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Antierosion cellular cover (AEC) for underwater pipelines protection

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ABSTRACT: Methods of bottom bed sections protection in places of river crossing with underwater pipelines and other buried communications are given. The methods described are based on structures use which allow both to stop the erosion process and promote the restoration of the initial bottom topography. It is well known that the process of change of river bed relief is continuous. In this connection, an emergency situation occurs as a result of soil washing and evacuation at some sections of underwater pipelines under operation, which can provoke pipeline failure and ecologic disaster. That's why timely detection of sections where processes of bottom erosion are progressing in a zone of piping and the following restoration of bed topography is extremely actual. One of the methods of bed washout protection as well as restoration of the washed out soil is a method based on use of antierosion rubber-cloth cover. The above cover was successfully used in bank slopes strengthening.

Along the whole length of main pipelines laying there are many crossings with water obstacles characterized by different hydrologic characteristics and types of river-bed development process. Crossings of the pipelines over small water obstacles have the following distinctive features: absence of reserve pipe branches, insufficient engineering survey under its design, implementation of construction chiefly without using underwater technical facilities, often weak control of the crossings states for the part of organizations performed the operation. Besides, crossings over small water obstacles form the overwhelming majority in the total amount of operated underwater crossings and to a considerable extent determine the main pipelines reliability.

In accordance with the requirements of current regulations the amount of depth of underwater pipelines burial to the ground is determined relatively to the line of anticipated limit profile of the bed washout. The amount of depth is calculated with the consideration of probable bed deformations and perspective dredging work. However, due to the fact that during the design the series of factors which have an effect on the bed washout dynamics and which are not considered in the regulations, are not taken into consideration in a proper way, as well as due to the imperfection of applied construction technique, the crossings come to a breakdown or marginal state long before the expiration of standard operation time, which threatens with emergencies resulting in serious engineering, economical and ecological after-effects.

The existing methods and procedures for elimination of uncovered sections and sagging sections of underwater pipeline crossings (filling, lifting, repeated laying) require substantial material and labor expenditures; the methods in question do not often solve the problem. At the same time the considerable experience in using geosynthetics is accumulated during hydraulic engineering construction and transport construction as well as during pipeline ballasting.

The antierosion cellular cover construction (AEC) represents the continuous mat made of geogrates attached one to another; the geogrates are filled with inert aggregate, namely crushed stone, pebble stone, small stone. Under the influence of external factors the construction of layer strengthened by means of geogrates, operates as a resilient flexible slab on the ground base.

The AEC construction geograte is made of rubber-fabric bands of 0.1 – 0.15m width (height) attached one to another; the bands have the following characteristics: high strength, durability, decay resistance and neutral reaction to the environment.

The bank slopes strengthening technique with using AEC includes the sequential carrying out of the following process procedures:

- preparation of the bank slope base by means of leveling the slope with preliminary removal of the fertile soil layer. The disposal of cut soil is evenly located on the longitudinal sides of the slope beyond the limits of strengthened bank area;
- layout of AEC mats, specification of geometric parameters of the cell, joining some mats one to another and attachment of loose edges of AEC construction within preliminary excavated trench located along the borders of the bank strengthening facilities. The construction is evenly attached over the whole area to the slope base by means of anchor poles of not less than 0.5 m length (Fig. 1);
- in the end the work on backfilling the trench with the attached edges of the AEC construction is performed as well as filling the cells with crushed stone and mineral soil with following compaction takes place.

Strengthening the river-bed section of underwater crossings by using AEC includes the sequential carrying out of the following process procedures:

- restoration of the fill over the pipeline within the river-bed section area of the crossing site by means of crushed stone to the width of 18m provided that the elevation of restored bottom exceeds the elevation of the pipe top by 0.1m;
- preparation of AEC constructions on the bank construction site for laying within the river-bed area;
- excavation of trench along the borders of AEC laying to the depth of 1m;
- laying of AEC construction cells over the river-bed section area of the crossing site by means of pontoon (Fig. 2); attachment of loose edges of the construction within the underwater trench;
- backfilling the underwater trench and filling the AEC construction cells with crushed stone.

The advantages of usage of the AEC cover for strengthening the river-bed section under capital repair of underwater crossings against traditional methods are given in the table.

The AEC cover and its application technique were used for strengthening the river-bed section and for strengthening the bank during the capital repair of the underwater crossing of DN 500 mm gas pipeline Pohvistnevskaya compressor station –

Kiryushinskoye underground gas storage over the Bolshoy Kinel river; the crossing in question is supported by Samaratransgaz Ltd. (Russia). The river width in the crossing site area is 43 m, maximum depth is 3.2 m. The bottom strengthening area amounts to 774 m^2. The bank strengthening area amounts to 1344 m^2 (Fig. 3).

Main conclusions:

- the designed AEC cover construction permits to provide the protection from the washout of river-bed and bank sections of underwater pipeline crossings;
- the proposed method permits to increase time between repairs providing the reliability and ecological safety of operating underwater crossings;
- the technique of capital repair of underwater crossings by using AEC cover differs from conservative methods (repeated laying, covering uncovered pipe sections and sagging sections with bags filled with cement-sand compound and others) in its processability, low labor expenditure and low cost of work.

Table 1. Technical and Economic Comparison of variants of Capital Repair of Underwater River Crossing of DN 1000 mm Gas Pipeline (100 m crossing length).

Engineering Data	Variants		
	Repeated laying	Bottom strengthening by using bags with sand-gravel mixture	Proposed
Consumption of materials:			
pipes, t	36.6	-	-
additional cast iron loads, t	50.6	-	-
polymeric insulating materials, t	0.84	-	-
lining bar, t	96.1	-	-
bags from synthetic fabric, pcs.	-	6000	-
sand-gravel mixture, m^3	-	300	-
AEC cover, m^2	-	-	1200
crushed stone, m^3	-	-	24
Labor Expenditures, man-days	394	260	81
Cost of Repair (in prices of 1984), thousand rubles	30.514	6.368	3.724
Advantages	full restoration of state of operability of the crossing	-	high mounting processability, low cost, low labor expenditures
Limitations	high cost, high labor expenditures	relatively high cost, high labor expenditures	-

Figure 1. Mounting of AEC Cover during bank strengthening.

Figure 2. Laying of AEC Cover in river-bed section area of crossing.

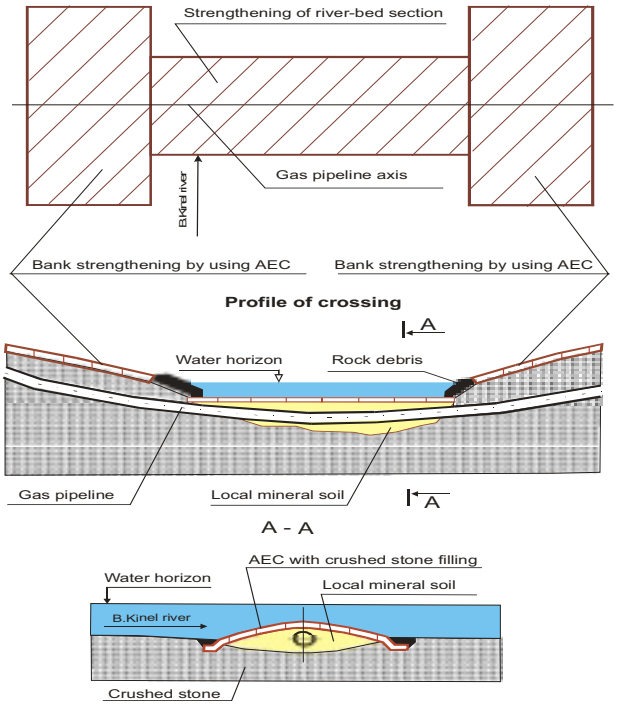

Figure 3. Construction for bank strengthening and bottom strengthening for underwater crossing of gas pipeline over the B. Kinel river.