Applications of Geofabric in Embankment Engineering of Yangtze River

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ABSTRACT: This article is a brief account of the application of geofabrics in the levee system along the Yangtze River in China. It first describes the necessity and ergency of such an application, and then cites, in three categories, several typical examples to show the broad prospective of extended use of the discussed materials over the river.

1 INTRODUTION

The Yangtze, the 3rd largest river in the world, plays an important role in the development of the nation's economy. Unfortunately, however, it now remains a flood-prone country, bring about frequent disasters, especially serious to its middle plain area. Where the ground is low-lying while the soil strata are complicated in distribution, with the top layer composed of clayey soils, which are underlaid by all sorts of pervious materials such as silt, fine sand, sand and gravel and the like. Some of these are outcropping even on the river bed, communicating directly with the stream flow iteself. Moreover, during the highwater period the water level there is often by up to about 10 m high than the land surface of cities in elevation. Hence a very serious problem of flood protection should be sloved. As for the flood control facilities so far available, they consist mainly of a levee system , totalling 30000 plus km long. It protects a land area of 120000 plus km^2. As high as up to 17～18m at the maximum, all the existimng embankments are, in nature, a result of progressive development in history. Their status is: low in design standard, poor in quality, and fairly weak in foundtion. These are the very factors leading to unceasing slope washing, bank failure as well as piping both behind and underneath the embankments proper, accompanied by constant dangerous events.

The materials for use in flood fighting and bank protection used to be such as brushwood, straw bag and jute sack in addition to natural soil, sand and gravel, etc. , and made from them all time were a variety of mattress revetments, brush-stone pillow protections, block rock revetments and riprap aprons. These traditional materials have been shown to be, after all, not much ideal, because they are rotten, liable to being decomposed and inconvenient for transport due to their large weight and volume; besides, their sources are rather limited. Emerging as the times require, the application of geofabrics has been providing a new yet fairly ideal source of materials for flood-fighting and rush emergeney control. As a protective material, geofabric has quite a few advantages to recommend it . It is, for example, high in strenghth, light in weight, rot-proof, wearresistant, easy to be constructed, and multi-functional in terms of filtering, separation, reinforcement, drainage (or anti-seepage) and so on. So , allowing to overcome many weak points inherent in the traditional materials, the newcome is expected to find yet more prompt and extensive application .

2 HISTORY OF THE GEOFABRICS APPLICATION IN YANGTZE

In the Yangtze embankment projects, use of geofa

rics began first with river band and bottom protection. For instance, in 1974, a flexible geofabric mattress was applied to the north bank of the Sima reach downstream; in 1978, a geofabric apron was provided for the Liuyu reach in Hangjiang county, where the fabric-protected river bed area had been up to 200000m² by the year 1992; in 1983, a geofabric mattress curtain protection was practised in the Jingjiang reach in the middle stream of Yangtze, over an area of as many as 300000m². In the meantime, progressively widespread application of flexible mattresses composed of earth-filled, fabric-enclosed pillows and cushions was seen in some apron projects in the valley. Since 1985, geofabrics have began to be utilized as materials for filtering and seepage diversion, and thought highly of as well in the rush work for piping emergency treatment. Early in the late 1980s, geofabrics became to be in common use for immediate treatment of the piping emergencies and disperced saturation troubles occurring in the earth dams throught the valley. Meanwhile, gradually developed were another techniques, namely, of using for slope protection the concrete or mortar-filled geofabric formed bags. In 1985 and 1986, successive tests were made, in the estuarine area, of its bank protection with similar concrete-filled formed bags, and earth-filled formed bags instead of the traditional ripraps, yielding fairly good results.

At present, earth-filled fabric bags have been directly used as embankment and dam building materials, and the benefits thus obtained, both economic and environmental, are rather good.

In a word, the use of geofabrics in the valley is now just unfolding, and they certainly will find more and more extensive application, yielding yet more remarkable teachnical results and economic benefits with the lapse of time.

3 SCOPE OF APPLICATION AND TYPICAL EXAMPLES

3.1 River bottom and bank protection

3.1.1 Geofabric earth pillows and geofabric cushions

In 1969 there occurred a breach in the Tianjiakou embankment at Honghu Lake in the middle stream of the Yangtze, which led to a bank failure, with the bottom silts undermined so as to make the breached portion a most dangerous section afterwards. Also in the midstream, situated at a bend and facing the main current, the Houzhou embankment, JianLi County, was once eroded and caved seriously. Both these two failure sections were geofabric-treated in 1984 following a special bank protection test done in abvance (see Fig. 1). In 1988, the scope of application of this type of protection was further widened. In several sections, including above, geofabric earth pillows and cushions were adopted, for the typical construction of which see Fig. 2. In those cases, the cushions were used instead of traditional mattresses while the soil pillows as a ballast weight instead of rock blocks. The geofabric there used is made from propylene. Each geofabric bag, filled with 6-7 ton soil (or sand), is 10 m long, 0.8m wild and 0.9m high. Each cushion applied measures 70m long and 10m wide, with both sides 10-12mm nylon rope-reinforced. Besides, at each end of the cushion there are 5-12m excessive lengths nylon ropes available for use as connectors with the quincuncial piles and the tail pillows on the shore.

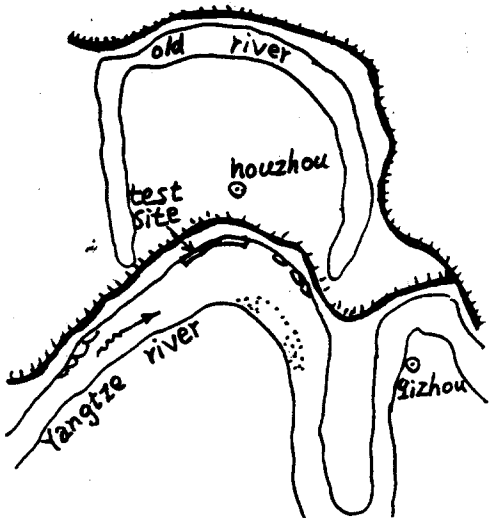

Fig. 1 The site of test for the Houzhou embankment.

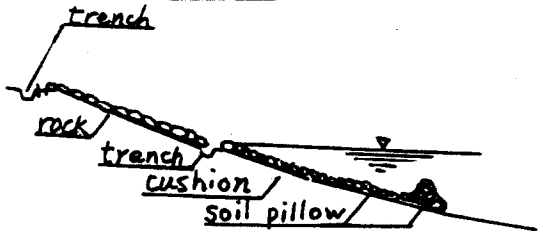

Fig. 2 Typical section of pilot project.

Applications showed that geofabric soil pillow and cushions are so flexible that they would be readily adaptable to river bottom deformations, and, consequently, kept tightly attached to the objectives treated, yielding good protective results. It can stand a

greater overlaid ballast weight more than 3 times bigger than the traditional brush-stone mattress.

3. 1. 2 Flexible mattresses

Flexible mattresses have now found fairly wide application over the river. Attention, however, should be paid whenever they are to be laid on the band slopes. Here, by the stability the author means not to allow occurring any plain slides, drifts or uplifts under the action of the stream flow. For this reason, any submerged mattress, when used, must be properly fixed on the slope and partly imbeded into a trench specially digged out at a given spot, and then rock ballasted accordingly. The ballast used might be of concrete blocks or cement-soil blocks. Shown in Fig. 3 is the typical section of geofabric bank protection design.

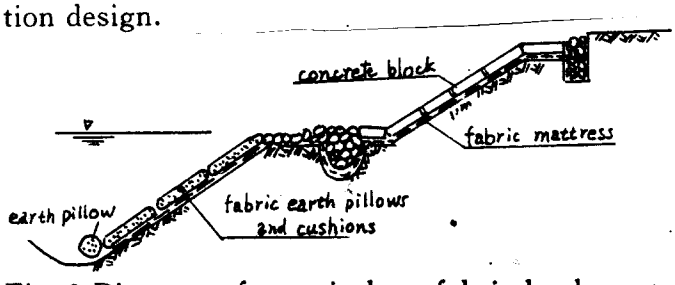

Fig. 3 Diagram of a typical geofabric bank protection design

A typical example of application of this type of mattresses is the bank protection done of the Sima reach within Jiangdo County stream. The Sima bend was once caved in seriously, and the river bank there collapsed at a length of as long as 66km. First, block protection was tried, but this method would involve a large amount of investment. As a substitute fabric flexible mattress was adopted.

Studies showed that a mattress as such is capable of resisting a flow velocity of 3 m/s when ballasted by a pressure intensity of 980 Pa. Through subaqueous inspection it was found that the mattress sunk did not make any move under the action of the flow except a slight degradation observed around, and it was still remained in place, tightly attached to the original soils. This means the protection made is performed well. Up to now, it has stood the test by two successive major floods, one in 1981 and another in 1985, and been still in good condition.

In addition ,its economic benefit is high enough, too; allows to save about 35% of the investment as compared with a riprap protection. This type of flexible mattress is, in general, adaptable to bank having a slope of 1 : 2. 5.

3. 1. 3 Hinged concrete slab-faced geofabric mattresses

In the Tianxingzhou bank protection project, Wuhan, a type of hinged concrete slab-faced geofabric mattress was adopted, based on the principle of using the slab and fabric for joint scour resistance.

It is strong in integrity , well-flexible, readily adaptable to deformations of the river bed, simple in implementation and durable as well as low in construction cost. It is by 15-35% cheaper than the brush-type mattress.

3. 1. 4 Geofabric formed bag

The geofabric formed bag is a pocket-shaped matter that is made from double-layered geofabric. Laid out on a slope that needs protecting, all the bags are to be filled in situ with concrete or mortar to form a facing of some 15-30cm in thickness. The technique is simple and suitable for being operated underwater. In 1986, a revetment of formed bags filled with concrete was provided for 266 m long section of the south river bank at zhenjiang, covering a total area of 4500m^2. The bags applied measured totally 17. 25m long down the slope, and 2. 5m long at the top of the bank.

3. 2 Rush treatment of embankment emergencies

In the flood season there frequently occur embankment emergencies along the river, and geofabric has become now a first-aid material in common use to this end, playing an important role in eliminating all kinds of potential troubles.

3. 2. 1 Rush treatment of bank collapses

On July 3rd, 1991, a foot undercutting took place with the front slope of the Huangdun protective embankment, Anhui Province. To treat this, an soil pillow-ballasted geofabric was laid on it, and the emergency was promptly eliminated (see Fig. 4—a)

3. 2. 2 Rush treatment of the leaks in embankment

In the high-water period of the year1991, there occurred a lot of leaks in the river embankment within Auhui Province. The number of leaks was as many as 61 in the Xiandie protective dyke on the Chuhe, and some of them had a diameter, at the outlet, of 10-15cm. They were, obviously, created by white ants. Carried out using geofabric ballasted by fabric-enclosed soil bags, the treatment yielded favourable results (Fig. 4—b)

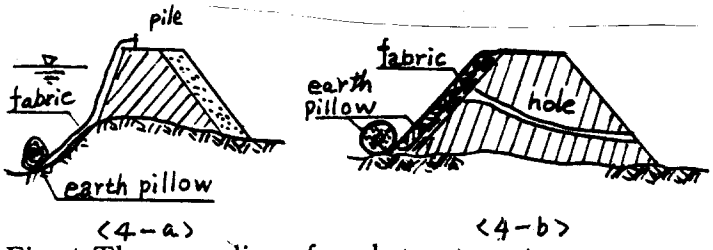

Fig. 4 The remedies of rush treatment

3. 2. 3 Regulation of the dispersed filtration

Whenever a saturation line is positioned too high in an embankment and escapes at the D/S slope, dispersed filtration will be for certain led to. To regulate this there are two measures available: one is to arrange some close-to-slope drains and another to cut trenches for seepage diversion. In both cases geofabric can be used as a means of treatment. (see Fig. 5)

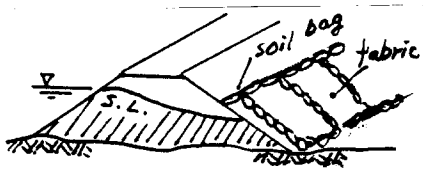

Fig. 5 The regulation work for treating the dispersed filtration.

3. 3 For building embankments and dams

It is nothing new to use geofabric for embankment and dam builing on the Yangtze. Many successful examples of this can be cited, especially those associated with the underwater dumped, fabric enclosed earth bags-based cofferdam building and embankment or dam toes protection. This type of earth bags allows to substitute a considerable amount of rock and soil materials.

Simple in construction and cost-saving, they are suitable for embankment and dam building in flowing water.

3. 3. 1 Use in an enclosing embankment for the intake of water works .

In the There Gorges area there are some water works, the intake of which is enclosed by an embankment some 15m high. To form the toe protections, upstream and downstream, of the embankment, earth-filled geofabric bags were originally dumped in the 10m -deep flowing water, with the central part filled with silt deposits excavated from the river bed. So , waste dumping sites could be saved, a factor much advantageous to environmental protection. To intersect the seepage flow one impervious cut off wall was provided in the silt-dumped body by high pressure jet mortar. Simple and speedy in construction, low in cost and effective, this technique is worth of spreading (see Fig. 6-a)

Another case is duming in the flowing water fabic-enclosed earth bags to form an enclosing embankment for use as ash storage cofferdam. For purposes of aging resistance and scour prevention, protective measures, such as riprap protection, will have to be taken on the outer slope of the embankment (see Fig. 6-b).

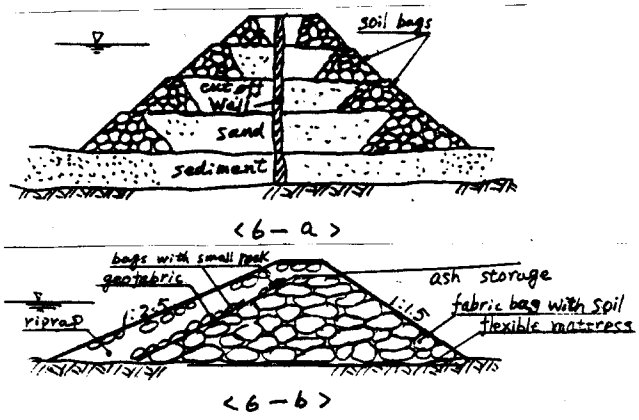

Fig. 6 The sections of two enclosing embankment

4 CONCLUSIONS

The application of geosynthetic materials over the Yangtze has a long history of nearly 20 years. Experiences showed that this sort of materials are unique in terms of their functioning in river bank and bottom protection, embankment and dam building as well flood-fighting. They have several advantges to recommend themselves. It can be expected that they will play more and more significant role in developing and harnessing the Yangtze River.

Issues due to be solved at present:

To develop yet more sorts of new materials suitable to the requirements of different engineering works .

To improve their aging resistance properties.

To develop and perfect the existing design philosophy and computation method .

To further reduce their construction cost.

To research new construction machines and tool suitable for use with geofabrics.

REFERENCES

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