Field test study on new technology of beach protection with permeable pipe

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Abstract. According to the field monitoring and analysis of the effect of the new permeable pipe for beach and sand protection, the correct using method of the technology is verified. In this paper, the topography was compared before and after the implementation of the permeable pipe. And the effect of the new type of permeable pipe for beach and sand protection was analysed. The applicable conditions of the new technology are summarized, which provides the basis for the popularization and application.

1. Introduction

The test site is located in the west section of Longdao in Caofeidian, Tangshan City, as shown in Figure 1. To the east of Caofeidian is a typical offshore sand bar lagoon system on sandy coast, which is transformed by the sediment from abandoned delta of Luanhe River under the lateral action of waves. Due to the construction of a reservoir in the upper reaches of Luanhe River in the 1970s, the amount of sediment transported into the sea decreased sharply and the sediment supply was insufficient, resulting in slight erosion of the sand bars along the coast. The sediment supply from the original Luanhe River moved from SW to the coastal area and turned into relatively weak sand bar scouring and sand supply. Longdao showed a trend of erosion in the northeast and siltation in the southwest. After the completion of the 14 and 15 artificial islands and the island linked dykes in Jidong Oilfield in 2008, the coastal sediment transport from the northeast to the southwest was completely cut off, resulting in the blocking of the coastal sediment transport at the southwest end of Longdao, the continuous erosion and retreat of the coastline, and the beach erosion in the middle of Longdao was the most serious. In the middle of Longdao, the erosion of high-quality beach surface is serious, and the erosion channel appears on the beach surface (Fig. 2). Under the current conditions, the erosion trend will continue because there is no coastal sediment transport supplement.

Figure 1. Project location
2. permeable pipe beach restoration scheme

The new technology of permeable pipe beach maintenance is to change the water pressure between sand grains, scouring on the beach of wave was slow down and the sediment settlement was accelerated, so as to play a role in promoting siltation and beach maintenance. It is a green and environmental protection method for beach and sand protection [1]. According to the current situation of beach erosion in Longdao, the length and width of the beach in the west section of Longdao in Caofeidian are 2000m and 100m, with an area of 200000 m² and 500 permeable pipes buried. According to the preliminary test results [2] and referring to the repair experience of relevant foreign cases [3-5], the arrangement of pervious pipes is 40 m along the coast and 10 m vertical to the coast. A total of 500 permeable pipes are buried, and the top elevation of the buried permeable pipes is between the lowest and the highest tide level of Longdao. The plane and vertical section of pervious pipe layout are shown in Fig. 3. The method and special permeable pipe for beach cultivation by permeable pipe are patented by Tianjin Institute of water transport engineering, Ministry of transport [1]. The processing, manufacturing and application of the pipe shall be authorized by Tianjin Institute of water transport engineering, Ministry of transport. The project adopts permeable pipe sand beach technology. The pipe is PVC plastic, 2m long, outer diameter 160mm, shell of pipe 4mm, with the horizontal gap and the gap width no more than 0.1mm. Each horizontal gap penetrates the shell of pipe, and the spacing between adjacent horizontal joints is 3mm. The structure of permeable pipe is shown in Fig. 4.
3. Embedding method of new permeable pipe
The embedding construction method of new pervious pipe is as follows: firstly, 2.5t diesel pile hammer is used to drive steel casing around the permeable pipe, and certain measures are taken to ensure that the steel sleeve is parallel to the permeable pipe. Secondly, the sediment in the pervious pipe and between the pervious pipe and the steel sleeve is pumped out with a sand pump; finally, the permeable pipe is lifted to the design elevation, the steel sleeve is pulled out and the surrounding of the permeable pipe is backfilled and levelled.

4. Analysis of nourishment effect
Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

4.1. Monitoring method and times
The whole field digital mapping method is adopted for topographic survey, and GPS RTK is used for topographic survey. Before operation every day, the detection is carried out on the control point "TK1" or "TK2". The maximum horizontal difference is 0.026m and the maximum vertical difference is 0.024m. After the implementation of the beach restoration project, topography monitoring was carried out for two years. The monitoring times were August 2017, November 2017, April 2018 and July 2018, November 2018, April 2019 and August 2019 [6].

4.2. Analysis of beach nourishment effect
4.2.1. Comparison of topography from 2006 to 2013.
In order to evaluate the effect of the new tec, some analysis results before the implementation of pervious pipe are cited. Figure 5 (a) shows the comparison of 0 m isobaths (85 Yellow Sea based level, close to Caofeldian mean sea level) of Longdao in 2006, 2010 and 2013. Shown as Figure 5 (a), the main topography changes in 2013 were that the outlet sand island at the southwest end of Longdao was shortened nearly 1km, and the beach on the west has been eroded nearly 100m, compared with 2006. In recent years, under the combined influence of sediment reduction and wave generated current, the engineering area is in erosion state. Figure 5 (b) shows the local erosion and deposition changes of Longdao from 2010.9 to 2013.5. The results show that the island body on the west side of Longdao island is eroded to a large extent; the island body on the west side of the wooden house in the public reception area and 550m away from the west side of the dike has a tidal ditch, with a width of 250m under average sea level conditions, the deepest depth is + 0.7m, with an average of + 0.8m; the bottom of the landscape wooden house near the sea side also has a certain degree of scouring depth, the current water depth is about + 0.5 ~ + 0.6m, the deepest is + 0.2m; the beach surface is flat The
adjustment of scouring and silting is small, and the local scour of approach bridge of artificial island wharf is slightly larger.

4.2.2. Comparison of topography from 2013 to 2017.

In order to study the recent dynamic geomorphic evolution near Longdao, plane and cross-section bathymetric surveys were carried out in 2015, February 2017 and August 2017. Figure 6 shows the local scouring and silting changes in the waters near Longdao from 2013 to 2015. During 2013-2015, there were still artificial sand mining activities near the island head on the west side of Longdao, so the topography changed dramatically, and the local deep trench caused by sand excavation was about 10m; meanwhile, the beach in the east section of Longdao was still eroding, but the amplitude was slowed down. Figure 7 (a) shows the measurement position of the section from February 2017 to August 2017, and Figure 7 (b) and (c) show the comparison of water depth of section 3 ◆ - 4 ◆. The section 3 ◆ and section 4 ◆ are within the implementation scope of the project. From the change of section in Figure 8, the cross-section presents the trend of scouring and moving towards the shore during the half year period of conventional wind wave action, and the scouring and silting intensity of section 3 # - 4 # - 0.10m and -0.04m, respectively.

4.2.3. Comparison of topography from 2017 to 2019.

A total of seven topographic surveys were carried out after the pervious pipe was installed. The topographic changes within the scope of each statistical survey are shown in Table 1. It can be seen from the table that the average erosion and deposition thickness of PEM test area from August 2017 to August 2019 after the implementation of the restoration project is 0.01M, which is generally siltation. The comparison before and after the construction of PEM permeable pipe on site is shown in Fig. 8. From table 1, it can be seen that during the period from November 2017 to April 2018 and from November 2018 to April 2019, the overall performance is scouring. During the scouring measurement period, all the time spans the winter. Under the strong wind and waves in winter, the lateral sediment transport is mainly offshore, and the shoreline is in the state of erosion. The rest of the survey sections are generally silted up, which is in line with the characteristics of "winter regression and summer silting" in Longdao. From July 2018 to November 2018, the overall performance of the project area is also scouring, which is mainly caused by the storm surge from August 15 to 20, 2018. The storm surge and wind wave caused a large range of scouring to the project area, and caused a certain amount of damage to the PEM permeable pipe in the project area. According to the measured data, the beach presents a typical storm type profile after the storm surge, which causes serious erosion in the wave breaking zone. Therefore, during the period from July 2018 to November 2018, the overall performance of the project area is scouring.

Compared with the measured values from February 2017 to August 2017, the scouring and silting intensities of section 3 and section 4 are -0.10m and -0.04m respectively. Taking the average value of the two sections as -0.07m, this area has the characteristics of winter recession and summer deposition. Therefore, the annual scouring intensity of the project area is bound to be greater than 0.07m. After the pervious pipe is installed for two years, the average sedimentation volume in the project area is 0.01M. In conclusion, the pervious pipe counter wave pipe can be obtained. The beach erosion under the action of waves can slow down the beach erosion and play a positive role in beach restoration. Fig. 8 shows the silting around the permeable pipe after the implementation of on-site permeable pipe.

Through the field test and research, it can be seen that the pervious pipe can effectively slow down the wave scouring on the beach, but it has no anti wave effect. Because the material of the permeable pipe body is PVC, and the pipe body is covered with water permeable and sand proof horizontal joints, the strength of the pipe body should be considered for areas with large wind and waves or freezing and thawing.
Figure 5. Topographic changes of Longdao from 2006 to 2013 (historical data)

Figure 6. Changes of local erosion and deposition in Longdao from 2013 to 2015

a) Section position

b) Measured change of section 3 and section 4

Figure 7. Measured change of section from 2017.02–2017.08

Figure 8. Comparison of siltation around pervious pipe before and after construction
| Number | Measuring times       | Average erosion and deposition (m) | Erosion or Sedimentation |
|--------|----------------------|-----------------------------------|--------------------------|
| 1      | 2017.08-2017.11      | 0.10                              | sedimentation            |
| 2      | 2017.11-2018.04      | -0.14                             | erosion                   |
| 3      | 2018.04-2018.07      | 0.05                              | sedimentation            |
| 4      | 2018.07-2018.11      | -0.03                             | erosion                   |
| 5      | 2018.11-2019.04      | -0.02                             | erosion                   |
| 6      | 2019.04-2019.08      | 0.05                              | sedimentation            |
| Summary| 2017.08-2019.08      | 0.01                              | sedimentation            |

5. Conclusion
The following conclusions are obtained through the experimental study on site of the beach and sediment protection technology of PEM permeable pipe:

(1) By analyzing the hydrodynamic conditions and sediment environment of Longdao, it can be seen that the source of sediment in the sea area is decreasing day by day, and the beach is in scouring state under the action of wave and tide.

(2) Compared with the measured data in February 2017 and September 2017, the average scouring depth is 0.07m. Within two years, the average scouring and silting thickness of the permeable pipe test area is 0.01m which is generally siltation, after the implementation of the new permeable pipe beach restoration project. Therefore, the pervious pipe can slow down the beach erosion under the action of waves and play a positive role in beach restoration.

(3) It can be seen from the field engineering test results that the permeable pipe can reduce the scouring by wave on the beach. The horizontal gap on the pervious pipe will reduce the strength of the pipe, so it is necessary to consider the permeable strength of the pipe in areas with large wind and waves and frozen areas.

(4) The 3D physical model study is needed before the implementation of the new method. According to the hydrodynamic conditions and sediment environment of the project location, the material strength, material size, layout form and reasonable construction parameters are analyzed based on the study results.

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