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METHODS OF STRENGTHENING FLOOD-EMBANKMENTS

METODY WZMACNIANIA WAŁÓW PRZECIWPowODZIOWYCH

Key words: building flood-embankment, sealing trunk elements, natural and artificial consolidation

Summary: Effective flood protection is one of the most important elements connected with the management of the Oder river-basin. This article introduces and describes briefly methods and technologies applied in modernization and protection against flood embankments.

Słowa kluczowe: wały przeciwpowodziowe, elementy uszczelniające, naturalne i sztuczne metody umocnień,

Streszczenie: Skuteczna ochrona przeciwpowodziowa to jeden z ważniejszych elementów związanych z zagospodarowaniem dorzecza Odry. W niniejszym artykule przedstawiono i scharakteryzowano metody oraz technologie stosowane w modernizacji i zabezpieczeniu obwałowań przeciwpowodziowych.

INTRODUCTION

Control of rivers and protection of drainage-basins of flooding is already no strange for anybody today. Experience of last years, and first of all the great floods on Odra-river and Vistula-river in 1997 year, clearly showed us results of negligence for many years in water economy. On base of these unpleasant experiences we learn rational and well-thought-out's using both forms of nature good deeds and as we broaden boldly about ways of protection in front of floods. Every works in the way of reconstruction of wore out flood-embankments and also as well as further going their modernization as well as change in global water economy, doubtless are causing to her modernization and effective flood protections. Row of engineering objects exists which determine (fulfill) active and passive anti-flood protection. Among them onto special attention the flood-embankments deserve (fig. 1). These are simply earth constructions to damm up the water and protect in front of flood economically developed valleys.

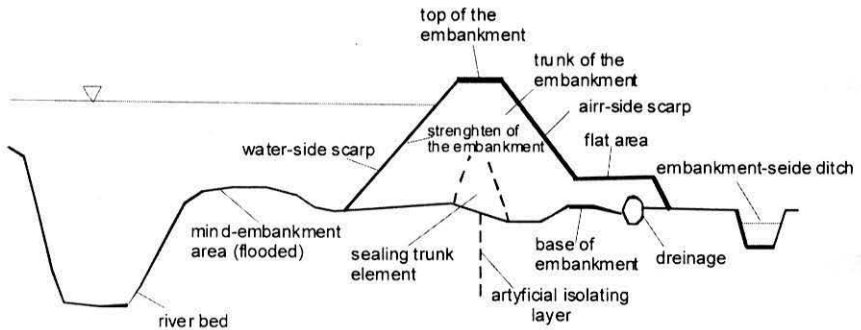


Fig. 1. Diagram of building flood-embankment

First flood-embankments on Oder-river come from XIII century [Grundfest, 2000; Kołodziejczyk, 2002; Müller, 1998]. Constructed they were initially into any ways, from accidental material, pell-mell (chaotic) and almost always nearby of flood threat. Both height and width and as well slope of inclination of scarps were at first dependent on all kind and properties of used material to them of building. Small effectiveness of that protections and next uncontrolled rising of water, they induced engineers buildings to look for such solutions which could fully fulfil the assignments which are put on this type of objects.

Technologies of consolidations (reinforcing) of flood-embankments can be based about different materials e.g.: stones, concrete, bituminous mixtures, steel, plastic and geo-membranes. Standards and norms of execution should be every time determined by the kind of given material to define the way of an arrangement of them in detail in embankment and as well as preservation. Constructions of consolidation have to guarantee the stability of strengthened object and guarantee required level of safety in the whole and as well as in component parts.

At selection the technology sealing of the floods embankments, most important thing is his susceptibility onto deformations and as well as possibilities of adjustment to existing conditions of basis. Particularly essential regard is potential settlement and consolidation of trunk embankment.

Large variety of applied materials in building new embankments, and also as well as in modernization of existing objects, it permits to distinguish the technologies leant on both penetrable and impenetrable materials.

USING OF THE IMPENETRABLE MATERIALS

One from the first and often applied (also today) protecting methods of making the water slope of embankment is covering it against of intensive filtration with layer of clay (fig. 2). Both the thickness and the sealing layer had to be so well-chosen to make

impossible its softening in case long-lasting moisture and as well as cracking during dries periods.

Experiences showed, that requirements of this is fulfilled by about one meter thick layer of soil which contents no less than 20%-35% of loamy fraction. Trunk of this kind of embankment is made of double-layer. In bottom layer, an impenetrable, high plastic, clay is applying, but in upper layer – plastic clay, more resistant onto cracking, and giving better possibility to cultivate the plants and as well as to keep strong sod. The suitable mixtures of grasses are applied to sowing, which apart from the low fertilize and watering requirements, possess strong root system and after mowing they grow slowly. In reinforcing of slopes no one should apply trees and shrubs, because they can cause damages of sod and stimulating development of small mammals. Described method in literature is often defined as kind of biological consolidations of embankments. It is applied mainly as supplement of different methods of modernization of anti-flood-embankments.

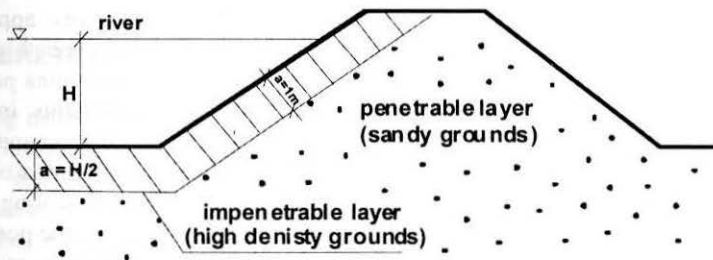


Fig. 2. Diagram of beds and trunk of an embankment tightened with artificial isolating layer

Another way of sealing embankments are special kind of screens and tight sides.

Such constructions are still considerably more expensive and much more susceptible to damages [Koślacz, 1999]. They are usually applied in these cases where:

- current of river swims directly along the embankment,
- unfavorable course of rampart and long run of wave causing strong waving,
- there is a large possibility of damage rampart by ice float or any other objects
- which are transported in a river (trees, beams),
- there is a limited possibility of using biological consolidations of embankments,
- e.g.: in places about limited growth of grasses (slopes under bridges),

Actually there are no clear causes which define necessity of applying of artificial consolidations of flood embankment. Because of high costs, consolidations of this kind are made at a level below of high reliable water which can happen once a 100 years.

Above this level, time of working of wave and current is so short that applying of mentioned consolidations is not necessary [Reszka, Warcholak, 2000; Reszka, 2001].

From among most popular consolidations which should guarantee full waterproof of the embankments there are: bituminous consolidation, concrete, screens and tight sides and dams.

Bituminous consolidations - use bituminous substances and mineral components. Bitumen – because of their mechanical proprieties – are mainly used as filling material or in form of mixtures, e.g. a stone-bituminous covering. Applying of mixtures of mastix and asphalt causes itself plastic maintenance very consolidation as well as its long duration guarantees. However this solution this is seldom used.

Concrete consolidations from attention onto low plasticity are recommended to use in case of already built embankment, well consolidated, in which process of settlement was regarded as very slight. It is advantage of applying of concrete plates because of their large durability and as well as possibility of fast assembly. However fact is defect of this method, that slabs can not fit exactly to settling beds, what in consequence lead often to them of undermining, and into result of hitting waves – cracking and washing up.

Best protections effects, in this type of consolidations, gives applying the waterproof screens from artificial materials. Foils from polythene about high density (PE-HD) predominate here mainly. They are characterized by high stamina parameters, which large effectiveness is advantage in protection of embankments in front of pervasion, at simultaneous scarce susceptibility onto corrosion. Arrangement of foil depends on horizontal laying down the sections of foil on previously prepared slope of an embankment, fixing them, and then connection the separate by sealing and next cover the foil with layer of soil. The disadvantage of this technology is the possibility of making holes in the foil layer by trees roots, or else caused destruction by mammals of boring holes in slopes of an embankment.

More resistant onto damages, and simultaneously checked method of protection the embankment, is applying of perpendicular screens (tight walls). They are usually assembled in trunk of an embankment or on the pre-embankment [Koślacz, 1999]. An effect of working of this consolidations is, first of all, the limitation or total cut off soaking, and therefore – limitation washing of soil during floods and also decreasing the pressure existing in trunk.

More often used, in this method, are wooden or steel pales, hammered closely one by one or joined on so-called “lock”. These methods, for the sake of large joined surfaces, they do not guarantee the full waterproof. What is more, they can crack during fixing and connecting and making in this way the barriers not tight. It is proper to say, that for the sake of that those materials have limited their durability, an administrator of the embankments has to remember about necessity of exchange the pales after the definite time of exploitation.

On the other hand more durable concrete elements are not recommended to applying in this form of tightening barriers because of difficulty in tight connection of individual elements.

The newness among mentioned barriers there are the walls of vinyl pales of type C-LOC which have wide use now. They can be applied both as elements of anti-floods consolidations protections of excavations, drainages ditches and as well as anti-corrosion covers.

The divisions' elements of wall pales of type C-LOC are made from PCV material (with addition of stabilisers), with smooth surface and good mechanical proprieties these materials, assuring them tightness and durability. It is proper to say, that elements of wall barriers of pales of type (C-LOC) also fulfil requirements in range of harmlessness in influence onto environment and have confirmed suitable certificates.

A modern way of strengthen of the embankments are hydro-protection screens, made by forcing injections of cement or bentonite solutions into earlier bored (drilled) openings.

The least inconvenient and comparatively often applied protections in flood protection they are (town) barriers divisions. They are made as the mass of the ground closed between two tight sides. Their main advantage is ability of fast constructing and the low costs.

They are mainly applied as a temporary embankments, recommended mainly in case of the modernizing works.

USING PENETRABLE MATERIALS

Among methods of tighten of the embankment penetrable materials are in common use. They are made as an arranged or loose thrown down elements from monolithic penetrable construction. These consolidations characterize good adjustment to the existing conditions of ground. From assume the elements of protection adhere (fix) closely to bed even in case of its possible deformation, an exception of that are here an arranged consolidations, which in consequence of bending effect of loose elements could be damaged, like in case of concrete slabs. For the sake of used materials, different technology of arrangement are applied.

Consolidations from loose stones should be made in this way to prevent taking them by current and prevent washing of the ground. Therefore, to raise the stability of consolidation, an arrangement of the tree layers in turn is made. The external layer is made of comparatively heavy materials, applied for equilibrations the pressure of wave and the power of current, the central layer mainly contains light ingredients of weight about 10-80 kg (at 1m²), and the internal layer is made from the smallest elements. The internal layer is usually strengthened with gabions made from steel mesh. In order to avoid of washing the soil up from the bed of trunk the drainages as the filter elements are additionally applied, situated at basis of embankment.

In constructions of that strengthening from arranged small bricks, usually square or rectangular concrete blocks or common pebbles are applied.

An assembly of this kind of consolidations depends on an arrangement of single elements on previously prepared the drainage's layer constructed from gravel or geofibrous.

An aim of this layer is decreasing the hydraulic pressure and also preventing of washing up the particles of basis through cracks and holes between individual elements of consolidation. Arranged blocks create the penetrable layer for the sake of existing cracks between separate elements.

In fact, the cracks becoming filled with mud after some time, so in this method, assurance of the suitable drainage or using blocks with irregular edges is very important.

During last years, in this method, both the bricks of diverse shapes (dimension) and porous slabs were also applied.

As the main element, of the separate method of consolidations of slopes of the embankments, the geo-fibrous is applied. One from methods depends on "packing" the rocky elements in sacks from geo-fibrous and arranged later closely on slope. In effect, the consolidation is gained by making the layer from stones or arranged rocky elements, completed with polypropylene fabric instead of bottom drainage's layer.

An advantage of this method is possibility of its applying on steep slopes, fast assembly, less corrosion and simplicity of execution.

Bituminous monolith is different an interesting example of protections of the anti-flood, embankment, it was applied only in experimental cases so far. Most important elements of this method are: stone porous asphalt made from crumbled gravels or covered limestones layer covered with adhesives and also sandy asphalt made from mixtures of sand and bituminous masses, which is considerably more plasticity than stone asphalt.

For the sake of a less coherence, and what goes after that – an insufficient resistance on working current and waves, sandy asphalt is usually used as filter layer, which is covered with stone porous asphalt as an external layer.

RESUME

Introduced here analysis of the ways of tighten of the anti-flood embankment proves, that there is no the best method, which is suitable in every conditions. The choice of proper method is dependent on: local conditions, a location, the proprieties of bed, on construction of the embankment and the power of flood risings. The method of modernization of the embankment is determined by the economic regards. It is proper to add, that joining of individual techniques gives best effects in flood protection by for example tighten and rising of a trunk and also by tighten of the basis of the embankment. But the preventing workings can not be neglected, which among others they should be dependent on creating of additional polders, widening the areas of mid-embankment, on displacing people away from flooded terrains, on permanent monitoring of rivers and education of society.

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