4.2. Embankment material

4.2.1 General

This investigation was carried out for embankment materials and to determine their design characteristics.

Laterite (red and reddish brown clay) can be used for railway embankment. These are widely distributed in the hilly land mostly in the vicinity of Cikampek.

Two borrow pits were sampled and tested for use as borrow pit materials as shown below:

Description	Q-SB-1	Q-SB-2
Name of Borrow	Dawuan	Warnasari
Soil Name	Laterite	Laterite
Area	26 ha.	60 ha.
Potential Quantities	780,000 m^3	6,000,000 m^3
Max. Capacity	1,000 m^3/Day	1,000 m^3/Day
Distance from Bekasi	55 km	45 km

The soils analysed for embankment material are laterite of which a total of 32 samples were taken by Test pit and Auger boring sampling. The following samples were analysed:

Test pit Sampling..... .16 Samples

Auger boring Sampling.....16 Samples Total 32 Samples

The laboratory test data are compiled in the Appendix

The test results conducted on the embankment materials show good physical and mechanical characteristics.

4.2.2 Soil Study

(1) Physical Properties

1) Particle Size Grading

The Embankment materials are mainly composed of fine particles with comparatively good grading.

The gradings of lateritic clay are shown in the following table 1-1

Lateritic clay contain silt (23.3～53.1%) and clay (45.8～73.8%) total 93.0～100.0 % by weight.

Table 4.2.1 Soil Grading Results

Soil Fraction / Stratum	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	No.10 (2.00) (%)	No.40 (0.425) (%)	No.200 (0.075) (%)
	Average	Average	Average	Average	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values
Lateritic Soil	0.5	1.5	37.3	60.7	99.5	99.0	98.0
	0-2.6	0 ~6.2	23.3~53.1	45.8~73.8	97.4-100.0	96.5~100.0	93.0~100.0

2) Consistency Test Results

The moisture content and index test results are summarized in table 4.2.2 and graphs in Figure 4.2.1. Consistency Chart

The embankment materials were found to be in stable condition, as described below;

- According to the classification chart, Ac-soil is classified as CH: 84.4 % : 11.1 MH-OH: 15.6%
- Colloidal activity
  - Non-active clay (mainly Kaolinite) A< 0.75.....6.2 %
  - Ordinary clay (mainly Illite) A=0.75~1.25..... 93.8%

Table 4.2.2 Moisture Content and Atterberg Test Results

Test/ Index / Stratum	Wn (%)	Wl (%)	Ip	If	It	Ic	Activity Ratio
	Average	Average	Average	Average	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values
Lateritic Soil	41.4	79.5	48.8	26.1	1.9	0.8	1.0
	36.2~46.6	72.7~86.3	41.8~55.9	21.2~31.0	1.5~2.4	0.7~0.9	0.8~1.1

3) Specific Gravity

Measured values of specific gravity are summarised in table 4.2.3 and shown on graphs in Figure 4.2.7

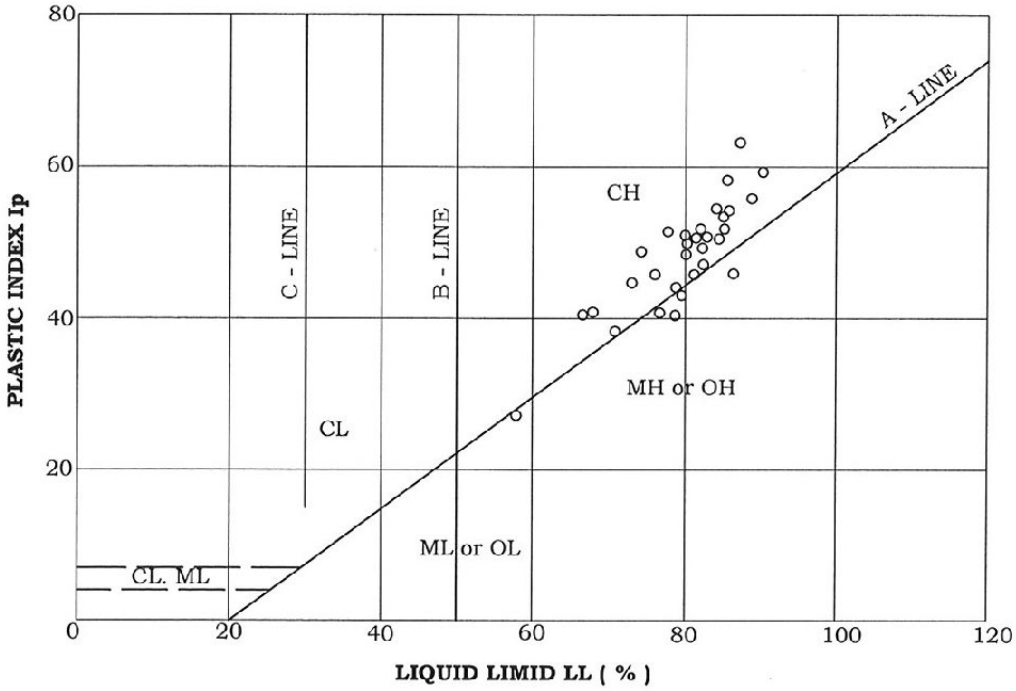
· Specific Gravity (Gs)

The test results yield consistent values with a standard deviation of 0.024

Table 4.2.3 Results of Gs, γt and e

Soil Properties / Stratum	Specific Gravity Gs	Wet Density γt	Voids Ratio e
	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values
Lateritic Soil	2.655	-	-
	2.631~ 2.778	-	-

PLASTICITY CHART



COLLOIDIAL ACTIVITY

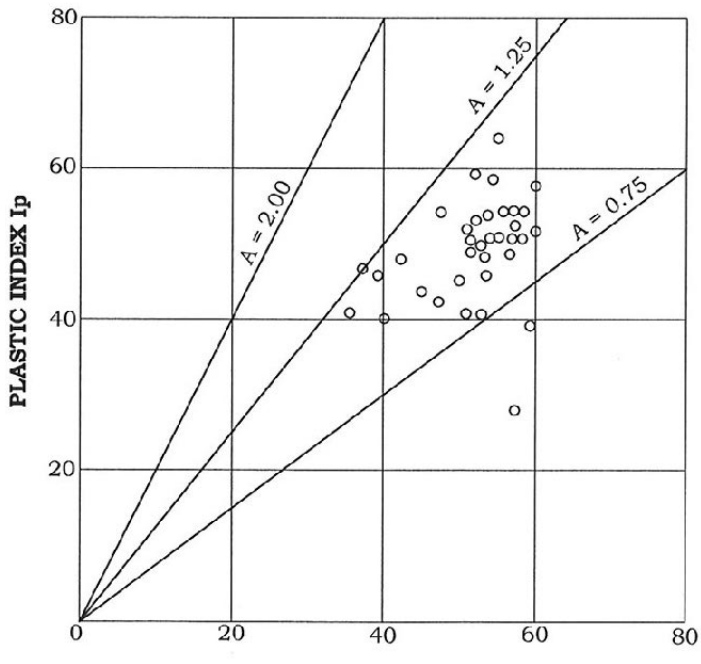
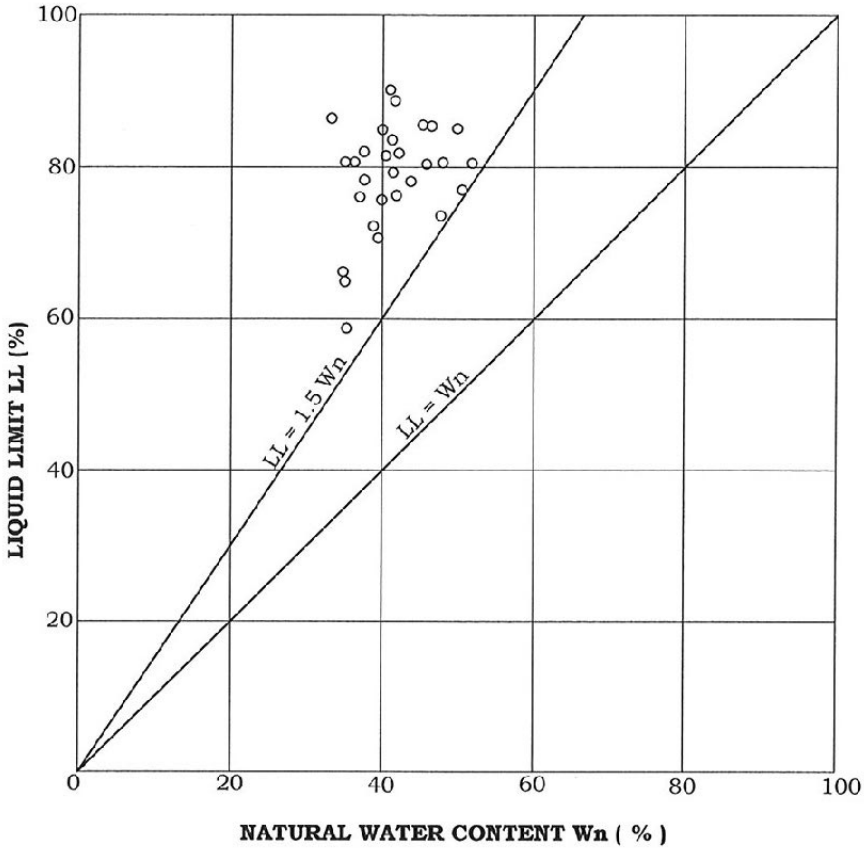


Figure 4-2-1	
THE DETAILED DESIGN STUDY OF RAILWAY ELECTRIFICATION AND DOUBLE-DOUBLE TRACKING OF THE JAVA MAIN LINE PROJECT	**CONSISTENCY CHART** (Laterite)



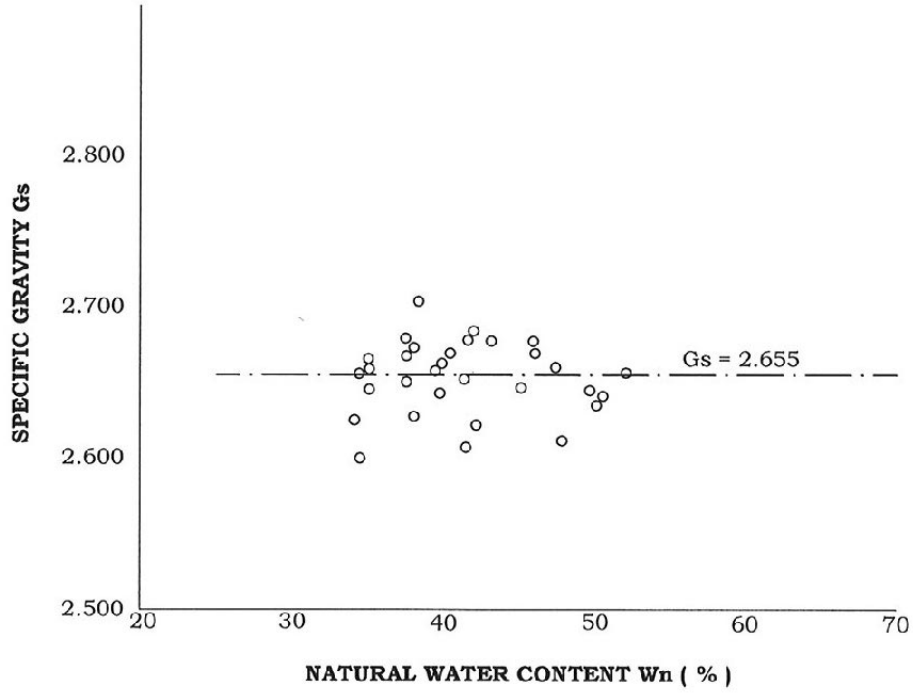


Figure 4-2-2

THE DETAILED DESIGN STUDY OF RAILWAY ELECTRIFICATION AND DOUBLE-DOUBLE TRACKING OF THE JAVA MAIN LINE PROJECT

RELATIVE CHART OF NATURAL WATER CONTENT (Wn) AND SPECIFIC GRAVITY Gs
(Laterite)

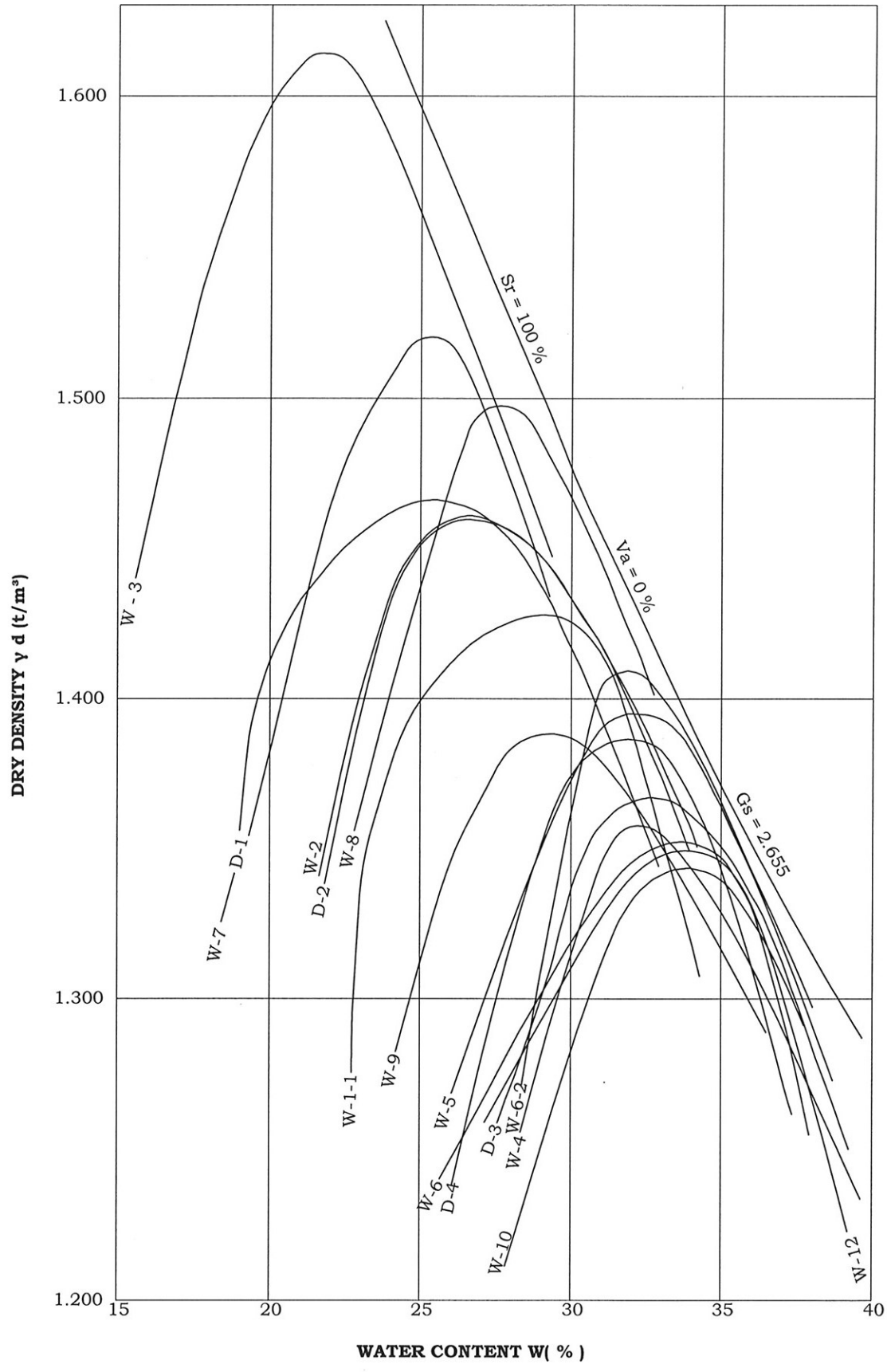


Figure 4-2-3

THE DETAILED DESIGN STUDY OF RAILWAY ELECTRIFICATION AND DOUBLE-DOUBLE TRACKING OF THE JAVA MAIN LINE PROJECT

COMPACTION CURVE FOR EMBANKMENT MATERIAL
(Laterite)

(2) Mechanical properties

1) Compaction Test

The test results using ASTM D-1557 are shown in Table 4.2.4 and Figure 4.2.3 The maximum dry density is stable with slight variation in Dawuan and Warnasari

Table 4.2.4 Results of Compaction Test

Name of Borrow Pit	BP-NO.	γ d max. (t/m^3)	Wopt (%)	Wn (%)	Note
Dawuan	BP-NO.1	1.470	25.2	47.5	
	BP-NO.2	1.460	26.7	49.6	Dark Red Laterite
	BP-NO.3	1.370	33.7	42.9	
	BP-NO.4	1.390	32.6	35.0	
	Ave. Value	1.430	29.6	43.8	
	R.Range	1.373~1.472	25.3~33.8	37.3~50.2	
Warnasari	BP-NO.1	1.430	29.0	41.9	
	BP-NO.2	1.360	34.0	50.4	
	BP-NO.3	1.360	32.1	47.7	
	BP-NO.4	1.620	22.5	35.0	
	BP-NO.5	1.360	34.0	40.9	
	BP-NO.6	1.400	32.9	34.8	Dark Red Laterite
	BP-NO.7	1.400	32.2	35.2	
	BP-NO.8	1.360	34.0	37.4	
	BP-NO.9	1.520	25.7	38.3	
	BP-NO.10	1.500	28.2	37.4	
	BP-NO.11	1.390	29.1	34.4	
	BP-NO.12	1.350	34.3	42.0	
	Ave. Value	1.421	30.7	39.6	
	R.Range	1.337~1.505	26.9~34.5	34.4~44.8	
Average Value		1.420	30.4	41.1	
Representative Range		1.350~1.500	26.5~34.2	36.2~46.6	
Standard Deviation σ n		0.080	3.8	5.2	

2) CBR Test

Embankment materials samples were soaked for four days and tested in accordance with ASTM D-1883.

Good test results were obtain for the embankment materials ranging from 5.8 %

to 6.4 % with a mean value of 6.1 % and shown in Table 4.5.2

The standard for judgment of test results are shown as follows:

CBR Value: more than 3%

Swell Value: Less than 3%

Table 4.2.5 Results of CBR Test

Name of Borrow Pit	BP-NO.	CBR (%)	ãd (t/m^3)	Wn (%)	Swell (%)	Note
Dawuan	BP-NO.1	6.0	1.400	47.5	2.2	Good
	BP-NO.2	6.2	1.390	49.6	1.4	Good
	BP-NO.3	6.5	1.300	42.9	0.5	Good
	BP-NO.4	6.0	0.320	35	1.3	Good
	Ave.Value	6.2	1.353	43.8	1.3	
	R.Renge	5.9~6.4	1.303~1.402	37.3~50.2	0.64~2.94	
Warnasari	BP-NO.1	6.0	1.380	41.9	1.6	Good
	BP-NO.2	5.9	1.290	50.4	0.3	Good
	BP-NO.3	6.2	1.290	47.7	1.4	Good
	BP-NO.4	6.3	1.530	35	0.9	Good
	BP-NO.5	6.0	1.300	40.9	0.4	Good
	BP-NO.6	6.3	1.330	34.8	0.4	Good
	BP-NO.7	6.5	1.330	35.2	1.6	Good
	BP-NO.8	5.8	1.290	37.4	0.3	Good
	BP-NO.9	6.2	1.450	38.3	1.1	Good
	BP-NO.10	6.0	1.430	37.4	0.7	Good
	BP-NO.11	5.8	1.320	34.4	0.4	Good
	BP-NO.12	6.4	1.280	42	0.7	Good
	Ave.Value	6.1	1.352	39.6	0.8	
	R.Renge	5.9~6.3	1.272~1.431	34.4~44.8	0.32~1.31	
Average Value		6.1	1.350	41.1	1.0	
Representative Range		5.9~6.4	1.28~1.42	36.2~45.6	0.4~1.6	
Standard Deviation ón		0.23	0.070	5.2	0.6	

3) Unconfined Compression Test

This test was made using "4 day soaked" samples made by ASTM D-1557 AASHTO T-180. Table 1-7 shows that qu ranged from 3.013 to 3.762 kg/cm^2 with an average of 3.27 kg/cm^2. Figure 1-4 shows relative chart of dry density and unconfined compression strength

4) Triaxial Compression Test

The test was carried out under unconsolidated and undrained conditions employing the same type of test samples as used in the unconfined compression tests.

As a result Cuu ranged from 0.67 to 2.17 kg/cm^2 (average 1.461 kg/cm^2) and ϕ uu ranged from 19.4° to 22.8° (average 19.8°), as shown in Table 4.2.6

Table 4.2.6 Results of qu and Cuu, Øuu Test

Name of Borrow Pit	BP-NO.	qu (kgf/cm^2)	Cuu (kgf/cm^2)	Øuu Degree	ãd (t/m^3)	γ t (t/m^3)
Dawuan	BP-NO.1	3.021	1.400		1.087	1.604
	BP-NO.2	3.029	1.390		1.077	1.611
	BP-NO.3	3.648	1.300		1.136	1.624
	BP-NO.4	3.273	0.320	21.8	1.199	1.618
	Ave.Value	3.243	1.353	21.8	1.125	1.614
	R.Renge	2.95~3.54	1.30~1.40	21.8	1.07~1.18	1.61~1.62
Warnasari	BP-NO.1	3.449	1.380		1.170	1.66
	BP NO.2	3.043	1.290		1.049	1.578
	BP-NO.3	3.503	1.290		1.097	1.621
	BP-NO.4	3.462	1.530	19.4	1.185	1.6
	BP-NO.5	3.209	1.300	21.6	1.145	1.614
	BP-NO.6	3.292	1.330	20.8	1.220	1.644
	BP-NO.7	3.762	1.330	22.8	1.200	1.622
	BP-NO.8	3.164	1.290	20.0	1.166	1.602
	BP NO.9	3.209	1.450		1.162	1.607
	BP-NO.10	3.040	1.430	20.3	1.189	1.633
	BP-NO.11	3.209	1.320	20.1	1.202	1.616
	BP-NO.12	3.013	1.280	22.4	1.144	1.625
	Ave.Value	3.280	1.352	21.0	1.161	1.619
	R.Renge	3.05~3.51	1.27~1.43	19.8~22.2	1.11~1.21	1.60~1.64
Avcrage Valuc		3.27	1.350	21.0	1.152	1.617
Representative Range		3.04~3.51	1.28~1.42	19.8~22.2	1.10~1.20	1.60~1.64
Standard Deviation ón		0.23	0.070	1.2	0.051	0.019

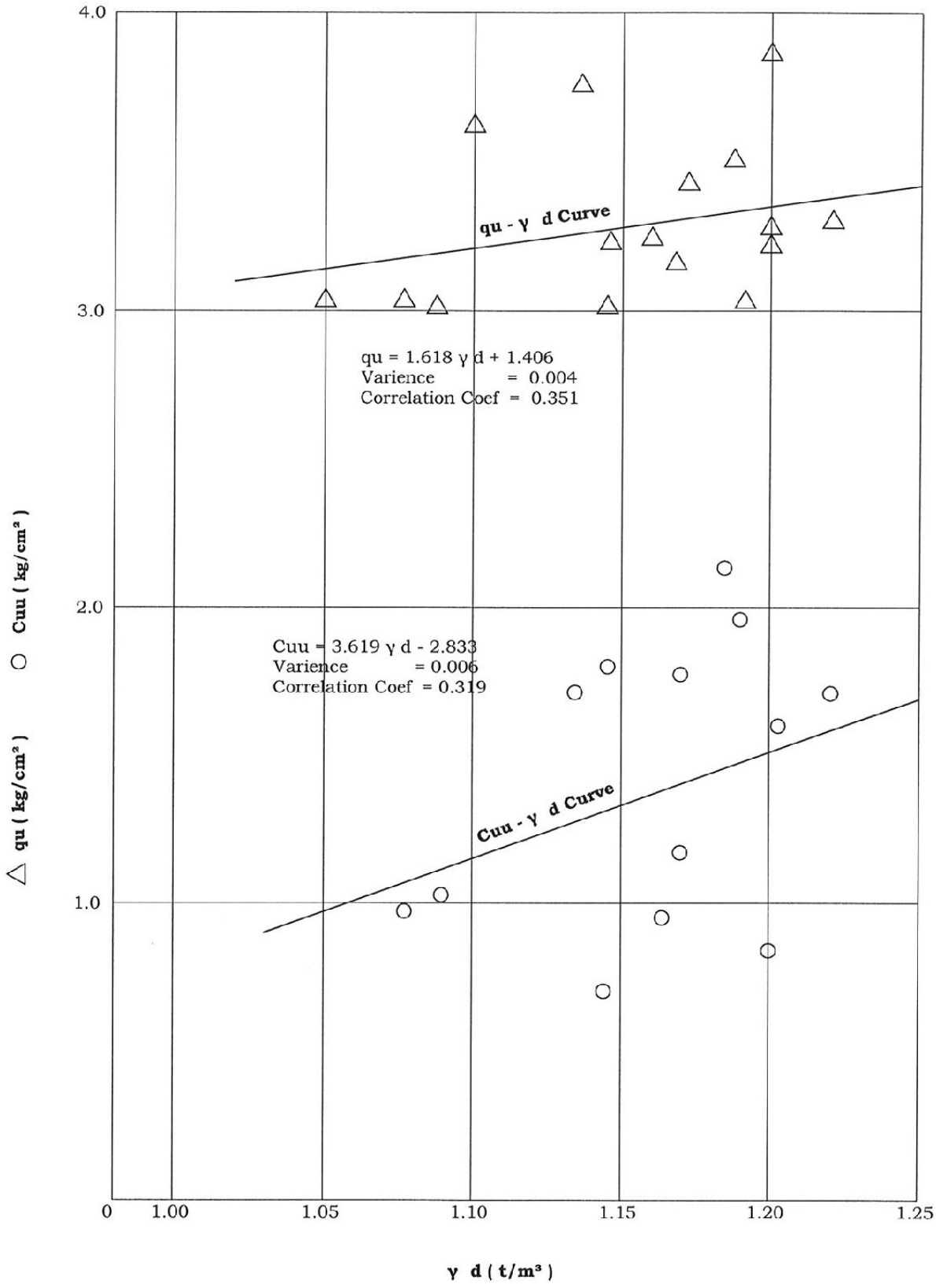


Figure 4-2-4

THE DETAILED DESIGN STUDY OF RAILWAY ELECTRIFICATION AND DOUBLE-DOUBLE TRACKING OF THE JAVA MAIN LINE PROJECT

RELATIVE CHART OF γ d AND qu, Cuu
(Laterite)

4.2.3 Determination of Design Soil Value

To enable the design of the earth works, the variation in the value of the soil parameters were established. These err on the side of safety for the purpose of design.

Embankment Materials

(1) CBR Design Value

Test values ranged from 5.7 to 6.5 % with an average of 6.1 %. The CBR design value is taken to be the lowest rounded value of 5.0 %

(2) Dry and wet density

Average values are used for the design. These are $\gamma d = 1.15$ t /m^3 and $\gamma t = 1.70$ t /m^3

(3) Plastic Index

The design value, Ip=48.8, is also taken to be the average of the tested values.

(4) Compression Strength

The relationship between dry density and unconfined, triaxial compression strength are shown in Fig.4.2.4.

Values of qu and Cuu corresponding to $\gamma d = 1.15$ t /m^3 were obtained using two equations. These are qu = 30 tf /m^2 and C = 12.8 tf /m^2.

The design value of qu = 6.0 tf/m^2 C = 2.2 tf /m^2 and $\phi = 10^\circ$ were taken as 20 % of the above values, ie. a factor of safety of five.

This allows for soil cracks occurring during construction and the non uniform nature of the soil.