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Hydraulic structures. Dams and reservoirs

Concrete dam engineering -1

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DAM BODY GEOMETRY

Elevations:

- Dam Crest El.
- Top of a Basic Triangle El.= NWL / MWL
- Foundation El.= f (River Bed El, geology)

Upstream Slope 1:m

Downstream Slope 1:n

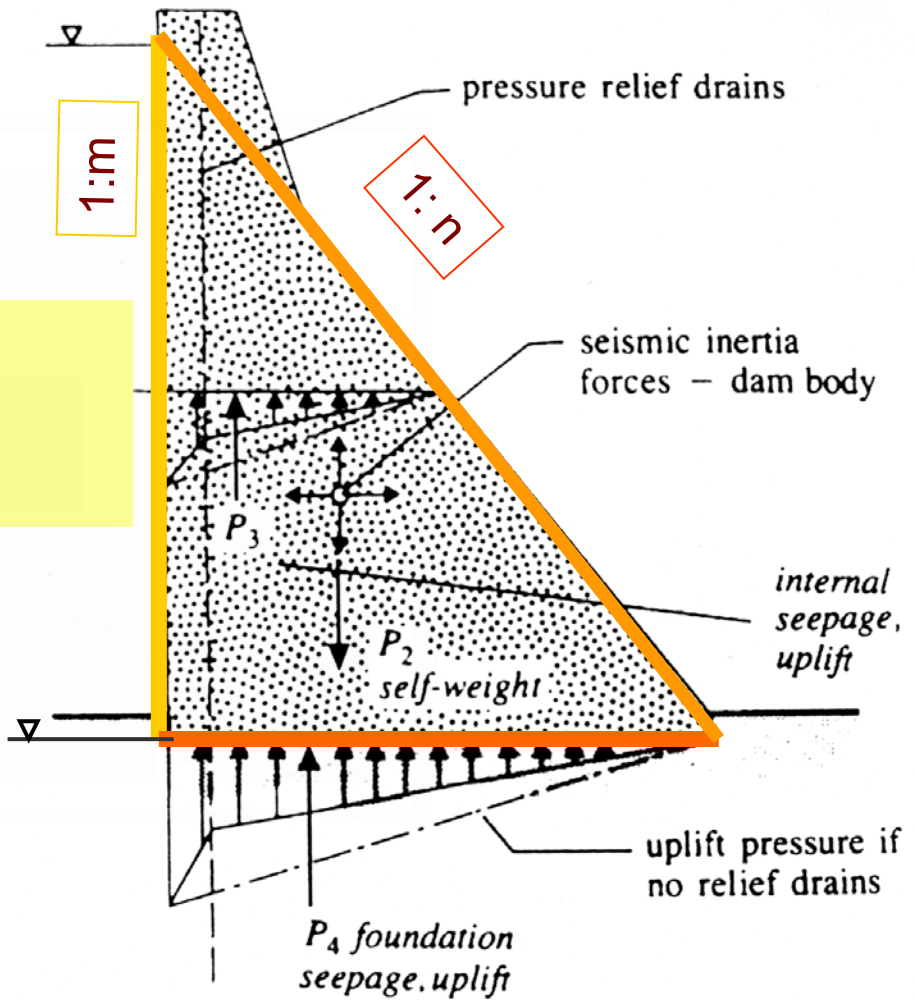
DAM BODY GEOMETRY

Top of a Basic Triangle El.= NWL / MWL

Dam body geometry

- 1:m, m=0.05…0.10
  1:n, n=1.68…1.75

Foundation El.= River Bed El.-(Al+WRock)



LOADS ON DAM

- ***primary loads*:** water and related seepage loads, self-weight loads;
- ***secondary loads*:** sediment load, hydrodynamic wave load, ice load
- ***exceptional loads:*** seismic load

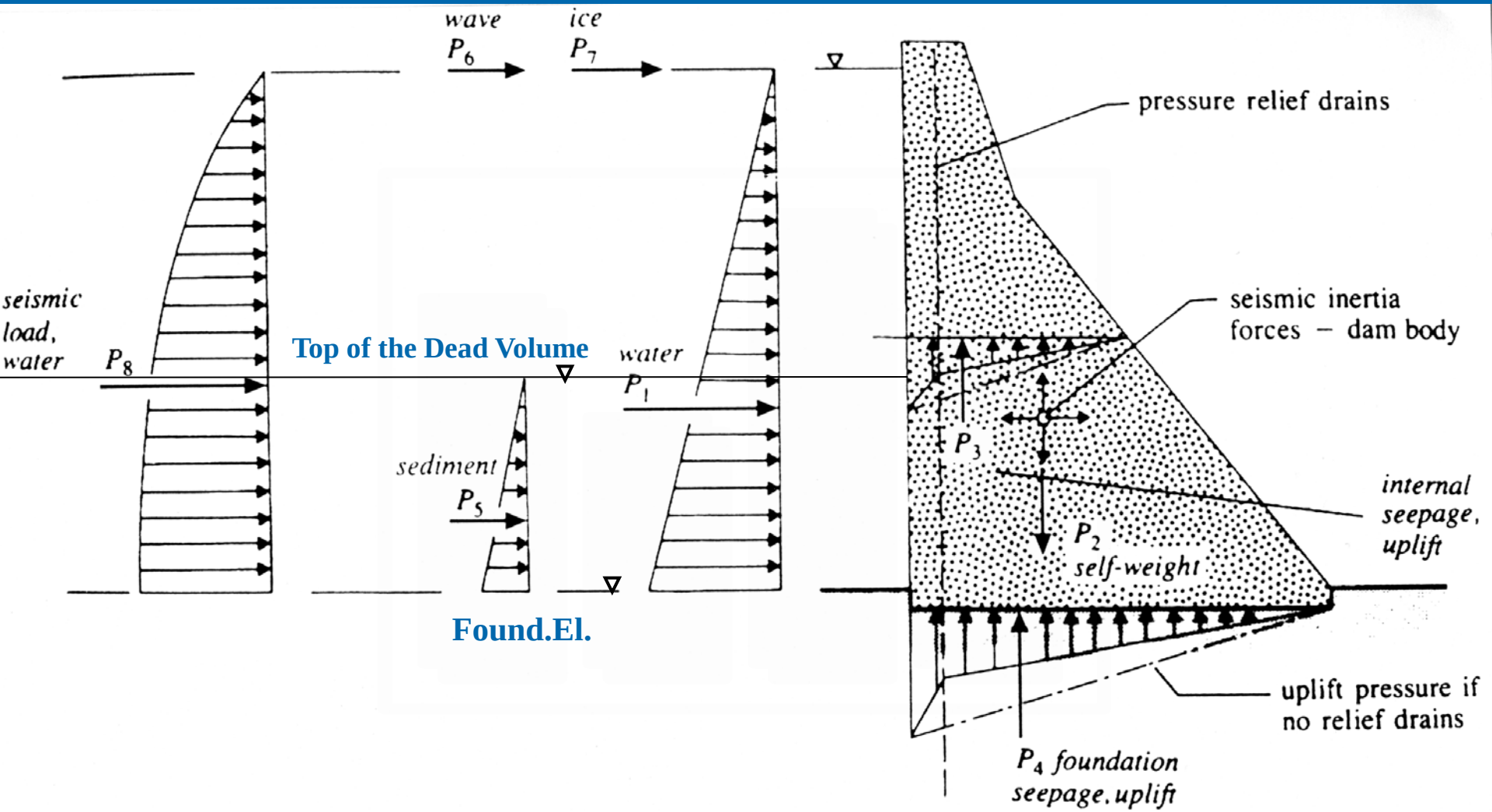


Fig. 1.8 Schematic of principal loads: gravity dam profile

Seepage control

Galery

-ease of construction and rehabilitation of the grout curtain and drains in foundation

-seepage water collection

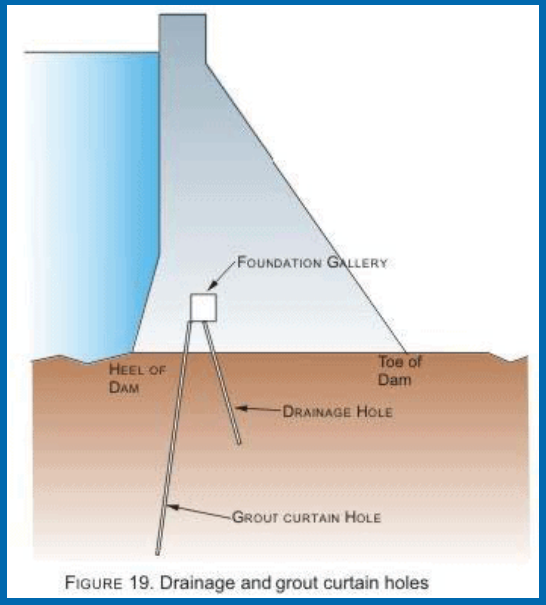
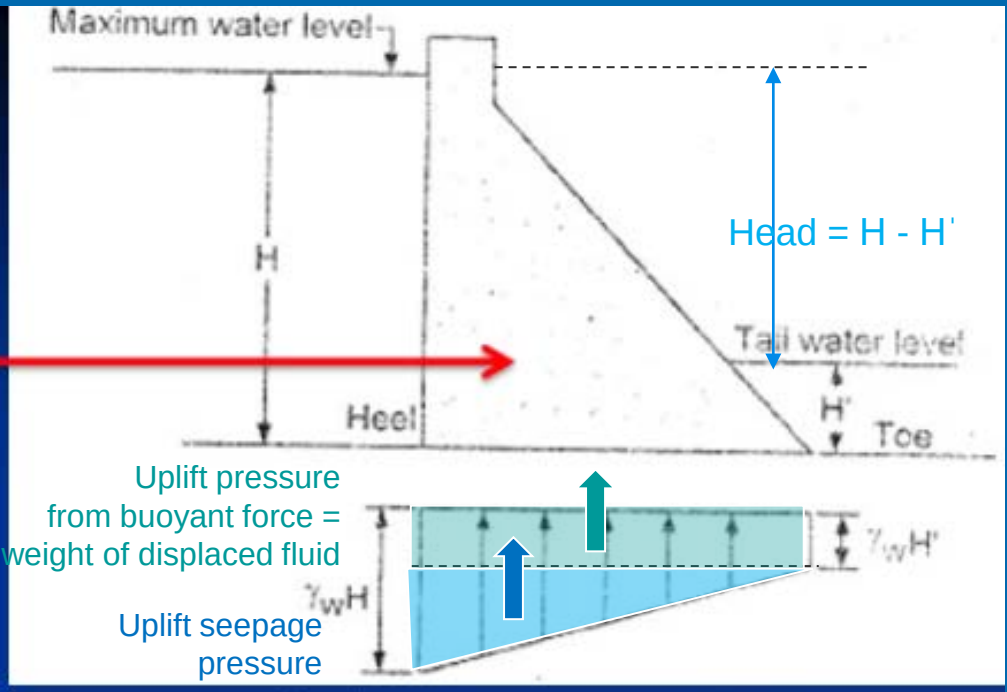


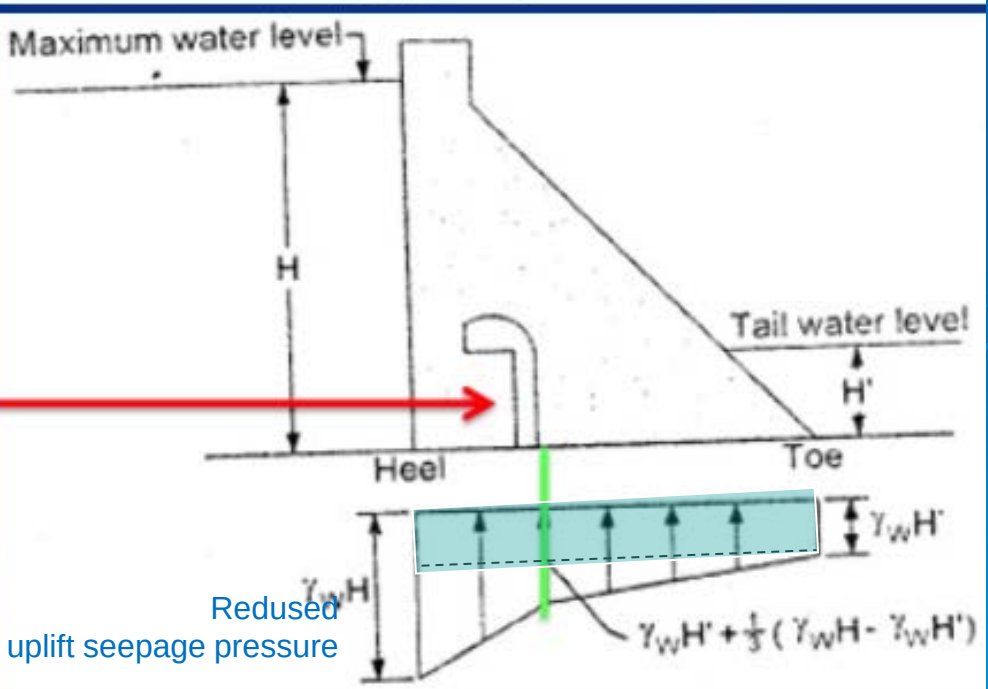
FIGURE 19. Drainage and grout curtain holes

Uplift Pressure

Without Gallery



With Gallery



Uplift pressure
from Archimedes' principle:
buoyant force =
weight of displaced fluid

Uplift seepage
pressure

$$\gamma_w H' + \frac{1}{3}(\gamma_w H - \gamma_w H')$$

LOAD COMBINATIONS

I. End of Construction :

Normal = G

Extreme = G + E

II. Operation :

Normal : $\nabla WL = \nabla NWL, G\ W_н\ W_v\ P_н\ W_ф$

Unusual: $\nabla WL = \nabla MWL, G\ W_н\ W_v\ P_н\ W_ф$

Extreme: $\nabla WL = \nabla NWL, G\ W_н\ W_v\ P_н\ W_ф + E$

LOADS ON DAM

- ***primary loads*: water and related seepage loads, self-weight loads;**
- ***secondary loads*: sediment load,**
- ***exceptional loads:* seismic load**

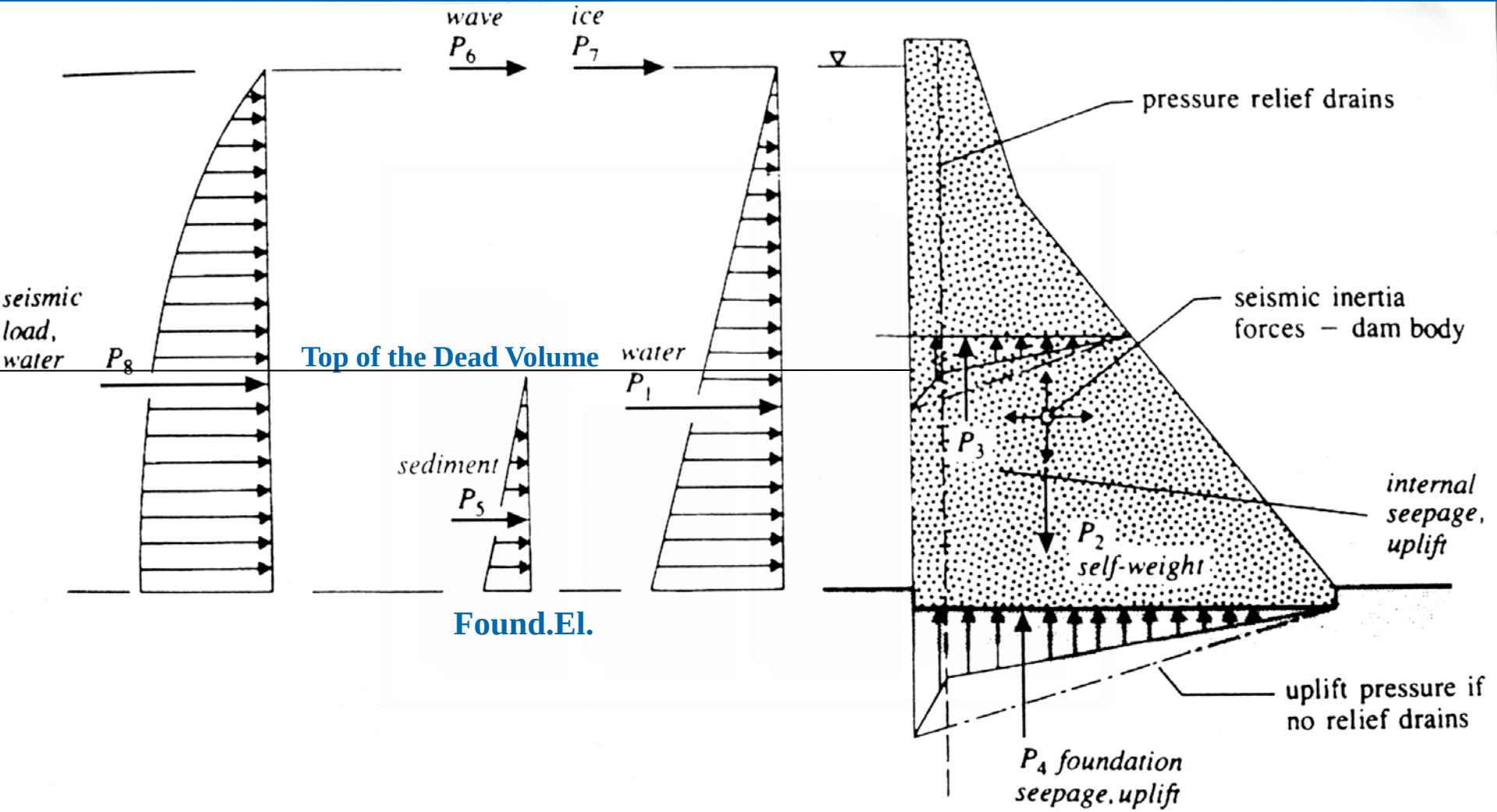


Fig. 1.8 Schematic of principal loads: gravity dam profile

THEORETICAL VALUES OF LOADS

Sediment Load

$$P_н = \frac{1}{2}.\gamma_н.H_н^2.\xi_a \quad (1)$$

H - from Top of the Dead Volume to Found.El.

DryUnit Weight:

$$\gamma_1 = 12 \div 14 \text{ kN/m}^3$$

For Submerged Unit Weight :

γ1+ ***n.****γw* ->the sediment saturated unit weight

$$\gamma_н = \gamma_1 - (1-n).\gamma_в$$

γH -> weighed sediment unit weight

Example

$$\gamma_н = 13 - (1-0,34).10 = 6,40 \text{ kN/m}^3$$

Where: n - pore space

$$\xi_a = \text{tg}^2\left(45° - \frac{\varphi}{2}\right) -$$ Active Lateral Pressure Coefficient

$$\varphi = 16° \div 18° -$$ Angle of Shearing Resistance of the Sediment

Example

$$\xi_a = \text{tg}^2\left(45° - \frac{17°}{2}\right) = 0,55$$

$$H_н = \nabla MO - \nabla \Phi = 1052,60 - 1021,20 = 31,40 \text{ m}$$

$$P_н = \frac{1}{2}.6,40.31,40^2.0,55 = 1735,29 \text{ kN/m}^1$$

LOADS ON DAM

- ***primary loads*:** water and related seepage loads, self-weight loads;
- ***secondary loads*:** sediment load,
- ***exceptional loads:*** seismic load

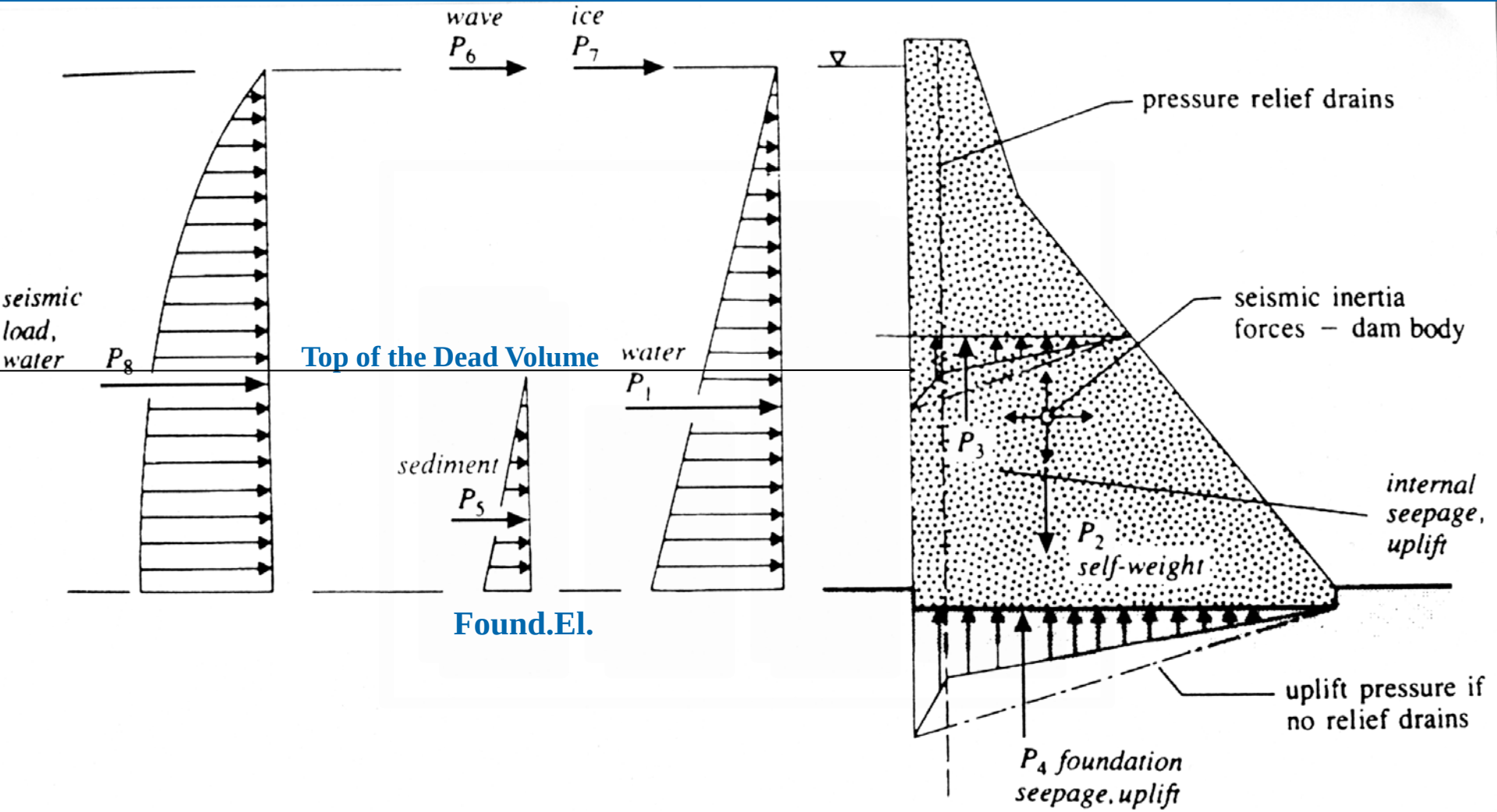
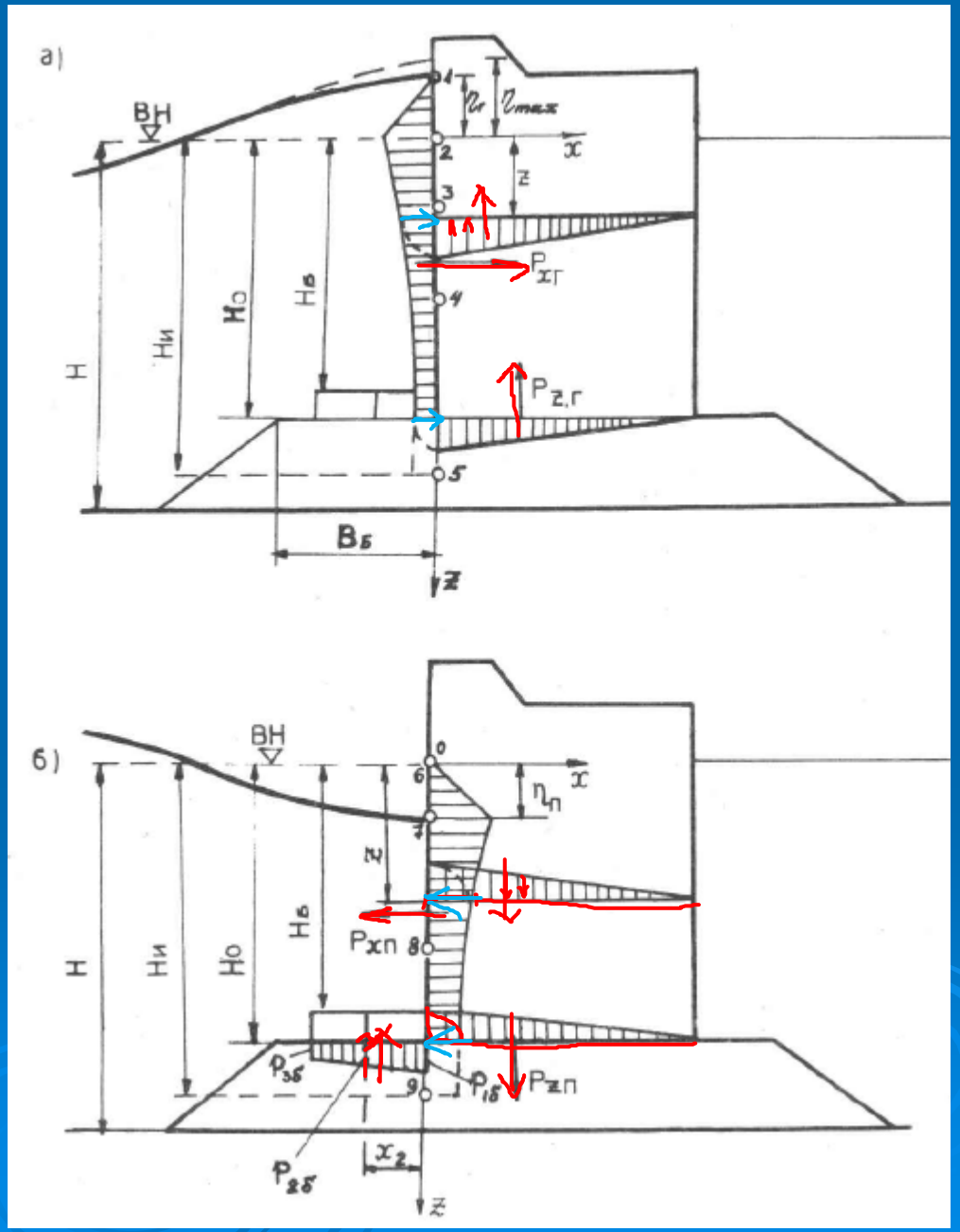


Fig. 1.8 Schematic of principal loads: gravity dam profile

Loading by wind wave



exceptional loads: seismic

Response-Spectrum Analysis

- We seek **maximum response** of the structure to the ground motion /response quantities:displacements, forces and stresses/

MAX EARTHQUAKE

CME */controlling max earthquake/*

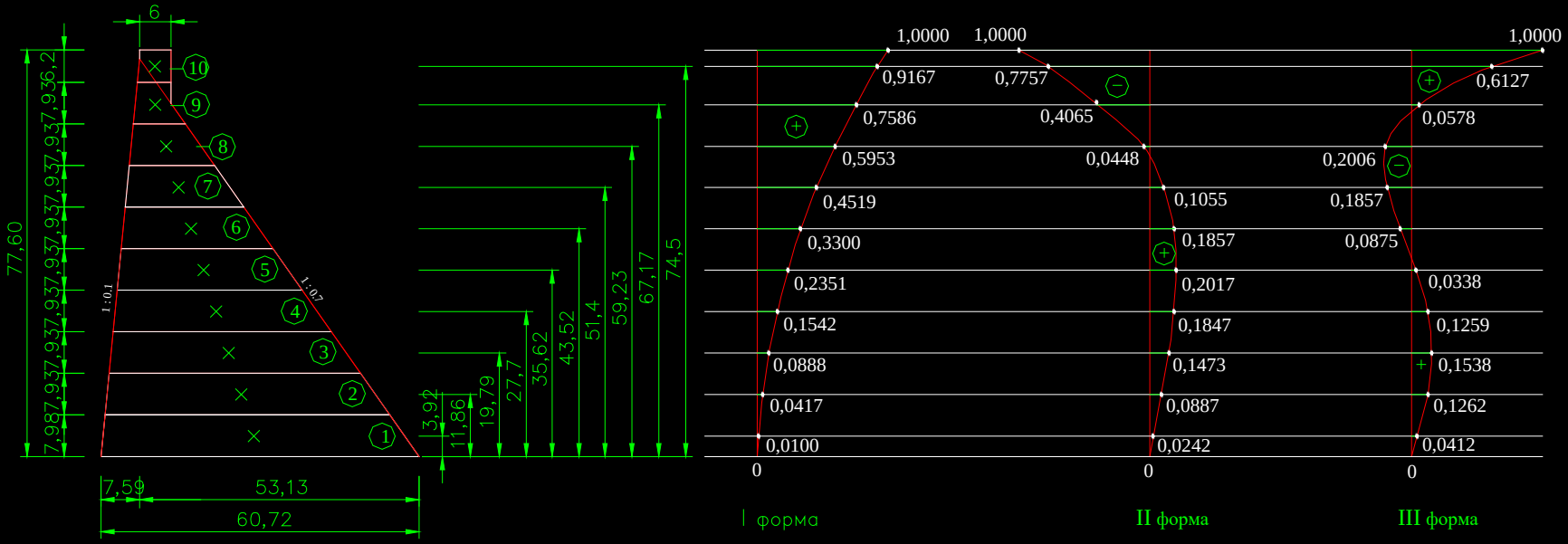
Response-Spectrum Method

In Spectral method seismic inertia loads are determined by modes of free oscillations i=1,2,3,4….

Design Earthquake Force
/Bulgarian code/

$$E_{ik} = cRK_c\beta_i\eta_{ik}Q_k$$

Modes of free oscillations depend on B/H dam value



$$E_k = \sqrt{\sum_i E_{ik}^2}$$

$$E_{ik} = cRK_c \beta_i \eta_{ik} Q_k$$

Where:

β_i - acceleration response versus the period T_i

Q_k – weight of “κ”lamella

$Q_{k=m.g}$

$$\eta_{i,k} = x_{i,k} \cdot \frac{\sum_1^n Q_j . x_{i,j}}{\sum_1^n Q_j . x_{i,j}^2}$$

-coefficient of the shape for “i”-mode on level “k”

c - coefficient of responsibility

c=1.5 for I class dam

R - coefficient of material and type of structure

R=0.3 for concrete gravity dam

K_c - earthquake coefficient / from the Earthquake map of the country

K_c = a/g = 0.1; 0.15; 0.27 / for VII; VIII; IX degree /

Algorithm:

1. Calculate the period of structure's free vibrations in modes 1,2,3 and the corresponding forms of free oscillations for B/H=???
2. Calculate coefficients beta,etha
3. Calculate seismic loads in modes 1,2,3
4. Calculate combination=total seismic load

SEISMIC LOAD

I. End of Construction :

Extreme = G + E

$$E_{ik} = cRK_c\beta_i\eta_{ik}Q_k$$

II. Operation :

Extreme: ∇WL = ∇NWL, G $W_н$ W_v $W_ф$ + E

$$E_{ik} = cRK_c\beta_i\eta_{ik}(Q_k + Q_{wk})$$

Operation

$$E_{ik} = cRK_c\beta_i\eta_{ik}(Q_k + Q_{wk})$$

ATTACHED MASS OF WATER
We replace the hydro-seismic pressure by adequate ATTACHED to the dam MASS OF WATER.

Then we have to calculate NEW free oscillations of the dam-water system.