Annex

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KM 00R	9,326,510.14	691,047.44	0.641	(= BM 09)
KM 00L	9,326,523.87	691,024.69	0.715	
KM 01R	9,326,409.43	690,983.00	0.758	
KM 01L	9,326,424.52	690,966.07	0.461	
KM 02R	9,326,368.73	690,908.43	0.833	
KM 02L	9,326,389.26	690,900.83	0.997	
KM 03R	9,326,351.38	690,858.22	0.373	
KM 03L	9,326,364.64	690,850.84	0.192	
KM 04R	9,326,291.82	690,756.55	1.984	
KM 04L	9,326,301.23	690,748.73	1.928	
KM 05R	9,326,289.93	690,754.06	1.974	
KM 05L	9,326,299.22	690,746.43	1.950	
KM 06R	9,326,231.63	690,671.03	0.920	
KM 06L	9,326,249.89	690,659.22	0.714	
KM 07R	9,326,163.98	690,577.05	0.824	
KM 07L	9,326,178.97	690,566.93	0.653	
KM 08R	9,326,079.42	690,459.09	0.393	
KM 08L	9,326,097.46	690,451.31	0.386	
KM 09R	9,326,049.24	690,403.32	0.613	
KM 09L	9,326,070.88	690,392.06	0.353	
KM 10R	9,326,000.26	690,305.09	0.288	
KM 10L	9,326,020.08	690,294.40	0.833	
KM 11R	9,325,963.26	690,227.41	0.261	
KM 11L	9,325,982.84	690,217.73	1.032	
KM 12R	9,325,910.79	690,124.38	0.228	
KM 12L	9,325,932.89	690,114.80	1.448	
KM 13R	9,325,873.22	690,046.06	0.199	
KM 13L	9,325,898.20	690,034.37	2.967	
KM 14R	9,325,832.69	689,964.95	0.860	
KM 14L	9,325,850.10	689,955.70	1.222	
KM 15R	9,325,814.89	689,934.73	2.378	
KM 15L	9,325,823.94	689,925.10	2.630	
KM 16R	9,325,799.48	689,912.67	1.725	
KM 16L	9,325,814.85	689,896.86	1.704	
KM 17R	9,325,768.91	689,858.35	0.054	
KM 17L	9,325,800.30	689,829.69	7.206	
KM 18R	9,325,708.06	689,770.68	1.400	
KM 18L	9,325,717.58	689,762.81	1.450	
KM 19R	9,325,634.41	689,695.00	1.460	
KM 19L	9,325,645.25	689,682.67	1.375	
KM 20R	9,325,627.12	689,691.91	1.332	
KM 20L	9,325,639.18	689,678.24	1.402	
KM 21R	9,325,608.39	689,667.26	0.529	
KM 21L	9,325,614.62	689,660.81	0.782	
KM 22R	9,325,539.37	689,611.62	0.339	
KM 22L	9,325,550.03	689,600.09	1.102	
KM 23R	9,325,468.46	689,547.75	0.278	
KM 23L	9,325,477.39	689,538.31	0.866	
KM 24R	9,325,407.69	689,506.77	0.138	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KM 24L	9,325,416.50	689,493.53	0.779	
KM 25R	9,325,317.16	689,468.58	0.294	
KM 25L	9,325,325.02	689,453.00	0.817	
KM 26R	9,325,242.84	689,434.35	0.323	
KM 26L	9,325,248.65	689,421.08	0.607	(= KH-C 00L)
KM 27R	9,325,126.38	689,413.09	0.608	
KM 27L	9,325,126.58	689,402.04	0.736	
KM 28R	9,325,019.69	689,426.28	0.386	
KM 28L	9,325,017.28	689,415.98	0.315	
KM 29R	9,324,941.95	689,439.31	0.206	
KM 29L	9,324,940.61	689,427.05	0.421	
KM 30R	9,324,877.57	689,450.24	0.831	
KM 30L	9,324,876.97	689,441.83	0.997	
KM 31R	9,324,875.67	689,450.34	0.848	
KM 31L	9,324,874.35	689,441.86	1.001	
KM 32R	9,324,802.84	689,458.20	0.569	
KM 32L	9,324,801.25	689,446.79	0.429	
KM 33R	9,324,704.85	689,475.61	0.676	
KM 33L	9,324,703.37	689,464.93	0.777	
KM 34R	9,324,649.23	689,483.55	0.922	
KM 34L	9,324,648.32	689,475.34	0.838	
KM 35R	9,324,597.11	689,492.43	0.772	
KM 35L	9,324,595.15	689,482.45	0.589	
KM 36R	9,324,454.12	689,509.61	1.947	
KM 36L	9,324,463.11	689,492.47	1.772	
KM 37R	9,324,444.59	689,510.33	1.963	
KM 37L	9,324,453.10	689,495.07	1.901	
KM 38R	9,324,419.96	689,511.89	1.846	
KM 38L	9,324,418.79	689,501.02	1.794	
KM 39R	9,324,297.23	689,530.13	1.464	
KM 39L	9,324,294.75	689,518.95	1.427	
KM 40R	9,324,295.40	689,530.37	1.478	
KM 40L	9,324,292.90	689,519.44	1.482	
KM 41R	9,324,143.59	689,548.14	1.020	
KM 41L	9,324,140.19	689,537.62	0.786	
KM 42R	9,324,141.55	689,548.35	1.062	
KM 42L	9,324,138.06	689,538.57	0.744	
KM 43R	9,324,032.67	689,565.13	1.259	
KM 43L	9,324,030.34	689,554.92	0.851	
KM 44R	9,323,975.55	689,572.30	1.660	
KM 44L	9,323,974.78	689,563.64	1.825	
KM 45R	9,323,972.36	689,572.66	1.699	
KM 45L	9,323,971.73	689,564.93	1.784	
KM 46R	9,323,897.36	689,581.44	0.852	
KM 46L	9,323,894.40	689,570.43	1.422	
KM 47R	9,323,810.97	689,613.65	1.477	
KM 47L	9,323,805.14	689,604.59	1.294	
KM 48R	9,323,737.35	689,651.84	1.123	(=KE 00L)
KM 48L	9,323,734.63	689,641.22	1.395	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KM 49R	9,323,630.06	689,569.22	2.214	
KM 49L	9,323,644.40	689,560.71	2.389	
KM 50R	9,323,622.27	689,560.56	2.241	
KM 50L	9,323,640.93	689,549.79	2.392	
KM 51R	9,323,575.85	689,488.70	1.711	
KM 51L	9,323,586.85	689,469.96	1.919	
KM 52R	9,323,522.52	689,402.00	1.520	
KM 52L	9,323,537.16	689,380.57	2.161	
KM 53R	9,323,473.17	689,337.89	2.169	
KM 53L	9,323,486.63	689,325.18	2.298	
KM 54R	9,323,467.51	689,331.39	2.160	
KM 54L	9,323,481.12	689,318.77	2.196	
KM 55R	9,323,383.54	689,218.92	1.325	
KM 55L	9,323,391.39	689,209.63	2.297	
KM 56R	9,323,298.18	689,136.81	1.568	
KM 56L	9,323,313.87	689,129.44	2.158	
KM 57R	9,323,225.75	689,073.61	1.416	
KM 57L	9,323,239.64	689,062.67	2.056	
KM 58R	9,323,163.14	688,983.06	1.310	
KM 58L	9,323,163.26	688,982.89	1.717	
KM 59R	9,323,085.15	688,910.03	1.203	
KM 59L	9,323,093.16	688,903.33	1.709	
KM 60L	9,323,037.66	688,829.83	2.413	
KM 61L	9,322,975.49	688,760.55	2.600	
KM 61R	9,322,963.41	688,771.61	2.331	(=KC-C 00R)

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KE 00R	9,323,741.02	689,658.68	1.474	
KE 00L	9,323,737.35	689,651.84	1.125	(= KM 48R)
KE 01R	9,323,710.47	689,678.36	1.584	
KE 01L	9,323,705.54	689,671.15	1.407	
KE 02R	9,323,629.36	689,731.98	1.159	
KE 02L	9,323,625.95	689,725.85	1.373	
KE 03R	9,323,516.89	689,813.03	1.481	
KE 03L	9,323,512.97	689,807.65	1.602	
KE 04R	9,323,435.21	689,871.42	1.571	
KE 04L	9,323,431.61	689,865.83	1.616	
KE 05R	9,323,369.05	689,917.71	1.935	
KE 05L	9,323,359.35	689,922.98	2.295	
KE 06R	9,323,367.60	689,923.00	2.318	
KE 06L	9,323,360.61	689,926.64	2.253	
KE 07R	9,323,385.90	689,950.60	2.469	
KE 07L	9,323,379.59	689,954.36	2.227	
KE 08R	9,323,366.83	690,011.71	2.406	
KE 08L	9,323,358.60	690,008.48	2.041	
KE 09R	9,323,371.50	690,062.50	2.184	
KE 09L	9,323,365.11	690,061.24	2.153	
KE 10R	9,323,372.60	690,068.21	2.110	
KE 10L	9,323,366.16	690,067.07	2.131	
KE 11R	9,323,295.34	690,119.52	2.323	
KE 11L	-	-	1.724	
KE 12R	9,323,234.31	690,157.75	2.186	
KE 12L	9,323,230.51	690,152.42	2.082	
KE 13R	9,323,142.41	690,216.30	2.323	
KE 13L	9,323,139.31	690,211.25	1.649	
KE 14R	9,323,100.02	690,242.92	2.090	
KE 14L	9,323,097.01	690,238.05	1.957	
KE 15R	9,323,038.08	690,284.33	1.991	
KE 15L	9,323,034.98	690,279.90	1.921	
KE 16R	9,322,965.99	690,335.13	2.252	
KE 16L	9,322,963.71	690,331.66	2.017	
KE 17R	9,322,911.17	690,371.93	2.292	
KE 17L	9,322,908.99	690,368.59	2.037	
KE 18R	9,322,836.34	690,423.57	2.187	
KE 18L	9,322,833.70	690,419.95	2.166	
KE 19R	9,322,745.62	690,488.66	2.379	
KE 19L	9,322,743.62	690,485.86	2.354	
KE 20R	9,322,709.14	690,515.25	2.144	
KE 20L	9,322,706.66	690,511.98	2.184	
KE 21R	9,322,648.00	690,559.31	2.319	
KE 21L	9,322,645.99	690,556.36	2.121	
KE 22R	9,322,611.44	690,568.02	2.556	
KE 22L	9,322,615.46	690,564.81	2.462	
KE 23R	9,322,598.23	690,562.87	2.713	
KE 23L	9,322,595.49	690,560.10	2.618	
KE 24R	9,322,531.03	690,629.85	1.848	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KE 24L	9,322,528.39	690,627.54	1.953	
KE 25R	9,322,472.99	690,686.16	1.816	
KE 25L	9,322,471.11	690,683.52	2.060	
KE 26R	9,322,370.18	690,798.45	2.001	
KE 26L	9,322,367.80	690,796.40	1.937	
KE 27R	9,322,267.96	690,847.35	1.888	
KE 27L	9,322,266.18	690,845.53	2.018	
KE 28R	9,322,216.17	690,895.18	2.268	
KE 28L	9,322,215.06	690,893.82	2.223	
KE 29R	9,322,163.55	690,946.07	2.115	
KE 29L	9,322,162.12	690,944.60	2.155	
KE 30R	9,322,052.18	691,069.81	2.496	
KE 30L	9,322,049.92	691,067.94	2.216	
KE 31R	9,321,933.99	691,199.94	2.401	
KE 31L	9,321,932.18	691,198.26	2.445	
KE 32R	9,321,866.12	691,280.94	2.665	
KE 32L	9,321,864.34	691,279.45	2.638	
KE 33R	9,321,801.11	691,406.20	2.819	(= KE 33.1R)
KE 33L	9,321,798.02	691,402.19	2.510	
KE 33.1L	9,321,795.39	691,403.98	2.740	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KM-C 00R	9,322,977.61	688,749.43	1.605	
KM-C 00L	9,322,984.72	688,757.42	1.870	
KM-C 01R	9,323,154.93	688,577.93	3.017	
KM-C 01L	9,323,163.26	688,587.48	2.954	
KM-C 02R	9,323,179.51	688,552.19	4.186	
KM-C 02L	9,323,191.37	688,564.75	4.181	
KM-C 03R	9,323,356.43	688,386.67	4.493	
KM-C 03L	9,323,368.19	688,399.28	4.490	
KM-C 04R	9,323,545.30	688,213.32	2.703	
KM-C 04L	9,323,561.15	688,230.53	3.011	

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KC- 00R	9,322,963.41	688,771.61	2.331	(=KM 61R)
KC-C 00L	9,322,956.86	688,765.14	2.332	
KC-C 01R	9,322,771.25	688,951.70	2.525	
KC-C 01L	9,322,764.82	688,943.78	2.698	
KC-C 02R	9,322,609.91	689,101.69	2.546	
KC-C 02L	9,322,603.35	689,094.05	2.800	
KC-C 03R	9,322,449.05	689,250.86	2.651	
KC-C 03L	9,322,442.10	689,243.11	2.921	
KC-C 04R	9,322,334.52	689,357.29	2.740	
KC-C 04L	9,322,328.03	689,349.51	2.975	
KC-C 05L	9,322,202.41	689,466.64	2.582	
KC-C 06L	9,322,058.83	689,599.24	2.440	
KC-C 07L	9,321,943.61	689,749.63	2.998	
KC-C 08L	9,322,081.71	689,944.07	3.086	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Kamal

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
KH-C 00L	9,325,248.65	689,421.08	0.594	(=KM 26L)
KH-C 00R	9,325,243.01	689,418.78	0.598	
KH-C 01R	9,325,131.36	689,313.34	1.252	
KH-C 01L	9,325,133.24	689,311.55	0.958	
KH-C 02R	9,325,042.48	689,113.38	1.905	
KH-C 02L	9,325,044.68	689,113.19	1.921	
KH-C 03R	9,325,001.93	688,966.05	2.820	
KH-C 03L	9,325,004.04	688,965.36	2.771	
KH-C 04R	9,324,940.94	688,760.53	2.877	
KH-C 04L	9,324,944.26	688,758.18	2.963	
KH-C 05R	9,324,864.64	688,574.94	3.004	
KH-C 05L	9,324,869.99	688,573.14	3.181	
KH-C 06R	-	-	3.152	
KH-C 06L	9,324,814.37	688,392.29	3.257	
KH-C 07R	9,324,748.54	688,312.49	3.214	
KH-C 07L	9,324,752.20	688,309.85	3.200	
KH-C 08R	9,324,650.85	688,153.64	3.476	
KH-C 08L	9,324,654.63	688,150.78	3.576	
KH-C 09L	9,324,459.62	687,982.66	3.419	
KH-C 09R	9,324,456.98	687,985.76	3.191	
KH-C 10R	-	-	2.810	
KH-C 10L	9,324,304.74	687,889.47	3.230	
KH-C 11R	9,324,107.89	687,783.09	3.114	
KH-C 11L	9,324,111.64	687,779.69	3.118	(=DTK 960)

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Tanjungan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
TM 00R	9,325,503.77	692,119.54	0.788	
TM 00L	9,325,511.84	692,112.09	0.326	
TM 01R	9,325,446.60	692,042.85	0.598	
TM 01L	9,325,455.81	692,035.10	0.676	
TM 02R	9,325,390.55	691,963.03	0.661	
TM 02L	9,325,400.84	691,955.33	0.867	
TM 03R	9,325,340.58	691,889.44	0.766	
TM 03L	9,325,351.99	691,883.13	0.809	
TM 04R	9,325,283.63	691,832.25	0.603	
TM 04L	9,325,291.29	691,823.23	0.908	
TM 05R	9,325,223.25	691,749.49	0.673	
TM 05L	9,325,231.35	691,741.96	0.643	
TM 06R	9,325,136.03	691,691.09	0.514	
TM 06L	9,325,142.26	691,680.73	0.637	
TM 07R	9,325,071.66	691,623.11	0.401	
TM 07L	9,325,079.83	691,617.32	0.366	
TM 08R	9,325,021.15	691,558.03	0.339	
TM 08L	9,325,028.03	691,549.34	0.539	
TM 09R	9,324,930.20	691,479.44	0.871	
TM 10R	9,324,927.10	691,474.83	0.901	
TM 10L	9,324,931.06	691,472.21	0.882	
TM 11R	9,324,893.29	691,386.99	0.440	
TM 12R	9,324,856.45	691,302.98	0.548	
TM 13R	9,324,833.63	691,266.61	0.664	
TM 14R	9,324,777.94	691,164.67	-1.681	
TM 15R	9,324,742.15	691,088.74	-1.657	
TM 16R	9,324,711.05	691,017.91	-1.524	
TM 17R	9,324,673.79	690,955.46	0.089	
TM 17L	9,324,678.91	690,951.09	0.142	
TM 18R	9,324,659.41	690,934.31	-0.010	
TM 18L	9,324,663.39	690,930.71	0.083	
TM 19R	9,324,599.94	690,856.34	0.140	
TM 19L	9,324,607.31	690,852.18	0.474	
TM 20R	9,324,540.86	690,775.53	-0.030	
TM 20L	9,324,549.83	690,770.27	0.591	
TM 21R	9,324,487.22	690,699.35	0.140	
TM 21L	9,324,494.78	690,694.63	0.888	
TM 22R	9,324,429.85	690,625.33	0.050	
TM 22L	9,324,438.19	690,619.00	0.651	
TM 23R	9,324,363.84	690,534.90	0.323	
TM 23L	9,324,372.34	690,528.06	0.712	
TM 24R	9,324,350.00	690,522.52	0.506	
TM 24L	9,324,361.77	690,514.38	0.440	
TM 25R	9,324,345.86	690,515.04	0.446	
TM 25L	9,324,355.45	690,508.55	0.575	
TM 26R	9,324,324.86	690,488.78	0.412	
TM 27R	9,324,324.26	690,480.11	0.345	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Tanjungan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
TM 28R	9,324,315.46	690,471.44	0.323	
TM 28L	9,324,313.78	690,468.69	0.360	
TM 29R	9,324,313.76	690,468.68	0.352	
TM 29L	9,324,317.65	690,466.52	0.391	
TM 30R	9,324,304.68	690,477.88	0.399	
TM 30L	9,324,303.13	690,475.47	0.386	
TM 31L	9,324,184.16	690,473.40	0.175	
TM 32R	9,324,175.59	690,488.53	0.321	
TM 32L	9,324,173.37	690,485.37	0.306	
TM 33R	9,324,162.49	690,483.39	0.362	
TM 33L	9,324,160.62	690,480.83	0.350	
TM 34R	9,324,050.42	690,532.68	0.038	
TM 35R	9,323,950.57	690,579.32	0.408	
TM 36R	9,323,893.01	690,662.78	0.233	
TM 36L	9,323,894.25	690,661.93	0.030	

Tanjungan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
TB 00L	9,324,663.39	690,930.71	0.083	
TB 01L	9,324,733.32	690,870.09	0.049	
TB 02L	9,324,800.02	690,810.37	0.119	
TB 03L	9,324,875.91	690,742.59	0.143	
TB 04L	9,324,923.38	690,700.13	0.157	
TB 05L	9,324,997.22	690,634.09	0.237	
TB 06L	9,325,071.19	690,567.83	0.264	
TB 07L	9,325,124.01	690,520.59	0.181	
TB 08L	9,325,196.15	690,455.92	0.117	
TB 09L	9,325,251.84	690,406.13	0.064	
TB 10L	9,325,321.96	690,343.42	0.082	
TB 11L	9,325,392.17	690,280.47	0.216	
TB 12L	9,325,462.85	690,217.29	0.373	
TB 13L	9,325,523.49	690,163.85	0.514	
TB 14L	9,325,594.26	690,100.34	0.663	
TB 15L	9,325,664.15	690,037.56	1.123	
TB 16L	9,325,735.03	689,974.00	1.739	
TB 17R	9,325,786.98	689,906.50	0.495	
TB 17L	9,325,787.97	689,910.08	0.584	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

PIK Junction

Post No.	North (m)	East (m)	Elevation(TTG.m)	Remarks
NM 00R	9,322,948.43	693,897.76	1.506	
NM 00L	9,322,977.75	693,896.58	0.299	
NM 01L	9,322,978.00	693,889.50	-0.569	
NM 02L	9,322,977.62	693,876.29	4.304	
NM 03L	9,322,980.35	693,789.94	3.734	
NM 04L	9,322,982.53	693,726.51	2.481	
NM 05L	9,322,985.87	693,631.11	0.859	
NM 06L	9,322,989.24	693,532.49	0.638	
NM 07L	9,322,992.34	693,443.46	0.697	
NM 08L	9,322,995.44	693,354.69	0.696	
NM 09L	9,322,998.63	693,265.66	0.981	
NM 10L	9,323,006.70	693,175.29	0.933	
NM 11L	9,323,022.35	693,087.66	0.860	
NM 12L	9,323,045.73	693,001.91	0.966	
NM 13L	9,323,076.08	692,919.08	0.839	
NM 14L	9,323,110.87	692,838.05	0.630	
NM 15L	9,323,146.32	692,755.20	0.609	
NM 16L	9,323,176.18	692,685.69	0.639	
NM 17L	9,323,211.37	692,603.97	0.644	
NM 18L	9,323,245.67	692,524.17	0.690	
NM 19R	9,323,266.43	692,456.90	0.543	
NM 19L	9,323,266.43	692,456.90	0.723	
NM 20L	9,323,300.89	692,376.64	0.509	
NM 21L	9,323,333.50	692,292.54	0.512	
NM 22L	9,323,364.66	692,209.77	0.563	
NM 23L	9,323,395.43	692,127.50	0.936	
NM 24L	9,323,412.76	692,041.86	1.600	
NM 25L	9,323,401.18	691,957.13	2.401	
NM 26L	9,323,387.65	691,872.04	2.307	
NM 27L	9,323,353.99	691,792.89	1.846	
NM 28L	9,323,281.94	691,745.52	1.765	
NM 29L	9,323,198.01	691,696.28	1.562	
NM 30L	9,323,119.58	691,650.08	2.016	
NM 31L	9,323,096.80	691,640.23	2.345	
NM 32L	9,323,080.07	691,631.04	2.090	
NM 33L	9,323,004.37	691,575.34	2.210	
NM 34L	9,322,907.39	691,515.23	2.230	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

PIK Junction

Post No.	North (M)	East (M)	Elevation (TTG.m)	Remarks
NA 00R	9,323,381.37	692,201.93	0.764	
NA 00L	9,323,384.68	692,203.35	1.011	
NA 01R	9,323,417.23	692,120.89	0.894	
NA 01L	9,323,425.18	692,125.46	1.067	
NA 02R	9,323,436.10	692,083.34	0.856	
NA 02L	9,323,446.68	692,089.03	1.019	
NA 03L	9,323,494.88	692,016.97	0.971	
NA 04L	9,323,552.95	691,942.23	1.026	
NA 05L	9,323,612.44	691,876.51	0.918	
NA 06L	9,323,677.50	691,814.51	0.639	
NA 07L	9,323,745.05	691,754.13	0.423	
NA 08L	9,323,801.81	691,703.25	0.367	
NA 09R	9,323,856.24	691,634.98	0.081	
NA 09L	9,323,866.25	691,645.61	0.304	
NA 10L	9,323,922.57	691,575.25	-0.049	
NA 11L	9,323,990.94	691,517.27	-0.111	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Gede/Bor

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
GM 00R	9,319,599.94	690,167.77	1.191	
GM 00L	9,319,602.05	690,175.67	1.074	
GM 01R	9,319,610.18	690,164.49	1.321	
GM 01L	9,319,612.21	690,171.44	1.363	
GM 02R	9,319,621.40	690,177.24	4.284	
GM 02L	9,319,619.41	690,170.13	4.328	
GM 03R	9,319,645.75	690,155.04	4.245	
GM 03L	9,319,648.29	690,162.79	4.281	
GM 04R	9,319,763.37	690,130.84	2.700	
GM 04L	9,319,763.90	690,136.46	2.674	
GM 05R	9,319,851.89	690,123.44	2.520	
GM 05L	9,319,852.13	690,126.43	2.873	
GM 06R	9,319,966.66	690,107.41	2.708	
GM 06L	9,319,966.79	690,111.61	2.939	
GM 07R	9,320,015.82	690,100.22	2.998	
GM 07L	9,320,015.99	690,108.91	3.017	
GM 08R	9,320,128.32	690,090.00	2.591	
GM 08L	9,320,128.59	690,095.06	2.860	
GM 09R	9,320,205.01	690,081.73	3.296	
GM 09L	9,320,205.26	690,087.91	3.640	
GM 10R	9,320,211.33	690,081.23	3.226	
GM 10L	9,320,211.65	690,087.59	3.070	
GM 11R	9,320,288.74	690,072.99	2.923	
GM 11L	9,320,288.51	690,077.61	2.872	
GM 12R	9,320,375.03	690,058.12	2.744	
GM 12L	9,320,375.09	690,062.46	2.785	
GM 13R	9,320,475.19	690,060.99	2.973	
GM 13L	9,320,474.45	690,066.15	2.922	
GM 14L	9,320,559.80	690,086.50	3.191	
GM 15R	9,320,654.50	690,106.50	3.366	
GM 15L	9,320,654.00	690,110.05	3.351	
GM 16L	9,320,701.50	690,056.50	3.253	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Gede/Bor

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
GM-C 00R	9,320,704.91	690,010.32	3.902	
GM-C 00L	9,320,713.30	690,010.41	3.565	
GM-C 01R	9,320,668.26	689,710.30	3.509	
GM-C 01L	9,320,676.72	689,710.30	4.016	
GM-C 02R	9,320,698.11	689,521.31	4.013	
GM-C 02L	9,320,705.74	689,523.89	4.113	
GM-C 03R	9,320,841.24	689,388.60	4.026	
GM-C 03L	9,320,851.30	689,390.73	4.045	
GM-C 04R	9,320,883.43	689,198.58	4.354	
GM-C 04L	9,320,893.69	689,200.83	4.352	
GM-C 05R	9,320,981.77	689,003.52	4.283	
GM-C 05L	9,321,190.38	688,755.70	4.265	
GM-C 06R	9,321,176.38	688,745.90	4.715	
GM-C 06L	9,321,184.60	688,752.27	4.771	
GM-C 07R	9,321,267.10	688,549.06	4.628	
GM-C 07L	9,321,276.89	688,550.13	4.637	
GM-C 08R	9,321,287.15	688,388.29	4.603	
GM-C 08L	9,321,296.88	688,389.56	4.557	
GM-C 09R	9,321,297.67	688,325.89	4.418	
GM-C 09L	9,321,302.94	688,325.79	4.430	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Gede/Bor

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
GA 00R	9,320,211.33	690,081.20	4.215	
GA 00L	9,320,213.48	690,081.19	4.058	
GA 01R	9,323,211.80	684,971.28	4.305	
GA 01L	9,320,213.23	689,971.30	4.172	
GA 02R	9,320,209.65	689,840.55	4.303	
GA 02L	9,320,204.77	689,840.57	4.634	
GA 03R	9,320,196.49	689,733.64	4.346	
GA 03L	9,320,198.44	689,733.69	4.377	
GA 04R	9,320,222.47	689,626.04	3.465	
GA 04L	9,320,229.17	689,623.94	4.274	
GA 05R	9,320,223.04	689,622.62	3.464	
GA 05L	9,320,247.72	689,529.29	3.421	
GA 06R	9,320,244.22	689,528.56	3.628	
GA 06L	9,320,248.86	689,529.28	3.567	
GA 07R	9,320,270.04	689,411.41	3.618	
GA 07L	9,320,273.22	689,412.08	3.595	
GA 08R	9,320,295.63	689,282.34	3.675	
GA 08L	9,320,298.85	689,283.01	3.667	
GA 09R	9,320,338.12	689,208.23	3.768	
GA 09L	9,320,340.71	689,210.28	3.775	
GA 10R	9,320,405.27	689,122.86	3.756	
GA 10L	9,320,409.53	689,125.69	4.012	
GA 11R	9,320,462.27	689,039.01	3.805	
GA 11L	9,320,465.37	689,040.75	3.835	
GA 12R	9,320,492.79	688,972.70	4.181	
GA 12L	9,320,496.59	688,973.29	4.194	(960041)

Saluran Cengkareng

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
CM 00R	9,320,954.08	693,671.41	0.577	
CM 00L	9,320,959.77	693,673.50	0.578	
CM 01R	9,320,955.15	693,659.59	2.171	
CM 01L	9,320,965.80	693,663.82	2.270	
CM 02R	9,320,953.57	693,657.41	1.324	
CM 02L	9,320,968.15	693,660.95	1.555	
CM 03R	9,321,030.20	693,543.08	1.193	
CM 03L	9,321,039.08	693,548.86	0.503	
CM 04R	9,320,998.32	693,433.41	1.450	
CM 05R	9,320,914.35	693,378.50	1.865	
CM 05L	9,320,920.40	693,369.31	1.844	
CM 06R	9,320,852.33	693,338.21	1.763	
CM 06L	9,320,858.78	693,328.68	1.243	
CM 07R	9,320,766.84	693,281.26	2.398	
CM 07L	9,320,774.64	693,270.93	2.114	
CM 08R	9,320,710.34	693,244.39	1.619	
CM 08L	9,320,717.27	693,235.56	1.813	
CM 09R	9,320,567.28	693,150.07	1.481	
CM 09L	9,320,573.04	693,141.37	1.389	
CM 10R	9,320,504.34	693,107.96	1.450	
CM 10L	9,320,509.97	693,099.32	1.447	
CM 11R	9,320,443.85	693,068.27	2.198	
CM 11L	9,320,450.81	693,058.61	2.087	
CM 12R	9,320,438.69	693,065.40	1.997	
CM 12L	9,320,445.73	693,055.03	2.081	
CM 13R	9,320,360.21	693,013.75	1.324	
CM 14R	9,320,282.76	692,927.29	1.252	
CM 14L	9,320,292.48	692,923.38	1.369	
CM 15R	9,320,268.17	692,864.57	2.082	
CM 15L	9,320,279.85	692,862.82	1.994	
CM 16R	9,320,252.61	692,789.28	0.887	
CM 16L	9,320,266.05	692,790.83	0.732	
CM 16.1L	9,320,265.90	692,786.75	0.954	
CM 17R	9,320,206.68	692,670.25	1.515	
CM 17L	9,320,214.21	692,663.83	0.718	
CM 18L	9,320,151.06	692,587.64	1.084	
CM 19R	9,320,100.25	692,536.98	0.951	
CM 19L	9,320,109.03	692,533.25	1.051	
CM 20R	9,320,028.58	692,435.41	1.244	
CM 20L	9,320,035.04	692,429.33	0.706	
CM 21R	9,319,973.32	692,360.32	1.719	
CM 21L	9,319,981.04	692,355.25	0.739	
CM 22R	9,319,933.78	692,302.75	1.486	
CM 22L	9,319,940.82	692,297.91	0.759	
CM 23R	9,319,906.58	692,206.90	1.548	
CM 23L	9,319,916.94	692,205.40	0.953	
CM 24R	9,319,892.95	692,106.30	0.891	(= 96008)
CM 24L	9,319,902.15	692,105.46	0.725	
CM 25R	9,319,919.82	692,016.79	0.999	
CM 25L	9,319,928.48	692,019.29	0.921	

Saluran Cengkareng

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
CM 26R	9,319,955.48	691,912.13	1.197	
CM 26L	9,319,963.89	691,914.80	1.175	
CM 27R	9,320,001.81	691,776.23	1.421	
CM 27L	9,320,009.82	691,778.92	1.465	
CM 28R	9,320,048.91	691,640.52	1.959	
CM 28L	9,320,057.30	691,640.85	1.920	
CM 29R	9,320,049.58	691,634.02	2.319	
CM 29L	9,320,056.48	691,634.42	2.329	
CM 30R	9,320,081.72	691,539.54	1.084	
CM 30L	9,320,090.03	691,541.92	1.078	
CM 31R	9,320,117.62	691,439.94	1.129	
CM 31L	9,320,125.13	691,443.57	1.104	
CM 32R	9,320,160.79	691,318.09	1.229	
CM 32L	9,320,168.51	691,320.56	1.205	
CM 33R	9,320,193.42	691,227.31	3.004	
CM 33L	9,320,201.03	691,230.73	3.174	
CM 34R	9,320,199.82	691,211.02	3.267	
CM 34L	9,320,208.93	691,215.43	3.233	
CM 35R	9,320,210.53	691,184.49	2.712	
CM 35L	9,320,221.68	691,188.31	2.282	
CM 36R	9,320,218.24	691,167.53	2.723	
CM 36L	9,320,232.72	691,172.26	2.408	
CM 37R	9,320,277.93	691,058.23	1.425	
CM 37L	9,320,282.72	691,060.95	1.341	
CM 38R	9,320,337.11	690,953.94	1.452	
CM 38L	9,320,341.51	690,956.40	1.512	
CM 39R	9,320,366.32	690,873.65	2.053	
CM 39L	9,320,371.56	690,875.81	1.801	
CM 40R	9,320,373.15	690,833.39	3.192	
CM 40L	9,320,387.97	690,834.93	3.166	
CM 41R	9,320,401.83	690,747.37	2.023	
CM 41L	9,320,410.34	690,749.12	2.075	
CM 42R	9,320,429.67	690,654.33	2.086	
CM 42L	9,320,438.00	690,656.43	2.087	
CM 43R	9,320,465.43	690,535.80	2.224	
CM 43L	9,320,469.62	690,537.62	2.186	
CM 44R	9,320,491.17	690,410.43	3.203	
CM 44L	9,320,504.23	690,411.65	3.281	
CM 45R	9,320,491.92	690,401.63	3.475	
CM 45L	9,320,509.09	690,403.34	3.313	
CM 46R	9,320,494.59	690,400.08	2.661	
CM 46L	9,320,501.02	690,400.58	2.904	
CM 47R	9,320,506.35	690,296.91	2.608	
CM 47L	9,320,514.83	690,297.97	2.728	
CM 48R	9,320,523.06	690,210.35	2.729	
CM 48L	9,320,531.18	690,211.96	2.741	
CM 49R	9,320,550.36	690,093.47	2.848	
CM 49L	9,320,556.71	690,094.94	3.029	
CM 50R	9,320,549.23	690,085.71	2.870	
CM 50L	9,320,558.81	690,087.58	3.194	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Pedongkelan

Posts No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
PM-C 00R	9,321,130.45	693,727.09	0.860	
PM-C 00L	9,321,133.18	693,728.44	0.899	
PM-C 01R	9,321,215.59	693,561.51	0.709	
PM-C 01L	9,321,221.25	693,564.98	0.741	
PM-C 02R	9,321,276.21	693,341.59	1.029	
PM-C 02L	9,321,282.34	693,345.23	0.958	
PM-C 03R	9,321,344.97	693,237.64	1.032	
PM-C 03L	9,321,350.86	693,242.89	1.093	
PM-C 04R	9,321,331.43	693,098.24	1.276	
PM-C 04L	9,321,340.80	693,100.92	1.283	
PM-C 05R	9,321,377.52	692,916.03	1.344	
PM-C 05L	9,321,384.61	692,922.74	1.345	
PM-C 06R	9,321,481.32	692,833.51	1.439	
PM-C 06L	9,321,487.56	692,841.08	1.442	
PM-C 07R	9,321,574.46	692,760.94	1.436	
PM-C 07L	9,321,580.18	692,768.60	1.342	
PM-C 08R	9,321,705.54	692,644.76	1.439	
PM-C 08L	9,321,713.58	692,650.50	1.295	
PM-C 09R	9,321,903.45	692,480.10	1.483	
PM-C 09L	9,321,909.32	692,487.40	1.530	
PM-C 10R	9,322,044.22	692,374.61	1.564	
PM-C 10L	9,322,050.30	692,382.33	1.548	
PM-C 11R	9,322,041.04	692,172.71	1.947	
PM-C 11L	9,322,049.20	692,166.37	1.924	
PM-C 12R	9,321,937.69	692,032.89	1.714	
PM-C 12L	9,321,943.08	692,029.08	1.646	
PM-C 13R	9,321,838.90	691,902.10	1.979	
PM-C 13L	9,321,844.49	691,897.96	1.992	
PM-C 14R	9,321,666.99	691,761.60	2.035	
PM-C 14L	9,321,667.51	691,755.48	2.036	
PM-C 15R	9,321,494.78	691,758.03	2.048	
PM-C 15L	9,321,494.50	691,751.20	1.828	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Pedongkelan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
PA-C 00L	-	-	0.794	
PA-C 00R	9,321,257.25	693,182.40	0.696	
PA-C 01R	9,321,083.87	693,047.03	1.036	
PA-C 01L	9,321,089.47	693,038.32	1.109	
PA-C 02R	9,321,035.74	692,844.73	1.128	
PA-C 02L	9,321,043.97	692,838.11	1.298	
PA-C 03R	9,320,973.41	692,763.40	1.257	
PA-C 03L	9,320,981.27	692,756.88	1.154	
PA-C 04R	9,320,898.47	692,673.35	1.497	
PA-C 04L	9,320,906.38	692,666.74	1.472	
PA-C 05R	-	-	2.611	
PA-C 05L	9,320,848.06	692,385.57	2.599	
PA-C 06R	9,320,831.51	692,408.81	1.586	
PA-C 06L	9,320,838.90	692,408.92	1.595	
PA-C 07R	9,320,831.62	692,384.44	1.863	
PA-C 07L	9,320,848.06	692,385.57	1.625	
PA-C 08R	9,320,838.16	692,036.63	1.938	
PA-C 08L	-	-	1.948	
PA-C 09R	9,320,892.73	691,791.63	1.867	
PA-C 09L	9,320,897.29	691,795.72	1.833	
PA-C 10R	9,321,169.57	691,743.35	2.117	
PA-C 10L	9,321,169.53	691,749.92	2.115	
PA-C 11R	9,321,392.01	691,748.69	1.939	
PA-C 11L	9,321,391.29	691,755.47	2.064	

Pedongkelan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
PB-C 00R	9,321,481.26	692,833.54	1.439	
PB-C 00L	9,321,485.79	692,829.83	1.444	
PB-C 01R	9,321,430.57	692,769.93	1.443	
PB-C 01L	9,321,435.06	692,766.34	1.371	
PB-C 02R	9,321,426.77	692,767.11	1.430	
PB-C 02L	9,321,431.97	692,762.60	1.449	
PB-C 03R	9,321,432.28	691,957.73	1.491	
PB-C 03L	9,321,288.99	692,585.35	1.447	
PB-C 04R	9,321,265.98	692,567.15	1.472	
PB-C 04L	9,321,271.15	692,562.62	1.559	
PB-C 05R	9,321,188.66	692,473.32	1.529	
PB-C 05L	9,321,191.29	692,467.05	1.529	
PB-C 06R	9,321,095.33	692,446.02	1.466	
PB-C 06L	9,321,096.95	692,439.89	1.452	
PB-C 07R	9,320,965.69	692,408.03	1.609	
PB-C 07L	9,320,967.62	692,402.10	1.606	
PB-C 08R	9,320,847.82	692,400.52	1.789	
PB-C 08L	9,320,848.04	692,385.57	1.649	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Pedongkelan

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
PC-C 00R	9,321,271.17	692,562.71	1.558	
PC-C 00L	9,321,278.38	692,562.79	1.626	
PC-C 01R	9,321,412.91	692,388.38	1.686	
PC-C 01L	9,321,418.26	692,392.06	1.756	
PC-C 02R	9,321,427.74	692,145.62	1.744	
PC-C 02L	9,321,434.24	692,145.70	1.778	
PC-C 03R	9,321,283.93	692,589.21	2.024	
PC-C 03L	9,321,438.66	691,957.82	2.037	
PC-C 04R	9,321,435.46	691,817.19	2.056	
PC-C 04L	9,321,441.90	691,817.11	2.038	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Menya area

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
MM 00-20R	9,315,457.77	690,707.37	8.734	
MM 00R	9,315,460.69	690,735.04	8.730	
MM 01R	9,315,463.11	690,824.08	8.590	
MM 02R	9,315,452.59	690,928.20	8.664	
MM 03R	9,315,435.70	691,032.84	8.399	(=MA 00R)
MM 04R	9,315,423.31	691,043.55	5.464	
MM 04L	9,315,425.03	691,031.23	5.771	
MM 05L	9,315,370.92	690,990.36	6.250	
MM 06R	9,315,294.96	691,001.63	6.434	
MM 06L	9,315,296.33	690,997.70	6.467	
MM 07R	9,315,288.07	690,998.91	6.395	
MM 07L	9,315,289.29	690,995.68	6.461	
MM 08R	9,315,271.37	691,042.46	6.444	
MM 08L	9,315,266.10	691,040.25	6.385	
MM 09R	9,315,259.59	691,052.17	6.491	
MM 09L	9,315,266.10	691,040.25	6.385	(=MM 08L)
MM 10R	9,315,219.83	691,017.42	6.305	
MM 10L	9,315,218.79	691,015.55	5.801	
MM 11R	9,315,156.69	691,049.39	6.120	
MM 11L	9,315,157.68	691,047.98	6.075	
MM 12R	9,315,079.56	690,992.87	6.417	
MM 12L	9,315,081.05	690,990.78	6.228	
MM 13R	9,315,013.19	690,945.44	7.145	
MM 13L	9,315,015.90	690,941.84	6.791	
MM 14R	9,314,929.53	690,883.06	7.838	
MM 14L	9,314,931.52	690,880.45	7.733	
MM 15R	9,314,878.92	690,909.36	6.193	
MM 15L	9,314,880.99	690,907.21	6.229	
MM 16R	9,314,783.58	690,842.42	6.456	
MM 16L	9,314,787.83	690,836.76	6.442	
MM 17R	9,314,780.97	690,842.80	6.442	
MM 17L	9,314,776.55	690,839.53	6.472	
MM 18R	9,314,744.59	690,891.10	6.375	
MM 19R	9,314,690.05	690,966.90	6.408	
MM 20R	9,314,649.05	691,019.34	6.638	
MM 21R	9,314,629.46	691,043.69	6.748	
MM 22R	9,314,584.30	691,106.91	8.564	
MM 23R	9,314,553.23	691,151.10	10.207	
MM 23L	9,314,552.78	691,150.83	10.036	
MM 24R	9,314,513.27	691,201.82	8.913	
MM 25R	9,314,485.06	691,241.60	9.140	
MM 26L	9,314,420.33	691,327.59	8.773	
MM 27L	9,314,356.30	691,414.10	8.664	
MM 28L	9,314,286.35	691,495.54	8.812	
MM 28R	9,314,291.75	691,499.81	8.835	

ANNEX. COORDINATES AND ELEVATIONS OF CROSS SECTION POSTS

Meruya area

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
MM 301	9,315,436.52	690,746.89	16.000	
MM 302	9,315,380.57	690,746.54	11.330	
MM 303A	9,315,361.94	690,803.75	10.090	
MM 303B	9,315,330.85	690,853.24	10.460	
MM 307	9,315,276.55	690,856.10	10.140	
MM 308	9,315,258.62	690,910.88	8.760	
MM 309	9,315,244.16	690,951.25	7.830	
MM 310	9,315,228.62	690,998.85	6.980	

Meruya area

Post No.	North (m)	East (m)	Elevation (TTG.m)	Remarks
MA 00R	9,315,435.70	691,032.84	8.399	(=MM 03R)
MA 01R	9,315,419.29	691,132.99	8.405	
MA 02R	9,315,413.70	691,170.87	8.315	
MA 03R	9,315,343.66	691,217.87	7.315	
MA 04R	9,315,262.08	691,311.95	9.918	
MA 05R	9,315,198.98	691,382.04	9.035	
MA 06R	9,315,126.50	691,469.76	7.275	
MA 07R	9,315,095.62	691,507.44	7.374	
MA 08R	9,315,074.84	691,534.53	7.885	

No. 3

Geo-Technical Investigation

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1 Introduction

The area of Jakarta and its surroundings are geomorphologically located in the Tertiary sedimentary basin of West Java. The basement rock is composed of sandstone, conglomerate and claystone of the Middle Miocene Rengganis Formation, which is unconformably overlain by sediments of the Middle Miocene Bojongmanik formation.. The northern part is widely covered by the Early Pliocene volcano-sedimentary rocks of the Genteng Formation, including pumice, tuffaceous sandstone, andesitic breccia. Plio-Pleistocene volcanic activities has formed young volcanic products.

The project area is located in the north-western outskirts of the city of Jakarta, near the coast of the Java sea, and covered by Holocene and Pleistocene deposits. The area is situated in the coastal plain, with several meters of ground height above the mean sea level.

1.1 Lithology in the Study Area

From the recovered drilling cores, the subsurface appeared to consist of young, fine grained Quaternary soils. 70% of the soils are clays, often silty and sandy and the remaining 30% are silty fine sands. Mixed soils and alternations of clay and sand in thin levels, are common. Most of the soil beds are laterally not continuous. At several depth levels the soils contain small percentages of coal or rests of organic material. Iron oxide (limonite) is a frequent component of the soils, as well as carbonate and shell fragments or small crystals of gypsum.

The nature of the soils reflect a mixed marine and continental origin, typical for tidal flat deposits. The sedimentation takes place in small, meandering creeks (shallow channels), showing typical "fining upward" soil sequences. During high tide, the sea water covers the entire flat area and submerges the creeks. After the withdrawal of the sea water a thin film of fine sediments is left. Organic matter and shell fragments are common in such deposits.

The lower portion of most of the drilling cores consists of hard clay, containing fragments of disintegrated rock. This clay could be of residual origin.

1.2 Thickness of the Soils

Down to the depth of 35 m, no bedrock has been encountered. The soil cover in the alluvial plain of Jakarta is supposed to be at least 250 m thick.

The thickness of the tidal deposits decreases from the coast to the south and so does the depth to the top of the residual soil. Consequently the soils in the coastal area, Kamal, Tangerang or along the toll road, are softer compared to the soils at Kali Bor, Cengkareng, Daan Mogot.

2 Contents of the Investigation

2.1 General

The main purposes of the present geotechnical investigation were to establish the characteristics of the foundation bed for the reparian structures and to evidence the subsidence, known to affect the entire alluvial plain around Jakarta. The investigated areas were Cengkareng and Meruya, as shown in Figs.1 and 2.

2.2 Investigation Plan

The field works consisted of the following items:

- Drilling with SPT- testing and undisturbed sampling
- Installing piezometers in the drill holes
- Laboratory Testing
- Dutch Cone Sounding
- Elevation Survey of Bench Marks.

The scheduled work quantities are listed as follows:

Work Item	Code/ Location	Depth/depth interval	SPT/Sounding (times)	Undisturbed samples
1. Drilling	A-1	35 m	32	6
	B-1	35 m	32	6
	B-2	30 m	27	5
	C-1	20 m	18	3
	D-1	20 m	27	3
	O-1	25 m	23	4
2. Piezometers	A-1			
	B-1	29 - 35		

Work Item	Code/ Location	Depth/depth interval	SPT/Sounding (times)	Undisturbed samples
	B-2			
	C-1			
	D-1			
	O-1			
3. Dutch Cone	KSC	11		
	TSC	8		
	NSC	7		
	KGSC	5		
	CSC	9		
	MSC	7		
4.Elevation	at 5 fixed and 5 target points			

Work Item	Samples	Physical tests	Triaxial UU CU or CD	Unconfined compression	Consolidation
5. Laboratory testing	A-1	6	6	6	5
	B-1	6	6	6	5
	B-2	5	5	5	4
	C-1	3	3	3	2
	D-1	3	3	3	2
	O-1	4	4	4	3

3 Results of the Investigation

3.1 Drilling

The drilling points are located in the Cengkareng area, as shown in Fig.1. Because of precocious destruction, the drill hole O-1 had to be redrilled. The new hole O-1B is located 50 m upstream. The results of the drilling are represented in cross-sections, Figs. 4 to 6 and summarized below:

a) The sections in figures show a superposition of four channels, a part of the tidal deposits, underlain by residual soil. Every channel contains a so called "fining upward sequence", meaning the sediments are coarse at the bottom of the channel (sands) and become finer toward the top (clays);

b) In section O-C-D, south of the toll road (Fig.6), the channels are more difficult to distinguish. The depth to the top of the residual soil is less and the tidal sediments are thinner;

c) In general the residual soil is stronger than the overlying tidal deposits but when judged from SPT data, weaker layers have been found at the bottom of the drill holes.

d) Combining data from the drilling and the Dutch cone sounding the subsurface appears to consist of a weaker layer (N < 20 blows), distributed as follows:

- 16 m deep, coastal area of Kamal, Tangerang
- 10 m deep along the toll road and the PIK Junction drainage channel
- 5 m deep at Kali Bor
- 7 to 9 m deep along the Cengkareng floodway;

e) Bigger structures such as bridges, sluiceways, gates shall have deeper foundations, below the depth mentioned above. This implies that a great number of structures will have a very stiff to hard clay foundation.

f) Most of the drill logs show a layer of cemented sand at the bottom of channel C2 (Figs. 4 to 6) This layer is the result of chemical cementation, probably by iron migrating from the overlying beds into a sand layer. It is therefor only locally and partially cemented and always underlain by softer, clay deposits. It has often been mistaken for bedrock.;

g) The cemented sand layer can be a strong foundation bed when its thickness is at least 5 m. Unfortunately this is not always the case as shown by drillings A-1 and B-1.

h) In the Meruya area, the subsurface consists of red soil, having a higher consistency than the tidal soils described so far. The soil cover is 5 to 10 m thick, possibly underlain by a hard residual soil.

3.2 Dutch Cone Sounding

A large amount of soundings have been effectuated along the planned channels Figs. 2 and 3, at 500 m intervals. In general the sounding data seem to be consistent.

3.2.1 Cone data correlations

Usually, the values for the cone resistance (qc) are taken as indicators of the bearing strength, at the corresponding sounding depth. Other correlations of the cone resistance to the SPT-values, to the cohesion, undrained shear strength, or soil classification, are possible, but do not always give satisfying results in practice.

3.2.2 Cone data conversion

A final conversion of the cone resistance into SPT- values has been tempted and than compared to the drilling data. For the conversion the nature of the soil has to be known. In the graph of the cone resistance (qc) versus depth, several layers of soil have been delimited. For every layer the average qc was calculated. The SPT-value has been obtained after dividing the cone resistance by a coefficient, depending on the nature of the soil.

3.2.3 Results of the correlations

The results of the conversion have been represented in profiles along every single channel, Figs 7 and 8. After accomplishment of the above conversions, the following observations can be made:

(a) At most sounding locations the upper 2 to 5 meters consisted of earth fill or reworked soil;
(b) "Softer" soils have been found in the coastal area, along the toll road and exceptionally in the vicinity of the Outer Ring Road;
(c) The sounding depth varies between 6 m and 20 m, depending on the consistency (strength) of the subsurface;
(d) The sounding results are less accurate with increasing depth, bending or deviation of the rods from the vertical position may occur;
(e) The cone could not penetrate through the cemented sands, nor through layers exhibiting an SPT-value superior to 25 blows, as for example alternations of sand and clay;
(f) The choice of the soil coefficient was difficult when there was no drilling in the vicinity of the sounding point, and thus, the nature of the soil unknown;
(g) Identification of the bottom layer in the soundings is not accurate;
(h) The soundings in the Meruya area are shallow (average 6 m), indicating the subsurface is stronger compared to the Cengkareng area.

3.3 Laboratory Test Results

The physical characteristics, as presented in Table 1, indicate that the soils from all of the locations and all depth' are fine, highly plastic soils, clayey, saturated and often overconsolidated.

3.3.1 Grain size

The samples show many similarities, most of them, containing more than 90% of fines. Only seven of the analyzed samples contain between 50 and 80 % of fines, coming from the shallower layers. The grainsize curves of 22 samples are shown in Figs. 9 and 10. All of the curves show a similar Z-shaped trace, the range of the curve distribution is narrow and 65% of them gather together in the upper right corner.

3.3.2 Atterberg limits

High values were obtained for the liquid limits, which often exceed 100% as well as for the plasticity indexes, mostly higher than 50%. Fig. 11 shows a plot of the Atterberg limits for all of the samples. One can observe that most soils are CH soils and a few of them, plotting close to the A-line, are classified as MH-OH.

3.3.3 Natural water content

The natural water contents of the samples are very high, 50- 85 % and so are the degrees of saturation, 90-115%, meaning some of the samples were oversaturated.

3.3.4 Unit weight

The saturated unit weights are very close to the natural unit weights of the soils, which corresponds to the high degree of saturation of the soils. The average unit weights of the soils are as follows:

clayey soils = 1.660 t/m^3
sandy soils = 1.720 t/m^3.

3.3.5 Triaxial tests

All clayey samples having a saturation percent of more than 95% have been tested in Unconsolidated Undrained conditions. The other clayey samples have been tested under Consolidated Undrained conditions. Three samples containing 40-50% of sand have been tested under Consolidated Drained conditions. The results are represented in Table 2.

(1) UU-tests
The UU test results are represented in Table 1 and Figs.12 and 13.The average cohesion and internal angle of friction values are:

$c = 0.4$ kg/cm^2
$\phi = 8°$

It shall be noticed that there are no changes in angle of friction with depth (Fig. 13), meaning the soils show a uniform behavior. The average values above shall be taken as design values for the clayey samples.

(2) CD-tests
The results are represented in Fig. 12. The obtained average values for sandy samples are:

$c = 0.45$ kg/cm^2
$\phi = 25°$

These values are recommended for design in sandy soils.

(3) CU-tests
The test results are represented in Fig. 14. The average values are as follows:

total stress	effective stress
$c = 0.5$ kg/cm^2	$c = 0.42$ kg/cm^2
$\phi = 15°$	$\phi = 27°$.

The results obtained for the total stress are close to those from the UU-tests and are considered to be representative for the clayey soils in the study area.

3.3.6 Unconfined compression tests

Such tests have been done for all the samples and the results are presented in Table 2. The obtained values for the compressive strength (qu) are low. These values have been converted into undrained shear strength, which is equal to the cohesion of the soils. The cohesion values obtained in this way are half or less of the cohesion values from the UU-tests. (Table 2). Because the tested samples were soft soils, the testing could have been difficult and the results less accurate. The unconfined compression tests shall not be considered for the design.

3.3.7 Consolidation tests

Consolidation tests have been carried out on the samples containing more than 50% of fines. The results are shown in Table 3 and Figs. 15 to 18. Most of the samples show similar behavior. The compression Index is high 0.2- 0.9, with an average close to 0.4, meaning the soils are compressible. From Fig.15 one can see that shallow soil samples have high compressibility 0.3 to 0.9. Samples from soils between 10 and 25 m have a compressibility of 0.3-0.4 and those deeper than 25 m only 0.2-0.3. As expected, the deeper soils are less compressible.

The preconsolidation pressures Pc range between 0.6 and 3 kg/cm^2. When compared to the overburden pressure most of the soils appear to be overconsolidated. The coefficient of consolidation varies in a wider range, from 200 to 700 cm^2/day.

3.4 Construction Material

3.4.1 Availability of embankment material

In the study area land reclamation has been done on a wide scale. The largest part of the area is therefor covered by red embankment soils 1 to 4 m thick, depending on the locations. The red soil can be found in situ in the Meruya area. They consist of sand silt and clay mixtures, gravely, low plastic and with low compressibility. Only at few locations the original surface soils are still in place.

During the channel excavations, a large amount of the recovered material will consist of earth fill. This soil, together or mixed with the original soil can be re-used for embankment purposes (protection dikes).

Embankment material usually used in this area comes from borrow sites in the Tangerang area (Parung Pajang), 20 km away. In general, the use of the red soils is preferable to the original soils in the project area.

3.4.2 Investigated soil material

Surface soil near two drilling locations has been tested for its properties as construction material. The samples are sandy silt and, plastic. The grainsize curves are represented in Fig. 19. The unit weights are slightly higher than for other samples, 1.-8-1.9 t/m^3.

The compaction test results showed 18% OMC for the silty sample and 30% OMC for the clayey sample at max.dry densities of 1.575 t/m^3 and 1.350 t/m^3 respectively. In both samples the optimum water content is much lower than the natural water content, meaning that when used as material such soils have to be dried. After compaction, the consolidation characteristics have been tested, showing low compressibility Cc = 0.158-0.224.

The results of the triaxial compression tests are shown in Table 2. Based on the above, the soils in the study area have poor embankment qualities, adjustments in the design may be required.

3.5 Ground Water Monitoring

A screened PVC pipe was installed in each of the six drill holes with the screen at varied depth, in order to examine the depth-wise distribution of the piezometric head or its changes with the depth. The piezometric head at any depth in the horizontally bedded clay, sand alternation, is supposed to meet the static head of the groundwater in normal condition. A series of excessive extraction of the groundwater from sand or sandy beds will change the pattern of pore pressure distribution. It will firstly lower the pressure in the sandstone beds from which the groundwater has been pumped up, and then gradually decrease the pressure in the clay aquiclude covering the sand.

In the area of ground subsidence the consolidation of the soils would be reflected by deviations in the piezometric head from the normal static head distribution.

The monitoring has been done sins October 1996, when the screen pipes have been installed. The record indicates fluctuation of the piezometric head during one month. The fluctuation, within one meter, seems to be related to the meteorological conditions at the ground surface, regional or local.

The table bellow shows that the piezometric heads are nearly similar to the groundwater table, without visible deviation from the static heads. Exceptionally, sand beds in the holes C-1 and B-2 show the piezometric head lower than the static head, approximately by 2.5 m and 1.2 m respectively. The sandy bed in C-1 is suppressed by a 8 m thick clayey bed and that in B-2 is under a 15 m thick clayey bed. These sandy beds at the depth not deeper than 23 m, however, are too shallow to be connected to the large-scale water extraction from the deep wells. They show only the effect of shallow water exploitation.

Hole No.	C-1	B-2	A-1	D-1	O-1	B-1
Depth(m)	20	30	35	20	25	35
El (m)	2.19	2.25	0.57	0.45	4.33	0.45
GWL						
Depth (m)	-1.8	-1.4	-1.2	-1.2	-7.7	-1.3
El(m)	0.4	0.9	-0.6	-0.8	-3.4	-0.9
Screen center						
Depth(m)	-10.5	-19	-9.4	-14.5	-13.7	-31.6
El(m)	-8.3	-18.8	-8.8	-14.1	-9.4	-31.2
Piezometric Head						
Depth (m)						
Oct 30	-4.56	-1.74	-0.82	-1.24	-8.11	
Nov 15	-4	-1.96	-0.95	-1.09	-7.89	-0.98
Dec 5	-4.41	-1.99	-0.97	-1.44	-8.14	-1.06
El(m)						
Oct 30	-2.37	-0.51	-0.25	-0.79	-3.78	
Nov 15	-1.81	-0.29	-0.38	-0.64	-3.56	-0.53
Dec 5	-2.22	-0.26	-0.4	-0.99	-3.8	-0.61

The pore pressure monitoring data from the drill holes cannot be connected to the regional subsidence of the Jakarta plain.

3.6 Subsidence

3.6.1 General

Subsidence of the sub-surface in the project area takes place because of the following two reasons:

- settlement due to consolidation (chapter 4), affecting the shallow soil beds after construction of a heavy structure.
- subsidence by self-weight consolidation, affecting the deeper soil beds and due to groundwater withdrawal.

The land settlement is restricted to the direct vicinity of the constructed structure while the self-weight consolidation affects a large area and is therefor more difficult to be evidenced and quantified. Accordingly, its impact on the sub-surface is far more important and the counter-measures imply long term decisions, on regional scale.

This chapter is concerned with the self-weight consolidation. The following chapters consist of general information, mainly based on previous studies. In order to evidence the subsidence, bench mark elevation survey has been done once again during the present study. The results are discussed below.

3.6.2 Previous Investigations

The first studies concerning the subsidence of the Jakarta basin, the groundwater and its relationship to subsidence have been started by the Department of Environmental Geology (Bandung), in behalf of the DKI Jakarta, in 1978. For this purpose 54 deep, monitoring wells (maximal 250 m deep), have been installed from 1982 to 1996. In most of these wells the water level is registered automatically. Five of these wells are located in the project area as shown in the table below and in Fig. 20. The well monitoring is done monthly and the data is presented in monthly reports from 1994 up to the present.

Well No.	Location	Monitoring depth interval (m)	Start of Monitoring
D 2	Cengkareng III	65-68 and 142-146	Sep/84
D 18	Kapuk	96-100	Dec/85
D 27	Tegal Alur	100-120	Mar/92
D 29	PT BASF	138-247	Dec/91

In parallel the DKI Jakarta has done repeated bench mark surveys in the area. The first survey has been done in 1974/1978 followed by 1989/1990, 1991/1992 and 1993/1994. The results of the measurements have been compared and a land subsidence map has been drawn , as presented in Fig.21. The same procedure has been adopted in the interim report of the Jabotabek study, 1996.

A more recent report on land subsidence (reference 3), presented by the Department of Environmental Geology in Bandung (1996), introduces a new plan for the monitoring of the ground movement. Four holes will be drilled to the depth of 300m and extensiometers will be installed at several depth intervals. The extensiometers will measure soil movements. One of the holes will be located in Cengkareng. Only one hole has been realized so far but the monitoring has not been started yet.

A new approach of the subsidence has been introduced by the study of the Saskatchewan Research Council, 1996 (reference 1). In this report the visco-elastic analytical model has been adopted. The subsidence is considered to be a vertical movement of soil, caused by fluid extraction.The results of the previous studies are summarized and discussed in the following sub-chapters.

3.6.3 Present investigation

The present field investigation included a short campaign of bench mark elevation survey, with the purpose to evidence the subsidence.Ten survey points have been selected, shown in Fig. 1. Five of these points are located on existing structures with pile foundations. Such structures are not affected by vertical soil movements, and the points are reffered to as fixed. The second group of five, are points on existing bench marks. The bench marks are affected by the soil movements. These points are called target points. All fixed and target points have been surveyed twice, at the beginning and at the end of the geotechnical investigation period. The first and second survey have been done at 1.5 month interval and the results are similar.

The reference points used for the present survey are the same as those of the TTG system. The latter has been introduced in 1981/1982. The results of the elevation survey of the fixed and target points is shown in Table 4.

Existing TTG bench marks along the Daan Mogot have been recovered, shown in Table T-4. Comparing elevation data from 1981 and 1996, the subsidence appears to be 50 to 100 cm. Unfortunately there are no TTG bench marks to the north of the Daan Mogot road and the subsidence could not be evidenced.

Many of the bench marks in the project area belong to an older leveling system (PP). The reference points for the PP system are different from those of the TTG system. Therefore elevations measured in the PP system have to be converted to the TTG system and vice-versa. Conversions do not always lead to meaningful results. Elevation data of some of the recovered PP benchmarks have been represented in Table 4 and the locations are shown in Fig.22.

3.6.4 Groundwater

The deposition environment during the Quaternary was a mixture of deltaic, lacustrine, lagoonal, swamp, terrestrial, tidal plain and shallow marine environments. The Jakarta basin has been filled with 200 to 250 m thick Quaternary sediments. As a result of the depositional environments, sand and clay deposits cannot be traced laterally over any significant distances. Previous drillings, 100 to 200 m deep, show that 75 to 80 % of the sediments consist of clay units and only 20 to 25 % of sand units. The latters are commonly comprised of silty sands and seldom consist of clean sands., their individual thickness is 2 to 6 m.

Because of the fact that lithological units cannot be traced, it is as well difficult to delimit the aquifers. A rough subdivision of the groundwater, as it appears in recent reports of the DPE Jakarta, is as follows:

- unconfined aquifer, occurring to the depth of 40 m below the ground surface
- upper confined aquifer, 40 to 100 m deep
- central confined aquifer, 100 to 140 m deep and
- lower confined aquifer, 140 to 250 m deep.

The groundwater recharge model adopted for the Jakarta basin is schematically represented in Fig.23. From the total rain amount a large volume of water runs off and only 800×10^6 m^3 is stored in the upper, unconfined aquifer. 5% from the stored volume leaks into the lower aquifer, representing 37×10^6 m^3. Lateral groundwater inflow, from the hinterland, is small, 1×10^6 m^3.

Deep groundwater is used for industrial purposes. The water is extracted from a number of more than 3000 wells. The highest withdrawals occur in the Sunter-Penggiligan Industrial area whereas the largest drawdowns and deepest water levels occur in the Kapuk-Cengkareng industrial area. Reported abstraction data for the latter are surprisingly low. The extracted water amounts in the Jakarta basin are as follows:

Year	Number of wells	Abstracted volumes (Qabs)
1991	2640 wells	31×10^6 m^3
1993	2800 wells	32.6×10^6 m^3
1994	3016 wells	33.8×10^6 m^3
1995	>3016 wells	32.2×10^6 m^3

There is inconsistency between the reported and the real data and the abstracted volumes are supposed to be 30 % higher than presented above. Therefore, the predicted abstraction volume for the future years will be 53×10^6 m^3 per year. This volume largely surpasses the recharge volume of approximately 37×10^6 m^3 per year (chapter), meaning the deep aquifers will be permanently discharged. On the other hand, the well observation data show that the groundwater table of the deep aquifers dropped 40 m. More precisely, between 1985 and 1993 the drawdown of the groundwater table was 4-6 m at 60 m depth and 10-11 m at 145 m of depth. The amounts of water extracted from the shallow, unconfined aquifer, are not known. This water is used for domestic supply and its withdrawal is not regulated.

3.6.5 Subsidence and groundwater withdrawal

The process of subsidence can be summarized as follows. The deeper aquifers are confined and the soil layers are saturated. When water is pumped out, the groundwater level decreases and the pore pressure in the underlying soil beds is reduced. A lower pore pressure means that the vertical effective stress increases and a clay bed, put under these conditions, will consolidate, due to its own weight.

From the former paragraph it is obvious that the groundwater level continues to drawdown. Consolidation of the clay beds is imminent and subsidence occurs continuously. In order to quantify the subsidence bench mark measurements and simulation models have been tried. The results are summarized in chapter.

Theoretically the subsidence can be stopped by ceasing the pumping activity and allow the groundwater level to recover. This is economically not possible and the remaining solution would be artificial recharge, a rather expensive solution and difficult to realize when the lithologic units are discontinuous.

3.6.6 Subsidence rates

After the intensive industrial development has been started, high amounts of subsidence were predicted in the Jakarta basin. Rismianto et all (1994) predicted that without control of the ground water abstraction the subsidence could reach 5 m by the year 2050 (Fig. 24) and even if the pumping stopped, the subsidence will be 1.8 m by the year 2000. The subsidence amount predicted using an anlytical model (reference 1) is 1.2 m from 1975 to the year 2000 (Fig. 25), taking into account data from the entire Jakarta basin. These predictions are very general, include many approximations and shall be regarded as averages over the entire Jakarta basin. In reality the amounts of subsidence vary depending on the intensity of the urban and industrial developments.

Most often the estimates on subsidence rates are based on bench mark measurements. The average subsidence rate for the Cengkareng area, adopted by the DKI Jakarta is 8.3 cm per year (reference 5). Table 4 contains elevations of several TTG bench marks which have been remeasured and also a few PP bench marks (see Fig.22 for location) for which the former elevations have been converted according to the TTG reference points. The calculated subsidence rates appear to be 5 to 11 cm per year along Daan Mogot, 5 to 7 cm along Kamal Raya and 5 cm along Kamal-Kapuk. Such measurements are not always turntable. Reference points for the different leveling surveys were not always the same and in some cases the reference points have been themselves affected by subsidence, meaning that all measurements during that particular survey were inaccurate. It is therefore not always meaningful to compare the results of different leveling campaigns between them.

In the Kapuk-Cengkareng area there are close to 300 wells. As shown in Fig.1 ,most of the wells are located along the Daan Mogot . This is the oldest and most developed part of the industrial area. Accordingly, the rate of subsidence is expected to be maximal. The average value of 8 cm/year, suggested by the DKI Jakarta can be applied here. Other, more recent wells are concentrated along the Jalan Kamal-Kapuk and a few along Kamal Raya, which will be developed in the near future. In these areas as well as along the Salurang-Cengkareng drainage channel the subidence rate is lower, in average 6 cm/year. The area in-between the highway and the coast line is covered by fish ponds and there is no industrial development. There is no subsidence of the deeper levels, but construction of heavy structures would lead to settlement of the upper soil beds.

3.6.7 Recommendations for future investigation

In order to obtain accurate magnitudes of subsidence the matter has to be studied on a regional scale, much larger than the present project. Long term bench mark survey and analitical modeling shall be continued in the future.

The bench marks established or recovered during this investigation shall be remeasured, taking the same fixed reference points and at time intervals of at least one year. New bench marks shall be established in the fish-pond area (Kamal, Tanjungan) and regularly measured.

The approach of the subsidence by an analitical, visco-elastic model, will involve the entire Jakarta basin. In its output the model shall specify subsidence magnitudes at every grid-point and produce a contour map and/or vertical profiles. Forecasts of the subsidence versus time are required as well. For such a model, following data will be required:

- geotechnical: distribution of the soil beds till 250 m of depth, and their lateral continuity
- hydrogeological: aquifer characteristics (hydraulic conductivity, storage, transmisivity, porosity, thickness)
- pumping data (number of wells, pumping rate, pumping depth)
- data about the reacharge of the aquifer (rain, seepage, inflow of ground water)
- boundary conditions
- long time monitoring conditions

The data collection will have to be systematic, involving a long period of time.

4 Considerations for Design in the West Cengkareng area

4.1 General

In order to decide the foundation depth for the structures, the "strength" of the soil beds, as reflected by the SPT-test values and the Dutch cone sounding results, shall be considered. Based on the "strength" criteria the following main layers can be distinguished, in stratigraphic order:

- Layer A1: very soft, SPT-value 0 to 3 blows, of clay and silt, extends from the coast to the Sediyatmo highway, 6 to 11 m thick, this layer passes laterally into layer A2; no sampling and no laboratory testing have been done
- Layer A2: soft, SPT- value 3 to 10 blows, clays and silty sands, extends over the entire area, 10 m thick along the Sediyatmo highway and in the Kapuk-Kamal area and 6 m thick from Kapuk-Kamal to the south (Daan Mogot road)
- Layer B: SPT-value 10-25 blows,stiff to very stiff clay, underlies layer A2, and is 2 to 8 m thick
- Layer C: SPT- value more than 25 blows, clay intercalated with sand, 5 to 15 m thick, contains a layer of partially cemented sand, CS:
- CS: sand or weakly cemented rock, SPT-value more than 50 blows, variable thickness, 0.5 to 10 m, is not continuously developed, has been found at 10 to 20 m depth below the surface, missing at some locations
- Layer D: very stiff or hard clay, SPT-value usually more than 30 blows

4.2 Bearing Strength of the Foundation Soil Beds

The bearing strength for shallow foundations, such as spread footings and dikes, has been calculated with Terzaghi`s formula for weak soils (coefficients Nc`, Nq` and Ng`). The allowable bearing strength has been taken as 1/3 of the calculated bearing strength value.

For the deep foundations, or pile foundations, the long term allowable bearing strength has been calculated with the formula for driven piles as published by Yamakata et al. (1974).

4.2.1 Shallow spread footings

Shallow spread footing foundations are considered for culverts, sluiceways and gates, to be constructed in the area extending to the south of the Jalan Tol Sediyatmo. At most locations the foundation bed will be layer A2. This layer consists mainly of weak clayey soils, but locally loose sands and silts, 4 m thick, have been observed (drilling B-1 and D-1). In the vicinity of drill hole O-1 (Fig.1), the foundation bed is a stiff clay corresponding to layer B.

The bearing strength has been calculated, assuming a square foundation, the foundation depth at 2 m, a minimal structure width of 1 m and the ground water level at 2 m depth. The soil parameters for the clayey soils are the average UU-test results or they are obtained from correlations of the SPT-value to the cohesion and the allowable bearing strength. For the loose sandy soils, the SPT-test values have been correlated to the internal angle of friction, using the curve of Terzaghi and Peck.

The soil parameters which have been considered are as follows:

- layer A2: cohesive soil: $\gamma n = 1.66\ t/m^3$
  $c = 0.4\ kg/cm^2$
  $\phi = 8°$ (UU- condition)
  non-cohesive soil: $\gamma n = 1.72\ t/m^3$
  $c = 0.1\ kg/cm^2$ $\phi = 21°$ (from N=3 blows)
- layer B: stiff cohesive soil: $\gamma n = 1.67\ t/m^3$
  $c = 1.2\ kg/cm^2$ $\phi = 0°$ (for N = 20 blows)

For the layer A2, the allowable bearing strength is 7-12 t/m^2., which could be sufficient in case of small structures. The results of calculation are represented in Tabel 5.

4.2.2 Dike foundations

Protection dikes are planned in the coastal area, north of the Jalan Tol Sediyatmo, at present covered by fish ponds. The dikes will be placed on layer A1, consisting of very soft clay and silt. Dutch cone sounding data converted into N-values indicate 0 blows for this layer. The soft bed spreads out over a distance of 1 Km from the sea. In the vicinity of the highway it passes laterally into a more consistent soil, SPT-value 3 blows. The soil parameters for layer A-1 as deducted from the SPT-values are:

- layer A1: $\gamma n = 1.5\ t/m^3$
  $c = 0.1\text{-}0.2\ kg/cm^2$ $\phi = 0°$ (for $N < 3$ blows).

Consequently the allowable bearing strength, according to Terzaghi, is less than 2 t/m^2. Such a layer is very weak and the possibility of failure has to be considered. Wooden piles or counter-weights may have to be considered for the foundation of the dikes in the critical portion of the Kamal channel.

4.2.3 Pile foundations

Several bridges are planned in the West Cengkareng area. From the results of the SPT-tests and the bearing strength calculations above, layers A1 and A2 are considered to be too weak to support a bridge. Pile foundations reaching the underlying layers B or C, with better foundation characteristics, have to be considered. The depth of the pile foundations depend on the location (Tabel 5) but in general more than 12-15 m shall be considered in the north part of the study area and 7-10 m in the south part. Depending on the nature of the foundation bed, friction piles and end bearing piles have to be considered.

The allowable bearing strength has been calculated with the following formula:

$$Ra = 1/3(30\eta * N * Ap + (Ns * Ls/5 + 2\,Nc * Lc) * t) - W$$

where:

Ra = allowable, long term bearing strength (t)
d = pile diameter (m), d = 0.3 m
N = average N-value in the section from 4d to -d of the pile
Ap = Section area of the end of the pile (m2)
Ns = average N-value in sandy beds surrounding the pile
Nc = average N-value in clayey beds surrounding the pile
Ls = total length of the pile through sandy beds (m)
Lc = total length of the pile through clayey beds (m)
t = circumferential length of the pile (m)
W = weight of the pile (t)
η = closing rate of the pile, $\eta = 1$ for closed pile.

(1) Friction piles

Friction piles, 15 m long are recommended in the Kamal and PIK Junction drainage channel areas. The bottom of the friction piles will penetrate trough stiff clay (bottom of layer B), or an alternance of sand, silt and clay (layer C), as seen in drill holes A-1 and B-1. The allowable bearing strength (Tabel 5) has been calculated with the following soil parameters:

- N-value at the bottom of the pile: 24 blows
- N-value for clayey beds: 11 blows, length of pile through clayey beds 10.5 m

- N-value for sandy beds: 7 blows, length of pile through sandy beds 4.5 m.

(2) End bearing piles

End bearing piles shall be used at locations where the layer CS (cemented sands) is thick enough to be used as a rigid substratum. This is the case in the south part of the study area where this layer can be reached within 6-8 m from the ground surface. This may be as well the case in the area of the soundings KSC-3, 4 and 12 (Fig.8). As seen in drillings A-1 and B-1, the CS layer can be very thin (or even non-existent). In such a case it is preferable to drive the piles through it, into the underlying soil. The extension and thickness of the CS layer are unfortunately unpredictable.

The long term allowable bearing strength as shown in Table 5, has been calculated for a pile length of 8 m and 30 cm in diameter. The considered soil parameters are as follows:

- N-value at the bottom of the pile: 24 blows
- N-value for clayey beds: 11 blows, length of pile through clayey beds 10.5 m
- N-value for sandy beds: 7 blows, length of pile through sandy beds 4.5 m.

4.3 Consolidation Characteristics

The clayey soils in the study have medium to high compressibility. Loading will lead to settlement by consolidation..

(1) Spread footing foundations

The footings of the designed sluiceways and gate structures are small and therefore the load applied to the sub-surface has been considered a point load. The final settlement of every single layer, has been estimated by the following formula:

$$S_f = Cc*H*\log((p+\Delta p)/p)/(1 + e_o)$$

The total settlement is obtained by addition of the settlement of every single layer. As shown in Fig. 26 the settlement values, calculated for different loads (10 and 50 t/m^2), are small. The values range from 2-8 cm in the upper layers and less than 2mm deeper than 10 m. The settlement of the lower layers can be left out of consideration.

The settlement magnitudes are higher in the Saluran-Cengkareng area , because of their pure clayey nature and their thickness. In the area of the Jalan Tol Sediyatmo, the clays are interbeded with sand, which reduces the compressibility of the layer as a whole.

The estimation above shall be seen as an indication only. A more elaborated calculation of the settlement is recommended for the design stage, once the size and shape of the structures have been defined.

(2) Dikes
The foundation bed under the dikes in the lower Kamal and Tanjungan areas, is very soft, SPT-value 0 blows. No data is available for this area but the settlement by consolidation is estimated to be more than 10 cm.

(3) Pile foundations
In case of pile foundations only the clay bed at the tip will settle and the load applied on the ground surface will be dispersed. For the calculation of the final settlement the same formula as above has been applied. From the available data, the settlement has been calculated at only two locations, assuming the load of the structure at $10t/m^2$. As shown in Table 6, the settlement of the soils under a friction pile foundation is in the range of a few millimeters.

4.4 Channel Excavations

Most of the channels will be excavated in compacted earth fill material, which covers an important part of the area and partly in original clayey and sandy, soft soils, of the remolded (especially in the vicinity of existing channels).

The mechanical characteristics of the surface soils have not been measured, but they are estimated to be $0.4\ kg/cm^2$ for the cohesion and 27° for the angle of friction.

In the lower Kamal and Tanjungan areas, the surface soils are very soft silts and clays, with poor stability. No samples from this area have been analyzed and the only available data are provided by the Dutch cone soundings. The estimated properties of these soils are $1\text{-}2\ t/m^2$ for the cohesion and 0° for the internal angle of friction.

In the Meruya area the channels will be excavated in red mixed soils which have a better consistency (chapter 5) and stability.

4.5 Conclusion

The recommended foundation conditions, along the planned drainage channels are summarized in Table 6. For the specified locations one shall refer to Fig. 2. The foundation conditions along the Saluran Cengkareng and the PIK Junction drainage channels have are partly unknown and need to be investigated in more detail in the future.

5 Considerations for Design in the Meruya Area

Only Dutch cone sounding has been done in this area and the results have been converted to SPT-values, as presented in profiles in Fig. 8.The Meruya area is covered by red soils. These are mixed type of soils, containing equal amounts of clay, silt and sand, locally with gravel. Such soils are generally stiff to hard. The soil thickness is 3 to 11 m.The upper layer of clayey or mixed soil, has SPT-values higher than 10 blows. The penetration depth of most of the soundings was 3-6 m, meaning that a hard layer has been encountered, possibly cemented sands.

6 Recommendations

Based on the results of the present investigation the following additional works are recommended for the future:

- additional drilling and testing for in the lower Kamal/ Tanjungan areas, in order to establish the strength of the foundation, its state of consolidation, stability in excavations
- mechanical testing of samples of compacted fill covering the West Cengkareng area
- additional drilling at in the Saluran Cengkareng and PIK Junction drainage channel areas, as well as near the main structures to be designed
- in-situ pile load testing
- repeated survey of benchmarks, using the same reference system as the present study (TTG) and at the locations defined in chapter of this report. The survey results shall be compared to the present data in order to quantify the subsidence.