grouted Rip-rap	m	27,000	13,005	351,135
Bridge Replacement	m	2,552,000	1,152	2,947,560
SUB-TOTAL				5,317,963
TOTAL (A)				68,377,187
TEMPORARY WORKS [(A)x5%]	LS		1	3,416,859
MISCELLANEOUS WORKS [(A)x10%]	LS		1	6,833,719
Contract Amount (B)				78,587,765
PHYSICAL CONTINGENCIES (C) [(B) x 10 %]	LS		1	7,858,777
ENGINEERING & SUPERVISION (D) [{(B) + (C)} x 10 %]	LS		1	8,644,654
LAND ACQUISITION (Average) (E)	m^2	18,500	804,510	14,833,435
COUNTERMEASURE COST (ELEPHANTS) (F)	LS		1	3,459,500
PROJECT COST {(B) + (C) + (D) + (E) + (F)}				113,434,131
AVERAGE COST (Per km)				619,859

Table 9.27 Land Compensation Unit Costs

Degree of Regional Development	Land Condition	Unit Rate (Rp/m²)
High	Land	25,000
	House incl. site	100,000
Medium	Land	15,000
	House incl. site	70,000
Low	Land	5,000
	House incl. site	50,000

8) The total length for environment protection will be 17 km and will include hand excavation of side ditches, land compensation costs, and planting costs, and was calculated at Rp. 203.5 million per km.

9.5.2 Road Maintenance Costs Estimate

(1) Contents of the Maintenance Costs:

The road maintenance work will consist of routine maintenance, periodic maintenance, betterment and reconstruction. Details of the work are described in Table 9.28 The life of the main works and project life is 25 years and the implementation years are given in the following Table.

Type of Maintenance	Main Item of Work	Implementation Year
Routine Maintenance	-	Every year
Periodic Maintenance	Overlay (40 mm)	2002, 2012
Betterment	Overlay (40+40=80 mm)	2007
Reconstruction	Re-pavement	2017

The implementation of road work and performance of road maintenance are given in Fig. 9.21, and have been taken from "Road Construction and the Roads".

Table 9.28 Road Maintenance Works

Kind of Maintenance Works	Routine Maintenance	Periodic Maintenance	Betterment	Reconstruction
Design Life	-	5 Years	10 Years	10 Years
Cleaning of pavement, ditches and culverts	0	-	-	-
Repair of ditches, culverts, cutting embankment and bridge	0	-	-	-
Repair of damage to road facilities	0	-	-	-
Pavement repair such as patching and seal coat	0	-	-	-
Strengthening of pavement by overlay	-	-	0	-
Repavement	-	-	-	0
Widening of pavement	-	-	0	0
Improvement of road shoulder	-	0	0	0
Extension of culverts	-	-	0	0
Realignment (new pavement)	-	-	0	0
Widening/Replacement of bridges	-	-	0	0

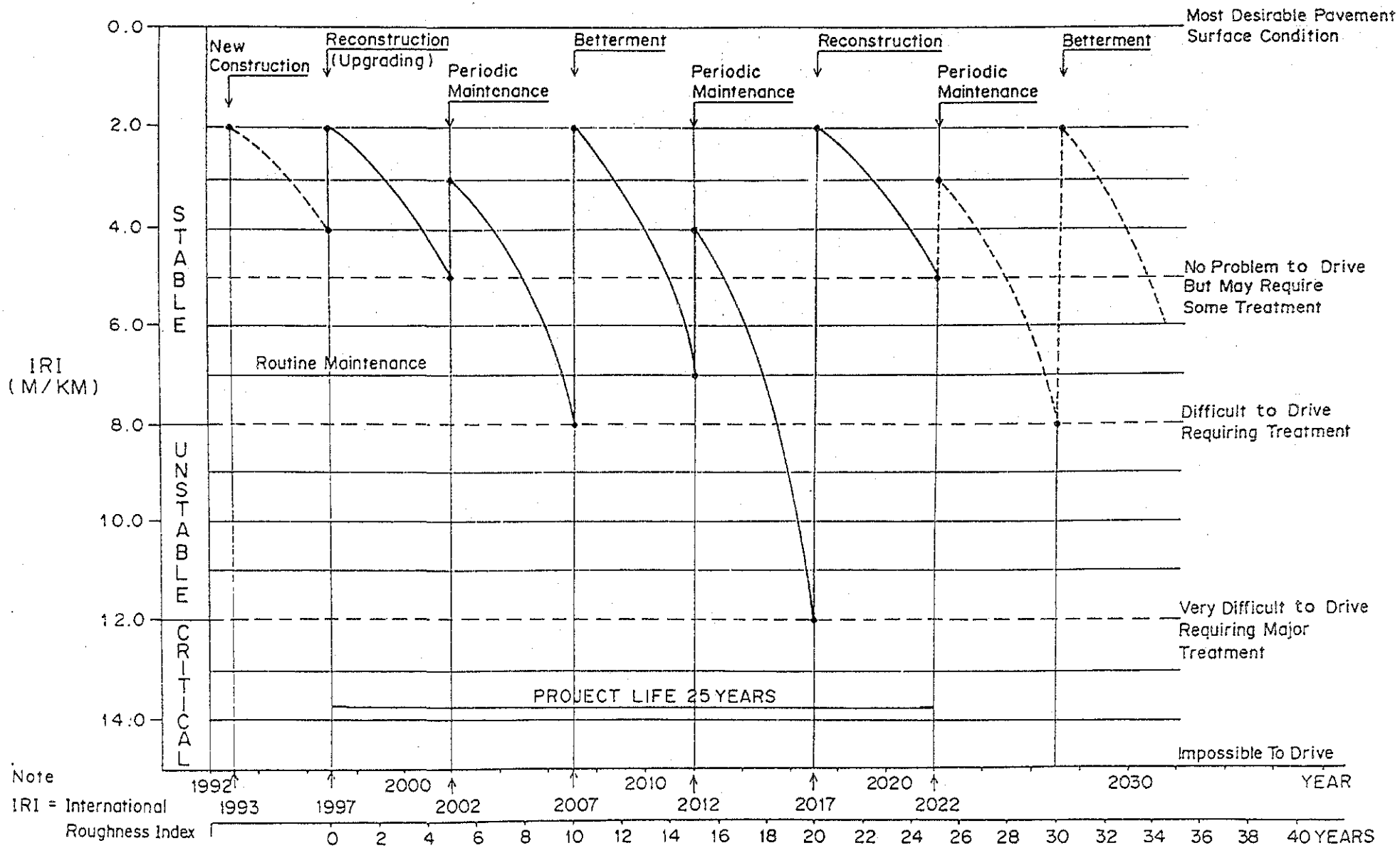


Fig. 9.21 Assumption of Relation of Road Condition and Road Works

(2) Establishment of the Estimating Conditions:

The basic pre-conditions for the estimate for maintenance for items other than those given below are similar to paragraph 9.5.1, Construction Costs Estimate.

a) The main items of work of routine maintenance and the unit costs are established as follows:

Description of Item	Unit of Measure	Unit Cost (Rp/Yr)
Pavement (incl. Bridges)	m^2	68
Shoulder	m^2	56
Drainage Facilities	m	75
Road Facilities	km	86,000

b) To estimate the periodic maintenance costs, the maintenance costs are assumed to be 5 % of the main works, and the technical costs are assumed to be 5 % of the construction costs.

c) The land costs for betterment/reconstruction due to improvement of the road alignment are trivial and are not estimated.

(3) Maintenance Costs:

The maintenance cost has been established as follows:

Type of Maintenance	Project Cost (Rp. 1,000)
Routine Maintenance	165,000
Periodic Maintenance	13,908,000
Betterment	33,617,000
Reconstruction	61,908,000

9.6 Project Economic Analysis

9.6.1 General

The major objectives of the project economic analysis are to examine the effect of the construction of the Feasibility Study road section of Kayuagung - Menggala from the national economic viewpoint.

The evaluation of quantified economic costs and benefits follows the conventional discounted cash flow methodology in determining the economic internal rate of return (EIRR), net present value(NPV) and benefit cost ratio (B/C).

9.6.2 Economic Project Costs

The economic investment costs are estimated in constant 1992 prices. The financial investment costs in terms of market price include the component of taxes. The economic costs for economic analysis are obtained by subtracting the portion of transfer payment such as taxes from financial costs. The financial and economic investment costs (initial investment) are summarized in Table 9.29.

The implementation schedule follows the analysis in the section. Construction is scheduled over three years from 1994 to 1996. The economic investment costs in constant 1992 prices are phased according to the implementation schedule as shown in Appendix A-9.8.

Table 9.29 Summary of Financial and Economic Project Costs (Initial Investment)

(Million Rp. at 1992 price)

	Financial Costs	Economic Costs
Construction Costs	89,906	81,733
Land Acquisition	14,883	14,883
Engineering Services	8,645	7,859
Grand Total	113,434	104,475

9.6.3 Economic Benefits

The economic benefits which would be realized from the implementation of the Project are defined as the savings in travel costs, composed of the vehicle operating cost and vehicle time cost, when comparing the "With" and "Without" project condition.

The benefit of vehicle operating costs is estimated as the difference of vehicle operating cost between "With" project and "Without" project. The vehicle operating cost is derived from the obtained daily vehicle-kilometers and the unit vehicle operating cost by vehicle type.

The benefit of vehicle time cost is estimated as the difference of vehicle time costs between "With" Project and "Without" Project. The vehicle time cost is derived from the obtained daily vehicle-hours and the unit vehicle time cost by vehicle type.

The vehicle-kilometers and vehicle-hours by vehicle type were estimated based on the calculated PCU (passenger car unit)-kilometers and PCU-hours by the traffic assignment process of the traffic demand forecast.

In this economic analysis, the conversion of PCU (passenger car unit) into the unit of vehicle type (passenger car, light truck, heavy truck, small bus and large bus) was made as follows:

- By applying the share ratio of PCU-Kilometers by vehicle type which were estimated by the traffic assignment process, PCU-kilometers were divided in terms of vehicle type. (The applied share ratio of PCU-Kilometers are provided in Appendix A-9.9.)

- Then, the divided PCU-kilometers were converted into unit of vehicle type by using the conversion factors below:

  - Passenger car : 1.00
  - Light truck : 1.65
  - Heavy truck : 3.20
  - Small bus : 1.25
  - Large bus : 2.50

- The vehicle-hours by vehicle type were obtained through dividing vehicle-kilometers by vehicle type by speed (speed = PCU-kilometers / PCU-hours).

9.6.4 Unit Vehicle Operating Cost

(1) General

The estimation of unit vehicle operating cost follows the method in the "Road User Cost Model, Bina Marga", compiled by Hoff & Overgaard a/s Denmark in association with PT. MULTI PHI BETA, Indonesia, May 1992.

(2) Unit Vehicle Operating Cost

According to the above study, the unit vehicle operating costs (VOC) are expressed by the following equations:

$$\text{Unit VOC} = \text{VOC Index} \times \text{Base Cost}$$

$$\text{VOC Index} = K1 + K2/V + K3 \times V^{\wedge 2} + K4 \times V \times IRI + K5 \times IRI^{\wedge 2}$$

where,

K1, K2, K3, K4, K5	:	Constants
V	:	Velocity
IRI	:	International Roughness Index

The values of Constants and Base Cost are different by vehicle type.

The vehicle categories in the study of "Road User Cost Model" are as follows:

- Passenger car
- Utility
- Light truck
- Medium truck
- Heavy truck
- Small bus
- Large bus

(3) Review of Vehicle Type

For application of the above equations of unit vehicle operating cost, the vehicle categories were reviewed.

The vehicle categories used in the traffic analysis in this Study are based on the 1991 National OD Survey Study, and are as follows:

- Passenger car
- Light truck
- Heavy truck
- Small bus
- Large bus

The vehicle category of "small bus" in the 1991 National OD Survey Study is for the mini-bus vehicle type, namely "Mitsubishi L300" class or smaller class. This vehicle type is equivalent to that of "utility" in the study of "Road User Cost Model". Accordingly, the unit vehicle operating cost equation for "utility" in the "Road User Cost Model" was applied for the "small bus' in this economic analysis.

The "large bus" in the National OD Survey Study includes both types of medium bus and large bus. However, since both were counted together, the share ratio of both types of bus is unknown. So, the unit vehicle operating cost equation for "large bus" is assumed to be applied for "large bus" in this economic analysis.

For "passenger car", "light truck" and "heavy truck", the equations for these vehicle types were directly applied.

As a result, the values of Constant and Base Cost in the above equation model of unit vehicle operating cost applied for this analysis are expressed as follows:

Vehicle Type	Constant					Base Cost
	K1	K2	K3	K4	K5	
Psg. Car	0.6838	24.851	0.00000252	0.0001050	0.001737	254.43
Light Truck	0.5422	24.086	0.00000956	0.0003420	0.000763	282.36
Heavy Truck	0.5603	16.601	0.00002290	0.0004070	0.000687	521.50
Small Bus	0.5547	28.008	0.00000927	0.0001410	0.001262	205.85
Large Bus	0.5807	20.159	0.00002140	0.0000785	0.002008	381.54

For convenience of calculation IRI (International Roughness Index) value = 5.0 was assumed to be applied for both planning years 1997 and 2010, and was estimated as the average IRI value in the IRI curve shown in Fig. 9.21.

9.6.5 Unit Vehicle Time Cost

In this analysis, vehicle time costs are assumed to be counted for the vehicle types of "passenger car", "small bus" and "large bus".

The estimations of unit vehicle time costs for these three vehicle types were made according to the following process:

1) The 1992 average value of per capita GRDP (gross regional domestic product) at current price excluding oil and gas in Sumatra area is estimated to be Rp. 987,000.

2) The annual working hours is assumed to be 2,040 hours (170 hours per month x 12).

3) The per capita GRDP for one hour is estimated as Rp. 484.

4) The trip purpose composition in Sumatra area is derived from the results of the 1991 National OD Survey as shown below:

Trip Purpose	Car Passengers	Bus Passengers
Business	27.0%	9.5%
Recreation	9.3	8.3
Visit families	44.7	50.4
Work	12.4	11.4
School	1.6	8.5
Shopping	2.2	2.8
Others	2.8	7.4
Unknown	0.0	1.7
(Total)	100.0	100.0

5) The coefficient factors for time value in the trip purposes are assumed 100% for "business" and "work" and 0% for other purposes.

6) The time values per passenger are estimated to be Rp. 191 for car passengers and Rp. 101 for bus passengers.

7) The occupancy rates of vehicles in Sumatra area are derived from the results of the 1991 National OD Survey as below:

Passenger car	:	3.0
Small bus	:	7.1
Large bus	:	34.8

8) The unit time costs for vehicles per hour are estimated as below:

Passenger car	:	Rp. 573
Small bus	:	Rp. 717
Large bus	:	Rp. 3,515

The estimation process is given in Appendix A-9.10.

9.6.6 Estimation of Economic Benefit

The quantified economic benefits in travel costs are defined as the savings in economic travel costs when comparing the "with' and "without' project situations. Travel costs are composed of vehicle operating cost and vehicle time cost.

The "with" project situation is the "with" project traffic assignment of road users on the road network with development of the project road. The "without" project condition is the traffic assignment of the above road users on the road network without development of the project road.

The total daily economic vehicle operating costs, in both the "with" and "without" conditions, were calculated based on the daily vehicle-kilometers of the traffic by vehicle type on each road link and the unit vehicle operating cost. These daily costs were then converted to total annual costs by multiplying by 365. The economic benefit in operating costs was then taken as the savings in vehicle operating costs when comparing the total "with" and "without" project vehicle operating costs.

A similar method was followed in estimating the economic benefits in time costs where the total vehicle-hours by vehicle type in the "with" and "without" project conditions were applied directly to the unit time costs per hour. After converting the total daily time costs to annual time costs, the costs were netted out to arrive at the savings in time costs.

The savings in vehicle operating costs and vehicle time costs are summarized for the planning years of 1997 and 2010 as shown in Table 9.30.

Table 9.30 Estimated Economic Benefits (Savings in Vehicle Operating Cost and Time Cost)

(Million Rp. at 1992 price)

		Benefits Amounts
1997	VOC Saving	9,871
	Time Saving	807
	Total	10,678
2010	VOC Saving	40,111
	Time Saving	3,797
	Total	43,908

9.6.7 Economic Cost-Benefit Analysis

(1) Basic Assumptions

The analysis followed the conventional discounted cash flow method in determining the economic internal rate of return (EIRR), the net present value (NPV) and the benefit cost ratio (B/C).

These efficiency measures establish the economic viability of the project road and indicate the sensitivity of the project's economic viability to the changes in project costs and benefits.

Apart from the elements previously discussed, the following basic assumptions were made for the economic project analysis:

Project life	:	25 years after development of the proposed road
Prices	:	1992 prices
Residual value	:	None

The NPV and B/C were calculated based on a discount rate of 15 percent.

(2) Economic Cost-benefit Analysis

The economic project costs were previously discussed in Section 9.6.2. The economic benefits from the savings in vehicle operating costs and time costs for the planning years were discussed previously in Section 9.6.6. The benefits in the intermediate years were interpolated and those beyond 2010 were assumed to be extrapolated by the annual average growth during 1997 - 2010.

The total economic project costs and benefits streams are presented in Table 9.31.

Following the conventional discounted cash flow methodology, the efficiency measures were calculated and the results are as follows:

Efficiency Measures	
EIRR	18.2%
NPV(Million Rp.)	26,200
B/C	1.3

Note) EIRR ------ Economic Internal Rate of Return
NPV------- Net Present Value at discount rate of 15%
B/C-------- Benefit Cost Ratio at discount rate of 15%

These results indicate that implementation of the Project (road construction of the section Kayu Agung - Menggala) is economically feasible.

9.6.8 Sensitivity Analysis

Assuming that the benefits and cost stream might alter ±10%, ±20%, the effect on the EIRR was tested and the results are summarized in Table 9.32.

In the most severe case of -20% benefit and +20% cost, the value of EIRR is 13.6%.

Table 9.32 EIRR by Altered Benefit and Cost

Cost	Benefit		
	Base	-10%	-20%
Base	18.2%	16.9%	15.6%
+10%	17.1%	15.8%	14.5%
+20%	16.0%	14.8%	13.6%

Table 9.31 Economic Project Analysis

EIRR = 18.20%
NPV = 26,161 Million Rp.
B/C = 1.31
(Discount Rate Used = 15%)

	Year	Benefit			Cost				Net Cash Flow
		VOC Saving	Time Saving	Total	Const.	Maint.	(Without)	Total Cost	
1	1993								
2	1994				28,504			28,504	-28,504
3	1995				41,707			41,707	-41,707
4	1996				34,265			34,265	-34,265
5	1997	9,871	807	10,678		150	101	49	10,629
6	1998	12,197	1,037	13,234		150	101	49	13,185
7	1999	14,523	1,267	15,790		150	101	49	15,741
8	2000	16,849	1,497	18,346		150	101	49	18,297
9	2001	19,176	1,727	20,903	12,644	150	8,569	4,225	16,678
10	2002	21,502	1,957	23,459		150	101	49	23,410
11	2003	23,828	2,187	26,015		150	101	49	25,966
12	2004	26,154	2,417	28,571		150	101	49	28,522
13	2005	28,480	2,647	31,127		150	101	49	31,078
14	2006	30,806	2,877	33,683	30,561	150	20,569	10,142	23,542
15	2007	33,133	3,107	36,240		150	101	49	36,190
16	2008	35,459	3,337	38,796		150	101	49	38,747
17	2009	37,785	3,567	41,352		150	101	49	41,303
18	2010	40,111	3,797	43,908		150	101	49	43,859
19	2011	42,437	4,027	46,464	12,644	150	8,569	4,225	42,240
20	2012	44,763	4,257	49,020		150	101	49	48,971
21	2013	47,089	4,487	51,576		150	101	49	51,527
22	2014	49,416	4,717	54,133		150	101	49	54,084
23	2015	51,742	4,947	56,689		150	101	49	56,640
24	2016	54,068	5,177	59,245	55,832	150	37,496	18,485	40,759
25	2017	56,394	5,407	61,801		150	101	49	61,752
26	2018	58,720	5,637	64,357		150	101	49	64,308
27	2019	61,046	5,867	66,913		150	101	49	66,864
28	2020	63,373	6,097	69,470		150	101	49	69,420
29	2021	65,699	6,327	72,026		150	101	49	71,977
	Total			1,033,796	216,155	3,750	77,323	142,582	891,214
	Discounted at rate of 15%			109,304				83,144	26,161

Chapter 10

ENVIRONMENT IMPACT STUDY

CHAPTER 10

ENVIRONMENT IMPACT STUDY

10.1 General

This section reports on the Feasibility Study for the Kayuagung - Menggala Section, approximately 190 km long, and the environmental impact caused by the Sumatra East Coast Highway Development Project.

The environmental impact evaluation is based on the Indonesian Law and Regulations, and Guidelines as follows:

- Republic of Indonesia Law No. 4: Principal Formulation of Managing Living Space.
- Republic of Indonesia Law No. 13 concerning Roads.
- Government Regulation No. 29: Environmental Analysis (AMDAL).
- Government Regulation No. 26 concerning Roads.
- Decree of the Minister of Demography and Living Space No. 49/MENKLH/1987: Guideline of Determining Important Impact.
- Decree of the Minster of Demography and Living Space No. 51/MEKLF/6/1987: Guideline of Formulizing Evaluation Study of Environmental Impact.
- Decree of the Minister of Demography and Living Space No. 52/MEKLH/6/1987: Time Limit of Formulizing Evaluation Study of Environmental Impact.
- Decree of the Minister of Demography and Living Space No. 02/MENKLH/1988: Determining Environmental Quality Standard.
- Decree of the Minister of Public Works No. 557/KPTS/1989: Implementing Environmental Management of Road Construction.
- Decree of the Minister of Public Works No. 46/PRT/1990: AMDAL Technical Guideline in Public Work Sector.

- Decree of the Minister of Public Works No. 779/KPTS/1990: AMDAL Guideline in Road and Bridge Sector.

- Decree of the Minister of Public Works: Defining Public Work Project which need AMDAL/SEMDAL.

In general, Environmental Impact Evaluations for Feasibility Studies prepared for Bina Marga are performed in accordance with the following steps:

Step 1 : The PIL Report is examined by the AMDAL Committee of Bina Marga. When it has been determined that there will not be any serious adverse impact on the environment, the environmental impact evaluation is completed. However, if it is determined that there will be a serious adverse impact on the environment, then Step 2 procedure will be taken.

Step 2 : The AMDAL Report (Environmental Impact Investigation) will be submitted to the committee composed of Bina Marga, Environment Authority, and other related organizations where it will be investigated. The results of the investigation will be evaluated by the Central Committee of the Ministry of Public Works.

In the Feasibility Study stage, the Environmental Impact Study was conducted by PT. Dacrea under a supervision of the Study Team. Through the discussion with Bina Marga, it is judged that there is no any serious adverse impact on the environment.

The study results are described below:

10.2 Purpose of the Investigation

The following investigations were performed to determine the impact on the environment by the Sumatra East Coast Highway Project.

- physical-chemistry field	water quality, soils, etc.
- ecological systems	flora and fauna,
- socio-economic field	relocation of residents, historical/cultural remains, etc.

10.3 Present Condition of the Natural Environment

10.3.1 Rivers

The rivers in the project site in Lampung Province and South Sumatra Province are as follows:

Lampung Province	South Sumatra Province
1. W. Tulang Bawang	8. W. Tugu Mulyo
2. W. Pedada	9. Bumi Arjo
3. W. Bujuk	10. S. Tebing Suluh
4. W. Buaya	11. W. Badak
5. W. Buaya Aquain	12. W. Sugkai
6. W. Irigasi	13. W. Burnai
7. W. Mesuji	14. W. Jahe
	15. W. Menanga
	16. W. Tembu Runtul
	17. W. Serapat
	18. W. Bunut II
	19. W. Bunut I
	20. Talang Pangeran

Table 10.1 and Table 10.2 give the amount of flow, water temperature, turbidity and suspended solids, pH, Cl, Total Nitrogen, DO, BOD, COD, Microbiology present as the results of the investigation.

10.3.2 Topography and Geology

The project site extends from Menggala to Kayuagung via Pematang Paggang for a distance of approximately 190 km. Topographically the region consist of hilly country in the east combined with low lands, and the elevation ranges from 56 m to 3 m from the west to the east. Generally the gentle slopes of the hills are cultivated and plant produces are grown in the elevation range of 0 ~ 25 m.

In the northeast area of this region there are many stream and rivers of all size flowing towards the northeast, and for this reason the area has a soft ground base.

The geology of the region is composed of sedimenting rocks of the Tertiary and Quaternary age which form the base over which there are alluvium and swamp deposits which are widely distributed in the area.

Table 10.1 Test Results of Water Quality in Lampung Province

No. of River	1	2	3	4	5	6	7
Distance (km) / (Water Parameter)	158.00	142.00	129.00	115.00	112.00	95.00	90.00
Quantity							
The width of the river	25.00	5.00	10.00	12.00	12.00	-	12.50
Depth	5 - 7	3.00	0.50	2.00	2.00	-	-
Quantity (M3/seconds)	25.50	6.30	-	5.52	5.52	-	-
Quality							
Physical							
- Temperature (°C)	31.00	31.00	29.00	30.00	30.00	30.00	29.00
- Turbidity (NTU)	34.10	11.80	22.00	47.60	54.90	13.79	26.90
- Conductivity (s/cm)	43.00	14.00	25.00	12.00	20.00	17.00	18.00
- Total Suspended Solid (ppm)	30.00	10.00	20.00	10.00	15.00	8.00	10.00
Chemical							
- pH	6.31	6.18	6.34	5.69	6.16	6.21	6.45
- Cholida (Cl)	5.32	3.54	5.32	4.43	6.20	7.08	5.32
- Total Nitrogen (%)	1.98	3.22	0.33	4.05	0.41	0.95	0.43
- DO (ppm)	3.80	3.20	3.40	5.20	4.80	4.60	2.60
- BOD (ppm)	2.60	1.95	5.21	1.30	7.81	6.83	6.83
- COD (ppm)	7.75	7.75	7.75	11.63	13.59	42.64	50.39
Microbiological							
- Total Coliform (MPN/100 ml)	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00

Note:

No. of River	Distance	Name of River
1	158	W. Tulang Bawang
2	142	W. Pedada
3	129	W. Bujuk
4	115	W. Buaya
5	112	W. Buaya Aquain
6	95	W. Irigasi
7	90	W. Mesuji

Table 10.2 Test Results of Water Quality in South Sumatra Province

No. of River	8	9	10	11	12	13	14	15	16	17	18	19	20
Distance (km) / (Water Parameter)	70.00		63.00	59.00	52.00	44.00	38.00	34.00	30.00	25.00	12.00	10.00	0.00
Quantity													
The width of the river	5.00	5.00	25.00	5.00	1 - 2	6.00	4.00	2 - 4	2 - 3	2 - 3	-	-	-
Depth	-	-	2.00	0.30	0.25	1.50	0.50	0.5 - 1	0.2 - 0.5	0.2 - 0.5	-	-	0.50
Quantity (M3/seconds)	1.67	0.00	18.00	-	0.03	1.50	0.11	0.2 - 0.0	0.7 - 0.25	0.7 - 0.25	-	-	-
Quality													
Physical													
- Temperature (°C)	31.00	31.00	30.00	31.00	29.00	29.00	30.05	29.00	28.00	29.00	27.00	29.00	32.00
- Turbidity (NTU)	32.10	37.30	44.50	52.60	37.60	36.70	36.30	50.30	117.30	88.70	1.57	7.27	19.80
- Conductivity (s/cm)	20.00	12.00	68.00	64.00	134.00	32.00	33.00	15.00	19.00	17.00	9.00	10.00	100.00
- Total Suspended Solid (ppm)	10.00	5.00	50.00	55.00	85.00	20.00	20.00	12.00	15.00	15.00	5.00	5.00	65.00
Chemical													
- pH	6.20	5.97	6.83	6.51	7.70	6.40	6.29	6.00	5.90	5.81	5.28	6.80	7.38
- Cholida (Cl)	5.32	5.32	4.43	5.32	5.32	5.32	5.54	5.32	3.57	7.08	5.32	5.32	5.32
- Total Nitrogen (%)	1.16	0.54	0.59	0.74	0.01	0.25	1.65	0.41	0.66	0.50	1.65	0.25	0.33
- DO (ppm)	4.00	2.60	3.40	2.40	6.60	2.80	2.80	2.60	3.40	3.40	0.30	0.80	3.80
- BOD (ppm)	6.51	0.98	2.28	10.09	10.41	11.39	15.86	10.42	10.41	6.51	14.32	12.36	13.01
- COD (ppm)	32.18	3.86	11.58	42.46	65.62	69.48	73.34	61.76	50.18	61.76	50.18	61.76	32.30
Microbiological													
- Total Coliform (MPN/100 ml)	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	540.00	1,600.00	920.00

Note:

No. of River	Distance	Name of River	No. of River	Distance	Name of River
8	70	W. Tugu Mulyo	15	34	W. Menanga
9		Bumi Arjo	16	30	W. Tambu Runtul
10	63	S. Tabing Suluh	17	25	W. Serapat
11	59	W. Badak	18	12	W. Bunut II
12	52	W. Sungkai	19	10	W. Bunut I
13	44	W. Burnai	20	0	Talang Pangeran
14	38	W. Jahe			

The Muaraenim formation of Pliocene age forms the base of the region and includes tuffaceous mudstone and sandstone with coal intercalation.

The Kasai formation consist of pumiceous tuff. Sandy tuff, tuffaceous sandstone and conformably overlies the Nuaraenim formation. There deposits are distributed all over the hilly areas.

The alluvial deposits are mainly distributed in the river basin and the low lands, and consist of clay, silt, sand gravel, etc.

The Swamp deposits are widely distributed in the low lands of the east coast, and consist of mud, silt, clay, sand, and humus, and together with the alluvial deposits form the soft ground.

10.3.3 Climate

Data on the temperature, humidity, wind velocity, and sun exposure is shown below for Menggala and Kayuagugn for the ten years from 1980 to 1989.

The average valuer for the ten years are as follows:

	Menggala	Kayuaging
Temperature (°C)	26.1	26.6
Humidity (%)	83	80
Wind Velocity (Knot)	2.4	2.2
Sun Exposure (%)	62	63

The above values give the general tendency in the region.

10.3.4 Flora and Fauna

1) Plants

Plant growth in the project site can be classified as shown in Table below.

No.	Classification	Name of Village
1.	Flat areas	- Way Tulang Bawang Village
		- Unit II
		- Mesuji Village
		- Bumi Arjo Village
		- Burnai Village
2.	Secondary Forest	- Way Buaya
		- Burnia Village
3.	Swamp Lands	- Waya Tulang Bawang Village
		- Mesuji Village
		- Muara Burnai Village

Plants that grow in the flat lands are:

Trees, fruit trees, vegetables, plantations, medicinal plants, flowering plants, etc.

Plants that will grow in the forest are:

Forest product, producing trees, fruit trees, medicinal plants, etc.

Plants that grow in the swamplands are:

Wet land grass, vegetables, short trees, weeds, etc.

2) Animals

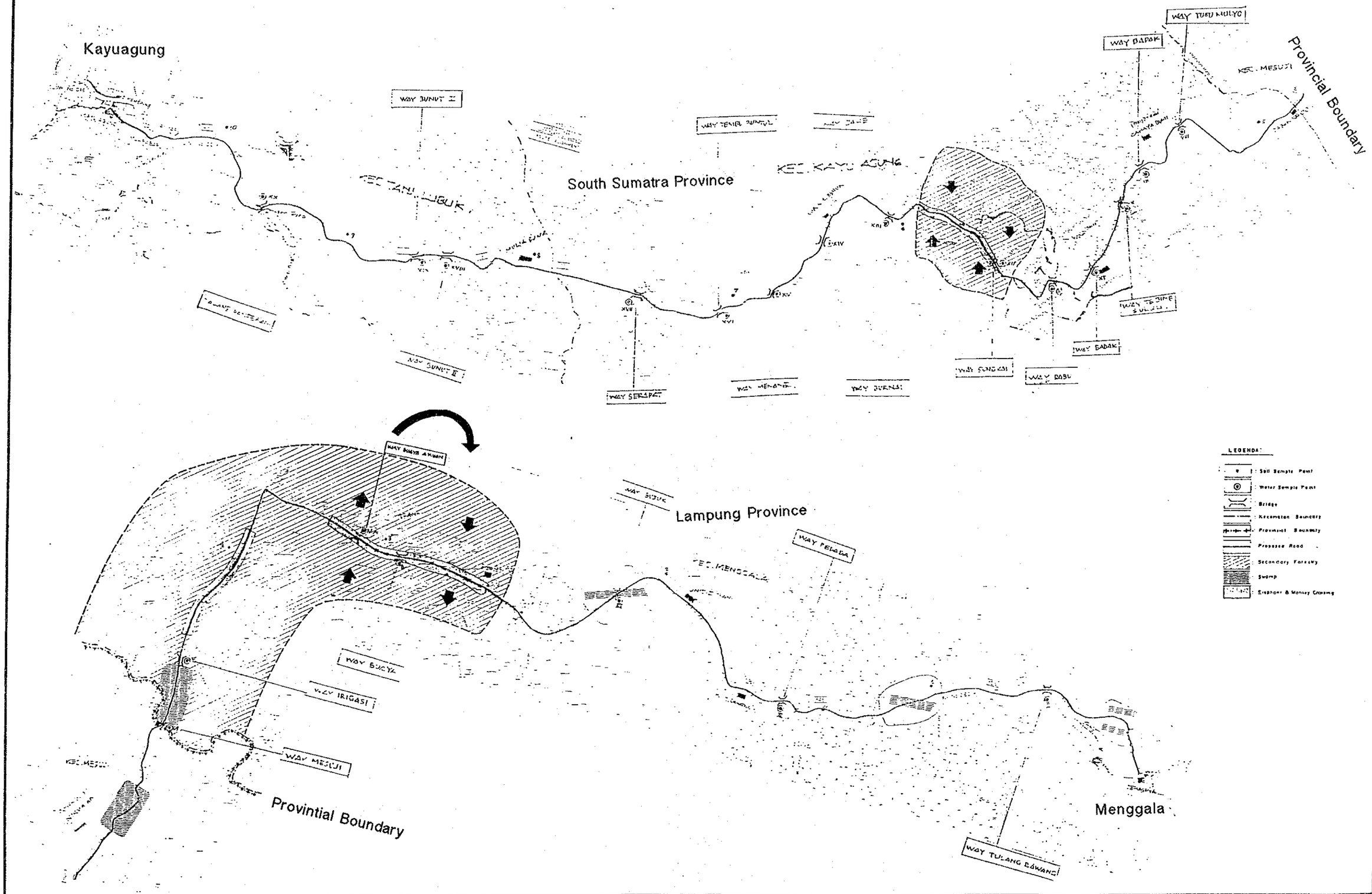
Animals living in the project site are given in Table 10.3 and Fig. 10.1.

Table 10.3 (1) List of Wild Animals

No.		Latin	Explanation
A.	MAMMAL		
1.	Wild pig	Sus vitatus	
2.	Big monkey	Macaca menesbrina	
3.	Bear	Helarctus malayonus	Protected
4.	Napu	Traqulus napu	
5.	Fox	Paradoaurus herma phrod itus	
6.	Monkey	Macaca fascicularis	
7.	Squirrel	Tupaia Sp	
8.	Elephant	Elephas maximus sumatrae	Protected
9.	Kingkang	Nicticebus concang	Protected
10.	Gibbon	Hylo bates sundicatelus	Protected
11.	Lynx	Felis Sp	Protected
12.	Goselle	Muntiacus muncak	Protected
13.	Trenggiling	Manis javonicus	
14.	Royal tiger	Neofelis nebulosa	Protected
15.	Land squirrel	Loriscus insignis	Protected
16.	Hutrap	I onyls Sp	Protected
17.	Squirrel walay	Kapo lomys horsfieldii	
18.	Porcupine	Hysarec brachyura	Protected
19.	Tapir	Tapalusiundicus	Protected
20.	Jelarang	Ratufa bicolor	Protected
21.	Beer	Vervus Sp	Protected
22.	Panther	Panthera tigris sumatrae	Protected
B.	REPTILE		
1.	Varam	Varanus Sp	
2.	Chamelon	Valotus jabatus	
3.	Hand forhose	-	
4.	Python Snake	Naya Sp	
5.	Serpent	-	
6.	Tree Snake	Elape Sp	
7.	Lizard	Mabuia pamulti fasciasa	
8.	Python	Phyton Sp	Protected
9.	Water Snake	Matris Sp	

Table 10.3 (2) List of Wild Animals

No.		Latin	Explanation
C.	AMPHIBIA		
	Frog	Rana Cancbifora	
	Toad	Buffo Sp	
	Arog Area	Hyla Sp	
D.	BIRD		
1.	Beo/tiong	Gracula religiosa	Protected
2.	Bubut	Centrapus Sp	
3.	Tugang		
4.	Murai batu		
5.	Tekukur	Streptopelia chinensis	
6.	Perkutut	Geopelia striata	
7.	Gereja	Passer montanus	
8.	Pipit	Lonchura leucogastroides	
9.	Ketilang	Picnonotus cafer	
10.	Ayam hutan	Gallus Spp	
11.	Kacer	Copsicus saularis	
12.	Alap-alap	Elanus Sp	
13.	Betet	Cissa Sp	
14.	Puyuh	Turnix Sp	
15.	Cerocok	Picnonotus Sp	
16.	Srigunting		
17.	Raja udang biru	Helcyon cyanoventris	Protected
18.	Bondol	Lonchura maja	
19.	Kucica		
20.	Cucak rawa	Picnonotus zeilanicus	
21.	Belibis	Dendrocygna javanica	
22.	Bangau putih	Egretta garzetta	
23.	Pecuk ular	Anhing Sp	Protected
24.	Layang-layang	Hirundo tahitica	
25.	Sesap madu	Anthreptes Sp	Protected
26.	Bangau	Ciconia episcopus	
27.	Kuau	Argusianus argus	Protected
28.	Manyar	Pleceus manyar	
29.	Jalak suren	Sturnus contra	



COASTAL ROADS IN EAST COAST OF SUMATRA

Fig. 10.1 Habitation Area of Animals

10.4 Evaluation of the Environmental Impact and Measures to Mitigate the Influence

10.4.1 Evaluation of the Environmental Impact

Results of the Evaluation of the Environmental Impact Problems of this project on the physical-chemical field and the socio-economic aspect are given in Tables 10.4 and 10.5.

From the PIL Investigation, the matters that are considered to have a comparatively large adverse impact on the surrounding area from this project are described as follows:

(1) During Construction:

The exhaust emission from the construction vehicles and the dust caused during the dry season by the construction vehicles and equipment are expected to create problems for the plant life in the vicinity of the project site.

(2) After the facilities have been opened to the public:

The exhaust emission from the vehicles using the completed facilities can be expected to cause adverse effects on plants and animals. Also the traffic will affect the movements and well being of the wild life in the area.

Elephants and monkey live around the project site in the Way Buaya and Way Sungkay wild life preserves and are protected by law. Wild elephants have been observed to cross the project road in herds of 5 to 25. Their numbers and patterns of movement are not yet fully known. This matter will have to be further studied.

10.4.2 Measures to Mitigate the Effects

The adverse effects caused by the project on the environment will have to be moderated by taking steps to mitigate their effects as follows:

- The planting of vegetation such as Mahoni Plants (see Fig. 10.2) along the project road to reduce the adverse effects on the environment of vehicle exhaust emission and noise. The precise measures to be taken will depend on the location. However the planting should be capable of preventing crossing of the project roadway.

Table 10.4 Environment Impact Assessment

Environmental Component	Implementing Activities								
	Pre-Construction		Construction					Operation	
	A	B	C	D	E	F	G	H	I
I. Physical Chemistry									
- Climate				-1 a				-1 a	
- Air Quality			-1 a	-1 a	-1 b	-1 a		-1 b	
- Rainfall									
- Soil/Land				-1 a	-1 a		-2 b	-1 a	
- Hydrology				-1 b			-2 b	-2 b	
- Space System		-1 a					-1 a	+3 c	
II. Biology									
- Vegetation		-1 a			-1 a				
- Wild Species			-1 a	-2 b	-1 b	-1 a		-3 c	-1 a
- Aquatic Biota			-1 a		-1 a	-1 a		-1 b	-1 a
III. Socio-Economy & Socio-Culture									
- Demography								+2 b	
- Education								+1 a	
- Health			-1 a	-1 b	-1 a	-1 a	-1 a	+1 a	
- Culture								+1 a	
- Income			+1 c	+1 c	+1 a	+1 c	-1 b	+2 c	+1 a
- Social Perception	+1 a	-1 a		-1 a				+2 b	+1 a

Explanation:

A. Preparation
B. Land Acquisition
C. Covering
D. Earth Work
E. Installing Batching Plant
F. Bridge Work
G. Making Drainage Channel
H. Using/Operating Road
I. Road Maintenance

Magnitude

1. Very Small
2. Small
3. Medium
4. Big
5. Very Big

Importance

a. Negligible
b. Slight
c. Moderate
d. Significant
e. Major

\+ = Positive Impact
\- = Negative Impact
Blank = No Impact

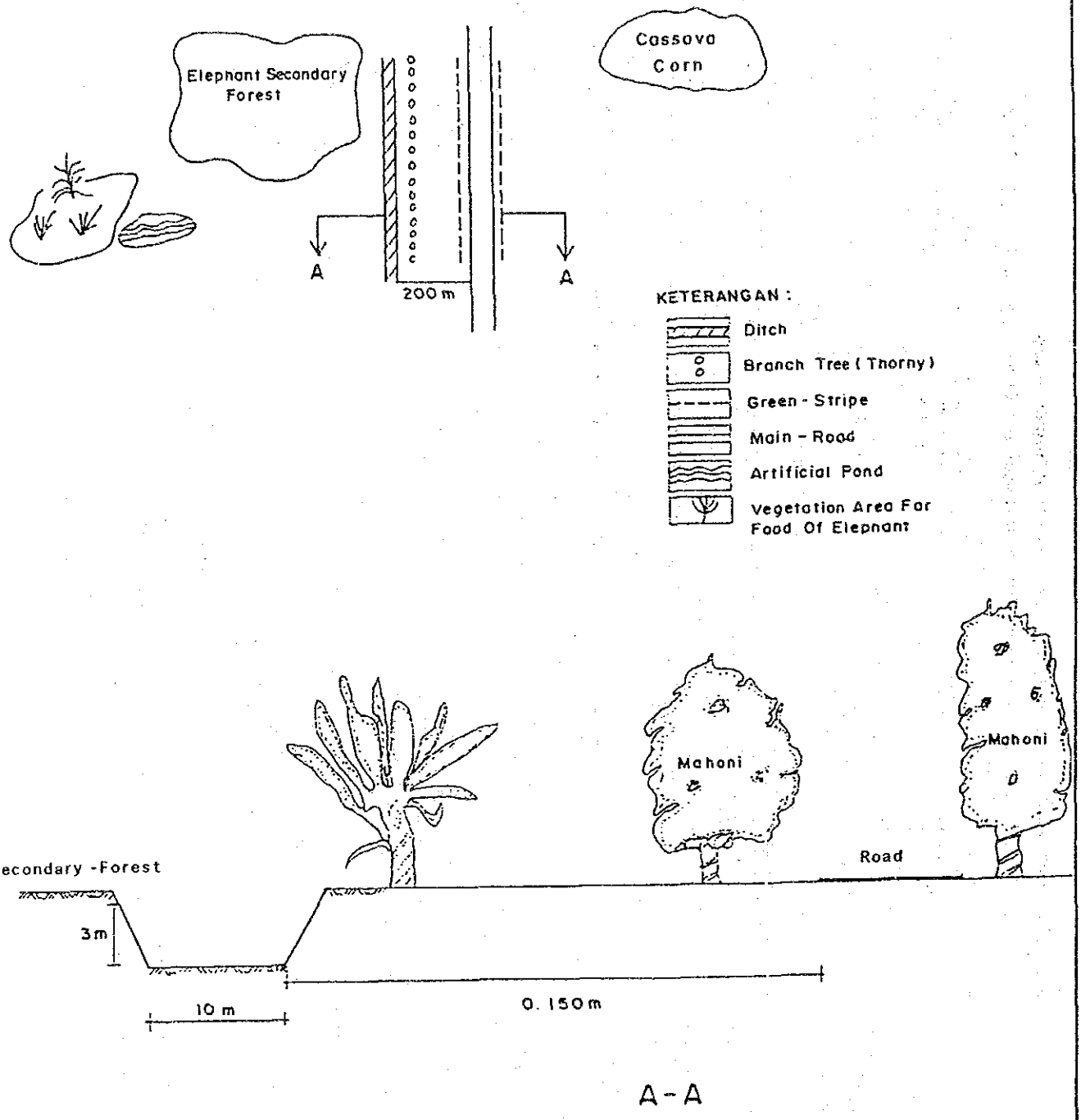
Table 10.5 Impact Evaluation Based on the Level of Impact Importance (The decree of Minister of Environmental and Living Space (No. 49/1990))

No.	Project Activities	Impact	Number of people affected by the impact	The extent of the impact	Life time of the Impact	Environmental Component by Impact	Impact Intensity	Impact Cumulative	Reversible & Irreversible	Remark
I.	Pre Construction - Land acquisition for widening	Obstructions to the project	P1 = 15 KK P2 = 200.000 kk P1/P2 = 0.7 % [1]	ADL = 4 HA ARK = 40,000 HA ADL/ARK = 0.01 % [1]	Pre Construction [1]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if the intensity is under control [1]	Less important Impact
II.	Construction - Material work and Mobilization - Earth Work	Public Road destruction Settlement Environment	P1 = 500 KK P2 = 200,000 kk P1/P2 = 0.25 % [1]	ADL = 200 HA ARK = 40,000 HA ADL/ARK = 0.5 % [1]	Construction [2]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if the intensity is under control [1]	Less important Impact
	- Operating AMP	Water Resource Pollution	- [1]	ADL = 4 HA ARK = 40,000 HA ADL/ARK = 0.1 % [1]	Construction [2]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if the intensity is under control [1]	Less important Impact
	- Excavation (in land and water body)	Pollution Water Resource Land Resource	- [1]	ADL = 150 HA ARK = 40,000 HA ADL/ARK = 0.4 % [1]	Construction [2]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if the intensity is under control [1]	Less important Impact
	- Bridge Work	Pollution Water Resource River Erosion	- [1]	ADL = 150 HA ARK = 40,000 HA ADL/ARK = 0.4 % [1]	Construction [2]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if the intensity is under control [1]	Less important Impact
	- Overlay	Settlement Environment	P1 = 500 KK P2 = 200,000 kk P1/P2 = 0.25 % [1]	ADL = 200 HA ARK = 40,000 HA ADL/ARK = 0.5 % [1]	Construction [2]	Not influence [1]	very low [1]	rather long aged effect [1]	Reflected if t he intensity is under control [1]	Less important Impact
III.	Operation & Maintenance - Operation of Road	Fauna (Elephant, Monkey)	- [1]	ADL = 600 HA ARK = 40,000 HA ADL/ARK = 15 % [2]	Operation [4]	Influence [4]	quite a lot [4]	relative is rather long aged [3]	Not reflected and there is a complex effect	Important Impact
		Flora (Trees Protected)	- [1]	ADL = 600 HA ARK = 40,000 HA ADL/ARK = 15 % [2]	Operation [4]	Influence [4]	quite a lot [4]	relative is rather long aged [3]	Not reflected and there is a complex effect	Important Impact

Note:

P1 = Number of people affected by the impact
P2 = Number of people subjected to the impact
ARK = The extent of the activity
ADL = The extent of the impact

[ ] = Negative impact
[1] = Less important
[2] = Fairly Important
[3] = Important
[4] = More important
[5] = Very important



COASTAL ROADS IN EAST COAST OF SUMATRA	**Fig. 10.2** **Measures to Mitigate Effects for Elephant**

- One method to discourage elephants from crossing the roadways is indicated in Fig. 10.2. The basic idea is to establish ditches parallel to the roadways, to discourage the free passage of the elephants. Also, to provide watering holes, and feeding areas so that their living patterns will not be adversely affected. Moreover, in the detailed design stage, at the locations, where elephant's crossing of the roadway can be predicted, preparation of a crossing where they can cross in safety (such as a flyover) is to be studied.

Chapter 11

CONCLUSION AND RECOMMENDATIONS

CHAPTER 11

CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

11.1.1 Necessity of the Project

This project (Sumatra East Coast Highway Project) is a most important project for the social and economic development of the Island of Sumatra, and is expected to perform the following important roles for the welfare of the island:

- Together with the existing Trans Sumatra Highway it will from the trunk road network on the Island of Sumatra.
- It will contribute to the development of road traffic on the east coast where road construction programmes have not been well developed.
- The East Coast Highway is expected to inter-connect the major core cities (Palembang, Jambi, Pekan Baru, etc.) on the east coast area.
- The highway will back-up the SIJORI Development Programme.

In summary, construction of the East Coast Highway will greatly contribute to the regional development, enhance the movement of agricultural and industrial products of the neighboring areas, and facilitate transportation to and from the island of Java.

11.1.2 Master Plan Concept

The concept of the Master Plan for the 1,900 km long highway from Medan to Bakahuni is to be realized based on the following policies:

- Inter-connection of the capital cities of the Provinces:
  Bakauhuni - Badan Lampung - Menggala - Palembang - Jambi - Dumai - Medan.

- The highway is not planned as an exclusive roadway but as a public road with unlimited access in keeping with the policy of developing the general road system.

- The number of lanes will be established basically to comply with the traffic demands. Where the existing road system cannot cope with the traffic demand the road will be widened or by-pass roads will be panned while taking into consideration the local conditions.

- Where the existing National or Principal Roads take a long roundabout route, by-pass routes will be planned to increase the benefit of the new highway by shortening the distances.

- The horizontal and vertical alignment will be improved as required.

- In the low swampland sections of the highways, the highway will be planned to be able to maintain the annual volume of traffic.

- The natural and environmental conditions will be preserved, and the adverse effects of road maintenance works on the environment will be kept to a minimum.

The road maintenance levels for the East Coast Highway will be as follows:

- The road design will be performed to Arterial Class II B.

  Design Speed will be 60 km/hour.

The road will be composed of:	No. of Lanes:	2 x 3.5 = 7.00 m
	Shoulder Width:	2 m, each side

- The designed traffic volume for the year 2010 will be:

Rural Areas:	15,000	-	20,000 pcu/day	(2-lane roads)
Urban Areas:	35,000	-	40,000 pcu/day	(4-lane roads)

- The construction costs will be based on 1992 costs for a total of Rp. 852 billion, with a EIRR of 24.6 %.

11.1.3 Pre-Feasibility Study

Road sections with high priority for completion by 1997, due to their physical and strategic needs, have been selected as follows:

Rengat - Jambi	255 km
Palembang - Menggala (Kayuagung)	183 km
Menggala - Bakahuni	189 km

The estimated costs and the EIRR for these highway projects are:

	Constr. Costs	EIRR
Rengat - Jambi	Rp. 127 bil.	12.5 %
Palembang - Menggala (Kayuaging)	Rp. 90 bil.	20.9 %
Menggala - Bakahuni	Rp. 125 bil.	18.0 %

The section with the highest EIRR, Palembang (Kayuagung) to Menggala, was selected for the Feasibility Study.

11.1.4 Feasibility Study

From the Pre-Feasibility Study, Kayuaging - Menggala section was selected for the Feasibility Study.

The construction cost and EIRR is as follows:

Construction Cost	Rp. 113 billion
EIRR	18.2 %

From the results of the economic analysis, the Feasibility Study indicates that the project is feasible.

11.1.5 Environmental Impact

From the PIL Study, the comparatively large adverse impacts that this project will have on the surrounding areas are as follows:

(1) During Project Execution

The exhaust emissions discharged by the project vehicles and equipment and the dust created by the construction equipment during the dry season will affect the trees and plants in the vicinity of the project site.

(2) After Road Implementation

It is expected that exhaust emissions from the vehicles using the highway will affect the wild plants and animal growth and that the traffic will affect their movements. The elephants, monkeys and wild life protected by law living in the Way Buaya and Way Sungkay Forests will be affected by being prevented from crossing the highway constructed by the project. The number of elephants and their behaviour are not yet accurately known. Detailed information of their habits will have to obtained.

11.2 Recommendations

11.2.1 Implementation of the Project

The results of the study indicate that the project is technically feasible, and from the national economic viewpoint high feasibility is indicated. It can be expected that the direct benefits will be high, and there will be a large indirect benefit to the related regions.

Also for the Feasibility Study section, high feasibility is indicated. It is therefore that the road development of the Feasibility Study section should be implemented as soon as practically possible.

11.2.2 Methods to Mitigate the Environmental Impact

In order to mitigate the adverse effects described above the following methods should be implemented:

- Mahoni and other plants should be planted along the roadway to reduce the effects of air pollution and noise. The Mahoni plant is considered to be able to prevent elephants from crossing the road.

- The reason for the elephants crossing the highway is to feed on the plant leaves described above, and so watering holes and feeding places will be established together with ditches which will be constructed to prevent elephants from crossing the road.

- Moreover, in the detailed design stage, at the locations where elephant's crossing of the roadway can be predicted, preparation of a crossing where they can cross in safety (such as a flyover) is to be studied.

Appendices

APPENDICIES

CONTENTS

CHAPTER 6 TRAFFIC DEMAND FORECAST

Appendix A-6.1 Trip Length Frequency Distribution A-1
Appendix A-6.2 Compressed Province - Province Observed and Synthesized Matrices by Mode in 1991 ..... A-4
Appendix A-6.3 Vehicle Owership Growth Factors A-10
Appendix A-6.4 Future Traffic Demand of Proposed Ports A-11

CHAPTER 7 PREPARATION OF A MASTERPLAN FOR SUMATRA EAST COAST HIGHWAY

Appendix A-7.1 Estimation of Indirect Development Benefit Related to Lampung Alternative Routes A-13
Appendix A-7.2 Economic Comparison of Route 7A, 7B and 7C A-17
Appendix A-7.3 Economic Comparison of Section 1 to 7 ..... A-18
Appendix A-7.4 Estimation of Indirect Economic Impact of East Coast Highway (Master Plan) A-21

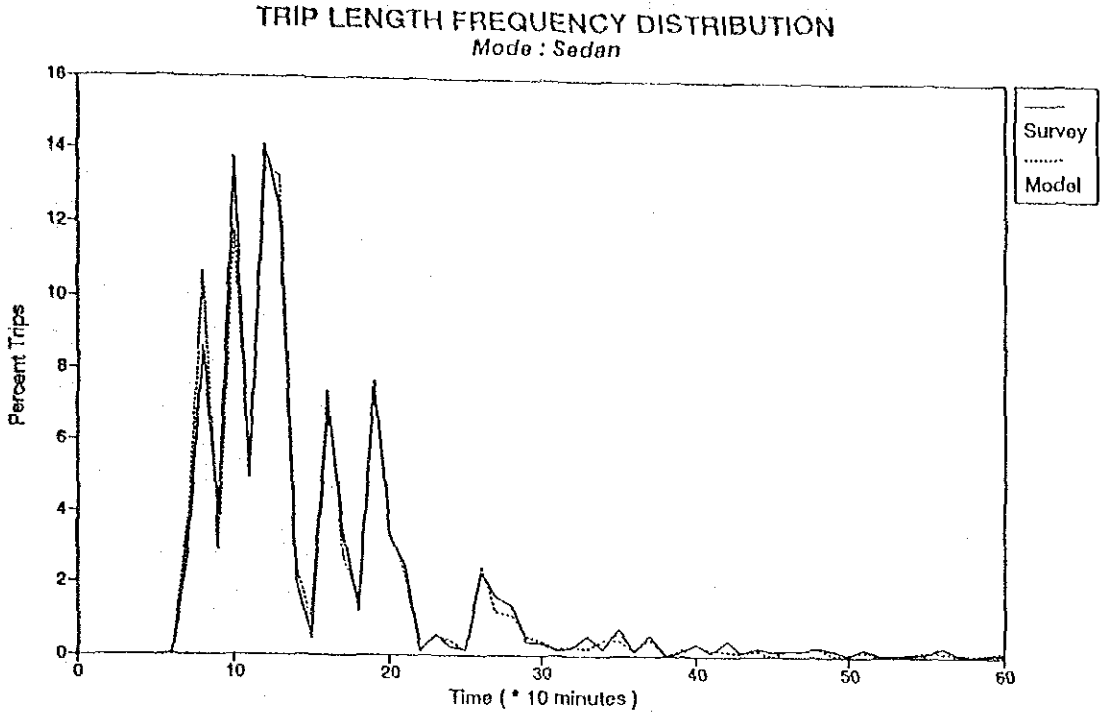
CHAPTER 8 PRE-FEASIBILITY STUDY

Appendix A-8.1 Economic Analysis for Pre-Feasibility Study Section A-23

CHAPTER 9 FEASIBILITY STUDY

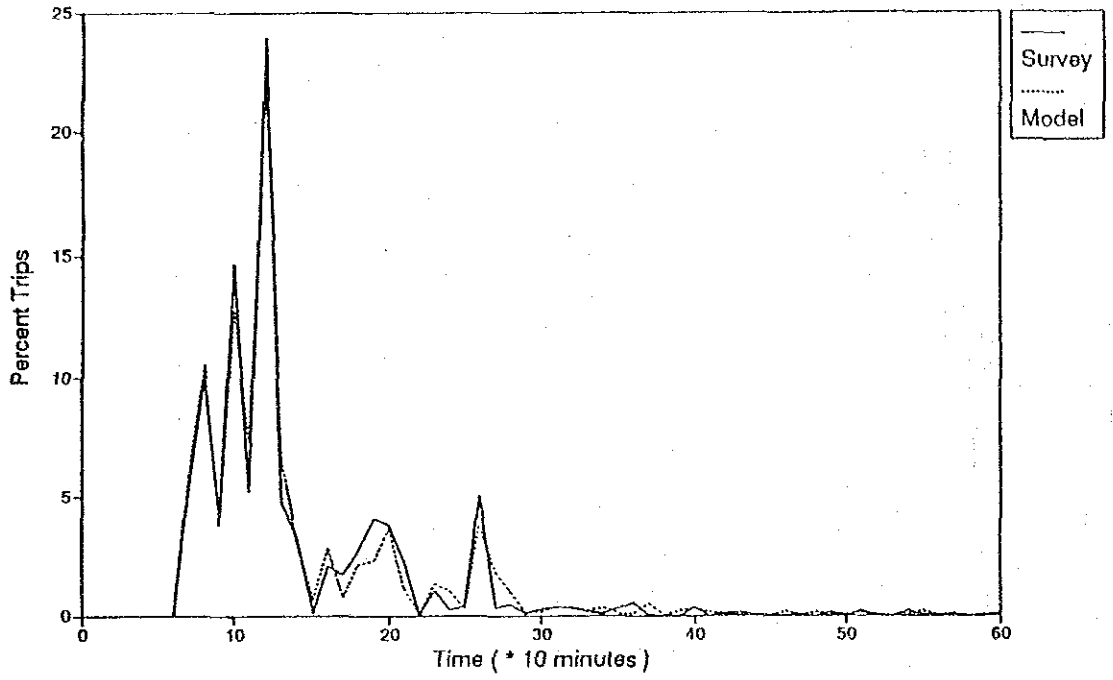
Appendix A-9.1 Analysis Data of Soil Investigation A-24
Table 1 Soil Section and Invariable Soil Value for Design A-24
Figure 1 Relative Chart for Loading Time and Settlement Value (Height = 2m) A-25
Figure 2 Relative Chart for Loading Time and Settlement Value (Height = 3m) A-26
Figure 3 Relative Chart for Loading Time and Settlement Value (Height = 4m) A-27
Appendix A-9.2 Road Inventory (1990) A-44
Appendix A-9.3 Road Inventory (1992) A-44
Appendix A-9.4 Bridge Inventory A-45
Appendix A-9.5 Administration Map in Project Area A-46
Appendix A-9.6 Settlement Location Map A-47
Appendix A-9.7 Swamp Areas in the Project Area A-48
Appendix A-9.8 Economic Project Costs Flows A-49
Appendix A-9.9 Estimated Share Ratio of PCU-Kilometers by Vehicle Type and by Road Section A-50
Appendix A-9.10 Estimation of Unit Vehicle Time Cost A-51

Appendix A-6.1 Trip Length Frequency Distribution



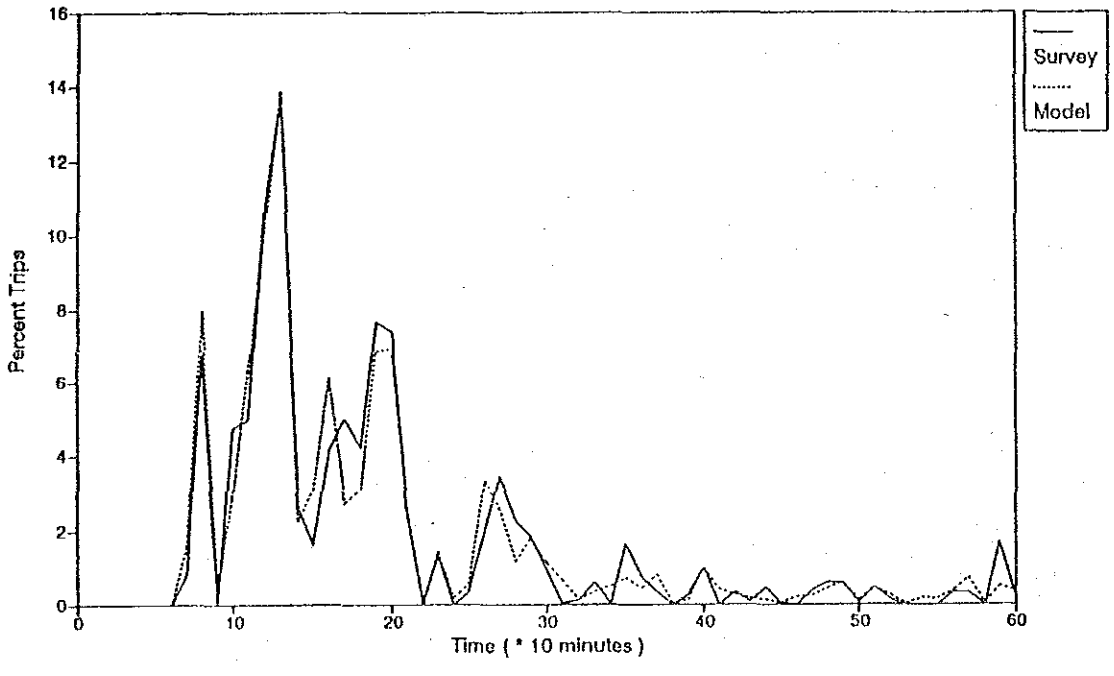
TRIP LENGTH FREQUENCY DISTRIBUTION

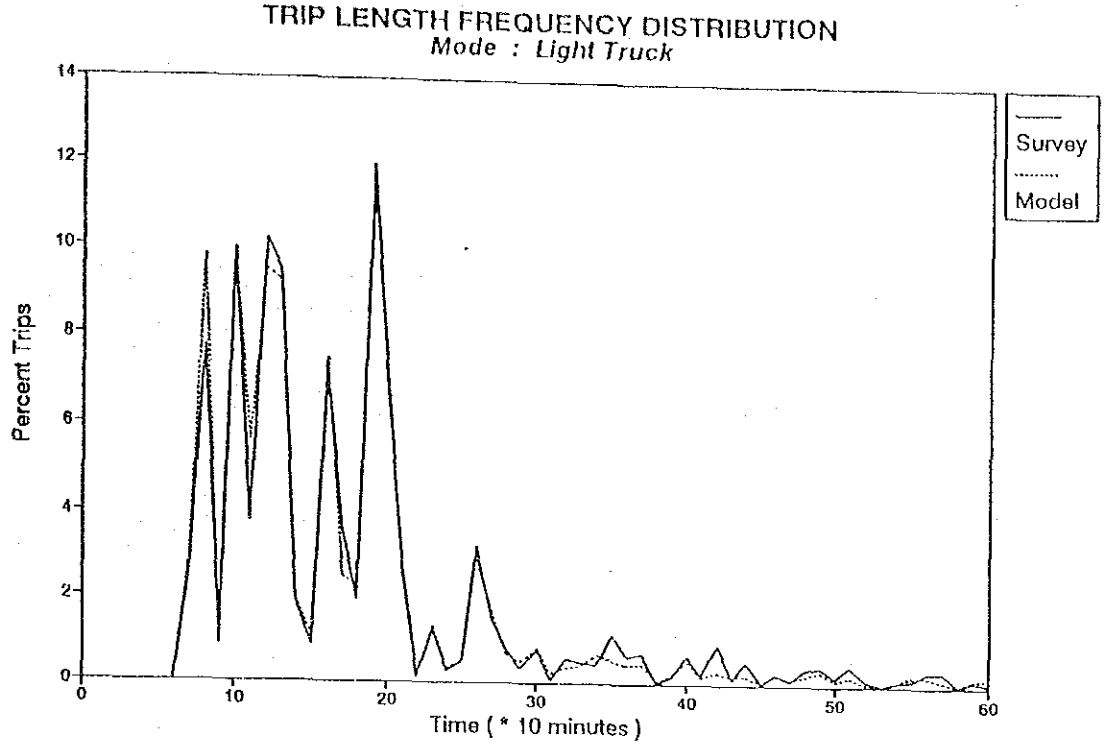
Mode : Small Bus

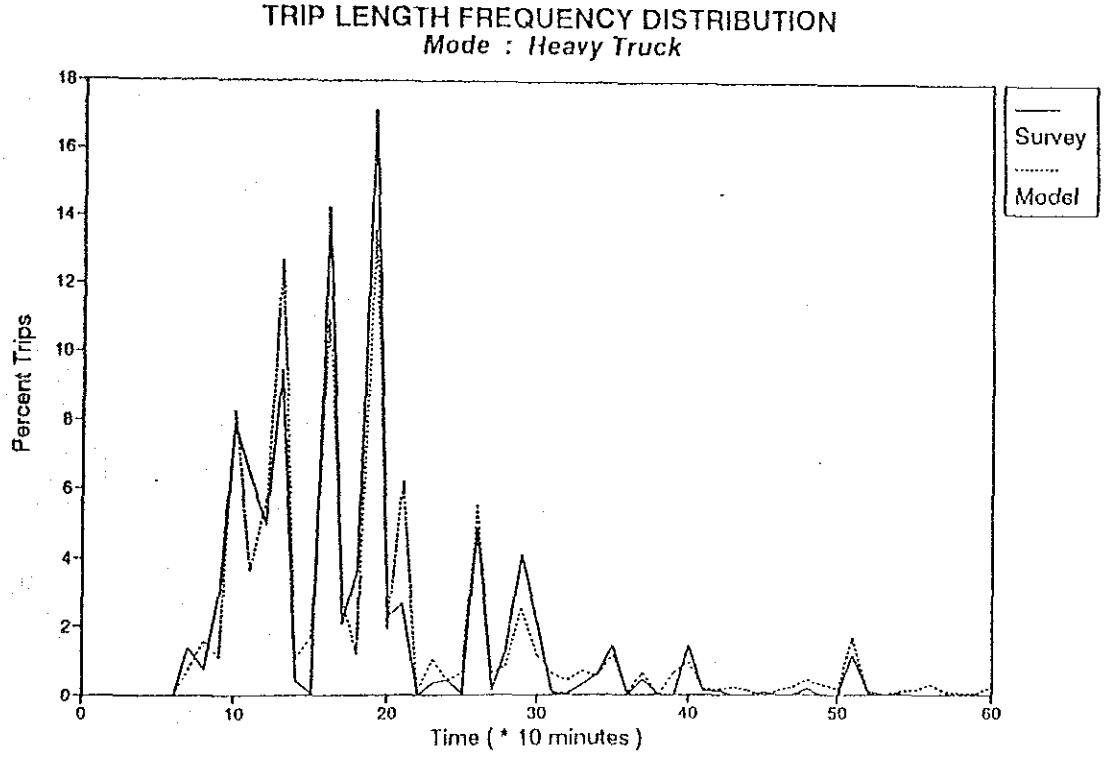


TRIP LENGTH FREQUENCY DISTRIBUTION

Mode : Large Bus




TRIP LENGTH FREQUENCY DISTRIBUTION
Mode : Light Truck
Percent Trips
Time (* 10 minutes)
Survey
Model
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60


TRIP LENGTH FREQUENCY DISTRIBUTION
Mode : Heavy Truck
Percent Trips
Time (* 10 minutes)
Survey
Model
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60

SEDANS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	673	365	17	6	1	0	0	0	28	1090
2	363	8025	83	78	18	9	8	0	58	8642
3	15	89	1516	102	41	11	14	9	24	1821
4	7	77	104	3549	60	13	11	8	44	3873
5	2	19	42	66	478	27	26	19	13	692
6	0	10	12	12	29	301	240	29	10	643
7	0	9	17	11	28	242	2538	48	39	2932
8	0	1	11	10	19	31	50	2123	95	2340
9	29	64	25	44	13	12	39	96	0	322
Total	1089	8659	1827	3878	687	646	2926	2332	311	22355

OBSERVED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	682	362	1	10	0	1	1	0	28	1085
2	364	8000	105	74	20	4	6	5	58	8636
3	1	106	1577	95	6	3	7	1	24	1820
4	12	79	95	3536	81	16	16	5	44	3884
5	0	18	6	82	536	3	28	3	13	689
6	1	5	3	15	4	346	262	2	10	648
7	1	9	9	13	29	257	2543	30	39	2930
8	1	5	1	4	3	3	30	2199	95	2341
9	29	64	25	44	13	12	39	96	0	322
Total	1091	8648	1822	3873	692	645	2932	2341	311	22355

SEDANS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	673	365	17	6	1	0	0	0	28	1090
2	363	8025	83	78	18	9	8	0	58	8642
3	15	89	1516	102	41	11	14	9	24	1821
4	7	77	104	3549	60	13	11	8	44	3873
5	2	19	42	66	478	27	26	19	13	692
6	0	10	12	12	29	301	240	29	10	643
7	0	9	17	11	28	242	2538	48	39	2932
8	0	1	11	10	19	31	50	2123	95	2340
9	29	64	25	44	13	12	39	96	0	322
Total	1089	8659	1827	3878	687	646	2926	2332	311	22355

OBSERVED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	682	362	1	10	0	1	1	0	28	1085
2	364	8000	105	74	20	4	6	5	58	8636
3	1	106	1577	95	6	3	7	1	24	1820
4	12	79	95	3536	81	16	16	5	44	3884
5	0	18	6	82	536	3	28	3	13	689
6	1	5	3	15	4	346	262	2	10	648
7	1	9	9	13	29	257	2543	30	39	2930
8	1	5	1	4	3	3	30	2199	95	2341
9	29	64	25	44	13	12	39	96	0	322
Total	1091	8648	1822	3873	692	645	2932	2341	311	22355

LIGHT TRUCKS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	2047	683	29	11	6	0	1	0	17	2794
2	684	10611	196	128	19	11	11	2	152	11814
3	28	198	3629	367	95	17	25	21	33	4413
4	11	131	367	4318	359	25	18	13	126	5368
5	5	20	95	358	585	8	26	37	31	1165
6	1	10	16	25	8	763	343	9	15	1190
7	0	11	26	17	26	342	4444	295	130	5291
8	0	2	21	15	34	9	293	4752	202	5328
9	18	153	34	128	31	16	134	202	0	716
Total	2794	11819	4413	5367	1163	1191	5295	5331	706	38079

OBSERVED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	2078	676	2	7	1	1	1	4	17	2787
2	681	10521	222	119	42	17	29	26	152	11809
3	3	219	3753	368	24	2	6	3	33	4411
4	7	123	368	4240	457	21	24	9	126	5375
5	1	49	24	456	578	3	22	8	31	1172
6	2	17	2	20	2	774	346	10	15	1188
7	1	31	6	22	22	348	4415	317	130	5292
8	4	26	3	10	8	9	318	4729	202	5309
9	18	153	34	128	31	16	134	202	0	716
Total	2795	11815	4414	5370	1165	1191	5295	5308	706	38059

HEAVY TRUCKS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	34	17	0	0	0	0	0	0	0	51
2	14	1172	44	6	0	0	0	0	4	1240
3	1	44	398	27	6	3	1	0	0	480
4	0	6	28	128	3	0	2	0	0	167
5	0	0	5	5	9	2	4	1	1	27
6	0	0	3	1	2	27	12	5	0	50
7	0	0	3	0	5	12	86	9	1	116
8	0	0	0	0	1	5	10	217	1	234
9	1	4	0	1	1	0	1	1	0	9
Total	50	1243	481	168	27	49	116	233	7	2374

OBSERVED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	48	4	0	0	0	0	0	0	0	52
2	3	1170	45	11	2	1	1	0	4	1237
3	0	46	427	7	0	0	0	0	0	480
4	0	12	8	149	0	0	0	0	0	169
5	0	2	0	0	22	0	3	0	1	28
6	0	1	0	0	0	46	2	0	0	49
7	0	1	0	0	2	2	109	1	1	116
8	0	0	0	0	0	1	0	232	1	234
9	1	4	0	1	1	0	1	1	0	9
Total	52	1240	480	168	27	50	116	234	7	2374

SMALL BUS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	457	31	2	1	0	0	0	0	0	491
2	23	3994	3	11	1	0	0	0	0	4032
3	2	3	379	56	12	2	3	0	0	457
4	0	11	53	2711	111	5	2	0	0	2893
5	0	0	11	121	388	15	79	2	0	616
6	0	0	3	7	16	716	255	17	0	1014
7	0	0	2	3	88	256	1716	119	0	2184
8	0	0	0	0	4	18	124	1108	0	1254
9	0	0	0	0	0	0	0	0	0	0
Total	482	4039	453	2910	620	1012	2179	1246	0	12941

OBSERVED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	471	21	0	0	0	0	0	0	1	493
2	20	3991	6	3	2	0	2	6	0	4030
3	0	7	399	46	9	0	0	0	0	461
4	0	3	43	2692	146	0	0	3	6	2893
5	0	2	9	146	341	4	109	7	2	620
6	0	0	0	0	4	763	247	3	1	1018
7	0	2	0	2	109	245	1711	116	0	2185
8	0	6	0	4	5	2	115	1119	1	1252
9	1	0	0	6	2	1	0	1	0	11
Total	492	4032	457	2899	618	1015	2184	1255	11	12963

LARGE BUS

SYNTHESISED TRIPS

	1	2	3	4	5	6	7	8	9	Total
1	426	94	13	5	5	1	0	0	7	551
2	92	2052	65	36	14	14	13	9	38	2333
3	11	64	382	86	14	7	11	12	28	615
4	7	41	86	706	72	11	9	12	17	961
5	5	15	16	71	115	12	32	17	10	293
6	2	12	7	10	13	76	36	23	6	185
7	1	15	10	10	33	36	609	88	7	809
8	0	9	14	12	17	24	88	391	1	556
9	7	38	25	18	10	6	6	1	0	111
Total	551	2340	618	954	293	187	804	553	114	6414

OBSERVED TRIPS

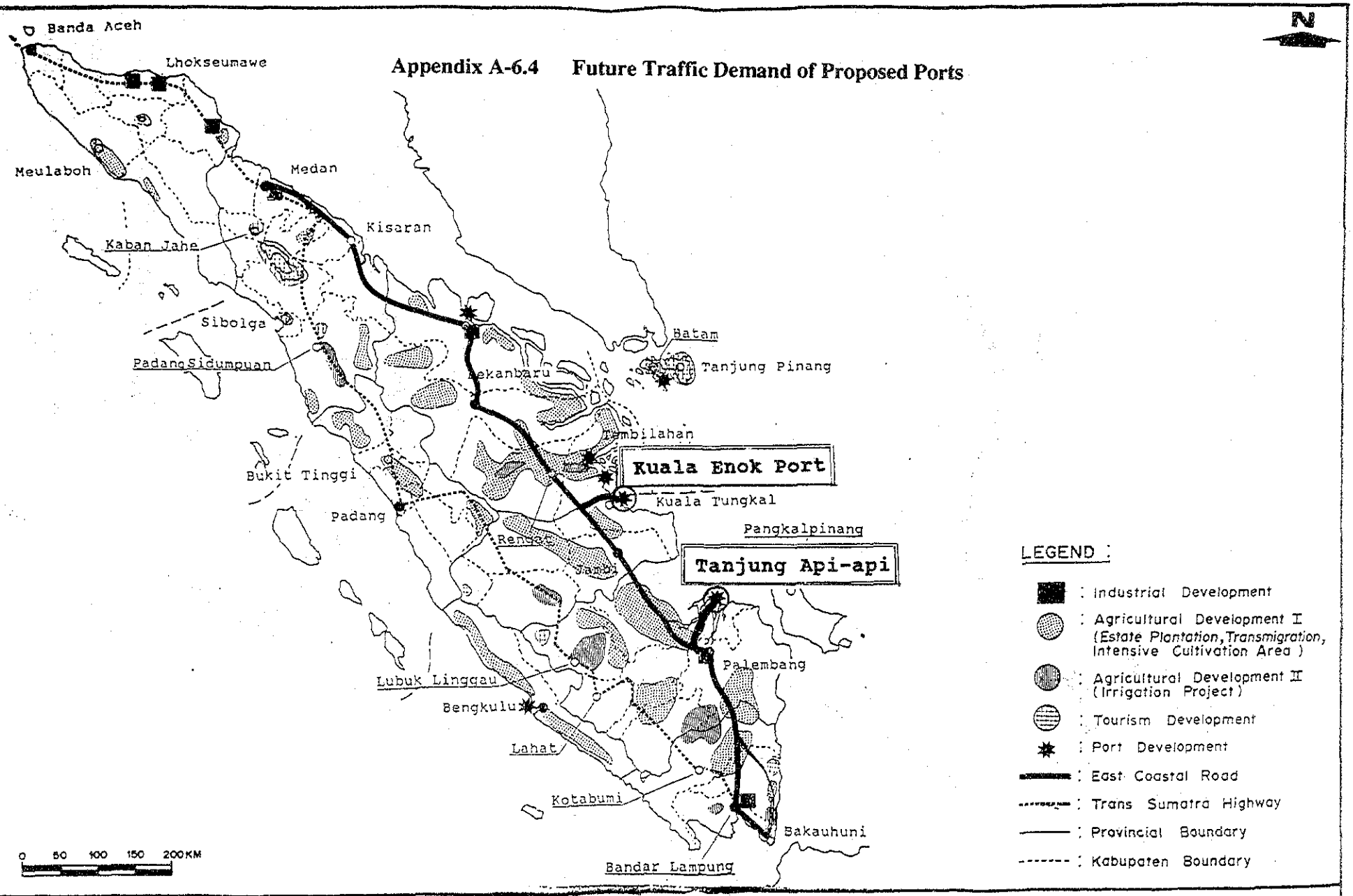
	1	2	3	4	5	6	7	8	9	Total
1	446	84	5	9	0	0	0	0	7	551
2	85	2067	42	73	12	4	11	3	38	2335
3	3	37	443	80	7	0	3	0	28	601
4	10	77	80	664	92	21	6	6	17	973
5	0	12	14	84	167	3	0	0	10	290
6	0	6	0	19	1	107	29	9	6	177
7	0	9	3	9	2	30	662	96	7	818
8	0	3	0	6	2	14	91	441	1	558
9	7	38	25	18	10	6	6	1	0	111
										0
Total	551	2333	612	962	293	185	808	556	114	6414

Appendix A-6.3 Vehicle Owership Growth Factors

Province	Zones	Sedan Growth Factors			Truck Growth Factors			Bus Growth Factors		
		1991-1997	1997-2010	1991-2010	1991-1997	1997-2010	1991-2010	1991-1997	1997-2010	1991-2010
Aceh	1-8	1.67	2.58	4.31	1.43	2.27	3.25	1.49	2.40	3.58
Sumatra Utara	9-18	1.37	2.30	3.15	1.29	2.17	2.80	1.35	2.35	3.17
Sumatra Barat	19-26	1.64	2.62	4.30	1.34	2.07	2.77	1.73	2.79	4.83
Riau	27-30	1.31	2.25	2.95	1.33	2.22	2.95	1.61	2.87	4.62
Jambi	31-35	1.74	3.08	5.36	1.71	3.14	5.37	2.17	3.96	8.59
Sumatra Selatan	36-41	1.64	2.45	4.02	1.59	2.51	3.99	2.01	3.15	6.33
Bengkulu	42-44	1.70	2.87	4.88	1.69	2.93	4.95	2.15	3.68	7.91
Lampung	45-47	1.86	3.36	6.25	1.76	3.43	6.04	2.23	4.31	9.61

Source : Consultants

Appendix A-6.4 Future Traffic Demand of Proposed Ports

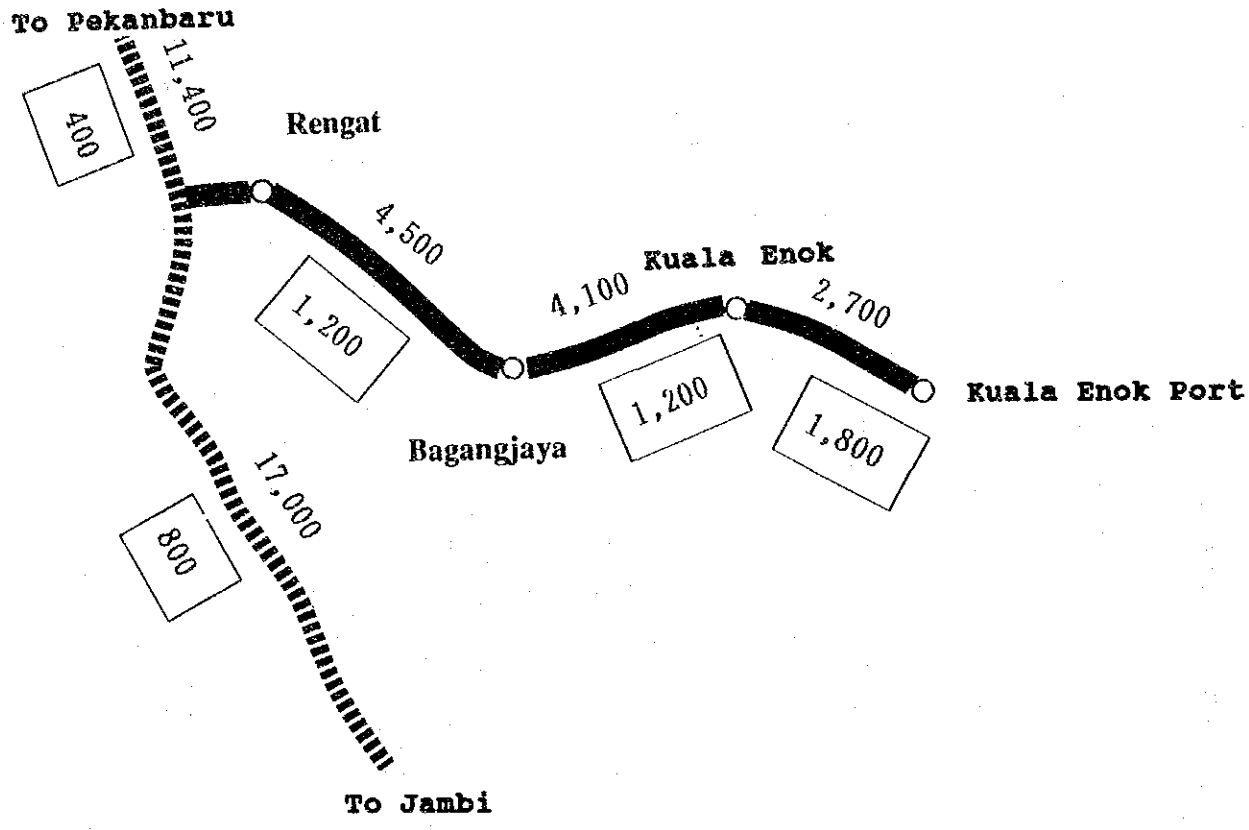


COASTAL ROADS IN EAST COAST OF SUMATRA

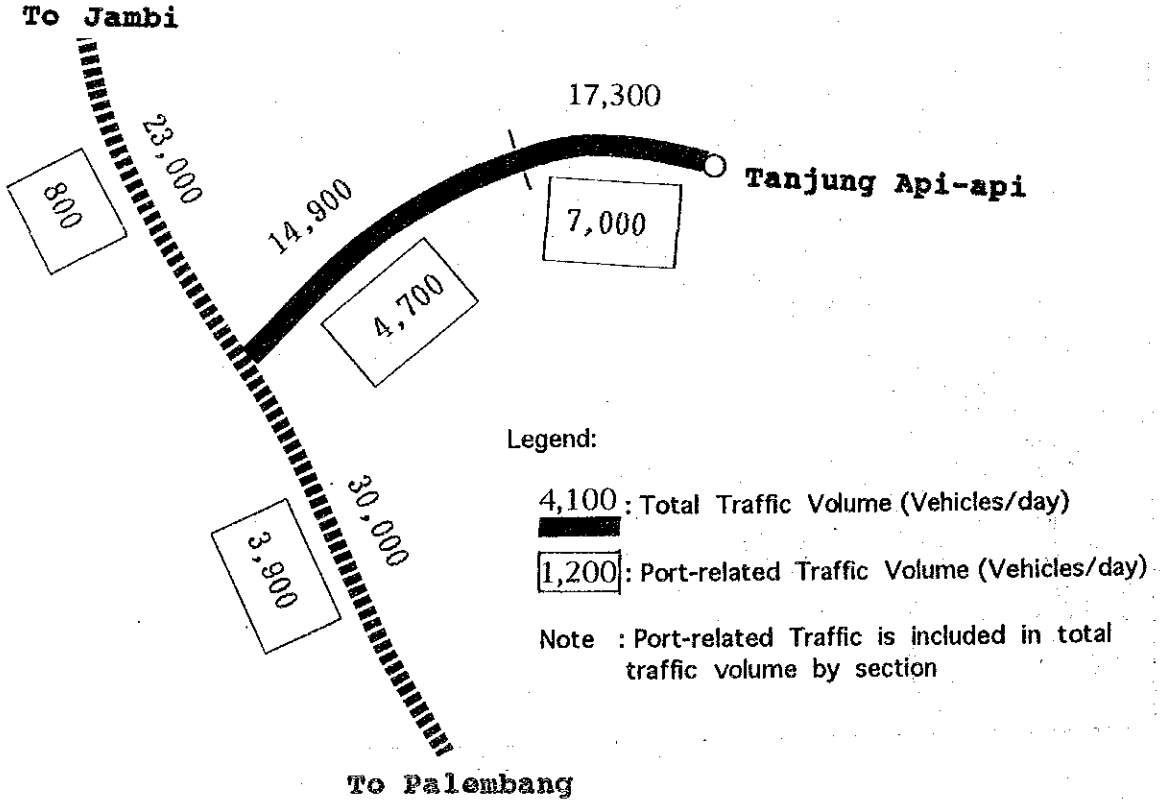
Location of Proposed Ports

FUTURE TRAFFIC DEMAND OF NEW PORT DEVELOPMENT

1. Kuala Enok Port



2. Tanjung Api-api Port



Appendix A-7.1 Estimation of Indirect Development Benefit Related to Lampung Alternative Routes

For comparing of each alternative routes (i.e. Route 7A, 7B and 7C) in Lampung Province, indirect development benefits are estimated focusing the effect of agricultural output increase in the vicinity along the each alternative routes .

The agricultural output increase in the vicinity along the alternative routes are assumed to be produced due to good access to market and also expansion of market area caused by road developments.

(1) Yield Rate

The actual wetland harvest area, production and wetland paddy yield rate (ton per hectare) for related areas in 1989 are shown as below:

Kabupaten	Wetland Harvest Area (ha)	Production (ton)	Wetland Paddy Yield Rate (ton/ha)
Lampung Selatan	89,284	390.786	4.38
Lampung Tengah	114,640	465,980	4.06
Lampung Utara	44,340	177,235	4.00
Lampung Total	248,264	1,034,001	4.16

Source: Agricultural Survey, Production of Cereals in Indonesia, 1989

The average annual growth rate of yield rate during 1975 - 1989 is estimated to 1.78%. Thus, based on this rate, the yield rate in 1992 is estimated to 4.4. Applying this growth rate of 1.78% for the 1992 yield rate, yield rate in 1997 and 2010 are estimated 4.8 and 6.0 as a natural trend.

However, 5.2 ton/ha. is considered as a limit of the yield rate in case without irrigation and road development. Therefore, the yield rate in 2010 is assumed to be 5.2.

(2) Targetted Yield Rate Caused by Road Development

The wetland paddy production rates (ton/ha.) for major provinces in Indonesia are shown as below:

Region	Wetland Paddy Production Rate (ton/ha.)
Lampung Province	4.16
Average of Sumatra	3.87
East Java Province	5.26
Average of Java	5.13
Average of Indonesia	4.52

Source: Agricultural Survey, Production of Cereals in Indonesia, 1989

In this examination of agricultural product increase, the yield rate is assumed to be improved due to good access to market by road development such as Java Island.

In this case, the future yield rate (ton per hectare) for the related area in 1997 is assumed to be increased upto the level of the present yield rate of the province of East Java in 1989. That is, the targetted yield rate is assumed to 5.2 in 1997, and 6.5 in 2010 (by applying the average annual growth rate of 1.78% during 1975 - 1989.)

(3) Deviation of Yield Rate between "Natural Trend" and "Targetted"

The deviations of yield rates between "natural trend" and "targetted' are as below:

Year	Natural Trend Yield Rate	Targetted Yield Rate	Deviation of Yield Rate
1997	4.8	5.2	0.4
2010	5.2	6.5	1.3

(4) Calculation of Indirect Development Benefit

The indirect development benefit is calculated base don the following formula:

$$B = A \times Y \times C \times P$$

where,

B : Indirect Development Benefit of Incremental Agricultural Product
A : Harvest Area of Wetland Cultivation
Y : Deviation of Yield Rate between "Natural Trend' and "Targetted"
C : Marketable Conversion Rate of Rice : 0.58 (Note)
P : Farm Gate Price of Rice

(Note) Marketable Conversion Rate of Rice:
Marketable production volumes subtracting thrashing loss, treatment loss and store as seed from harvest production volumes (refer to "Progress Report I of the Study on the Integrated Regional Development Plan for the Southern Part of Sumatra, October 1991, JICA")

(5) Harvest Area Related to Each Alternative Route

Based on the landuse map, the harvest areas for each related area of alternative route are estimated as below:

Route A : 37,583 (ha.)
Route B : 66,243 (ha.)
Route C : 73,248 (ha.)

(6) Estimated Incremental Yield Volumes Related to Each Alternative Route

Applying the deviation of yield rate previously mentioned for the above harvest areas, the incremental future yield volumes are estimated as below:

		1997	2010
Route A	:	15,033	48,860 (tons)
Route B	:	26,497	86,116
Route C	:	29,299	95,222

For the convenience of calculation of monetary basis, the above incremental agricultural yield volumes are converted to the incremental yield volumes in terms of rice by using the marketable conversion rate of 0.58:

		1997	2010
Route A	:	8,719	28,339 (tons)
Route B	:	15,368	49,947
Route C	:	16,994	55,229

(7) Estimated Incremental Yield Values Related to Each Alternative Route

The farm gate prices of rice are assumed to be Rp. 483 per Kg in 1997 and Rp. 632 per Kg in 2010.

As a result, the incremental yield values (= indirect development benefit) related to each alternative route are estimated as below:

			1997	2010	
Route A	: Values	:	4,214	17,910	(million Rp.)
Route B	: Values	:	7,428	31,567	
Route C	: Values	:	8,213	34,905	