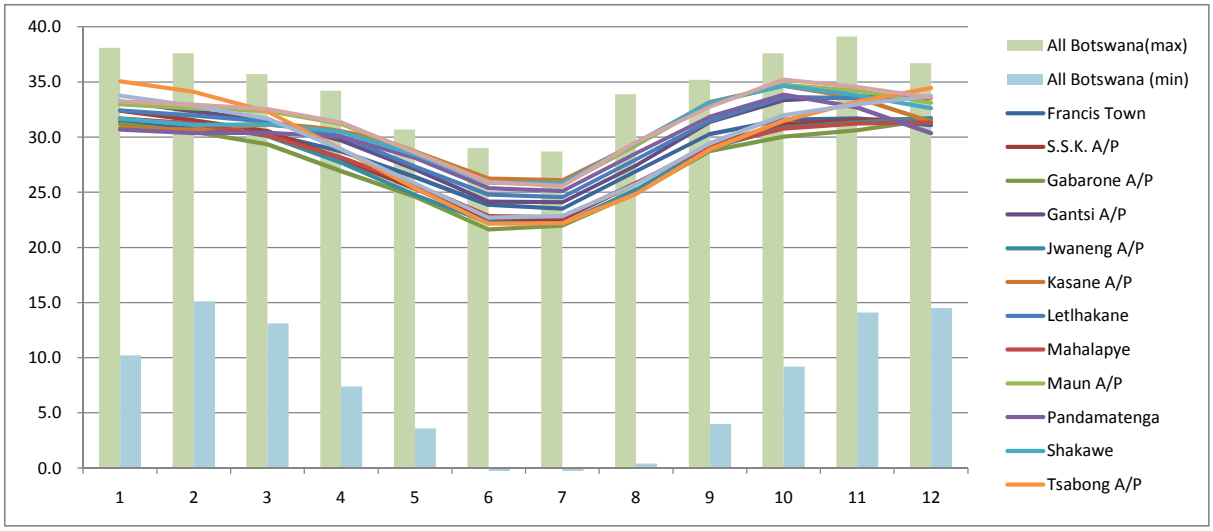
APPENDICES FOR CHAPTER 5

Appendix 5-1 Temperature of Botswana (1/2)

TEMPERATURE OF BOTSWANA Reffer : Meteorological Center

Month	1	2	3	4	5	6	7	8	9	10	11	12
1	Francis Towen (033-FRAN Latitude 21:09:526 Longitude 27:29:137 Alt:1,000m)											
Ave.	31.3	30.8	30.3	28.7	26.4	23.9	23.5	26.9	30.3	31.6	31.7	31.1
max	34.5	35.6	33.6	31.7	29.3	26.9	26.1	30.7	32.8	34.9	**35.1**	33.8
min	17.0	15.1	14.6	11.1	6.4	**1.9**	2.4	2.5	10.5	13.8	15.9	16.5
2	S.S.K A/P											
Ave.	32.4	31.5	30.5	28.0	25.3	22.5	22.6	25.8	29.3	31.2	31.6	31.6
max	36.2	**36.5**	33.1	32.1	28.2	25.3	24.3	28.0	32.0	33.6	34.3	34.4
min	16.4	15.4	14.9	10.6	4.1	2.7	**1.5**	5.7	9.8	13.8	14.8	16.6
3	Gabarone Met. Sta.(037-GABO Latitude 24:33:21 Longitude 25:55:08 Alt:1,006m)											
Ave.	31.2	30.5	29.3	26.9	24.6	21.6	22.0	24.9	28.7	30.0	30.6	31.6
max	36.8	**36.9**	33.2	31.1	28.2	23.8	24.4	28.8	34.6	33.8	34.8	34.6
min	10.2	16.7	15.5	11.1	6.6	**1.9**	2.2	5.7	10.5	13.1	15.7	17.0
4	Gantsi A/P (039-GANT Latitude 21:41:905 Longitude 21:39:190 Alt:1,137m)											
Ave.	33.2	32.3	31.5	29.7	27.1	24.2	24.1	27.4	31.4	33.3	33.7	33.6
max	36.4	**37.3**	34.3	32.7	29.0	27.1	25.9	30.1	33.8	36.2	36.0	36.3
min	17.7	17.5	14.4	9.5	6.6	1.8	**1.2**	5.1	9.8	12.3	15.8	17.7
5	Jwaneng A/P (053-JWAN Latitude 24:35:969 Longitude 24:42:042Alt:1,189m)											
Ave.	31.6	31.2	30.1	27.7	24.7	22.3	22.1	25.3	29.0	30.9	31.3	31.7
max	35.4	**35.9**	32.9	31.1	27.0	25.6	23.8	28.7	31.1	33.1	33.7	34.2
min	16.6	16.1	13.1	9.7	5.0	2.5	**1.3**	4.4	8.5	13.1	14.1	15.5
6	Kasane A/P (064-KASA Latitude 17:49:907 Longitude 25:09:541 Alt:1,003m)											
Ave.	30.8	30.7	31.1	30.5	28.7	26.2	26.1	29.4	33.2	34.6	33.6	31.4
max	33.8	**35.8**	33.6	33.3	30.0	28.2	28.7	31.8	34.9	36.6	35.7	34.2
min	17.1	16.4	16.6	14.2	9.8	7.0	**5.5**	9.4	12.6	17.1	18.9	17.3
7	Letlhakane Met. Sta. (093-LET2 Latitude 21:24:671 Longitude 25:04:425 Alt:984m)											
Ave.	32.4	32.0	31.4	30.1	27.3	24.8	24.6	28.0	31.5	33.6	33.5	32.5
max	35.2	34.8	34.4	32.5	29.9	27.3	26.2	30.3	33.0	35.4	**35.9**	35.4
min	16.4	15.8	15.0	11.8	7.3	4.9	**3.9**	7.3	12.1	16.0	16.6	16.5
8	Mahalapye Met. Sta. (106-MAHA Latitude 20:06:751 Longitude 26:51:540 Alt:1,011m)											
Ave.	31.7	31.2	30.1	28.2	25.7	22.9	22.7	25.9	29.2	30.8	31.2	31.3
max	34.6	**35.4**	33.9	31.2	28.5	25.9	24.9	29.3	31.6	33.3	33.7	33.6
min	17.8	17.6	14.8	11.0	6.7	**1.6**	2.5	6.7	11.3	13.8	16.7	17.6
9	Maun A/P (130-MAUN Latitude 19:32:591 Longitude 26:04:608 Alt:905m)											
Ave.	33.0	32.6	32.4	31.2	28.7	25.9	25.7	29.3	33.0	34.7	34.2	33.1
max	36.3	37.2	35.2	34.2	30.7	28.9	28.0	32.2	34.9	37.6	**39.1**	36.4
min	11.7	17.1	17.0	13.0	9.3	**5.1**	5.1	8.3	13.2	16.6	18.8	14.5
10	Pandamatenga Met. Sta. (183-PAN2 Latitude 18:32:409 Longitude 25:38:092 Alt:1,072m)											
Ave.	30.7	30.4	30.4	30.0	28.1	25.4	25.1	28.5	31.8	33.8	32.7	30.4
max	33.7	32.4	33.5	31.3	29.4	27.2	27.9	30.2	33.4	**35.3**	34.2	32.7
min	18.5	17.7	17.0	14.4	10.1	7.8	**6.8**	9.7	13.8	17.9	18.6	18.4
11	Shakawe Met. Sta. (223-SSHA Latitude 18:22:113 Longitude 21:50:359 Alt:1,030m)											
Ave.	31.7	31.1	31.2	30.5	28.4	25.9	25.8	29.5	33.1	34.6	33.8	32.6
max	35.3	35.2	33.9	33.5	30.4	28.7	28.3	31.6	35.2	**37.4**	36.5	35.5
min	18.0	18.1	16.5	13.1	6.9	4.5	3.1	5.9	10.5	15.9	17.3	18.8
12	Tsabong A/P (224-TSAB Latitude 26:01:881 Longitude 22:24:051 Alt:970m)											
Ave.	35.1	34.1	32.3	28.9	25.4	22.1	22.2	24.9	28.9	31.5	33.2	34.4
max	**38.1**	37.0	34.1	31.7	27.5	25.4	24.5	26.8	32.4	33.8	35.8	36.7
min	17.2	16.1	14.6	7.4	3.6	-1.6	**-1.9**	0.4	6.2	9.2	14.1	15.9
13	Tshane Met. Sta. (251-TSHA Latitude 24:01:156 Longitude 21:52:113 Alt:1,123m)											
Ave.	33.8	32.8	31.7	28.9	25.8	22.7	22.8	25.7	29.4	32.0	33.0	33.7
max	**37.0**	36.7	34.0	31.6	28.0	26.7	24.6	28.3	32.6	34.2	35.1	36.0
min	17.6	17.3	14.7	8.4	6.0	**1.0**	2.4	3.9	4.0	12.5	16.1	16.8
14	Sua Pan Met. Sta. (333-SUAP Latitude 20:32:591 Longitude 26:04:705 Alt:1,072m)											
Ave.	33.2	33.0	32.5	31.3	28.6	25.9	25.6	29.5	32.7	35.2	34.5	33.6
max	36.6	**37.6**	35.7	33.9	30.5	29.0	27.5	33.9	34.7	37.1	37.2	36.1
min	18.8	18.2	16.4	12.9	8.5	5.2	**2.9**	6.0	11.7	15.6	18.1	19.1
	All Country											
max	38.1	37.6	35.7	34.2	30.7	29.0	28.7	33.9	35.2	37.6	**39.1**	36.7
min	10.2	15.1	13.1	7.4	3.6	-1.6	**-1.9**	0.4	4.0	9.2	14.1	14.5

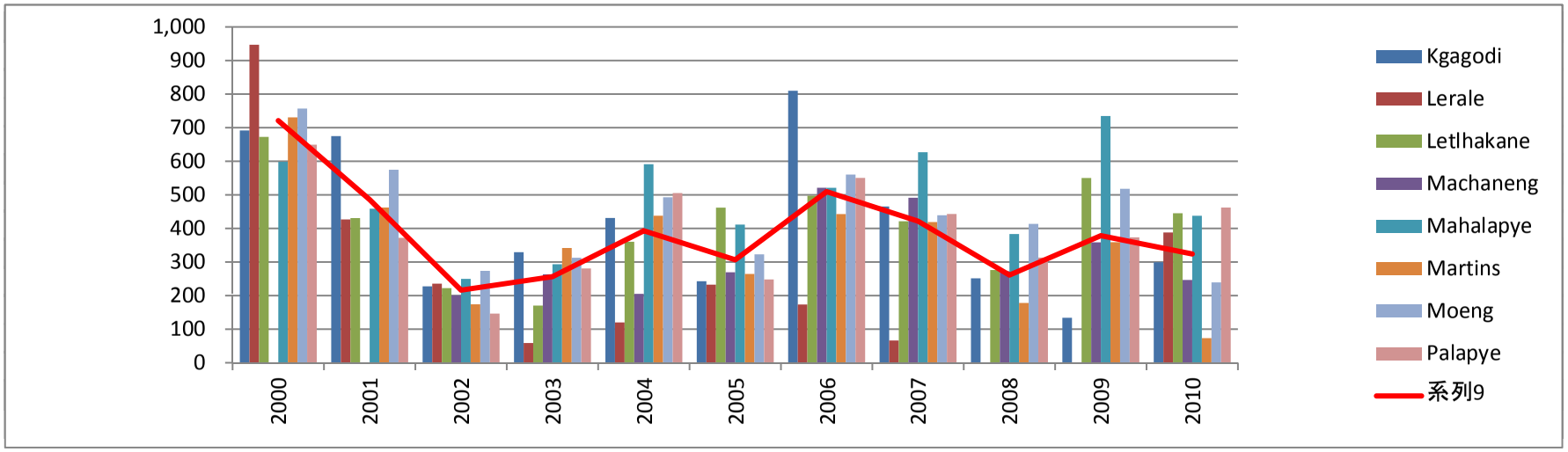
Appendix 5-1 Temperature of Botswana (2/2)



Appendix 5-2 Precipitations

Vicinity of Palapye

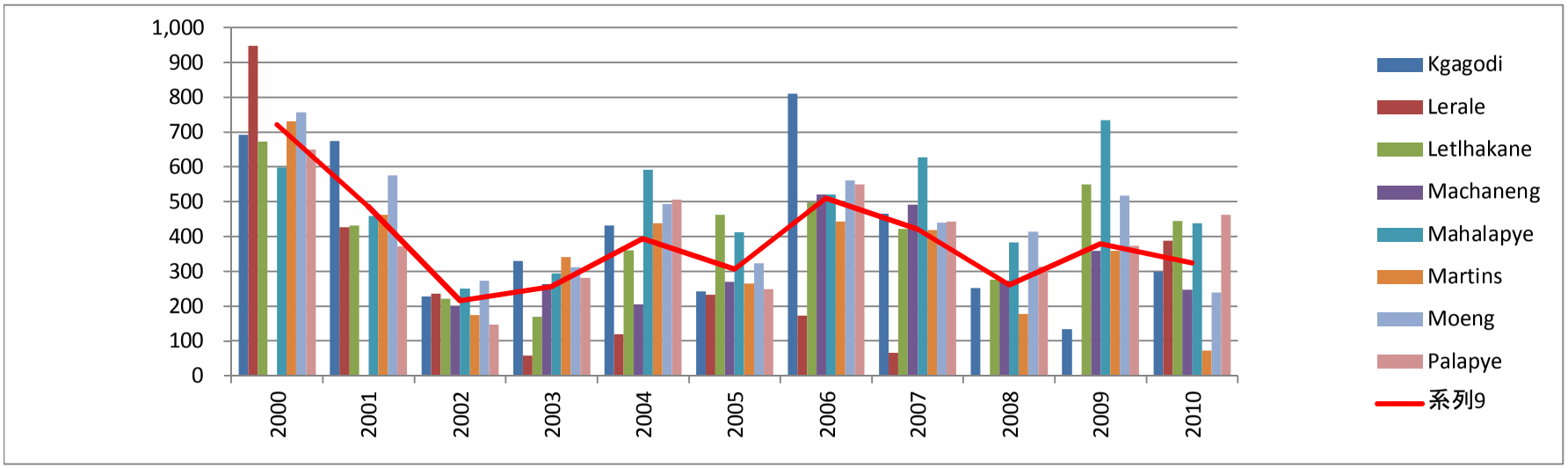
	Kgagodi	Lerale	Letlhakane	Machaneng	Mahalapye	Martins	Moeng	Palapye	Ave.
2000	692	947	673	–	598	731	757	649	721
2001	675	427	431	–	459	462	575	372	486
2002	228	236	222	201	250	174	274	146	216
2003	329	59	170	263	293	342	313	281	256
2004	431	120	360	205	591	438	493	505	393
2005	243	233	462	270	411	265	323	248	307
2006	810	174	498	521	521	443	560	550	510
2007	465	66	421	491	627	419	439	443	422
2008	251	0	276	273	383	178	414	313	261
2009	134	0	550	359	735	359	518	373	378
2010	299	388	445	247	438	73	239	462	324



Appendix 5-3 precipitations (1/1

Vicinity of Palapye

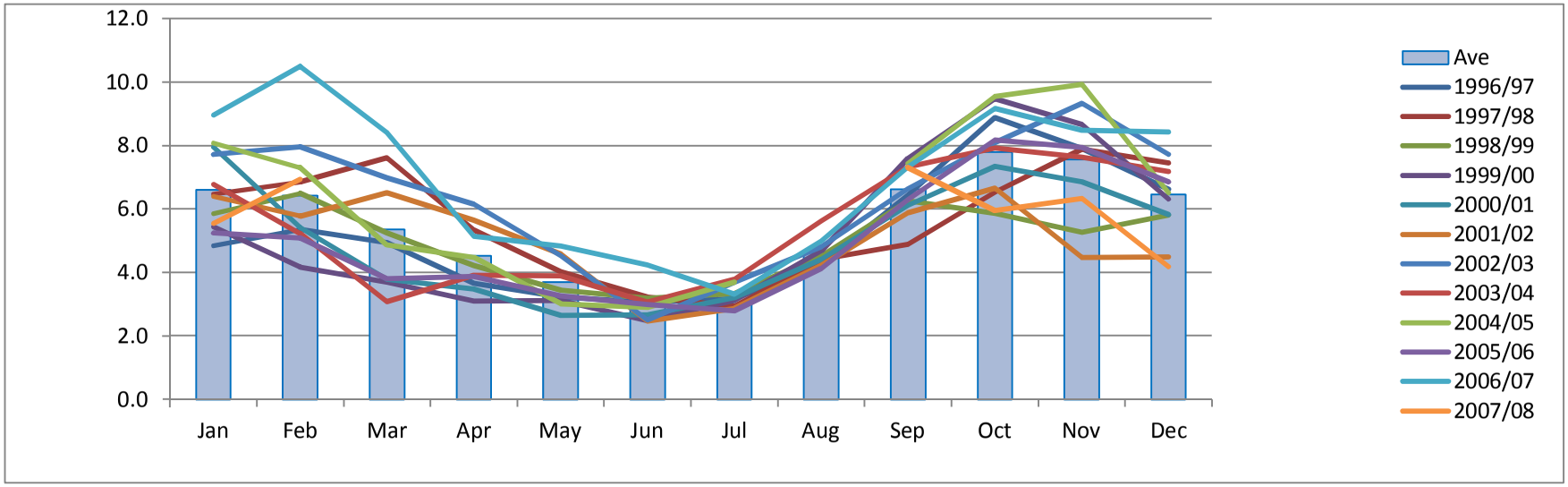
	Kgagodi	Lerale	Letlhakane	Machaneng	Mahalapye	Martins	Moeng	Palapye	Ave.
2000	692	947	673	–	598	731	757	649	721
2001	675	427	431	–	459	462	575	372	486
2002	228	236	222	201	250	174	274	146	216
2003	329	59	170	263	293	342	313	281	256
2004	431	120	360	205	591	438	493	505	393
2005	243	233	462	270	411	265	323	248	307
2006	810	174	498	521	521	443	560	550	510
2007	465	66	421	491	627	419	439	443	422
2008	251	0	276	273	383	178	414	313	261
2009	134	0	550	359	735	359	518	373	378
2010	299	388	445	247	438	73	239	462	324

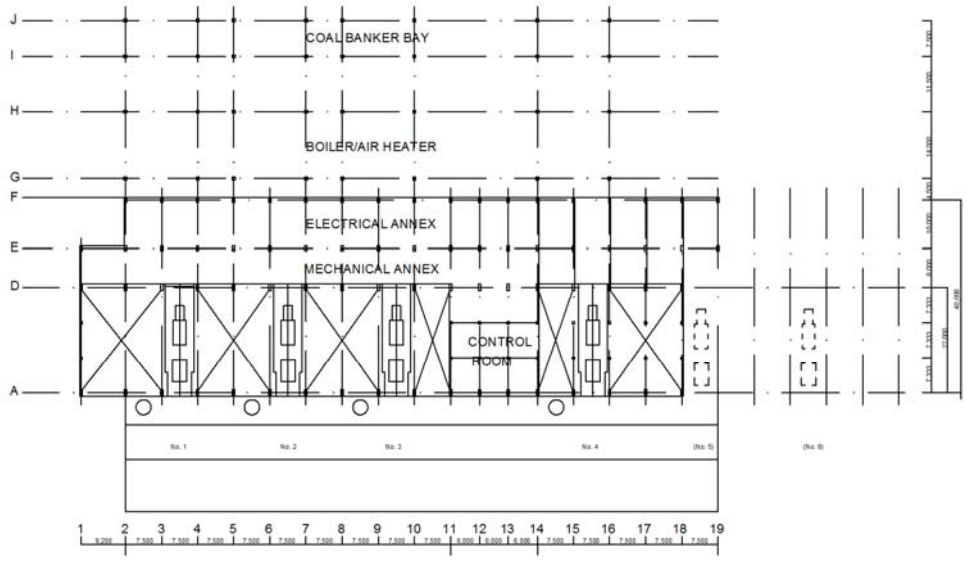


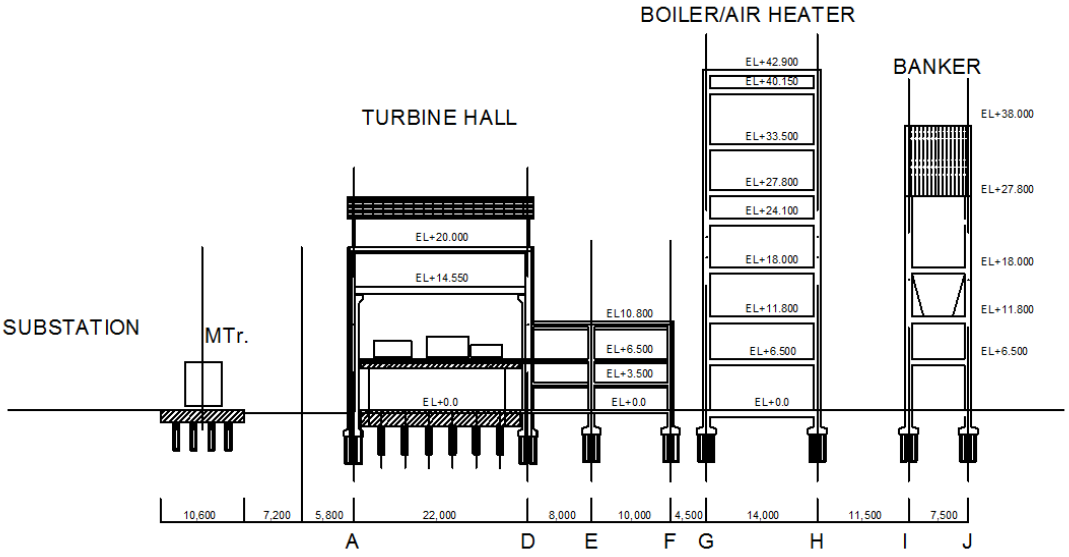
Appendix 5-4 Evaporation

106-MAHA MAHALAPYE MET. STATION 23 Deg 7 Min S 26 Deg 50 Min E Elevation: 1005 Metres

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996/97	4.8	5.4	4.9	3.7	3.2	3.1	3.2	4.3	6.4	8.9	7.9	6.6
1997/98	6.5	6.9	7.6	5.3	4.0	3.2	2.9	4.4	4.9	6.5	7.9	7.4
1998/99	5.9	6.5	5.2	4.2	3.5	3.2	3.3	4.5	6.3	5.9	5.3	5.8
1999/00	5.4	4.2	3.7	3.1	3.1	2.5	3.1	4.7	7.6	9.5	8.7	6.3
2000/01	7.9	5.4	3.8	3.5	2.7	2.7	3.2	4.4	6.1	7.3	6.9	5.8
2001/02	6.4	5.8	6.5	5.6	4.6	2.5	2.9	4.2	5.9	6.7	4.5	4.5
2002/03	7.7	7.9	7.0	6.2	4.5	2.5	3.7	4.8	6.6	8.1	9.3	7.7
2003/04	6.8	5.2	3.1	3.9	3.9	3.1	3.8	5.6	7.3	7.9	7.6	7.2
2004/05	8.1	7.3	4.9	4.5	3.0	2.9	3.7		7.4	9.5	9.9	6.5
2005/06	5.2	5.1	3.8	3.9	3.3	3.0	2.8	4.1	6.3	8.2	7.9	6.8
2006/07	9.0	10.5	8.4	5.1	4.8	4.2	3.3	5.0	7.3	9.2	8.5	8.4
2007/08	5.5	6.9		5.4			4.1		7.3	6.0	6.3	4.2
Ave	6.6	6.4	5.4	4.5	3.7	3.0	3.3	4.6	6.6	7.8	7.6	6.4
Max	9.0	10.5	8.4	6.2	4.8	4.2	4.1	5.6	7.6	9.5	9.9	8.4
Min	4.8	4.2	3.1	3.1	2.7	2.5	2.8	4.1	4.9	5.9	4.5	4.2







TURBINE HALL AND ANNEXES

Appendix 5-6 Concrete Test (1/3)

Beam Slab No.	REBOUND (R) by Schmidt Hammer						Average	Concrete Strength (N/mm2)	Concrete Neutralization (mm)	Remark
	1		2		3					
	R	N/mm2	R	N/mm2	R	N/mm2				
EL+6.50										
A-1/2	50.0	45.5	56.0	53.1	55.0	51.9	53.7	50.16		
A-2/3	54.0	50.6	55.0	51.9	60.0	58.2	56.3	53.54		
A-3/4	55.0	51.9	51.0	46.8	58.0	55.7	54.7	51.43		
A-4/5	57.0	54.4	45.0	39.2	52.0	48.0	51.3	47.19		
A-5/6	49.0	44.2	48.0	43.0	42.0	35.3	46.3	40.84		
A-6/7	52.0	48.0	56.0	53.1	58.0	55.7	55.3	52.27		
A-7/8	55.0	51.9	44.0	37.9	52.0	48.0	50.3	45.92		
A-8/9	52.0	48.0	42.0	35.3	56.0	53.1	50.0	45.50		
A-9/10	48.0	43.0	48.0	43.0	51.0	46.8	49.0	44.23		
A-10/11	45.0	39.2	50.0	45.5	58.0	55.7	51.0	46.77		
A-11/12	56.0	53.1	54.0	50.6	54.0	50.6	54.7	51.43		
A-12/13	52.0	48.0	46.0	40.4	51.0	46.8	49.7	45.08		
A-13/14	–	–	–	–	–	–	–	–		
A-14/15	–	–	–	–	–	–	–	–		
A-15/16	56.0	53.1	58.0	55.7	50.0	45.5	54.7	51.43		
A-16/17	48.0	43.0	50.0	45.5	50.0	45.5	49.3	44.65		
A-17/18	50.0	45.5	54.0	50.6	52.0	48.0	52.0	48.04		
								47.90		
EL+6.50										
D-1/2	50.0	44.2	52.0	48.0	58.0	55.7	53.3	49.73		
D-2/3	48.0	45.5	50.0	45.5	50.0	45.5	49.3	44.65		
D-3/4	46.0	46.8	54.0	50.6	46.0	40.4	48.7	43.81		
D-4/5	44.0	48.0	50.0	45.5	45.0	39.2	46.3	40.84		
D-5/6	46.0	49.3	48.0	43.0	42.0	35.3	45.3	39.57		
D-6/7	48.0	50.6	46.0	40.4	48.0	43.0	47.3	42.11		
D-7/8	46.0	51.9	52.0	48.0	46.0	40.4	48.0	42.96		
D-8/9	48.0	53.1	52.0	48.0	50.0	45.5	50.0	45.50		
D-9/10	50.0	54.4	48.0	43.0	48.0	43.0	48.7	43.81		
D-10/11	48.0	55.7	42.0	35.3	50.0	45.5	46.7	41.27		
D-11/12	44.0	56.9	42.0	35.3	44.0	37.9	43.3	37.03		
D-12/13	44.0	58.2	44.0	37.9	48.0	43.0	45.3	39.57		
D-13/14	–	–	–	–	–	–	–	–		
D-14/15	–	–	–	–	–	–	–	–		
D-15/16	48.0	43.0	46.0	40.4	46.0	40.4	46.7	41.27		
D-16/17	46.0	40.4	48.0	43.0	42.0	35.3	45.3	39.57		
D-17/18	48.0	43.0	44.0	37.9	50.0	45.5	47.3	42.11		
								42.25		
EL+6.50										
Turbin Foundfation										
#1	46.0	40.4	47.0	41.7	44.0	37.9	45.7	40.00		
#2	48.0	43.0	44.0	37.9	50.0	45.5	47.3	42.11		
#3	50.0	45.5	47.0	41.7	44.0	37.9	47.0	41.69		
#4	47.0	41.7	45.0	39.2	46.0	40.4	46.0	40.42		Cracking
								41.06		
EL+6.50										
Slab										
#1	54.0	50.6	49.0	44.2	48.0	43.0	50.3	45.92		
#2	50.0	45.5	52.0	48.0	51.0	46.8	51.0	46.77		
#3	54.0	50.6	52.0	48.0	48.0	43.0	51.3	47.19		
#4	47.0	41.7	45.0	39.2	46.0	40.4	46.0	40.42		
								45.08		
EL+11.80										
Boiler Beam										
#1	47.0	41.7	46.0	40.4	52.0	48.0	48.3	43.38		
#2	52.0	48.0	58.0	55.7	57.0	54.4	55.7	52.70		
#3	55.0	51.9	58.0	55.7	54.0	50.6	55.7	52.70		
								49.59		
Berner										
#1	55.0	51.9	58.0	55.7	50.0	45.5	54.3	51.00		
#2	52.0	48.0	58.0	55.7	55.0	51.9	55.0	51.85		
#3	48.0	43.0	48.0	43.0	51.0	46.8	49.0	44.23		
								49.03		
							Average	**45.35**		

Column No.	REBOUND (R) by Schmidt Hammer							Concrete Strength (N/mm2)	Concrete Neutralization (mm)	Remark
	1		2		3		Average			
	R	N/mm2	R	N/mm2	R	N/mm2				
BOILER										
G-2	48.0	43.0	44.0	37.9	52.0	48.0	48.0	42.96		
G-3	–	–	–	–	–	–	–	–		**Boiler #.1**
G-4	48.0	46.0	60.0	58.2	50.0	45.5	52.7	48.89		
G-5	58.0	55.7	52.0	48.0	58.0	55.7	56.0	53.12		
G-6	–	–	–	–	–	–	–	–		**Boiler #.2**
G-7	52.0	48.0	44.0	37.9	48.0	43.0	48.0	42.96		
G-8	56.0	53.1	52.0	48.0	54.0	50.6	54.0	50.58		
G-9	–	–	–	–	–	–	–	–		**Boiler #.3**
G-10	50.0	45.5	50.0	45.5	49.0	44.2	49.7	45.08		
G-15	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
G-16	–	–	–	–	–	–	–	–		**Boiler #.4**
G-17	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
								47.26		
H-2	52.0	48.0	51.0	46.8	46.0	40.4	49.7	45.08		
H-3	–	–	–	–	–	–	–	–		**Boiler #.1**
H-4	43.0	36.6	51.0	46.8	54.0	50.6	49.3	44.65		
H-5	44.0	37.9	43.0	36.6	46.0	40.4	44.3	38.30		
H-6	–	–	–	–	–	–	–	–		**Boiler #.2**
H-7	51.0	46.8	50.0	45.5	51.0	46.8	50.7	46.35		
H-8	58.0	55.7	57.0	54.4	44.0	37.9	53.0	49.31		
H-9	–	–	–	–	–	–	–	–		**Boiler #.3**
H-10	56.0	53.1	58.0	55.7	52.0	48.0	55.3	52.27		
G-15	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
G-16	–	–	–	–	–	–	–	–		**Boiler #.4**
G-17	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
								45.99		
BURNER										
I-2	49.0	45.5	62.0	60.7	49.0	44.2	53.3	49.73		
I-3	–	–	–	–	–	–	–	–		**Burner #.1**
I-4	55.0	48.0	51.0	46.8	58.0	55.7	54.7	51.43		
I-5	57.0	49.3	54.0	50.6	45.0	39.2	52.0	48.04		
I-6	–	–	–	–	–	–	–	–		**Burner #.2**
I-7	58.0	51.9	55.0	51.9	50.0	45.5	54.3	51.00		
I-8	59.0	53.1	55.0	51.9	50.0	45.5	54.7	51.43		
I-9	–	–	–	–	–	–	–	–		**Burner #.3**
I-10	48.0	55.7	45.0	39.2	51.0	46.8	48.0	42.96		
I-15	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
I-16	–	–	–	–	–	–	–	–		**Burner #.4**
I-17	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
								49.10		
J-2	50.0	58.2	51.0	46.8	51.0	46.8	50.7	46.35		
J-3	–	–	–	–	–	–	–	–		**Burner #.1**
J-4	52.0	48.0	43.0	36.6	54.0	50.6	49.7	45.08		
J-5	57.0	54.4	56.0	53.1	54.0	50.6	55.7	52.70		
J-6	–	–	–	–	–	–	–	–		**Burner #.2**
J-7	45.0	39.2	44.0	37.9	50.0	45.5	46.3	40.84		
J-8	46.0	40.4	52.0	48.0	51.0	46.8	49.7	45.08		
J-9	–	–	–	–	–	–	–	–		**Burner #.3**
J-10	48.0	43.0	42.0	35.3	43.0	36.6	44.3	38.30		
J-15	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
J-16	–	–	–	–	–	–	–	–		**Burner #.4**
J-17	Steel	Steel	Steel	Steel	Steel	Steel	Steel			
								44.72		
							Average	46.77		

Appendix 5-6 Concrete Test (3/3)

Column No.	REBOUND (R) by Schmidt Hammer						Average	Concrete Strength (N/mm2)	Concrete Neutralization (mm)	Remark
	1		2		3					
	R	N/mm2	R	N/mm2	R	N/mm2				
A-1	44.0	37.9	60.0	58.2	60.0	58.2	54.7	51.43		
A-2	60.0	58.2	58.0	55.7	54.0	50.6	57.3	54.81		
A-3	58.0	55.7	60.0	58.2	62.0	60.7	60.0	58.20		Cracking
A-4	58.0	55.7	58.0	55.7	60.0	58.2	58.7	56.51		Turbin #.1
A-5	56.0	53.1	48.0	43.0	56.0	53.1	53.3	49.73		
A-6	46.0	40.4	52.0	48.0	40.0	32.8	46.0	40.42		
A-7	54.0	50.6	58.0	55.7	60.0	58.2	57.3	54.81		Turbin #.2
A-8	57.0	54.4	44.0	37.9	52.0	48.0	51.0	46.77		Cracking(ジャンカ)
A-9	62.0	60.7	40.0	32.8	57.0	54.4	53.0	49.31		Cracking
A-10	54.0	50.6	56.0	53.1	51.0	46.8	53.7	50.16		Turbin #.3
A-11	54.0	50.6	60.0	58.2	62.0	60.7	58.7	56.51		Cracking
A-12	–	–	–	–	–	–	–	–		
A-13	–	–	–	–	–	–	–	–		
A-14	56.0	53.1	54.0	50.6	59.0	56.9	56.3	53.54		剥離
A-15	54.0	50.6	44.0	37.9	54.0	50.6	50.7	46.35		
A-16	60.0	58.2	62.0	60.7	52.0	48.0	58.0	55.66		
A-17	52.0	48.0	58.0	55.7	58.0	55.7	56.0	53.12		Turbin #.4
A-18	52.0	48.0	44.0	37.9	48.0	43.0	48.0	42.96		
								51.27		
D-1	58.0	44.2	60.0	58.2	60.0	58.2	59.3	57.35		Cracking
D-2	48.0	45.5	52.0	48.0	48.0	43.0	49.3	44.65		
D-3	48.0	46.8	58.0	55.7	44.0	37.9	50.0	45.50		
D-4	45.0	48.0	50.0	45.5	45.0	39.2	46.7	41.27		Turbin #.1
D-5	44.0	49.3	44.0	37.9	44.0	37.9	44.0	37.88		
D-6	50.0	50.6	44.0	37.9	48.0	43.0	47.3	42.11		
D-7	44.0	51.9	52.0	48.0	48.0	43.0	48.0	42.96		Turbin #.2
D-8	48.0	53.1	52.0	48.0	52.0	48.0	50.7	46.35		
D-9	52.0	54.4	46.0	40.4	44.0	37.9	47.3	42.11		
D-10	48.0	55.7	42.0	35.3	48.0	43.0	46.0	40.42		Turbin #.3
D-11	42.0	56.9	40.0	32.8	48.0	43.0	43.3	37.03		
D-12	–	–	–	–	–	–	–	–		
D-13	–	–	–	–	–	–	–	–		
D-14	46.0	58.2	44.0	37.9	48.0	43.0	46.0	40.42		
D-15	48.0	43.0	44.0	37.9	48.0	43.0	46.7	41.27		
D-16	48.0	43.0	46.0	40.4	48.0	43.0	47.3	42.11		
D-17	48.0	43.0	44.0	37.9	50.0	45.5	47.3	42.11		Turbin #.4
D-18	44.0	37.9	44.0	37.9	46.0	40.4	44.7	38.73		
								42.64		
F-1	56.0	53.1	53.0	49.3	54.0	50.6	54.3	51.00		
F-2	52.0	48.0	52.0	48.0	50.0	45.5	51.3	47.19		
F-3	50.0	45.5	50.0	45.5	52.0	48.0	50.7	46.35		
F-4	52.0	48.0	51.0	46.8	46.0	40.4	49.7	45.08		(Turbin #.1)
F-5	50.0	45.5	54.0	50.6	54.0	50.6	52.7	48.89		
F-6	56.0	53.1	60.0	58.2	50.0	45.5	55.3	52.27		
F-7	50.0	45.5	58.0	55.7	48.0	43.0	52.0	48.04		(Turbin #.2)
F-8	48.0	43.0	52.0	48.0	54.0	50.6	51.3	47.19		
F-9	48.0	43.0	50.0	45.5	56.0	53.1	51.3	47.19		
F-10	50.0	45.5	54.0	50.6	57.0	54.4	53.7	50.16		(Turbin #.3)
F-11	52.0	48.0	50.0	45.5	46.0	40.4	49.3	44.65		
F-12	44.0	37.9	50.0	45.5	42.0	35.3	45.3	39.57		
F-13	42.0	35.3	48.0	43.0	46.0	40.4	45.3	39.57		
F-14	48.0	43.0	50.0	45.5	42.0	35.3	46.7	41.27		
F-15	45.0	39.2	52.0	48.0	54.0	50.6	50.3	45.92		
F-16	42.0	35.3	52.0	48.0	50.0	45.5	48.0	42.96		
F-17	48.0	43.0	50.0	45.5	52.0	48.0	50.0	45.50		(Turbin #.4)
F-18	54.0	50.6	52.0	48.0	57.0	54.4	54.3	51.00		
								46.32		
							Average	46.73		

CONCRETE DIAGNOSIS				No.
Building	TURBINE HALL			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-1			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	44.0	60.0	60.0	
Average Strength	51.43 N/mm2			
Diagnosis Verification	Concrete strength is Sufficient			

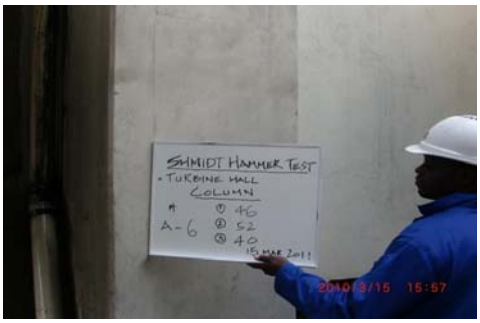
CONCRETE DIAGNOSIS				No.
Building	TURBINE HALL			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-2			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	60.0	58.0	54.0	
Average Strength	54.81 N/mm2			
Diagnosis Verification	Concrete strength is Sufficient			

CONCRETE DIAGNOSIS				No.
Building	TURBINE HALL			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-3			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	0.3mm			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	58.0	60.0	62.0	
Average Strength	58.20 N/mm2			
Diagnosis Verification	Surface Coating			

CONCRETE DIAGNOSIS				No.
Building	Tubine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-4			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	58.0	58.0	60.0	
Average Strength	56.51 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			

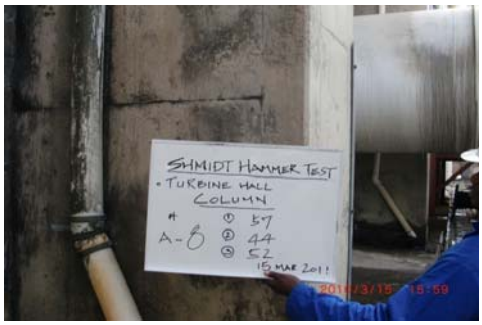
CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-5			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	56.0	48.0	56.0	
Average Strength	49.73 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-6			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	46.0	52.0	40.0	
Average Strength	40.42 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			



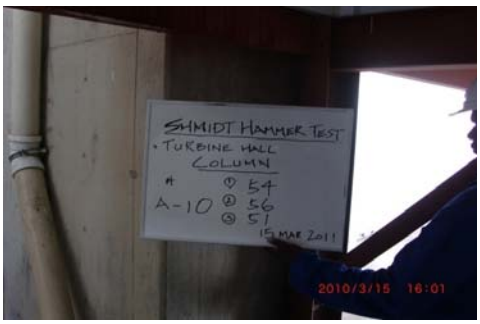
CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-7			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	54.0	58.0	60.0	
Average Strength	54.81 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-8			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	○			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	0.5mm			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	57.0	44.0	52.0	
Average Strength	46.77 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			



CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-9			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	0.5mm			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	62.0	40.0	57.0	
Average Strength	49.31 N/mm2			
Diagnosis Verification	Concrete strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-10			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	54.0	56.0	51.0	
Average Strength	50.16 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			



CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-11			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	0.3mm			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	54.0	60.0	62.0	
Average Strength	56.51 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-14			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	56.0	54.0	59.0	
Average Strength	53.54 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-15			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	54.0	44.0	54.0	
Average Strength	46.35 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-16			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	52.0	58.0	58.0	
Average Strength	53.12 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	A-17			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	52.0	58.0	58.0	
Average Strength	53.12 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS10160)			
TEST No.	A-18			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	52.0	44.0	48.0	
Average Strength	42.96 N/mm2			
Diagnosis Verification	Concrete Strength is sufficieent			

CONCRETE DIAGNOSIS				No.
Building				**Photo**
Design Specification	BSI 8100			
TEST No.				
Deterioration	Column	Beam	Slab	
Abrasion				
Exfoliation				
Corrosion				
Cracking				
Displacement				
Cracking				
Scouring				
Exfoliation				
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer				
Average Strength				
Diagnosis Verification				

CONCRETE DIAGNOSIS				No.
Building				**Photo**
Design Specification	BSI 8100			
TEST No.				
Deterioration	Column	Beam	Slab	
Abrasion				
Exfoliation				
Corrosion				
Cracking				
Displacement				
Cracking				
Scouring				
Exfoliation				
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer				
Average Strength				
Diagnosis Verification				

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-1			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	58.0	60.0	60.0	
Average Strength	53.54 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-2			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	52.0	48.0	
Average Strength	44.65 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-3			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	58.0	44.0	
Average Strength	45.50 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-4			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	45.0	50.0	45.0	
Average Strength	41.27 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-5			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	44.0	44.0	44.0	
Average Strength	37.88 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-6			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	50.0	44.0	48.0	
Average Strength	42.11 N/mm2			
Diagnosis Verification				

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-7			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	44.0	52.0	48.0	
Average Strength	42.96 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-8			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	52.0	52.0	
Average Strength	46.35 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-9			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	52.0	46.0	44.0	
Average Strength	42.11 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-10			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	42.0	48.0	
Average Strength	40.42 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-11			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	42.0	40.0	48.0	
Average Strength	37.03			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-14			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	46.0	44.0	48.0	
Average Strength	40.42 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-15			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	44.0	48.0	
Average Strength	41.27 N/mm2			
Diagnosis Verification	Concrete Strength is Sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-16			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	46.0	48.0	
Average Strength	42.11 N/mm2			
Diagnosis Verification	Concrete Strength is Sufficient			

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-17			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	48.0	44.0	50.0	
Average Strength	42.11 N/mm2			
Diagnosis Verification				

CONCRETE DIAGNOSIS				No.
Building	Turbine Hall			**Photo**
Design Specification	BSI 8100 (SANS 10160)			
TEST No.	D-18			
Deterioration	Column	Beam	Slab	
Abrasion	-			
Exfoliation	-			
Corrosion	-			
Cracking	-			
Displacement				
Cracking	-			
Scouring	-			
Exfoliation	-			
Neutralization	no			
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer	44.0	44.0	46.0	
Average Strength	38.73 N/mm2			
Diagnosis Verification	Concrete Strength is sufficient			

CONCRETE DIAGNOSIS				No.
Building				**Photo**
Design Specification	BSI 8100			
TEST No.				
Deterioration	Column	Beam	Slab	
Abrasion				
Exfoliation				
Corrosion				
Cracking				
Displacement				
Cracking				
Scouring				
Exfoliation				
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer				
Average Strength				
Diagnosis Verification				

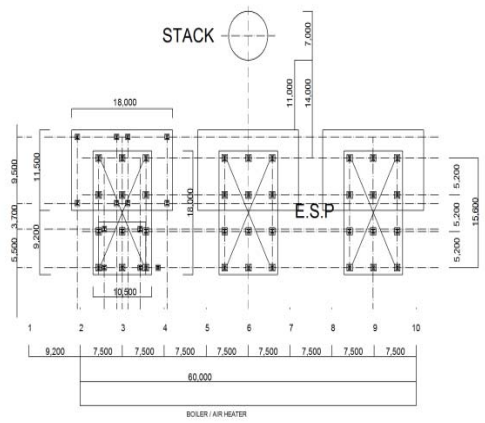
CONCRETE DIAGNOSIS				No.
Building				**Photo**
Design Specification	BSI 8100			
TEST No.				
Deterioration	Column	Beam	Slab	
Abrasion				
Exfoliation				
Corrosion				
Cracking				
Displacement				
Cracking				
Scouring				
Exfoliation				
Neutralization				
Concrete Strength	No.1	No.2	No.3	
Schmidt hammer				
Average Strength				
Diagnosis Verification				

Foundation Design

The size and load conditions for the design the foundation depend on the types of FGD. However for estimate of the cost and construction schedule, the foundation is designed assuming the Semi-dry Circulation type FGD being applied.

1. Location of Civil Works

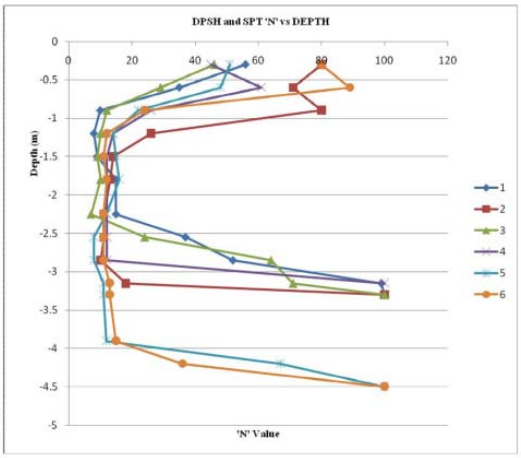
For the Environmental Abetment of Morupule “A” Power Station, the Flue Gas Desulfurization (FGD) and the new Electrostatic Precipitation (ESP) will be installed at the same location where existing Electrostatic Precipitation is at the rear of Boiler Bank. However, the new foundation must be constructed because the existing foundation cannot support new FGD/ESP due to heavy weight. Furthermore, the protection and the temporary works such as retaining wall must be considered for the neighboring facilities in order to avoid the any accident because the location is narrow and there are existing facilities such as Stack, Control building, Duct and Belt conveyer in operation.



(Prepared by JIC Study Team)

Figure 1-1 Location around ESP

2. Bearing Capacity for Foundation



As a result of soil investigation such as Standard Penetration Test (Nos.6) and the trial pit (Nos.4) in the site by JICA study team, the stratum is indicated the following figure. The surface is covered powder sand of Kalahari Desert, and is consisted of the fine sand and coarse sand up to GL -3.0m. Under the sand, the stratum is the weathered rock and hard rock in places. The firm base is considered the hard rock at GL-4.5m and the bearing capacity is estimated more than 10 t/m2.

(Prepared by JIC Study Team)

Figure 1-2 SPT results

Table 1-1 Results of Trial Pit

TP-1	TP-2	TP-3	TP-4
Fine sand GL-2.25 Coarse sand GL-3.70 Mixed aggregate GL-3.90 Weathered rock **GL-4.30** Hard rock	Fine sand GL-2.45 Coarse sand GL-4.40 Mixed aggregate GL-4.70 Weathered rock **GL-4.90** Hard rock	Fine sand GL-2.75 Coarse sand GL-4.00 Mixed aggregate GL-4.20 Weathered rock **GL-4.50** Hard rock	Fine sand GL-3.10 Coarse sand GL-3.70 Mixed aggregate GL-3.85 Weathered rock **GL-4.30** Hard rock

3. Wind Load

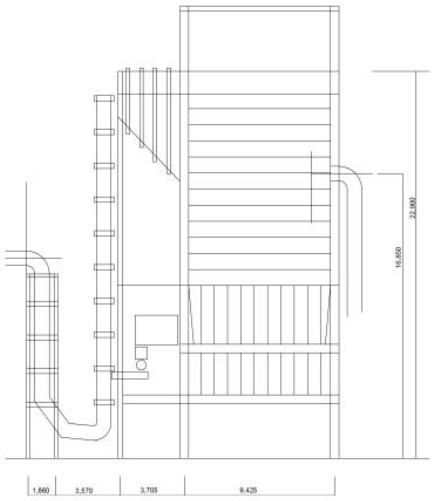
According to SANS-No.10160, the design wind velocity is set at 28m/s in Botswana. Therefore, the wind load shall be calculated as the horizontal force due to the projected area of facility.

4. Seismic Load

According to the USGS, the earthquake was recorded occurring on 1st May 2009 in northern area in Botswana with Magnitude 4.0, and on 16th September 2010 in southern area with Magnitude 3.1. For the design of foundation or structure, the seismic condition of 0.05G which is set by SANS 10160 shall be considered.

5. FGD/ESP Foundation

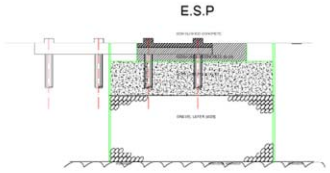
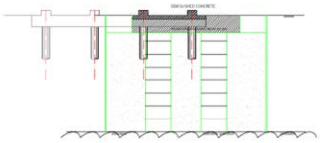
The environmental abetment in Morupule “A” Power Station will remove the existing ESP behind coal banker at first and will install new FGD/ESP equipment which is suitable for environmental standard. The weight of the equipment is estimated 600 tons per one unit and the size of foundation is assumed as 11.5m×18.0m. For the construction plan, the demolition and construction works of No.3 and No.4 will be started at first while No.1 and No.2 are still in operation. The equipment of No.1 and No.2 will be demolished and constructed after the completion of No.3 and No.4 continuously. The protection such as the retaining wall must be considered for the operation of adjacent facilities to avoid any influence of construction. Consequently, two types of foundation are examined and compared as shown in the following Table.



Prepared by JICA Study Team

Figure 1-3 New FGD/ESP

Table 1-2 Comparison with Foundation Works

Comparison	Replacement	Pile Foundation
		
Method	The bearing capacity is supported by replacement of gravel or earth concrete after removal of loose sand until GL-4.5m. The retaining wall must be considered to avoid collapse of underground.	Caisson pile using precast concrete is scuttled and excavated inside of caisson. The caisson pile is embedded on top of hard strata at GL-4.5m.
Merit	The works is simple and quick construction.	The retaining wall is not necessary.
Demerit	The retaining wall is necessary in order to protect adjoining facilities.	The work is slow comparing with replacement and requires strictly accurate vertical line.
Cost	Low cost by JCB equipment.	High cost due to man power

In consideration of stability and workability, the replacement method is recommended for the new FGD/ESP's foundation to support the weight of 600 tons and it is shorter construction period. The replacement material will be poor mixing concrete (Lean Concrete Grade-15) in order to avoid the settlement. The other hand, the supplemental foundation such as Dryer facilities and Stock yard shall be replaced by gravel due to light equipments.

6. Other Civil Works

1) Foundation of Dehydration Facility

The coal must be dehydrated before conveying to FGD. The foundation will support the dehydration facility and the mixing facility of the coal. The weight is not heavy and the size of foundation will be 10m×20mx0.8. Under the foundation, the loose sand will be replaced by good quality gravel and the foundation will be constructed by the Grade-30 concrete according to SANS.

2) Stock Yard

The foundation for the stock yard for lime stone is estimated at 30m×20m with 0.8m thickness. The foundations for the belt conveyer up to the dehydration facility are also necessary.

3) Water Tank foundation

The foundation for water tank estimated at 20 tons for FGD is estimated at 10m x 10m with 0.8m thickness. The water is supplied from the reservoir in the power station.

Appendix 5-8 Foundation Design (4/4)

4) Control Building

The existing control building for ESP will be demolished and the new control buildings will be constructed for operating the new FGD/ESP at the same location. The size of the buildings will be 10m×5m and the floor is higher in 300mm than ground level.

Two control building of which one for FGD/ESP No.1 and No.2, the other for No.3 and No.4 will be installed.

5) Cable Trench

The Cable trench is two types. One is for control cable and the other is for power cable. Both trench will be 450mm×450mm inside and made by precast concrete with 1.2m long per one block.

6) Strength Support for Condenser

As the condenser structure on the Turbine building was built before 1986, the seismic and wind condition seems to be not considered in the design. According to the standard of SANS published in 2010, the horizontal force caused by the wind and seismic must be considered. The supporting structure (H-beam 300 mm x 300 mm) of the condenser for cooling the steam installed on the roof of the turbine building is seemed to be too small and less braces. The reinforcement of the structure against horizontal force shall be needed.

Consequently, the supporting structure must be strengthened by additional members of L200mm×200mm. The rehabilitation of the water proofing at the turbine building's roof using bituminous materials is recommended as well.

7) Measures for Cracks on Column

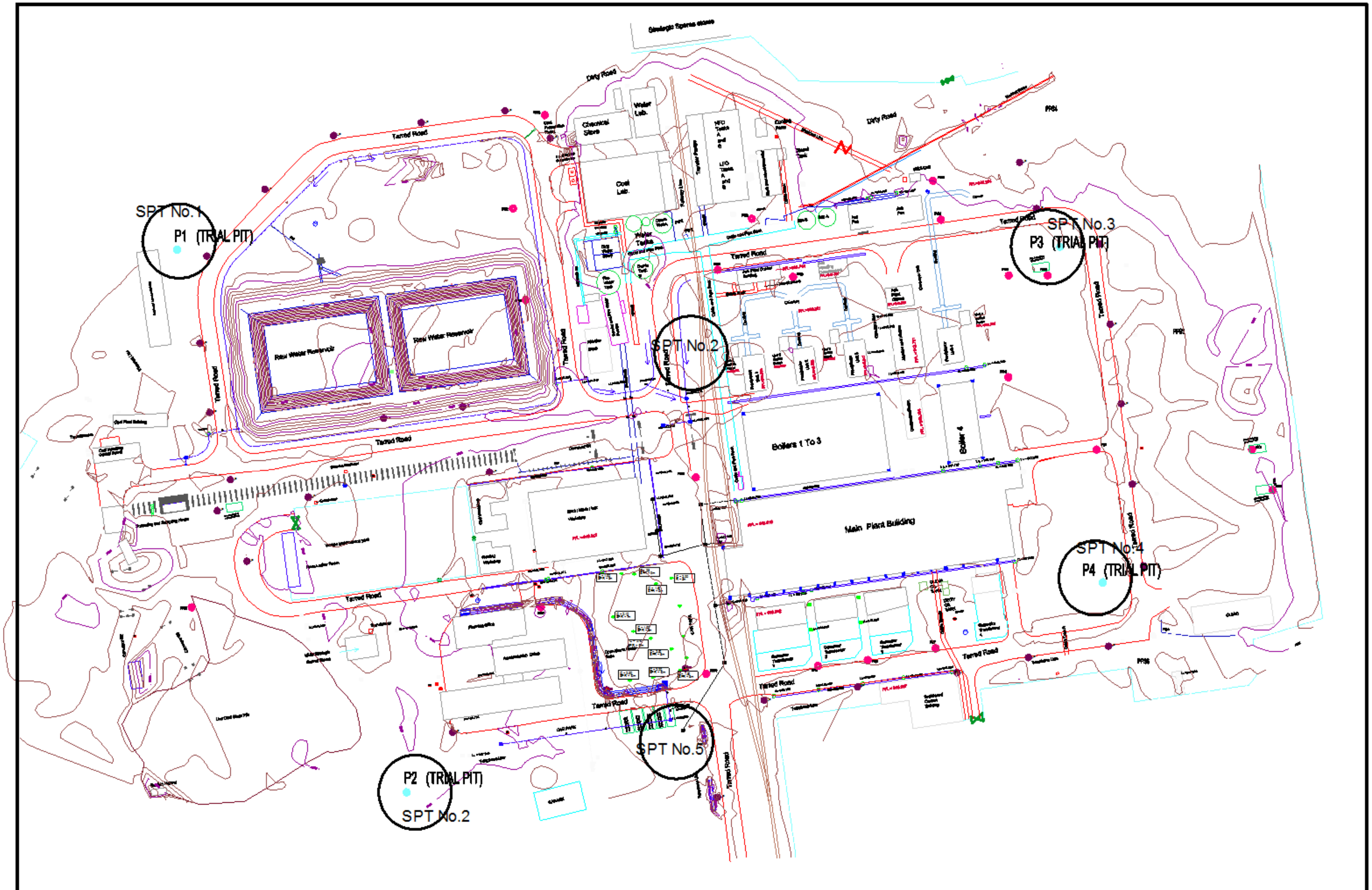
Having diagnosed the building, some cracks on the concrete surface of the column or slab are found . To prevent the corrosion of reinforced bar in concrete of column and slab, epoxy injection with carbon fiber bonding at column of TC-10、TC-12、TC-13 and No.4 Turbine foundation is recommended.

8) Road for Maintenance

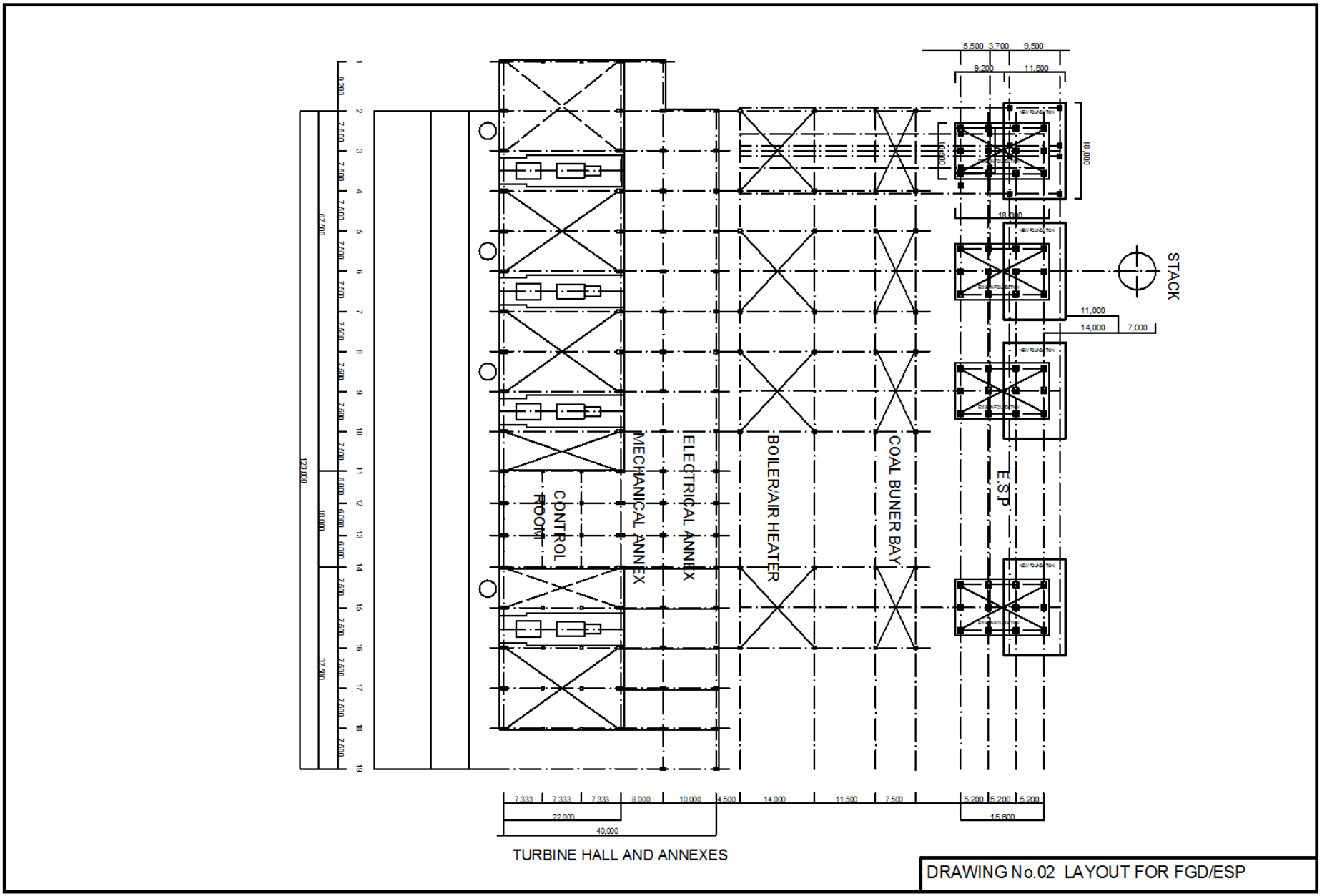
The road will be constructed for accessing to the FGD/ESP, dehydration facility and stock yard. The width is estimated 5.0m.

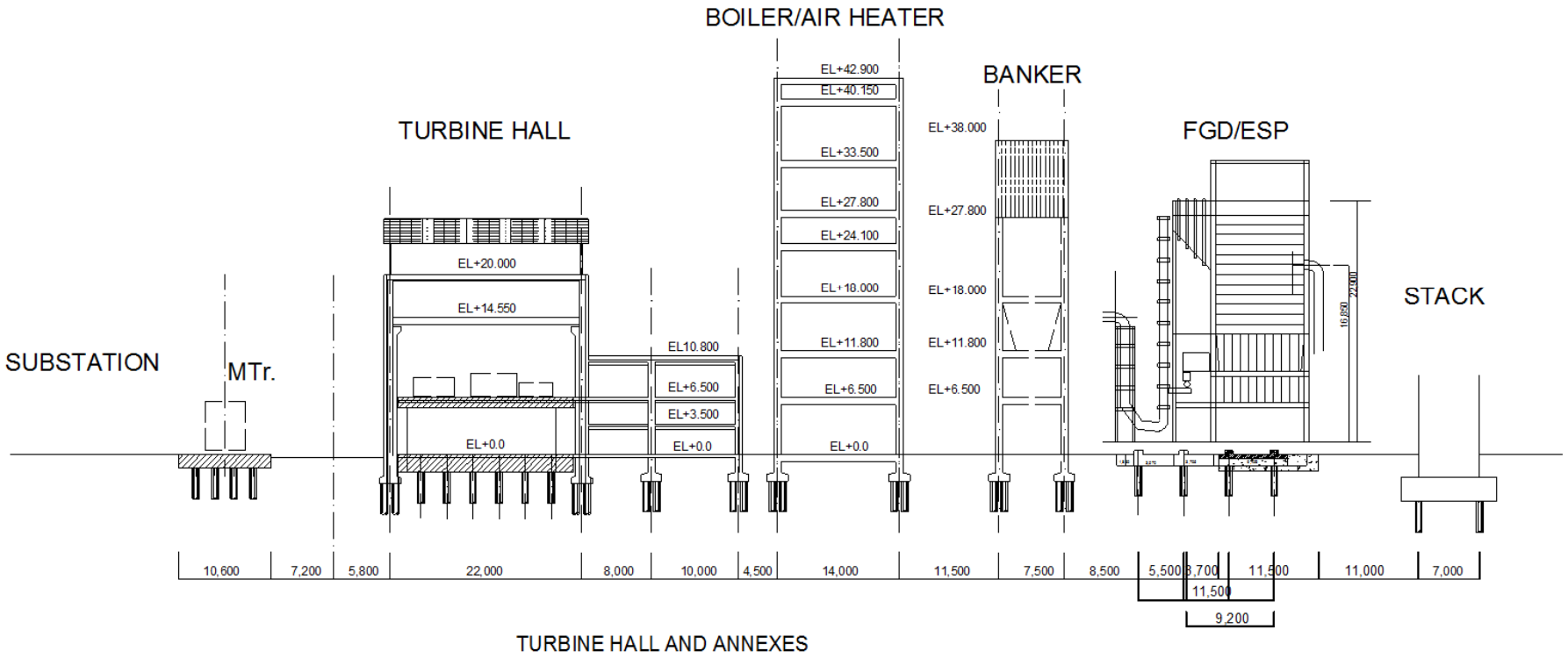
9) Drainage

The drainage will be set up for treated water from FGD/ESP and rain. The size is 450mm×450mm and 1.2m long per one block by precast concrete.



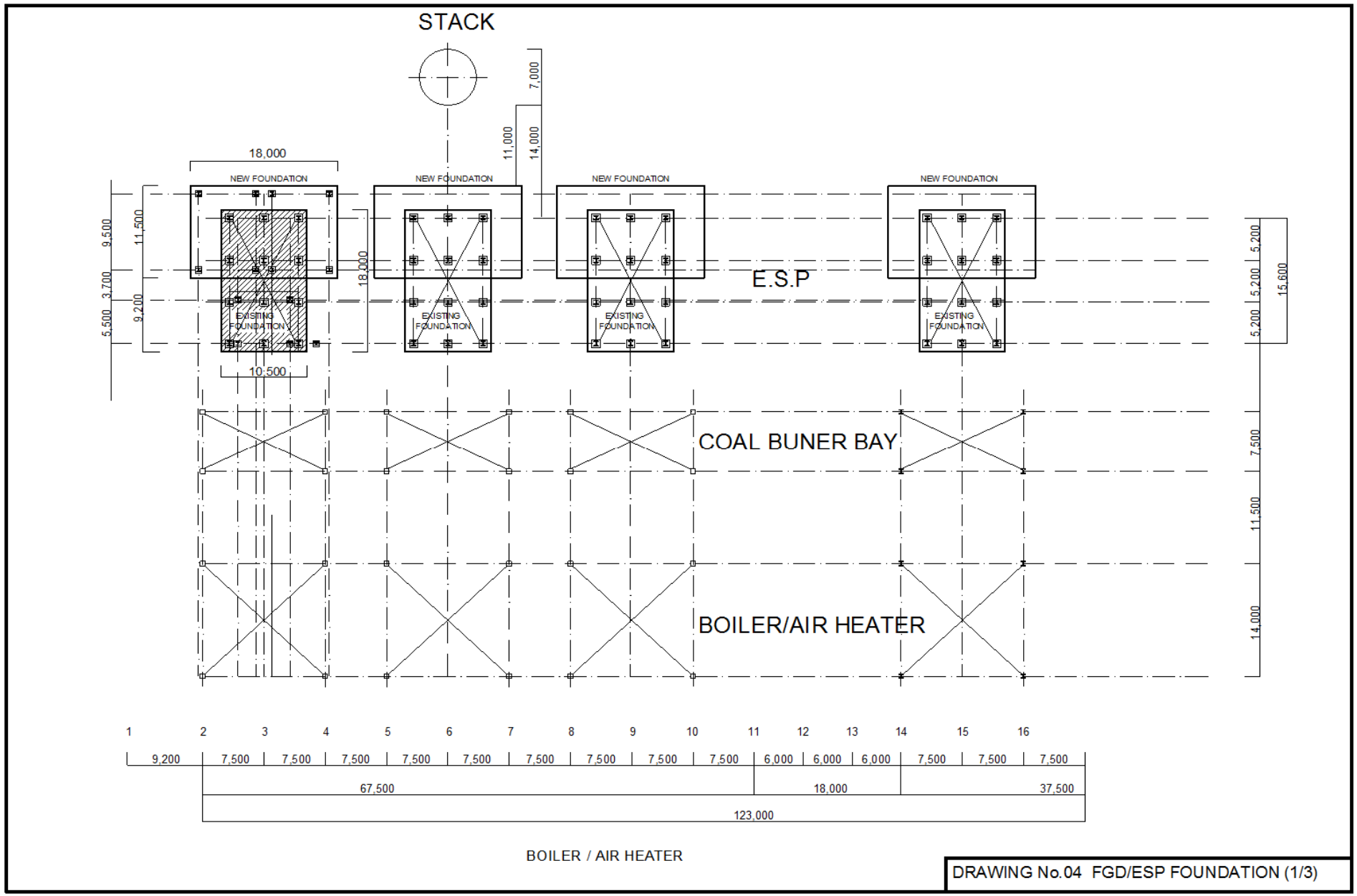
DRAWING No.01 LOCATION OF SPT & TRIAL PIT

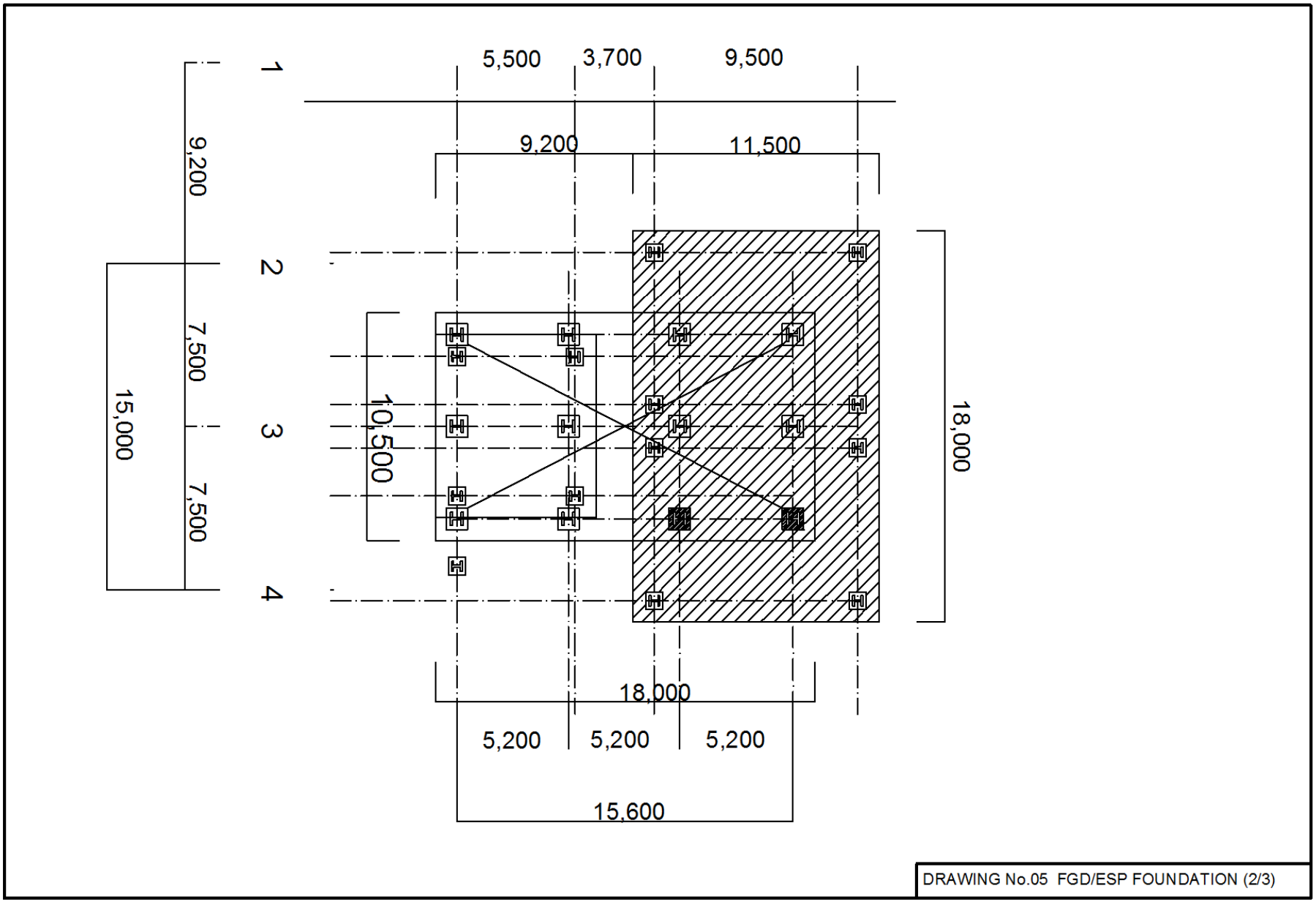

CONTROL ROOM
MECHANICAL ANNEX
ELECTRICAL ANNEX
BOILER/AIR HEATER
COAL BUNER BAY
E.S.P
STACK
TURBINE HALL AND ANNEXES
DRAWING No.02 LAYOUT FOR FGD/ESP

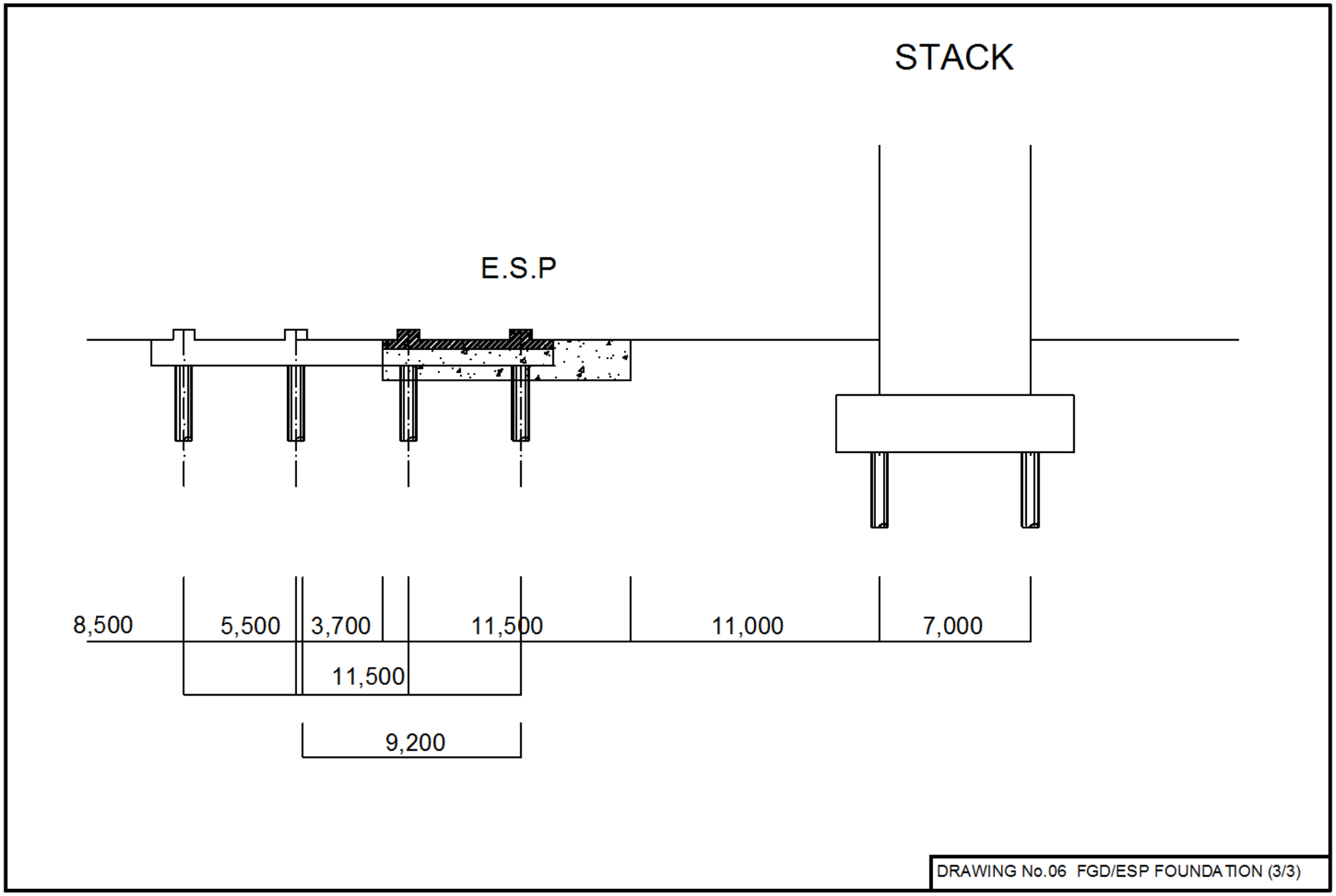


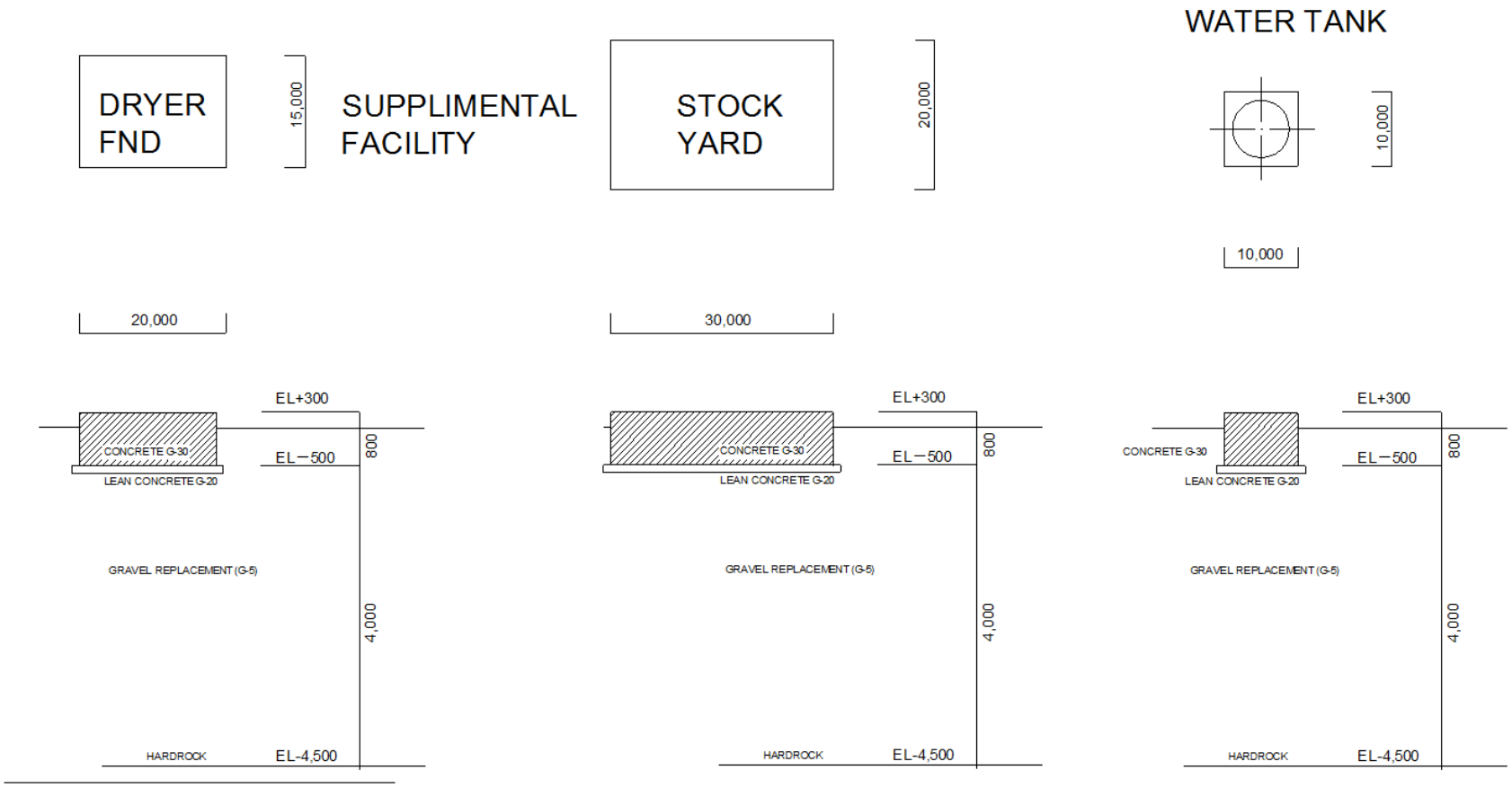
TURBINE HALL AND ANNEXES

DRAWING No.03 ELEVATION FOR FGD/ESP


STACK
7,000
11,000
14,000
18,000
NEW FOUNDATION
NEW FOUNDATION
NEW FOUNDATION
NEW FOUNDATION
9,500
11,500
3,700
9,200
5,500
18,000
EXISTING FOUNDATION
EXISTING FOUNDATION
EXISTING FOUNDATION
EXISTING FOUNDATION
10,500
E.S.P
5,200
5,200
5,200
15,600
COAL BUNER BAY
7,500
11,500
BOILER/AIR HEATER
14,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
9,200 7,500 7,500 7,500 7,500 7,500 7,500 7,500 7,500 7,500 6,000 6,000 6,000 7,500 7,500 7,500
67,500
18,000
37,500
123,000
BOILER / AIR HEATER
DRAWING No.04 FGD/ESP FOUNDATION (1/3)

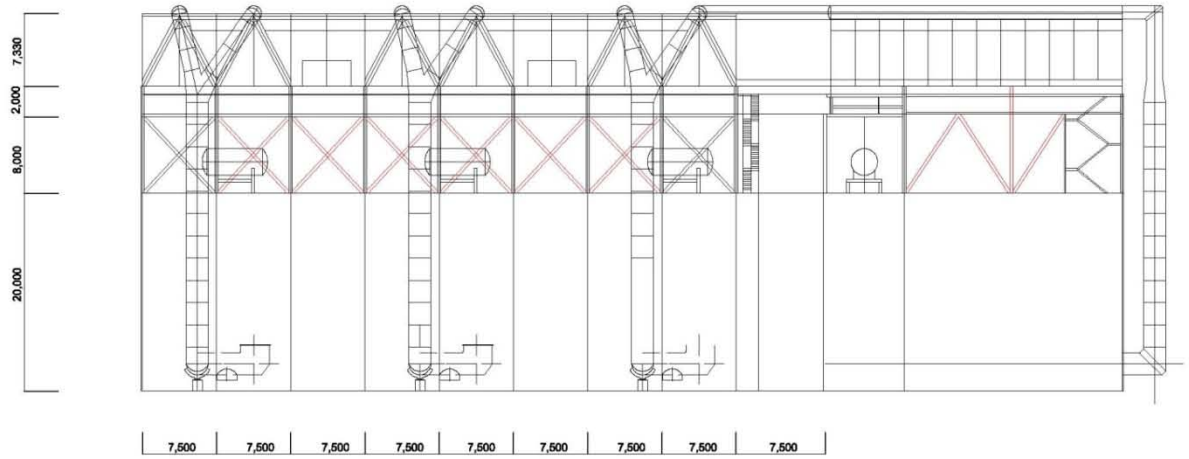

5,500
3,700
9,500
9,200
11,500
1
2
3
4
9,200
7,500
7,500
15,000
10,500
18,000
18,000
5,200
5,200
5,200
15,600
DRAWING No.05 FGD/ESP FOUNDATION (2/3)


STACK
E.S.P
8,500
5,500
3,700
11,500
11,000
7,000
11,500
9,200
DRAWING No.06 FGD/ESP FOUNDATION (3/3)

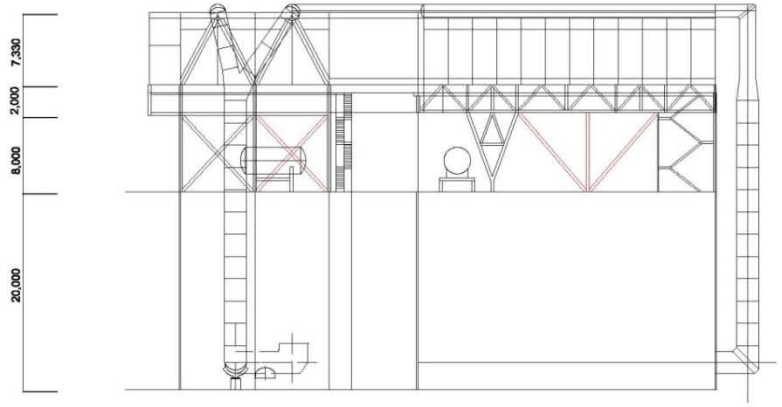


DRAWING No.07 SUPPLIMENTAL FACILITY

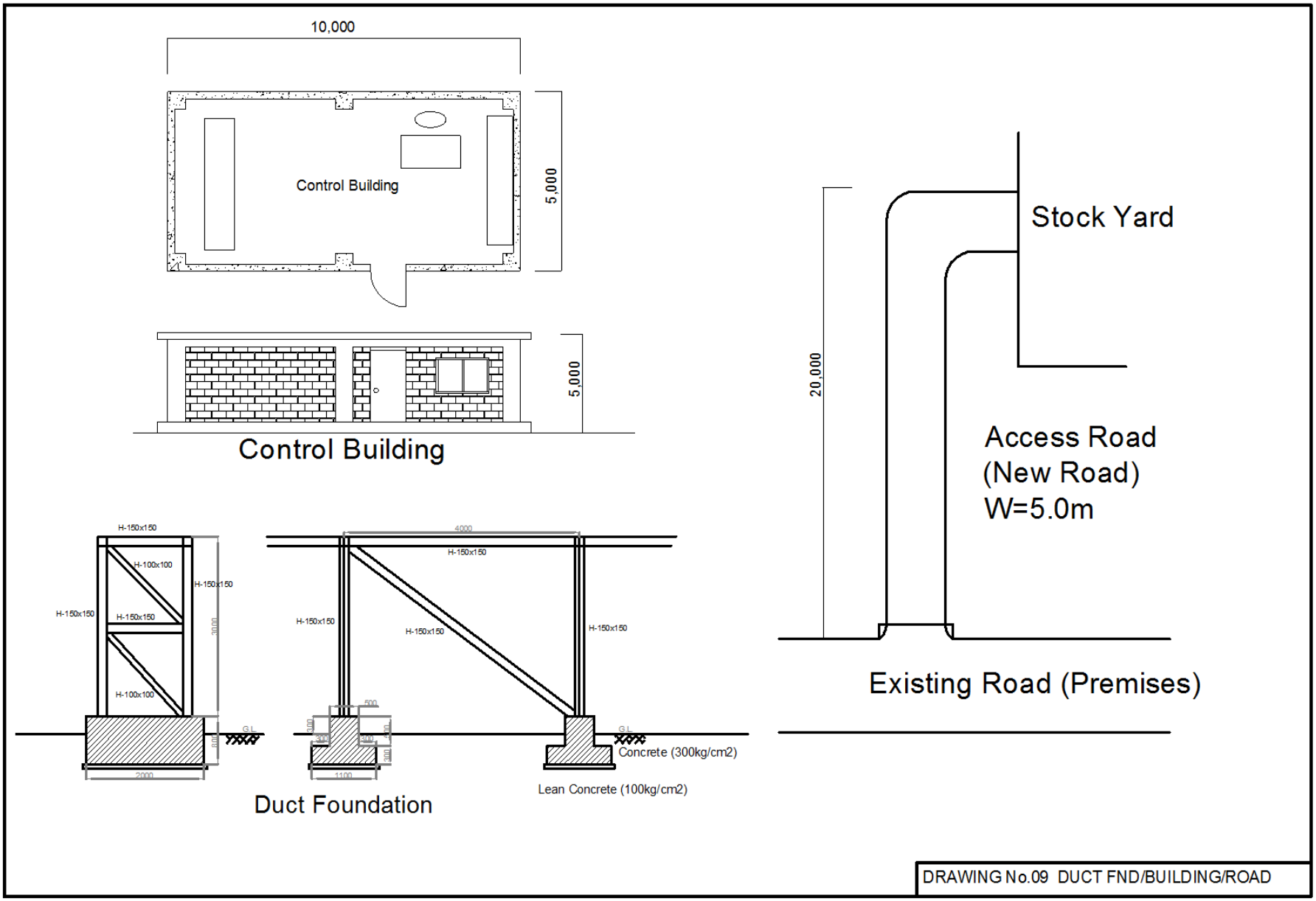
CONDENSER

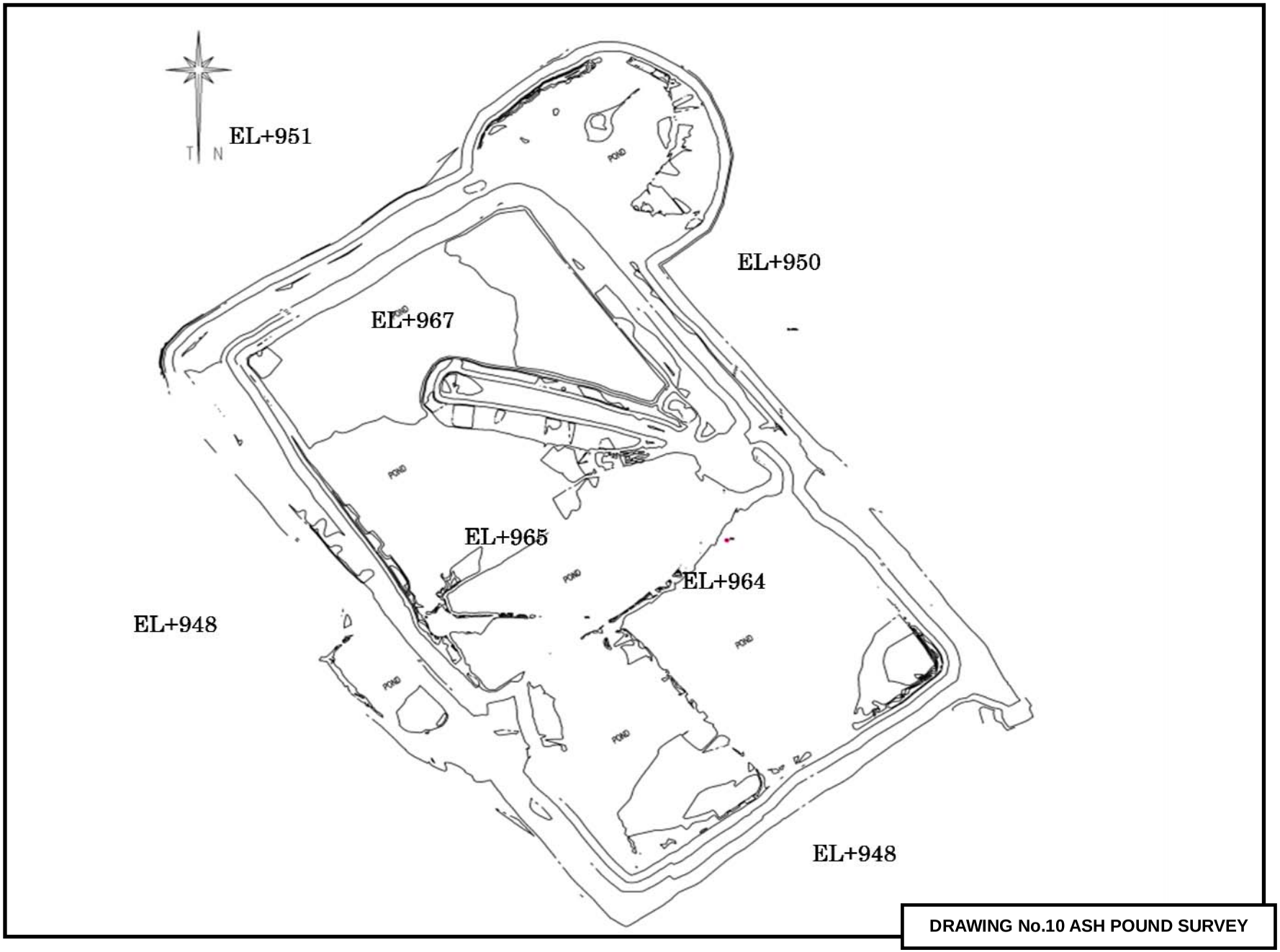


CONDENSER



DRAWING No.08 MOUNTING STRUCTURE


10,000
Control Building
5,000
5,000
Control Building
H-150x150
H-100x100
H-150x150
H-150x150
H-150x150
H-100x100
3000
800
2000
4000
H-150x150
H-150x150
H-150x150
H-150x150
500
300
300
300
1100
GL
GL
Concrete (300kg/cm2)
Lean Concrete (100kg/cm2)
Duct Foundation
20,000
Stock Yard
Access Road
(New Road)
W=5.0m
Existing Road (Premises)
DRAWING No.09 DUCT FND/BUILDING/ROAD


T N
EL+951
EL+950
EL+967
EL+965
EL+964
EL+948
EL+948
DRAWING No.10 ASH POUND SURVEY

Appendix 5-10 Unit Cost Comparison (1/7)

Unit Price (Civil Works)

Ref. No.	Item No.	Item of Works	Unit	Price	Remark
1	Labor Costs				
	1.01	Foreman	month	30,000	
	1.02	Skilled Rabor	month	25,000	
	1.03	Unskill Rabor	month	10,000	
	1.04	Reinforement Works	month	20,000	
	1.05	Scaffolding	month	20,000	
	1.06	Formworker	month	20,000	
	1.07	Carpenter	month	20,000	
	1.08	Plastere	month	20,000	
	1.09	Mason	month	20,000	
	1.10	Painter	month	20,000	
	1.11	Welder	month	20,000	
	1.12	Electricial	month	20,000	
	1.13	Plumber	month	20,000	
	1.14	Guardman	month	15,000	
	1.15	Driver	month	20,000	
	1.16	Clerical Staff	month	20,000	
	1.17	Typist	month	15,000	
	1.18	Engineer (more than 20 years)	month	40,000	
	1.19	Engineer (more than 10 years)	month	25,000	
	1.20	Surveyer	month	15,000	
	1.21	Architect	month	20,000	
	1.22	Technician	month	15,000	
	1.23	Draftman	month	15,000	
	1.24	Accountar	month	15,000	
	1.25	Office Boy	month	10,000	
2	Material Prices				
	2.01	Steel (Grade 250 H-200x200 t=8mm)	m		
	2.02	Steel (Grade 450 H-200x200 t=8mm)	m		D16*6.0m (P95)
	2.03	Steel (Grade 250 L-100x100 t=6mm)	m		
	2.04	Steel (Grade 450 L-100x100 t=6mm)	m		
	2.05	Reinforcement Bar (Grade 450 Deform)	m		
	2.06	Reinforcement Bar (Grade 450 Round)	m		
	2.07	Wier Mesh	m2		
	2.08	Cement (Poltland / Sulpher Resistance)	m3	55 to 65	
	2.09	Fine Aggregate for Concrete	m3	20	
	2.10	Coarse Aggregate (20mm)	m3	20	
	2.11	Coarse Aggregate (40mm)	m3	20	
	2.12	Rubble Stone	m3	20	
	2.13	Crusher Stone	m3	20	
	2.14	Sand	m3	20	
	2.15	Plywood Panel (t=10mm)	panel	50	1,220X24403.2mm
	2.16	Wooden Board (t=12mm)	panel	80	
	2.17	Asphalt Concrete	m3		
	2.18	Bitumen	m3		
	2.19	Asphalt Mixture	m3		
	2.20	Asphalt emulsion	m3		
	2.21	PVC Pipe (D50mm L=4.0m)	No.	60	6.0m
	2.22	PVC Pipe (D100mm L=4.0m)	No.	60	
	2.23	PVC Pipe (D150mm L=4.0m)	No.	60	
	2.24	Concrete Pipe (D300mm L=3.0m)	No.		
	2.25	Concrete Pipe (D500mm L=3.0m)	No.		
	2.26	Concrete Pipe (D800mm L=3.0m)	No.		
	2.27	GP Pipe (D=20mm L=5.0m)	No.	200	6.0m
	2.28	GP Pipe (D=50mm L=5.0m)	No.	200	
	2.29	Vinyl Sheet (t=2.0mm)	m2		
	2.30	Epoxy Paint	20 Lit.	440	
	2.31	Cable (6Cx2.5mm2)	m	260	
	2.32	Cable (6Cx1.5mm2)	m	170	
3	Oil & Gasoline				
	3.01	Gasoline	litter	7	
	3.02	Petrol	litter	7	
	3.03	Oil	litter	20	
	3.04	Diesel Oil	litter		

Appendix 5-10 Unit Cost Comparison (2/7)

Unit Price (Civil Works)

Ref. No.	Item No.	Item of Works	Unit	Price	Remark
4	Construction Equipment				
	4.01	Bulldozer, 15 ton	hr	485	
	4.02	Backhoe, 0.7m3	hr	385	JCB 24t
	4.03	Dump Truck, 11 ton	hr	150	
	4.04	Vibratory, plate compactor	hr		
	4.05	Concrete pump truck with boom, 130HP	hr		
	4.06	Crawler crane, 30 ton	hr		
	4.07	Heavy breaker, 600-800kg	hr		
	4.08	Generator, 200kVA	No.	7,200	HGS 4500
	4.09	Arc welding machine, 250A	No.	12,000	13Hp 7K
	4.10	Air compressor, 7.5 m3/min	No.	800	1.5HP24L
	4.11	Rent-a-car (sedan)	month	9,000	1.4 Lit
		Rent-a-car (sedan)	month	14,000	2.0 Lit.
5	Office Tool				
	5.01	Desk (W=120cm)	No.	2,700 to 4,000	
	5.02	Desk for meeting	No.	35,000	
	5.03	Chair	No.	1,800	
	5.04	Bookshelf	No.	30,000	
	5.05	Cabinet	No.	45,000	
	5.06	Computer (Window 7)	No.	5,500	Windows 7
	5.07	Laser Printer	No.	3,000	
	5.08	Ploter	No.	22,000	

Unit Cost Comparison

Ref. No.	Item No.	Items of Work	Unit	Qty.	A Unit Cost	B Unit Cost	C Unit Cost	Reasonable	Remark
	1	**Preliminary and General**							
DWG No.1	1.1	Establisment	l.s.	1	545,240				
DWG No.2	1.2	Time Related Items	l.s.	1	1,505,862				
	1.3		l.s.	1					
	1.4		l.s.	1					
	1.5		l.s.	1					
							925,000		1,000,000
	2	**Demolishing & Removal**							
	2.1	ESP Foundation (Plan A)	Sum	1	334,880	76,072			
	2.2	Existing Ducts Foundation	Sum	1	47,840	76,072			
	2.3	Existing Road for Access Road	Sum	1	1,700	96,600			
						248,744	410,000		410,000
	3	**Construction of New Foundations**							
	3.1	**ESP Foundation**							
DWG No.3	3.1.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
DWG No.4	3.1.2	Gravel bedding for Replacement	m3	0.0	825	193	175	590	from Fancistown (250km)
	3.1.3	Lean Concrete (G-20)	m3	0.0	1,250	1,166	1,140	1,250	
	3.1.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.1.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	15,248	12,000	15,248	
	3.1.6	Copper Wier incl. Accessories (200mm2)	m	0.0	20	446		446	
	3.1.7	Copper Load (D25mm L=3.0mm)	set	0.0	-	3,502		3,502	
	3.1.8	Frame Base (H-200mmx200mm t=8mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.1.9	Anchor Bolt (D22mm L=300mm)	set	0.0	225	240	750	240	
	3.1.10	Cinder Concrete (G-20)	m3	0.0	1,400	1,156	1,140	1,250	
	3.1.11	Template (L-200mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.1.12	Temporary Retaining Sheet for Collapse (type 3)	m2	0.0	-	20,000	30,000	30,000	
	3.2	**FGD Foundation**							
DWG No.3	3.2.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
DWG No.4	3.2.2	Gravel bedding for Replacement	m3	0.0	825	193	175	590	from Fancistown (250km)
	3.2.3	Lean Concrete (G-20)	m3	0.0	1,250	1,165	1,140	1,250	
	3.2.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.2.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	15,248	12,000	15,248	
	3.2.6	Copper Wier incl. Accessories (A=200mm2)	m	0.0	20	446		446	
	3.2.7	Copper Rod (D25mm L=3.0m)	set	0.0	-	3,502		3,502	
	3.2.8	Frame Base (H-200mmx200mm t=8mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.2.9	Anchor Bolt (D22mm L=300mm)	set	0.0		240	750	240	
	3.2.10	Cinder Concrete (G-20)	m3	0.0	1,400	1,156	1,140	1,250	
	3.2.11	Template (L-200mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.2.12	Temporary Retaining Sheet for Collapse	lot	0.0	-	20,000	30,000	30,000	
	3.3	**Supplemental Facility (Dehydranted Dryer)**							
DWG No.5	3.3.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
	3.3.2	Gravel bedding for Replacement	m3	0.0	825	193	175	590	from Fancistown (250km)
	3.3.3	Lean Concrete (G-20)	m3	0.0	1,250	1,166	1,140	1,250	
	3.3.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.3.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	15,248	12,000	12,000	
	3.3.6	Steel Structure	m2	0.0	5,000	21,735	25,000	25,000	
	3.3.7	Roof	m2	0.0	-	229			
	3.3.8	Wall	m2	0.0	-	261			
	3.4	**Supplemental Facility (Stockpile for Limestone)**							
DWG No.5	3.4.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
	3.4.2	Gravel bedding for Replacement	m3	0.0	825	193	175	590	from Fancistown (250km)
	3.4.3	Lean Concrete (G-20)	m3	0.0	1,250	1,166	1,140	1,250	
	3.4.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.4.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	15,248	12,000	15,248	
	3.4.6	Steel Structure	t	0.0	20,000	21,735	25,000	25,000	
	3.4.7	Roof	m2	0.0	5,000	229			
	3.4.8	Wall	m2	0.0		261			
	3.5	**Water Tank Foundation (200t)**							
DWG No.6	3.5.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
	3.5.2	Gravel bedding for Replacement	m3	0.0	825	193	175	590	from Fancistown (250km)
	3.5.3	Lean Concrete (G-20)	m3	0.0	1,250	1,166	1,140	1,250	
	3.5.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.5.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	15,248	12,000	15,248	
	3.2.8	Frame Base (H-200mmx200mm t=8mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.2.9	Anchor Bolt (D22mm L=300mm)	set	0.0	225	240		240	
	3.6	**Ducts**							
	3.6.1	Excavation/Backfilling	m3	0.0	50	235	135	135	
	3.6.2	Sand	m3	0.0	140	193	175	193	sand
	3.6.3	Lean Concrete (G-20)	m3	0.0	1,250	1,166	1,140	1,250	
	3.6.4	Concreting incl. Form Work (G-30)	m3	0.0	1,670	1,647	1,700	1,700	
	3.6.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	0.0	9,600	9,840	12,000	12,000	
	3.6.6	Mountaining Structure (H-100mm)	t	0.0	20,000	21,735	25,000	25,000	
	3.6.7	Anchor Bolt (D22mm L=300mm)	t	0.0	225	240			

Unit Cost Comparison

Ref. No.	Item No.	Items of Work	Unit	Qty.	A Unit Cost	B Unit Cost	C Unit Cost	Reasonable	Remark
	3.7	**Condenser for water cooling**							
	3.7.1	Strengthen Steel Structure	t	0.0	20,000	21,735	25,000	25,000	
	3.7.2	Supply and Processing	lot	0.0				2,500	0
	3.7.3	Delivery and Erection	lot	0.0				5,000	0
	3.7.4	Foundation (500mmx500mmx300mm)	set	0.0	1,670	1,647		1,700	
	3.7.5	Water proofing (Bitumious membrane 3 layers)	m2	0.0	220	471		471	
	3.8	**Repair of Existing Concrete Structures**							
	3.8.1	Chipping	m2	0.0		109		109	
	3.8.2	Epoxy Injection	m2	0.0		4,216		4,216	
	3.8.3	Carbon Fiber Bonding (t=3mm)	m2	0.0		6,762		6,762	
	4.1	**Premises Road for FGD**							
	3.8.1	Excavation	m3	0.0	15	235	135	135	
	3.8.2	Gravel bedding	m3	0.0	68	193	175	590	from Fancistown (250km)
	3.8.3	Sub Base Course (t=300mm)	m2	0.0	86	58	150	150	
	3.8.4	Base Course (t=150mm)	m3	0.0	92	193	175	175	
	3.8.5	Concrete Surface incl. Form Work	m3	0.0	1,300	1,647	1,700	1,700	
	3.8.6	Tai Bar	set	0.0	800	21,735	12,000	800	
	3.5.7	Curb Stone	m	0.0	180	2,492	1,700	1,700	
	4.2	**Cable Trench (Type A for Control)**							
	4.2.1	Excavation/Backfilling	m3	0.0	50	235		135	
	4.2.2	Sand	m3	0.0	140	193		193	Sand
	4.2.3	Lean Concrete	m3	0.0		1,166		1,250	
	4.2.4	Concreting (incl. Form Work)	m3	0.0		1,647		1,700	
	4.2.5	Reinforcing Bar	t	0.0		15,248		25,000	
	4.3	**Cable Treanch (Type B for Power)**							
	4.3.1	Excavation/Backfilling	m3	0.0	50	235		135	
	4.3.2	Gravel bedding	m3	0.0	140	193		590	from Fancistown (250km)
	4.3.3	Lean Concrete	m3	0.0		1,166		1,250	
	4.3.4	Concreting (incl. Form Work)	m3	0.0		1,647		1,700	
	4.3.5	Reinforcing Bar	t	0.0		15,248		25,000	
	4.4	**Drainage (300mmx300mm)**							
	4.4.1	Excavation/Backfilling	m3	0.0	50	235		135	
	4.4.2	Gravel bedding	m3	0.0	140	193		590	from Fancistown (250km)
	4.4.3	Lean Concrete	m3	0.0		1,166		1,250	
	4.4.4	Concreting (incl. Form Work)	m3	0.0		1,647		1,700	
	4.4.5	Reinforcing Bar	t	0.0		15,248		25,000	
	5	**Other**							
	8.1.2	Water Proofing for Fuel oil station	m2	0.0	220	470		470	
	8.1.3	Water Proofing for Local pumping and treatment station	m2	0.0	220	470		470	
	8.1.4	Demineralizing plant	m2	0.0		175		175	
	10	**Day Works**	day		477			477	
					Total		**VAT 12%**		
							Escalation 7%		

Appendix 5-10 Unit Cost Comparison

Bill of Quantity (Civil)

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Item No.	Items of Work	Unit	Qty.	Unit Cost	Amount	Remark
1	Preliminary and General					
1.1	General Item	l.s.				
1.2	Mobilization & Demobilization	l.s.			1,000,000	(2.0%)
1.3	Contrctor's Temporary Facilities	l.s.				Civil Works
1.4	Additional Survey	l.s.	0	-		3.0M/3.0M
1.5	Additional Soil Investigation	l.s.	0	-		
	Sub-total				1,000,000	
2	Demolishing & Removal					
2.1	ESP Foundation (Concrete)	m3	520	750	390,000	
2.2	Existing Road for Access Road	m3	10	120	1,200	
	Sub-total				410,000	
3	Lot 1 (#3,#4 Works)					
3.1	FGD/ESP Foundation					
3.1.1	Excavation/Backfilling	m3	1,532	135	206,861	
3.1.2	Gravel bedding for Replacement	m3	0	590		Transpotation
3.1.3	Lean Concrete (G-15)	m3	1,226	1,250	1,532,250	SRC
3.1.4	Concreting incl. Form Work (G-30)	m3	372	1,700	632,230	SRC
3.1.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	30	15,248	452,866	
3.1.6	Copper Wier incl. Accessories (200mm2)	m	152	446	67,881	
3.1.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.1.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.1.9	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
3.1.10	Cinder Concrete (G-20)	m3		1,250		
3.1.11	Template (L-200mm)	t		25,000		
3.1.12	Temporary Retaining Sheet for Collapse	m2	775	20,000	15,494,000	Sheet Pile
	Sub-total				18,400,095	
3.2	Dryer Facilities FND					
3.2.1	Excavation/Backfilling	m3	2,241	135	302,535	
3.2.2	Gravel bedding for Replacement	m3	1,904	590	1,123,360	
3.2.3	Lean Concrete (G-15)	m3	63	1,250	78,500	
3.2.4	Concreting incl. Form Work (G-30)	m3	240	1,700	408,000	
3.2.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	19	15,248	292,762	
3.2.6	Copper Wier incl. Accessories (200mm2)	m	78	446	34,788	
3.2.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.2.8	Frame Base (H-200mmx200mm t=8mm)	t		25,000	0	
3.2.9	Anchor Bolt (D22mm L=300mm)	set		240	0	
3.2.10	Cinder Concrete (G-20)	m3	60	1,250	75,000	
3.2.11	Template (L-200mm)	t	0	25,000	0	
3.2.12	Temporary Retaining Sheet for Collapse (type	m2	0	20,000	0	
	Sub-total				2,328,953	
3.3	Supplimental FND					
3.3.1	Excavation/Backfilling	m3	3,895	135	525,798	
3.3.2	Gravel bedding for Replacement	m3	3,344	590	1,972,960	
3.3.3	Lean Concrete (G-15)	m3	124	1,250	155,000	
3.3.4	Concreting incl. Form Work (G-30)	m3	480	1,700	816,000	
3.3.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	38	15,248	585,523	
3.3.6	Copper Wier incl. Accessories (200mm2)	m	108	446	48,168	
3.3.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.3.8	Frame Base (H-200mmx200mm t=8mm)	t		25,000	0	
3.3.9	Anchor Bolt (D22mm L=300mm)	set		240	0	
3.3.10	Cinder Concrete (G-20)	m3	0	1,250	0	
3.3.11	Template (L-200mm)	t	0	25,000	0	
3.3.12	Temporary Retaining Sheet for Collapse (type	m2	0	20,000	0	
	Sub-total				4,117,457	

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Item No.	Items of Work	Unit	Qty.	Unit Cost	Amount	Remark
3.4	Water Tank FND					
3.4.1	Excavation/Backfilling	m3	1,037	135	140,036	
3.4.2	Gravel bedding for Replacement	m3	864	590	509,760	
3.4.3	Lean Concrete (G-15)	m3	22	1,250	27,000	
3.4.4	Concreting incl. Form Work (G-30)	m3	80	1,700	136,000	
3.4.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	6	15,248	97,587	
3.4.6	Copper Wier incl. Accessories (200mm2)	m	41	446	18,197	
3.4.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.4.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.4.9	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
3.4.10	Cinder Concrete (G-20)	m3	0	1,250	0	
3.4.11	Template (L-200mm)	t	0	25,000	0	
3.4.12	Temporary Retaining Sheet for Collapse (type	m2	0	20,000	0	
	Sub-total				942,588	
3.5	Control Building					
3.5.1	Building (10m × 5m)	m2	50	10,000	500,000	
3.5.2	Window (2m × 1m)	set	1	4,000	4,000	
3.5.3	Door (1m × 2m)	set	1	5,000	5,000	
	Sub-total				509,000	
3.6	Duct FND (#3/#4)					
3.6.1	Excavation/Backfilling	m3	480	135	64,800	
3.6.2	Gravel bedding for Replacement	m3	0	590	0	
3.6.3	Lean Concrete (G-15)	m3	10	1,250	12,000	
3.6.4	Concreting incl. Form Work (G-30)	m3	252	1,700	427,550	
3.6.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	20	15,248	308,010	
3.6.6	Copper Wier incl. Accessories (200mm2)	m	0	446	0	
3.6.7	Copper Load (D25mm L=3.0mm)	set	0	3,502	0	
3.6.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.6.9	Anchor Bolt (D22mm L=300mm)	set	40	240	9,600	
	Sub-total				821,960	
	Total Lot 1				27,120,052	
4	Lot 2 (#1,#2 Works)					
4.1	FGD/ESP Foundation					
4.1.1	Excavation/Backfilling	m3	1,684	135	227,354	
4.1.2	Gravel bedding for Replacement	m3	0	590		Transpotation
4.1.3	Lean Concrete (G-15)	m3	1,347	1,250	1,684,125	SRC
4.1.4	Concreting incl. Form Work (G-30)	m3	372	1,700	632,060	SRC
4.1.4	Reinforcing Bar (G-450 for Sulfer Resistance)	t	30	15,248	452,866	
4.1.5	Copper Wier incl. Accessories (200mm2)	m	116	446	51,736	
4.1.6	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
4.1.7	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
4.1.8	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
4.1.9	Cinder Concrete (G-20)	m3		1,250		
4.1.10	Template (L-200mm)	t		25,000		
4.1.11	Temporary Retaining Sheet for Collapse	m2	675	20,000	13,500,000	Sheet Pile
	Sub-total				16,562,148	
4.2	Control Building					
4.2.1	Building (10m × 5m)	m2	50	10,000	500,000	
4.2.2	Window (2m × 1m)	set	1	4,000	4,000	
4.2.3	Door (1m × 2m)	set	1	5,000	5,000	
	Sub-total				509,000	

Appendix 5-10 Unit Cost Comparison

Bill of Quantity (Civil)

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Item No.	Items of Work	Unit	Qty.	Unit Cost	Amount	Remark
4.3	**Duct FND (#1/#2)**					
4.3.1	Excavation/Backfilling	m3	480	135	64,800	
4.3.2	Gravel bedding for Replacement	m3	0	590	0	
4.3.3	Lean Concrete (G-15)	m3	10	1,250	12,000	
4.3.4	Concreting incl. Form Work (G-30)	m3	252	1,700	427,550	
4.3.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	20	15,248	308,010	
4.3.6	Copper Wier incl. Accessories (200mm2)	m	0	446	0	
4.3.7	Copper Load (D25mm L=3.0mm)	set	0	3,502	0	
4.3.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
4.3.9	Anchor Bolt (D22mm L=300mm)	set	40	240	9,600	
	Sub-total				821,960	
4.4	**Control Cable Trench (300m)**					
4.4.1	Excavation/Backfilling	m3	315	135	42,525	
4.4.2	Gravel bedding for Replacement	m3	0	590	0	
4.4.3	Lean Concrete (G-15)	m3	51	1,250	63,750	
4.4.4	Precast Concrete (l=1.2m)	Nos.	250	970	242,500	
	Sub-total				348,775	
4.5	**Power Cable Trench (100m)**					
4.5.1	Excavation/Backfilling	m3	105	135	14,175	
4.5.2	Gravel bedding for Replacement	m3	0	590	0	
4.5.3	Lean Concrete (G-15)	m3	17	1,250	21,250	
4.5.4	Precast Concrete (l=1.2m)	Nos.	84	970	81,480	
	Sub-total				116,905	
4.6	**Drainage (L=500)**					
4.6.1	Excavation/Backfilling	m3	105	135	14,175	
4.6.2	Gravel bedding for Replacement	m3	0	590	0	
4.6.3	Lean Concrete (G-15)	m3	17	1,250	21,250	
4.6.4	Precast Concrete (l=1.2m)	Nos.	84	970	81,480	
	Sub-total				116,905	
	Total Lot 2				**18,475,693**	
5	Others					
5.1	**Improvement Structure (Condenser)**					
5.1.1	Strength Supporting Structure (G-460)	t	10	25,000	250,000	
5.1.2	Processing & Supply	l.s.			50,000	20%
5.1.3	Delivery & Erection	l.s.			25,000	10%
5.1.4	Basement	t	3	25,000	75,000	
	Sub-total				400,000	
5.2	**Premises Road (W=5m L=20m)**					
5.2.1	Excavation/Backfilling	m3	96	135	12,960	
5.2.2	Sub Base Course (t=300mm)	m3	36	590	21,240	
5.2.3	Base Course (t=300mm)	m3	36	590	21,240	
5.2.4	Concrete Surface (t=200mm)	m3	24	1,700	40,800	
5.2.5	Tai Bar	set	6	240	1,440	
5.2.6	Curb Stone (L=0.6m)	Nos.	84	120	10,080	
	Sub-total				107,760	
5.3	**Water Proofing**					
5.3.1	Turbin Building	m2	2,240	470	1,052,800	
5.3.2	Fuel Oil Station	m2	20	470	9,400	
5.3.3	Local Pumping & Treatment Building	m2	20	470	9,400	
	Sub-total				1,071,600	
5.4	**Epoxy Coarting for Concrete Structure**					
5.4.1	Chipping	m2	10	110	1,100	
5.4.2	Epoxy injection	m2	10	4,215	42,150	
5.4.3	Carbon Fiber Bonding (t=3mm)	m2	10	6,762	67,620	
	Sub-total				110,870	
	Total Others				1,690,230	
	Ground Total				**48,695,975**	**¥633,047,674**

Cost estimation for Civil Works

As a result of unit price for civil works, the evaluation have studied through three contractors which has experience of power plant in Botswana in order to obtain concerning local manner and information for civil works. The quotation of civil works is calculated by the adequate price is tabulated the following. (Appendix 5-9)

Item	Amount	Remark
Preliminary and General	P.1,000,000/lot	
Demolition of site	P.500,000/lot	
Lot 1 (for No.3 and No.4)	P.23,515,634	
Lot 2 (for No.1 and No.2)	P.16,048,742	
Others civil works	P.1,179,360	
Total	**P.42,078,737**	**Approx. 4 % of Total Cost**
VAT (12%)	P. 5,049,448	
Grand Total	**P.47,128,185**	**Escalation 7% per year**

	Bill of Quantity (Civil)					10 Aug. 2011
Item No.	Items of Work	Unit	Qty.	Unit Cost	Amount	Remark
1	Preliminary and General					
1.1	General Item	l.s.				
1.2	Mobilization & Demobilization	l.s.			1,000,000	(2.0%)
1.3	Contrctor's Temporary Facilities	l.s.				Civil Works
1.4	Additional Survey	l.s.	0	-		3.0M/3.0M
1.5	Additional Soil Investigation	l.s.	0	-		
	Sub-total				1,000,000	
2	Demolishing & Removal					
2.1	ESP Foundation (Concrete)	m3	520	750	390,000	
2.2	Existing Road for Access Road	m3	10	120	1,200	
	Sub-total				410,000	
3	Lot 1 (#3,#4 Works)					
3.1	FGD/ESP Foundation					
3.1.1	Excavation/Backfilling	m3	1,532	135	206,861	
3.1.2	Gravel bedding for Replacement	m3	0	590		Transpotation
3.1.3	Lean Concrete (G-15)	m3	1,226	1,250	1,532,250	SRC
3.1.4	Concreting incl. Form Work (G-30)	m3	372	1,700	632,230	SRC
3.1.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	30	15,248	452,866	
3.1.6	Copper Wier incl. Accessories (200mm2)	m	152	446	67,881	
3.1.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.1.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.1.9	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
3.1.10	Cinder Concrete (G-20)	m3		1,250		
3.1.11	Template (L-200mm)	t		25,000		
3.1.12	Temporary Retaining Sheet for Collapse	m2	775	20,000	15,494,000	Sheet Pile
	Sub-total				18,400,095	
3.2	Dryer Facilities FND					
3.2.1	Excavation/Backfilling	m3	2,241	135	302,535	
3.2.2	Gravel bedding for Replacement	m3	1,904	590	1,123,360	
3.2.3	Lean Concrete (G-15)	m3	63	1,250	78,500	
3.2.4	Concreting incl. Form Work (G-30)	m3	240	1,700	408,000	
3.2.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	19	15,248	292,762	
3.2.6	Copper Wier incl. Accessories (200mm2)	m	78	446	34,788	
3.2.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.2.8	Frame Base (H-200mmx200mm t=8mm)	t		25,000	0	
3.2.9	Anchor Bolt (D22mm L=300mm)	set		240	0	
3.2.10	Cinder Concrete (G-20)	m3	60	1,250	75,000	
3.2.11	Template (L-200mm)	t	0	25,000	0	
3.2.12	Temporary Retaining Sheet for Collapse (type 3)	m2	0	20,000	0	
	Sub-total				2,328,953	
3.3	Supplimental FND					
3.3.1	Excavation/Backfilling	m3	3,895	135	525,798	
3.3.2	Gravel bedding for Replacement	m3	3,344	590	1,972,960	
3.3.3	Lean Concrete (G-15)	m3	124	1,250	155,000	
3.3.4	Concreting incl. Form Work (G-30)	m3	480	1,700	816,000	
3.3.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	38	15,248	585,523	
3.3.6	Copper Wier incl. Accessories (200mm2)	m	108	446	48,168	
3.3.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.3.8	Frame Base (H-200mmx200mm t=8mm)	t		25,000	0	
3.3.9	Anchor Bolt (D22mm L=300mm)	set		240	0	
3.3.10	Cinder Concrete (G-20)	m3	0	1,250	0	
3.3.11	Template (L-200mm)	t	0	25,000	0	
3.3.12	Temporary Retaining Sheet for Collapse (type 3)	m2	0	20,000	0	
	Sub-total				4,117,457	

3.4	**Water Tank FND**					
3.4.1	Excavation/Backfilling	m3	1,037	135	140,036	
3.4.2	Gravel bedding for Replacement	m3	864	590	509,760	
3.4.3	Lean Concrete (G-15)	m3	22	1,250	27,000	
3.4.4	Concreting incl. Form Work (G-30)	m3	80	1,700	136,000	
3.4.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	6	15,248	97,587	
3.4.6	Copper Wier incl. Accessories (200mm2)	m	41	446	18,197	
3.4.7	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
3.4.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.4.9	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
3.4.10	Cinder Concrete (G-20)	m3	0	1,250	0	
3.4.11	Template (L-200mm)	t	0	25,000	0	
3.4.12	Temporary Retaining Sheet for Collapse (type 3)	m2	0	20,000	0	
	Sub-total				942,588	
3.5	**Control Building**					
3.5.1	Building (10m×5m)	m2	50	10,000	500,000	
3.5.2	Window (2m×1m)	set	1	4,000	4,000	
3.5.3	Door (1m×2m)	set	1	5,000	5,000	
	Sub-total				509,000	
3.6	**Duct FND (#3/#4)**					
3.6.1	Excavation/Backfilling	m3	480	135	64,800	
3.6.2	Gravel bedding for Replacement	m3	0	590	0	
3.6.3	Lean Concrete (G-15)	m3	10	1,250	12,000	
3.6.4	Concreting incl. Form Work (G-30)	m3	252	1,700	427,550	
3.6.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	20	15,248	308,010	
3.6.6	Copper Wier incl. Accessories (200mm2)	m	0	446	0	
3.6.7	Copper Load (D25mm L=3.0mm)	set	0	3,502	0	
3.6.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
3.6.9	Anchor Bolt (D22mm L=300mm)	set	40	240	9,600	
	Sub-total				821,960	
	Total Lot 1				**27,120,052**	
4	**Lot 2 (#1,#2 Works)**					
4.1	**FGD/ESP Foundation**					
4.1.1	Excavation/Backfilling	m3	1,684	135	227,354	
4.1.2	Gravel bedding for Replacement	m3	0	590		Transpotation
4.1.3	Lean Concrete (G-15)	m3	1,347	1,250	1,684,125	SRC
4.1.4	Concreting incl. Form Work (G-30)	m3	372	1,700	632,060	SRC
4.1.4	Reinforcing Bar (G-450 for Sulfer Resistance)	t	30	15,248	452,866	
4.1.5	Copper Wier incl. Accessories (200mm2)	m	116	446	51,736	
4.1.6	Copper Load (D25mm L=3.0mm)	set	4	3,502	14,008	
4.1.7	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
4.1.8	Anchor Bolt (D22mm L=300mm)	set	0	240	0	
4.1.9	Cinder Concrete (G-20)	m3		1,250		
4.1.10	Template (L-200mm)	t		25,000		
4.1.11	Temporary Retaining Sheet for Collapse	m2	675	20,000	13,500,000	Sheet Pile
	Sub-total				16,562,148	
4.2	**Control Building**					
4.2.1	Building (10m×5m)	m2	50	10,000	500,000	
4.2.2	Window (2m×1m)	set	1	4,000	4,000	
4.2.3	Door (1m×2m)	set	1	5,000	5,000	
	Sub-total				509,000	

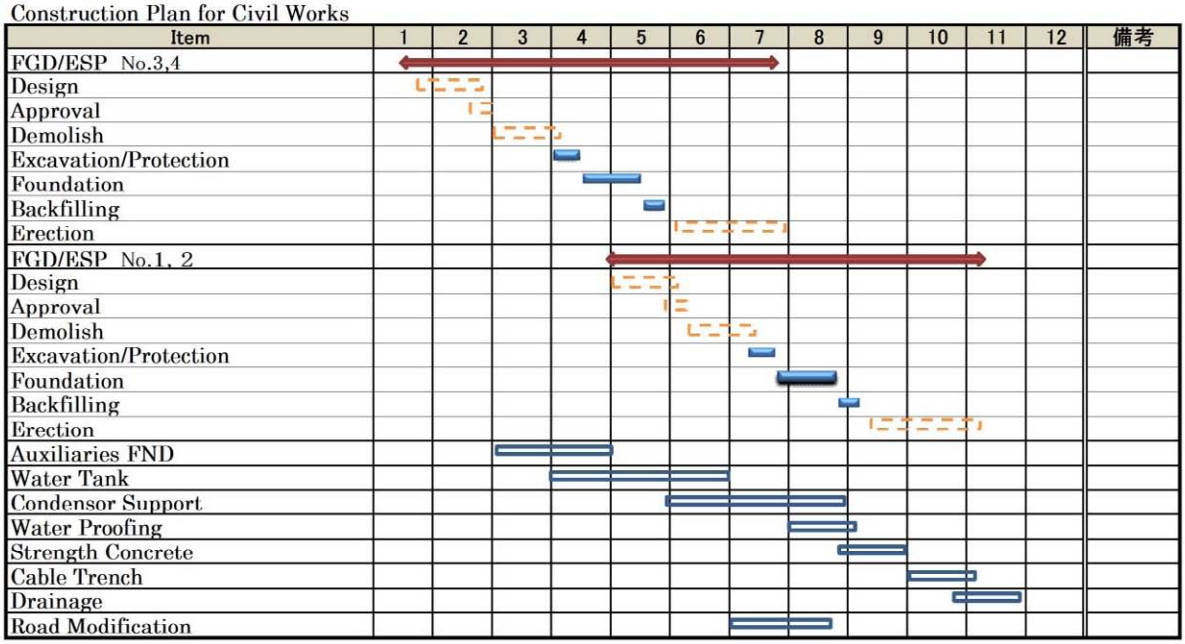
Appendix 5-11 Cost Estimation (4/4)

4.3	**Duct FND (#1/#2)**					
4.3.1	Excavation/Backfilling	m3	480	135	64,800	
4.3.2	Gravel bedding for Replacement	m3	0	590	0	
4.3.3	Lean Concrete (G-15)	m3	10	1,250	12,000	
4.3.4	Concreting incl. Form Work (G-30)	m3	252	1,700	427,550	
4.3.5	Reinforcing Bar (G-450 for Sulfer Resistance)	t	20	15,248	308,010	
4.3.6	Copper Wier incl. Accessories (200mm2)	m	0	446	0	
4.3.7	Copper Load (D25mm L=3.0mm)	set	0	3,502	0	
4.3.8	Frame Base (H-200mmx200mm t=8mm)	t	0	25,000	0	
4.3.9	Anchor Bolt (D22mm L=300mm)	set	40	240	9,600	
	Sub-total				821,960	
4.4	**Control Cable Trench (300m)**					
4.4.1	Excavation/Backfilling	m3	315	135	42,525	
4.4.2	Gravel bedding for Replacement	m3	0	590	0	
4.4.3	Lean Concrete (G-15)	m3	51	1,250	63,750	
4.4.4	Precast Concrete (l=1.2m)	Nos.	250	970	242,500	
	Sub-total				348,775	
4.5	**Power Cable Trench (100m)**					
4.5.1	Excavation/Backfilling	m3	105	135	14,175	
4.5.2	Gravel bedding for Replacement	m3	0	590	0	
4.5.3	Lean Concrete (G-15)	m3	17	1,250	21,250	
4.5.4	Precast Concrete (l=1.2m)	Nos.	84	970	81,480	
	Sub-total				116,905	
4.6	**Drainage (L=500)**					
4.6.1	Excavation/Backfilling	m3	105	135	14,175	
4.6.2	Gravel bedding for Replacement	m3	0	590	0	
4.6.3	Lean Concrete (G-15)	m3	17	1,250	21,250	
4.6.4	Precast Concrete (l=1.2m)	Nos.	84	970	81,480	
	Sub-total				116,905	
	Total Lot 2				**18,475,693**	
5	**Others**					
5.1	**Improvement Structure (Condenser)**					
5.1.1	Strength Supporting Structure (G-460)	t	10	25,000	250,000	
5.1.2	Processing & Supply	l.s.			50,000	20%
5.1.3	Delivery & Erection	l.s.			25,000	10%
5.1.4	Basement	t	3	25,000	75,000	
	Sub-total				400,000	
5.2	**Premises Road (W=5m L=20m)**					
5.2.1	Excavation/Backfilling	m3	96	135	12,960	
5.2.2	Sub Base Course (t=300mm)	m3	36	590	21,240	
5.2.3	Base Course (t=300mm)	m3	36	590	21,240	
5.2.4	Concrete Surface (t=200mm)	m3	24	1,700	40,800	
5.2.5	Tai Bar	set	6	240	1,440	
5.2.6	Curb Stone (L=0.6m)	Nos.	84	120	10,080	
	Sub-total				107,760	
5.3	**Water Proofing**					
5.3.1	Turbin Building	m2	2,240	470	1,052,800	
5.3.2	Fuel Oil Station	m2	20	470	9,400	
5.3.3	Local Pumping & Treatment Building	m2	20	470	9,400	
	Sub-total				1,071,600	
5.4	**Epoxy Coarting for Concrete Structure**					
5.4.1	Chipping	m2	10	110	1,100	
5.4.2	Epoxy injection	m2	10	4,215	42,150	
5.4.3	Carbon Fiber Bonding (t=3mm)	m2	10	6,762	67,620	
	Sub-total				110,870	
	Total Others				1,690,230	
	Ground Total				**48,695,975**	**¥633,047,674**

Construction Schedule for Civil works

The construction schedule for civil works will be estimated 3 month in case of Lot 1 and other three months for Lot 2 including the foundation curing. The work process is considered for the preparation for site (one week), excavation including protection (one week), foundation works including fabrication of re-bar and form work (one week), concrete curing (four weeks), anchor setting and backfilling (one week). Total works for the foundation is necessary at least 3 months. The following is civil works for each item including Lot 1, Lot 2 and these supplemental facilities.

Construction Plan for Civil Works



BAUER CONSULT (Pty) Ltd

MORUPULE A – POWER STATION A REHABILITATION AND POLLUTION ABATEMENT
Ground Investigation Report

April 2011
AJH/008/2011

Material Testing Services (Pty) Ltd

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CONTENTS

FIGURES

TABLES

APPENDIX

1.0 INTRODUCTION

Bauer Consult (Pty) Ltd have appointed Material Testing Services (Pty) Ltd to undertake a ground investigation for the proposed Rehabilitation and Pollution Abatement to be carried out at the Morupule A Power Station A. Material Testing Services (Pty) Ltd have appointed A J Hammond and Associates to write the report on the investigation based on the results of the fieldwork and laboratory tests.

This report summarises the findings of the investigations and makes recommendations for the construction of foundations and the subgrade preparation beneath the surface beds.

2.0 INFORMATION AVAILABLE

The following information was made available:

i) The profiles of four test pits.

ii) The results of six combined DPSH and SPT test results.

iii) The results of six foundation indicator tests with natural moisture content determinations.

iv) The results of two complete California Bearing Ratio tests with normal indicator tests.

v) The results of two Consolidometer Tests.

vi) Site Sketch showing the positions of the test pits and combined DPSH and SPT tests.

vii) Site Description prepared by Material Testing Services (Pty) Ltd.

3.0 PROPOSED DEVELOPMENT

The proposed development will comprise the construction of a number of lightly loaded pipe rack bases with bearing pressures of less than 50kN/m^2. Additional equipment to be mounted on plinths with bearing pressures of less than 100 kN/m^2. There will also be heavy equipment with total loads of about 1500 kN which if placed on a solid base under wind loads will have contact stresses of about 300 kN/m^2.

4.0 THE SITE

The site is on the construction platform of the existing Morupule A Power Station A, there is an existing power plant as well as workshops and offices see Figure 1. It is important to note that there are numerous buried services as well as overhead power lines.

5.0 FIELD INVESTIGATION

The fieldwork undertaken comprised the excavation of four test pits with a TLB hired by MTS. The test pits excavated were inspected and the soil strata encountered described using standard terminology (Jennings, Brink and Williams, 1973). In addition to the test pits six combined Dynamic Probe Super heavy (DPSH) and Standard Penetration (SPT) tests were carried out. The plan positions of the pits and tests are shown on the site plan, Figure 1. Representative samples were taken from the sides of the test pits for laboratory testing.

6.0 GEOLOGY

The site, which is underlain at depth by sediments of the Karroo Supergroup, has been shown to be underlain by transported soils, overlying residual sandstone and sandstone bedrock.

The following soil and rock horizons were observed in the test pits:

Transported: The natural transported soil was seen to be a slightly moist orange brown loose to medium dense fine silty SAND which occurred to depths of between 2,25 m and 3,1 m.

Residual Sandstone: The underlying sandstone bedrock has weathered to a slightly moist cream white becoming reddish brown mottled white medium dense medium grained sandstone GRAVEL coated in calcrete with fine sand and traces of silcrete gravel and becoming less calcretised with depth. This horizon occurred to depths of between 3,9 m and 4,85 m.

Sandstone Bedrock: The sandstone bedrock was a reddish brown very soft rock which rapidly became a reddish brown speckled black hard rock or very ard rock on which the TLB refused at between 4,3 m and 4,9 m.

Groundwater was not found in any of the pits.

7.0 FIELD AND LABORATORY TESTING

7.1 Field Testing

The field testing comprised the performance of six combined Dynamic Probe Super-heavy (DPSH) and Standard Penetration (SPT) tests. These tests consisted of driving the DPSH cone and then replacing the cone with the Raymond Spoon used for the Standard Penetration test to undertake an SPT test at 1,5m intervals. The results of these tests have been summarised in Table 1 below and the detailed results are attached in Appendix A.

Table 1 – Summary of DPSH and SPT Test Results

Depth (m)	Test 1 N	Test 2 N	Test 3 N	Test 4 N	Test 5 N	Test 6 N
O,3	56	80	46	45	51	80
0,6	35	71	29	61	48	89
0,9	10	80	12	26	22	24

1,2	8	26	10	14	14	12
1,5	9	14	9	12	15	11
1,8	15	13	10	12	16	12
2,25	15	11	7	12	12	11
2,55	37	11	24	12	8	11
2,85	52	10	64	12	8	11
3,15	99	18	71	Ref 3,03	11	13
3,3	Ref 3,18	106	Ref 3,22		11	13
3,9		Ref 3,59			12	15
4,2					67	36
4,5					Ref 4,25	Ref 4,44

7.2 **Laboratory Testing**

The laboratory testing programme undertaken by MTS comprised the following:

- Particle size distribution by sieving
- Particle size distribution by hydrometer analysis
- Moisture density relationship at the modified AASHTO compactive effort
- California Bearing Ratio
- Consolidometer Tests

The results of these tests, which have been summarised in Table 2, showed that the transported soil was non plastic with grading moduli of 0,86 and 0,87, it classified as A.2.4 (0) in the USPRA classification system. The residual sandstone and sandstone were very similar, they were also non plastic but were much coarser grained with grading moduli of between 1,51 and 2,48. These soils classified as A.2.4 (0), A.1a (0) or A.1b (0).

The transported soil had maximum dry densities of 1854 kg/m^2 and 1889 kg/m^2 at optimum moisture contents of 6,6 % and 7,3 % respectively, with CBR values of 15 and 48 at 93% compaction, both samples classified as G7 materials.

Two Consolidometer tests were carried out on samples of the transported soil, the samples were soaked under a bedding load of 10 kPa and then loaded in increments to a maximum load of 1600 kPa and off loaded in decrements to 10 kPa. The results of these tests are summarised in Table 3 below:

Table 3 – Summary of Consolidometer Tests

Hole No.	Depth	Consistency	Initial Void Ratio	Strain % at 10 kPa	Strain % at 1600 kPa	E'_v kPa
TP 1	0 – 2,25	Loose to Medium Dense	0,9014	9,03	20,82	13 452
TP 3	0 – 2,7	Loose to Medium Dense	0,7797	7,91	21,34	11 839

8.0 EVALUATION AND RECOMMENDATIONS

8.1 Site Clearing and Grading

The site lies on the construction platform of the existing power station and no further site clearing will be required.

8.2 Excavations

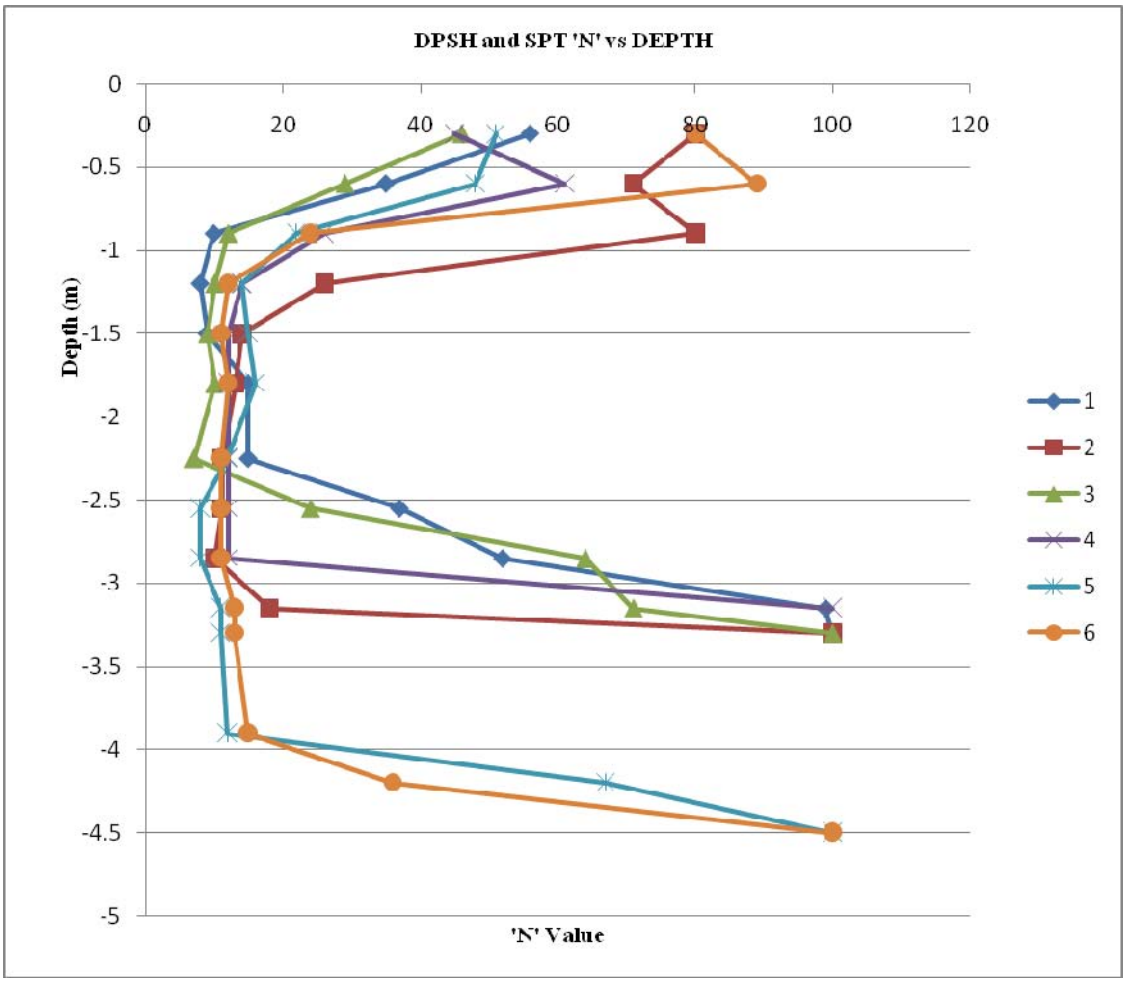
The transported and residual sandstone soils may be excavated with a TLB similar to that used in the investigation down to the depths attained in the test pits, namely 4,3 m to 4,9 m. Excavation in the sandstone bedrock below the depths of refusal of the excavator will require ripping and possibly blasting.

8.3 Foundations

8.3.1 General

The DPSH and SPT tests have been plotted on Figure 2 below:

Figure 2 – DPSH and SPT Tests vs Depth



From Figure 2 it can be seen that the surface of the construction platform has been toughened by desiccation and trafficking. The underlying soils are then of loose to medium dense or medium dense consistency with refusal occurring at depths of between 3,03 m and 4,44 m.

The consolidometer tests on the transported soil showed that when soaked at 10 kPa these samples strained by between 7,91% and 9,03%. They had drained moduli of elasticity of between 11 839 kPa and 13 452 kPa. These soils are considered to be both potentially collapsing and compressible, consequently they are not considered to be a suitable founding stratum in their natural state.

8.3.2 Lightly Loaded Pipe Rack and Machine Bases

The transported soils are considered to be potentially collapsing and compressible, consequently they are not considered to be suitable as a founding stratum in their natural state. We recommend that the lightly loaded Pipe Racks and the Plinths for the light machinery be founded on ground improvement.

Ground improvement involves destroying the collapsible fabric of the soils by either of the techniques which are described below:

Option 1 - Over-excavate and recompact

This option involves the excavation of the collapsing soil in an excavation 1,5B x 1,5L , where B and L are the width and length of the footing, to a depth of at least 1,5B below the bottom of the footing and replacement of the same material in 150mm thick layers compacted to the required founding depth. A compacted density of at least 95% of the modified AASHTO maximum dry density should be achieved in the recompacted layers below founding level, which will provide a suitable founding stratum for conventional footings. Compaction control testing should be carried out to ensure that the required compaction has been achieved. Allowable bearing pressures of up to 100kPa may then be placed on the compacted soils.

Option 2 - Soilcrete

An alternative to recompaction of the soils as outlined above is to excavate the foundation trench as described for Option 1, and backfill with soilcrete. Soilcrete is formed by mixing the sandy soils with cement in a concrete mixer and adding water to form a slurry which is poured into the foundation trenches, the entrapped air being removed by using a vibratory poker. For costing purposes, 5% cement by mass should be used, but this will have to be confirmed by laboratory testing.

Allowable bearing pressures of up to 100kPa may then be placed on the ground improvement.

8.3.3 Heavy Machine Bases

The transported soils have been shown to be between 2,25 m and 3,1 m thick. These soils will not be suitable as a founding stratum even after ground improvement unless the contact stresses can be limited to 100 kPa or less. We consider that for the more heavily loaded machine bases the most appropriate foundation solution would be to found on the very soft rock sandstone bedrock at depths of between 4,3 m and 4,9 m. For footings contact stresses of up to 1000 kPa may be used on the very soft rock. In view of the depth to the very soft rock consideration should be given to using an augered pile solution.

We recommend that all of the foundation excavations be inspected by a suitably qualified person to confirm that they have been taken down to the very soft rock.

8.4 **Surface Beds and Paved Pedestrian Areas**

The following subgrade preparation for surface beds and paved pedestrian areas at ground level is recommended:

i) Strip any vegetated soil to spoil.

ii) Rip the next 150mm of soil and recompact to 93% of the Modified AASHTO maximum dry density at the optimum moisture content (OMC) + or - 1%.

iii) Place additional make up layers, if required, of either transported soil obtained from excavations on site or a G7 material compacting each 150mm thick layer to 93% of the Mod AASHTO maximum dry density at OMC + or - 1%.

iv) Place a damp proof membrane and cast slabs free of the walls so that they are free to move "float" without applying load to the walls.

8.5 Roads and Paved Vehicle Areas

The subgrade beneath access roads and parking areas should be prepared in the same way as described in Section 8.4 above. The subbase and basecourse layers should be designed for the anticipated traffic loading.

8.6 Drainage

The sandy surface horizon of transported soil is expected to be well drained. These sandy soils are erodible, however, and care should be taken to prevent erosion taking place around structures by the provision of adequate drains and storm water control.

Although groundwater was not found in any of the test pits a perched groundwater table may be expected to form above the very soft rock sandstone after rain. We recommend that suitable precautions be taken in any excavation to ensure that a potential groundwater table is adequately catered for. Where shallow foundations may interrupt the flow of sub surface water particular care needs to be taken with the water proofing.

9.0 REFERENCES

1. Jennings, J.E., Brink, A.B.A. and Williams, A.A.B., 1973. Revised guide to soil profiling for engineering purposes in Southern Africa. Trans. SAICE., 151, 3-12.

SKETCH PLAN

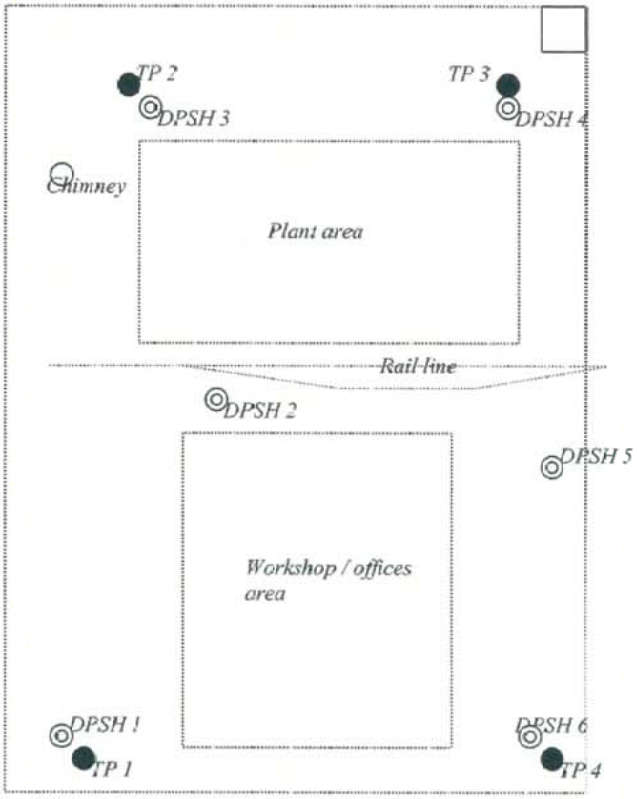

TP 2
TP 3
DPSH 3
DPSH 4
Chimney
Plant area
Rail line
DPSH 2
DPSH 5
Workshop / offices area
DPSH 1
DPSH 6
TP 1
TP 4
N

TABLE 2 : SUMMARY OF LABORATORY TEST RESULTS

TEST POSITION	DEPTH (m)	MATERIAL DESCRIPTION	ATTERBERG LIMITS			GRADING				PERCENTAGE FINER THAN (mm)			GM	CBR AT % MOD AASHTO				MDD (*) kg/m³	OMC (*) (%)	SPECIFIC GRAVITY SOILS	NMC (%)	CLASSIFICATION	
			LL	PI (*)	LS	CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	0,075	0,425	2,0		90	93	95	98					USPRA	TRH14
TP 1	0 - 2,25	Transported	NP	NP	-	17,9		82,1	0	17,9	96,0	100	0,86	42	48	51	55	1889	7,3	2.54	-	A.2.4 (0)	G7
TP 1	2,25 - 3,70	Residual Sandstone	NP	NP	-	3,5	8,2	38,4	49,9	11,7	40,2	50,1	1,98								11,2	A.1b (0)	
TP 1	3,70 - 3,90		-	-	-	-	-	-	-	-	-	-	-							2.59	-	-	-
TP 1	3,90 - 4,30	Sandstone	NP	NP	-	2,5	4,6	27,1	65,8	7,1	28,3	34,2	2,30								10,4	A.1a (0)	
TP 2	0,00 - 2,45		-	-	-	-	-	-	-	-	-	-	-							2.59			
TP 2	2,45 - 4,40		-	-	-	-	-	-	-	-	-	-	-							2.26			
TP 2	4,70 - 4,90	Sandstone	NP	NP	-	1,9	3,3	20,0	74,8	5,2	21,5	25,2	2,48								11,7	A.1a (0)	
TP 3	0 - 2,75	Transported	NP	NP	-	15,6		84,4	0	15,6	97,2	100	0,87	10	15	20	27	1854	6,6	-	-	A.2.4 (0)	G7
TP 3	2,75 - 4,00		-	-	-	-	-	-	-	-	-	-	-							2.37			
TP 3	4,0 - 4,2	Residual Sandstone	NP	NP	-	2,7	4,7	29,7	62,9	7,4	30,9	37,1	2,25								9,3	A.1b (0)	
TP 3	4,2 - 4,5	Sandstone	NP	NP	-	2,5	4,2	25,9	67,4	6,7	27,8	32,6	2,33								11,2	A.1a (0)	
TP 4	3,1 - 4,7	Residual Sandstone	NP	NP	-	5,4	12,9	51,4	30,3	18,3	60,9	69,7	1,51							2.19	11,9	A.2.4 (0)	

NOTE:

LL - LIQUID LIMIT
PI (*)- PLASTICITY INDEX (PI OF WHOLE SAMPLE)
LS - LINEAR SHRINKAGE
GM - GRADING MODULUS

OMC - OPTIMUM MOISTURE CONTENT
USPRA- UNITED STATES PUBLIC ROAD ADMINISTRATION
NMC - NATURAL MOISTURE CONTENT
MDD- MAXIMUM DRY DENSITY

Bauer Consult (Pty) Ltd

Morupule A Power Station A – Rehabilitation & Pollution Abatement

Detailed Test Pit Profiles

TP 1

0 – 2250	Slightly moist orange brown loose to medium dense fine silty SAND. Transported
2250 – 3700	Slightly moist cream white medium dense medium grained sand stone gravel coated in calcrete with fine sand and traces of silcrete gravel.
3700 – 3900	Slightly moist reddish brown mottled white medium dense medium grained weathered calcretised sand stone gravel.
3900 – 4300	Reddish brown very soft to soft ROCK sand stone.
4300 +	Nominal refusal on reddish brown spotted black hard ROCK sand stone fine to medium grained.

TP 2

0 – 2450	Slightly moist orange brown loose to medium dense fine silty SAND. Transported
2450 – 4400	Slightly moist cream white medium dense medium grained sand stone gravel coated in calcrete with fine sand and traces of silcrete gravel.
4400 – 4700	Slightly moist reddish brown mottled white medium dense medium grained weathered calcretised sand stone gravel.
4700 – 4900	Reddish brown very soft to soft ROCK sand stone.
4900 +	Nominal refusal on reddish brown spotted black hard ROCK sand stone fine to medium grained.

TP 3

0 – 2750	Slightly moist orange brown loose to medium dense fine silty SAND. Transported
2750 – 4000	Slightly moist cream white medium dense medium grained sand stone gravel coated in calcrete with fine sand and traces of silcrete gravel.
4000 – 4200	Slightly moist reddish brown mottled white medium dense medium grained weathered calcretised sand stone gravel.
4200 – 4500	Reddish brown very soft to soft ROCK sand stone.
4500 +	Nominal refusal on reddish brown spotted black hard ROCK sand stone fine to medium grained.

TP 4

0 – 3100	Slightly moist orange brown loose to medium dense fine silty SAND. Transported
3100 – 4700	Slightly moist cream white medium dense medium grained sand stone gravel coated in calcrete with fine sand and traces of silcrete gravel.
4700 – 4850	Slightly moist reddish brown medium dense medium grained weathered sand stone gravel.
4850	Reddish brown very soft to soft ROCK sand stone.
4300 +	Nominal refusal on reddish brown very hard ROCK sand stone fine to medium grained.

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DPSH AND SPT RECORD SHEET

FIELD DATA

TEST	DEPTH	BLOWS	TEST	DEPTH	BLOWS
CPT	0.3	56	CPT	5.55	
	0.6	35		5.85	
	0.9	10		6.15	
	1.2	8		6.45	
	1.5	9		-	
SPT	75	3	SPT	75	
	75	3		75	
	75	3		75	
	75	4 (N = 18)		75	
	75	4		75	
	75/1.95m	4		75/6.9m	
CPT	2.25	15	CPT	7.2	
	2.55	37		7.5	
	2.85	52		7.8	
	3.15	99		8.1	
SPT	75	50	SPT	75	
	75			75	
	75			75	
	75	(N = Refusal)		75	
	75	Refusal @ 3.18m		75	
	75/3.60m			75/8.55m	
CPT	3.9		CPT	8.85	
	4.2			9.15	
	4.5			9.45	
	4.8			9.75	
SPT	75		SPT	75	
	75			75	
	75			75	
	75			75	
	75			75	
	75/5.25m			75/8.55m	

HOLE NO / CHAINAGE: **Test No. 1**

PROJECT: **Morupule A Power Station A – Rehabilitation & Pollution Abatement**

CLIENT: **Bauer Consult (Pty) Ltd**

TECHNICIAN: **Joel** DATE: **14th April 2011**

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DPSH AND SPT RECORD SHEET

FIELD DATA

TEST	DEPTH	BLOWS	TEST	DEPTH	BLOWS
CPT	0.3	80	CPT	5.55	
	0.6	71		5.85	
	0.9	80		6.15	
	1.2	26		6.45	
	1.5	14		-	
SPT	75	4	SPT	75	
	75	4		75	
	75	3		75	
	75	3 (N = 17)		75	
	75	4		75	
	75/1.95m	3		75/6.9m	
CPT	2.25	11	CPT	7.2	
	2.55	11		7.5	
	2.85	10		7.8	
	3.15	18		8.1	
SPT	75	6	SPT	75	
	75	6		75	
	75	6		75	
	75	7 (N = Refusal)		75	
	75	43		75	
	75/3.60m	50		75/8.55m	
CPT	3.9	100	CPT	8.85	
	4.2	Refusal @ 3.59m		9.15	
	4.5			9.45	
	4.8			9.75	
SPT	75		SPT	75	
	75			75	
	75			75	
	75			75	
	75			75	
	75/5.25m			75/8.55m	

HOLE NO / CHAINAGE: **Test No. 2**

PROJECT: **Morupule A Power Station A – Rehabilitation & Pollution Abatement**

CLIENT: **Bauer Consult (Pty) Ltd**

TECHNICIAN: **Joel** DATE: **14th April 2011**