Table 9.9 Examination of Repayability of Project Loans (Case3-2)

Tariff rate=USc5.0/kWh; FC:LC=85%:15%; FC=5.0% p.a. (US$ million)

No.	Year	Power sales revenue	Loans received Foreign (85%)	Loans received Domestic (15%)	Total sources	Capital costs F.C.	Capital costs L.C.	Capital costs Total	O & M costs	Outstanding loan principal	Repayment of principal	Interest payment Foreign (5.0%)	Interest payment Domestic (13.0%)	Resources tax & VAT	Total uses	Current surplus	Corporate tax payment	Surplus after tax	Cumulative surplus	Year
1	2001		6.7	1.2	7.9	5.2	2.7	7.9		7.9				0.0	7.9	0.0	0.0	0.0	0.0	2001
2	2002		15.6	2.8	18.4	6.6	11.8	18.4		26.3				0.0	18.4	0.0	0.0	0.0	0.0	2002
3	2003		37.6	6.6	44.2	17.4	26.8	44.2		70.5				0.0	44.2	0.0	0.0	0.0	0.0	2003
4	2004		70.1	12.4	82.5	40.1	42.4	82.5		153.0				0.0	82.5	0.0	0.0	0.0	0.0	2004
5	2005		114.7	20.2	134.9	72.6	62.3	134.9		287.9				0.0	134.9	0.0	0.0	0.0	0.0	2005
6	2006		170.3	30.0	200.3	124.6	75.7	200.3		488.2				0.0	200.3	0.0	0.0	0.0	0.0	2006
7	2007		160.8	28.4	189.2	119.2	70.0	189.2		677.4				0.0	189.2	0.0	0.0	0.0	0.0	2007
8	2008	37.9	38.8	6.8	83.5	28.2	17.4	45.6	2.5	723.0				4.5	52.7	30.8	7.7	23.1	23.1	2008
9	2009	75.7	3.6	0.6	79.9	3.6	0.6	4.2	5.4	727.2				9.1	18.7	61.2	15.3	45.9	69.0	2009
10	2010	82.9			82.9				6.0	695.7	31.5	31.5	14.9	9.9	93.9	(11.0)	0.0	(11.0)	57.9	2010
11	2011	82.9			82.9				6.0	664.2	31.5	28.8	11.3	9.9	87.7	(4.8)	0.0	(4.8)	53.1	2011
12	2012	82.9			82.9				6.0	632.7	31.5	27.8	9.9	9.9	85.2	(2.4)	0.0	(2.4)	50.7	2012
13	2013	82.9			82.9				6.0	601.2	31.5	26.8	8.5	9.9	82.8	0.1	0.0	0.0	50.8	2013
14	2014	82.9			82.9				6.0	569.6	31.5	25.8	7.1	9.9	80.3	2.5	0.6	1.9	52.6	2014
15	2015	82.9			82.9				6.0	538.1	31.5	24.7	5.7	9.9	77.9	5.0	1.2	3.7	56.4	2015
16	2016	82.9			82.9				6.0	506.6	31.5	23.7	4.3	9.9	75.4	7.4	1.9	5.6	61.9	2016
17	2017	82.9			82.9				6.0	475.1	31.5	22.7	2.8	9.9	73.0	9.9	2.5	7.4	69.3	2017
18	2018	82.9			82.9				6.0	443.6	31.5	21.6	1.4	9.9	70.5	12.3	3.1	9.2	78.5	2018
19	2019	82.9			82.9				6.0	412.1	31.5	20.6	0.0	9.9	68.1	14.8	3.7	11.1	89.6	2019
20	2020	82.9			82.9				6.0	391.5	20.6	19.6	0.0	9.9	56.2	26.7	6.7	20.0	109.6	2020
21	2021	82.9			82.9				6.0	370.9	20.6	18.5	0.0	9.9	55.1	27.7	6.9	20.8	130.4	2021
22	2022	82.9			82.9				6.0	350.3	20.6	17.5	0.0	9.9	54.1	28.7	7.2	21.6	152.0	2022
23	2023	82.9			82.9				6.0	329.7	20.6	16.5	0.0	9.9	53.1	29.8	7.4	22.3	174.3	2023
24	2024	82.9			82.9				6.0	309.1	20.6	15.5	0.0	9.9	52.0	30.8	7.7	23.1	197.4	2024
25	2025	82.9			82.9				6.0	288.5	20.6	14.4	0.0	9.9	51.0	31.8	8.0	23.9	221.3	2025
26	2026	82.9			82.9				6.0	267.9	20.6	13.4	0.0	9.9	50.0	32.9	8.2	24.7	245.9	2026
27	2027	82.9			82.9				6.0	247.2	20.6	12.4	0.0	9.9	48.9	33.9	8.5	25.4	271.4	2027
28	2028	82.9			82.9				6.0	226.6	20.6	11.3	0.0	9.9	47.9	34.9	8.7	26.2	297.6	2028
29	2029	82.9			82.9			169.8	6.0	206.0	20.6	10.3	0.0	9.9	216.7	(133.8)	0.0	(133.8)	163.7	2029
30	2030	82.9			82.9				6.0	185.4	20.6	9.3	0.0	9.9	45.9	37.0	9.2	27.7	191.5	2030
31	2031	82.9			82.9				6.0	164.8	20.6	8.2	0.0	9.9	44.8	38.0	9.5	28.5	220.0	2031
32	2032	82.9			82.9				6.0	144.2	20.6	7.2	0.0	9.9	43.8	39.1	9.8	29.3	249.3	2032
33	2033	82.9			82.9				6.0	123.6	20.6	6.2	0.0	9.9	42.8	40.1	10.0	30.1	279.3	2033
34	2034	82.9			82.9				6.0	103.0	20.6	5.2	0.0	9.9	41.7	41.1	10.3	30.8	310.2	2034
35	2035	82.9			82.9				6.0	82.4	20.6	4.1	0.0	9.9	40.7	42.1	10.5	31.6	341.8	2035
36	2036	82.9			82.9				6.0	61.8	20.6	3.1	0.0	9.9	39.7	43.2	10.8	32.4	374.1	2036
37	2037	82.9			82.9				6.0	41.2	20.6	2.1	0.0	9.9	38.6	44.2	11.1	33.2	407.3	2037
38	2038	82.9			82.9				6.0	20.6	20.6	1.0	0.0	9.9	37.6	45.2	11.3	33.9	441.2	2038
39	2039	82.9			82.9				6.0	0.0	20.6	0.0	0.0	9.9	36.6	46.3	11.6	34.7	475.9	2039
40	2040	82.9			82.9				6.0	0.0	0.0	0.0	0.0	9.9	16.0	66.9	16.7	50.1	526.1	2040

Note: 1) Abbreviations:
F.C.: Foreign currency portion
L.C.: Local currency portion
2) Project construction cost:

	F.C.	L.C.	Total
Civil	176.9	182.4	359.3
Metal	150.6	19.2	169.8
Others	90.0	108.1	198.1
Total	417.5	309.7	727.2

Table 9.9 Examination of Repayability of Project Loans (Case3-3)

Tariff rate=USc5.0/kWh; FC:LC=85%:15%; FC=8.5% p.a.

(US$ million)

No.	Year	Power sales revenue	Loans received Foreign (85%)	Loans received Domestic (15%)	Total sources	Capital costs F.C.	Capital costs L.C.	Capital costs Total	O & M costs	Outstanding loan principal	Repayment of principal	Interest payment Foreign (8.5%)	Interest payment Domestic (13%)	Resources tax & VAT	Total uses	Current surplus	Corporate tax payment	Surplus after tax	Cumulative surplus	Year
1	2001		6.7	1.2	7.9	5.2	2.7	7.9		7.9				0.0	7.9	0.0	0.0	0.0	0.0	2001
2	2002		15.6	2.8	18.4	6.6	11.8	18.4		26.3				0.0	18.4	0.0	0.0	0.0	0.0	2002
3	2003		37.6	6.6	44.2	17.4	26.8	44.2		70.5				0.0	44.2	0.0	0.0	0.0	0.0	2003
4	2004		70.1	12.4	82.5	40.1	42.4	82.5		153.0				0.0	82.5	0.0	0.0	0.0	0.0	2004
5	2005		114.7	20.2	134.9	72.6	62.3	134.9		287.9				0.0	134.9	0.0	0.0	0.0	0.0	2005
6	2006		170.3	30.0	200.3	124.6	75.7	200.3		488.2				0.0	200.3	0.0	0.0	0.0	0.0	2006
7	2007		160.8	28.4	189.2	119.2	70.0	189.2		677.4				0.0	189.2	0.0	0.0	0.0	0.0	2007
8	2008	37.9	38.8	6.8	33.5	28.2	17.4	45.6	2.5	723.0				4.5	52.7	30.8	7.7	23.1	23.1	2008
9	2009	75.7	3.6	0.6	79.9	3.6	0.6	4.2	5.4	727.2				9.1	18.7	61.2	15.3	45.9	69.0	2009
10	2010	82.9			82.9				6.0	695.7	31.5	55.7	14.9	9.9	118.0	(35.2)	0.0	(35.2)	33.8	2010
11	2011	82.9			82.9				6.0	664.2	31.5	49.0	11.3	9.9	107.9	(25.0)	0.0	(25.0)	8.7	2011
12	2012	82.9			82.9				6.0	632.7	31.5	47.3	9.9	9.9	104.7	(21.9)	0.0	(21.9)	(13.1)	2012
13	2013	82.9			82.9				6.0	601.2	31.5	45.5	8.5	9.9	101.5	(18.7)	0.0	(18.7)	(31.8)	2013
14	2014	82.9			82.9				6.0	569.6	31.5	43.8	7.1	9.9	98.4	(15.5)	0.0	(15.5)	(47.3)	2014
15	2015	82.9			82.9				6.0	538.1	31.5	42.0	5.7	9.9	95.2	(12.3)	0.0	(12.3)	(59.7)	2015
16	2016	82.9			82.9				6.0	506.6	31.5	40.3	4.3	9.9	92.0	(9.2)	0.0	(9.2)	(68.9)	2016
17	2017	82.9			82.9				6.0	475.1	31.5	38.5	2.8	9.9	88.9	(6.0)	0.0	(6.0)	(74.9)	2017
18	2018	82.9			82.9				6.0	443.6	31.5	36.8	1.4	9.9	85.7	(2.8)	0.0	(2.8)	(77.7)	2018
19	2019	82.9			82.9				6.0	412.1	31.5	35.0	0.0	9.9	82.5	0.3	0.1	0.2	(77.5)	2019
20	2020	82.9			82.9				6.0	391.5	20.6	33.3	0.0	9.9	69.9	13.0	3.2	9.7	(67.7)	2020
21	2021	82.9			82.9				6.0	370.9	20.6	31.5	0.0	9.9	68.1	14.7	3.7	11.1	(56.7)	2021
22	2022	82.9			82.9				6.0	350.3	20.6	29.8	0.0	9.9	66.4	16.5	4.1	12.4	(44.3)	2022
23	2023	82.9			82.9				6.0	329.7	20.6	28.0	0.0	9.9	64.6	18.2	4.6	13.7	(30.6)	2023
24	2024	82.9			82.9				6.0	309.1	20.6	26.3	0.0	9.9	62.9	20.0	5.0	15.0	(15.6)	2024
25	2025	82.9			82.9				6.0	288.5	20.6	24.5	0.0	9.9	61.1	21.7	5.4	16.3	0.7	2025
26	2026	82.9			82.9				6.0	267.9	20.6	22.8	0.0	9.9	59.4	23.5	5.9	17.6	18.3	2026
27	2027	82.9			82.9				6.0	247.2	20.6	21.0	0.0	9.9	57.6	25.2	6.3	18.9	37.2	2027
28	2028	82.9			82.9				6.0	226.6	20.6	19.3	0.0	9.9	55.9	27.0	6.7	20.2	57.5	2028
29	2029	82.9			82.9			169.8	6.0	206.0	20.6	17.5	0.0	9.9	223.9	(141.1)	0.0	(141.1)	(83.6)	2029
30	2030	82.9			82.9				6.0	185.4	20.6	15.8	0.0	9.9	52.3	30.5	7.6	22.9	(60.7)	2030
31	2031	82.9			82.9				6.0	164.8	20.6	14.0	0.0	9.9	50.6	32.3	8.1	24.2	(36.5)	2031
32	2032	82.9			82.9				6.0	144.2	20.6	12.3	0.0	9.9	48.8	34.0	8.5	25.5	(11.0)	2032
33	2033	82.9			82.9				6.0	123.6	20.6	10.5	0.0	9.9	47.1	35.8	8.9	26.8	15.8	2033
34	2034	82.9			82.9				6.0	103.0	20.6	8.8	0.0	9.9	45.3	37.5	9.4	28.1	43.9	2034
35	2035	82.9			82.9				6.0	82.4	20.6	7.0	0.0	9.9	43.6	39.3	9.8	29.4	73.4	2035
36	2036	82.9			82.9				6.0	61.8	20.6	5.3	0.0	9.9	41.8	41.0	10.3	30.8	104.1	2036
37	2037	82.9			82.9				6.0	41.2	20.6	3.5	0.0	9.9	40.1	42.8	10.7	32.1	136.2	2037
38	2038	82.9			82.9				6.0	20.6	20.6	1.8	0.0	9.9	38.3	44.5	11.1	33.4	169.6	2038
39	2039	82.9			82.9				6.0	0.0	20.6	0.0	0.0	9.9	36.6	46.3	11.6	34.7	204.3	2039
40	2040	82.9			82.9				6.0	0.0	0.0	0.0	0.0	9.9	16.0	66.9	16.7	50.1	254.4	2040

Note: 1) Abbreviations:

F.C.: Foreign currency portion

L.C.: Local currency portion

2) Project construction cost:

	F.C.	L.C.	Total
Civil	176.9	182.4	359.3
Metal	150.6	19.2	169.8
Others	90.0	108.1	198.1
Total	417.5	309.7	727.2

Table 9.9 Examination of Repayability of Project Loans (Case4-1)

Tariff rate=USc5.0/kWh; FC:LC=70%:30%; FC=3.5% p.a.

(US$ million)

No.	Year	Power sales revenue	Loans received Foreign (70%)	Loans received Domestic (30%)	Total sources	Capital costs F.C.	Capital costs L.C.	Capital costs Total	O & M costs	Outstanding loan principal	Repayment of principal	Interest payment Foreign (3.5%)	Interest payment Domestic (13.0%)	Resources tax & VAT	Total uses	Current surplus	Corporate tax payment	Surplus after tax	Cumulative surplus	Year
1	2001		5.5	2.4	7.9	5.2	2.7	7.9		7.9				0.0	7.9	0.0	0.0	0.0	0.0	2001
2	2002		12.9	5.5	18.4	6.6	11.8	18.4		26.3				0.0	18.4	0.0	0.0	0.0	0.0	2002
3	2003		30.9	13.3	44.2	17.4	26.8	44.2		70.5				0.0	44.2	0.0	0.0	0.0	0.0	2003
4	2004		57.8	24.8	82.5	40.1	42.4	82.5		153.0				0.0	82.5	0.0	0.0	0.0	0.0	2004
5	2005		94.4	40.5	134.9	72.6	62.3	134.9		287.9				0.0	134.9	0.0	0.0	0.0	0.0	2005
6	2006		140.2	60.1	200.3	124.6	75.7	200.3		488.2				0.0	200.3	0.0	0.0	0.0	0.0	2006
7	2007		132.4	56.8	189.2	119.2	70.0	189.2		677.4				0.0	189.2	0.0	0.0	0.0	0.0	2007
8	2008	37.9	31.9	13.7	83.5	28.2	17.4	45.6	2.5	723.0				4.5	52.7	30.8	7.7	23.1	23.1	2008
9	2009	75.7	2.9	1.3	79.9	3.6	0.6	4.2	5.4	727.2				9.1	18.7	61.2	15.3	45.9	69.0	2009
10	2010	82.9			82.9				6.0	688.4	38.8	17.9	29.8	9.9	102.4	(19.5)	0.0	(19.5)	49.4	2010
11	2011	82.9			82.9				6.0	649.6	38.8	16.6	22.7	9.9	94.1	(11.2)	0.0	(11.2)	38.2	2011
12	2012	82.9			82.9				6.0	610.8	38.8	16.0	19.9	9.9	90.7	(7.8)	0.0	(7.8)	30.4	2012
13	2013	82.9			82.9				6.0	572.1	38.8	15.4	17.0	9.9	87.2	(4.4)	0.0	(4.4)	26.0	2013
14	2014	82.9			82.9				6.0	533.3	38.8	14.8	14.2	9.9	83.8	(0.9)	0.0	(0.9)	25.1	2014
15	2015	82.9			82.9				6.0	494.5	38.8	14.3	11.3	9.9	80.4	2.5	0.6	1.9	26.9	2015
16	2016	82.9			82.9				6.0	455.7	38.8	13.7	8.5	9.9	76.9	5.9	1.5	4.4	31.4	2016
17	2017	82.9			82.9				6.0	416.9	38.8	13.1	5.7	9.9	73.5	9.3	2.3	7.0	38.4	2017
18	2018	82.9			82.9				6.0	378.1	38.8	12.5	2.8	9.9	70.1	12.8	3.2	9.6	47.9	2018
19	2019	82.9			82.9				6.0	339.4	38.8	11.9	0.0	9.9	66.6	16.2	4.1	12.2	60.1	2019
20	2020	82.9			82.9				6.0	322.4	17.0	11.3	0.0	9.9	44.2	38.6	9.7	29.0	89.1	2020
21	2021	82.9			82.9				6.0	305.4	17.0	10.7	0.0	9.9	43.6	39.2	9.8	29.4	118.5	2021
22	2022	82.9			82.9				6.0	288.5	17.0	10.1	0.0	9.9	43.0	39.8	10.0	29.9	148.3	2022
23	2023	82.9			82.9				6.0	271.5	17.0	9.5	0.0	9.9	42.5	40.4	10.1	30.3	178.6	2023
24	2024	82.9			82.9				6.0	254.5	17.0	8.9	0.0	9.9	41.9	41.0	10.2	30.7	209.4	2024
25	2025	82.9			82.9				6.0	237.6	17.0	8.3	0.0	9.9	41.3	41.6	10.4	31.2	240.5	2025
26	2026	82.9			82.9				6.0	220.6	17.0	7.7	0.0	9.9	40.7	42.2	10.5	31.6	272.2	2026
27	2027	82.9			82.9				6.0	203.6	17.0	7.1	0.0	9.9	40.1	42.8	10.7	32.1	304.3	2027
28	2028	82.9			82.9				6.0	186.6	17.0	6.5	0.0	9.9	39.5	43.4	10.8	32.5	336.8	2028
29	2029	82.9			82.9			169.8	6.0	169.7	17.0	5.9	0.0	9.9	208.7	(125.8)	0.0	(125.8)	210.9	2029
30	2030	82.9			82.9				6.0	152.7	17.0	5.3	0.0	9.9	38.3	44.6	11.1	33.4	244.4	2030
31	2031	82.9			82.9				6.0	135.7	17.0	4.8	0.0	9.9	37.7	45.1	11.3	33.9	278.2	2031
32	2032	82.9			82.9				6.0	118.8	17.0	4.2	0.0	9.9	37.1	45.7	11.4	34.3	312.5	2032
33	2033	82.9			82.9				6.0	101.8	17.0	3.6	0.0	9.9	36.5	46.3	11.6	34.8	347.3	2033
34	2034	82.9			82.9				6.0	84.8	17.0	3.0	0.0	9.9	35.9	46.9	11.7	35.2	382.5	2034
35	2035	82.9			82.9				6.0	67.9	17.0	2.4	0.0	9.9	35.3	47.5	11.9	35.6	418.1	2035
36	2036	82.9			82.9				6.0	50.9	17.0	1.8	0.0	9.9	34.7	48.1	12.0	36.1	454.2	2036
37	2037	82.9			82.9				6.0	33.9	17.0	1.2	0.0	9.9	34.1	48.7	12.2	36.5	490.7	2037
38	2038	82.9			82.9				6.0	17.0	17.0	0.6	0.0	9.9	33.5	49.3	12.3	37.0	527.7	2038
39	2039	82.9			82.9				6.0	0.0	17.0	0.0	0.0	9.9	33.0	49.9	12.5	37.4	565.1	2039
40	2040	82.9			82.9				6.0	0.0	0.0	0.0	0.0	9.9	16.0	66.9	16.7	50.1	615.3	2040

Note: 1) Abbreviations:
F.C.: Foreign currency portion
L.C.: Local currency portion
2) Project construction cost:

	F.C.	L.C.	Total
Civil	176.9	182.4	359.3
Metal	150.6	19.2	169.8
Others	90.0	108.1	198.1
Total	417.5	309.7	727.2

Table 9.9 Examination of Repayability of Project Loans (Case4-2)

Tariff rate=USc5.0/kWh; FC:LC=70%:30%; FC=5.0% p.a.

(US$ million)

No.	Year	Power sales revenue	Loans received Foreign (70%)	Loans received Domestic (30%)	Total sources	Capital costs F.C.	Capital costs L.C.	Capital costs Total	O & M costs	Outstanding loan principal	Repayment of principal	Interest payment Foreign (5.0%)	Interest payment Domestic (13.0%)	Resources tax & VAT	Total uses	Current surplus	Corporate tax payment	Surplus after tax	Cumulative surplus	Year
1	2001		5.5	2.4	7.9	5.2	2.7	7.9		7.9				0.0	7.9	0.0	0.0	0.0	0.0	2001
2	2002		12.9	5.5	18.4	6.6	11.8	18.4		26.3				0.0	18.4	0.0	0.0	0.0	0.0	2002
3	2003		30.9	13.3	44.2	17.4	26.8	44.2		70.5				0.0	44.2	0.0	0.0	0.0	0.0	2003
4	2004		57.8	24.8	82.5	40.1	42.4	82.5		153.0				0.0	82.5	0.0	0.0	0.0	0.0	2004
5	2005		94.4	40.5	134.9	72.6	62.3	134.9		287.9				0.0	134.9	0.0	0.0	0.0	0.0	2005
6	2006		140.2	60.1	200.3	124.6	75.7	200.3		488.2				0.0	200.3	0.0	0.0	0.0	0.0	2006
7	2007		132.4	56.8	189.2	119.2	70.0	189.2		677.4				0.0	189.2	0.0	0.0	0.0	0.0	2007
8	2008	37.9	31.9	13.7	83.5	28.2	17.4	45.6	2.5	723.0				4.5	52.7	30.8	7.7	23.1	23.1	2008
9	2009	75.7	2.9	1.3	79.9	3.6	0.6	4.2	5.4	727.2				9.1	18.7	61.2	15.3	45.9	69.0	2009
10	2010	82.9			82.9				6.0	688.4	38.8	25.9	29.8	9.9	110.5	(27.6)	0.0	(27.6)	41.3	2010
11	2011	82.9			82.9				6.0	649.6	38.8	23.8	22.7	9.9	101.2	(18.4)	0.0	(18.4)	23.0	2011
12	2012	82.9			82.9				6.0	610.8	38.8	22.9	19.9	9.9	97.5	(14.7)	0.0	(14.7)	8.3	2012
13	2013	82.9			82.9				6.0	572.1	38.8	22.1	17.0	9.9	93.8	(11.0)	0.0	(11.0)	(2.7)	2013
14	2014	82.9			82.9				6.0	533.3	38.8	21.2	14.2	9.9	90.2	(7.3)	0.0	(7.3)	(10.0)	2014
15	2015	82.9			82.9				6.0	494.5	38.8	20.4	11.3	9.9	86.5	(3.6)	0.0	(3.6)	(13.6)	2015
16	2016	82.9			82.9				6.0	455.7	38.8	19.5	8.5	9.9	82.8	0.1	0.0	0.0	(13.6)	2016
17	2017	82.9			82.9				6.0	416.9	38.8	18.7	5.7	9.9	79.1	3.7	0.9	2.8	(10.8)	2017
18	2018	82.9			82.9				6.0	378.1	38.8	17.8	2.8	9.9	75.4	7.4	1.9	5.6	(5.2)	2018
19	2019	82.9			82.9				6.0	339.4	38.8	17.0	0.0	9.9	71.7	11.1	2.8	8.3	3.1	2019
20	2020	82.9			82.9				6.0	322.4	17.0	16.1	0.0	9.9	49.1	33.8	8.4	25.3	28.5	2020
21	2021	82.9			82.9				6.0	305.4	17.0	15.3	0.0	9.9	48.2	34.6	8.7	26.0	54.4	2021
22	2022	82.9			82.9				6.0	288.5	17.0	14.4	0.0	9.9	47.4	35.5	8.9	26.6	81.1	2022
23	2023	82.9			82.9				6.0	271.5	17.0	13.6	0.0	9.9	46.5	36.3	9.1	27.2	108.3	2023
24	2024	82.9			82.9				6.0	254.5	17.0	12.7	0.0	9.9	45.7	37.2	9.3	27.9	136.2	2024
25	2025	82.9			82.9				6.0	237.6	17.0	11.9	0.0	9.9	44.8	38.0	9.5	28.5	164.7	2025
26	2026	82.9			82.9				6.0	220.6	17.0	11.0	0.0	9.9	44.0	38.9	9.7	29.2	193.8	2026
27	2027	82.9			82.9				6.0	203.6	17.0	10.2	0.0	9.9	43.1	39.7	9.9	29.8	223.6	2027
28	2028	82.9			82.9				6.0	186.6	17.0	9.3	0.0	9.9	42.3	40.6	10.1	30.4	254.1	2028
29	2029	82.9			82.9			169.8	6.0	169.7	17.0	8.5	0.0	9.9	211.2	(128.4)	0.0	(128.4)	125.7	2029
30	2030	82.9			82.9				6.0	152.7	17.0	7.6	0.0	9.9	40.6	42.3	10.6	31.7	157.4	2030
31	2031	82.9			82.9				6.0	135.7	17.0	6.8	0.0	9.9	39.7	43.1	10.8	32.3	189.7	2031
32	2032	82.9			82.9				6.0	118.8	17.0	5.9	0.0	9.9	38.9	44.0	11.0	33.0	222.7	2032
33	2033	82.9			82.9				6.0	101.8	17.0	5.1	0.0	9.9	38.0	44.8	11.2	33.6	256.3	2033
34	2034	82.9			82.9				6.0	84.8	17.0	4.2	0.0	9.9	37.2	45.7	11.4	34.2	290.5	2034
35	2035	82.9			82.9				6.0	67.9	17.0	3.4	0.0	9.9	36.3	46.5	11.6	34.9	325.4	2035
36	2036	82.9			82.9				6.0	50.9	17.0	2.5	0.0	9.9	35.5	47.4	11.8	35.5	360.9	2036
37	2037	82.9			82.9				6.0	33.9	17.0	1.7	0.0	9.9	34.6	48.2	12.1	36.2	397.1	2037
38	2038	82.9			82.9				6.0	17.0	17.0	0.8	0.0	9.9	33.8	49.1	12.3	36.8	433.9	2038
39	2039	82.9			82.9				6.0	0.0	17.0	0.0	0.0	9.9	33.0	49.9	12.5	37.4	471.3	2039
40	2040	82.9			82.9				6.0	0.0	0.0	0.0	0.0	9.9	16.0	66.9	16.7	50.1	521.4	2040

Note: 1) Abbreviations:
F.C.: Foreign currency portion
L.C.: Local currency portion
2) Project construction cost:

	F.C.	L.C.	Total
Civil	176.9	182.4	359.3
Metal	150.6	19.2	169.8
Others	90.0	108.1	198.1
Total	417.5	309.7	727.2

Table 9.9 Examination of Repayability of Project Loans (Case4-3)

Tariff rate=USc5.0/kWh; FC:LC=70%:30%; FC=8.5% p.a.

(US$ million)

		Power	Loans received			Capital costs				Outstanding	Repayment	Interest payment		Resources			Corporate	Surplus		
		sales	Foreign	Domestic	Total				O & M	loan	of	Foreign	Domestic	tax	Total	Current	tax	after	Cumulative	
No.	Year	revenue	(70%)	(30%)	sources	F.C.	L.C.	Total	costs	principal	principal	(8.5%)	(13%)	& VAT	uses	surplus	payment	tax	surplus	Year
1	2001		5.5	2.4	7.9	5.2	2.7	7.9		7.9				0.0	7.9	0.0	0.0	0.0	0.0	2001
2	2002		12.9	5.5	18.4	6.6	11.8	18.4		26.3				0.0	18.4	0.0	0.0	0.0	0.0	2002
3	2003		30.9	13.3	44.2	17.4	26.8	44.2		70.5				0.0	44.2	0.0	0.0	0.0	0.0	2003
4	2004		57.8	24.8	82.5	40.1	42.4	82.5		153.0				0.0	82.5	0.0	0.0	0.0	0.0	2004
5	2005		94.4	40.5	134.9	72.6	62.3	134.9		287.9				0.0	134.9	0.0	0.0	0.0	0.0	2005
6	2006		140.2	60.1	200.3	124.6	75.7	200.3		488.2				0.0	200.3	0.0	0.0	0.0	0.0	2006
7	2007		132.4	56.8	189.2	119.2	70.0	189.2		677.4				0.0	189.2	0.0	0.0	0.0	0.0	2007
8	2008	37.9	31.9	13.7	83.5	28.2	17.4	45.6	2.5	723.0				4.5	52.7	30.8	7.7	23.1	23.1	2008
9	2009	75.7	2.9	1.3	79.9	3.6	0.6	4.2	5.4	727.2				9.1	18.7	61.2	15.3	45.9	69.0	2009
10	2010	82.9			82.9				6.0	688.4	38.8	45.8	29.8	9.9	130.4	(47.5)	0.0	(47.5)	21.4	2010
11	2011	82.9			82.9				6.0	649.6	38.8	40.4	22.7	9.9	117.8	(35.0)	0.0	(35.0)	(13.5)	2011
12	2012	82.9			82.9				6.0	610.8	38.8	38.9	19.9	9.9	113.6	(30.7)	0.0	(30.7)	(44.3)	2012
13	2013	82.9			82.9				6.0	572.1	38.8	37.5	17.0	9.9	109.3	(26.4)	0.0	(26.4)	(70.7)	2013
14	2014	82.9			82.9				6.0	533.3	38.8	36.1	14.2	9.9	105.0	(22.2)	0.0	(22.2)	(92.8)	2014
15	2015	82.9			82.9				6.0	494.5	38.8	34.6	11.3	9.9	100.7	(17.9)	0.0	(17.9)	(110.7)	2015
16	2016	82.9			82.9				6.0	455.7	38.8	33.2	8.5	9.9	96.4	(13.6)	0.0	(13.6)	(124.3)	2016
17	2017	82.9			82.9				6.0	416.9	38.8	31.7	5.7	9.9	92.2	(9.3)	0.0	(9.3)	(133.6)	2017
18	2018	82.9			82.9				6.0	378.1	38.8	30.3	2.8	9.9	87.9	(5.0)	0.0	(5.0)	(138.7)	2018
19	2019	82.9			82.9				6.0	339.4	38.8	28.8	0.0	9.9	83.6	(0.8)	0.0	(0.8)	(139.4)	2019
20	2020	82.9			82.9				6.0	322.4	17.0	27.4	0.0	9.9	60.4	22.5	5.6	16.9	(122.6)	2020
21	2021	82.9			82.9				6.0	305.4	17.0	26.0	0.0	9.9	58.9	23.9	6.0	18.0	(104.6)	2021
22	2022	82.9			82.9				6.0	288.5	17.0	24.5	0.0	9.9	57.5	25.4	6.3	19.0	(85.6)	2022
23	2023	82.9			82.9				6.0	271.5	17.0	23.1	0.0	9.9	56.0	26.8	6.7	20.1	(65.5)	2023
24	2024	82.9			82.9				6.0	254.5	17.0	21.6	0.0	9.9	54.6	28.3	7.1	21.2	(44.3)	2024
25	2025	82.9			82.9				6.0	237.6	17.0	20.2	0.0	9.9	53.1	29.7	7.4	22.3	(22.0)	2025
26	2026	82.9			82.9				6.0	220.6	17.0	18.7	0.0	9.9	51.7	31.1	7.8	23.4	1.4	2026
27	2027	82.9			82.9				6.0	203.6	17.0	17.3	0.0	9.9	50.3	32.6	8.1	24.4	25.8	2027
28	2028	82.9			82.9				6.0	186.6	17.0	15.9	0.0	9.9	48.8	34.0	8.5	25.5	51.3	2028
29	2029	82.9			82.9			169.8	6.0	169.7	17.0	14.4	0.0	9.9	217.2	(134.3)	0.0	(134.3)	(83.0)	2029
30	2030	82.9			82.9				6.0	152.7	17.0	13.0	0.0	9.9	45.9	36.9	9.2	27.7	(55.3)	2030
31	2031	82.9			82.9				6.0	135.7	17.0	11.5	0.0	9.9	44.5	38.4	9.6	28.8	(26.5)	2031
32	2032	82.9			82.9				6.0	118.8	17.0	10.1	0.0	9.9	43.0	39.8	10.0	29.9	3.3	2032
33	2033	82.9			82.9				6.0	101.8	17.0	8.7	0.0	9.9	41.6	41.2	10.3	30.9	34.3	2033
34	2034	82.9			82.9				6.0	84.8	17.0	7.2	0.0	9.9	40.2	42.7	10.7	32.0	66.3	2034
35	2035	82.9			82.9				6.0	67.9	17.0	5.8	0.0	9.9	38.7	44.1	11.0	33.1	99.4	2035
36	2036	82.9			82.9				6.0	50.9	17.0	4.3	0.0	9.9	37.3	45.6	11.4	34.2	133.6	2036
37	2037	82.9			82.9				6.0	33.9	17.0	2.9	0.0	9.9	35.8	47.0	11.8	35.3	168.8	2037
38	2038	82.9			82.9				6.0	17.0	17.0	1.4	0.0	9.9	34.4	48.5	12.1	36.3	205.2	2038
39	2039	82.9			82.9				6.0	0.0	17.0	0.0	0.0	9.9	33.0	49.9	12.5	37.4	242.6	2039
40	2040	82.9			82.9				6.0	0.0	0.0	0.0	0.0	9.9	16.0	66.9	16.7	50.1	292.7	2040

Note: 1) Abbreviations:
F.C.: Foreign currency portion
L.C.: Local currency portion
2) Project construction cost:

	F.C.	L.C.	Total
Civil	176.9	182.4	359.3
Metal	150.6	19.2	169.8
Others	90.0	108.1	198.1
Total	417.5	309.7	727.2

35

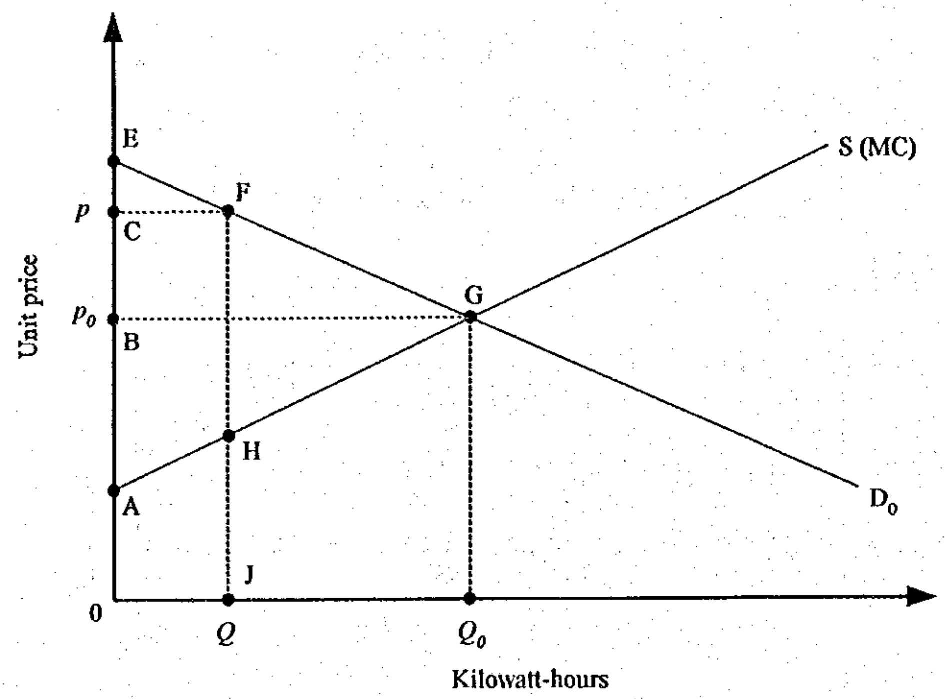


Figure 9.1 Net Benefit of Electricity Consumption

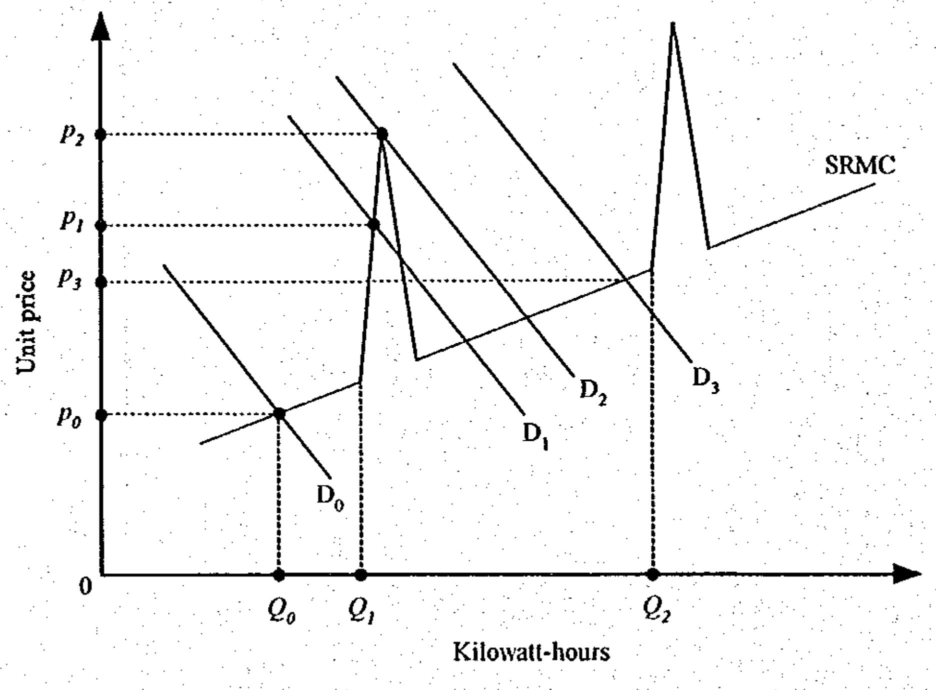


Figure 9.2 Change of Demand and SRMC

CHAPTER 10 TRANSFER OF TECHNOLOGY

10.1 On-the-job Training

The counterparts of EVN assigned to this Feasibility Study both on long term and short term basis have been generally well educated and trained in their respective fields. In the course of the Study, the JICA Study Team members tried to introduce the latest knowledge relevant to the Study in the respective fields and expand their experiences. In addition to the day to day works performed with the respective counterparts, various meetings on technical matters held on an ado-hoc basis were functional as the effective means to do the transfer of technology.

10.2 Technology Transfer Seminar

As described in the Inception Report, the JICA Study Team proposed to hold a transfer technology seminar in the Fifth Field Investigation scheduled (Draft Final Report stage) at the meeting held on the Interim Report in December 1999. The proposal was accepted by EVN as recorded in the Minutes of Meeting of December 1999.

The seminar was held in the Fifth Field Investigation as scheduled, focussing on the explanation of contents of the Draft Final Report and outcomes of the Feasibility Study.

10.3 Counterpart Training in Japan

Under the program of technical cooperation by the Government of Japan, one counterpart personnel of EVN was scheduled to visit Japan in March 2000 to receive a series of training in accordance with the training program.

The program includes the site visit to representative projects similar to the Project as well as lectures by and discussions with the Study Team members.

CHAPTER 11 RECOMMENDATIONS

11.1 General

The Feasibility Study has proved that the Dong Nai No.3 and No.4 Combined Hydropower Project is technically feasible, economically viable and environmentally sound. Therefore, it is recommended that the Project be proceeded to the next stage of the implementation. The Project implementation may include clearance of various requirements on the side of the Government of Vietnam, the financial arrangement with lending agency, procurement of consultant(s), the additional field investigations for the detailed design, execution of the detailed design, procurement of contractors, and construction of the Project.

As mentioned in Chapter 8, the first power unit of the Project is planned to be commissioned by the year 2007 and the entire implementation period after the Feasibility Study will take approximately 7.5 years at the earliest. Therefore very careful and speedy implementation is essential for completion of the Project as planned in this Final Report.

Only essential points are briefed below for convenience of EVN.

11.2 Clearance of Various Requirements on the side of the Government of Vietnam

There will be a lot of things to be cleared by the Government organizations concerned including local authorities before final decision of the Project implementation by EVN.

Among the things, it will be of the paramount importance that all approval procedures for the Environmental Impact Assessments should be completed by the Government authorities before visit of project appraisal mission of lending agency if the Project financing is sought from a certain lending agency.

It is intended that necessary documents for the approval procedures can be prepared with this Final Report and its supporting documents attached here.

11.3 Detailed Design

The current design has been prepared as a feasibility-grade design and therefore further elaboration to grade it up to a level of detailed design will be required in the stage of the Project implementation upon commencement of the consulting services.

For further elaboration the following additional engineering work will be required:

- Industry and construction : 45%
- Review of hydrological analyses in this Study, based on the hydrological data that will be obtained from the newly installed hydrological stations near Dong Nai No.3 dam site
- Field Investigations
  1) Topographic survey
  2) Geotechnical investigation
- Hydraulic model test for spillway
- Minor adjustment of major structures such as power stations by incorporating

further field investigation results

Attachment

to

Main Report

Attachment to Main Report

DESIGN CRITERIA FOR FEASIBILITY-GRADE DESIGN

Table of Contents

List of Table

List of Figures

List of Annexes

Design Condition on Feasibility Study
On Dong Nai No.3 and No.4 Combined Hydropower Project

1. Main Dam

The Dong Nai No.3 dam and No.4 dam are categorized to be the Grade-I dam in accordance with the Vietnamese criteria as shown in Annex-1. The principal dam design criteria to be adopted in the feasibility-grade design are shown in Annex-2, which also presents the Vietnamese and Japanese design codes.

(1) Location of main dam axes : to be selected on 1 to 1,000 scaled topographic maps to be newly produced, that would be almost same as those selected in the stage of Progress Report No.1.

(2) Type of main dam : Rock-fill dam with vertical clay core, Concrete gravity dam and Combined dam of rock-fill and concrete dam portions.

(3) Crest level of main dam : Crest level of Non-overflow section + 0.5m (in case of Rockfill dam)

(4) Crest level of Non-overflow section of main dam (=Crest level of Vertical clay core):

Based on the Design Criteria for Dams (Japanese National Committee on Large dams) and compared to the Vietnamese standard (refer to (7) of Annex-II).

(a) Crest level of Non-overflow section :

[(Flood water level + Freeboard 1*) or (Full supply water level + Freeboard 2*)]

Note:

- Freeboard 1 = Wave height due to wind + Allowance for Uncertainty in calculating these effects.
- Freeboard 2 = Wave height due to wind + Wave height due to earthquake + Allowance for Uncertainty in calculating these effects.

(b) Wave height due to wind : Calculated by SMB method and Saville's method.

(c) Wave height (he) due to earthquake : Calculated by Sato's formula.

$he = 1/2kT/\pi\,(gHo)^{1/2}$ where; k : Design seismic intensity
T : Period of seismic wave in second
H0 : Depth of reservoir water

(d) Allowance for uncertainty :

- Rise of water level caused by unexpected accident in operating spillway gates (=0.5m)
- Additional height according to type and importance of dams (Fill type : 1.0m)

(5) Zoning and details of main dam

(a) Upstream and downstream slopes : To be decided through a stability analysis against sliding (refer to (9) of Annex-II):

Zone of Main Dam	Slope	
	Upstream	Downstream
Rock	-	-
Vertical clay zone	1:0.30 or 0.4	1:0.30 or 0.4
Filter zone	1:0.35 same thickness	1:0.35 same thickness

(b) Dam crest width : 10.0 m (refer to (2) of Annex-II)

(c) Crest width of the clay core zone : 4.0 m

(d) Upstream and downstream width of the filter zone : 4.5 m and 6.5 m ,respectively.

(e) Upstream cofferdam : Placed in the dam body.

(f) Berms on the dam body : Not placed except the crest of the upstream cofferdam as required

(g) Slope protection : Provided for upstream slope surface from dam crest to 2-3m below MOL (Refer to (4) of Annex-II)

(h) Stability of Dam : Checked up the safety against sliding of slope in rock-fill dam and sliding of foundation in concrete gravity dam
(Refer to (9) of Annex-II for the safety factor rock-fill dam, and refer to (10) of Annex-II for the safety factor concrete gravity dam).

(i) Seismic coefficient : determined to be to be 0.1 with reference to the value adopted in the Dai Nin HPP and other seismic quiet areas such as Korea and Sri Lanka.(Refer to (8) of Annex-II).

2. Foundation

2.1 Dam Foundation

(1) The foundation of the core zone :

Dam height	Rock classification *
H< 30m	IA_1
30m<H<80m	IA_2
80m<H	IB

Note : The rock classification standard in Vietnam is shown in Table-1

(2) The foundation of filter and rock zone : IA_1

(3) Blanket grouting : 5m deep for whole area of the core zone

(4) Curtain grouting : A single line in the center of the core zone and both abutments from the dam body to the point of intersection between FSL and ground water level.

(5) Depth of Curtain grouting (D) : Determined by the upstream water head (H) using following equation.

D= 1/3 H + C , where; C: Constant (8-25m) , D min : 10m.

(6) Grouting gallery : Not installed.

2.2 Excavation and Embankment Slopes for Structures Other than Dam

(1) Excavation slope (refer to Figure-1) :

Rock Classification	Temporary Slope	Permanent Slope
Soil and deposit	1:1.25	1:1.5
IA	1:0.5-1:0.3	1:1.0
IB	1:0.3	1:0.5
IIA	1:0.3	1:0.3

(2) Berms for excavation slope : Placed on all slopes at maximum 10 m height with 2m wide except the dam foundation.

(3) Embankment slope (refer to Figure-1)

Material	Permanent and Temporary		
	Slope 1:n	Height H(m)	Berm W(m)
1. Excavated rock	1.5	5.0	2.5
2. Earth with compaction	2.0	5.0	3.0
3. Earth without compaction	2.5	5.0	3.0

3. Spillway

(1) Design flood : 1,000-year flood , and its freeboard will be checked for 10,000-year flood (refer to (6) of Annex-II)

(2) Location : Compared right bank and left bank

(3) Spillway type (Control structure) : Center overflow type with radial gates on ogee crest
(Discharge carrier) : Chute type
(Dissipation structure) : Flip bucket type with plunge pools

(4) Approach velocity of the flood flow : Less than 4 m/sec

(5) Ratio width to height (w/h) : More than 1/5

Where, w : approach channel water depth below overflow crest
H : design overflow depth

(6) Freeboard on spillway crest gate : 0.5m at full supply level.

(7) Pier thickness : 3.5m.

(8) Maximum spillway gate size : Within 18m wide and 21m high.

(9) Foundation of spillway structure : Rock classification of IB.

4. Outlet facilities : The necessity of their installation is to be decided subject to environmental requirements (Refer to (13) of Annex-II).

5. Diversion tunnel

(1) Design flood for diversion facility: 20-year probable flood with check up against 3% recurrence flood to ensure non-overtopping (Refer to (1) of Annex-II)

(2) Shape of diversion tunnel : Circle shape

(3) Number of diversion tunnels : Two (for presently proposed discharge volume 3,500 and 3,750m^3/s in Pre-F/s, which will be revised through the present hydrological study.)

(4) Distance between tunnels : Thee times of tunnel diameter at center to center of the tunnel.

(5) Lining thickness of diversion tunnel : No reinforcement bars at sound rock portions

Location	Thickness (m)
Entrance to 1.0 x D	0.10 x D
Other portions	0.06 x D (The max. thickness is 60 cm)

Note: D is inner diameter of tunnel.

(6) Outlet structure : To be decided subject to environmental requirements

(7) Foundation of tunnel entrance : Rock classification of IA.

6. Cofferdam

(1) Type of cofferdam : Rockfill dam with inclined clay facing or other type in case of combined dam.

(2) Cofferdam crest level : Flood water level + Freeboard (=1.0 m)

(3) Flood water level : Determined to provide the sufficient diversion capacity for the design flood.

(4) Crest width of cofferdam : 10 m.

(5) Upstream and downstream slopes of each zone :

Zone Cofferdam	Slope	
	Upstream	Downstream
Rock	Same as main dam	1:1.5
Transition	Depending on upstream rock slope	1:1.5
Impervious	1:3.0	-

7. Intake

(1) Design velocity in Intake : Less than 1.0 m/sec.

(2) Type of intake : The inclined type that consists of the inlet inclined trashrack and inclined gates or vertical type of intake as an alternative

8. Headrace tunnel

(1) Diameter of headrace tunnel : Economical diameter minimized construction cost and benefit decrease due to head loss.

(2) Thickness of lining concrete : 0.08D m at maximum (D: Inner diameter of headrace tunnel). No reinforcement bars at sound rock portions

(3) Foundation of tunnel entrance portion : Rock classification of IB.

9. Surge tank

(1) Type : Restricted orifice surge tank , non-overflow type in consideration of easy construction as well as the cheapest cost among the conceivable types for the Project

(2) Diameter of surge shaft : to be determined by hydraulic analysis. While, the required internal diameter thereof is estimated at about 17 m under the project features presented in the Progress Report No.1.

(3) Thickness of lining concrete : 1.0 m

(4) Top level of headrace tunnel at surge tank : 5m lower than the lowest surging level.

(5) Basic conditions for hydraulic analysis : to be performed under the two cases, namely the full load rejection and half load increase, applying the following hydraulic design values;

Item	Case	
	Full Load Rejection	Half Load Increase
i) Reservoir water level	FSL	MOL
ii) Coefficient of roughness of concrete		
- Initial value(Normal condition)	0.014(0.012)	0.014(0.012)
- For rejection or increase	0.012(0.011)	0.016(0.013)
iii) Change of discharge	From Q=Qp to Q=0.0	From Q=Qp/2 to Q=Qp

Note : (1) Qp is maximum power discharge.

(2). Figures in parenthesis are coefficient of roughness to steel

10. Penstock

(1) Type : Embedded pipe

(2) Diameter of penstock pipe : Economical diameter minimized construction cost and benefit decrease due to head loss

(3) Inclined angle of penstock : 45 degrees.

(4) Minimum ground cover : Three times of the tunnel diameter.

(5) Diameter of penstock pipe :

- Upper horizontal, inclined and lower horizontal portion before the bifurcation : Same size
- Downstream of bifurcation : Half of the section area of the pipe upstream of the bifurcation.

(6) Filling concrete thickness around penstock pipe : 0.6 m.

(7) Maximum design head of penstock pipe at center of turbine (Hmax) :

Hmax=Hp1+Hwh+Hp2

Where, Hp1 : Hydrostatic pressure between Full Supply Level(FSL) and center of turbine
Hwh : Water hammer pressure
Hp2 : Hydrostatic pressure between FSL and upper surging water level .

(10) Design load of penstock pipe : Inner hydro pressure.

(11) Minimum thickness (Tmin) of penstock pipe :

T min = (800+D)/400

Where, Tmin : Minimum thickness (mm)
D : Diameter of pipe (mm)

(12) Material of penstock pipe : SM490, allowable tension stress 1,750 kgf/cm^2.

11. Powerhouse

(1) Number of generating units : Two or three.

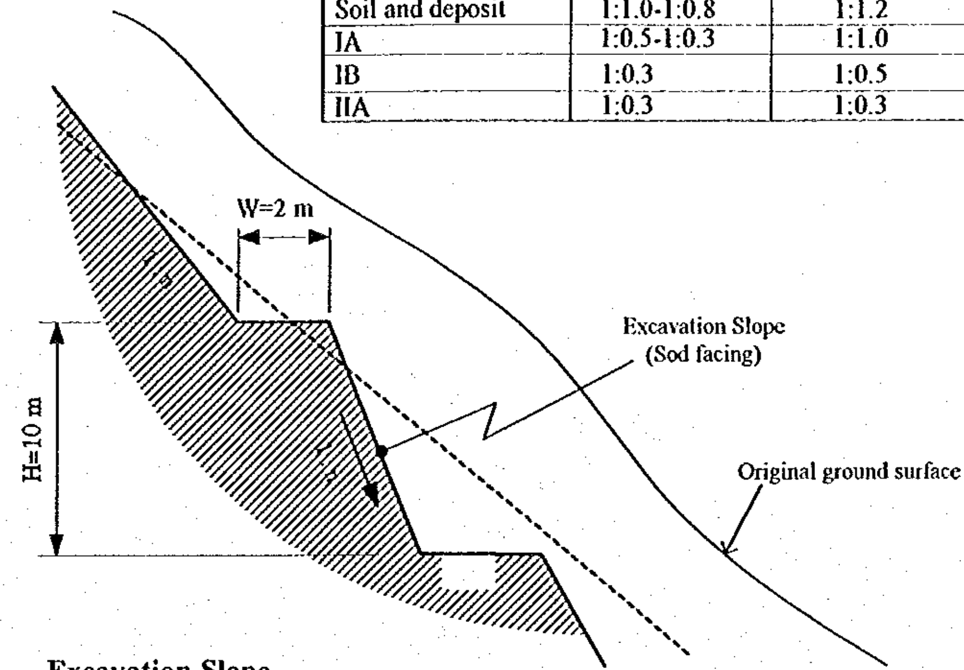
(2) Design water level for the tailrace wall and assembly floor: Calculated by the 100-year probable flood.

Table-1 Comparison of Rock Classification

Grade		Weathering	Description
PIDC2	ISRM		
IIB	I/Fr	Very Fresh	No visible sign of material weathering, very strong, shape of cores 0.3-1.0 m. Physical mechanical property is high and does not change by depth. The permeability is very low and does not change by depth.
IIA		Fresh	No visible sign of material weathering. Perhaps, slight discoloration on major discontinuity surfaces, very strong, shape of cores 0.3-1.0 m. Physical mechanical property is high and change by depth. The permeability is low and changes by depth.
IB	II/SW	Slightly weathered	All or some of the rock material may be discolored by weathering and may be somewhat weaker extremely then when fresh, hard rock shape of cores 0.05-0.1 m. Physico-mechanical property is high and decreases by depth. The permeability is high and changes by depth.
IA2	III/MW	Moderately weathered	< Half the rock material is decomposed and disintegrated to a soil. Fresh and discolored rock is present as either continuous framework or corestones.
IA1	IV/HW	Highly weathered	> Half the rock material is decomposed and disintegrated to a soil. Fresh and discolored rock is present as either continuous framework or corestones.
dQ - eQ	V/CW	Completely weathered	All rock material is decomposed and/or disintegrated to or soil. The original mass structure is still largely intact.

Excavation Slope by Rock Classification (1: n)

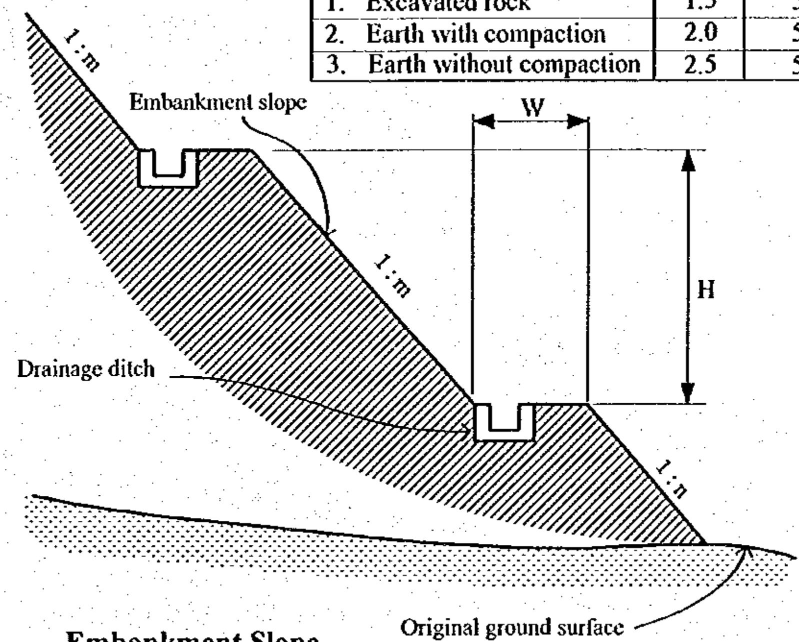
Rock Classification	Temporary Slope	Permanent Slope
Soil and deposit	1:1.0-1:0.8	1:1.2
IA	1:0.5-1:0.3	1:1.0
IB	1:0.3	1:0.5
IIA	1:0.3	1:0.3



Excavation Slope

Embankment Slope (1: m)

Embankment Material	Slope 1:m	Permanent and Temporary Height H(m)	Permanent and Temporary Berm W(m)
1. Excavated rock	1.5	5.0	2.5
2. Earth with compaction	2.0	5.0	3.0
3. Earth without compaction	2.5	5.0	3.0



Embankment Slope

Note: Concrete drainage ditch shall be provided on each berm.
Besides a circumfluent drainage ditch is necessary on outer edge of slope.

Figure-1 Slopes of Excavation and Embankment (for Structures Other than Dam)

Annex-I : Grade of Dam and Powerhouse in Vietnam

Table 1-1 Grade of Dam in Vietnam (in accordance with Dam Height)

Local Material Dam			Concrete and reinforced concrete dam, masonry submerged structure of power station, lock, lift ship, retaining wall, and the other concrete and reinforced concrete works forming the pressure site			Grade of Works
Foundation condition						
Rock	Sand gravel, clay at solid and semi-solid state	Saturated clay at plastic state	Rock	Sand gravel, clay at solid and semi-slid state	Saturated clay at plastic state	
Dam Height (m)						
H>100	H>75	H>50	H>100	H>50	H>25	I
100>=H>70	75>=H>35	50>=H>25	100>=H>60	50>=H>25	25>=H>20	II
70>=H>25	35>=H>15	25>=H>15	60>=H>25	25>=H>10	20>=H>10	III
25>=H>15	8>=H>15	15>=H>8	25>=H>10	10>=H>5	10>=H>5	IV
15>H	8>H	8>H	10>H	5>H	5>H	V

Notes:

1. If the damage of storage works has serious consequences for the cities, industrial area and the defense region, the traffic lines, populated area at the head works downstream, grade of works will be decided from above Table 1-1, and upgraded to suit the consequences scale when there is an appropriate feasibility.
2. If the damage of storage works has not serious consequences for downstream (works laying at a thinly populated area, near the sea), its grade will be determined from above Table 1-1, and lower one grade.
3. Both of Dong Nai No 3 and No.4 dams are defined to be the Grade I dam from above Table 1-1.

Table 1-2 Grade of Hydraulic Work in Vietnam

Output of Power Station (10^3 kW)	Hydrosystem		Water Supply Works with Discharge (m3/sec)	Grade of Long-term Works	
	Irrigation	Drainage		Main	Secondary
1,000>H>300				I	III
300>=H>50	H>50	H>50	20>=H>15	II	III
50>=H>2	50>=H>10	50>=H>10	15>=H> 5	III	IV
2>=H>0.2	10>=H>2	10>=H>2	5>=H>1	IV	IV
0.2>H	2>H	2>H	1>H	V	V

Notes:

1. Power station with installed output of more than 1,000,000 kW, belongs to a special grade, and it must be designed with an exceptional design standard.
2. Both of Dong Nai No.3 and No.4 power stations are defined to be the Grade-II power station from above Table 1-2.

Annex-II : Principal Design Criteria of Dam to be Adopted for Feasibility-Grade Design on Dong Nai N0.3 and No.4 Combined HPP (1/5)

Item of Design Criteria	Vietnamese Code	Japanese Code	Recommended Deign Criteria in the Dong Nai No.3 & No.4 HPP F/S
(1) Design flood for diversion facilities	In case of fill type dam of the Grade-I dam (refer to Annex-I), a 20-year probable flood is adopted as the design flood for diversion facilities.	Not definitely coded. Usually, the similar magnitude of flood to that in the Vietnamese code is adopted.	The following magnitudes of design floods for diversion facilities will be adopted taking the Vietnamese code into consideration: - Fill type dam : 20-year probable flood with check up by 3% recurrence flood as an extraordinary flood - Concrete dam : 5-year probable flood
(2) Crest width of dam	Taking into consideration the workability during construction and preparation of the service road after completion of the Project, the dam crest width should be 10.0 m for all dams in the project.	Not definitely coded.	The Vietnamese Code is to be adopted. The dam crest width is to be taken at 10 m.
(3) Step (for fill type dam)	(Article 3.16-3.17) Although steps should be arranged on both upstream and downstream slopes of homogeneous earthfill dams because of construction requirement (step should be provided with each 10 to 15 m in height and width of those steps to be 5.0 m), whereas in case of rockfill dam those steps do not need to be provided if the construction technology does not require.	Not definitely coded.	The steps will not be provided unless they are needed for the purpose of the construction, following the Vietnamese code.
(4) Slope protection (for fill type dam)	(Article 3.16-3.17, 3.41) Riprap with selected rock should be provided on the upstream slope of rockfill dams for the reinforcement against sliding, weathering and erosion, and for good appearance as well. As for the homogeneous earthfill dams, upstream side slope should be also reinforced by rock material. The thickness of riprap layer and the rock size should be determined to ensure that the dam body is durable against erosion by wave. The reinforced layer of upstream side should be laid out from the top of dam to the foot of upstream slope. Basalt and/or sandstone available at the site, which have a sufficient strength and durability, will be used for the material of slope protection. Rock used for the slope protection should be selected by its quality, size and shape, however, it is possible to use less qualified material within the limit of 25 % of total amount if it can be spread and be trimmed equally as the selected rock along the slope. The top of each dam should be covered with cobblestones or macadam, and asphalt concrete.	Not definitely coded. On the other hand, it is recommended to provide riprap for the upstream slope from dam crest to minimum operation level of reservoir (MOL).	The upstream dam slope will be covered with riprap from dam crest level to 2-3m below MOL.
(5) Impervious structure (for fill type dam)	(Article 4.44-3.52) The dimensions of impervious core of rockfill dam must be determined according to the requirement of permeability capacity to be enough against the seepage gradient as well as taking the condition of construction work and capability of the machines into consideration. The thickness of impervious core in rockfill dam should be increased gradually from the top to the bottom. The thickness at the top should not be less than 0.8 m and that at bottom taken from the gradient of seepage flow should be the value of not less than 10 % of static water head. The top elevation of impervious core zone must be higher than the normal high water level with the water surge caused by wind, and not be lower than flood water level. The dam foundation treatment must be performed for the impervious core zone.	Not definitely coded.	The impervious core zone will be designed adopting the Vietnamese design criteria which are judged to be appropriate and applicable to this Project.

Annex-II : Principal Design Criteria of Dam to be Adopted for Feasibility-Grade Design on Dong Nai N0.3 and No.4 Combined HPP (2/5)

Item of Design Criteria	Vietnamese Code	Japanese Code	Recommended Deign Criteria in the Dong Nai No.3 & No.4 HPP F/S
(6) Design flood for spillway	For the Dong Nai No.3 and No.4 dams that are both categorized to be the Grade-1 dam in accordance with the Vietnamese criteria in Annex-I, a 1,000-year probable flood is to be adopted as the design flood for spillway.	In Japan, the design floods are adopted by the dam type as follows: - Fill type dam including rockfill dam : 1.2 times of 200-year probable flood - Concrete gravity dam : 200-year probable flood	The Vietnamese design code will be adopted.
(7) Freeboard	Dam crest elevation of each dam should be the design maximum water surface level plus freeboard. Freeboard above the full supply level should consist of the several kind of allowances and be evaluated by the more critical case out of the following two cases: Case-1 : $hf + hw_1 + ha_1 + hb$ Case-2 : $hw_2 + ha_2 + hb$ Where, hf : surcharge height due to the flood of 1,000-year return period (0.1 %) hw : height of wave due to design wind velocity, including the wash of water at upstream face of dam(hw_1 is wave height due to the wind of 2-year return period (50 %) and hw_2 is that of 50-year return period (2 %)) ha : constant by the water level (ha1 is 0.7 m for flood condition, and ha2 is 1.0 m for normal condition) hb : constant by the dam height, adopted 1 % of maximum dam height	The crest elevation of non-overflow section of dams must be equal to the maximum design water surface level plus freeboard. The freeboard has to be determined considering the extraordinary flood discharge, wave due to wind or earthquake, rise of water surface level caused by unexpected accident in operating the spillway gate, and operation method of the reservoir. Type and importance of dam must also remain in consideration. The crest elevation of non-overflow section, in case of fill type dam, means to be equal to the elevation of the top in impervious core zone. The design values of freeboard should be larger one of the values computed by the following two formulae: Case-1 : $h_w + h_e + h_a + h_l$ Case-2 : $h_f + h_w + h_a + h_l$ Where, hf : surcharge height due to the design flood hw : height of wave due to design wind velocity, including the rise of water at upstream face of the dam he : height of wave due to the earthquake ha : constant by the spillway gates, ha is normally 0.5 m h_l : constant by the type of dam, h_l is normally 1.0 m Height of wave due to the wind should be obtained by combining the S.M.B. Method with Saville Method, and height of wave due to earthquake should be estimated by the following formula: $h_e = \frac{1}{2} \cdot \frac{kT}{\pi} \sqrt{gH_0}$ where, k : seismic coefficient T : period of earthquake wave (sec) H_0 : maximum water depth in the reservoir (m)	The freeboard will be determined to satisfy both the Vietnamese and Japanese codes in terms of the design flood. Besides, a freeboard of 0.5 m will be secured against Probable Maximum Flood (PMF).
(8) Seismic coefficient	Not known. The seismic coefficient is determined for each project.	The design value is determined based on the regional coefficients in Japan, which are coded by the Japanese authorities.	The seismic coefficient is finally determined to be 0.1 in accordance with the current international practice against uncertainities such as artificial earthquake to be triggered by reservoir filling.

Annex-II : Principal Design Criteria of Dam to be Adopted for Feasibility-Grade Design on Dong Nai N0.3 and No.4 Combined HPP (3/5)

<table>
<tr><th>Item of Design Criteria</th><th>Vietnamese Code</th><th>Japanese Code</th><th>Recommended Deign Criteria in the Dong Nai No.3 & No.4 HPP F/S</th></tr>
<tr>
<td>(9) Minimum safety factor against sliding stability of fill (rockfill) type dam by Slip Circle Method

(for fill type dam)</td>
<td>(i) Method

The slip circle method should be applied for checking the safety factors against sliding failure in several conditions, which are obtained by following formula. The method conforms to the contents in Handbook for Hydraulic Design.

$$sf = \frac{\sum (G - P_B)\cos\alpha \cdot \tan\phi + C \cdot B / \cos\alpha}{\sum G \cdot \sin\alpha + f \cdot F / R}$$
$$P_B = \gamma_w \cdot h \cdot B / \cos\alpha$$
Where,
G : weight of each slice
C : cohesion of material on each slice of slip circle
B : width of each slice
α : angle between vertical line and the line connected center of circle and the slice
ϕ : angle of internal friction of material on slip circle of each slice
f : seismic force acting on each slice
F : vertical length from the center of circle to gravity center in each slice
R : radius of circle
γ_w : unit weight of water
h : water depth above each slice

(ii) Calculation Cases

The stability analysis should be done for the following cases applying the above formula to determine the upstream and downstream slopes of each dam:

<table>
<tr><th>Calculation Case</th><th>Conditions</th></tr>
<tr><td>Case-A</td><td>steady condition of the reservoir water level being at normal high water level under the condition with and without earthquake by design seismic coefficient.</td></tr>
<tr><td>Case-B</td><td>flood condition that the reservoir water level is at the maximum water level under the condition without earthquake.</td></tr>
<tr><td>Case-C</td><td>at low water level after rapid drawdown from normal high water level under the condition without earthquake.</td></tr>
<tr><td>Case-D</td><td>at high water level under the condition that the drainage structure is out of function by plugging, without earthquake.</td></tr>
</table>

(To be Continued)</td>
<td>(i) Method

The slip circle method should be applied for checking the safety factors against sliding failure in several conditions, which are obtained by the following formula:

$$S_f = \frac{\sum \{C \cdot l + (N - U - N_e)\tan\phi\}}{\sum (T + T_e)}$$
where,
Sf : safety factor
N : normal force acting on slip circle of each slice
T : tangential force acting on slip circle of each slice
U : pore pressure acting on slip circle of each slice
Ne : normal force of earthquake loading acting on slip circle of each slice
Te : tangential force of earthquake load acting on slip circle of each slice
ϕ : angle of internal friction of materials on slip circle of each slice
C : cohesion of materials on slip circle of each slice
l : arc length of slip circle of each slice

ii) Loads to be considered

The loads to be considered in the slip circle analysis are as follows:

<table>
<tr><th>Load</th><th>Conditions</th></tr>
<tr><td>Dead weight</td><td>Dead weight to be adopted for analyzing the safety of dam should be wet density of materials used for the portion above pheratic line, and saturated density of materials used below that.</td></tr>
<tr><td>Hydrostatic Pressure</td><td>A difference between upstream side water pressure and downstream side one should be considered as effective hydrostatic pressure to act on the slices, however the value is small enough as a rule.</td></tr>
<tr><td>Pore Pressure</td><td>Pore pressure should be assumed to act normally on sliding faces. In analyzing the safety of dam, pore pressure due to the seepage of reservoir water should be considered for impervious zone. In case of rapid drawdown, ebbing water in the upstream side of impervious zone should be regarded as negligible owing to low permeability coefficient of material.</td></tr>
<tr><td>Earthquake load</td><td>Hydrodynamic pressure caused by earthquake should be estimated as extremely small to be neglected in case of rockfill and earth fill dams.</td></tr>
</table>

(To be Continued)</td>
<td>The Japanese design criteria will be used.</td>
</tr>
</table>

<table>
<tr><th>Item of Design Criteria</th><th>Vietnamese Code</th><th>Japanese Code</th><th>Recommended Deign Criteria in the Dong Nai No.3 & No.4 HPP F/S</th></tr>
<tr>
<td></td>
<td>
iii) Safety Factor
The target of the minimum safety factor in each combined calculation case above is as follows:
<table>
<tr><th>Earthquake Condition</th><th>Case-A</th><th>Case-B</th><th>Case-C</th><th>Case-D</th></tr>
<tr><td>with earthquake</td><td>1.125</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>without earthquake</td><td>1.250</td><td>1.125</td><td>1.125</td><td>1.125</td></tr>
</table>
</td>
<td>
(iii) Calculation Cases
The stability analysis should be done for the following conditions by applying the above formula to determine the upstream and downstream slopes of each dam:
<table>
<tr><th>Calculation Case</th><th>Conditions</th></tr>
<tr><td>Case-A</td><td>steady condition of the reservoir water level being at full supply level under the condition with and without earthquake by design seismic coefficient.</td></tr>
<tr><td>Case-B</td><td>flood condition at maximum water level under the condition without earthquake.</td></tr>
<tr><td>Case-C</td><td>at low water level after rapid drawdown from full supply level under the condition with and without earthquake by design seismic coefficient.</td></tr>
</table>
In the earthquake condition in Case-C above, the seismic coefficient can be reduced or be neglected depending on the probability of occurrence of the combined severe situation.

(iv) Safety factor
The target of the minimum safety factor in each combined calculation case of the above should be as follows:
<table>
<tr><th>Earthquake Condition</th><th>Case-A</th><th>Case-B</th><th>Case-C</th></tr>
<tr><td>with earthquake</td><td>1.10</td><td>-</td><td>1.10</td></tr>
<tr><td>without earthquake</td><td>1.25</td><td>1.20</td><td>1.25</td></tr>
</table>
</td>
<td></td>
</tr>
<tr>
<td>(10) Safety factor for sliding stability of concrete dam

(for concrete gravity dam)</td>
<td>Not known.</td>
<td>
The concrete gravity dam has to satisfy the following conditions under the critical loading combination:
(1) At the upstream end of dam body, no tensile stress take place in concrete-rock contact face,
(2) The maximum compressive strength in concrete-rock contact face is not larger than the allowable one,
(3) The shear-friction factor of safety computed by the following Henney's formula is more than 4.0:
$$n = \frac{fV + \tau_0 l}{H}$$
where,
n : shear-friction factor of safety
f : coefficient of internal friction (=tan ø)
ø : internal friction angle (°)
V : total vertical force per unit length acting on concrete-rock contact surface (ton/m)
τ_0 : shear strength (ton/m2)
l : length of shear strength considered for concrete-rock contact face (m)
H : shear force (total horizontal force) per unit width, including seismic force (ton/m)
For the foundation rock of the Dong Nai No.3 and No.4 dams, the shear strength (τ_0) and internal friction (ø) angle are determined with reference to the values adopted for the similar rocks in Japan as follows:
τ_0 = 250 ton/m2
ø = 40°
</td>
<td>The Japanese code will be used.</td>
</tr>
</table>

Annex-II : Principal Design Criteria of Dam to be Adopted for Feasibility-Grade Design on Dong Nai N0.3 and No.4 Combined HPP (5/5)

Item of Design Criteria	Vietnamese Code	Japanese Code	Recommended Deign Criteria in the Dong Nai No.3 & No.4 HPP F/S
(11) Seepage calculation (for fill type dam)	In case of comparative thin impervious core such as that for rockfill dam, the total seepage amount can be estimated by the following formula with the functions obtained by flow net. $q = k \cdot \Omega$ where, q : unit seepage water through the dam body; k : permeability coefficient; Ω : total integrated provided by vertical and horizontal components of hydraulic gradient in each flow line	The dam body and foundation must be safe against seepage. The quantity and the velocity of seepage water should be confirmed to be small enough to prevent piping phenomena. Seepage flow should be analyzed by Finite Element Method (FEM) with two dimensional steady flow condition. Assuming that the seepage flow in the dam body and foundation is subject the Darcy's Low, continuous equation of seepage flow is given as the following quasi-harmonic equation: $\frac{\partial}{\partial x}\left(k_x \frac{\partial \phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_y \frac{\partial \phi}{\partial y}\right) + Q = 0$ where, kx, ky : permeability coefficient in x and y dimension; Q : seepage water in element; Φ : static pressure at each element by static hydrostatic pressure and fluid density. Considering the boundary conditions, solution of the above equation should be obtained by working out the following functional equation: $E = \iint \left[\frac{1}{2}\left\{k_x\left(\frac{\partial \phi}{\partial x}\right)^2 + k_y\left(\frac{\partial \phi}{\partial y}\right)^2\right\} - Q \cdot \phi\right] dxdy + \int q\phi dS$ $\frac{\partial E}{\partial \phi_i} = 0$ Safety for piping phenomena should be confirmed by the comparison of seepage flow with the critical flow velocity on Justin's Theory.	The seepage analysis dose not need to be carried out in the feasibility study stage.
(12) Measuring devices	The measuring devices such as pore pressure meters, water level, settlement and horizontal displacement measuring devices should be installed for observation and monitoring of the performance and conditions of dams and its foundations during construction and after completion. Installation of seismometers will be examined for major dams such as Dong Nai No.3 main dam and Dong Nai No.4 main dam, if required.	The measuring devices are installed in accordance with the dam operation and maintenance regulation in Japan..	The necessity of the measuring devices will not be examined in the feasibility study stage, but necessary costs will be estimated in accordance with the past experiences.
(13) Outlet facilities	Not definitely coded, but usually the outlet facilities are not provided.	The outlet facilities need to be installed to release the required maintenance flow and to cope with the emergency situation on dam adequately.	Principally, the outlet facilities should be installed. Whether or not the outlet facilities are installed will be determined through the discussion with EVN.

JICA