Geotextile tube as an alternate solution for coastal remediation

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ABSTRACT: The abrasion process in coastal area is an emerging challenge for the residence at the coastal area. The abrasion may change the coastline and finally reach to their residential area. The solutions that is usually applied for this problem are by using concrete breakwater, sheet pile, gabion, etc. However, cost, time and installation process are often being the consideration of choosing the appropriate solution for coastal remediation problems. By considering cost, time, and easiness of the installation process, geotextile can be an alternate solution applied to the coastal area. The design of geotextile tube must consider the condition on site, strength of the materials, the stability of the tubes, and the fill material that is used for filling process. In this paper will be discuss the design approach of geotextile tube based on the coastal condition, the determination of the tensile strength of the materials, and the stability of the arrangement of geotextile tube. Those factors must be considered during the analysis until the construction on site. The case studies on Java Island, Indonesia will also describe the use of geotextile tube for coast remediation.

Keywords: abrasion, coast, geotextile, remediation

1 INTRODUCTION

The problem of abrasion in coastal area is an emerging challenge in northern coast of Java island, Indonesia. The abrasion process gives several problems like road damage, the collapse of the house, and the facility along the coastline.

Figure 1. The effect of abrasion in north coastal Java island

Based on this problem, the solution is needed to remediate the coastal line and to “refill” the coastland. Common solution of the abrasion is using the concrete breakwater, sheet pile, or gabion. On the other hand, the cost of those solutions may high. The other solution is using geotextile tube which using the sand from the area itself as the filling material.

Geotextile tube is a structure of giant tube that composed from geotextile woven or non-woven polypropylene/ polyethylene which are resistant from the ultra violet ray, abrasion, and high durability. In this case, the geotextile tube is composed from two geotextile non-woven materials. The chose of the materials must consider the properties of the filling material.

2 LITERATURE

In general, geotextile is divided into two types, Woven and Non-Woven. Both of the materials are easy to find, economical, adaptable to the coast condition, durable, easy to implement, and can be filled using the local materials. The material that is used for the remediation must fulfil the specification requirement of the mechanical, hydraulic, and physical properties. The sample must be tested using the international standard as below.

Table 1. Testing standard of geotextile non-woven

Properties	Testing Standard
Tensile Strength (MD)	1.2
Tensile Strength (CD)	1.3
Elongation MD	ASTM D4595
Elongation CD	ASTM D4595
Static Puncture Resistance	ASTM D6241
Thickness Under 2 kPa	ASTM D5199
Weight	ASTM D5261
Permittivity	ASTM D4491
Charateristics Opening Size	EN ISO 12956

The other parameter that affect the choose of the geotextile materials is the condition of the coast itself. The data of the behavior of the sea wave, the current, the depth of the sea, the sediment transport, and the soil investigation must be available for the design process and the execution. The gradation of the filling material must be higher than the opening size of the geotextile to make sure the filling process is workable.

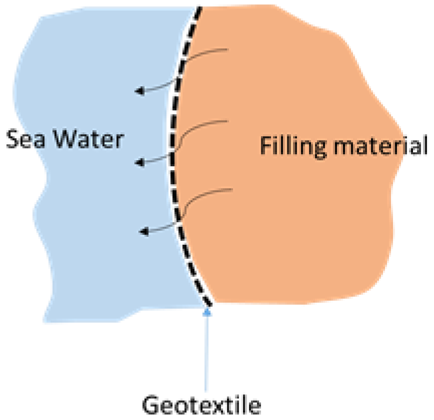

Figure 2. The choose of geotextile materials

The permeability of the geotextile should be high to prevent the excess pore water pressure during the filling process. The permeability should be ten times higher than the permeability of the filling material, hence the material will be retained in the tube.

Table 2. Material aspect

Material	D_{50} (m)	ks (m/s)	Type of internal water movement
Clay	<2.10^{-6}	$10^{-10} – 10^{-8}$	Laminar
Silt	$2.10^{-6} – 63.10^{-6}$	$10^{-8} – 10^{-6}$	Laminar
Sand	$63.10^{-6} – 2.10^{-3}$	$10^{-6} – 10^{-3}$	Laminar
Gravel	$2.10^{-3} – 63.10^{-3}$	$10^{-3} – 10^{-1}$	Turbulent
Armourstone	$63.10^{-3} – 0.4$	$10^{-1} – 5.10^{-1}$	Turbulent
Armourstone (coarse)	0.4 - 1	$5.10^{-1} – 1$	Turbulent

In the coastal area, the material that may be easy to find is the sand. The advantages of using the sand as the filling material is easy to find in a large amount, more stable than fine grained material, consistency of the volume, and predictable engineering properties. In the contrary, the sand has no cohesion, and the particle tends to budge.

Table 3. Sand properties

Condition	Sand (D>60µm)
Stationary hydraulic condition	$O_{90} < 5D_{10}Cu^{1/2}$ and $O_{90} < D_{90}$
Dynamic hydraulic (Wave attack)	$O_{90} < 1{,}5D_{10}Cu^{1/2}$ and $O_{90} < D_{90}$

Where $Cu = D_{60}/D_{10}$.

The other factor that may affect the result of the geotextile tube is the seam strength. In general, there are five types of the seam. The prayer seam, the J-seam, the overlap Z-seam, the butterfly seam, and the double J-seam. The seam strength must be able to retain the pressure during the filling.

Figure 3. Type of geotextile seam

According to A. Bezujien and E.W. Vastenburg, each seam type has a specific strength as describe in the table below.

Table 4. Type of the seam

Seam type	Strength
Prayer seam	30-50%
J-Seam	30-60%
Overlap Z-seam	>80%
Butterfly seam	40-70%
Double J-seam	50-70%

3 DESIGN APPROACH

In designing the geotextile tube, there are several factors that must be considered. The hydraulic stability, internal stack stability, the stability against the settlement, underneath scouring, and the global stability of the tubes. The design should meet the criteria of below.

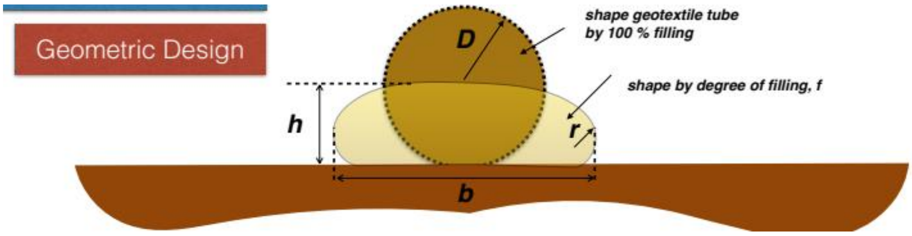

Figure 4. Criteria of geometric design of geotextile tube

The ratio: $h \geq (1 - \sqrt{(1-f)})\,D$ and $b \leq h + \frac{1}{2}\pi\,(D-h)$ to obtain the stability of the geotextile tube. The f value is described in the table below.

Table 5. the f value for the dimension of geotextile tube (Bezuijen and Vastenburg, 2013)

f	r (m)	b (m)	h (m)
1	1 R	2 R	2 R
0.95	0.7 R	2.28 R	1.59 R
0.9	0.58 R	2.4 R	1.42 R
0.85	0.5 R	2.49 R	1.29 R
0.8	0.43 R	2.56 R	1.17 R
0.75	0.37 R	2.63 R	1.07 R
0.7	0.32 R	2.69 R	0.98 R
0.65	0.28 R	2.74 R	0.89 R
0.6	0.24 R	2.79 R	0.81 R

The design of the geotextile tube is analyzed using computer program called GeoCoPS. The design must consider the location of the geotextile tube on site whether the tube is above the sea water, partially submerge, or submerge in the water. In this coastal remediation project, the geotextile tube is designed partially submerge and submerged to trap the sand that brought by the sea wave.

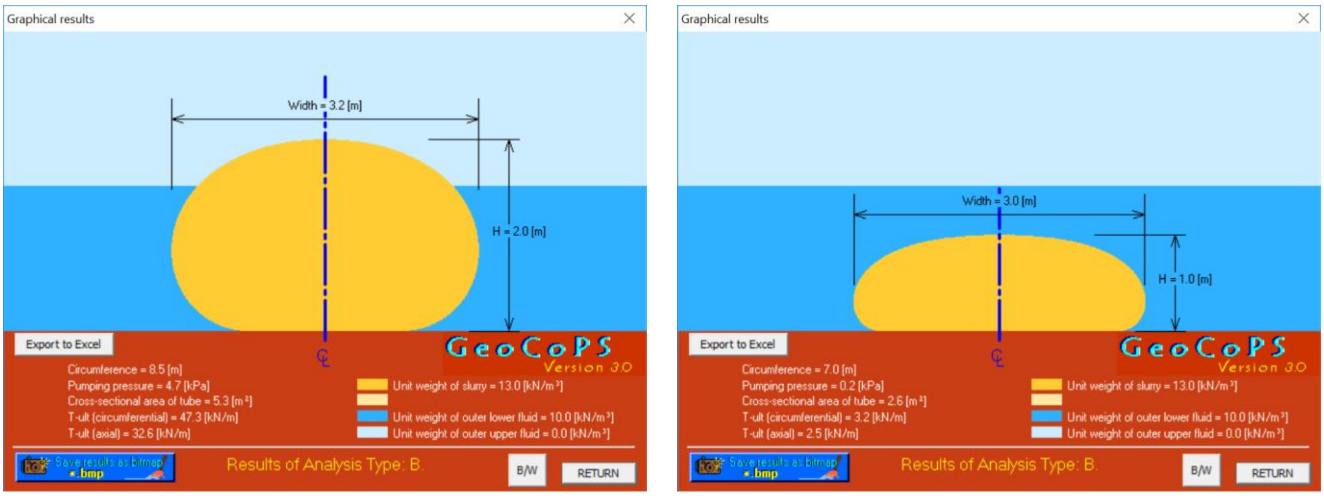

Figure 5. Design of geotextile tube using GeoCoPS

The ultimate tensile strength must meet the material specification and the pumping machine must be able to pump with the certain pressure from the analysis. From the analysis above, the 8,5 m of geotextile tube circumference and 2 meters high, the width of tube is 3,2 meters. The ultimate tensile strength of the circumference is 47 kN/m and the ultimate axial tensile strength is 32 kN/m.

Figure 6. construction of geotextile tube

Figure 7. The result of geotextile tube

4 RESULT

After approximately 12 months, the coast line is starting to remediate as the picture below.

Figure 8. the coast line is refilled with sand

The material of geotextile tube is remained stable where the tube is becoming harder.

Figure 9. The geotextile tube after 12 months of installation

From this project of coastal remediation, it may be concluded that the geotextile tube can be used as an alternative way beside the conventional solution for coast remediation. With a proper design by considering the surrounding factors, the geotextile tube can replace the common breakwater system and to restore the coastline.

5 CONCLUSION

The use of geotextile tubes as coastal remediation is able to restore the coastal area that has been reduce due to abrasion. The design of geotextile tube must consider several factors like the filling material, the strength of the geotextile, and the configuration of the geotextile tubes. All of these factors can be design with a specific software like GeoCOPS that result in the cross-sectional area of the tube. From the case at north of Java coast, the coast restoration took place approximately 12 months.

REFERENCES

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