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MODEL Analysis

- For predicting performance of the hydraulic structures (such as dams, spillway, etc) or hydraulic machines (such as turbine pumps etc) before actually constructing or manufacturing models of the structure are made.

- Model → Small scale replica of the actual structure or machine

- Prototype → Actual structure or machine

not necessary that the model should be smaller than prototype

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Similitude - Types of Similarities →

(1) Three type of Similarity exist b/w model and prototype

1. Geometric Similarity →
Ratio of all corresponding linear dimension in model and prototype are equal

Let L_m = Length of model
D_m = Dia of model

b_m = width of model
$\forall_m$ = volume of model

and

$L_p, b_p, D_p, A_p, \forall_p$ = Corresponding value of Prototype

Geometric Similarity made and Prototype

$$\frac{L_p}{L_m} = \frac{b_p}{b_m} = \frac{D_p}{D_m} = L_r$$

L_r = Scale ratio

Area's ratio $\frac{A_p}{A_m} = \frac{L_p \times b_p}{L_m \times b_m} = L_r \times L_r$

$= L_r^2$

$$\frac{\forall_p}{\forall_m} = \left(\frac{L_p}{L_m}\right)^3 = \left(\frac{b_p}{b_m}\right)^3 = \left(\frac{D_p}{D_m}\right)^3$$

(2) Kinematic Similarity ⇒

- Similarity of motion b/w model and Prototype

- Kinematic Similarity means model and the Prototype of the ratio of the velocity and acceleration at the corresponding point in the model and at the corresponding point in the Prototype are the same.

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Let V_{p_1} = Velocity of fluid at pt 1 in prototype
V_{p_2} = Velocity of fluid at pt 2 in Prototype
a_{p_1} = Acceleration of fluid at pt 1
a_{p_2} = Acceleration of fluid at pt 2

V_{m_1}, V_{m_2}, a_{m_1}, a_{m_2} = corresponding to model

$$\frac{V_{p_1}}{V_{m_1}} = \frac{V_{p_2}}{V_{m_2}} = V_r$$

$$\frac{a_{p_1}}{a_{m_1}} = \frac{a_{p_2}}{a_{m_2}} = a_r$$

(3) Dynamic Similarity → force b/w model and Prototype are same

Let $(F_i)_p$ = inertial force at a point in prototype
$(F_v)_p$ = Viscous force at the point in prototype
$(F_g)_p$ = Gravity force at point in prototype
etc.

$(F_i)_m$, $(F_v)_m$, $(F_g)_m$ = Corresponding to the model

$$\frac{(F_i)_p}{(F_i)_m} = \frac{(F_v)_p}{(F_v)_m} = \frac{(F_g)_p}{(F_g)_m} = F_r$$

F_r is the force ratio.

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TYPES of Force acting in moving fluid

Inertia force →
Product of mass and acceleration
• acts in the opposite direction

Viscous force →
Product of Shear Stress due to Viscosity and Surface area of flow

Gravity force →
Product of mass and acceleration due to gravity. • it is present in open Surface.

Pressure force →
Product of pressure intensity and cross-sectional area of flowing fluid is case of pipe flow

Surface tension → (force)
Product of Surface tension and length of Surface flowing

Elastic force →
Product of elastic Stress and area of the flowing fluid.