Efficiency Simulation and Design of Settling Basin

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ABSTRACT

The objective of this study is to develop a two-dimensional numerical model as well as the optimal regression equations for the determining settling basin dimension, and then to simulate and compare the deposition efficiency of the selected settling basins. On the basis of the simulation results, the advantages and drawbacks of the existing settling basin design methods are evaluated. Furthermore, the economic sizes of the settling basins are determined through the numerical simulations based on assumed basin geometries, flow fields, and sediment properties. The obtained results may provide as a design reference to the associated agencies.

1. INTRODUCTION

Increasing the amount of surface runoff, changing land cover, and agricultural reclamation will cause additional soil erosion rate. To prevent from the disaster of the mud flow from the catchments, settling basins are usually adopted. For a long time the deposition efficiency in the settling basin design procedure has not been evaluated adequately, so the better size of settling basins cannot be attained. In the aspect of engineering economics, there still has the room for improvement in the settling basin design. Hence a horizontal 2-D settling basin numerical model is developed to simulate the mechanics of the deposition in the settling basin and the simulation results are analyzed to suggest a more economic design size in this study.

Decrease of the flow velocity in the basin to assure the sediment particle remaining time longer than the settling time is the main design idea of settling basin. To achieve this goal, widening the basin width and lowering the basin bottom are the common procedures. However, the same deposition efficiency may be attained by different combinations of length, width, and depth. The economic design of the settling basin with the specific efficiency is the focus of this study.

Traditional settling basin design methods, such as proposed by Camp (1964), Sumer(1977), Vanoni(1975), Garde et al.(1990) and the Soil and Water Conservation Standard (Taiwan), are all considering the required settling basin length under certain deposition efficiency and flow velocity. Nevertheless in the view of mass conservation:

$Q = V \cdot A$ (1)

where, Q = discharge; V = velocity; and A = cross-sectional area. Eq.(1) shows that there exists an cross-sectional area if the discharge and the velocity are specified. However, a cross-sectional area may be composed by different combinations of width and depth. Such a situation may cause the width and depth design of settling basins as an art. Thus the design criteria in the Soil and Water Conservation Standard(Taiwan) only suggests a range of 1.5-2.0 meters for the settling basin depth design without further designing details.

Taiwan's Soil and Water Conservation Standard does not provide the design guideline for determining the economic design of the settling basins. Vittal et al. (1997) derived a minimum earth work objective function to determine the optimal basin size. However, the approach is only valid for large discharges (10-200cms). In this study, the case of small discharges (0.1-10cms) will be investigated, and the derived optimal equations for basin size design will also be compared with the numerical results obtained from a 2-D movable-bed developed by the authors.

2. OPTIMIZATION METHODS FOR SETTLING BASIN DIMENSIONS

2.1 Non-dimensional settling basin length

Vittal et al. (1997) used the model proposed by Garde et al. (1990) to derive the procedures for determining the optimal settling basin dimensions. Garde et al. suggested an equation to calculate settling basin length L:

$$\eta = \eta_0[1 - \exp(-K\frac{L}{D})] \quad (2)$$

where, D = flow depth in the basin; K = coefficient; η = settling efficiency; η_0 = limiting value of η obtained for a given value of W_s / U_*; W_s = fall velocity of the sediment particle size d; U_* = shear velocity of flow.

Adopting following procedures, L can be obtained:

1. For assumed width B and depth D of the basin, calculate friction slope S_f and shear velocity U_* using Manning's equation as:

$$S_f = \frac{Q^2 n^2}{B^2 D^2 R^{4/3}} \quad (3)$$

$$U_* = \sqrt{gRS_f} \quad (4)$$

where, Q = discharge; R = hydraulic depth; n = Manning's roughness coefficient; and

g = gravitational acceleration.

2. Fall velocity W_s of sediment can be determined by using the equation Swamee et al. (1991) proposed.
3. From Fig.8 of Garde et al. (1990) read K and η_0 against W_s/U_*, and L can be calculated from Eq.(2).

By choosing d as the scaling parameter, the non-dimensional relation can be derived as :

$$L_* = f_1(Q_*, n_*, \eta, B_*, D_*) \tag{5}$$

in which

$$Q_* = \frac{Q}{g^{1/2} d^{5/2}} \; ; \; n_* = \frac{g^{1/2} n}{d^{1/6}} \; ; \; L_* = \frac{L}{d} \; ; \; B_* = \frac{B}{d} \; ; \; D_* = \frac{D}{d}$$

2.2 The best solution of objective function

By evaluating the cost of settling basin construction, Vittal et al. (1997) developed a minimum earth work objective function:

$$Min\ V_{e*} = Min\ f_2(Q_*, n_*, \eta, B_*, D_*) \tag{6}$$

V_e (equivalent volume of earthwork)is the function of basin dimensions; superscript * represents non-dimension.

The physical variable ranges are: Q = 10-200 cms; d_s = 0.1～0.75 mm; n = 0.013～0.20; η = 50～95%. Solving (5) and (6) by multiple regression analysis, Vittal et al. obtained the following expressions:

$$L_* = 3.75 \times 10^{-3} \times Q_*^{0.43} \times n_*^{0.98} \times \eta^{2.1} \tag{7}$$

$$B_* = 6.7 \times Q_*^{0.52} \times n_*^{1.18} \times \eta^{-0.008} \tag{8}$$

$$D_* = 4.12 \times Q_*^{0.42} \times n_*^{0.984} \times \eta^{0.004} \tag{9}$$

where, correlation coefficient= 0.998, and standard error = 0.033 in Eq. (7); correlation coefficient= 0.993, and standard error = 0.057 in Eq. (8); and correlation coefficient= 0.996, and standard error = 0.042 in Eq. (9).

In this study, similar procedures are followed to obtain the optimal dimensions of the settling basin for the smaller range of discharge: Q = 0.1-10 cms.

$$L_* = 2.3\times10^{-4}\times Q_*^{0.62}\times n_*^{0.639}\times\eta^{1.8} \quad (10)$$

$$B_* = 1.2\times10^{4}\times Q_*^{0.074}\times n_*^{-1.08}\times\eta^{-0.466} \quad (11)$$

$$D_* = 2.9\times Q_*^{0.511}\times n_*^{0.402}\times\eta^{-0.43} \quad (12)$$

where, correlation coefficient= 0.943, and standard error = 0.13 in Eq.(10); correlation coefficient= 0.940, and standard error = 0.065 in Eq.(11); and correlation coefficient= 0.970, and standard error = 0.085 in Eq.(12).

One may notice that the exponents of η in Eq. (11) and (12) are quite similar, and we cannot neglect the effects of removal efficiency to width B and depth D. According to the study of Vittal et al., Eq(8) and (9), it can be seen that the design of settling basin width and depth is more sensitive to the value of η for the case of smaller discharge.

3. NUMERICAL SIMULATION OF SETTLING EFFICIENCY

From previous analysis, less emphasis was put on the effect of the variation of width and depth on the design of settling basin. In order to consider the basin dimension varying effect, some design cases were selected for numerical simulation in this study. In the proposed numerical model, the EFA (explicit finite analytic) method was used to calculate the convective terms in the flow equations, while the other terms were discretized by finite difference method. The sediment transport mode in this model was divided into bedload and suspended-load and the interaction between these two loads was considered. Through the simulation, the deposition in the basin can be calculated, and the results will be compared with the former optimal equations. The development and calibration of the proposed numerical model can be referred to Yeh et al. (2002).

3.1 Cases design for numerical simulation

3.1.1 Geometry shapes

There are 25 horizontal geometry shapes of the settling basin in the design cases with following combinations: 20m(in length) × 20m(in width), 20m × 40m, 20m × 60m, 20m × 80m, 20m × 100m, 40m × 20m, 40m × 40m, 40m × 60m, 40m × 80m, 40m × 100m, 60m × 20m, 60m × 40m, 60m × 60m, 60m × 80m, 60m × 100m, 80m × 20m, 80m × 40m, 80m × 60m, 80m × 80m, 80m × 100m, 100m × 20m, 100m × 40m, 100m × 60m, 100m × 80m, 100m × 100m. The basin depth is 1.5m for all the cases.

3.1.2Initial bed elevation

The bed elevation of the upstream entrance and downstream outlet channel is kept at 1.5m, while the basin bottom is kept at 0 meter.

3.1.3 Upstream entrance discharge per unit width

The upstream entrance discharge per unit width is set to be 1cms/m, 2cms/m, and 3cms/m. The upstream entrance width is 10 m.

3.1.4 Downstream water elevation

The downstream water elevation is set to be 2.5m.

3.1.5 Upstream sediment concentration

The upstream inflow sediment concentration is set to be 2,000ppm, and the density of sediment is 2,650 kg/m^3.

3.1.6 Sediment particle

Six sediment sizes are chosen: 2.0mm, 1.4mm, 0.8mm, 0.2mm, 0.1mm, and 0.05mm.

3.1.7 Simulation time

The simulation time in all cases is 3 hours.

According to the 25 sets of basin geometry shapes, 3 sets of upstream discharges, and 6 sets of sediment particles, there are 18 runs for each geometry shape and there are 450 runs in total.

3.2 Simulation results

3.2.1 Comparison of settling

Table1 shows the settling efficiency for all dimensions and sediment particles when the upstream discharge is 1cms/m. It can be seen that the settling efficiency is better when the sediment particle size is larger. Take the case 20m$\times$20m for example, when the particle size is 0.05mm, the settling efficiency is only 37.0%, while the particle size increases to 2.0mm, the settling efficiency increases to 98.8%. However, the difference of the settling efficiencies of these two particles reduces, when the basin length increases. Take the case 100m$\times$20m for example, the settling efficiencies of the above two particles are 98.0% and 100%, respectively. These two values are close. In addition, for a given fixed basin length, the best settling efficiency does not necessarily correspond to the widest case. Take the cases of sediment particle size equal to 0.05mm, and basin length equal to 20m for examples, when the width is 40m, the deposition efficiency is 42.9%, which is higher than 41.4% of the case of 100m in width. The simulated results show that the settling efficiency of the basin may reduce due to the intensive turbulence resulted from the sudden cross-section expansion of the entrance channel into the settling basin.

In the cases of sediment particle size equal to 0.2mm, the average simulated efficiency is 60.0%, which is much higher than 15.8% obtained from Eq.(2). This reflects that the settling efficiency estimated by Garde et al. (1990) might be too conservative, which means more construction cost is required.

Table2 shows the settling efficiency in all shapes and sediment particles when the upstream discharge is 2cms/m. Compared to the results of Table1, the efficiency is a little lower, which means the higher velocity will decrease the deposition rate. Table3 represents the settling efficiency in all shapes and sediment particles when the upstream discharge is 3cms/m. Significant decrease of the settling efficiency can be observed due to the increase of the flow velocity in the basin, especially for small size cases. To sum up, when the inlet flow is smaller, even the sediment particle is finer, as long as the basin horizontal area is large enough, the better settling efficiency can be obtained. However, when the inlet flow is increased, for example, upstream inlet discharge equal to 3cms/m, even in the largest basin area case, the settling efficiency can not reach a better value (say, 90%) in the case of finer sediment particle. According to the simulated basin sizes, some cases have the same area, only differ in the combinations of length and width. From Table1 to Table3, these cases show the tendency of longer basin length having larger settling efficiency.

3.2.2 The economic dimension of the settling basin

Table4 to Table6 are the settling efficiency per unit basin area. Set the area of 20m×20m as the unit area, and the area ratios of all the other cases are listed in the table. All the relative settling efficiency per unit basin area is equal to the original settling efficiency divided by the area ratio. The larger values in these tables represent the more economic dimensions of the basins. From Table4 (inflow = 1cms/m), it can be seen that the most economic size of the basin is 20m×20m for all sediment particles. From Table5 (inflow = 2cms/m), the most economic basin dimension is 20m×20m for the sediment particle sizes of was equal to 2.0mm and 0.8mm, 40m×20m for particle size of 1.4mm, and 60m×20m for particle sizes ranged from 0.05mm to 0.2mm. From Table6 (inflow = 3cms/m), the most economic basin dimension is 20m×20m for sediment particle sizes ranged from 0.8mm to 2.0mm, and 80m×20m for particle sizes ranged from 0.05mm to 0.2mm. It can also be found that the most economic basin size lengthens as the upstream inlet discharge increases, especially in the cases of smaller sediment particle (from 0.05mm to 0.2mm). The most economic case is 20m×20m under the upstream inlet discharge of 1cms/m; 60m×20m for inflow of 2cms/m; 80m×20m for inflow of 3cms/m.

Furthermore, the best settling efficiencies per unit basin area for smaller sediment particles is less than that those for larger particle sizes. For example, the largest settling for the case of 0.05mm is 15.77%, while that for the case of 2.0mm is 43.18%, as can be seen from Table6.

This shows that the smaller particles are more difficult to deposit than the bigger ones in the settling basin of the same size. In other words, higher cost must be paid in collecting the finer particles.

The simulation results are compared with those obtained from Vittal et al.'s optimal equations under the same settling efficiencies (1997), as shown in Table7. From Table7, the results of Vittal et al. (1997) seem too conservative. Such a situation becomes severer when the upstream inlet discharge increases. For example, when the upstream inlet discharge is 3cms/m, the basin volume calculated from Vittal et al.'s (1997) equations is 5.6 times of the proposed numerical result. Table7 also indicates that the length of the basin is over-estimated and the width and depth are under-estimated in Vittal et al.'s equations. This may come from the negligence of the complex velocity field occurred in the basin. The correction coefficients are listed in the table for reference.

4. CONCLUSIONS

In this study, the optimal relations proposed by Vittal et al. (1997) for large inflow case(10-200cms) and by the writers for small inflow case(0.1-10cms) to determine the settling basin dimensions(length, depth, and width) are introduced. Being unable to consider the complex flow field caused by the settling basin geometry, traditional settling basin deposition efficiency theory may provide conservative estimation. To reasonably simulate the complicated flow field and sediment deposition behavior due to different layouts of the basin geometry, the writers use the 2-D finite analytic movable-bed model. On the basis of the simulated results of the 450 numerical experiments and the comparison with the optimal relations, following conclusions can be drawn:

1. Traditional settling basin design formulas are suitable for basins with large length-width ratio. As the length-width ratio of the basin decreases, the applicability of the optimal relations for the basin dimensions should be checked. Better understanding of the deposition mechanism could be obtained by applying the 2-D or 3-D numerical model.
2. The optimal (or economic) dimensions of the settling basin estimated from the optimal relations proposed by Vittal et al. (1997) are conservative in comparison with the simulated results in this study, especially when the inflow discharge increases and sediment particle sizes are small. However, the discrepancy and applicability between the two approaches needs further identification through the physical model experiments in future.

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Table1 Settling efficiency (inflow = 1cms/m)

	Sediment particles					
Sizes	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	37.00%	40.95%	61.24%	87.32%	98.14%	98.78%
20x40	42.86%	48.27%	70.96%	89.42%	97.38%	93.16%
20x60	40.73%	45.79%	68.93%	93.54%	99.60%	97.94%
20x80	41.07%	46.56%	71.52%	86.52%	87.62%	89.32%
20x100	41.43%	46.90%	71.16%	94.99%	99.18%	96.64%
40x20	59.30%	65.53%	91.15%	99.92%	99.96%	99.99%
40x40	83.73%	87.71%	96.09%	99.93%	99.99%	99.99%
40x60	86.63%	89.38%	96.80%	99.97%	100.00%	100.00%
40x80	89.44%	92.78%	98.64%	99.79%	99.96%	99.99%
40x100	87.81%	90.54%	96.59%	99.73%	99.96%	100.00%
60x20	90.97%	93.26%	97.64%	99.93%	100.00%	100.00%
60x40	92.78%	94.99%	98.76%	99.95%	100.00%	100.00%
60x60	96.10%	97.40%	99.24%	99.97%	100.00%	100.00%
60x80	96.11%	97.33%	99.16%	99.90%	99.99%	100.00%
60x100	97.22%	98.32%	99.57%	99.92%	99.99%	100.00%
80x20	96.66%	97.84%	96.30%	99.97%	100.00%	100.00%
80x40	98.90%	99.01%	99.79%	99.98%	100.00%	100.00%
80x60	99.25%	99.52%	99.79%	99.94%	99.99%	100.00%
80x80	98.78%	99.23%	99.69%	99.91%	99.91%	100.00%
80x100	99.25%	99.53%	99.81%	99.93%	99.99%	100.00%
100x20	97.99%	98.87%	97.37%	99.97%	100.00%	100.00%
100x40	98.52%	99.08%	99.69%	99.96%	100.00%	100.00%
100x60	99.00%	99.31%	99.71%	99.95%	100.00%	100.00%
100x80	99.18%	99.17%	99.85%	100.00%	100.00%	100.00%
100x100	99.33%	99.36%	99.75%	99.89%	99.98%	100.00%

Largest efficiency	99.33%	99.53%	99.85%	100.00%	100.00%	100.00%
Size	100x100	80x100	100x80	100x80	40x60	40x60
Area ratio	25	20	20	20	6	6

Table2 Settling efficiency (inflow = 2cms/m)

	Sediment particles					
Sizes	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	13.22%	13.74%	12.07%	44.81%	43.08%	50.51%
20x40	21.11%	22.85%	31.09%	40.13%	47.24%	52.23%
20x60	19.76%	21.22%	31.11%	49.05%	62.59%	67.66%
20x80	19.90%	21.02%	28.50%	46.74%	57.32%	63.39%
20x100	19.32%	20.54%	37.47%	42.61%	51.56%	57.98%
40x20	25.04%	24.39%	25.32%	79.56%	97.22%	98.97%
40x40	55.40%	60.03%	78.15%	93.04%	95.93%	95.90%
40x60	76.76%	81.33%	87.62%	94.18%	98.41%	100.00%
40x80	65.50%	69.79%	85.20%	98.15%	99.12%	99.88%
40x100	78.04%	80.36%	86.26%	95.61%	99.29%	100.00%
60x20	63.69%	66.20%	82.88%	93.79%	97.65%	98.77%
60x40	68.98%	73.06%	85.35%	97.19%	98.77%	99.80%
60x60	82.55%	85.52%	90.39%	98.83%	99.71%	99.90%
60x80	81.83%	81.83%	92.66%	99.17%	99.74%	99.87%
60x100	87.46%	88.96%	92.32%	99.13%	99.67%	99.85%
80x20	78.79%	80.87%	89.70%	98.90%	99.73%	99.87%
80x40	78.91%	82.03%	90.09%	98.00%	99.38%	99.89%
80x60	88.44%	90.22%	93.61%	99.44%	99.84%	99.92%
80x80	90.28%	91.61%	94.79%	99.12%	99.67%	99.85%
80x100	92.51%	92.89%	97.18%	99.57%	99.80%	99.92%
100x20	82.43%	87.88%	89.72%	99.40%	99.86%	99.95%
100x40	89.51%	91.82%	95.74%	99.61%	99.90%	99.95%
100x60	91.22%	93.09%	96.20%	99.14%	99.75%	99.89%
100x80	93.86%	93.34%	97.09%	99.83%	99.98%	99.99%
100x100	93.04%	92.64%	95.07%	98.54%	99.54%	99.79%

Largest efficiency	93.86%	93.34%	97.18%	99.83%	99.98%	100.00%
Size	100x80	100x80	80x100	100x80	100x80	40x60
Area ratio	20	20	20	20	20	6

Table3 Settling efficiency（inflow = 3cms/m）

	Sediment particles					
Sizes	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	7.18%	3.81%	2.68%	42.54%	39.23%	43.18%
20x40	13.62%	13.75%	12.76%	30.78%	43.10%	45.47%
20x60	12.15%	11.96%	15.02%	18.05%	35.60%	36.63%
20x80	11.92%	10.97%	12.13%	11.04%	28.93%	35.39%
20x100	11.89%	11.40%	21.68%	20.87%	31.48%	34.58%
40x20	9.36%	-7.84%	1.75%	57.05%	74.36%	84.49%
40x40	41.08%	45.80%	60.13%	81.52%	90.42%	93.08%
40x60	61.06%	59.61%	71.10%	93.61%	98.83%	97.94%
40x80	50.93%	54.52%	71.02%	89.23%	97.50%	98.19%
40x100	56.67%	56.82%	65.59%	87.32%	96.92%	98.13%
60x20	44.55%	45.27%	61.99%	84.02%	91.66%	93.49%
60x40	53.53%	55.86%	69.10%	91.64%	97.93%	98.03%
60x60	72.63%	75.14%	82.24%	93.55%	99.11%	99.75%
60x80	72.77%	75.02%	83.53%	97.02%	99.06%	99.52%
60x100	77.85%	77.08%	85.31%	95.31%	97.50%	100.00%
80x20	63.09%	73.14%	95.33%	95.33%	97.72%	98.43%
80x40	67.87%	65.54%	78.54%	94.88%	98.42%	99.33%
80x60	77.68%	80.26%	87.34%	98.85%	99.53%	99.79%
80x80	83.40%	83.13%	90.35%	97.92%	99.45%	99.76%
80x100	81.66%	81.09%	89.16%	98.34%	99.64%	99.73%
100x20	58.63%	60.23%	78.55%	95.38%	98.45%	99.21%
100x40	78.46%	82.25%	88.63%	96.43%	98.17%	98.80%
100x60	84.35%	86.82%	91.41%	97.90%	99.16%	99.66%
100x80	84.74%	85.77%	93.73%	98.79%	99.75%	99.93%
100x100	85.86%	84.51%	91.88%	97.55%	99.01%	99.46%

Largest efficiency	85.86%	86.62%	95.33%	98.85%	99.75%	100.00%
Size	100x100	100x60	80x20	80x60	100x80	60x100
Area ratio	25	15	4	12	20	15

Table4 Settling efficiency per unit basin area（inflow = 1cms/m）

		Sediment particles					
Sizes	Area ratio	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	1	37.00%	40.95%	61.24%	87.32%	98.14%	98.78%
20x40	2	21.43%	24.14%	35.48%	44.71%	48.69%	46.58%
20x60	3	13.58%	15.26%	22.98%	31.18%	33.20%	32.65%
20x80	4	10.27%	11.64%	17.88%	21.63%	21.91%	22.33%
20x100	5	8.29%	9.38%	14.23%	19.00%	19.84%	19.33%
40x20	2	29.65%	32.77%	45.58%	49.96%	49.98%	50.00%
40x40	4	20.93%	21.93%	24.02%	24.98%	25.00%	25.00%
40x60	6	14.44%	14.90%	16.13%	16.66%	16.67%	16.67%
40x80	8	11.18%	11.60%	12.33%	12.47%	12.50%	12.50%
40x100	10	8.78%	9.05%	9.66%	9.97%	10.00%	10.00%
60x20	3	30.32%	31.09%	32.55%	33.31%	33.33%	33.33%
60x40	6	15.46%	15.83%	16.46%	16.66%	16.67%	16.67%
60x60	9	10.68%	10.82%	11.03%	11.11%	11.11%	11.11%
60x80	12	8.01%	8.11%	8.26%	8.33%	8.33%	8.33%
60x100	15	6.48%	6.55%	6.64%	6.66%	6.67%	6.67%
80x20	4	24.17%	24.46%	24.08%	24.99%	25.00%	25.00%
80x40	8	12.36%	12.38%	12.47%	12.50%	12.50%	12.50%
80x60	12	8.27%	8.29%	8.32%	8.33%	8.33%	8.33%
80x80	16	6.17%	6.20%	6.23%	6.24%	6.24%	6.25%
80x100	20	4.96%	4.98%	4.99%	5.00%	5.00%	5.00%
100x20	5	19.60%	19.77%	19.47%	19.99%	20.00%	20.00%
100x40	10	9.85%	9.91%	9.97%	10.00%	10.00%	10.00%
100x60	15	6.60%	6.62%	6.65%	6.66%	6.67%	6.67%
100x80	20	4.96%	4.96%	4.99%	5.00%	5.00%	5.00%
100x100	25	3.97%	3.97%	3.99%	4.00%	4.00%	4.00%

Largest efficiency		37.00%	40.95%	61.24%	87.32%	98.14%	98.78%
Size		20x20	20x20	20x20	20x20	20x20	20x20
Area ratio		1	1	1	1	1	1

Table5 Settling efficiency per unit basin area (inflow = 2cms/m)

		Sediment particles					
Sizes	Area ratio	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	1	13.22%	13.74%	12.07%	44.81%	43.08%	50.51%
20x40	2	10.55%	11.42%	15.54%	20.06%	23.62%	26.12%
20x60	3	6.59%	7.07%	10.37%	16.35%	20.86%	22.55%
20x80	4	4.98%	5.26%	7.12%	11.69%	14.33%	15.85%
20x100	5	3.86%	4.11%	7.49%	8.52%	10.31%	11.60%
40x20	2	12.52%	12.19%	12.66%	39.78%	48.61%	49.49%
40x40	4	13.85%	15.01%	19.54%	23.26%	23.98%	23.98%
40x60	6	12.79%	13.55%	14.60%	15.70%	16.40%	16.67%
40x80	8	8.19%	8.72%	10.65%	12.27%	12.39%	12.48%
40x100	10	7.80%	8.04%	8.63%	9.56%	9.93%	10.00%
60x20	3	21.23%	22.07%	27.63%	31.26%	32.55%	32.92%
60x40	6	11.50%	12.18%	14.23%	16.20%	16.46%	16.63%
60x60	9	9.17%	9.50%	10.04%	10.98%	11.08%	11.10%
60x80	12	6.82%	6.82%	7.72%	8.26%	8.31%	8.32%
60x100	15	5.83%	5.93%	6.15%	6.61%	6.64%	6.66%
80x20	4	19.70%	20.22%	22.42%	24.73%	24.93%	24.97%
80x40	8	9.86%	10.25%	11.26%	12.25%	12.42%	12.49%
80x60	12	7.37%	7.52%	7.80%	8.29%	8.32%	8.33%
80x80	16	5.64%	5.73%	5.92%	6.20%	6.23%	6.24%
80x100	20	4.63%	4.64%	4.86%	4.98%	4.99%	5.00%
100x20	5	16.49%	17.58%	17.94%	19.88%	19.97%	19.99%
100x40	10	8.95%	9.18%	9.57%	9.96%	9.99%	10.00%
100x60	15	6.08%	6.21%	6.41%	6.61%	6.65%	6.66%
100x80	20	4.69%	4.67%	4.85%	4.99%	5.00%	5.00%
100x100	25	3.72%	3.71%	3.80%	3.94%	3.98%	3.99%

Largest efficiency		21.23%	22.07%	27.63%	44.81%	48.61%	50.51%
Size		60x20	60x20	60x20	20x20	40x20	20x20
Area ratio		3	3	3	1	2	1

Table.6 Settling efficiency per unit area basin (inflow = 3cms/m)

		Sediment particles					
Sizes	Area ratio	0.05mm	0.1mm	0.2mm	0.8mm	1.4mm	2.0mm
20x20	1	7.18%	3.81%	2.68%	42.54%	39.23%	43.18%
20x40	2	6.81%	6.88%	6.38%	15.39%	21.55%	22.73%
20x60	3	4.05%	3.99%	5.01%	6.02%	11.87%	12.21%
20x80	4	2.98%	2.74%	3.03%	2.76%	7.23%	8.85%
20x100	5	2.38%	2.28%	4.34%	4.17%	6.30%	6.92%
40x20	2	4.68%	-3.92%	0.88%	28.53%	37.18%	42.25%
40x40	4	10.27%	11.45%	15.03%	20.38%	22.61%	23.27%
40x60	6	10.18%	9.93%	11.85%	15.60%	16.47%	16.32%
40x80	8	6.37%	6.81%	8.88%	11.15%	12.19%	12.27%
40x100	10	5.67%	5.68%	6.56%	8.73%	9.69%	9.81%
60x20	3	14.85%	15.09%	20.66%	28.01%	30.55%	31.16%
60x40	6	8.92%	9.31%	11.52%	15.27%	16.32%	16.34%
60x60	9	8.07%	8.35%	9.19%	10.39%	11.01%	11.08%
60x80	12	6.06%	6.25%	6.96%	8.08%	8.26%	8.29%
60x100	15	5.19%	5.14%	5.69%	6.35%	6.50%	6.67%
80x20	4	15.77%	18.29%	23.83%	23.83%	24.43%	24.61%
80x40	8	8.48%	8.19%	9.82%	11.86%	12.30%	12.42%
80x60	12	6.47%	6.69%	7.28%	8.24%	8.29%	8.32%
80x80	16	5.21%	5.20%	5.65%	6.12%	6.22%	6.24%
80x100	20	4.08%	4.05%	4.46%	4.92%	4.98%	4.99%
100x20	5	11.73%	12.05%	15.71%	19.08%	19.69%	19.84%
100x40	10	7.85%	8.22%	8.86%	9.64%	9.82%	9.88%
100x60	15	5.62%	5.79%	6.09%	6.53%	6.61%	6.64%
100x80	20	4.24%	4.29%	4.69%	4.94%	4.99%	5.00%
100x100	25	3.43%	3.38%	3.68%	3.90%	3.96%	3.98%

Largest efficiency		15.77%	18.29%	23.83%	42.54%	39.23%	43.18%
Size		80x20	80x20	80x20	20x20	20x20	20x20
Area ratio		4	4	4	1	1	1

Table7 Comparison of settling basin dimension (1/2)

q=1cms/m d=0.1mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	8.05	20.00	2.48
B(m)	38.74	20.00	0.52
D(m)	2.88	1.50	0.52
V(m^3)	899.67	600.00	0.67

q=2cms/m d=0.1mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	29.74	60.00	2.02
B(m)	55.34	20.00	0.36
D(m)	3.86	1.50	0.39
V(m^3)	6351.74	1800.00	0.28

q=3cms/m d=0.1mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	43.65	80.00	1.83
B(m)	68.27	20.00	0.29
D(m)	4.58	1.50	0.33
V(m^3)	13636.88	2400.00	0.18

Table7 Comparison of settling basin dimension (1997) (2/2)

q=1cms/m d=0.2mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	15.89	20.00	1.26
B(m)	27.37	20.00	0.73
D(m)	2.49	1.50	0.60
V(m^3)	1081.55	600.00	0.55

q=2cms/m d=0.2mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	40.42	60.00	1.48
B(m)	39.15	20.00	0.51
D(m)	3.33	1.50	0.45
V(m^3)	5264.74	1800.00	0.34

q=3cms/m d=0.2mm			
	Vittal et al. (1997)	Numerical simulation	Correction coefficient
L(m)	70.67	80.00	1.13
B(m)	48.27	20.00	0.41
D(m)	3.94	1.50	0.38
V(m^3)	13456.90	2400.00	0.18