APPENDICES

Appendix A: - The Old Bridge Problem

When a supercritical flow passes through a gate or a culvert or a flume, or a constriction, as in the case of water passing through Kassala old bridge a hydraulic jump is created downstream the gate or the existing structure. The constriction could either be vertical or horizontal i.e.narrowing the breadth as in the presence of spurs or narrowing the overhead opening as in the case of the old bridge. In both cases a critical flow can be created at the constriction. The creation of the critical depth in the constriction can be obtained by either optimum vertical or horizontal narrowing of the opening, whence the flow will not head up upstream the structure. Fortunately, in the case of old Kassala Bridge the two actions can be conducted.

When spurs constrict the flow, the scouring action caused by narrowing the channel will cause a great water drop in level compared with the level of the upstream approaching flow. If the bed level at the constriction of the bridge accumulated silt it means that neither the vertical nor the horizontal narrowing was optimized. Optimization of horizontal narrowing is obtained by the completion of the pairs of spurs downstream at kilo 0.500 north the bridge as proposed in the short-term solutions. The narrowing will have immediate effect due to the scouring action that will result associated with drop in water level in the viscinity of bridge pier as well as at the heads of the downstream spurs.

The stream force will be directed to the accumulated silt under the bridge and it will be scoured and carried downstream. This can be demonstrated by the following example.

A horizontal channel 3.0 meters wide carries water flowing at a depth of 2.0 meters. At a certain section there is a smooth transition to a width of 2.25

meters with a rise in bed level of 0.25 meter (similar to that under the bridge-siltation), the water surface is observed to drop 0.1 meter through the transition as shown in figure(**5.13**). If the water level is to remain the same upstream and downstream (as required in the Gash River), the discharge can be estimated and bed level can also be estimated as follows: -

Assuming no energy loss through the transition, from the geometry of the energy line: -

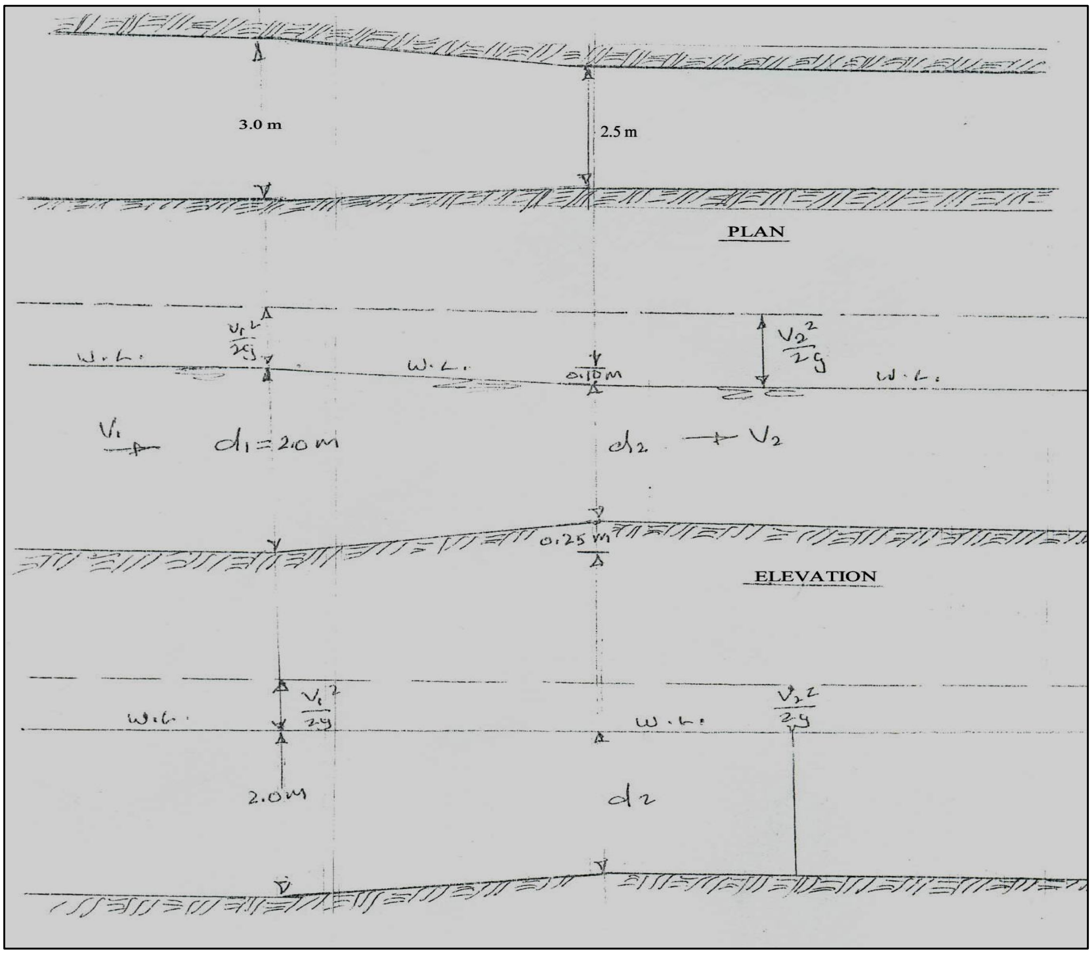


Fig (5.13): Effect of Stream Force Scouring

<u>Bed At Contraction</u>

$$d_1 + \frac{v_1^2}{2g} = d_2 + 0.25 + \frac{v_2^2}{2g}$$

$$0.25 + d_2 + 0.1 + \frac{v_1^2}{2g} = d_2 + 0.25 + \frac{v_2^2}{2g}$$

$$0.25 + d_2 + 0.1 = d_1$$

$$\frac{v_2^2}{2g} - \frac{v_1^2}{2g} - 0.1 = Zero$$

$$Q = v_1 A_1 = v_2 A_2$$

$$\therefore \frac{Q^2}{2g}\left[\frac{1}{A_2^2} - \frac{1}{A_1^2}\right] = 0.1$$

$$A_2 = 2.25 \times 1.65 - - and - - A_1 = 2 \times 3$$

$$\frac{Q^2}{2 \times 9.81}\left[\frac{1}{(2.25 \times 1.65)^2} - \frac{1}{(2 \times 3)^2}\right] = 0.1$$

$$Q = 6.6 m^3 / \sec.$$

For no change of water surface level: -

$$\frac{v_1^2}{2g} = \frac{v_2^2}{2g} - - and - - \therefore v_1 = v_2 ; A_1 = A_2$$

$$A_1 = 2 \times 3 = 6 m^2$$

$$A_2 = 2.25 \times d_2$$

$$\therefore d_2 = \frac{6}{2.25} = 2.66 m$$

This means that if the water level is to remain horizontal, the bed after the transition should drop by a depth =0.66 meter figure (5.13).

The stream force will scour the required depth, which is exactly similar to the Gash River case.

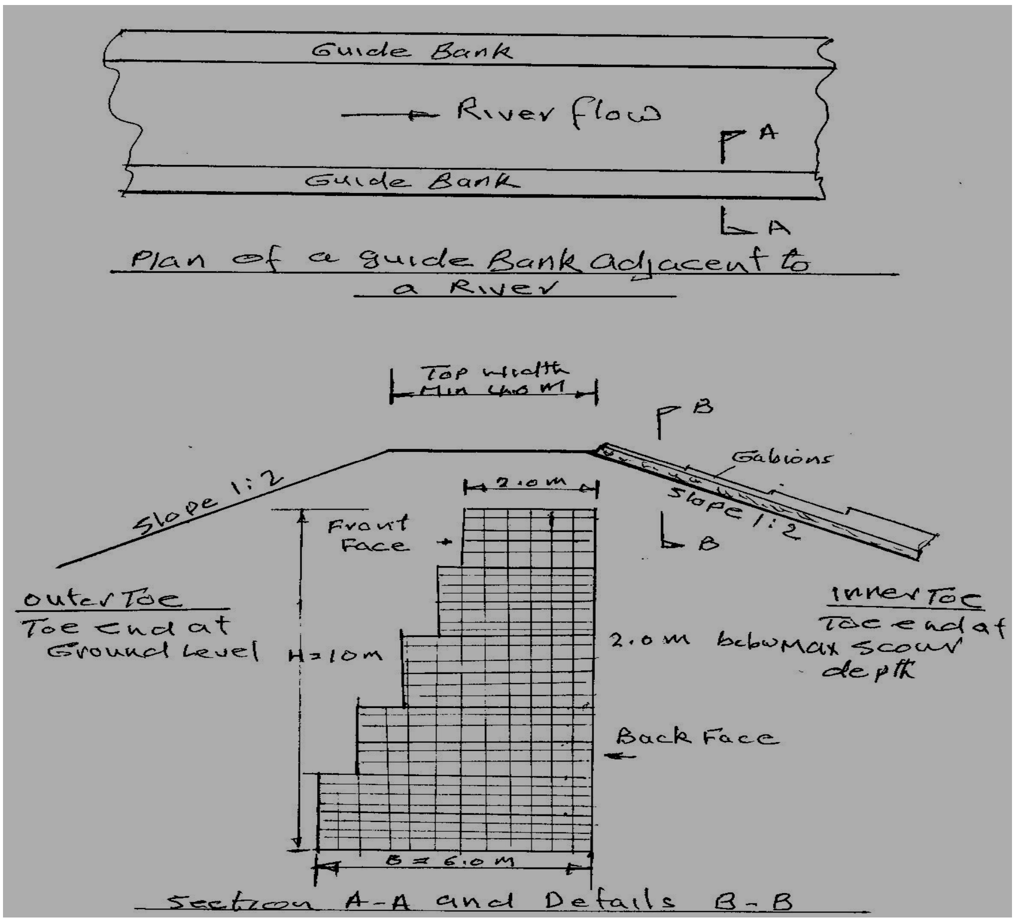
Appendix B: - The Three Classes of the Embankments:-

The three classes of the embankments are :-

- The guide banks adjacent to rivers. These are earth banks covered with dry stone pitching, they are known as dry pitching revetment .In recent development they are preferably build of gabion cages filled with stones. Figure (5.14), shows an embankment cross section of a typical transverse bank construction.

- ❖ Transverse banks perpendicular or at an angle with the river bank. These are similar to the previous class but are wider and stronger. There are known as spurs or groins. Figure (5.15), shows an embankment cross section of a typical guide bank construction.
- ❖ Earth banks surrounding the village far away from the river. These are made of compacted hard clay without stone pitching. Figure (5.16), shows an embankment cross section of a typical earth bank construction.

The method adopted in the design of these protection banks is based on practical experience on one hand and experimental findings on the other.



Fig(5.14): Guide Banks Adjacent To Rivers

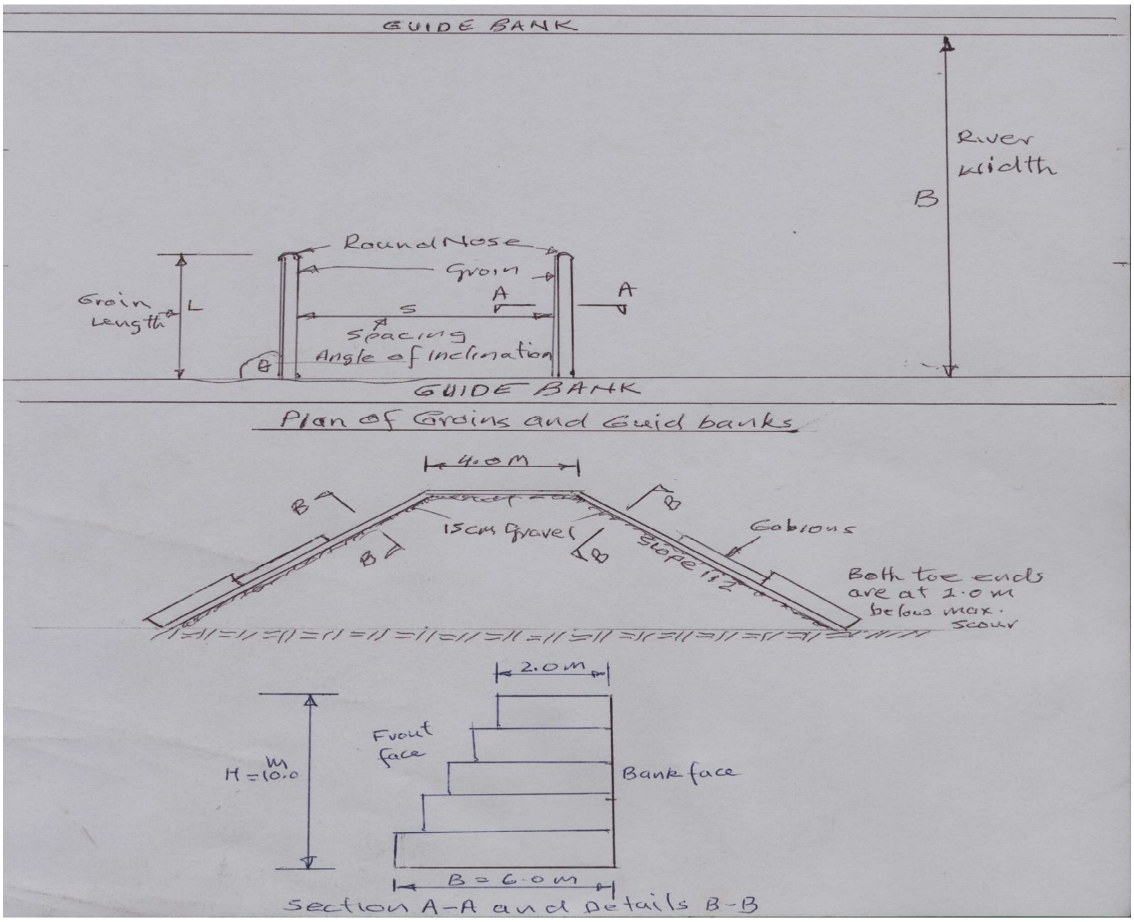


Fig. (5.15): Transverse banks (Spurs or Groins)

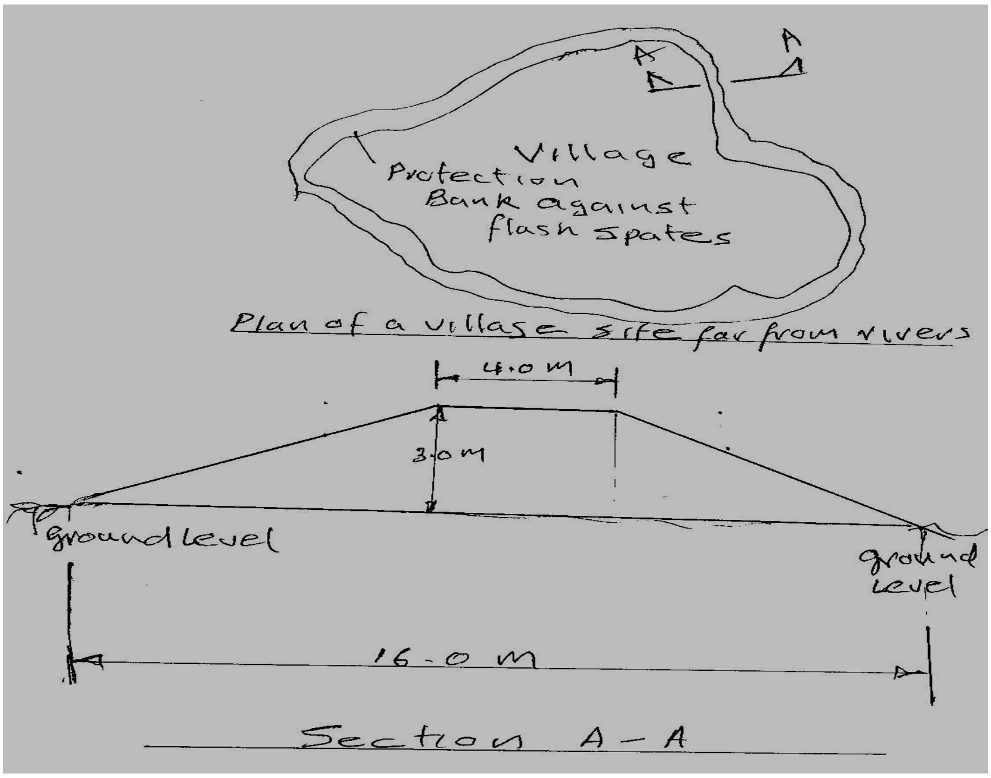


Fig (5.16): Earth Banks

The method adopted in the design of these protection banks is based on Kassala River Training Department (Unit) practical experience on one hand and experimental findings on the other carried out by Ibrahim. The design of groins is based on the emperical equations relating the length of the groin to its eddy length and width and the expected scour depth. The equations are of the forms:

$$\frac{d_s}{D} = 4.821\left(\frac{E_L}{b}\right)^{-0.094}\left(\frac{E_W}{B}\right)^{0.289} F_r^{0.455}\left(\theta = \frac{\pi}{2}\right) \text{---------------} (5.1)$$

$$\frac{d_s}{D} = 2.639\left(\frac{E_L}{b}\right)^{-0.092}\left(\frac{E_W}{B}\right)^{0.248}\left(\frac{\tau}{\gamma_{sub} d_{50}}\right)^{0.106}\left(\theta = \frac{\pi}{2}\right) \text{-----------------} (5.2)$$

$$\frac{E_L}{b} = 0.089\left(\frac{b}{B}\right)^{-1.995} F_r^{-0.899}\left(\theta = \frac{\pi}{2}\right) \text{----------------} (5.3)$$

$$\frac{E_W}{B} = 0.736\left(\frac{b}{B}\right)^{0.604} F_r^{-0.135}\left(\theta = \frac{\pi}{2}\right) \text{----------------} (5.4)$$

Where: -

D = Depth of flow, d_s = Scour depth, b = Length of groin, E_L =Eddy length generated, E_W =Eddy width generated, B =Width of channel, F_r = Froude number of approaching flow, θ = Angle of inclination of the groin with the bank, τ =Tractive shear stress, d_{50} =Diameter of sediment particle,and, γ_{sub} =Submerged weight of sediment particle.

Figure (5.17) shows a typical picture of gabion protection works.Figure(5.18) shows a typical groin cabion construction. Figure (5.19), shows a typical bank failure when there are undesired activities in the area, which include digging the bank slope, building houses or water channels on the top or side slope of the bank...etc.

Figure (517): Typical Guide Bank Gabion Walls

Fig.(5.18): Typical Gabion Groins Construction

Fig. (5.19): Guide Bank Failure

Appendix C: -Tentative Estimations For Short Term Solutions:-

Referring to figure (5.1) of existing and proposed training and protection works in the neighbourhood of Kassala town after 30th of July 2003 flood, and adopting the proposed cross section of 4.0 meters top width, (maximum flood 3.0 meters + 1.5 meters free board) 4.5 meters bank height (from bed level to top bank), with side slopes of 1 vertical to 2 horizontal, the volume of earthwork per meter run is approximately 60 cubic meters. The proposed cross section is shown in figure (5.20), to be building from the Gash River bed material for building outer guide banks in the spurs and dykes system networks. The banks of the spur shanks and the continuous revetments are also to be build from the Gash River bed material, but must be backed with 15 centimeters gravel backing to avoid excessive seepage figure(5.21). These banks will be safe if the law of the Gash River protection banks and training works is implemented. The tentative estimations for both rehabilitation of the spurs and dykes system as well as building of new proposed spurs are to be calculated The required equipmets are bulldozers, drag lines, tipper trucks together with the gabions having suitable dimensions e.g. (4.0 m x 2.0 m x 1.0) stone and gravel for dry pitching. The bulldozers, the draglines and the tippers together with the gabions should be on site at optimum time. The work should start by building access roads while the bulldozers and the draglines start working in digging the foundations.

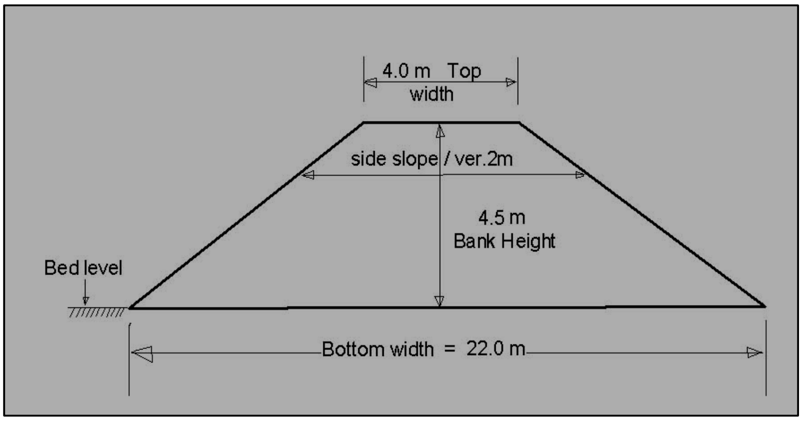


Fig.(5.20):Cross Section Of Outer Guide Bank

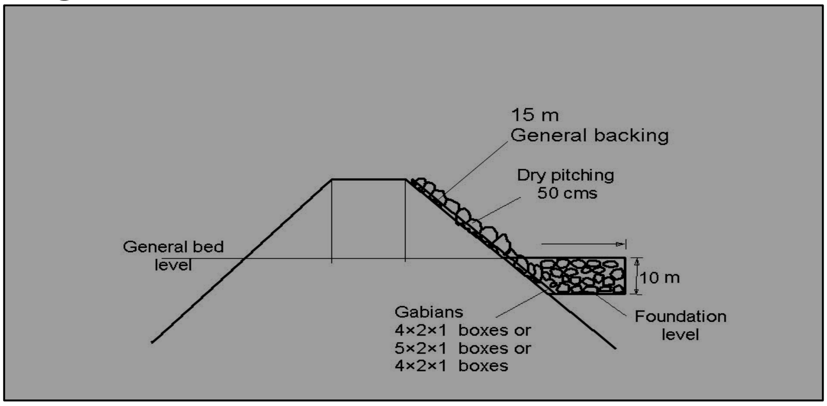


Fig.(5.21):Spur Shank And Part Of Outer Bank