3.5 MODEL STUDIES

Model: Model is the small scale replica of the actual structure or machine. It is not necessary that models should be smaller than the prototypes (although in most of the cases it is), they may be larger than the prototypes.

Prototype: The actual structure or machine

Model analysis: Model analysis is the study of models of actual machine.

Advantages:

• The performance of the machine can be easily predicted, in advance.

• With the help of dimensional analysis, a relationship between the variables influencing a flow problem in terms of dimensional parameters is obtained. This relationship helps in conducting tests on the model.

• The merits of alternative designs can be predicted with the help of model testing. The most economical and safe design may be, finally, adopted.

Type of forces acting in the moving fluid

Inertial force: it is equal to the mass and acceleration of the moving fluid.

$$F_i = \rho A V^2$$

Viscous force: it is equal to the shear stress due to viscosity and surface area of the flow.It present in the flow problems where viscosity is having an important role to play.

$$F_v = \tau A = \mu \frac{du}{dy} A = \mu \frac{U}{d} A$$

Gravity force: product of mass and acceleration due to gravity.

$$F_g = \rho A L g$$

Pressure force: product of pressure intensity and flow area.

$$F_p = pA$$

Surface tension force: product of surface tension and the length of the surface of the flowing fluid.

$$F_s = \sigma d$$

Elastic force: product of elastic stress and area of the flow.

$$F_e = Elastic\ stress \times Area = KA$$

Classification of model

• Undistorted models: are those models which are geometrically similar to their prototype. In other words the scale ratio for the linear dimensions of the model and its prototype are the same.

• Distorted models: are those models which are geometrically not similar to its prototype. In other words the scale ratio for the linear dimensions of the model and its prototype are not same.

For example river: If the horizontal and vertical scale ratios for the model and the prototype are same then it is undistorted model. In this case the depth of the water in the model becomes very small which may not be measured accurately.

Thus for cases distorted model is useful.

The followings are the advantages of distorted models

- ✓ The vertical dimension of the model can be accurately measured
- ✓ The cost of the model can be reduced
- ✓ Turbulent flow in the model can be maintained

Though there are some advantage of distorted models, however the results of such models cannot be directly transferred to prototype.

Scale Ratios for Distorted Models

Let: $(\mathrm{L_r})_H = \frac{L_P}{L_m} = \frac{B_P}{B_m}$ Scale ratio for horizontal direction

$(\mathrm{L_r})_V = \frac{h_P}{h_m}$ =Scale ratio for vertical direction

Scale Ratio for Velocity: $\mathrm{Vr=V_P / V_m} = \frac{\sqrt{2gh_P}}{\sqrt{2gh_m}} = \sqrt{(L_r)_V}$

Scale Ratio for area of flow: $\mathrm{Ar=A_P / A_m} = \frac{B_P h_P}{B_m h_m} = (L_r)_H (L_r)_V$

Scale Ratio for discharge: $\mathrm{Qr=Q_P / Q_m} = \frac{A_P V_P}{A_m V_m} = (L_r)_H (L_r)_V \sqrt{(L_r)_V} = (L_r)_H (L_r)_v^{3/2}$