457.562 Special Issue on River Mechanics (Sediment Transport) .19 Scour Processes



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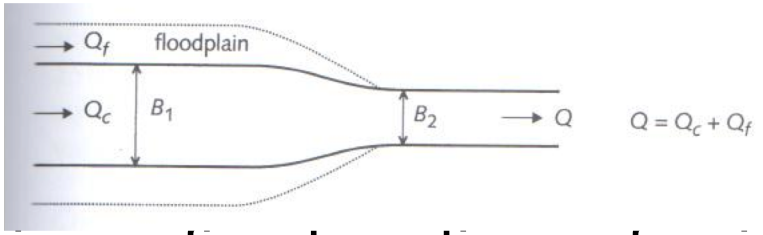
General

- Scour which occur at (or near) a structure can be divided into general scour and local scour.
- General scour
  - Time scale is generally longer than the time scale for local scour.
  - Long term change in the bed level of a river, scour due to a constriction, scour in a bend or at a confluence.

General Scour

- Overall degradation
  - From modification to the stable regime conditions to which river has become adjusted.
    - Flood embankments, flood detention basins, weirs
    - Channel improvement schemes involving dredging, weed cle arance, mining of sand and gravel
    - Changed in water patterns (confluence, bifurcation etc)
    - Schemes for transfer of water between river basins,
    - Meander cut-offs
  - River bed changes can be obtained from a one-dimension al morphological model.

Constriction Scour



- Construction scour occurs in confined sections of a river and results in a lowering of the bed level across the widt h of the river.

$$\frac{y_{m,e} + h_0}{h_0} = \frac{1}{(1-m)^{\beta}}$$

$y_{m,e}$ = Scour depth in constriction

h_0 = Flow depth upstream of the constrictuion

m = B_2 / B_1 constriction ratio

β= coefficient; which lies between 0.67 and 0.8

- If there is bank over flow with discharge Q_f.

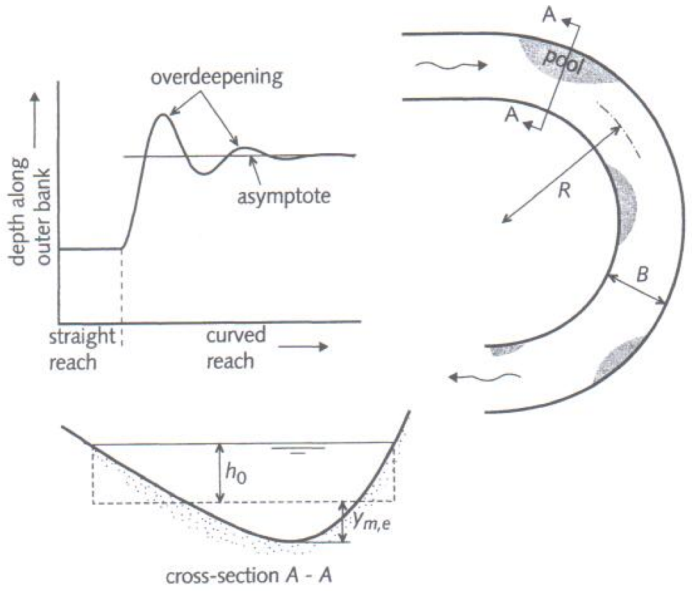
$$\frac{y_{m,e} + h_0}{h_0} = \frac{1}{(1-m)^{\beta}} \frac{Q}{Q - Q_f}$$

Bend Scour

- Bend scour depends on local parameters (bend curvatur e, flow depth, grain size) and upstream influences (redist ribution of flow and sediment transport).
- The excess bed scour is due to the spiral flow and an ov ershoot.

$$\frac{y_{m,e}}{h_0} = 1.07 - \log\left[\frac{R}{B} - 2\right],$$

$$for \quad 2 < \frac{R}{B} < 22$$



Confluence Scour

- When two branches of a river meet, both the angle of co nfluence and water level may differ.
- Through mathematical models are available at present, t hese models are of limited value because of the one-dim ensional modeling.

$$\frac{y_{m,e}}{h_0} = c_0 + 0.037\theta$$

C_0 = coefficient depending on material properties (1.29-2.24)

h_0 = average flow depth of the two branches

θ = angle between the two upstream branches.

Local Scour

- Local scour results directly from the impact of the structu re on the flow.
- According to Breusers (1966), the development of the sc our process depends on the flow velocity and turbulence intensity at the transition between the fixed and the erodi ble bed.
  - Therefore, the scour prediction can be restricted to one co mputation; no information is needed concerning the near b ed velocities and bed turbulence in the scour hole.
- From the previous works, important conclusion was mad e as
  - The shape of the scour hole independent of bed material a nd flow velocity.

Local Scour

- The scour process as function of time (no flow velocity & bed material), provided the prediction of the equilibrium s cour depth is satisfactory

$$\frac{y_m}{\lambda} = \left(\frac{t}{t_1}\right)^{\gamma}$$

t = Time

t_1 = Characteristic time as which $y_m = \lambda(s)$

y_m = Maximum scour depth at t

$y_{m,e}$ = Equilibrium scour depth

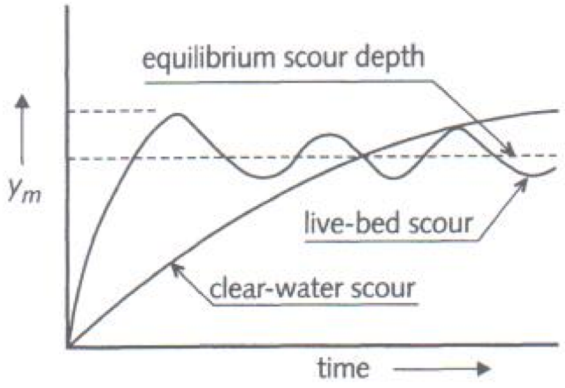
γ = Coefficient

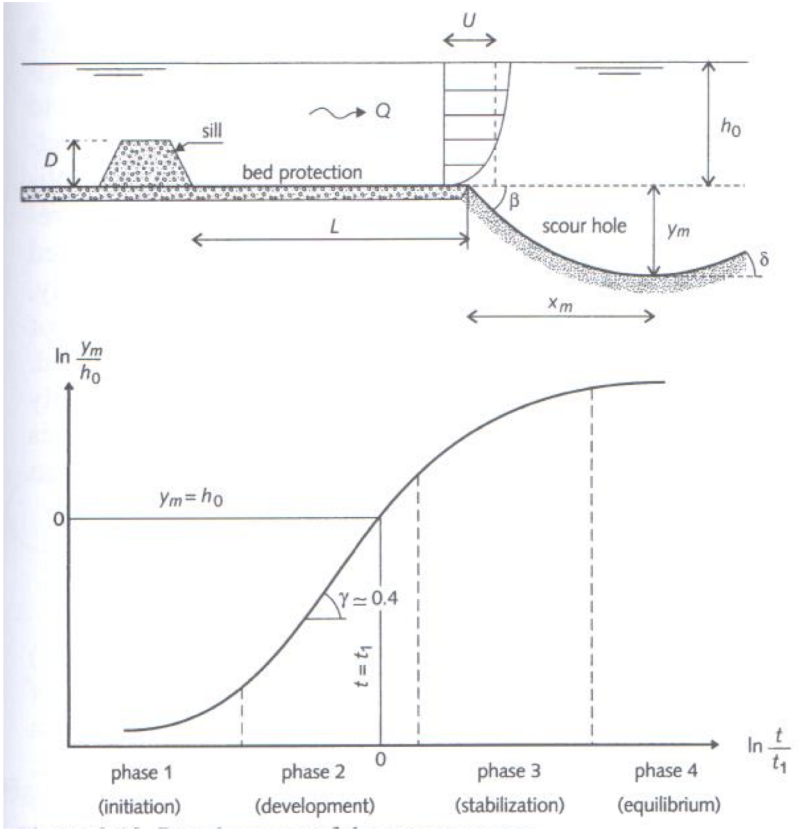
λ = Characteristic length scale

(Can be largest eddy as h_0 or the Kolmogorov scale)

Conditions

- Clear-water scour occurs when no upstream sediment is present.
- Live-bed scour : scour with sediment transport over the u pstream undisturbed bed.

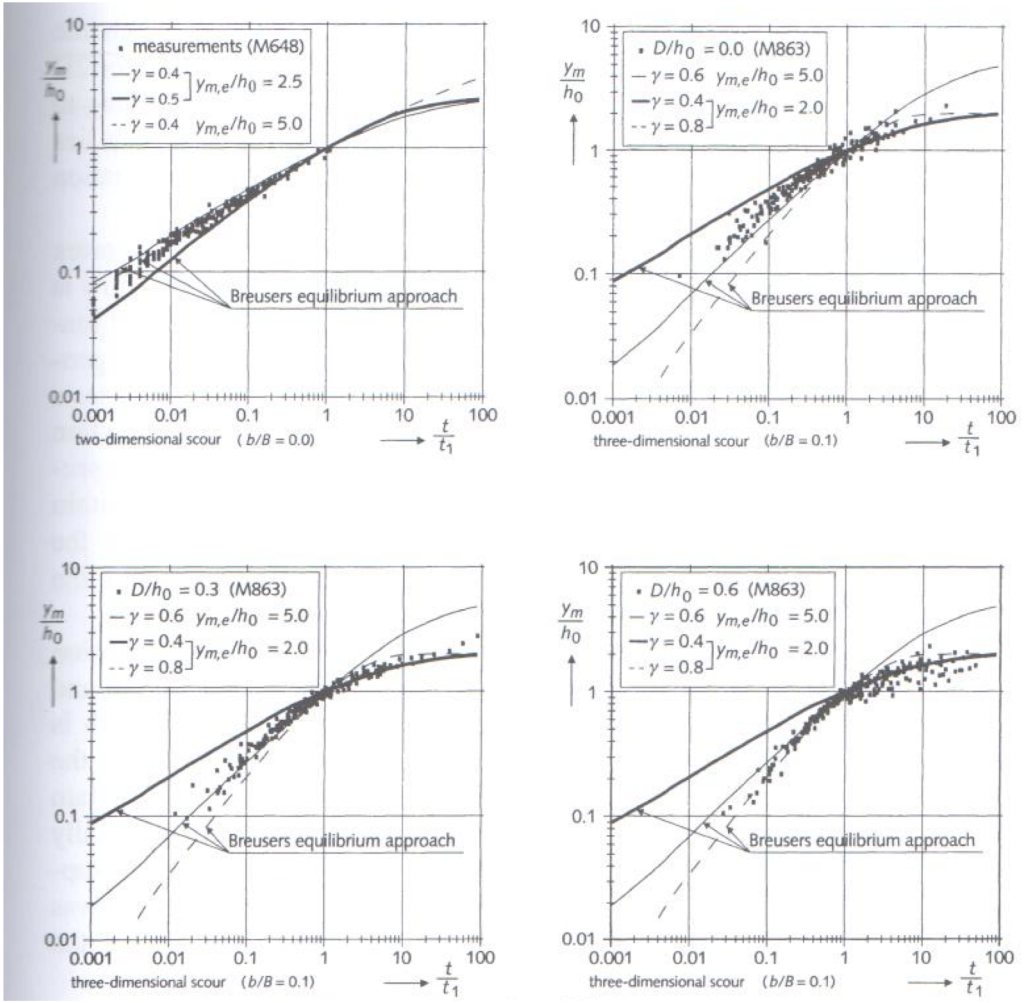




Dutch Scour Depth Modelling

- The magnitude of the maximum scour depth depends on the bed sh ear-stress and the turb ulence condition near t he bed.
- Also, density of sedim ent, size distribution, p orosity are also critical

$$\frac{y_m}{h_0} = \left(\frac{t}{t_1}\right)^{\gamma}$$



3-D situations

- Scour in a horizontal constriction, a vortex street occurs.
- The flow is very turbulent and large vortices intermittently erode and transport bed material.
- Her gamma is strongly dependent on the degree of turbulence generated by vortices.