APPENDIX A

Analysis of Test Data

Table A-1 Computation of V^2R/L value

Tube size	Tube length (ft.)	turb.	turb.	Turb. removed (percent)	Flowrate		V^2R/L x 10^{-7}
					fpm.	gpm./sq. ft.	
small galvanized steel corrugated sheet	3	63	6.6	89.5	0.947	7.05	10.72
	3	57	5.6	90.2	0.710	5.30	6.02
	3	65	3.6	94.5	0.474	3.53	2.70
	3	64	2.0	96.9	0.316	2.25	1.19
	3	62	1.6	97.4	0.158	1.18	0.30
	2	60	10.0	83.3	0.947	7.05	16.08
	2	55	6.0	89.1	0.710	5.30	9.04
	2	60	3.7	93.8	0.474	3.53	4.03
	2	58	3.0	94.8	0.316	2.35	1.79
	2	57	2.7	95.3	0.158	1.18	0.45
	1	56	19	66.1	0.948	7.65	32.16
	1	60	16	73.3	0.711	5.30	15.07
	1	61	12	78.7	0.474	3.53	8.06
	1	63	10	84.2	0.316	2.35	3.58
	1	55	10	81.9	0.158	1.18	0.89

Note Tube cross section area = 0.415 $in.^2$, Wetted perimeter = 3 in.

Hydraulic radius (R) = 0.415/3 x 12 = 0.0129 ft.

Table A-1 (Cont.)

tube size	tube length (ft.)	turb.	turb.	turbidity removed (percent)	Flowrate		$\frac{V^2R}{L} \times 10^{-7}$
					fpm	pgm/sq. ft.	
Medium galvanized steel corrugated sheet	3	63	7.6	87.9	0.934	7.6	21.23
	3	63	6.6	89.5	0.700	5.25	12.23
	3	65	4.8	92.6	0.469	3.5	5.50
	3	63	3.9	93.8	0.312	2.30	2,43
	3	60	3.3	94.5	0.156	1.17	0.61
	2	51	13.0	77.2	0.934	7.0	31.85
	2	56	11.0	80.4	0.700	5.25	18.35
	2	59	5.3	91.0	0.469	3.5	8.25
	2	60	4.3	92.8	0.312	2.30	3,65
	2	57	6.0	89.5	0.156	1.17	0,92
	1	59	20	66.1	0.934	7.0	63,70
	1	56	16	71.4	0.700	5.25	36,70
	1	55	12	78.2	0.469	3.5	16.50
	1	55	10	81.8	0.312	2.30	7.30
	1	57	10	82.5	0.156	1.17	1,84

Note Tube cross section area = 2.10 in^2 Wetted perimeter = 6.5 in. Hydraulic radius (R) = 2.10/6.5 x 12

= 0.027 ft.

Table A-1 (Cont.)

tube size	tube length (ft.)	turb.	turb.	turbidity removed (percent)	Flow rate		$V^2 R/L \times 10^{-7}$
					fpm	gpm /sq.ft.	
Asbestos cement corrugated sheet.	3	62	11.0	82.3	1.16	8.65	31.5
	3	60	8.1	86.5	0.87	6.50	19.7
	3	56	7.0	87.5	0.58	4.36	8.5
	3	63	4.8	92.4	0.39	2.88	3.9
	3	63	3.5	94.4	0.19	1.44	1.0
	2	62	17.0	72.6	1.16	8.65	52.3
	2	58	12.0	79.3	0.87	6.50	29.6
	2	56	10.0	82.1	0.57	4.30	12.7
	2	62	5.6	91.0	0.39	2.88	5.8
	2	50	6.3	87.4	0.19	1.44	1.5
	1	61	28.0	63.9	1.16	8.65	104.5
	1	56	18.0	67.9	0.87	6.50	59.1
	1	56	16.0	71.4	0.51	4.30	25.4
	1	55	14.0	74.5	0.39	2.88	11.6
	1	56	12.0	78.6	0.19	1.44	2.9

Note Tube cross section area = 2.11 in^2 Wetted perimeter = 6.33

Hydraulic radius (R) = 2.11/6.33 x 12 = 0.028 ft.

Table A-2 Analysis of test Data for tube length 3 ft.

	X turb. removed %	$V^2R/Lx10^{-7}$	Y log $(V^2R/Lx10^{-7})$	X^2	XY	X'	X - X'	$(X - X')^2$
1	89.5	10.72	1.0302	8010.25	92.20290	88.49	1.01	1.0201
2	90.2	6.02	0.7796	8136.04	70.31992	90.97	- 0.77	0.5929
3	94.5	2.70	0.4314	8930.25	40.76730	94.41	0.09	0.0081
4	96.9	1.19	0.0755	9389.61	7.31595	97.93	- 1.03	1.0609
5	87.9	21.23	1.3269	7726.41	116.63451	85.56	2.34	5.4756
6	89.5	12.23	1.0874	8010.25	97.32236	87.93	- 1.86	3.4596
7	92.6	5.50	0.7404	8574.76	68.56164	91.36	1.24	1.5376
8	93.8	2.43	0.3856	8798.44	36.16928	94.86	- 1.06	1.1236
9	82.3	31.5	1.4983	6773.29	123.31009	83.87	- 1.57	2.4649
10	86.5	19.7	1.2945	7482.25	111.97425	85.88	0.62	0.3844
11	87.5	8.5	0.9294	7656.25	81.32250	89.49	1.99	3.9601
12	92.4	3.9	0.5911	8537.76	54.61764	92.83	- 0.43	0.1849
Σ	1083.60		10.1703	98025.56	900.51768			21.2727
Av	90.30		0.847525					1.7727

$$m = \frac{\Sigma xy - nX_{av}Y_{av}}{\Sigma x^2 - n(X_{av})^2}$$

$$= \frac{900.51768-918.37809}{98025.56-97849.08}$$

$$= -0.1012$$

$$b = Y_{av} - mX_{av}$$

$$= 9.9859$$

$$Y = -0.1012X + 9.9859$$

$$X = -9.8814Y + 98.6749$$

$$\sigma = \sqrt{1.7727}$$

$$= 1.331$$

Table A-3 Analysis of test Data of tube length 2 ft.

	X turb. removed %	$V^2R/Lx10^{-7}$	Y log $(V^2R/Lx10^{-7})$	X^2	XY	X'	X - X'	$(X - X')^2$
1	83.3	16.08	1.2062	6938.89	100.47646	82.48	0.82	0.6724
2	89.1	9.08	0.9581	7938.81	85.36671	86.88	2.22	4.9284
3	93.8	4.30	0.6335	8798.44	59.42230	92.65	1.15	1.3225
4	94.8	1.79	0.2527	8987.04	23.97492	99.41	- 4.61	21.2521
5	77.2	31.85	1.5031	5959.84	116.03932	77.20	0	0
6	80.4	18.35	1.2637	6464.16	101.60148	81.46	- 1.06	1.236
7	91.0	8.25	0.9165	8281.00	83.40150	87.62	3.38	11.4244
8	92.8	3.65	0.5623	8611.84	52.18144	93.91	- 1.11	1.2321
9	72.6	52.30	1.7185	5270.76	124.76310	73.38	- 0.78	0.6084
10	79.3	29.60	1.4713	6288.49	116.67469	77.77	1.53	2.3409
11	82.1	12.70	1.1038	6740.41	90.62198	84.30	- 2.2	4.8400
12	91.0	5.80	0.7634	8281.00	69.46940	90.34	0.66	0.4356
Σ	1027.4		12.3533	88560.68	1023.9927			50.1804
Av	85.6167		1.0294					4.1817

$$m = \frac{1023.9927-1057.6471}{88560.68-87962.6318}$$

$$= -0.0563$$

$$b = 1.0294-4.8202$$

$$= 5.8496$$

$$Y = -0.0569X+5.8497$$

$$X = -17.7620Y+103.9023$$

$$\sigma = \sqrt{4.1817}$$

$$= 2.045$$

Table A-4 Analysis of test Data of tube length 1 ft.

	X turb. removed %	$V^2R/L \times 10^{-7}$	Y log (V^2R/L x10^{-7})	X^2	XY	X' = Y +90.285	X-X'	$(X-X')^2$
1	66.1	32.2	1.5079	4369.21	99.67219	69.76	- 3.66	18.4125
2	73.3	15.1	1.1790	5372.89	86.42070	74.23	- 0.93	0.8649
3	78.7	8.1	0.9085	6193.69	71.49895	77.91	0.79	0.6241
4	84.2	3.6	0.5563	7089.64	46.84046	82.69	1.51	2.2752
5	66.1	63.7	1.8041	4369.21	119.25101	65.74	0.36	0.1311
6	71.4	36.7	1.5647	5097.96	111.71958	68.99	2.41	5.8053
7	78.2	16.5	1.2175	6115.24	95.20850	73.71	4.49	20.1785
8	81.8	7.3	0.8633	6691.24	70.61794	78.52	3.28	10.7556
9	82.5	1.8	0.2553	6866.25	21.06225	86.78	- 4.28	18.3292
10	63.9	104.5	2.0191	4083.21	129.02049	62.82	1.08	11.1735
11	67.9	59.1	1.7716	4610.41	120.29164	66.18	1.72	2.9603
12	71.4	25.4	1.4048	5097.96	100.30272	71.16	0.24	0.0561
13	74.5	11.6	1.0645	5550.25	79.30525	75.79	- 1.29	1.6557
14	78.6	2.9	0.4624	6177.96	36.34464	83.97	- 5.37	28.8092
Σ	1038.60		16.5990	77625.12	1187.556320			107.0313
Av	74.1857		1.18421					7.6451

$$m = \frac{1187.55632-1229.92442}{77625.12-77049.253}$$

$$= -0.07357$$

$$b = 1.1842+5.7580$$

$$= 6.6422$$

$$Y = -0.07357X+6.6422$$

$$X = -13.5869Y+96.2486$$

$$\sigma = \sqrt{7.6451}$$

$$= 2.765$$

Appendix B. Example on Cost Comparision.

Let the plant has a capacity of 1,000 m^3./day

Operating period 8 hours

Design flow rate 1,000/8 = 125 m^3/hr.

<u>Conventional Sedimentation Tank</u>

Detention time 2 hr.

Depth of tank 2.5 + 0.5 m. for sludge storage

Horizontal velocity of flow in tank 0.2 fpm. = 10 m./hr.

Tank volume 2 x 125 = 250 m^3

Required surface area 250/2.5 = 100 m^2

Cross section area 125/10 = 12.5 m^2

Required width 12.5/2.5 = 5 m Use 6 m.

Required length 100/6 = 17 m.

Dimension of tank 6 m. wide x 17 m. long x 3.0 deep.

Reinforced concrete 20 cm. thickness was used.

Required volume of concrete = 20 x 6 x 0.2 + 2(6 x 3.60 x 0.2)

2(17 x 3.6 x 0.2)

= 57.12 m^3 Say 58 m^3

Concrete cost + Labour cost 550 Bt./m^3

Total cost of concrete work 58 x 550 = 31,900 Bt.

Required steel reiforcement 75 kg./m^3 of concrete

Total steel required 75 x 58 = 4,350 kg.

= 4.35 ton.

Steel cost + Labour cost 7,000 Bt./ton

Total cost of steel $\quad 7,000 \times 4.35 = 30,450$ Bt.

Area required for form work $\quad (17 \times 4.025 + 6 \times 4.025)2 \times 2$

$= 370.3\ m^2$

Formwork cost + Labour cost $= 80$ Bt./m^2

Total cost of formwork $\quad 370 \times 80 = 29,600$ Bt.

Total cost of tank (not include piping, other equipment and foundation)

$= 31,900 + 30,450 + 29,600$

$= 91,950$ Bt.

Sedimontation Tank using Tube Settler

Medium galvanized steel corrugated sheets of 2 ft. long were used as tube settler.

Tank depth $= 0.52$ m. + 0.20 m. free board + 1 m. for sludge storage

Design flow rate $= 125\ m^3/hr.$

From this study for 90 percent removal efficiency the overflow rate ranged from 2 gpm./sq.ft. ($5.0\ m^3/hr.-m^2$) to 30 gpm./sq.ft. ($7.5\ m^3/hr.-m^2$)

To ensure that the required removal efficiency is obtained the over flow rate of 6. $m^3/hr.-m^2$ will be used in the design purpose.

Surface area required for tube settler

$= 125/6 \qquad = 21\ m^2$

Width of medium galvanized steel corrugated sheet is 0.65 m.

Use 4 rows of corrugated sheets

Total width for tube settler unit $= 2.6$ m.

Length $= 21/2.60$

$= 8.2$ m. + 0.30 m.

Dimension of settling tank used tube settler is

2.60 m. wide x 8.50 m. long x 1.75 m. high

Total number of corrugated sheet (length 2 ft.) = 1,540

Material cost + Labour cost for corrugated sheet = 4.25 Bt./ft.

Total cost = 1,540 x 2 x 4.5 = 13,150 Bt.

The major advantage of sedimentation tank using tube settlers is that the height of the tank can be reduced to 1.75 m. . masonry wall can be applied.

Total surface area required for masonry wall

= (9.50 x 1.75 + 2.60 x 1.75) x 2

= 42.33 m^2. Say 45 m^2.

Material cost + Labour cost = 150 Bt./m^2.

Total cost 15.0 x 45 = 6,750 Bt.

Volume of concrete required for slab and column

= (11 x 2.60 x 0.2)2 + (.15 x .15 x 1.75)8

+ 24(.2 x .15)

= 6.76 m^3. Say 7 m^3.

Material cost + Labour cost = 550 Bt./m^2.

Total cost = 7 x 550 = 3,850 Bt.

Form work cost = 1,600 Bt.

Total cost for steel reinforcement = 1,000 Bt.

Cost for supports of tube module = 3,000 Bt.

Total cost for sedimentation tube use medium galvanized steel corrugated sheet as tube settler is 13, 150 + 6,785 + 3,850 + 1,000 + 3,000

+ 1,600

= 29,350 Bt.

= 31.9 percent of conventional tank.

Summary

	Conventional Tank	Tube settler using corrugated sheet
Cost of construction (Bt.) (excluded equipment and piping)	91,950	29,350
Area required (m^2)	102	24.7

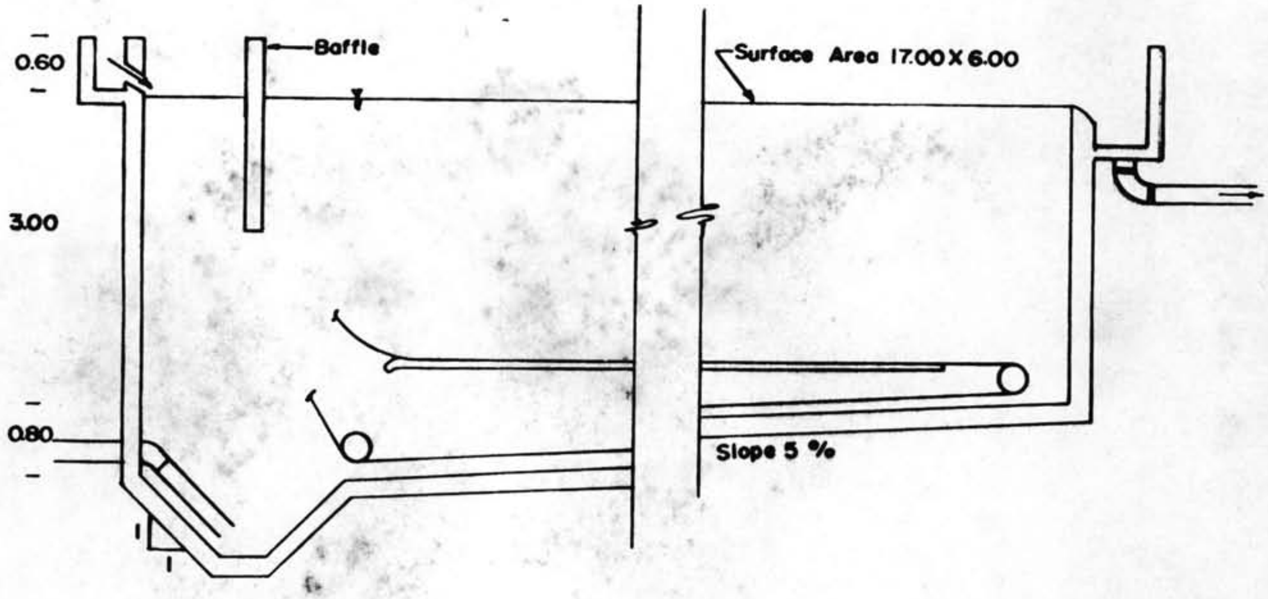

Fig 36 Conventional Sedimentation Tank (Capacity 1000 m^3/day)

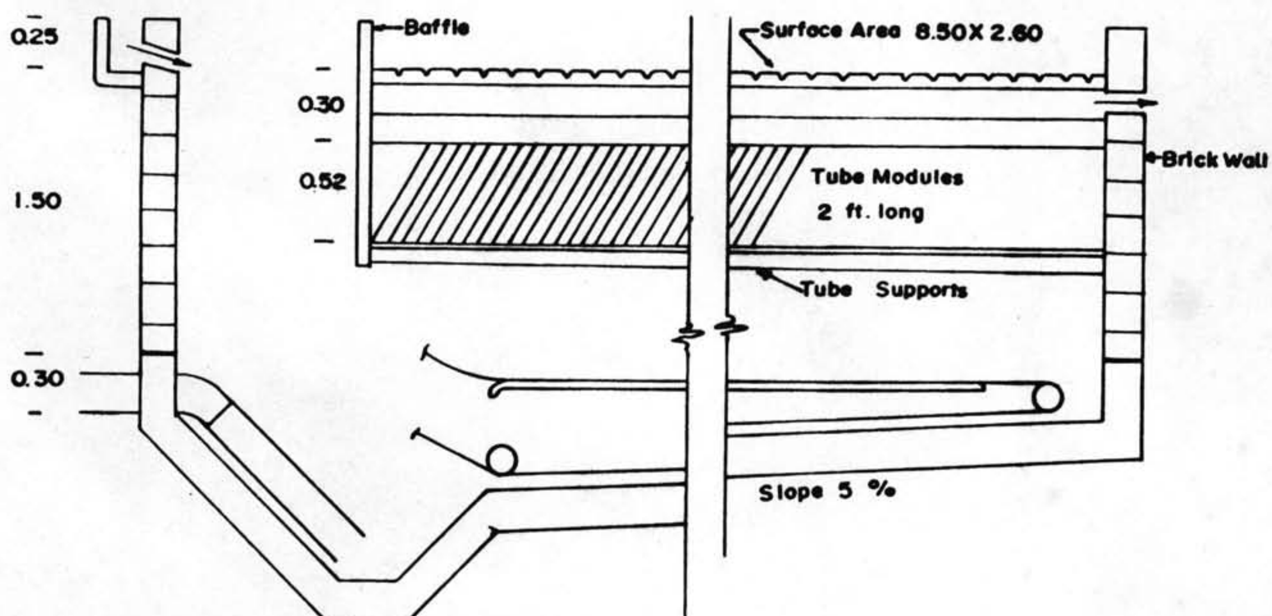

Fig 37 Sedimentation Tank using Medium Gal. Steel Corrugated Sheets as Tube Settlers (Capacity 1000 m^3/day)

VITA

The author, Sukhum Kosaisaevee received a Bachelor's Degree of Engineering in Sanitary Engineering from Chulalongkorn University in 1972 and a Diploma in Urban Surveys with Aerial Photography from ITC. Enschede, The Netherlands in 1974. At the time writing the thesis, he is serving as the government official of City Planning Division, Bangkok Metropolis.