CHAPTER - 2

THE HYDRAULIC DESIGN OF SUCTION INTAKES

2.1 SUCTION SUMPS

Rotodynamic pump performance may be adversely affected by unsatisfactory approach flow conditions.

With increase in specific speed and NPSH requirements the sensitiveness to adverse flow conditions also increases.

The above applies in particular to high specific speed pumps of the mixed flow and axial flow type.

Where the close proximity of blade inlets to suction and lack of space for flow guidance in the pump inlet casing itself makes the units highly susceptible to an unfavourable flow environment.

Whilst the designs of pump intakes may be governed by site conditions, approved good flow conditions must be appreciated and provided as far as practicable.

The following points are important and should be noted.

* Flow conditions at the pump intake should be uniform, steady and of single phase:

  Uniform flow - the velocity, in magnitude and direction of fluid particles is the same at all points across the section considered.

  Steady flow - the velocity in magnitude and direction, does not change with time.

  Single phase - there is no entrained air, vapour or other gases.

* Sewage Pump Sumps;

  A sump which handles solid matter in suspension needs special care. The velocity should not fall so low that solid matter is deposited on the floor. There must be no stagnant areas, since these would provide a chance for the fluid to become septic. Typical minimum mean velocity for design purposes would be 0.7 m/s.

The main aspects of adverse conditions are listed below:

* **Bad Distribution**

  Results in uneven loading between pump units.

* **Pre-rotation around the Pump Suction**

  Direction of rotation opposite to that of the pump can overload the prime-mover, whilst if the rotation is the same as that of the pump, power absorbed becomes less. Severe wear, failure of pump parts can result in both cases.

* **Surface Swirls**

  Surface swirls can lead to air-entraining vortices with lowering of output, unstable performance, mechanical wear and air into the system.

* **Unnecessary acceleration and deceleration**

  Unnecessary acceleration and deceleration are breeding ground for vortices, unwarranted losses affecting the suction head.

  Where the suction layout is suspect it is advisable to conduct scale model tests, to ensure a satisfactory design. The model tests should be carried out prior to the finalisation of the design.

  On a scale model, it is not possible to achieve exactly similar conditions to those on site in all respects. However, close similitude can be obtained provided the more significant factors are recognised for each case.

The optimum sump volume

This is usually decided upon with due regard to the maximum permissible starts/hour of the pump motor.

Points to consider are;

* **Discharge rate and retention time.**

* **Number of pumps.**

* **Discharge rate of each pump.**

* **Operating level of each pump.**

* **Fixed or variable speed pumps.**

If variable speed pumps are used, the number of starts per hour criterion no longer applies and the sump volume is governed by the control system for varying the pump speed. Typically the water level can be held to within 150 mm of a set point for the type of control.

* **Minimum sump volume (V)**

It can be proved that the pump starts frequently when the flow-rate into the sump is exactly half the pumping rate Q and that the cycle time (T) is determined as follows:

$T = 4V/Q$ OR $V = QT/4$

Where,

V = Sump volume m^3

Q = Pumping Rate m^3/min

T = Cycle Time in Min.

Hence for a frequency of 10 starts/hour (i.e. T = 6 min)

V = (3/2) * Pump discharge/min.

If more than one pump is involved additional capacity is required to allow a vertical distance of 150 mm between the start or stop level of consecutive pumps.

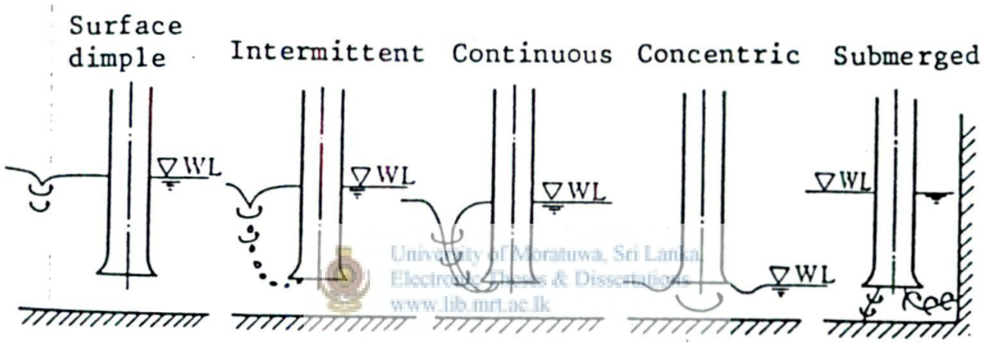
2.2 FLOW IN SUCTION SUMP

Flow around a vertical shaft pump of wet pit type or a suction pipe suspended in a sump tends to form air-entrained vortices due to poor shape or wrong dimensions of the suction sump and depth of submergence.

The following adverse effect on the pump and its facilities can result in;

* **Vibration and Noise.**
* **Suction of air causing pump performance to deteriorate.**
* **Unstable swirling flows at the impeller eye.**
* **Damages to Impeller.**
* **Overloading of the prime mover.**

When vortex is formed on the liquid surface around the intake pipe, it will eventually develop into an air-entrained vortex as the water level is lowered as shown below. Further decrease of the level will produce a concentric vortex around the pipe. Sometimes a submerged vortex can be formed from the wall to pipe inlet.



Sump Vortices

The swirling flow around the bellmouth is caused by increased velocity in suction sump, non uniform flow and drift flow in the suction sump.

Pump performance is highly sensitive to swirling flow around the pump inlet.

When the inlet flow is whirling in the direction of impeller rotation the head produced will be lowered due to pre-rotation at the impeller eye.

When the whirling is in the opposite direction to that of impeller rotation, the head produced will increase resulting in increased shaft power thereby over-loading the prime mover. Symmetrical uniform flow around the pump inlet is essential especially for high specific speed pumps.

2.3 BASIC SHAPES AND STANDARD DIMENSIONS

The basic shape, dimensions and the velocity of approach can cause the formation of vortices. The main dimensions in a suction sump are;

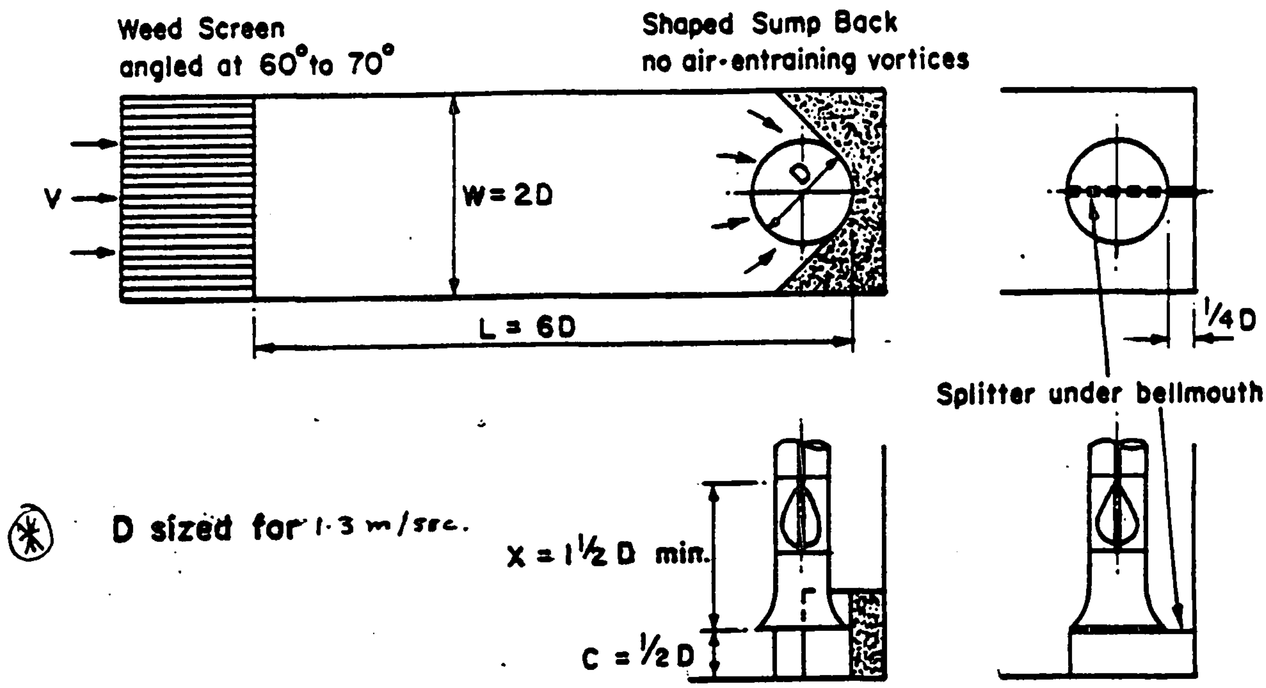
* **Depth of Submergence (E)**
* **Sump width (3D)   Where D = Pump Bore**
* **Bottom clearance (F)**
* **Back wall clearance (G)**
* **Parallel portion (l)**

Due consideration should be given in planning sump layouts in order to provide favourable flow patterns around the suction inlet.

The figures and the tables in over leaves give the typical shape of suction sumps and their dimensions.

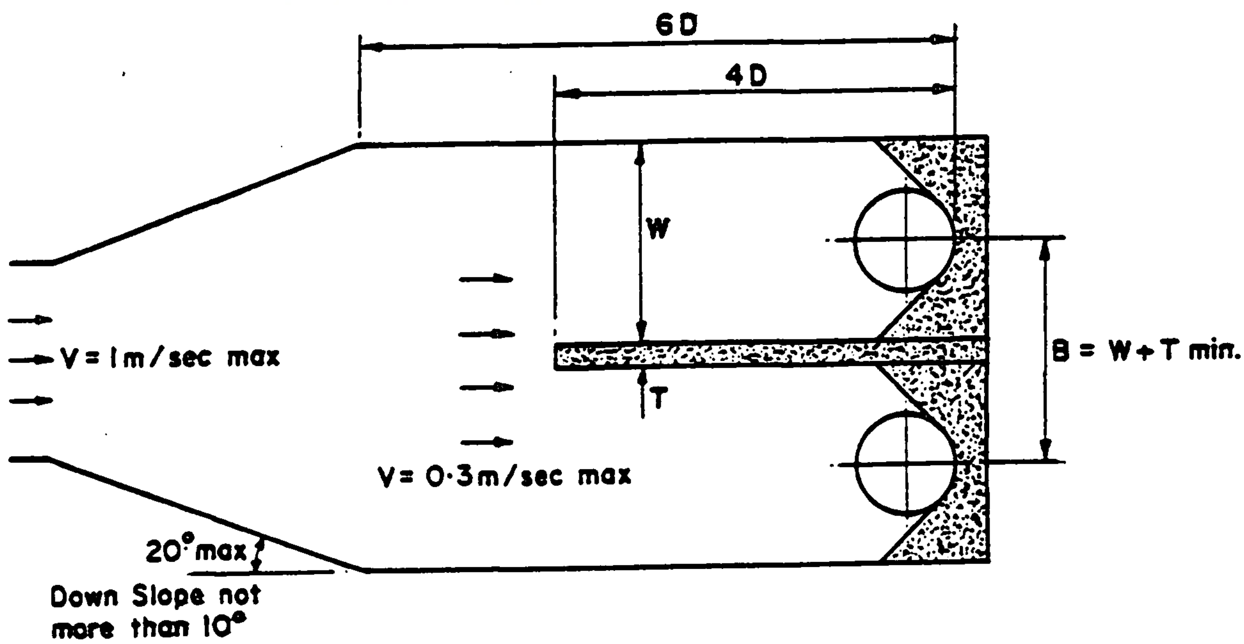
Annexes 2.1, 2.2, 2.3 and 2.4 give the undesirable suction layout and their improvements.

(Source : Pumping Station Engineering Hand Book 1991)



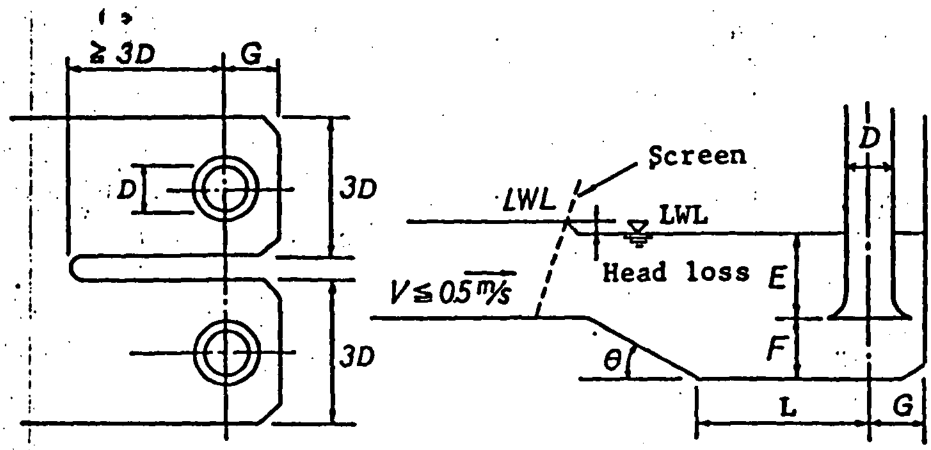
SINGLE PUMP BAY
Axial Flow Pump

Alternative Arrangement under Bellmouth for Mixed Flow Pumps



MULTIPLE PUMP BAY

Source : Water Industry Training Association 1988



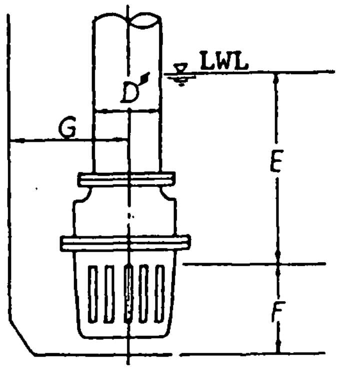
D: pump bore

L > 3D for = 30°
L > 4.5D for = 45°

E = 1.7D
F = D
G = 1.1D

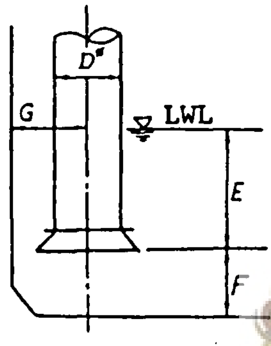
Bore (mm)	Dimensions (mm) E	F	G	Bore (mm)	Dimensions (mm) E	F	G
600	1,100	600	700	1,350	2,300	1,350	1,500
700	1,300	700	800	1,500	2,500	1,500	1,650
800	1,400	800	900	1,650	2,700	1,650	1,800
900	1,600	900	1,000	1,800	2,900	1,800	2,000
1,000	1,700	1,000	1,100	2,000	3,300	2,000	2,200
1,200	2,000	1,200	1,300	2,200	3,600	2,200	2,400

Standard Sump Arrangement



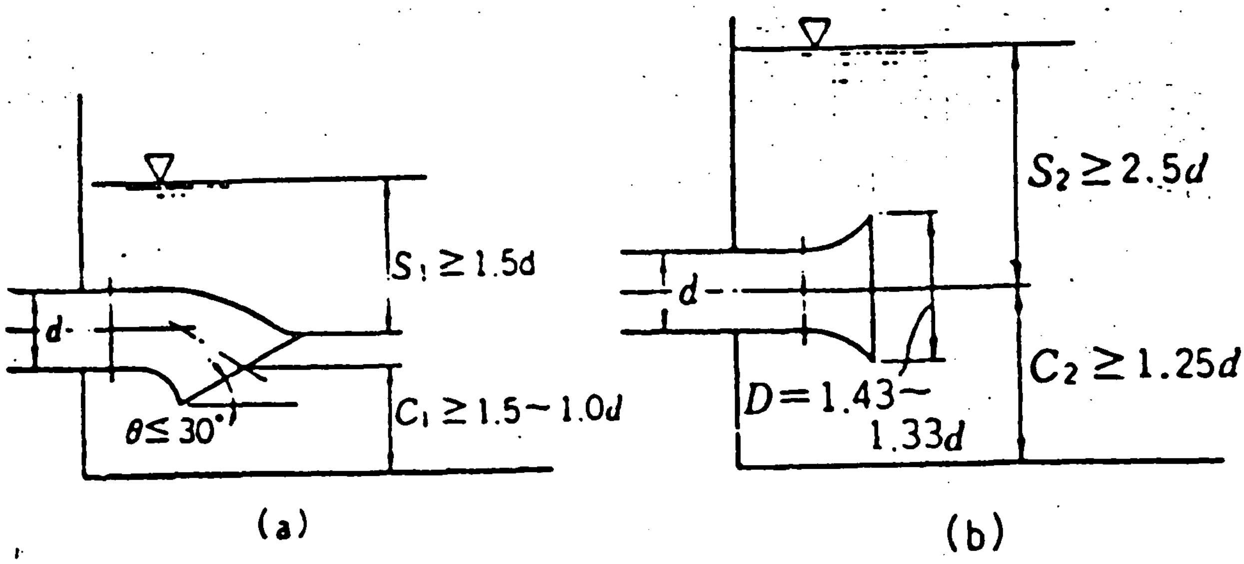
Bore (mm)	Dimensions (mm) E	F	G	Bore (mm)	Dimensions (mm) E	F	G
65	280	150	200	150	500	380	250
80	310	200	200	200	600	500	400
100	330	250	200	250	720	620	400
125	420	310	250	300	850	740	450

Sump for Suction Pipe with Foot Valve



Bore (mm)	Dimensions (mm) E	F	G	Bore (mm)	Dimensions (mm) E	F	G
150	500	250	250	350	670	350	450
200	500	250	300	400	760	400	500
250	500	250	350	450	860	450	550
300	570	300	400	500	950	500	600

Sump for Suction Pipe with Bellmouth



Horizontal Intake