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

تأثير شكل أحواض التهدئة على النحر خلف منشآت الحجز

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خلاصة :

يختص هذا البحث بدراسة مدى تأثير شكل أحواض التهدئة على خواص السريران و النحر خلف منشآت الحجز . تم تصميم ستة و عشرون نموذج مختلفة الشكل لأحواض التهدئة خلف الهدار - تم إجراء اثنين و سبعون تجربة على الأشكال المختلفة لأحواض التهدئة مع تغيير خواص السريران المختلفة . وأمكن بهذه الدراسة ربط العلاقات الناتجة عن خواص السريران وأشكال أحواض التهدئة بعلاقات بيانية و نأمل أن تكون هذه الدراسة مفيدة لمصممي أحواض التهدئة خلف منشآت 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 studies 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 structures. 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.

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 maximum scour depth.

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

L_s : the length of scour hole.

L_m : the length to the location of maximum scour 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 $D_{50} = 0.58\text{mm}$. 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 ($q = 51.26, 70.38, \text{ and } 86.96 \text{ cm}^3/\text{sec}/\text{cm}$). 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 in 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 $d/D, L_s/D, L_m/D$, 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/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/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/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/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/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 following 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 length and depth on the scour hole dimensions is relatively small.
- 2- Increasing Froude number increases the maximum scour 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) Continued

Type	q = 51.26 cm ² /cm ² sec						q = 70.38 cm ² /cm ² sec						q = 86.96 cm ² /cm ² sec																																					
	D	d _r	d _{r/D}	L _m	L _{w/D}	L _c	D	d _r	d _{r/D}	L _m	L _{w/D}	L _c	D	d _r	d _{r/D}	L _m	L _{w/D}	L _c	D	d _r	d _{r/D}	L _m	L _{w/D}	L _c	D	d _r	d _{r/D}	L _m	L _{w/D}	L _c																				
14	4.1	0.8	0.185	6	1.463	10	2.439	25.73	4.6	1.2	0.261	10	2.174	17.3	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	4.83	3.5	2.8	0.8	13	3.714	34	9.714	5.685	
15	4.1	0.9	0.22	5.5	1.585	10	2.439	25.73	4.6	1.2	0.261	11.5	2.5	3.077	20	5.128	11.75	4.6	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	1.42	0.278	15	2.941	27.2	5.333	17.21	
16	4.1	0.8	0.185	6	1.463	10	2.439	25.73	4.6	1.2	0.261	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	1.5	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		
17	4.1	0.8	0.185	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		
18	4.1	1.3	0.619	3.75	2.768	13	6.19	3.956	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	5.685	4.1	1	0.244	7.2	1.756	10.5	2.561	25.73	4.6	1.4	0.304	13	2.828	20	4.349	19.29	5.1	1.7	0.333	14	2.745	27	5.294	17.21		
19	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	2.828	30	6.522	12.63	4.1	1.6	0.762	8	3.81	14	6.667	3.956	2.9	2.5	0.852	14	4.828	25	8.621	4.83	3.5	3.2	0.914	13	3.714	36	10.29	5.685		
20	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	4.1	1.5	0.714	5	1.707	10.5	2.561	11.8	5.619	3.956	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	5.685
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	0.396	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	0.396	15	2.941	25.2	4.941	17.21		
22	4.1	1.5	0.38	7	1.707	10.5	3.621	9.1	3.9	1.7	0.436	11	2.821	20	5.128	11.75	4.6	2.02	0.396	15.2	2.98	29.2	5.725	17.21	2.9	1.1	0.344	7	1.707	10	2.439	25.73	4.6	1.6	0.348	11	2.821	18.1	3.935	19.29	5.1	2.02	0.396	15.2	2.98	29.2	5.725	17.21		
23	4.1	0.6	0.146	8	1.951	10.8	2.634	25.73	4.6	1.4	0.304	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	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		
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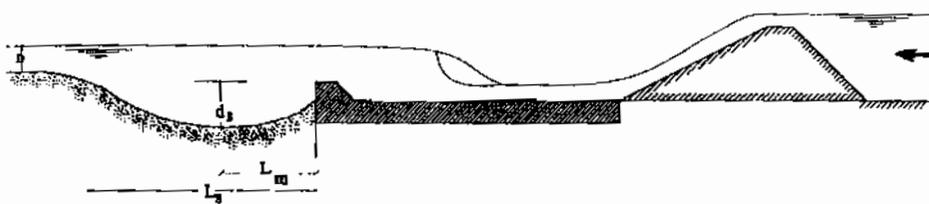
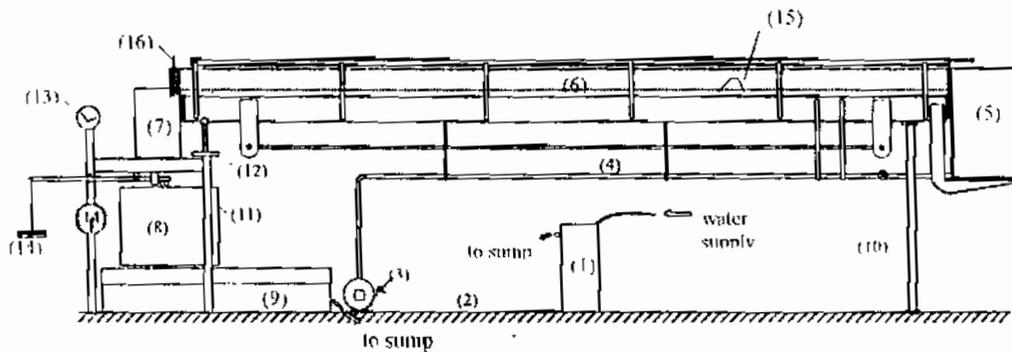


Fig. (1) : Definition sketch for basin test



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

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

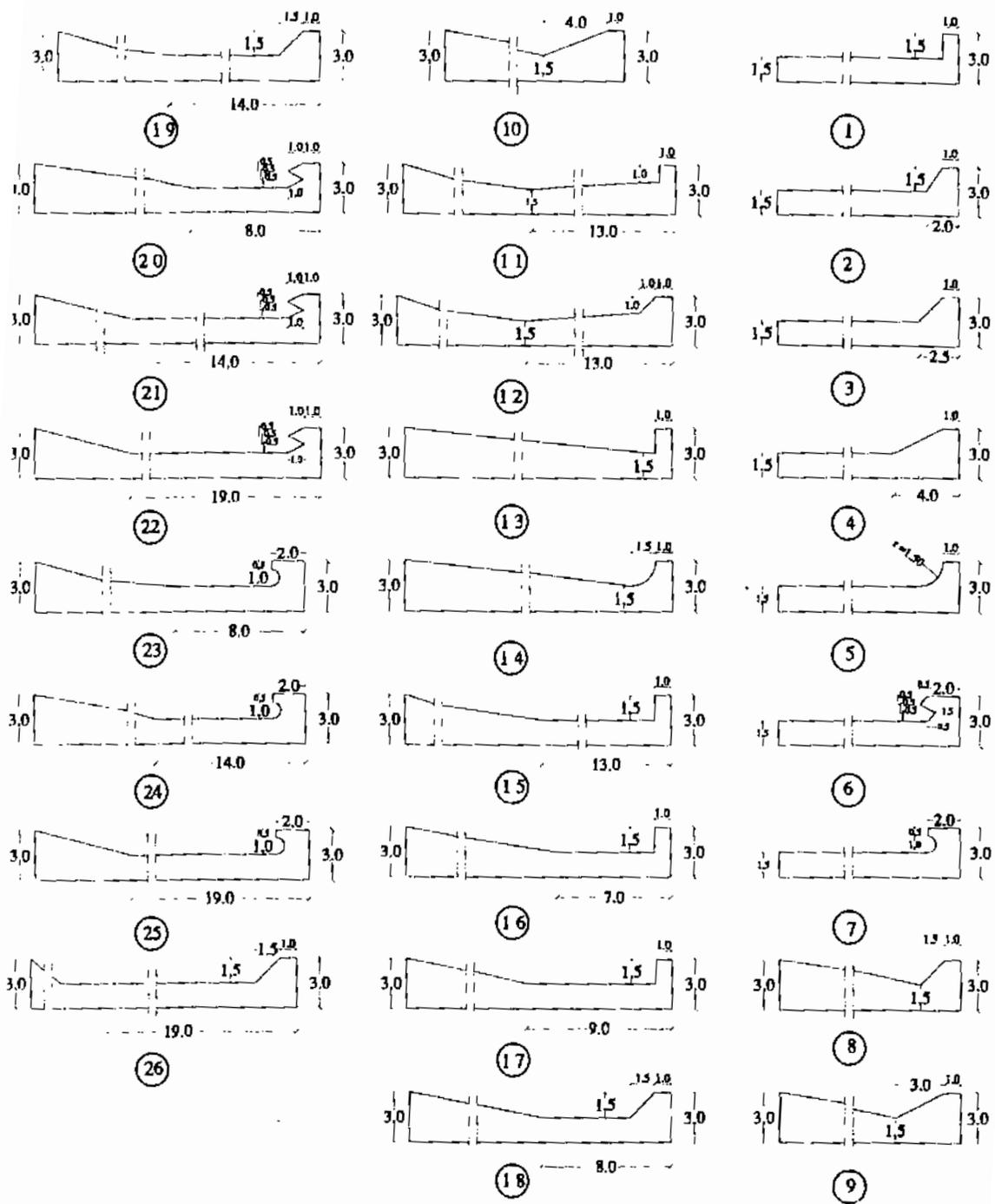


Fig (3) : Different types of stilling basin used in the investigation
 (Dimensions in cm)

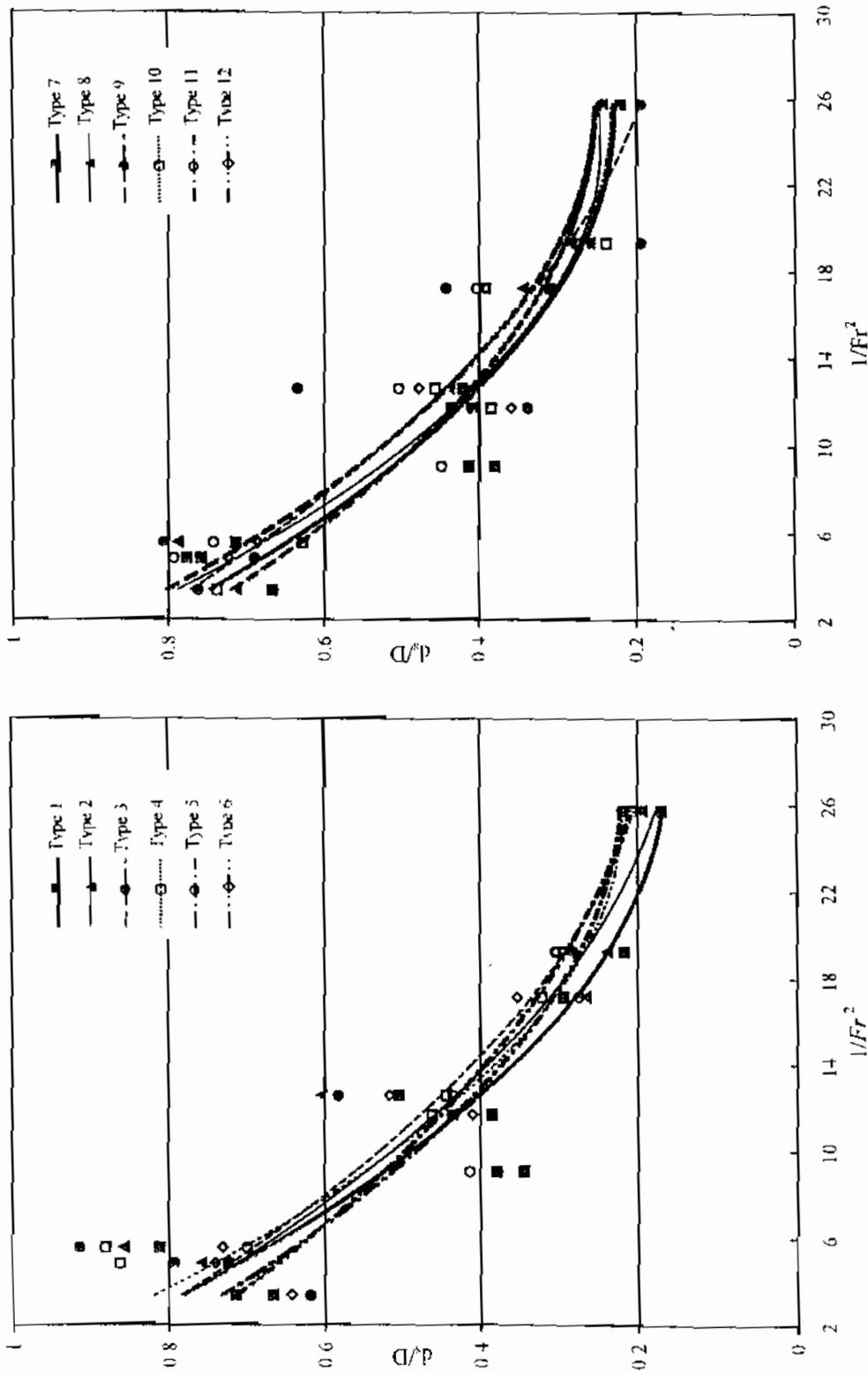


Fig. (4. a) Variation of d_v/D with $1/Fr^2$ for different types of snilling basins.

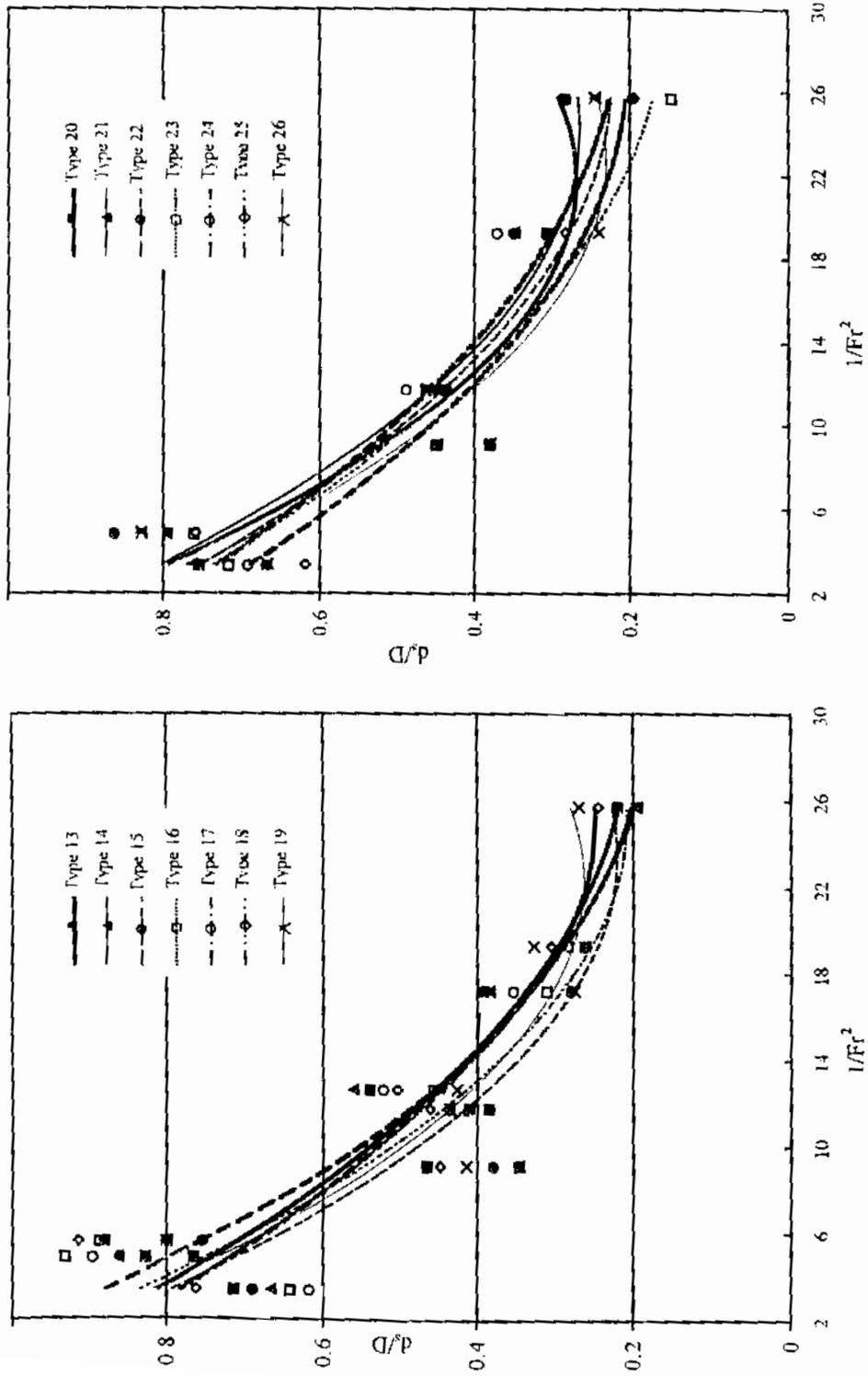


Fig. (4. b) Variation of d_v/D with $1/Fr^2$ for different types of stilling basins.

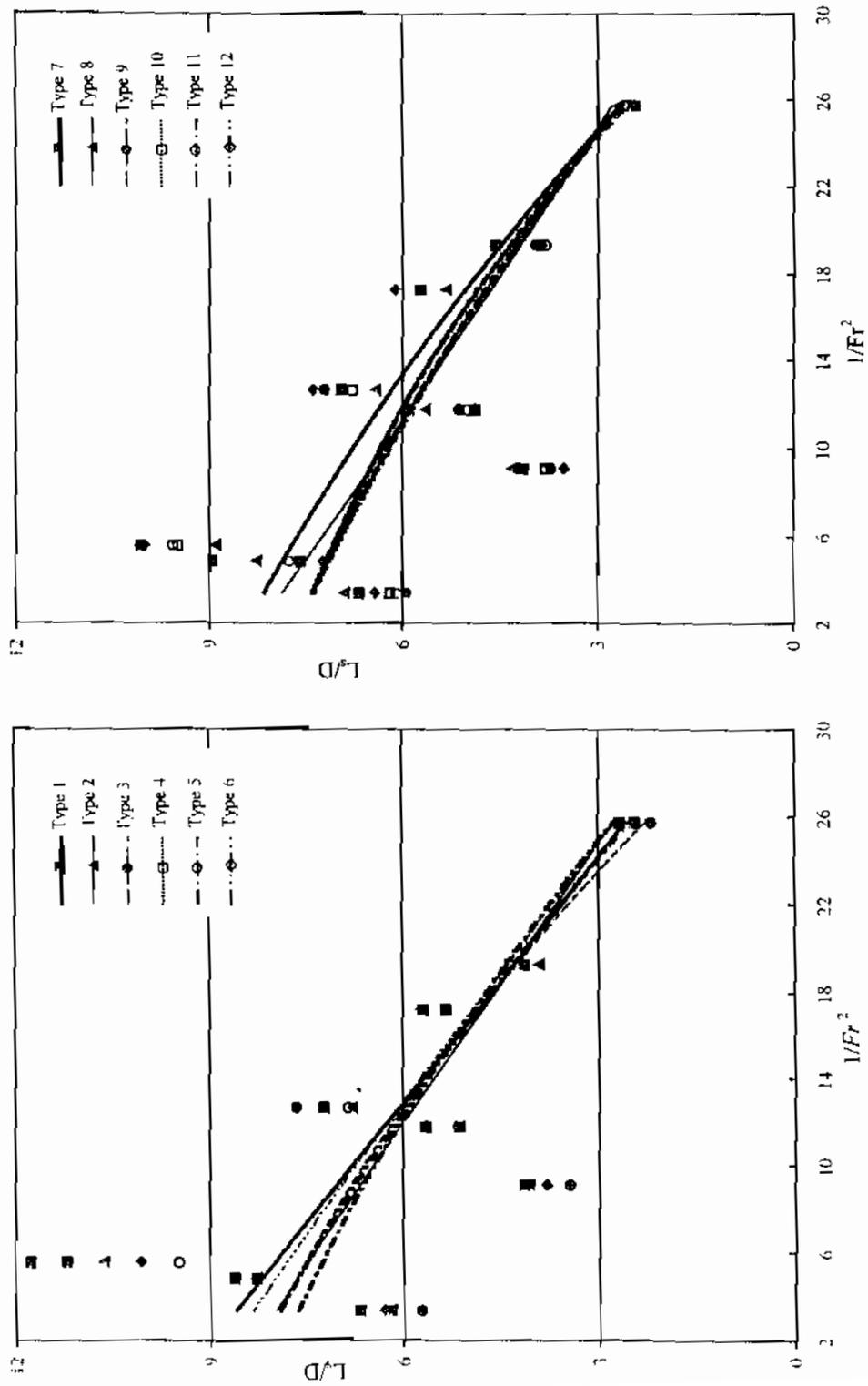


Fig. (5. a) Variaton of L/D with $1/Fr^2$ for different types of stilling basins.

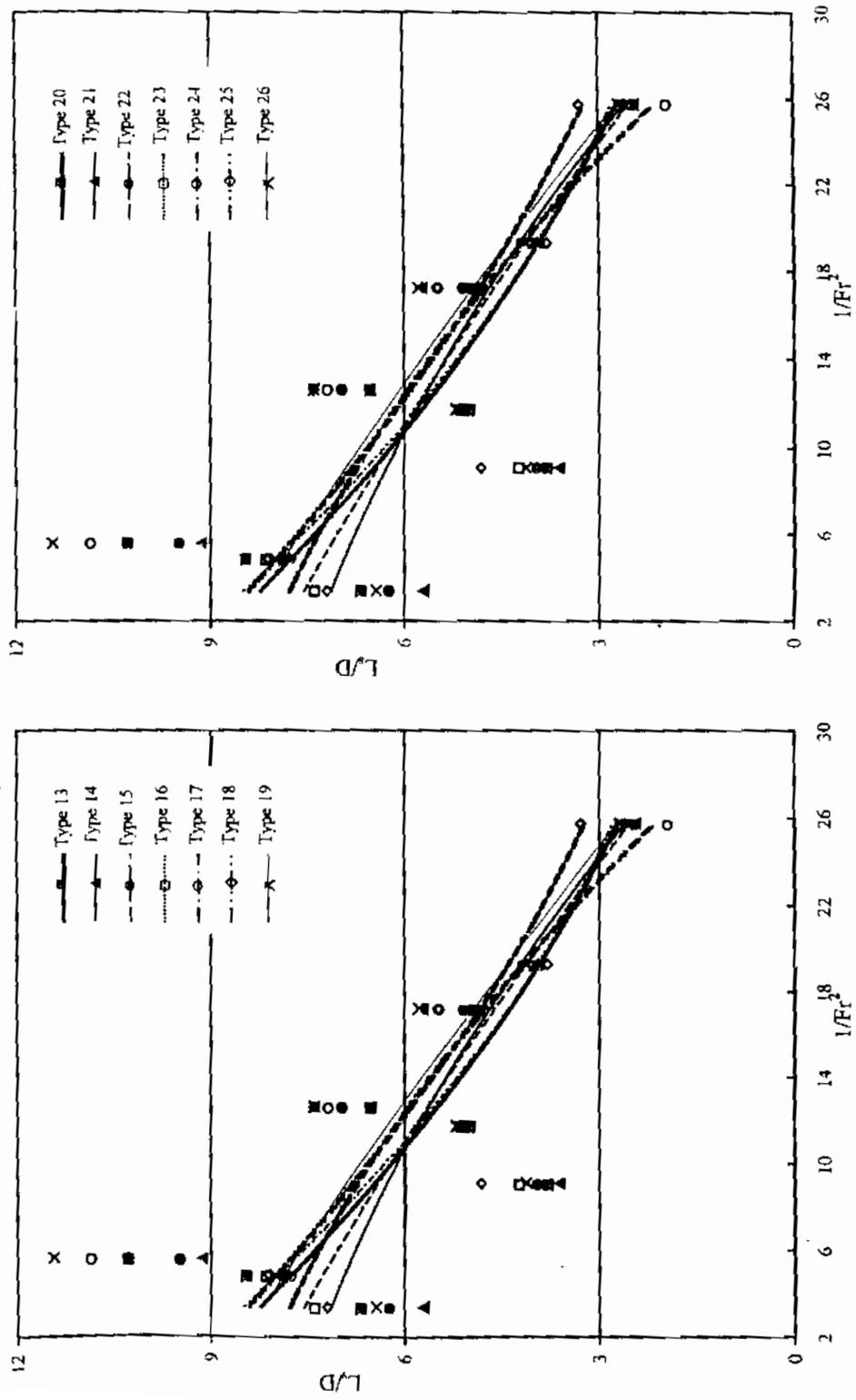


Fig. (5. b) Variation of L/D with $1/Fr^2$ for different types of stilling basins.

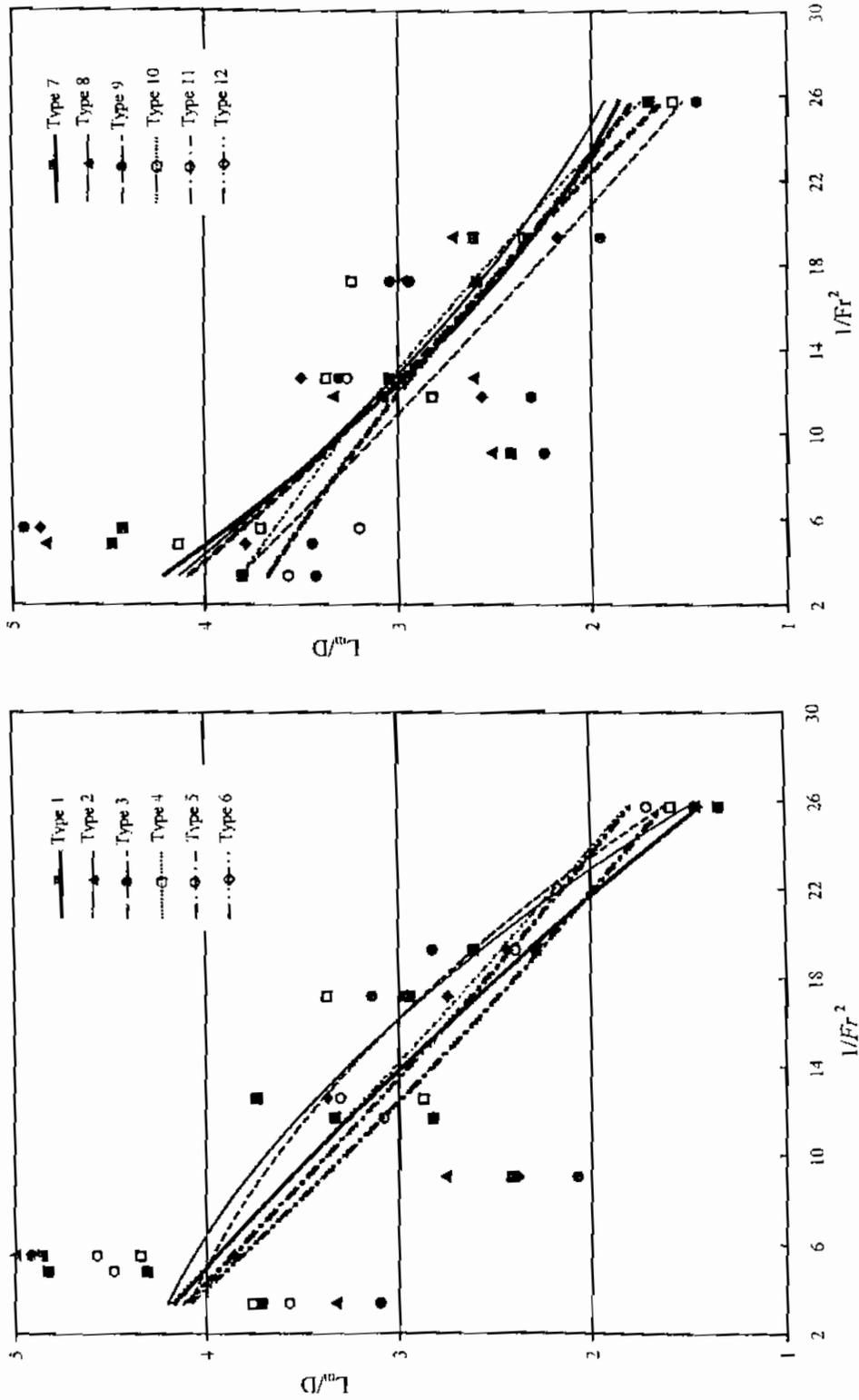


Fig. (6. a) Variation of L_m/D with $1/Fr^2$ for different types of stilling basins.

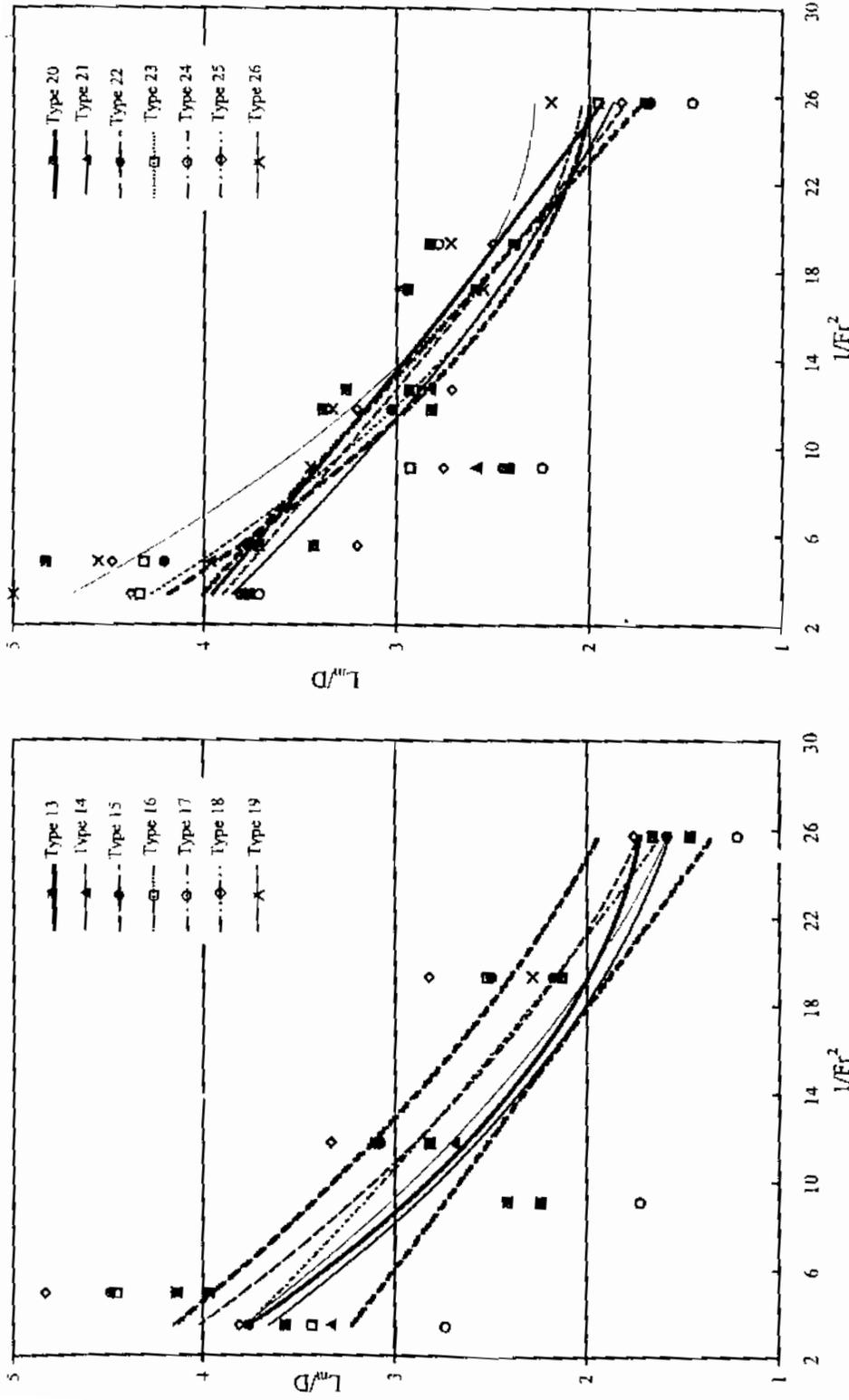


Fig. (6. b) Variation of L_m/D with $1/Fr^2$ for different types of stilling basins.

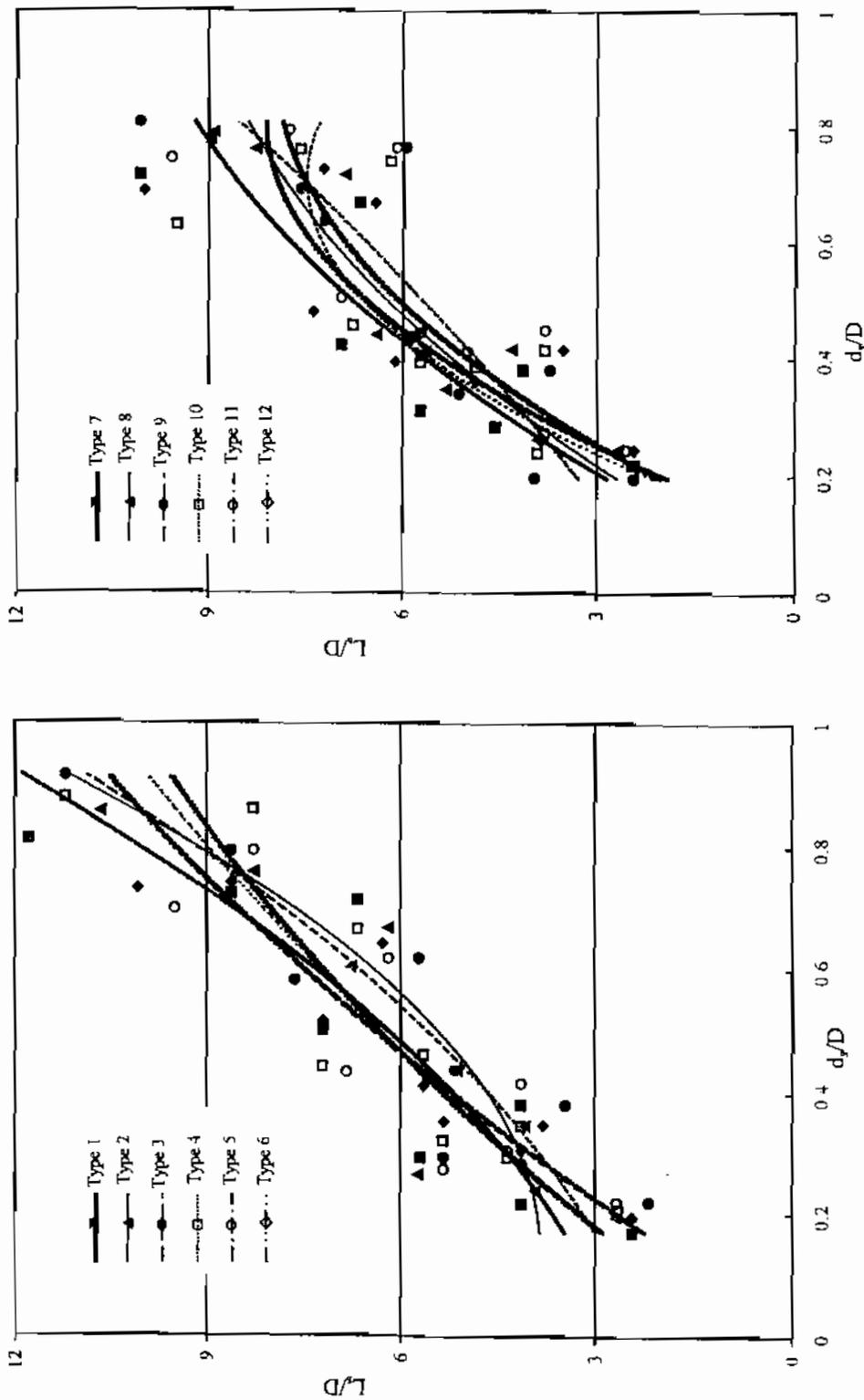


Fig. (7. a) Relation between L_v/D and d_v/D for different types of stilling basins.

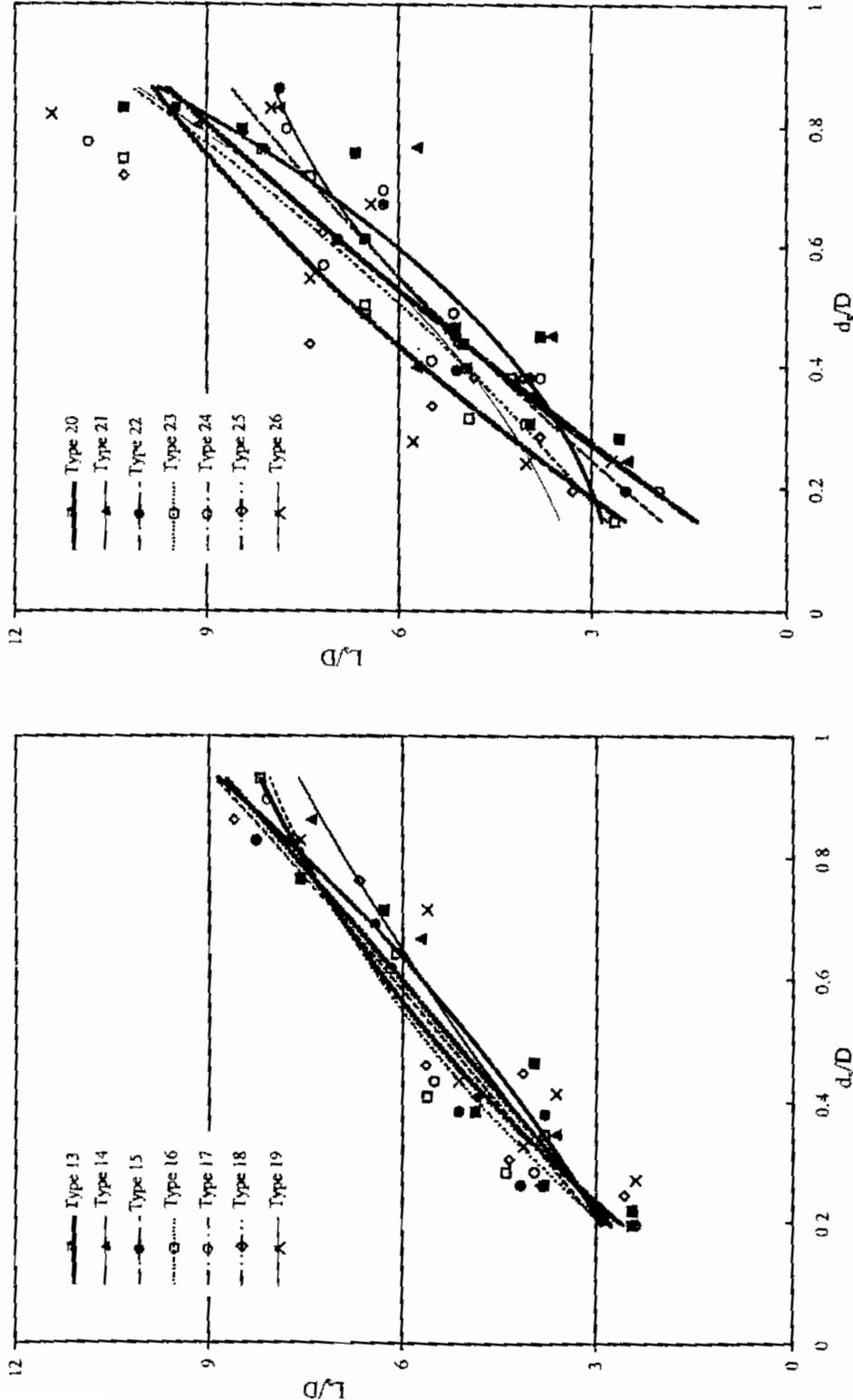


Fig. (7. b) Relation between L_v/D and d_v/D for different types of stilling basins.