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Investigating the Effect of Structures in Controlling Flood to Protect Soil and Control Sedimentation of Basin (Case Study: Goyjabel Ahar)

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ABSTRACT

The main purposes of building rock and soil dams (bond) include obtaining water resources, artificial nutrition and reinforcing underground water resources, controlling flood, increasing relative damp and adjusting temperature, collecting seasonal raining and its distribution in downstream farm lands, maintenance and increasing regional water power and optimal using of runoff, preventing soil destruction of basin upstream, sedimentation in reservoirs, flood plains, increase and improving farming and increasing income of people living around the basin. Using Hec-Ras software, this research studies the effect of building structures to control flood and protecting soil of basin, controlling flood and controlling sedimentation of Goyjabel.
Keywords: Controlling Flood, Soil Protection, Controlling Sedimentation, Goyjabel Basin

1. INTRODUCTION

Flooding occurs when there is no control on harmful outputs of basin watershed. Inappropriate management cause problems such as destruction of basin upstream soil, sedimentation in reservoirs, flood plains, pollution of water resources and disturbance of its quality, and negative effects on economy of the whole basin. Accurate management of water resources not only maintains and improves water power of the region, but prevents destruction of worthy and wealthy fields, increases income and lightens traffic.

Disadvantages of this destruction can be obvious change of hydrologic system of basin, decrease of quality and quantity of water resources, decreasing focus time of canals and changing hydrograph of basin flood. In this project, using non-type cement-rock bond and type gabion bond were considered as complementary watershed activities in Goyjebel project of Ahar to clarify quantitative results of their implementation and make clear how their use help to control sedimentation and flood of under study basin.

Geographically, this area is located in 47°, 64′, 21.26°- 56, 46′, 53.64° east longitude and 38°, 21′, 42.13° - 38°, 27′, 39.04° northern latitude. The basin is 74.628 Km^2 (equivalent to 7462.8 hec.). Maximum height of the surrounding mountains is 2495 meter and the least height is in the exit gate equal to 1373.2 meters. Goyjabel river is a branch of Ahar river.

2. HYDROLOGICAL DIVISION OF BASIN

To have a detailed and accurate study, each basin was divided to smaller units known as separate hydrologic units. Hydrologic units include a bound of a basin watershed level by specific waterway drainage, and a single exit, but lacking entrance as waterway. Table 1 summarizes the division of basin into hydrologic units.

Table 1. Division of under study area

Sub-basin	$\mathbf{G_1}$
Sub-basin	G_2
Sub-basin	$G_3 = G_{3-1} + G_{3-2} + G_{3-3} + G_{3-4} + G_{3-5} + G_{3-6} + G_{3-int}$
$\mathbf{G_{int}}$	inter-basin that G_1, G_2, G_3 terminate in it
G (total basin)	$G = G_1 + G_2 + G_3 + G_{-int}$

3. DESIGN AND NUMBER OF STRUCTURES

Main objectives of building cement and soil rocky bonds are trying to obtain water resources, artificial nutrition and supporting underground water resources, controlling flood, increasing relative damp and adjusting heat level (temperature), collecting seasonal rains and distributing it to downstream fields, maintaining and improving water power of the region and optimal use of runoff, preventing destruction of upstream basin soil,

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sedimentation in canals, flood plains, improving farming and increasing income of inhabitants of under study region.

Type and number of structures were selected through local survey and using the results of hydrological and geological studies. In suggested area, there are suitable topographical circumstances to support maximum volume of canals. Geotechnical and geological circumstances of suggested bond boundaries show there is suitable position and appropriate topographical situation to build reservoirs with specific heights. Meanwhile, there are good angle layers against river run which strengthen foundations. Details and sort of geological layers presented in reports show that the structures were placed in regions consisting of layers mainly made of silt stone, mudstone, and sand stone of fine grains and lower permeability (1).

4- DIFFERENT TYPES AND PLACES OF CONSTRUCTING STRUCTURES

The main factors in selecting type of bond are compatibility of bond with objectives of project, easy performance, of economic, easy preparation of building materials, necessary equipment, expenses of maintaining and operation, and experience on research objectives. In this project rock and non-type cement bonds are used to control flood and sedimentation. Due to high cost of performance and lack of appropriate strength of rock supports, concrete structures were deleted. Goyjabel basin includes 23 non-type rock and mortar structures and 12 type gabion structures. The position of building place and their technical status are shown in table 2. Estimated and average volume of reservoir was presented regarding the height of structure.

Table 2. A summary of technical specifications and volume of reservoir

Sub-basin	Number of Gabion type structure	Number of rock and mortar non-type structures	Volume of reservoirs in each sub-basin (m^3)
G3-6	-	10	11085
G3-4	-	1	9360
G3-3	10	1	14510
G3-1	2	4	4620
G3	-	2	3310
G3-5	-	3	4810
G2	-	1	1790
G1	-	1	2560
Total	12	23	52045

5- HYDRAULIC DESIGN

Using local investigation and other related reports, it was determined that in 23 points the direction and angle of joints and cracks of reservoir or base were vertical to water flow or had appropriate angle with it, therefore these places were selected and designed as the final places of rock and cement bond. These types of cement-rock bond were built along with water ways to control sedimentation and flooding delay. Cement-rock bond function similar to gabion bond; the only difference is that it is built and carried on areas with relatively high strength soil, and carrying materials to building area is economically justifiable. In this regard, based on the situation on Goy'jaBe'l, these bonds were selected and designed in the suggested areas. To design these bonds the amount of used water, deposition and materials are as follow [1, 4]

Special weight of concrete is 2/3 tone/m^3, special weight of cement and rock composition 2/2 tone/m^3, special weight of water 1 tone/m^3. This pressure is on upstream vertical image. Since static pressure is applied on whole upstream height, additional pressure caused by the weight of immersion of sediments with immersion (special weight 0.30 tone/m^3) was added to water pressure (0.30 tone/m^3 particles deposited in water added to water density; and finally density of deposition were applied as 1.3 tone/m^3). Hydraulic design of cement and rock bonds are done using HEC-RAS software.

4. OVERFLOW

Based on the objectives and socio-economic importance of the project, overflow capacity of cement-rock bond was designed based on recommendations of USBR on flood evacuation with 50 years return period. Following formula is used in designing overflows:

1) $$Q = 0.552 C_d L H^{1.5}$$

where Q is flow intensity m^3/s, C flow coefficient (since h/H>1.33 in overflow bonds, the effect of velocity potential is ignorable (h= height of overflow), and C=4.03. Final flow coefficient in 1 is 2.225), L length of overflow (m) and H head of flow (m).

5. EVACUATION CANALS

In flood evacuation system, these bonds are beneath the evacuator to support requirements of downstream. Drain pipes are circle sections with entrance alike upstream wall with 10 cm diameters. Canal act when it is full. The following relation is the base of design:

2) $$Q = A\sqrt{2g(H_T + H_L)}$$

where H_T is the total head and H_L the total drop. Function of these canals attempts to support requirements of exploiting in downstream structures. Resistant polyethylene pipes with 10 cm diameter were used on specified places of the map [5, 6].

6. HYDRAULIC POSITION OF PEACE BASIN

Peace basin of USBR type is considered as energy discharger system. According to the situation of peace basin entrance, hydraulic mutation characteristics were determined and to maintain security of bond and deep evacuator system, it's necessary to design a suitable peace basin based on energy discharging flow using hydraulic mutation forming before leading the flow to river. Flood return period of peace basin design is equivalent to exit flood peak with 50 years return period. To design peace basin, energy relation was used to measure depth of flow at the entrance of peace basin (y_1) and flow velocity (V_1). According to figure 1 we have:

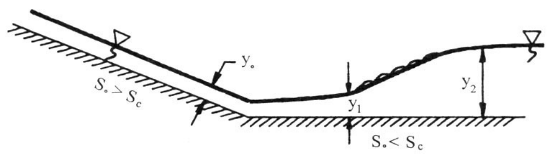

Figure 1- Schematic hydraulic jump

3) $$V_1 = 0.98 \times (\sqrt{2g(\frac{H_d}{2} + P)}) \times \alpha$$

Where H_d is height of water blade on overflow (m), P height of overflow and α function as coefficient of overflow stair.

Based on the USBR, α coefficient is used in overflow performed like stair on downstream. These overflows were used in Goyjabel project. This coefficient is variable in different types of overflow stair ranged 0.1-0.9. In wide stair of overflow stairs, velocity can be reduced up to 90%. Stair overflow reduces length of peace basin. In this project, according to the dimensions of stair overflow, α coefficient is 0.7. Following formula is used to measure depth of water after hydraulic mutation [5]:

4) $$Fr = \frac{V_1}{\sqrt{gy_1}}$$

5) $$y_2 = \frac{y_1}{2}(\sqrt{(1+8Fr^2)} - 1)$$

Following formula can be used to measure the length of peace basin:

6) $$L_b = 5.9(y_2 - y_1) \qquad he \geq \frac{1}{6} y_2$$

where y_2 is the secondary depth of hydraulic mutation (m), y_1 primary depth of hydraulic mutation (m), h_e height of terminal denticle (m) and L_b is the length of peace basin (m) [6,7].

9- HYDRAULIC STUDIES OF RIVER AND CEMENT-ROCK bond

In order to complete the data needed in primary design, such as determining mirage and coastal flow-base bond, it's essential to do studies on profile of water level. In Goyjabel project, these studies were done through numerical modeling of river from about 100 meters of downstream of bond to 50 meters of its upstream, using existing plans.

HEC-RAS software v.3.1 was used to stimulate the project; its input data include information about different exploring level of topographic plans of the area, specification of overflow bonds, discharge flood etc. Ultimately, hydraulic situation of river and after building situation of bonds were evaluated using output results.

10- HYDRAULIC STIMULATION

HEC-RAS software was used to stimulate hydraulic measuring of rivers and bonds. First, assume there is no bond, flood extent of 25-year-old discharge was determined. Results of measures done on river hydraulic in presence of 7GN structure were also presented. Figure 2, 3 and 4 represent a sample of outputs to be compared [8, 9].

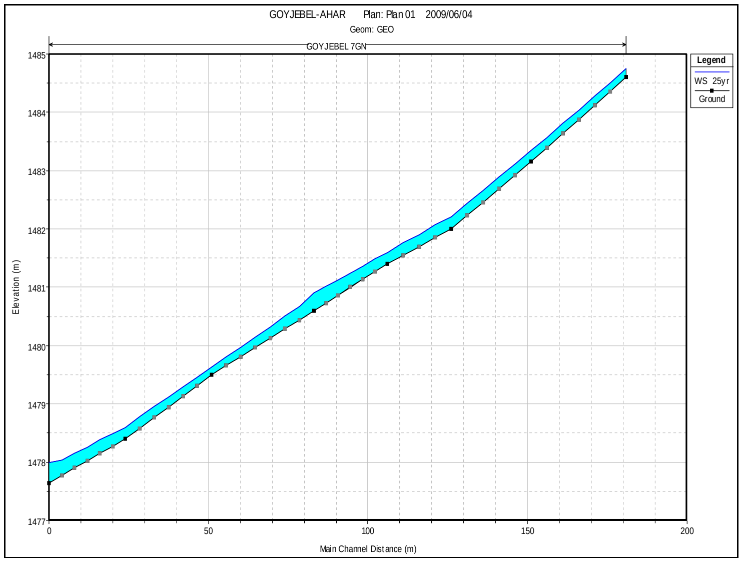

Figure 2. Longitude profile of the river and water level without any bond in the way

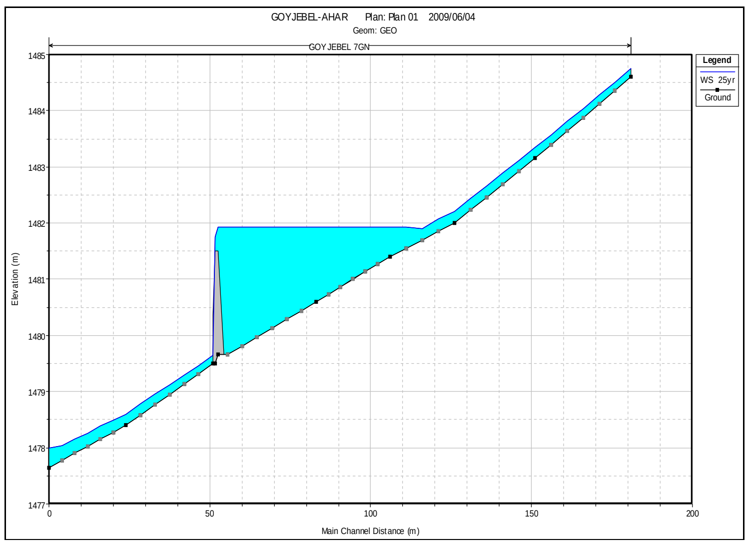

Figure 3. Lateral profile of the river and water level for bond axis section 7GN

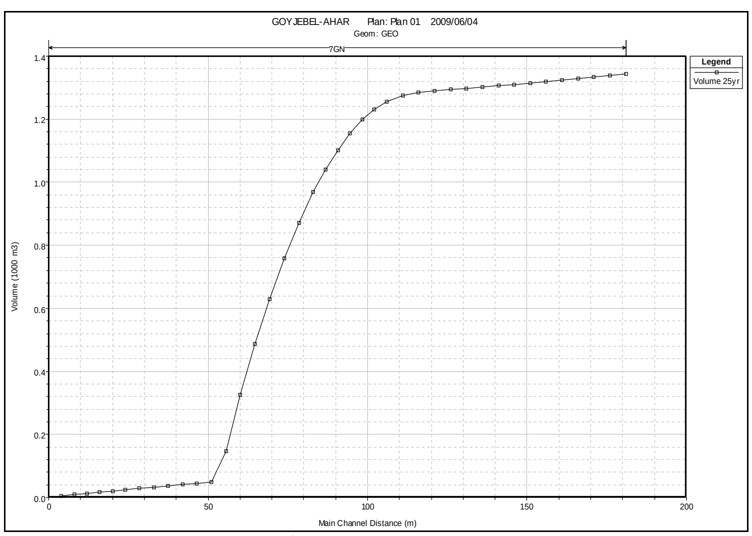

Figure 4. Changes of bond reservoir volume along the way

11- RESULTS

Results of this study are briefly described as follow:

1. Investigating and determining expected effect of structures on objectives of the project

To investigate the effect of suggested structures, volume of upstream reservoir of either type or non-type structures were determined. These volumes can be compared to annual sediment mutagenicity beneath the basins and measure the effect of structures under the basins to control sedimentation. Results of this study are shown in table 3. As it's obvious, suggested structures control sedimentations of 5.15 year sedimentations of the whole basin.

To determine the amount of underground water nutrition, storable waters on bed can be calculated assuming 30% porosity. To do so, we assume that annually upstream reservoir of structures are filled with flood. The result of the study is shown in table 3. The table show that average amount of nutrimental water in upstream sedimentations of structures in whole basin is about 15613 m^3 per year. By implementing suggested sediment retention structures in Goyjabel basin, their effects on basin are as follow:

a) controlling sedimentation and protecting soil
b) runoff extraction
c) increasing under cultivation area
d) increasing agricultural production

Table 3. Determining the effect of structures in watershed objectives of Goyjabel basin

Sub-basin	Estimation of sedimentation in each sub-basin (m^3/year)	Number of control year in each sub-basin (year)	Volume of water sources in each sub-basin (m^3/year)
G3-6	1014.48	10.93	3325.5
G3-4	2812.10	3.33	2808
G3-3	1126.14	12.88	4353
G3-1	357.12	12.94	1386
G3	6358.81	0.52	993
G3-5	874.47	5.50	1443
G2	767.62	2.33	537
G1	866.56	2.95	768
Total	10097.44	5.15	15613

2. The effect of structures on controlling sediments and protecting soil of basin

According to estimation of sediment retention structure reservoirs and above mentioned structures, during their useful life, reservoirs are able to sequestrate at least 52045 m^3 of soils.

3. The effect of structures on water extraction

Due to the reduction of waterway slope, water collected on the back of structures loses its natural velocity and starts to penetrate. It's predicted that after constructing suggested structures, volume of all of the structures reservoirs will reduce to its half due to gradual sedimentation. Water will be penetrable when the total volume of reservoirs is filled and the slopes be adjusted. Water of saturated sediments will be transferred to downstream areas through alluvium waterways. Sometimes water of sediments return to waterway beds due to weak permeability and form the water of waterway base. It's evident that function of sediment retention structure in alluvial waterways will improve irrigated agriculture that is economically beneficial.

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