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ENVIRONMENTAL EFFECTS OF T-SHAPED GROINS BUILT ON THE EASTERN BLACK SEA COAST ON SHORE PROTECTION

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ABSTRACT

The construction of the double highway on the Black Sea Coast was initiated in 1998, completed in 2000. During the construction, T-shaped groins where were built to protect the shore. In this article, the contribution of T-shaped groins to beach formation and their positive or negative effects on the change of coast and submarine topography were environmentally examined.

For this purpose, before the research on the map the groins were marked then the places where the groins would be constructed were levelled by taking soundings and their bathymetric maps were prepared. After the groins were built, the surrounds of the T-groins were determined by taking data with the echo sounders device and their bathymetric maps were prepared again.

Afterwards, these are whose construction was completed were observed at the beginning of winter, at the end of winter, at the beginning of summer, and at the end of summer. These observations investigated whether a beach was formed on the coast and the environmental effects conclusions were investigated. At the end of the study, the effects of the groins on submarine topography in terms of shore protection and the positive or negative environmental contributions to the shore were determined and the data were shown in graphs and figures.

KEYWORDS:
Environmental protection, T-head groin, Coastal protection, Eastern Black Sea, Sediment

INTRODUCTION

The coasts; the sediments dragged by the creeks, streams, and rivers, the coastal structures and coastal currents are effected of the wind and waves. As long as there is no invention, it will reach the state of equilibrium after a long period of time. Each intervention affects the coastal dynamics and contributes the movement to reach the state of equilibrium.

The impacts of wind, currents and the sediment transport should be taken into consideration in order to ensure that coastal structures do not disturb the coastal equilibrium.

The project designer should make a project with the best approach that will not disturb the balance by analysing these effects thoroughly. These works should be done before the project starts. After the start of the project, any new developments should be monitored and if necessary the balance of the coast should be protected through adjustments [1, 2].

Otherwise, the coastal balance can be quickly deteriorated and it may lead to a massive loss of property and life. The human factor should not be ignored while conducting these studies and the applications that help to establish human-coastal relations should be preferred.

For the establishment of a coastal-human relationship, the best way to protect the coast is to build sandbanks on the coast. The groins are the most important engineering constructions made within the scope of the coastal protection [3, 4].

The groins are coastal protection structures built generally perpendicular to the shore in order to create a shoreline along the coast that keeps the sediment and prevents the coastal erosion. It is built in the form of I, T, Y, r and L. They are constructed in a way that the intermediate distance will be 2-3 times of the length depending on the shape of the coast, the direction and amount of the sediment transport and the wave climate of the region [5-7].

In addition the groins also is awkward serve to hold the moving material on the shore, preserving the balance of the existing beach, keeping the large items on the upper part of the beach, preventing the harbour and the fishermen’s shelters from being filled and ensuring a smooth beach formation.

The groins which are constructed as a result of the analysis of the coastal parameters ensure the formation of the beach in a short time and accelerate the coastal-human relationship. In addition, they meet the market’s need for sand and gravel by holding the sediment carried by the rivers and taking them according to the engineering procedures [8, 9].

When coastal structures are to be constructed, the conditions of the region should be carefully examined. The direction of the dominant wave and accordingly the direction of the sediment transport along the coast should be determined. If there is a structure on the shore, the upstream side of the structures which is affected by the sediment transport will start to be filled, while its downstream side will be subjected to erosion. This situation provides different results for the structures which are constructed in series [10, 11].

Again, according to the reviews it was found that exact results were not given about the length, space and heading lengths of the groins. When a coastal structure is built on any coast the followings factors affect the shoreline changes; the height of the wave (H), wave period (T), the angle of the wave (α), bottom slope (tan β), grain diameter (d_{50}), the size of the structure (L_x), the distance between the structures (L_g) and the amount of the sediment transport along the coastline (Q).

It is understood from the literature studies that when a structure is constructed along the shoreline, the balance of the shore changes and the shoreline is affected. If there is not any structure, the shore remains in balance [12, 13].

The groins built on coasts are coastal structures that are usually built upright on the shore to prevent coastal sediment should be movements, to reduce its amount, to prevent erosion occurring on the coast and to create a new shoreline or protective beach. They are also used to reduce the sediment movement on the upstream side and to prevent the port and the fishery shelters from being filled.

The interaction between the groins and the sediment transport along the shoreline has a very complex relationship. Therefore, the ability to set very precise guidelines for projecting can be only the requires long work results.

While constructing a groin, the connection of the groin to the coast should be strong and it should enter at least a 6 m. area. The groins should be placed in such a way, that the sediments moving towards the shore should not go beyond the angle of the structure. In this case, the most important factors to considered are the direction and development of the waves and the movement of the material.

The length of the groins varies from about 30 to 200 meters. The average angle is taken approximately as,

$$L_G = (1-3).L_X \quad (1)$$

The "T" groins hold the shore materials from both sides and provide better protection according to the straight groins. A series of T-groins, that work together in order to protect a long part of the shore is called the groin system. The T-groins are both functionally and structurally different from the breakwater. The breakwaters are made from heavier and larger components and therefore they are larger and higher. The length of a groin determines the amount of the coastal sediment transport and it is used to determine the gap between the groins. In the groins when the transport towards the shore increases, the transport towards the angle is decreased and the transport towards the downwards of the shore is protected. As a result the sand which was carried to the shore will form a hill. Although the groins which were examined in this study were made of stones, there are also groins type according to the types and function of the used materials. They can be classified in the following way.

According to the Type of the Used Material. Wooden groin, steel groin, concrete groin, asphalt and stone groins

According to the Function. Permeable, impermeable groins, high and low groins, fixed and adjustable groins

According to the Form. Plain (I) groins, T groins, L groins, Y groins, ɼ groins

MATERIALS AND METHODS

The wave climate of the Eastern Black Sea region; In the simplest sense, it can be said that wave is a mess that distorts and turns the balance of the hydraulic system upside-down. The waves seen in the seas, lakes and gulfs occur due to dependant forces such as tides and wind. They are named according to the name of the events they came from such as Tidal waves, wind waves etc. There are also waves which occur due to the volcanic eruptions and undersea earthquakes. Waves are classified according to the depths of the sea, the characteristics of the wave motions and the forces producing the wave.

Since the measurement of the wind wave is difficult and expensive, the observations are rather short. In Turkey, a regular wave measurement network has not been established yet. Therefore, the data which are required for the project estimated with the help of the wind records. The wind data which is used in the estimation of the wave is obtained from the meteorological wind data or from the synoptic wind maps [14-16].

Several methods have been developed to convert the wind data obtained from both sources into wave estimates. The most common of these is the SMB (Sverdrup Munk Bretschneider) method. The wind data used in this method is transformed into significant wave height and period.

The dominant wave direction of the shore region is N, NNW and NW and the significant wave heights vary between 1.5 m and 7.5 m. In some extreme values this can also reach 11.5 m. (At the storm which occurred in the region at the beginning of April 2002, a 200 kg heavy part of the lighthouse threw which was situated 12 meter high into the harbour).

Since the wave data obtained from the meteorological data are smaller than those obtained from the synoptic maps, the data obtained from the SMB data were used for the safety of the structure.

The rivers in the Eastern Black Sea Regions are wild as their slopes are quite large due to the topographic structure of the region. Therefore, their flow rates are very high. This leads to significant sediment transport. This amount is estimated to be about 3-5 million tons / years [17-19].

The flow rate of the sediment carried by the stream depends on the flow conditions and the properties of the fluid and sediments.

$$Q=f(v,\rho_s,\upsilon,d,\rho,h,R,j) \quad (2)$$

(v: mean flow rate, ρ_s: specific weight of the sediment; υ: fluid viscosity; d: grain diameter; ρ: specific weight of the fluid; h: water depth; R: hydraulic radius; j: base slope of the river).

The general formula is given above. The general substance transport formula was developed by E. I..E.

$$Q=14.153.101.26016.\log.A \quad (3)$$

(A: basin area Km^2 ; Q: flow rate of the sediment tonnes/ year)

In addition, an equation was developed according to the data taken from the rivers in the Eastern Black Sea Region.

$$Q = q, Q_{ort} \quad (4)$$

a and b are regression coefficients, Q_{ort} is the daily average flow rate m^2/ sec. Q: the flow rate of the sediment transport tonnes / day.

The sediment transport made by the rivers in the Eastern Black Sea Region are estimated to be 3-5 million tonnes / year.

The sediment transport in the coast. The source of the sediment transport is the material which occurs as the result of the erosion of the land and the breakdowns of the rocks and is transported to the shore with the help of the rivers. The sediment which reaches the sea in this way is constantly moving in the coastal zone. This movement continues after adding the existing sediments. The movement of the sediments in the coasts is examined on the cross section of the coastal section of the unit width which is taken perpendicular to the shore and these sections are called the coastal profile. The coastal profiles are also classified according to the wave effects among themselves. The profile of the waves when they are small and less is called the "Normal Profile" or "Summer Profile" and when the waves are more and high then it is called the "Storm Profile" or "Winter Profile".

Although the main parameter which affects the coastal profile is the transport which is perpendicular to the coast, the effect of the parallel transport is also excessive. Here the effective factors are the settling velocity of the deep sea particle (w), mean wave stiffness (Ho/ Lo), and diameter of the sediment (d_{50}).

In addition, the sand- gravel which is taken randomly from the coast or from the coastal areas in improper manner can also change the coastal profile. The transport which is parallel to the shore is the transport caused by the coastal currents [20].

The impact of the groins onto the sediment distribution along the coast; T-groins are built along the route of the Black Sea Double Highway and are constructed to parallel the shore in most places where coastal protection is necessary according to the project criteria. The T-groins which have successfully been implemented in countries such as Japan, Britain, the USA and Israel have been constructed in groups in sequential order. Unlike the plain and L-groins they hold the sediment and do not leave it back during the transport which is upright or parallel to the shore.

The sand and gravel which constitutes the majority of the transport along the coast are kept by the groins built sequentially and as a result great sanding occurs on the shore. This new sanding creates a new shoreline and acquires a natural beach view. Thus, it contributes to the development of the coastal tourism and to the acceleration of the coastal-human relationship and allows people to benefit from the coast to the maximum extent.

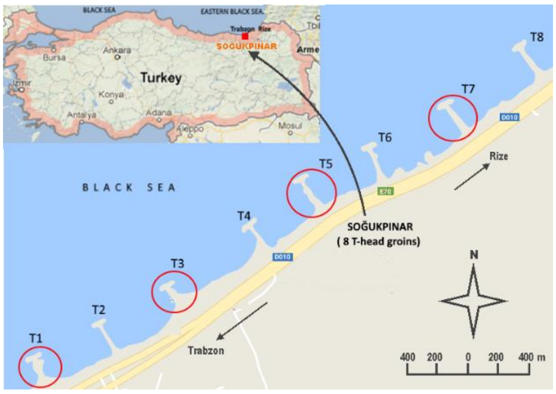


FIGURE 1
The place and location of the T-groins

The sanding caused by the T-groins provides the opportunity to obtain a wide beach by continuing the coastal circulation. The coast ensures the balanced distribution of the sediment transport. The coast ensures the hydrodynamic balance as well as it helps to protect the highway from the wave effects and reinforcing the coastal-human relationship. It creates environmental health. On the other hand, the T- groins which are not built sequentially in a system along with the flat and L-groins may cause undesirable results such as damaging the shore. On the one hand, they fill the shore (by holding the sand-gravel), but on the other hand they may cause erosion (carving) [22].

Coastal erosion is one of the most frequent serious consequences that disrupt the coastal-human relations. The classic coastal protection structures which are made to prevent this are very large and expensive. Moreover, they completely disrupt the ecological balance of the place where they are built. They are causing environmental disasters.

The coastal engineers have started to look for effective solutions which can replace the classical coastal protection structures and which change the natural structure of the coast as little as possible. In this context, it can be easily said that the natural beaches are the best coastal protection structures. Therefore, the way to formation natural beach is to make T-groin.

This study examined the T-groins built on the coast of Trabzon Of - Soğukpınar for protection within the scope of the Black Sea Double Highway. The coast which was selected as the study area is a 1.7 km-long part of the Of coast whose total length is 11 km. There are 8 T-groins along the route (Figure 1). Also this route includes the port of Of, one fishery shelter and a boat yard.

The construction of the T-groins started in 2000 and in the same year all from this route were completed. They were constructed by combining them into groups. There are8 T-groins within the working area. In this study they are referred to as 1,2,3,4,5,6,7,8 from west to east [21].

All of the constructed groins are in the same size and the space between the groins (a) in the group is usually twice the size of the groin. Only the size of the No 3,4,5,6 groins along Soğukpınar is between 20 and 30 meters. The length of their headings (c) is half of the length of the groins (c= b/2). The size and the altitude are the same. The groin's height is b=75m, the length of the head is c=37.5 m, the space between the groins is a=150m, the width is 10 m, while the altitude of the groin is +1 m.

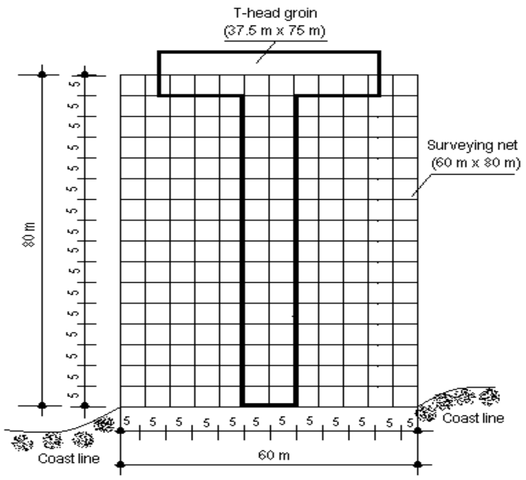
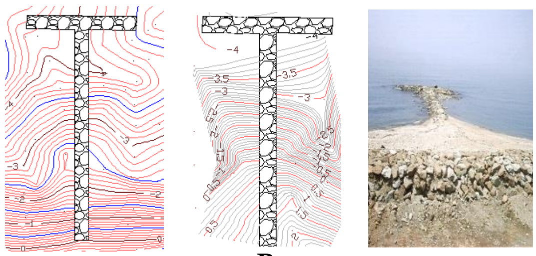


FIGURE 2
Measurement Grid

First of all visual inspections were performed on the constructed groins to determine whether there was any damage, filling or loss around the groin, if there was any sand-gravel accumulation around the heels. In addition, the groins are 60 m parallel to the sea and 80 m perpendicular to the sea. 5 x5 m grid sounding line capacity was realized on the area whose length is 60 x 80m (Figure 2).

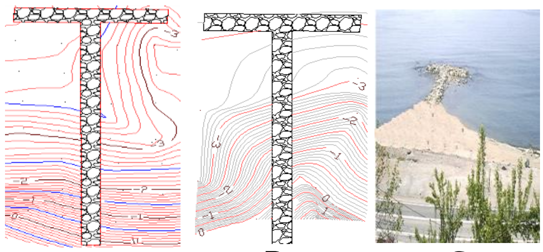
The contour lines of the groins were obtained by processing the obtained sounding values in a computer. This process was made separately according to the sounding values of the years between 2000 and 2016 and this gave the opportunity to compare the changes occurred within 16 years.

As a result; it was investigated whether there was material accumulation around the groins depending on the sediment motion and the groins were subjected to functional evaluation. The examination and evaluation was carried out 2 by 2 from west to east [23-28].



A B C

FIGURE 3
Soğukpınar T1 (A) July 2000, (B) July 2016, (C) Current view



A B C

FIGURE 4
Soğukpınar T3 (A) July 2000, (B) July 2016, (C) Current view

RESULT AND DISCUSSION

As a result of the research and investigation the groins were measured and evaluated 2 by 2 and the following results were obtained. In addition, the fullness % is according to the inside area of the T.

The transport which is parallel to the coast is also from west to east. So, the direction of the maximum transport dominant wave is north- west (NW). This means that the results of the investigation, measurement and observation are in agreement with the theoretical information. This shows that the approach is correct. According to this: the T-head groins were constructed along the coast of Soğukpınar where there are 8 T-head groins in a group, an amount of material accumulated on the heel like sand, gravel et. on the No. T1, T2 and T3 groins. 33% fullness up to +2 altitudes has observed on the right heel of the Soğukpınar T4 groin (Figure 3-4 A-B-C).

There is a 35% fullness up to +2,5 altitudes on the heels of the Soğukpınar T5 and T6 groins. These groins which are filled with thin material are the groins that have had the most fullness so far. They are used as beache (Figure 5 A-B-C).

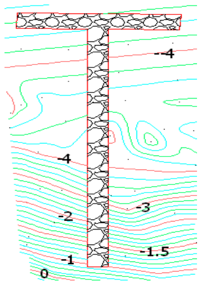
There is 50% fullness with fine material at the Soğukpınar T7 and T8 T-head groins. These overfilled T-head groins are used as beaches nowadays (Figure 6 A-B-C).

Their fullness rate is increasingly growing; they are used as beaches. There are 80% fullness with fine material at the Soğukpınar T7 and T8 T-head groins. These are the most filled groins according to the other T-head groins. They have very high environmental contribution and are used as beaches (Figure 3-4-5-6 A-B-C).

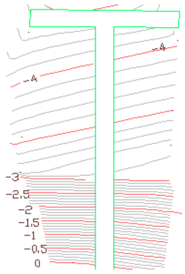
RESULS AND DISCUSSION

When the study area was investigated by walking along the coast, it was seen that the selection of the size was right, however the selection of the place was not done properly because, attention was not paid to the geometry of the groins and the altitude was too high (+1,5-2m). However, in some places on the beach T groin construction may be on agenda along the route until the end of the road construction. When these will be constructed in groups, it should be considered to calculate the distance between groins as 3 times of the length of the T and sufficient attention should be paid to the fishery shelters, boat yards and ports and the height of the construction should not exceed +0,5m. This allows the incoming waves to pass over the construction and reach the other T-groin, to release more materials and to speed up the filling.

Over time, the groins will be completely covered with sand and will disappear and a natural beach will be created. In this way, an environment will be occurred which can be used by the people more easily. In addition, the coastal changes should be monitored periodically, the occurred damages should be repaired, sand-gravel should be removed from the overfilled groins, and artificial filling can be done on some groins which need to be used as beaches. The coast must be monitored continuously and data bank should be established. It will be also useful to set up wave measurement stations at certain places along the coast in a region such as the Black Sea Region which provides too many values in this regard. In this way, data-based feedback will be ensured and the information reinforcement about the land and observation results will be realized. This data will increase the approach rate in the results after it is supported by empirical studies.



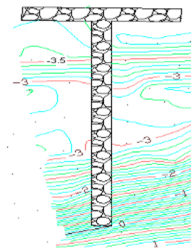
A



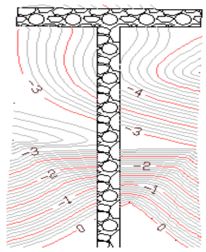
B

C

FIGURE 5
Soğukpınar T5 (A) July 2000, (B) July 2016, (C) Current view



A



B

FIGURE 6
Soğukpınar T7 (A) July 2000, (B) July 2016, (C) Current view

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