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EFFECT THE SHAPE OF STILLING BASIN ON SCOUR DOWNSTREAM HEADING-UP STRUCTURES

تأثير شكل أحواض التهدئة علي النحر خلف منشات الحجز

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خلاصة :

يختص هذا البحث بدراسة مدى تأثير شكل أحواض التهدئة علي خواص السريان و النحر خلف منشأت الحجز . تم تصميم ستة و عشرون نموذج مختلفة الشكل لحوض التهدئة خلف الهدار – تم إجراء أثنين و سبعون تجربة على الأشكال المختلفة لأحواض التهدئة مع تغيير خواص السريان المختلفة . وأمكن بهذه الدراسة ربط العلاقات الناتجة عن خواص السريان و أشكال أحواض التهدئة بعلاقات بيانية و نأمل أن تكون هذه الدراسة مفيدة لمصممى أحواض التهدئة خلف منشأت الحجز.

ABSTRACT

The objective of this research is to investigate how the shape of stilling basin affects the flow and the principal dimension of local scour downstream heading up Structures. Twenty-sixth type shapes of stilling basin have been designed in conjunction with weirs. Seventy-two runs were conducted considering various stilling basin shape with different flow conditions. Relationship between the shape of the stilling basin, flow conditions and scour parameters were developed from the data obtained from experimental tests.

INTRODUCTION

Many laboratory stndies have been made on stilling basin to investigate the efficiency of anti-scour designs downstream of hydraulic structures. To mention a few of the experimenters who contributed basic information there are Bradley and Peterka, U.S. Bureau of Reclamation, Laursen and others, Mohamed Ali, Peterka, Uymaz, Pillai et al, Breusers and Raudkivi, Baghdadi, Hoffmans. There is probably no phase of stilling basin that has received more attention, yet, from a practical viewpoint, there is still much to be worked. Therefore, it was the objective of this study to investigate how the shape of stilling basin affects the flow and the characteristic of scour downstream heading up structnres. In this paper twenty sixth type shape of stilling basin were used to minimize the scour depth and to develop the best shape of stilling basin. The present experimental program include the experiments for investigate the changes of shape and dimension of stilling basin.

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DIMENSIONAL ANALYSIS

Experimental program require correlation between the gathering of data and its graphical representation. In the present study the independent variables considered in the dimensional analysis are chosen to represent the experimental condition of the problem,

Referring to Fig (1), the following parameters are used,

q: discharge per unit width of flume

D: the tail water depth.

d_s: the maximnm scour depth.

F_r: Froude number = $v/(g.\ D)^{0.5}$.

L_s: the length of scour hole.

L_m: the length to the location of maximum sconr depth.

The variables are numerous and preclude rigorous mathematical analysis therefore; a model study was performed based on the principles of similitude to obtain and empirically analyze the data. The scour hole dimension of d_s, L_s, and L_m were converted to dimensionless parameters d_s/D, L_s/D, L_m/D and the kinetic flow factor $1/F_r^2$.

EXPERIMENTAL SET-UP

A series of experiments were conducted in a plexiglass flume 4.80 m long, 0.075m wide, and 0.17 m deep, of a circulating type. The flume was divided into an upstream section, a test reach, and a downstream section, as shown in Fig. (2). The upstream section consisted of a reception area for the laboratory water and a solid horizontal bed. To dampen disturbance and to provide an even flow distribution across the flume a performed screen was placed in the upstream section before the upstream weir. The fixed bed was situated 0.05 m above the flume bottom. The test reach was composed of movable bed with a bed soil material to a depth of 0.05 m. A solid floor bed with a depth of 0.05 m locked up the bed soil material. The downstream section consists of a water level control sluice gate at the out flow point of the channel. To represent the erodable bed the rear portion of channel is filled with sand with D_{50} = 0.58mm. A point gauge operating in a flume measured the water depth and the scour hole dimension.

DESIGN OF DIFFERENT TYPES OF STILLING BASIN

Twenty-six model of wooden are made to form the stilling basin as given in Fig (3). The design shapes of stilling basin have been based upon field experience works, which have not been incorporated in established design procedure. To simplify the investigations the length and the depth of all stilling basins are considered constant 25 cm and 1.50cm respectively.

EXPERIMENTAL RESULTS

To study the performance of each type of stilling basins three discharges are considered (q = 51.26, 70.38, and 86.96 cm3/sec/cm). For each discharge, three water depths downstream the structure are used. The procedure followed in each test of this experiments was to first establish a flow. Also, the sandy soil was firmly packed and leveled horizontally before each experimental run. Seventy-eight runs were conducted, for each run, backwater feeding is started first until its depth reaches higher than required downstream water depth D, then upstream feeding is started. Three hours after many trails was chosen as a constant time for all runs. After this time, here was no appreciable change is scour hole dimensions. After the running time, the run was stopped and the flume was evacuated. The length and depth of scour hole profile along the centerline of the flume was recorded by a point gauge immediately downstream the basin. The results of the measurements and computations are tabulated in Table (1). The measured quantities are tabulated as follows discharge per centimeter width of flume, tail water depth, length of scour hole at the deepest point of scour and the whole length of scour hole. The dimensions parameters d_s/D, L_s/D, L_m/D, and $1/F_r^2$ were computed.

ANALYSIS

Experimental results were expressed in dimensionless forms and graphically represented to study the performance of different type of suggested stilling basin on scour hole dimensions. The relation between the dimensionless maximum scour depth ratio (d_s/D) and the dimensionless ratio ($1/F_r^2$) for different types of basin is shown in Fig. (4). The figures show that, ratio (d_s/D) is inversely proportional to the ratio ($1/F_r^2$). The respective figures also show that; for types of basin No. (5,7,15,16,17,18,19, 25,26) gives the smallest values of the ratio (d_s/D), and type of basin No. (2,4,8,10,13,18,20,32) gives the greatest value of this ratio. The type of basin No. (1,2,23) gives the smallest values of ratio (d_s/D) when ($1/F_r^2$) more than 22.

Fig. (5) presents the relation between the scour length ratio (L_s/D) and the dimensionless ratio ($1/F_r^2$) for different types of basin. The figures show that ratio (L_s/D) is also inversely proportional to the ratio ($1/F_r^2$). It is noted that for type of basin No. (5,7,15,16,17,18,19,25,26) gives the smallest values of the scour length ratio (L_s/D) while the greatest scour length ratio occurs when used type of basin No. (2,4,8,10,13,18,20,32). As shown in Fig. (5) the greatest values of scour length ratio occur when used basin No. (1,4,8) and ($1/F_r^2$) less than about 6.

The distance from the end of the floor to the point of maximum scour depth, L_m is recorded and used to illustrate the variation of L_m/D with ($1/F_r^2$). It has been observed that the dimensionless ratio (L_m/D) and is inversely proportional to the ratio ($1/F_r^2$). Fig. (6) shows that the type of basin No. (2,4,7, 8,16,17,26) gives the greatest values of ratio (L_m/D) when the ratio ($1/F_r^2$) is less than 6, and the type basin No. (4,10,13,21) have the smallest value of ratio L_m/D.

The results show that the scour length ratio (L_s/D) is directly proportional to the scour depth ratio (d_s/D) for all types of different basins. It is also noted that, the type of basin No. (1,2,3,4) gives the greatest scour length ratio when the scour depth ratio is about 0.8, while the smallest scour length ratio is evident wheu used type of basin No. (13,14,15,16) with scour depth ratio is about 0.2.

CONCLUSIONS

The followiug may now be concluded from the results of the present research:

1. **The effect of the variation of the shape of stilling basins having same leugth and depth on the scour hole dimensions is relatively small.**
2. **Increasing Froude number increases the maximum sconr depth.**
3. **The distance from the end of the floor to the point of maximum scour depth is directly proportional to the scour length.**
4. **The variation of the shape of end sill of stilling basin is controlling the amount of energy dissipated within the vicinity of the stilling basin.**
5. **The effect of the variation of sloping bed of stilling basing on the scour hole dimension is relatively small when compared with the respective effect of the variation of the shape of end sill.**

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Table (1) Experimental data for twenty-six type of stilling basin

type	q = 51.26 cm²/cm/sec								q = 70.38 cm²/cm/sec								q = 86.96 cm²/cm/sec							
	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$
	4.1	0.7	0.171	5.5	1.341	10	2.439	25.73	4.6	1	0.217	10.5	2.283	19	4.13	19.29	5.1	1.5	0.294	15	2.941	29	5.686	17.21
	2.9	1.1	0.379	7	2.414	12	4.138	9.1	3.9	1.5	0.385	11	2.821	20	5.128	11.75	4.6	2.32	0.504	17.2	3.739	33.2	7.217	12.63
1	2.1	1.5	0.714	7.8	3.714	14	6.667	3.356	2.9	2.1	0.724	12.5	4.31	25	8.621	4.83	3.5	2.84	0.811	17	4.857	41.2	11.77	5.565
	4.1	0.8	0.195	8	1.463	11	2.683	25.73	4.6	1.1	0.239	12	2.609	18	3.913	19.29	5.1	1.36	0.267	15.2	2.98	29.2	5.725	17.21
	2.9	1	0.345	8	2.759	11.8	4.069	9.1	3.9	1.7	0.436	13	3.333	20	5.128	11.75	4.6	2.78	0.604	17.2	3.739	31.2	6.783	12.63
2	2.1	1.4	0.667	7	3.333	13	6.19	3.356	2.9	2.2	0.759	14	4.828	24	8.276	4.83	3.5	3	0.857	17.5	5	37.2	10.63	5.565
	4.1	0.9	0.22	6	1.463	9	2.195	25.73	4.6	1.3	0.283	13	2.826	19	4.13	19.29	5.1	1.5	0.294	16	3.137	27.2	5.333	17.21
	2.9	1.1	0.379	6	2.069	10	3.448	9.1	3.9	1.7	0.436	13	3.333	20.1	5.154	11.75	4.6	2.68	0.583	17.2	3.739	35.2	7.652	12.63
3	2.1	1.3	0.619	6.5	3.095	12	5.714	3.356	2.9	2.3	0.793	15	5.172	25	8.621	4.83	3.5	3.2	0.914	17.2	4.914	39.2	11.2	5.565
	4.1	0.85	0.207	6.5	1.585	10.9	2.659	25.73	4.6	1.35	0.293	12	2.609	20	4.348	19.29	5.1	1.64	0.322	17.2	3.373	27.2	5.333	17.21
	2.9	1	0.345	7	2.414	12	4.138	9.1	3.9	1.8	0.462	13	3.333	22	5.641	11.75	4.6	2.04	0.443	13.2	2.87	33.2	7.217	12.63
4	2.1	1.4	0.667	7.9	3.762	14	6.667	3.356	2.9	2.5	0.862	14	4.828	24	8.276	4.83	3.5	3.08	0.88	15.2	4.343	39.2	11.2	5.565
	4.1	0.9	0.22	7	1.707	11	2.683	25.73	4.6	1.4	0.304	11	2.391	20	4.348	19.29	5.1	1.4	0.275	15.2	2.98	27.2	5.333	17.21
	2.9	1.2	0.414	7	2.414	12	4.138	9.1	3.9	1.7	0.436	12	3.077	22	5.641	11.75	4.6	2	0.435	15.2	3.304	31.5	6.848	12.63
5	2.1	1.3	0.619	7.5	3.571	13	6.19	3.356	2.9	2.3	0.793	13	4.483	24	8.276	4.83	3.5	2.45	0.7	16	4.571	33.2	9.486	5.565
	4.1	0.8	0.195	6	1.463	10	2.439	25.73	4.6	1.4	0.304	11.2	2.435	19	4.13	19.29	5.1	1.8	0.353	14	2.745	27.2	5.333	17.21
	2.9	1	0.345	6.9	2.379	11	3.793	9.1	3.9	1.6	0.41	11	2.821	22	5.641	11.75	4.6	2.38	0.517	15.5	3.37	33.2	7.217	12.63
6	2.1	1.35	0.643	7.8	3.714	13.2	6.286	3.356	2.9	2.15	0.741	14	4.828	25	8.621	4.83	3.5	2.56	0.731	13.5	3.857	35.2	10.06	5.565
	4.1	0.9	0.22	7	1.707	10	2.439	25.73	4.6	1.3	0.283	12	2.609	21	4.565	19.29	5.1	1.58	0.31	13.2	2.588	29.2	5.725	17.21
	2.9	1.1	0.379	7	2.414	12	4.138	9.1	3.9	1.7	0.436	12	3.077	23	5.897	11.75	4.6	1.94	0.422	14	3.043	32	6.957	12.63
7	2.1	1.4	0.667	8	3.81	14	6.667	3.356	2.9	2.25	0.776	13	4.483	26	8.966	4.83	3.5	2.5	0.714	15.5	4.429	35.2	10.06	5.565
	4.1	1	0.244	7	1.707	11	2.683	25.73	4.6	1.2	0.261	12.5	2.717	18	3.913	19.29	5.1	1.76	0.345	15.2	2.98	27.2	5.333	17.21
	2.9	1.2	0.414	7.3	2.517	12.5	4.31	9.1	3.9	1.6	0.41	13	3.333	22	5.641	11.75	4.6	2.02	0.439	12	2.609	29.5	6.413	12.63
8	2.1	1.5	0.714	8	3.81	14.5	6.905	3.356	2.9	2.2	0.759	14	4.828	24	8.276	4.83	3.5	2.76	0.789	13.5	3.857	31.2	8.914	5.565
	4.1	0.8	0.195	6	1.463	10	2.439	25.73	4.6	0.9	0.196	9	1.957	18.2	3.957	19.29	5.1	2.26	0.443	15	2.941	29.2	5.725	17.21
	2.9	1.1	0.379	6.5	2.241	10.8	3.724	9.1	3.9	1.32	0.338	9	2.308	20	5.128	11.75	4.6	2.92	0.635	15.2	3.304	33.2	7.217	12.63
9	2.1	1.6	0.762	7.2	3.429	12.5	5.952	3.356	2.9	2	0.69	10	3.448	22	7.586	4.83	3.5	2.82	0.806	17.3	4.943	35.2	10.06	5.565
	4.1	0.9	0.22	6.5	1.585	10.1	2.463	25.73	4.6	1.1	0.239	10.8	2.348	18	3.913	19.29	5.1	2	0.392	16.5	3.235	29.2	5.725	17.21
	2.9	1.2	0.414	7	2.414	11	3.793	9.1	3.9	1.5	0.385	11	2.821	19	4.872	11.75	4.6	2.1	0.457	15.5	3.37	31.2	6.783	12.63
10	2.1	1.55	0.738	8	3.81	13	6.19	3.356	2.9	2.2	0.759	12	4.138	22	7.586	4.83	3.5	2.2	0.629	13	3.714	33.2	9.486	5.565
	4.1	1	0.244	6	1.463	10.5	2.561	25.73	4.6	1.25	0.272	10.7	2.326	17.5	3.804	19.29	5.1	2.06	0.404	15.5	3.039	29.2	5.725	17.21
	2.9	1.3	0.448	6.5	2.241	11	3.793	9.1	3.9	1.6	0.41	11	2.821	19.5	5	11.75	4.6	2.32	0.504	15	3.261	32	6.957	12.63
11	2.1	1.6	0.762	7.5	3.571	12.8	6.095	3.356	2.9	2.3	0.793	13	4.483	22.5	7.759	4.83	3.5	2.6	0.743	11.2	3.2	33.5	9.571	5.565
	4.1	1	0.244	7	1.707	10	2.439	25.73	4.6	1.2	0.261	10	2.174	17.8	3.87	19.29	5.1	2	0.392	15.5	3.039	31.2	6.118	17.21
	2.9	1.2	0.414	7	2.414	10.2	3.517	9.1	3.9	1.4	0.359	10	2.564	19	4.872	11.75	4.6	2.2	0.478	16.1	3.5	34	7.391	12.63
12	2.1	1.4	0.667	8	3.81	13.5	6.429	3.356	2.9	2.1	0.724	11	3.793	21	7.241	4.83	3.5	2.4	0.686	17	4.857	35	10	5.565
	4.1	0.9	0.22	6.8	1.659	10	2.439	25.73	4.6	1.2	0.261	9.8	2.13	17.5	3.804	19.29	5.1	2	0.392	15	2.941	32	6.275	17.21
	2.9	1.35	0.466	7	2.414	11.5	3.966	9.1	3.9	1.5	0.385	11	2.821	19	4.872	11.75	4.6	2.48	0.539	15	3.261	33	7.174	12.63
13	2.1	1.5	0.714	7.5	3.571	13.2	6.286	3.356	2.9	2.22	0.766	11.5	3.966	22	7.586	4.83	3.5	3.08	0.88	13.2	3.771	35.5	10.14	5.565

Table (1) Continued

type	q = 51.26 cm²/cm/sec								q = 70.38 cm²/cm/sec								q = 86.96 cm²/cm/sec							
	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$	D	d_s	d_s/D	L_m	L_m/D	L_s	L_s/D	$1/Fr^2$
	4.1	0.8	0.195	6	1.463	10	2.439	25.73	4.6	1.2	0.261	10	2.174	17.8	3.87	19.29	5.1	1.96	0.384	13.2	2.588	29.2	5.725	17.21
	2.9	1	0.345	6.5	2.241	10.5	3.621	9.1	3.9	1.6	0.41	10.5	2.692	19	4.872	11.75	4.6	2.58	0.561	13.2	2.87	32	6.957	12.63
14	2.1	1.4	0.667	7	3.333	12	5.714	3.356	2.9	2.5	0.862	12	4.138	21.5	7.414	4.83	3.5	2.8	0.8	13	3.714	34	9.714	5.565
	4.1	0.9	0.22	6.5	1.585	10	2.439	25.73	4.6	1.2	0.261	11.5	2.5	19.2	4.174	19.29	5.1	1.42	0.278	15	2.941	27.2	5.333	17.21
	2.9	1.1	0.379	7	2.414	11	3.793	9.1	3.9	1.5	0.385	12	3.077	20	5.128	11.75	4.6	2.06	0.448	13	2.826	29.5	6.413	12.63
15	2.1	1.45	0.69	7.9	3.762	13.5	6.429	3.356	2.9	2.4	0.828	13	4.483	24	8.276	4.83	3.5	2.64	0.754	13	3.714	33.5	9.571	5.565
	4.1	0.8	0.195	6	1.463	10	2.439	25.73	4.6	1.3	0.283	11.6	2.522	20.2	4.391	19.29	5.1	1.58	0.31	14	2.745	27	5.294	17.21
	2.9	1	0.345	6.5	2.241	11	3.793	9.1	3.9	1.6	0.41	12.1	3.103	21.9	5.615	11.75	4.6	2.1	0.457	13.2	2.87	32	6.957	12.63
16	2.1	1.35	0.643	7.2	3.429	12.8	6.095	3.356	2.9	2.7	0.931	12.9	4.448	23.8	8.207	4.83	3.5	3.1	0.886	15	4.288	39.5	11.29	5.565
	4.1	0.8	0.195	5	1.22	9.8	2.39	25.73	4.6	1.3	0.283	10	2.174	18.2	3.957	19.29	5.1	1.8	0.353	17.2	3.373	29.2	5.725	17.21
	2.9	1.1	0.379	5	1.724	11	3.793	9.1	3.9	1.7	0.436	11	2.821	21.5	5.513	11.75	4.6	2.4	0.522	15.2	3.305	33.2	7.217	12.63
17	2.1	1.3	0.619	5.75	2.738	13	6.19	3.356	2.9	2.6	0.897	12	4.138	23.5	8.103	4.83	3.5	2.8	0.8	12	3.429	37	10.57	5.565
	4.1	1	0.244	7.2	1.756	10.5	2.561	25.73	4.6	1.4	0.304	13	2.826	20	4.348	19.29	5.1	1.7	0.333	14	2.745	27	5.294	17.21
	2.9	1.3	0.448	7	2.414	12	4.138	9.1	3.9	1.8	0.462	13	3.333	22	5.641	11.75	4.6	2.32	0.504	13	2.826	30	6.522	12.63
18	2.1	1.6	0.762	8	3.81	14	6.667	3.356	2.9	2.5	0.862	14	4.828	25	8.621	4.83	3.5	3.2	0.914	13	3.714	36	10.29	5.565
	4.1	1.1	0.268	6	1.463	9.8	2.39	25.73	4.6	1.5	0.326	10.5	2.283	19	4.13	19.29	5.1	1.4	0.275	17.2	3.373	29	5.686	17.21
	2.9	1.2	0.414	7	2.414	10.5	3.621	9.1	3.9	1.7	0.436	11	2.821	20	5.128	11.75	4.6	1.96	0.426	17	3.696	32	6.957	12.63
19	2.1	1.5	0.714	7.5	3.571	11.8	5.619	3.356	2.9	2.4	0.828	12	4.138	22	7.586	4.83	3.5	2.8	0.8	15.2	4.343	37	10.57	5.565
	4.1	1.15	0.28	7	1.707	10.5	2.561	25.73	4.6	1.4	0.304	13	2.826	18.2	3.957	19.29	5.1	2.02	0.396	15	2.941	25.2	4.941	17.21
	2.9	1.3	0.448	7	2.414	11	3.793	9.1	3.9	1.7	0.436	13.2	3.385	19.5	5	11.75	4.6	2.8	0.609	13.5	2.935	30	6.522	12.63
20	2.1	1.58	0.752	7.9	3.762	14	6.667	3.356	2.9	2.3	0.793	14	4.828	24.5	8.448	4.83	3.5	2.9	0.829	12	3.429	36	10.29	5.565
	4.1	1	0.244	7	1.707	10	2.439	25.73	4.6	1.6	0.348	11	2.391	18.1	3.935	19.29	5.1	2.02	0.396	15.2	2.98	29.2	5.725	17.21
	2.9	1.3	0.448	7.5	2.586	10.5	3.621	9.1	3.9	1.8	0.462	11	2.821	20	5.128	11.75	4.6	2.2	0.478	13	2.826	30	6.522	12.63
21	2.1	1.6	0.762	8	3.81	12	5.714	3.356	2.9	2.4	0.828	11.5	3.966	22.8	7.862	4.83	3.5	2.8	0.8	13.2	3.771	32	9.143	5.565
	4.1	0.8	0.195	6.9	1.683	10.1	2.463	25.73	4.6	1.6	0.348	11	2.391	18.5	3.935	19.29	5.1	2	0.392	15	2.941	26	5.098	17.21
	2.9	1.1	0.379	7.1	2.448	11.5	3.966	9.1	3.9	1.75	0.449	11.8	3.026	20	5.128	11.75	4.6	2.8	0.609	15	3.261	32	6.957	12.63
22	2.1	1.4	0.667	8	3.81	13.1	6.238	3.356	2.9	2.5	0.862	12.2	4.207	23.6	7.862	4.83	3.5	2.9	0.829	13.2	3.771	33.2	9.486	5.565
	4.1	0.6	0.146	8	1.951	10.8	2.634	25.73	4.6	1.4	0.304	11	2.391	19.3	4.022	19.29	5.1	1.6	0.314	13.2	2.588	25	4.902	17.21
	2.9	1.1	0.379	8.5	2.931	12.3	4.241	9.1	3.9	1.8	0.462	11	2.821	20.1	5.128	11.75	4.6	2.3	0.5	15	3.261	30	6.522	12.63
23	2.1	1.5	0.714	9.1	4.333	15.5	7.381	3.356	2.9	2.2	0.759	12.5	4.31	22.5	8.138	4.83	3.5	2.6	0.743	13	3.714	36	10.29	5.565
	4.1	0.8	0.195	6	1.463	8	1.951	25.73	4.6	1.7	0.37	12.8	2.783	17.5	4.196	19.29	5.1	2.08	0.408	15	2.941	28	5.49	17.21
	2.9	1.1	0.379	6.5	2.241	11	3.793	9.1	3.9	1.9	0.487	13.1	3.359	19.8	5.154	11.75	4.6	2.6	0.565	13.2	2.87	33	7.174	12.63
24	2.1	1.45	0.69	7.8	3.714	13.1	6.238	3.356	2.9	2.3	0.793	14	4.828	23.5	7.759	4.83	3.5	2.7	0.771	13.2	3.771	38	10.86	5.565
	4.1	0.8	0.195	7.5	1.829	13.5	3.293	25.73	4.6	1.3	0.283	11.5	2.5	18.5	3.804	19.29	5.1	1.7	0.333	13.2	2.588	28	5.49	17.21
	2.9	1.1	0.379	8	2.759	14	4.828	9.1	3.9	1.7	0.436	12.5	3.205	20.3	5.077	11.75	4.6	2	0.435	12.5	2.717	34	7.391	12.63
25	2.1	1.3	0.619	9.2	4.381	15.1	7.19	3.356	2.9	2.2	0.759	13	4.483	23.2	8.103	4.83	3.5	2.5	0.714	11.2	3.2	36	10.29	5.565
	4.1	1	0.244	9	2.195	11	2.683	25.73	4.6	1.1	0.239	12.5	2.717	18	4.022	19.29	5.1	1.4	0.275	13	2.549	29.5	5.784	17.21
	2.9	1.1	0.379	10	3.448	12	4.138	9.1	3.9	1.8	0.462	13	3.333	19.5	5.205	11.75	4.6	2.5	0.543	15	3.261	34	7.391	12.63
26	2.1	1.4	0.667	10.5	5	13.5	6.429	3.356	2.9	2.4	0.828	13.2	4.552	22.5	8	4.83	3.5	2.86	0.817	13	3.714	40	11.43	5.565

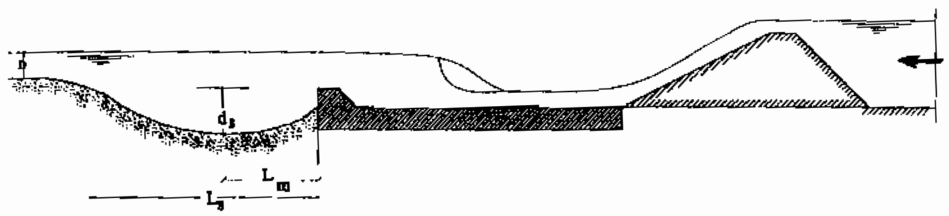
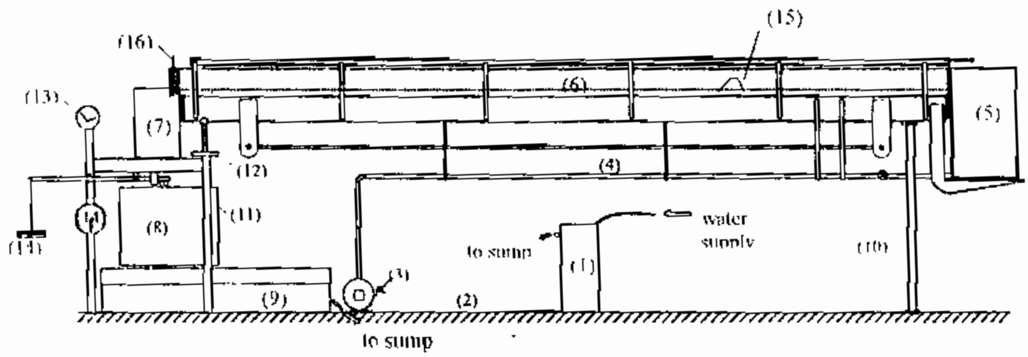


Fig. (1) : Definition sketch for basin test



1) Constant head tank (1)
2) Supply pipe from tank (1)
3) I.H.P pump
4) Supply pipe from pump
5) Constant head tank (2)
6) Movable bed sand
7) Tail tank
8) Weighing tank
9) Sump
10) U.S. carrier
11) D.S. carrier
12) Controlling screw
13) Clock
14) Weights
15) Weir
16) Tail gate
17) Performed Screen

Fig. (2) General arrangement of the experimental set-up

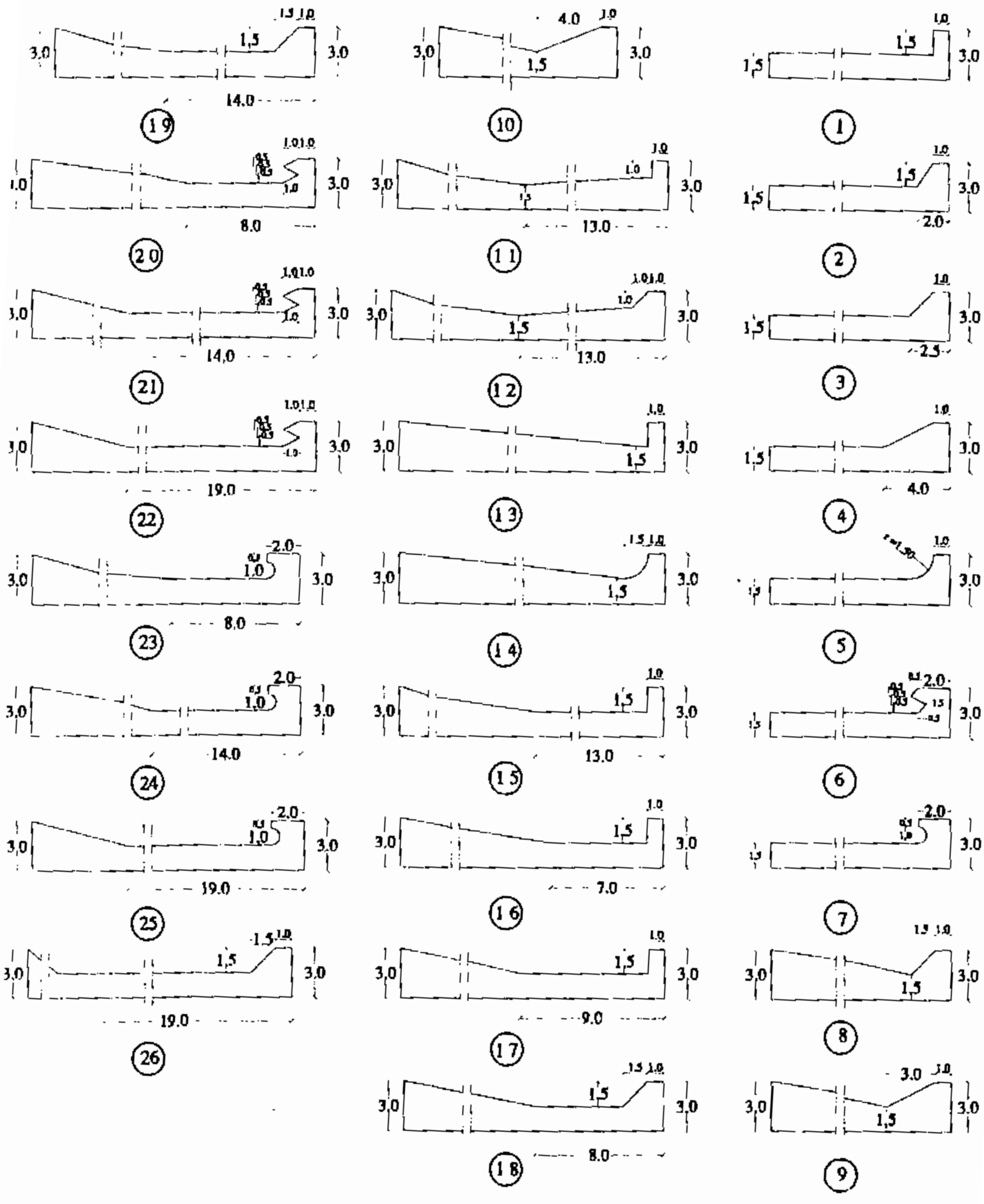


Fig (3) : Different types of stilling basin used in the investigation
(Dimensions in cm)

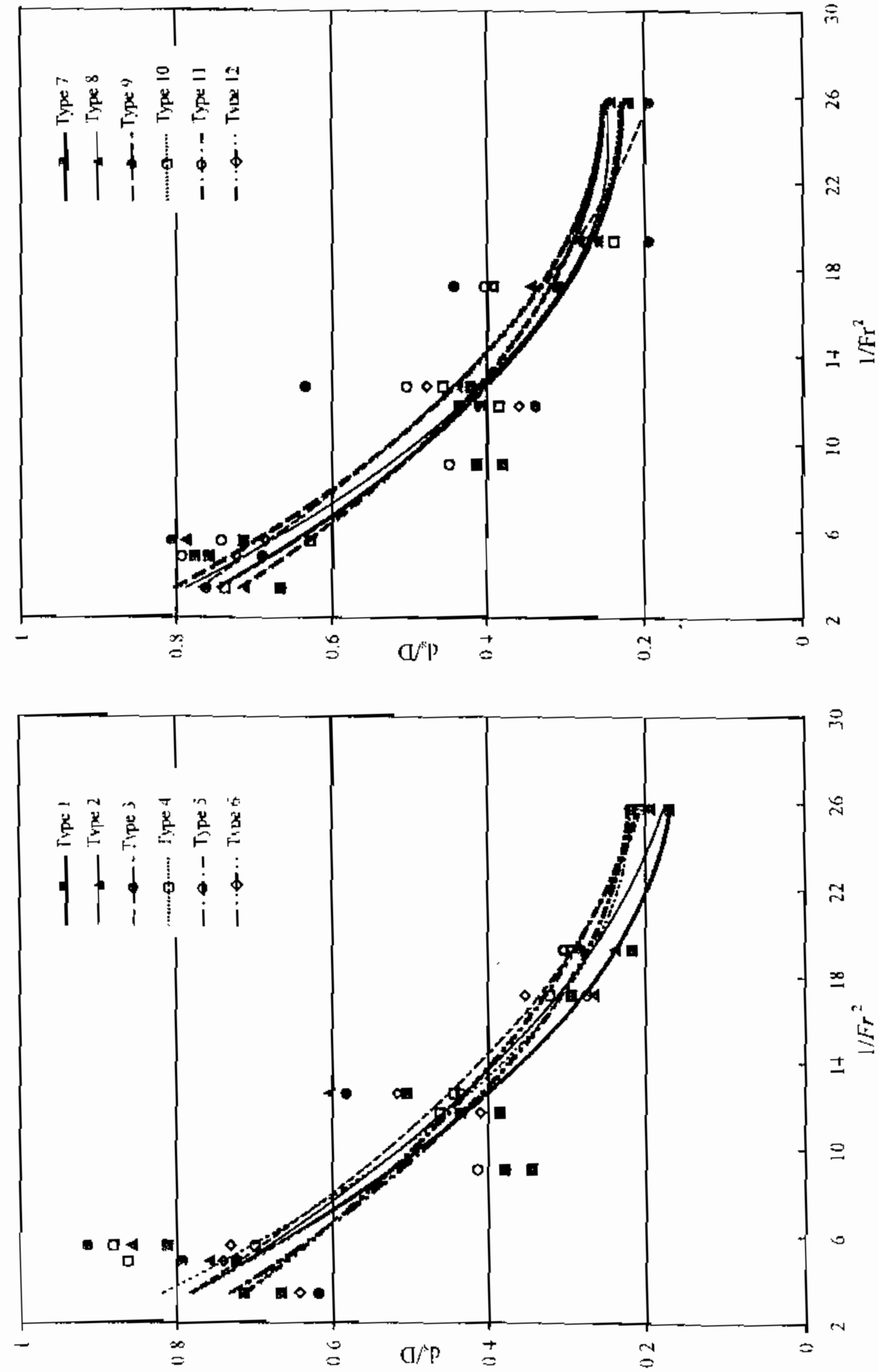


Fig. (4. a) Variation of d_s/D with $1/Fr^2$ for different types of stilling basins.

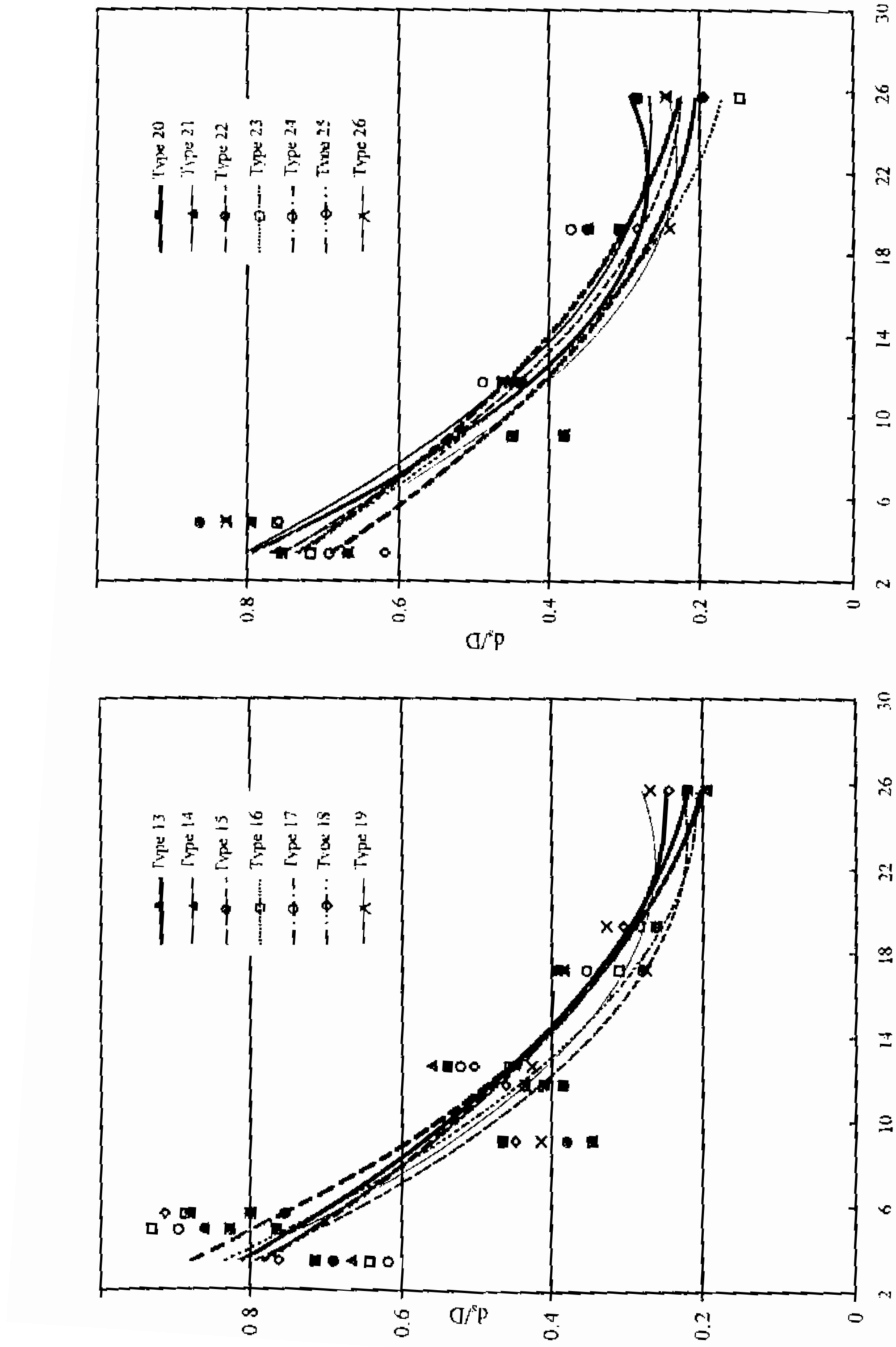


Fig. (4. b) Variation of d_s/D with $1/Fr^2$ for different types of stilling basins.

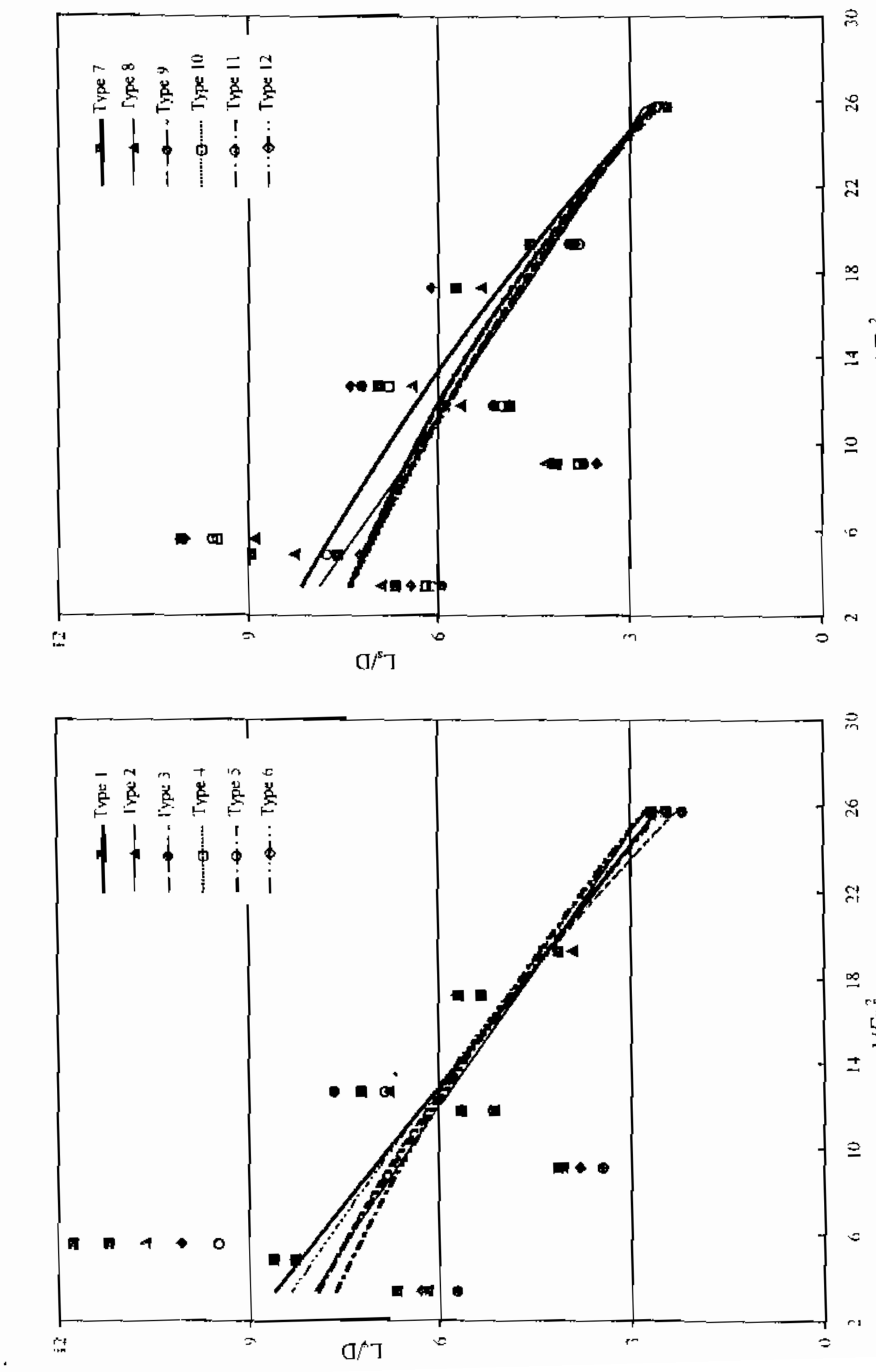


Fig. (5. a) Variation of L_s/D with $1/Fr^2$ for different types of stilling basins.

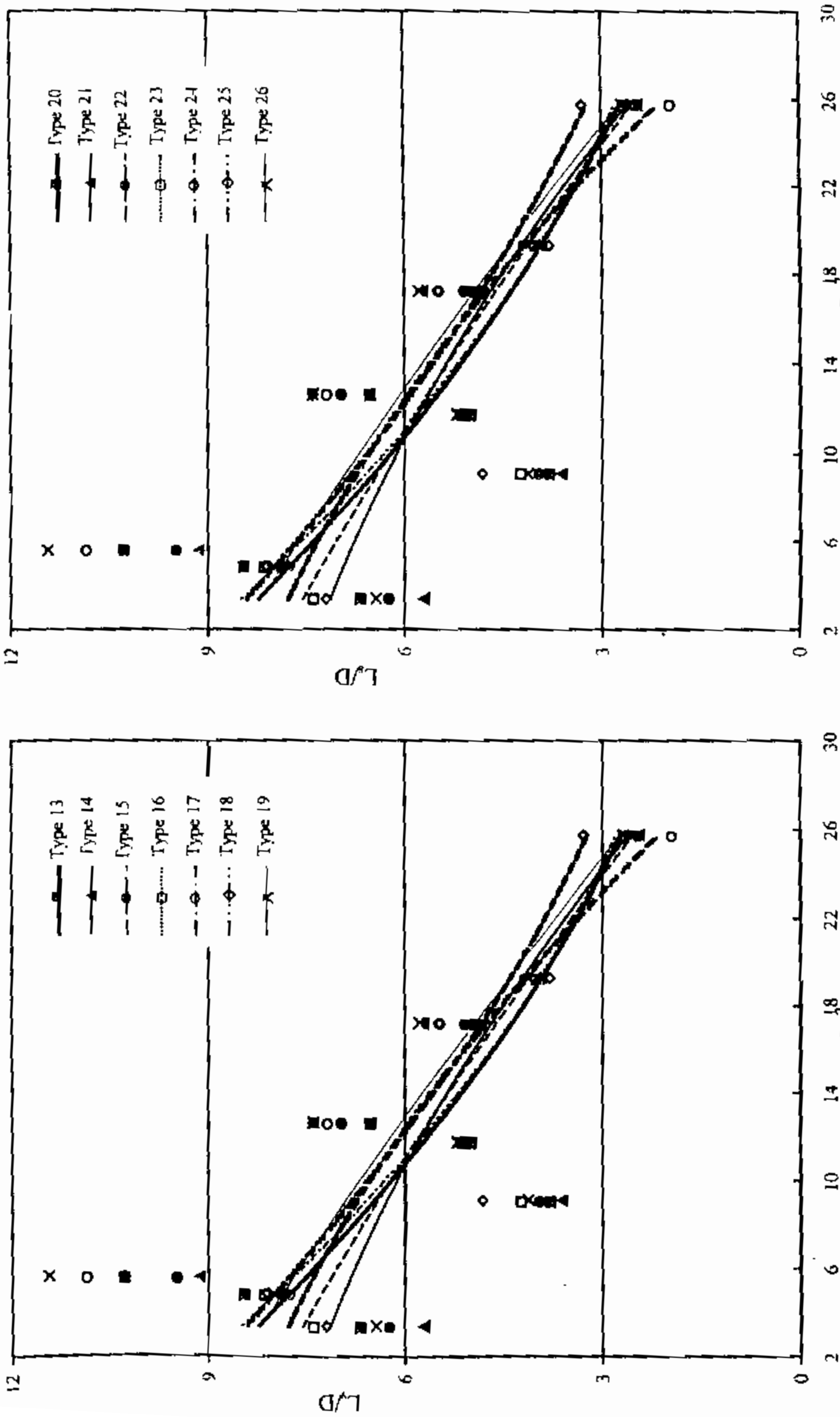


Fig. (5. b) Variation of L_s/D with $1/Fr^2$ for different types of stilling basins.

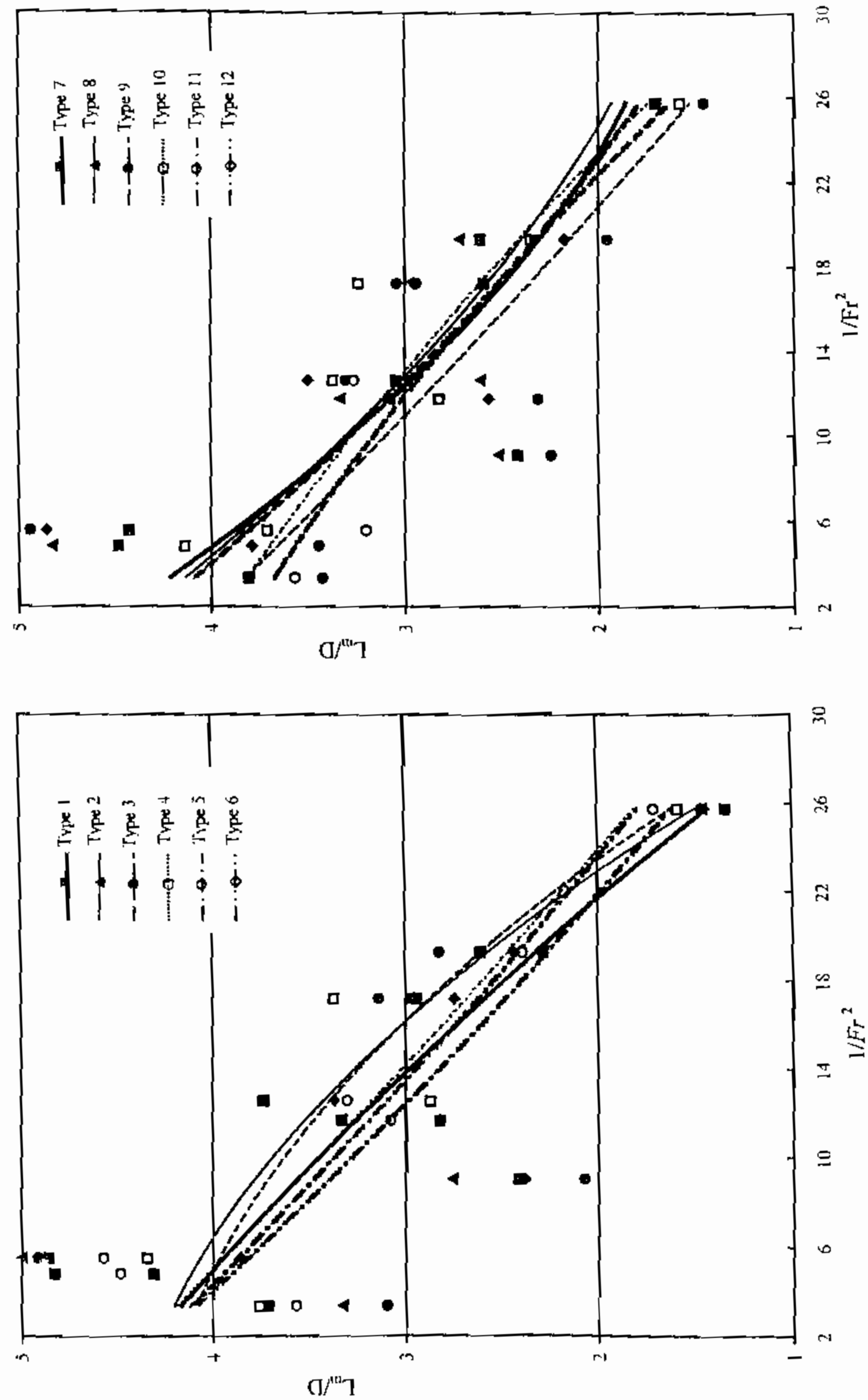


Fig. (6. a) Variation of L_m/D with $1/Fr^2$ for different types of stilling basins.

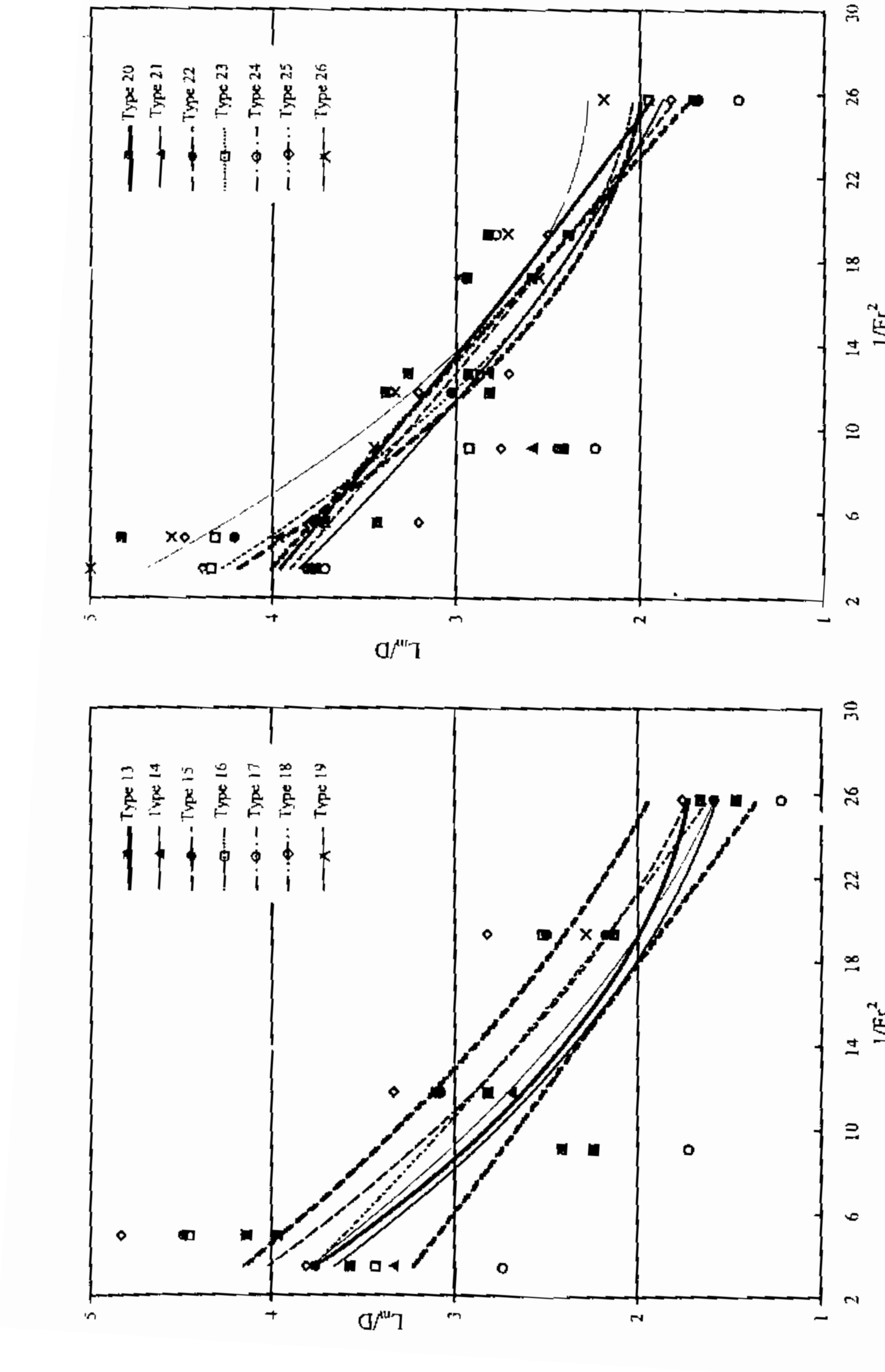


Fig. (6. b) Variation of L_m/D with $1/Fr^2$ for different types of stilling basins.

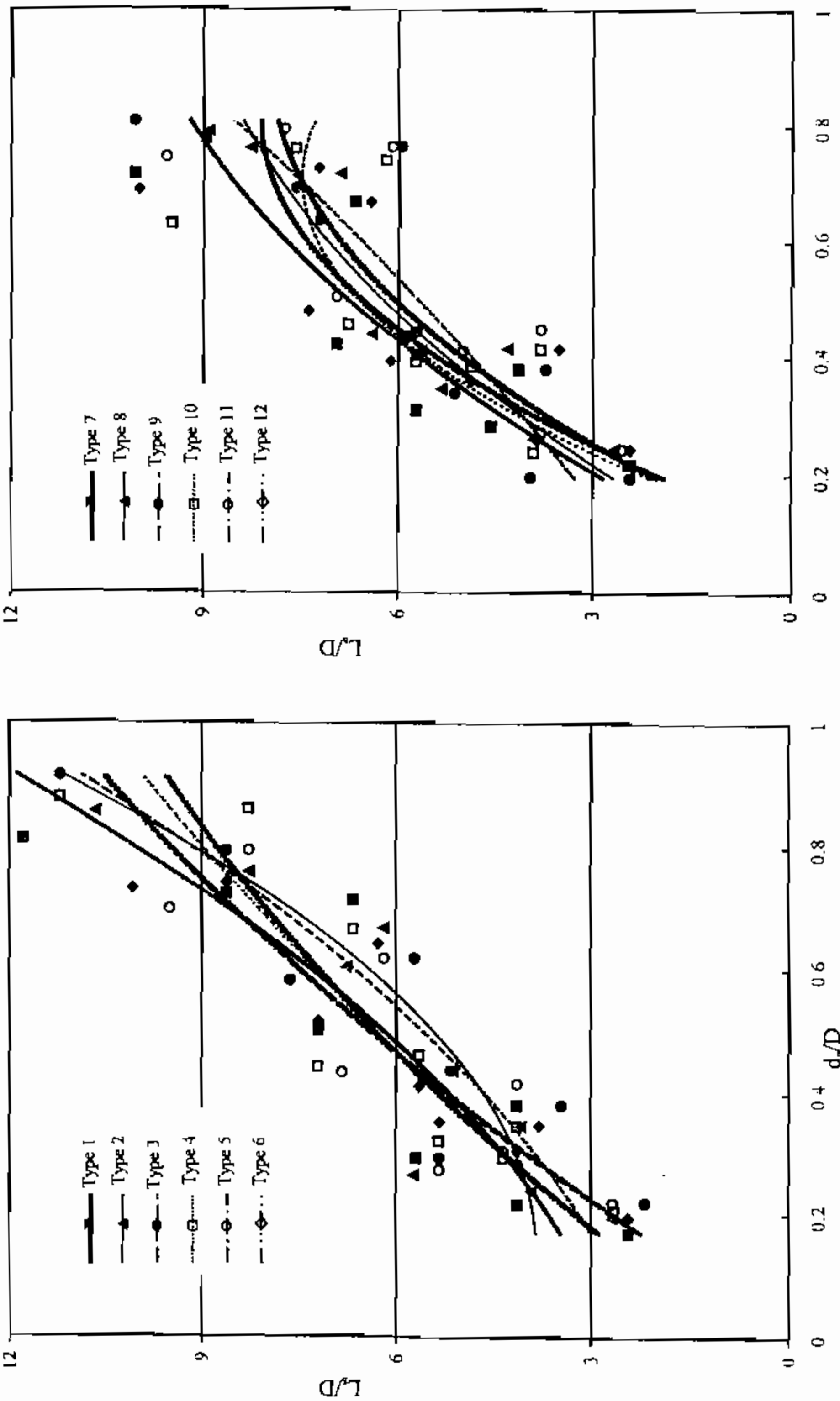
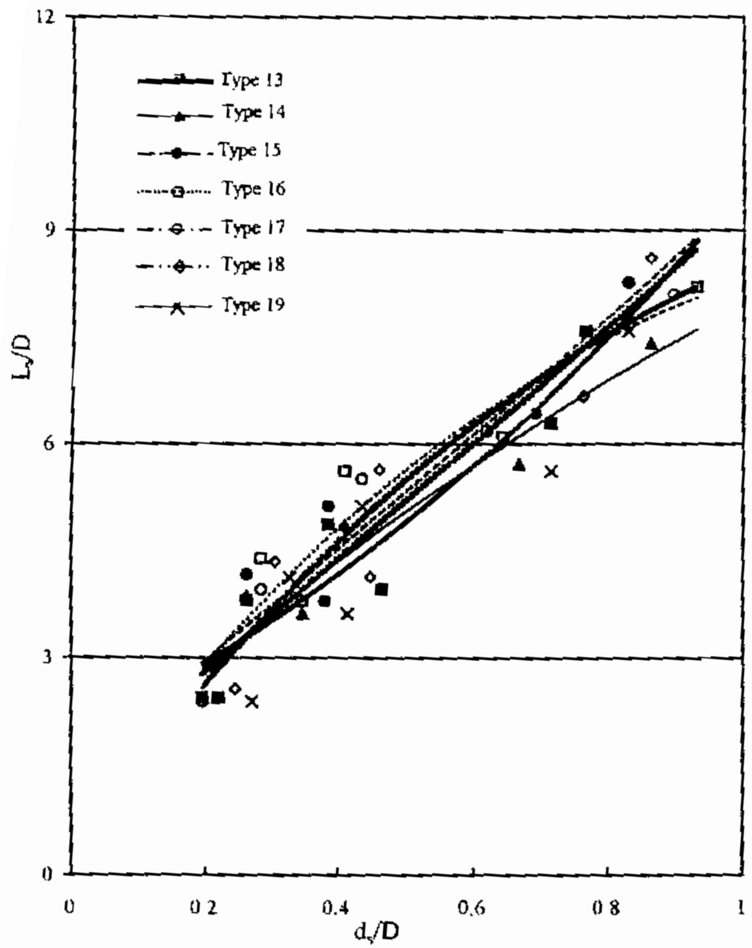


Fig. (7. a) Relation between L_s/D and d_s/D for different types of stilling basins.



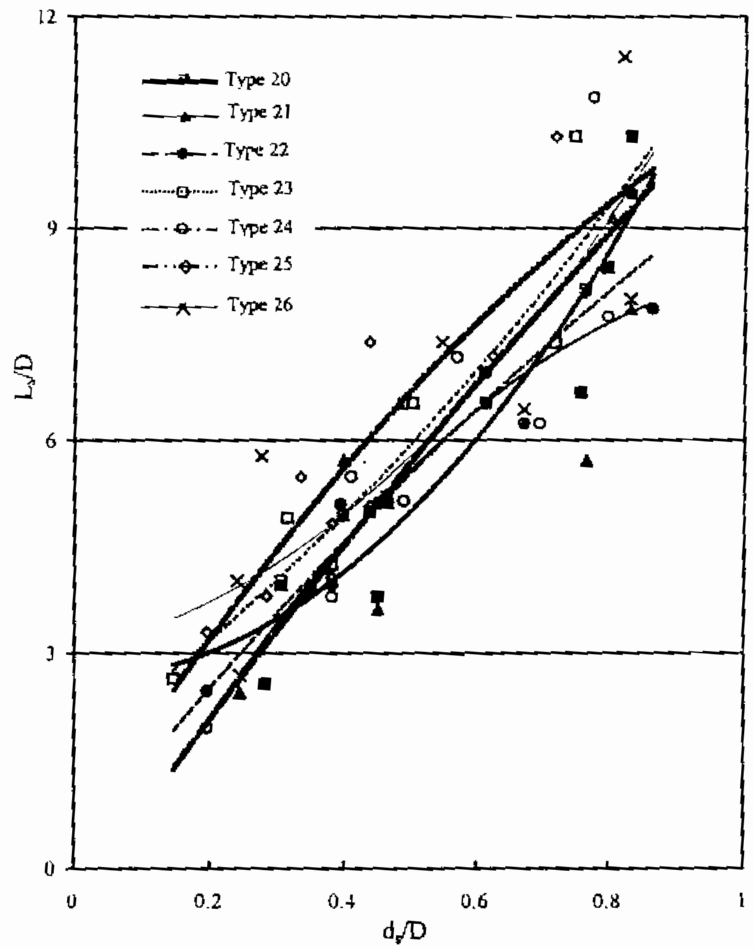


Fig. (7. b) Relation between L_s/D and d_s/D for different types of stilling basins.