C.R. Coll. Int. Sols Textiles. Paris 1977

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A case history of the large scale application of woven synthetic filter fabrics on the banks of the River Yssel

Historique de l'utilisation sur une grande échelle de tissus synthétiques filtrants sur les rives de la rivière Yssel.

L'historique d'une méthode d'utilisation sur une grande échelle de tissus synthétiques filtrants aux bords de la rivière Yssel.

Le sujet renferme une facette de l'application de nouveaux matériaux dans les travaux hydrauliques notamment le long de l'Yssel, un des bras de rivières en Hollande.
Depuis 1955 là-bas une forte érosion des rives se manifestait, qui menaçait les travaux réalisés (entre autres les épis) d'une façon considérable et qui devenait un encombrement pour la navigation par suite d'un ensablement de la voie navigable.
Les constructions classiques de défence nécessitaient une main d'oeuvre tellement importante que la solution des problèmes aurait pris trop de temps.
L'apparition sur le marché de matériaux synthétiques (tissus filtrants) était l'instigation au développement d'un système de protection de berges dont la mise en oeuvre se faisait rapidement et qui donnait en même temps un résultat solide et durable.
Ce système comporte les mêmes propriétés que le méthode de protection de berges classique causant une action filtrante au moyen d'une construction en brins d'osier.
Cette action filtrante est maintenant faite par le tissu qui, bien qu'étant suffissamment perméable à l'eau, retient les sables en place.
Le problème de mettre en oeuvre également un tissu sur berge et fond en eau courante a été résolu dans le méthode même tout en fixant ce tissu à un grillage simple en brins d'osier.
Cela donne une capacité flottante et une rigidité qui suffisent à prendre à la remorque la construction et de l'échouer. A cet effet on utilise un ponton spécial auquel la construction reste fixée par un appareil aussi simple qu'ingénieux jusqu'au moment où cette construction aura été échouée au fond par un recouvrement d'enrochements.
La simplicité de cette methode a donné lieu à l'installation de 2 millions mètres carrés de constructions de protection de berges de l'Yssel dans une période de 8 ans.

Introduction:

The disaster that struck the south western part of the Netherlands in 1953 made the Dutch feel obliged to launch gigantic hydraulic engineering projects to close a number of sea arms by means of massive dams, the so-called Delta Project.
Soon it became apparent that these works could not be carried out according to the working methods known so far; neither the required materials nor the man power to handle these were sufficiently available. Moreover, the extent of the works required completely new working methods.
In the Delta Department of Rijkswaterstaat, responsible for the execution of these works a special department at the time headed by civil engineer Nico Smit, deals with the development of these new working methods.
In this development considerable attention was paid to the possibilities which were offered by synthetic fabrics.
Thus sandbags filled with sand were used in 1957 already to close a dam under construction, while in 1960 a bottomprotection was installed which consisted of a nylon double-fabric filled with sand.(1*)
In 1966 a functional analysis of bottom- and slopeprotection construction systems was drawn up by this department, based on the experience obtained so far.
In this particular publication some ten starting-points were indicated as directives for further developments. (2*)
The continued use and the development of new synthetic fabrics links up with that in a logical way.
During all these developments the wellknown textile manufacturers NICOLON B.V. of Enschede played a very important part.
The subject of this paper includes only one facet of the application of these new materials in hydraulic engineering. In this case,

however, not in the framework of the aforesaid large scale operations but in a much more modest area, namely along the embankments of the River Yssel.

The problem.

The Gelderse Yssel is one of the Dutch riverarms which flows from Arnhem in Northern direction into the Lake Yssel, the former Zuider Zee. The waterflow in this river arm has a considerable variation and depends on the flow of the Upper Rhine. After the canalization of the Rhine, which was completed a few years ago, summerflows of 250-350 cubic metres per second are aimed at, while the highest flow known amounted to approximately2300 cubic metres per second. The embankments consist prominently of sand, the grain of which is varying and decreases in downstream direction from coarse to fine. From 1880 on normalization works have been carried out in order to restrict the excess water, occurring frequently until that year. The navigable waterway which was as well created in this way, is suitable for ships up to 1300 tons.
The fall and the streamvelocities, connected with it, are rather strong, in particular in the upper course of the river.
However, in the fifties it appeared that along a similar river of modest size, considerable problems could occur. In that period the riverbanks became subject to erosion even on a very large scale

Not only resulted this in the loss of agricultural land, but also in the formation of local raisings of the waterwaybed, which caused serious obstructions for navigation. Moreover, the aforesaid normalizationworks (groynes etcetera) were threatened now at the land side, by which they were in danger of loosing their function. The extent of the erosion in particular obliged to drastic interference. After comprehensive studies of the various possibilities one decided to the large scale installation of bankprotections between the groynes on those slopes which required a defense. Moreover it turned out to be necessary to enlarge and possibly improve the normalization works on account of the new developments which took place in the meantime.
About 1968 a scheme covering the ten years 1968-1978 was started, which could be well carried out because new working methods could be applied.
So also in this case the availability of synthetic fabrics caused a real revolution, now in this particular field of hydraulic engineering.
We shall now discuss and explain this more in detail.

Backgrounds.

For those particular parts of the slopes, which remained under water more or less permanently, the usual constructions at that time consisted of osierwood mattresses, constructed in an ingenious, but labour consuming way, and which, covered with a layer of stones, eliminated the eroding actions caused by the watermovements on the riverbanks.
Above the mean summer level a revetment of stones in stretcher bond - which was labour-consuming too - was applied, reposed on a row of creosoted wooden stakes.

During the drawing up of the schemes it soon became apparent that the restricted time available during low water to carry out these works, the extent of the job to be executed and the very few skilled workmen available, especially for the Delta works, would make it impossible to make the necessary arrangements.

By Rijkswaterstaat, the aforesaid manufacturers and the contractors for maintenance works, a lot of attention was paid to the use of synthetic fabrics and a few rather simple tests were made.
It proved that this material could in principle be the ideal replacement for the complicated osierwood constructions. However, the practical application was still a big problem, which may appear from the following.
From an analysis of the factors causing desintegration of the riverbanks two points came to the front in particular.
The first is the watermovement from the riverside, like flows, turbulance and waveaction caused by wind and navigation.
The second is the watermovement from the landside, caused by quick variations of the waterlevel.
In order to cope with the firstmentioned element, the embankment should have a revetment made in such a way that the watermovements are controlled in time, till below the critical point on which sandparticles are taken away. This can be done, for example by rubble in different forms and sizes.
To fight the erosion from the landside one should see to it that the water, leaving the banks because of the variations of the level does not take away sand particles either, in other words that a waterfiltering action is obtained.
This effect was achieved by the classic osierwood mattresses with more or less success. A fabric, however, is a filter and is ideal for this purpose, provided it has the correct dimensions.

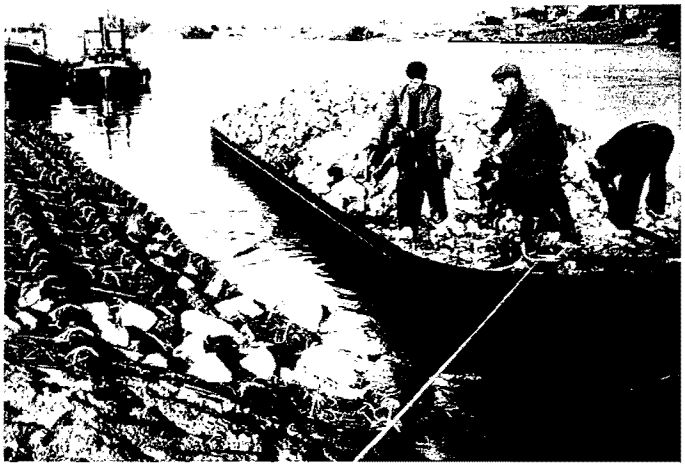
Solution.

Although the very good suitability of synthetic fabrics was fully recognized, the possibility of application turned out to be a big problem as yet, especially when one wanted to apply the material exclusively, that is to say not in combination with the conventional mattresses. For the filtercloth should be applied under water, yes under flowing water even, on the specially prepared slope.
By thinking the criteria out consistently, the solution was finally found, very simple as it should be!! The new material was attached to a single layer of osierwood, like the one also used in the construction of conventional mattresses; the fabric is stretched to it, as it were.
The osierwood gives sufficient floating capacity and rigidity to the total construction in order to tug it over the watersurface and manoeuvre it into position, which is necessary in most cases, because the mattresses are being built on a restricted number of sites.
A grillage, as mentioned before, consists of a number of fascine poles which are laid perpendicularly on each other at a mutual distance of one metre and which are tied up at the crossings.

The fascine poles consist of mechanically made bundles of osierwood. which combine a good flexibility to the strength required.
The fastening of the fabric to the grillage as originally thought of, was "translated" by the textile engineers in such a way that an extremely simple but practical solution was found.
On the construction patent was applied for and obtained.

On behalf of the protection of the banks a method was developed which is somewhat analogous to a development in the "big" business, namely the sinking in upstream direction. (see picture page 4)
The flow in the water is used to press the mattress partly loaded with stone to the bottom.
On the sites in question the mattress was fastened to a steel bar hanging on two small cranes which had been placed on a pontoon. The fastening is done in such a way that it can easily be loosened after the sinking has been completed. During these operations the pontoon is mounted at the upstream direction of the mattress and is just like the steel bar held in the flow by means of mooring ropes and anchors.

By loading the mattress with rubble in the land and upstream direction and then by lowering it from the steel sinking bar a downgoing movement is started which is strengthened by the flow in the water. After the mattress has completely sunk on the slope and bottom it is covered with rubble. Then the connection with the sinking beam is broken, the beam is turned up again and is made ready with the pontoon for sinking the following mattress.
The simplicity of construction and working method of this bankprotection has indeed created the possibility to face the arisen problems in a quick and efficient way.



The material.

The development of raw materials for the synthetic fabrics which were applied in hydraulics, has naturally not stood still over the years.
Whereas the first fabrics which were used in hydraulics were manufactured of nylon multifilament, in the mid of the sixties synthetic fibres became available which had been developed on the base of petrochemical products, the polyolefines of which the main representatives were polyethylene and polypropylene. These raw materials, which are used both in the form of multifilaments, tapes and monofilaments, were the base for a series of fabrics.
However, the waterpermeability of the fabrics made of these tapes and yarns varies.
If it is used as a light simple tape fabric then the water permeability is very limited. This will improve if the tapes are twisted, whether bundled or not.
The strong mattresses woven from this material are suitable for large-scale application. For the revetment of sandy riverbanks (in my opinion) monofilament fabrics are strongly to be preferred. The waterpermeability of this material with equal compactness of sand is considerably higher which may be a great advantage especially in the long run, while the monofilament is to be considered better proof against erosion in various forms. The dimensions of meshes of the material used were initially determined non-scientifically, that is to say primarily based on the originally developed thickness of thread of 300 microns and found appropriate on the ground of observation.
Experiences in practice led to the application of material with coarser meshes on the Upper Yssel so that in the end the dimensions of meshes of 340, 500 and 850 microns were used.

In the meantime extensive investigations have been made with the Waterloopkundig Laboratory by order of and in co-operation with the Delta Department of Rijkswaterstaat with regard to the hydraulic characteristics of synthetic fabrics and filters (3)*
Standards and methods have been developed which enable to determine on the basis of sieveanalysis of samples of the bank or bottom to be protected, to which requirements of waterpermeability and sandcompactness the fabric to be used has to come up to at any rate.

When applying the outcome of this scientific method of research, the restrictions, however, should be clearly examined.
The determination of thecorrect filter constructions under the circumstances is a matter where we cannot do without the expert judgement based on experience. It is a fact that when making a choice between available fabrics preference must be given to the material that offers the greatest waterpermeability under the circumstances of an equal sandcompactness.

Conclusion.

What precedes has been dedicated to the solution of a big problem by the application of new materials.
Though not relevant I will not keep you from the results of another experiment, the more so as these only emphasize the suitability of the method followed.
When searching for a solution of the problem as outlined in the beginning, additional attention was naturally paid to strong and large scale mechanization.
This might be achieved by constructing the bank protection from one material namely stone in different gradations and not - like in the past - from different materials.
In this way a granular filter could be built which, provided that the upper layer would be sufficiently stable, could meet all requirements.

Because of the fact that this theoretical approach could not be contradicted, Rijkswaterstaat created the economical possibility to apply it in practice.
The extent of the required equipment, the dependence on suitable waterlevels and last but not least the high investments and working expenses were the reasons why this method, which was dealt with by the industry with enthusiasm was abandoned soon.
Besides the fact that the method followed now meets the requirements which may be made on a good slope protection, this method has the great advantage that the supply and the application can take place by such simple means that also or possibly exactly for medium firms of contractors a big market opens here.

In the way as sketched in what precedes more than 2.000.000 square metres bank protection has been applied along the whole of the Yssel since 1967 and this system or similar methods have found worldwide application since.

The ten-year plan which was deemed necessary at the time has amply been accomplished as to the volume of work to be done which could be foreseen then.
The progress in the erosion which occurred in the meantime and the necessity to further normalization entail a lot of work which is still in progress; nevertheless the end is in sight.

These results have been achieved thanks to a close co-operation of the authorities and industry. They fill the persons concerned both from the firms of contractors, the textile industry and Rijkswaterstaat with some pride.

Literature:

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